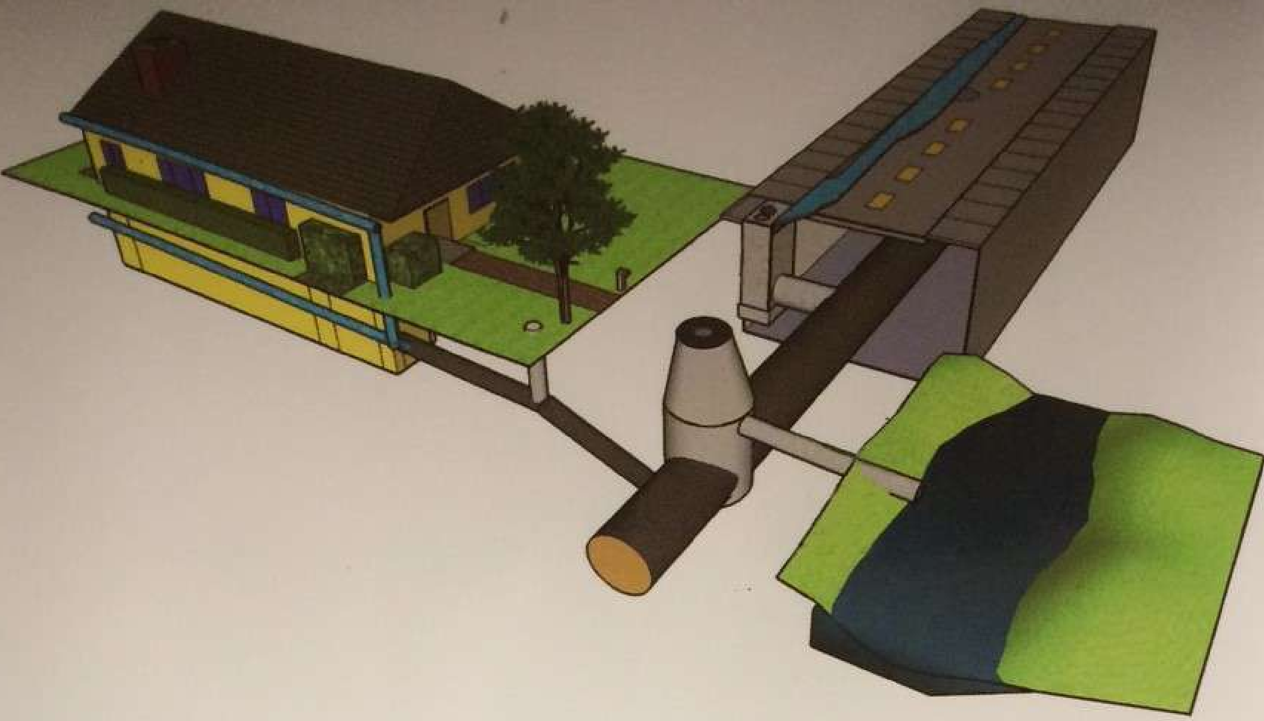

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Editors

J. Premalatha • Bhaarathi Dhurai • N. Saraswathy

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1.

A fructified way of treatment of *Garcinia cambogia* spent wash water using Cyanobacteria/Microalgal species

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ABSTRACT

Garcinia cambogia, a Malabar tamarind is a tropical fruit and popularly used as a weight-loss supplement. The active ingredient Hydroxy citric acid present in this fruit is said to boost fat burning and hence helps in weight loss. The active ingredient is extracted in the form of Calcium or Sodium salts using water as the main extracting solvent. The water used in extraction of this component is huge and after extraction, the spent wash water is left to the environment as such. This wash water could be a good source for Cyanobacterial/ Microalgal species for its growth and the cultivated microbial species can be used for lipid extraction which could be a fructified way of treating spent wash water with simultaneous biofuel production using extracted lipid. In the present study, five different species of *Scenedesmus abundans, Chlorella pyrenoidosa, Oscillatoria cortiana, Phormedium valderianum* and *Synechococcus elongatus* have been used for spent wash water treatment. The *Chlorella* and *Scenedesmus* species were found to grow well in the spent wash water with treatment efficiency of 87% and 76%.

KEYWORDS: *Garcinia cambogia,* spent wash water, Cyanobacteria, Microalgae

INTRODUCTION

Wastewater from various industries serves as a good medium for microalgae growth with carbon dioxide addition. Wastewater contains plenty of nutrients which saves cost and eliminates the need of fresh water thereby treating the wastewater by assimilating organic and inorganic pollutants into their cells, and eliminates the CO_2 emissions associated with wastewater treatment [1–3]. Phycoremediation is also possible with microalgae which utilize various phosphates and nitrates present in wastewater as nutrient which reduce eutrophication. There are also huge amount of toxic materials like chromium zinc lead etc, present in industrial wastewater which can be treated with specific type of microalgae. Each and every type of wastewater has to be identified with level of toxicity and type of toxic material and appropriate type of microalgae should be used for the treatment. Microalgae have an extensive range of extracellular and intracellular mechanism to cope up with heavy metal toxicity by induction of several antioxidants, including diverse enzymes such as superoxide dismutase, catalase, glutathione peroxidase and ascorbate peroxidase, and the synthesis of low molecular weight compounds such as carotenoids and glutathione [4].

Garcinia cambogia, a Malabar tamarind is a tropical fruit and popularly used as a weight-loss supplement. The active ingredient Hydroxy citric acid (HCA) present in this fruit is said to boost fat burning and hence helps in weight loss. Water is being used as a extracting solvent and HCA present in the water extract is converted into calcium hydroxy citrate by reacting with calcium hydroxide. The water is being used in huge quantities for extracting the HCA and the extracted calcium hydroxy citrate is filtered and dried. The spent wash water is left to the environment.

In the present study, the *G. cambogia* spent wash water is used as a growth medium for microalgae to see the growth and treatment efficiency.

MATERIALS AND METHODS

Materials

All the chemicals used in this study are of high purity and purchased from HiMedia Laboratories Private Limited, Mumbai.

Collection of *Garcinia cambogia* spent wash water

The spent wash water sample of the dried *Garcinia cambogia* rind was collected from a local herbal extract facility unit.

Selection of microorganism

Five different microalgal/ cyanobacterial species *Scenedesmus abundans, Chlorella pyrenoidosa, Oscillatoria cortiana, Phormedium valderianum* and *Synechococcus elongatus* were selected based on the literature survey and were procured from NCL, Pune and NFMC, Bharathidasan University, Tiruchirapalli. The microbial species were grown on BG11 and ASN medium.

Effect of initial concentration of spent wash water on microalgal/cyanobacterial growth

The *Scenedesmus abundans* and *Chlorella pyrenoidosa* were grown in 250 mL Erlenmayer flask containing 100 mL of BG11 medium supplemented with 25 %, 50 %, 75 % and 100% spent wash water. Similarly, *Oscillatoria cortiana, Phormedium valderianum* and *Synechococcus elongatus* were grown in ASN III medium supplemented with 25 %, 50 %, 75 % and 100% spent wash water. The effect of varying initial concentration of spent wash water on microalgal/cyanobacterial growth was studied. 2ml of 1.2 OD value of microalgal culture were added and incubated at 23°C under 150rpm. The microalgal growth was monitored by taking OD at 750 at specific time intervals.

Effect of sequential increase in concentration of spent wash water on microalgal/cyanobacterial growth

The *Scenedesmus abundans* and *Chlorella pyrenoidosa* were initially grown in BG11 medium and then the grown culture was further subcultured in BG11 medium supplemented with 25 % spent wash water. The grown culture in BG11 medium containing 25 % spent wash water was further subcultured with 50 % and then further with 75 % spent wash water. The growth was observed for all these experiments. Similar experiments were conducted with *Oscillatoria cortiana, Phormedium valderianum* and *Synechococcus elongates* but with ASN III medium and the results were observed.

***G. cambogia* spent wash water treatment efficiency with microalgae/cyanobacteria**

The experiment with various cultures that were best grown was identified and treatment of wash water with five different microalgal/cyanobacterial species was conducted and the treatment efficiency was calculated using the formula

Treatment efficiency = [(Initial OD – Final OD) / Initial OD] X 100

RESULTS AND DISCUSSION

The selected microalgal/cyanobacterial species were grown in growth medium supplemented with various concentrations of spent wash water at single instance and sequentially and the results obtained are discussed as follows.

Effect of initial concentration of spent wash water on microalgal/cyanobacterial growth

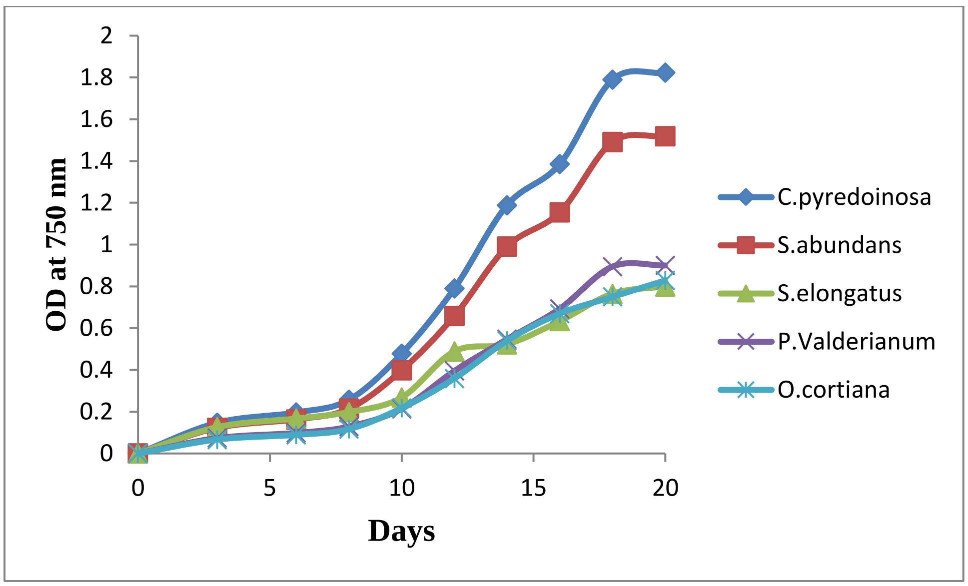

Fig 1. Growth curve of various microalga/cyanobacteria on growth medium supplemented with 25% spent wash water

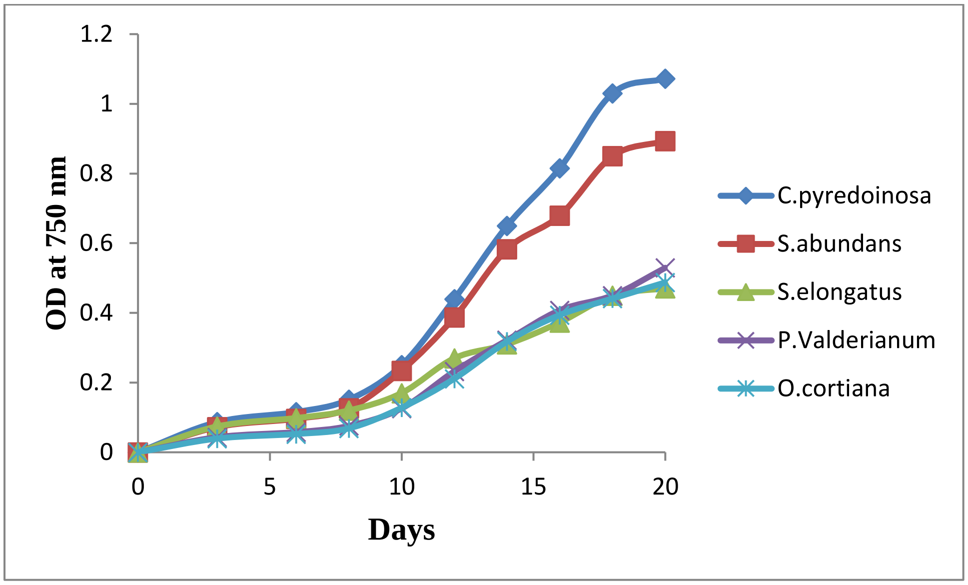

Fig 2. Growth curve of various microalga/cyanobacteria on growth medium supplemented with 50% spent wash water

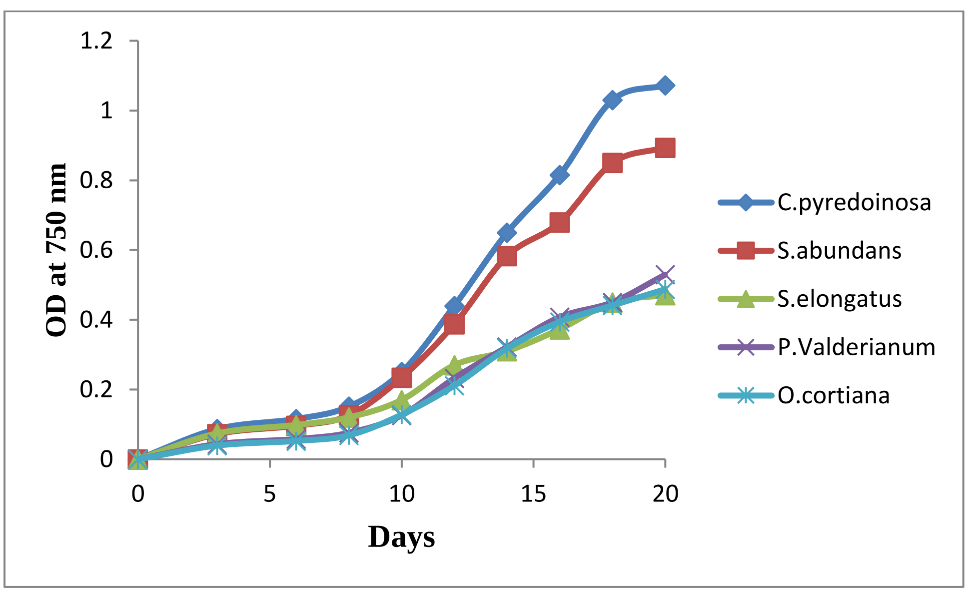

Fig 3. Growth curve of various microalga/cyanobacteria on growth medium supplemented with 75% spent wash water

The *C. pyredoinosa* and *S.abundans* were found to grow well compared to all other species in the growth medium supplemented with 25, 50 and 75% spent wash water. The growth of all the species were higher in 25% wash water supplemented medium and little lesser in 50% supplemented medium and further more lesses in 75% supplemented medium. This may be due to less availability of medium with increase in concentration of spent wash water.

Effect of sequential increase in concentration of spent wash water on microalgal/cyanobacterial growth

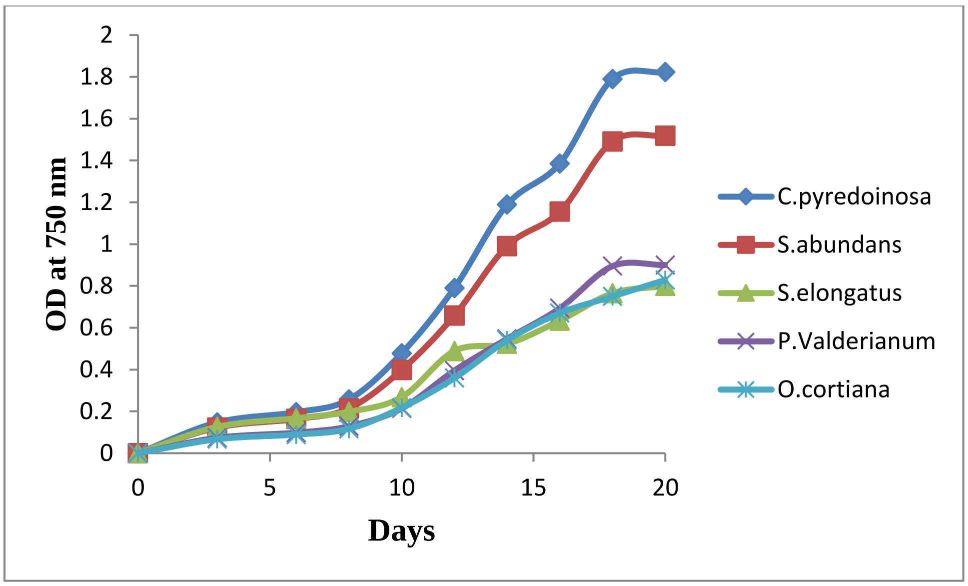

Fig 4. Growth curve of various microalga/cyanobacteria on growth medium supplemented with 25% spent wash water

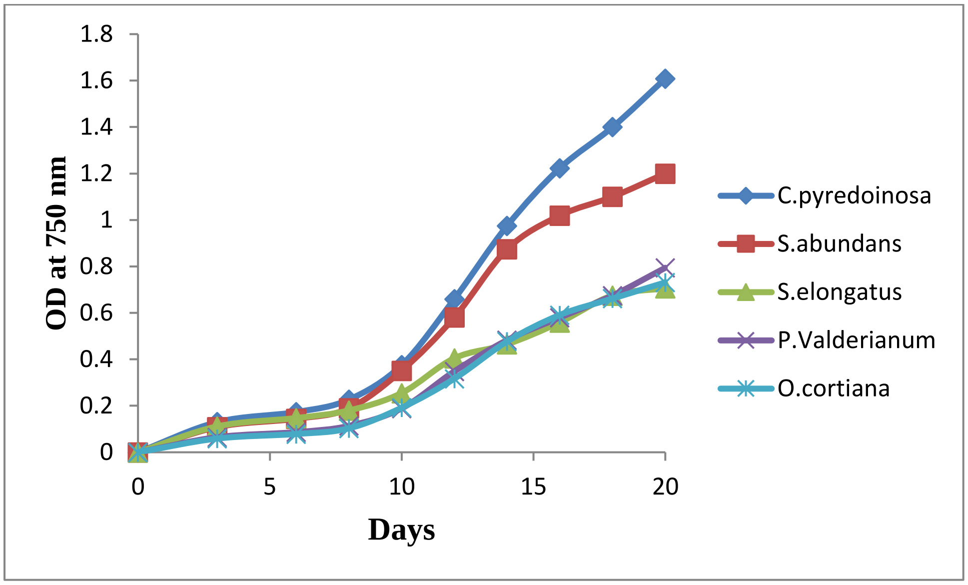

Fig 5. Growth curve of various microalga/cyanobacteria on growth medium supplemented with 50% spent wash water that was previously grown on 25% spent wash water for sequential concentration increase

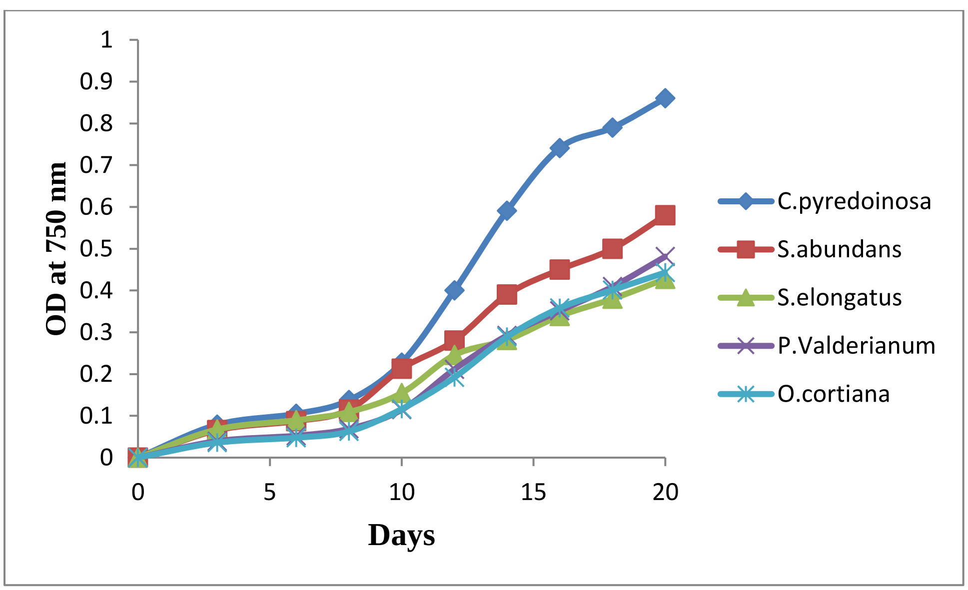

Fig 6. Growth curve of various microalga/cyanobacteria on growth medium supplemented with 75% spent wash water that was previously grown on 50% spent wash water for sequential concentration increase

The *C. pyredoinosa* and *S.abundans* were found to grow well compared to all other species and all the species were found to grow well when spent wash water was sequentially increased in concentration compared to giving the same concentration of wash water at single instance. This make the species adapt to the wash water and helps treating it more effectively.

***G.cambogia* spent wash water treatment efficiency**

The treatment efficiency by various microalga/cyanobacteria species was conducted with growth medium supplemented with 75% spent wash water that was previously grown on 50% supplemented growth medium

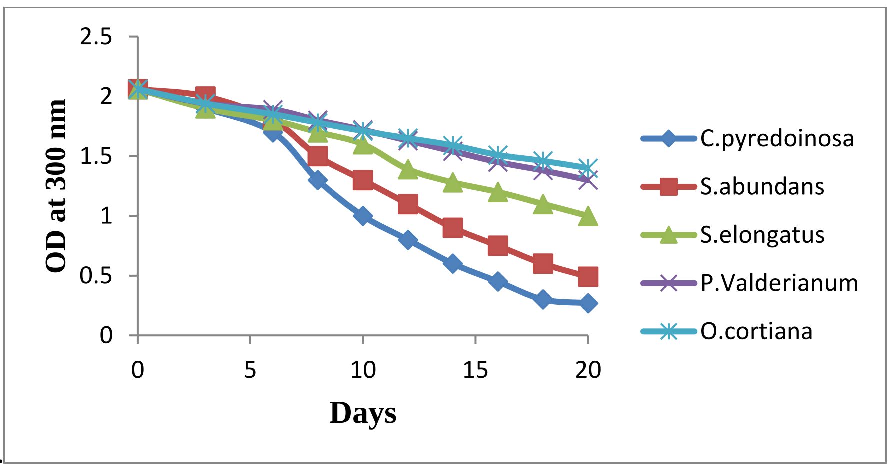

Fig 7. Decolorization of spent wash water with various microalgal/cyanobacterial species

The *C.pyredoinosa* was found to decolorize the spent wash water more effectively than any other species and a treatment efficiency of 87% was evidenced compared to 76% treatment efficiency by *S.abundans*.

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2.

A Study On Low Cost Treatment Of Textile Industry Effluent Using Adsorption And Aerobic Treatment Towards Zero Liquid Discharge

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ABSTRACT

In India, the textile industry has been synonymous with its water pollution. In a textile city like Tirupur, the industrial effluents have always posed environmental challenges and the most of the solutions have not been viable due to economics and efficiency. In this paper, we propose a low cost technology aimed at Individual Effluent treatment plants that shall enable Zero Liquid Discharge. (ZLD). The low cost technology would involve the decolorization of the textile effluent using coir pith as an adsorbent. The adsorption is to be followed by aerobic treatment using sequential batch reactor (SBR). This combined adsorption and aeration would ensure decolorization as well as reduction in BOD and COD. The effluent is then passed through sawdust for further removal of colour and TDS. A bench scale experimental study was conducted using the following process. The efficiency of the color removal was found to be 86.14% after adsorption with coir pith and 96.44% after the entire treatment. The decolorized water when subjected to aerobic treatment using the sequential batch reactor process effected more than 25% reduction and ultimately more than 30% reductions in BOD and COD values. The reduction in TDS levels are also remarkably more than 60%. The treated water conforms to the standards of General Standards or Discharge of Environmental Pollutants Part-A: Effluents

(Land for Irrigation) of The Environmental (Protection) Rules 1986. The bench scale study has

established that low cost treatment using adsorption of textile industry effluent using coir pith followed by sequential batch reactor based aerobic treatment and adsorption using sawdust would lead to drastic reduction of colour, TDS, BOD and COD, lead to land application of treated effluent and thereby ensure zero liquid discharge.

KEYWORDS: Textile industry, Effluent, Adsorption, Aerobic treatment, Zero liquid discharge

1. INTRODUCTION

The textile industry caters to the basic human need of clothing and is also a very vital cog in the industrial economy scenario. All the same, they are identified as one of the most polluting industrial units particularly pollution of water bodies. The Textile industry can be broadly classified into three categories viz., vegetable fibers such as cotton; animal fibers such silk; and a wide range of synthetic materials such as nylon, polyester etc. depending upon the raw materials used.

The raw materials used in the textile production determine both quantity of water consumed and the quality of wastewater. The increasing water crisis has made it a challenge to source water resources for industrial purposes as domestic supply is the first priority. The issue of availability of water for processing is on the verge of becoming a major issue. The effluents are generated from various processing units of the textile industries such as desizing, scouring, bleaching, mercerizing, dyeing, printing, and packing. These processes require huge amount of the organic chemicals of complex structure and all of them are not contained in the final product, they become waste and cause disposal problems. The wastewater resulting from these processes will differ greatly in composition, due to the differences in processes, used fabrics and machinery.

In this regard, a paradigm shift in the objective of wastewater treatment can be observed. The onus is no more to treat the wastewaters from the dyeing units before discharge to the environment. The solution is to recycle the treated wastewater for industrial process or use it for land application for gardening or other purposes. The concept of Zero Liquid Discharge (ZLD) is no more a luxury but essence.

In a textile city like Tirupur, the industrial effluents have always posed environmental challenges and the most of the solutions have not been viable due to economics and efficiency. Tirupur is one of the largest contributor to India's textile output In this district almost 700 dyeing units release 100 million liters of untreated effluents every day. Tirupur's textile mills exported over Rs 17,800 crore worth of products in 2013-14, of which 65 per cent went to Europe. The emergence of Individual Effluent Treatment Plants and later the Common Effluent Treatment plants have failed to deliver. It is always advisable to employ individual effluent treatment plant and rather than a common technology, a technology suitable for the nature and quantum of waste should be devised. The chosen technology should satisfy not only the environmental criteria, but it should also be economic and easy to implement.

The major parameters identified in the textile industry effluents are Total Dissolved Solids (TDS), biological oxygen demand (BOD), chemical oxygen demand (COD), colour, pH and other solution substances. When compared to the other parameters, the treatment for BOD, COD and removal of colour can have a telling effect on the other parameters as well. The effluent treatment for textile industry effluents involve various physiochemical processes like , coagulation, oxidation, precipitation, filtration, ozonation, chemical precipitation, membrane filtration, reverse osmosis electrochemical treatment and also biological techniques to remove the BOD, COD and the colour from wastewater.

Such costly technologies can be suitable for large volume of wastes from synthetic fiber units. However for low cost natural fiber units that is not able to afford such treatment, a low cost alternative that ensures ZLD is attractive. The adsorption process provides an attractive alternative to the above processes because of low cost and ready availability to control the various pollutants from the wastewater. Treatment using good low cost and non-conventional adsorbents may contribute to the sustainability of the environment and offer promising benefits in the future.

The low cost technology would involve the decolorization of the textile effluent using coir pith as an adsorbent. The adsorption is to be followed by aerobic treatment using sequential batch reactor (SBR). This combined adsorption and aeration would ensure decolorisation as well as reduction in BOD and COD. The effluent is then passed through sawdust for further removal of colour and TDS.

2. REVIEW OF LITERATURE

Sivakumar Durairaj and Shankar Durairaj studied the adsorption capacities of low cost adsorbents like orange peels, neem leaves, coconut coir pith and peanut shell powders to remove colour in a textile industry wastewater. The experiments were conducted at pH of 7 with different process parameters like temperature, adsorbent dosage, agitator speed and contact time using adsorption method. From the experimental investigations, the maximum colour removal was obtained at an optimum temperature of 330 K, an optimum adsorbent dosage of 300 mg, an optimum agitator speed of 600 rpm and at an optimum contact time of 75 min. From the validation experiments, it was found that the maximum colour removal percentage in textile industry wastewater is about 79.3, 74.2, 80.7 and 85.6 % respectively for orange peels, neem leaves, coconut coir pith and peanut shell powders.

D. Shankar, D. Sivakumar, M.Thiruvengadam and M.Manojkumar investigated experiments to remove the colour from the textile industry wastewater using coconut coir pith as an adsorbent. The experiments were conducted by different process parameters like adsorbent dosage and agitation speed against the pH of 7 and initial concentration of 45 mg/L to reduce colour in a textile industry wastewater. The results showed that the maximum removal of colour was found to be 88.6%.

U.J. Etim, S.A.Umorenand U.M. Eduok investigated adsorption of methylene blue from aqueous solution onto coconut coir dust (CCD) in a batch process. Adsorption was studied as a function of amount of adsorbent, pH and concentration with time. Analyses of the adsorbent suggest that adsorption of the dye was through a chemical interaction of the functional groups on the surface of the adsorbent.

Jeyanthi and Masilamai Dhinakaran investigated the use of reasonable and eco-friendly adsorbents as an alternative substitution of activated carbon for removal of dyes from wastewater. Adsorbents prepared from coconut coir pith, was used to remove the methylene blue from an aqueous solution in a batch wise column at changing adsorbent dosage, dye concentration, pH and contact time.

V.K. Gupta and Suhas analyzed that among various methods adsorption occupies an important place in dye removal. This review highlights and provides an overview of these LCAs comprising natural, industrial as well as synthetic materials/wastes and their application for dyes removal. It was found that some LCAs, in addition to having wide availability, have fast kinetics and appreciable adsorption capacities too.

Thus from the literature review it was understood that adsorption method using low cost adsorbents proves to be an economical method for color removal. Combined adsorption and aeration when adopted can help achieve zero liquid discharge.

3. OBJECTIVE

The objective of the study is to evolve a low cost technology based on adsorption and aeration and present the case with an experimental study.

A bench scale experimental study was conducted using the following process (1) adsorption using coir pith as adsorbent is to be followed by (2) aerobic treatment using sequential batch reactor (SBR) and (3) filtration through sawdust for further removal of colour and TDS.

The quality of the treated effluent would be checked for conformity with General Standards or Discharge of Environmental Pollutants Part-A: Effluents (Land for Irrigation) of The Environmental (Protection) Rules 1986

4. METHODOLOGY

The methodology adopted for the study can be listed as follows:

- Collection of wastewater from textile industry.
- Collection of coconut coir pith from the coir industry.
- Testing the characteristics of the collected wastewater.
- Conducting Absorption Studies.
- Testing the characteristics of the adsorbed water.

- Performance of the Sequential Batch Reactor (SBR) process.
- Testing the characteristics of aerated water
- Filtration using Saw Dust
- Testing the characteristics of treated effluent

4.1. Collection of wastewater from textile industry - The sample of the textile wastewater is collected from the raw effluent of the textile industry situated in Veerapandi, Tirupur district. The textile industry uses vegetable fibres. The sample quality indicated by its colour is presented in Figure 1.

Fig 1: Wastewater Sample collected from the Industry

4.2. Collection of Coir pith - The coconut coir pith, a waste product from the coir industry was collected from Pollachi, Coimbatore District. The coir pith was available in powder form and it was used as an adsorbent. The sample is shown in Figure 2.

Fig 2: Powdered Coir pith

4.3. Testing the characteristics of the collected wastewater - The characteristics of the wastewater sample namely pH, Turbidity, Hardness, TDS, Fluoride, Dissolved Oxygen, BOD and COD were determined using standard laboratory procedures.

4.4. Conducting Absorption Studies – The adsorption process for decolorization is carried out using Filtration Apparatus after determination of optimum dosage by Jar Test Apparatus as shown in Figure 3. 250 ml of the collected sample (adsorbate) was taken in the jars of the jar test apparatus.

The coconut coir pith (adsorbent) is added to the jars. (0.1, 0.2, 0.3, 0.4 and 0.5 g per 250 ml or 0.4, 0.8, 1.2, 1.6 and 2 g/l respectively).The contact time was established between the adsorbent and the adsorbate (25, 50, 75,100 and 125 minutes).The jars are then placed in the Jar Test Apparatus. The mixing process at a speed of 100 rpm is then carried out for about 3 hours. After one hour allowance, the clear supernatant is collected from the jar. The process was repeated until satisfactory results were obtained. Decolorized sample is shown in Figure 4.

Fig 3: Jar test apparatus

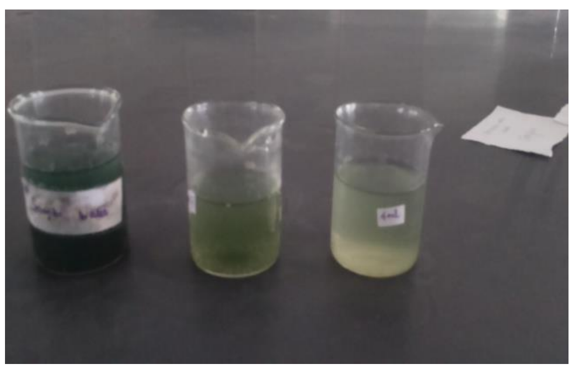

Fig 4: Decolorized sample

4.5 Testing the characteristics of the adsorbed water. - The characteristics of the first stage and the second stage decolorized sample are tested as per standard laboratory procedures

4.6 Performance of Sequential Batch Reactor (SBR) Process - The decolorized sample is then subjected to aerobic treatment using SBR process as shown in Figure 5 for the reduction of the BOD and COD values. One liter of the sample is taken along with the cow dung (ten percent of the total volume) and mechanical mixing using stirrer is carried out for about one hour. Aeration is carried out at this stage. Aeration is performed using the fine air bubble diffuser from the bottom of the tank. The process is carried out for about 5 hours. Then it is left undisturbed for settling. The time period given for the settlement process is about one hour. One hour time period is given for the decant stage so that the clear supernatant liquid is collected at the top of the tank. For one liter of the sample 200 ml of the clear supernatant liquid is obtained. Thus one cycle gets completed by 8 hours.

Fig 5: SBR Process

4.7. Testing Characteristics of Aerated Wastewater - The BOD and the COD value is noted down for the supernatant sample after aeration. The parameters colour and TDS are specially noted to enable process control.

4.8. Filtration using Saw Dust – The aerated wastewater is allowed to filter with another natural low cost material saw dust using filtration apparatus

4.9. Testing the characteristics of the collected wastewater - The characteristics of the treated wastewater sample namely pH, Turbidity, Hardness, TDS, Fluoride, Dissolved Oxygen, BOD and COD were determined using standard laboratory procedures

5. RESULTS AND DISCUSSIONS

The characteristics of the raw wastewater obtained from the textile industry are presented in Table 1. The test results are indicative of pollution due to various textile industry processes. The characteristics help in understanding the level of pollution as well as the suitability of the proposed treatment. The parameters are typical of textile industry wastewater.

Table 1. Characteristics of Textile Industry Wastewater

S.No.	Parameter	Test Values
1	pH	7.4
2	Colour	5400 Hazen Units
3	Turbidity	12.8 NTU
4	Hardness	640mg/l
5	TDS	3500 mg/l
6	Fluoride	4.0mg/l
7	Dissolved Oxygen	2.1 mg/l
8	Biological Oxygen Demand	190 mg/l
9	Chemical Oxygen Demand	320mg/l

The dosage studies of adsorbent yielded the following results. For an adsorbent dosage of 0.3g and for the contact time 25, 50, 75,100 and 125 minutes, the color removal was uniform in all the five jars. For a contact time of 75 minutes and adsorbent dosages 0.1, 0.2, 0.3, 0.4 and 0.5 g the color removal was maximum at an adsorbent dosage of 0.3g. Thus a contact time of 75 minutes for an optimum dosage of 0.3 m was chosen.

The characteristics of the sample after adsorption using coir pith are presented in Table 2.

Table 2. Characteristics of Textile Industry Wastewater adsorbed using coir pith

S.No.	Parameter	Test Values
1	pH	7.1
2	Colour	740 Hazen Units
3	Turbidity	4.8 NTU
4	Hardness	240 mg/l
5	TDS	2000 mg/l
6	Fluoride	2.0 mg/l
7	Dissolved Oxygen	3.1 mg/l

8	Biological Oxygen Demand	155 mg/l
9	Chemical Oxygen Demand	280 mg/l

The performance of the aeration process using Sequential Batch Reactor is a very important component of the study. There was a reduction in BOD and COD values after subjected to SBR process. BOD value was found to be 45 mg/l and COD value was found to be 118.42 mg/l. (The ratio of BOD to COD is 0.38; hence it has no toxic content). For the second cycle, the BOD value was found to be 41 mg/l and COD value was found to be 113.89 mg/l. For the third cycle, the BOD value was found to be 36 mg/l and the COD value was found to be 105.88 mg/l. For the fourth cycle, the BOD value was found to be 30 mg/l and the COD value was found to be 93.75 mg/l. For the fifth cycle, the BOD value was found to be 23 mg/l and the COD value was found to be 76.67 mg/l. Hence from the above values it is seen that there is a reduction in BOD and COD values. This augured for the efficiency and effectiveness of the SBR process.

Table 3. SBR Cycle Efficiency

S.No	Description	Efficiency (%)
1	First cycle result	6.25
2	Second cycle result	8.89
3	Third cycle result	12.2
4	Fourth cycle result	16.67
5	Fifth cycle result	23.33

The characteristics of the sample after aeration show good improvement in the overall parameters as well as drastic reduction in BOD and COD values. They are presented in Table 4.

Table 4. Characteristics of Textile Industry Wastewater after SBR process

S.No.	Parameter	Test Values

1	pH	7.2
2	Colour	160 Hazen Units
3	Turbidity	2.4 NTU
4	Hardness	180 mg/l
5	TDS	1600 mg/l
6	Fluoride	0.9 mg/l
7	Dissolved Oxygen	7.1 mg/l
8	Biological Oxygen Demand	25 mg/l
9	Chemical Oxygen Demand	45 mg/l

The characteristics of the sample after aeration after filtration using saw dust is also presented in Table 5.

Table 5. Characteristics of Textile Industry Wastewater after filtration with saw dust

S.No.	Parameter	Test Values
1	pH	7.1
2	Colour	20 Hazen Units
3	Turbidity	0.2 NTU
4	Hardness	60 mg/l
5	TDS	580 mg/l
6	Fluoride	0.4 mg/l
7	Dissolved Oxygen	7.2 mg/l
8	Biological Oxygen Demand	20 mg/l
9	Chemical Oxygen Demand	36 mg/l

Table 6. illustrates the percentage removal of four significant parameters after each stage of the bench scale study.

Table 6. Comparative Study of the Various Treatment Processes

S.No.	Parameter	Removal after adsorption (%)	Removal after aeration (%)	Removal after Filtration (%)
1	Colour	86.14	96.44	99.62
2	TDS	57.14	65.71	82.85
3	BOD	18.42	86.84	89.47
4	COD	12.5	85.93	89.64

The quality of the final treated effluent is compared with General Standards or Discharge of Environmental Pollutants Part-A: Effluents (Land for Irrigation) of The Environmental (Protection) Rules 1986. The comparison indicates total conformity and it is evident that the water can be used for land application and is able to achieve the challenge of Zero Liquid Discharge.

Table 7. Comparison between Treated Effluent and Discharge Standards

S.No.	Parameter	Treated Effluent	Standard Value
1	pH	7.1	5.5 to 9
2	Colour	20 Hazen Units	5 to 25
3	Turbidity	0.2 NTU	< 5 NTU
4	Hardness	60 mg/l	-
5	TDS	580 mg/l	600 mg/l
6	Fluoride	0.4 mg/l	1.5 mg/l
7	Dissolved Oxygen	7.2 mg/l	> 4 mg/l
8	Biological Oxygen Demand	20 mg/l	100 mg/l
9	Chemical Oxygen Demand	36 mg/l	250 mg/l

6. CONCLUSION

The objective of the study is to evolve a low cost technology based on adsorption and aeration and present the case with an experimental study. A bench scale experimental study was conducted using the following process (1) adsorption using coir pith as adsorbent is to be followed by (2) aerobic treatment using sequential batch reactor (SBR) and (3) filtration through sawdust for further removal of colour and TDS.

The efficiency of the color removal was found to be 86.14% after adsorption with coir pith and 96.44% after the entire treatment. The decolorized water when subjected to aerobic treatment using the sequential batch reactor process effected more than 25% reduction and ultimately more than 30% reductions in BOD and COD values. The reduction in TDS levels are also remarkably more than 60%. The treated water conforms to the standards of General Standards or Discharge of Environmental Pollutants Part-A: Effluents (Land for Irrigation) of The Environmental (Protection) Rules 1986.

The bench scale study has established that low cost treatment using adsorption of textile industry effluent using coir pith followed by sequential batch reactor based aerobic treatment and adsorption using sawdust would lead to drastic reduction of colour, TDS, BOD and COD, lead to land application of treated effluent and thereby ensure zero liquid discharge. The technology should be experimented at a pilot level before full implementation which would lead to low cost but effective treatment of textile industry effluent.

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3.

A study on scale up process in phycoremediation of Rice mill effluent by *Scenedesmus Abundans*

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ABSTRACT

Phycoremediation is the economic as well as eco-friendly technique in the wastewater treatment, mostly employed in treating the agro-based industrial effluent. Rice mills are the agro-produce processing units which discharge huge as well as nutrient rich effluent, without proper treatment, causes threat to the environment (eutrophication in water/land/soil and soil infertility). Most of the rice mill industries in the country, fit in small and medium scale industries where the knowledge on the treatment system is comparatively less. Phycoremediation is the technique in which algae assimilate the nutrients and pollutants in the wastewater for their growth and metabolism thereby treating the wastewater effluent. Also, the biomass accumulated in the treatment system is the source of valuable by-products, bio-fuel, aquatic feed and the raw materials for medicine, cosmetics etc. The treatment efficiency and biomass production of phycoremediation varies based on the operating conditions such as scale and mode of cultivation, light, temperature etc. In this experimental study, the growth potential and pollutant removal efficiencies of algal sp. *scenedesmus abundans* have been investigated in lab scale (100ml culture in 250ml conical flasks) as well as in scale up condition (1.5l culture in 1-2 litres polybags) under constant temperature (27ºC), inoculum size (20% v/v) and light conditions (1200 lux). Growth indicators of maximum biomass dry weight, cell concentration or no of cells and chlorophyll-a content in lab scale are measured as 1.95 g/l, 9.36x10^04 cells/ml and 11.04 mg/l respectively which are 14%, 25% and 18% higher than that of 1.5l culture. The maximum ammonical nitrogen (NH_3-N) removal of 80.67% has been achieved in lab scale whereas it was 74.32% in 1.5l culture. Removal percentages of phosphorous (PO_4^{3-}) in lab scale and poly bags are reported as 99.45% and 94.96% respectively. This is mainly due to faster growth of microalgae in lab scale (conical flask) due to its occurrence of interaction with the nutrients of growth medium (RME). The treated wastewater was checked for its suitability for reuse, after harvesting microalgae by centrifugation

Key words: Phycoremediation, rice mill effluent, lab scale, scale-up process

1. INTRODUCTION

Disposal of untreated industrial effluent to the environment is a major concern of developing countries. Now a days, government policies, rules and regulations enforce the industries to follow the effluent standards for the safe disposal of waste. Hence, there is an increase in capital borne by industries which results in the requirement of economic and efficient treatment. Phycoremediation is one such technique which utilizes the algae to treat the wastes or wastewater [1]. Microalgae are small photosynthetic organisms, adopted to any kind of possible environment and utilizes the nutrients or pollutants in wastewater for their growth metabolism in the presence of light energy. The biotransformation of pollutants occurring in the microalgae cell, leads to the accumulation of lipids and proteins and is thereby useful in bio energy production [2, 3].

Rice mill industries are agro-based production industries. They play a vital role in the country's food requirement as rice is the staple food for almost 65% of the population in India. Also, India is the second largest rice producer in the world next to China. Processing of rice in milling industries involves various processes including soaking of paddy in water. This is the foremost process of rice production and requires 1.3 times of water per kg of paddy [4]. The soaking process releases huge quantities of effluent to the environment. Rice Mill Effluent (RME) does not contain any toxic substances but is rich in organic contents. It pollutes the medium on which it is disposed (water/land). Further, the country holds mostly small and medium scale industries and the knowledge on the treatment system is negligible among them. The treatment efficiency of phycoremediation of industrial wastewater is mainly dependent on operating parameters such as light, temperature, scale of operation, mode of cultivation and types of aeration provided for the system and most of the studies were conducted in lab scale (conical flasks) [5-9]. The application of lab scale to the field is the challenging task and the present study intended to provide the assessment on growth parameters and pollutant removal efficiency of scale up process (1-2 litres polybags) in comparison with lab scale culture.

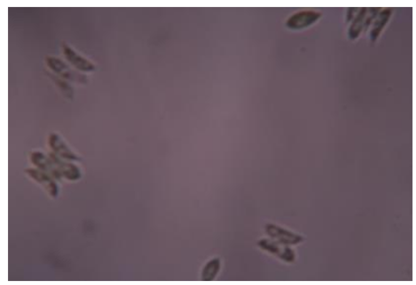
2. MATERIALS AND METHODS

The micro algae *Scenedesmus abundans* (Figure 1b) was purchased from National Centre of Industrial Microorganism (NCIM), Pune and cultured in Blue Green (BG 11) medium which contains $NaNO_3$(1.5g), K_2HPO_4(0.04g), $MgSO_4.7H_20$(0.075g), $CaCl_2.2H_20$(0.036g), Citric acid(0.006g), Ammonium ferric citrate (0.006g), EDTA disodium salt(0.001g), Na_2CO_3(0.02g), H_3BO_3(2.86mg), $MnCl_2.4H_20$(1.81mg), $ZnSO_4.7H_20$(0.22mg), $Na_2MoO_4.2H_20$(0.39mg), $CuSO_4.5H_20$(0.079mg) and $CO(NO_3)_2.6H_20$(0.049mg) per litre of distilled water and pH of the medium is adjusted to 7.1 by using 1M NaOH or HCl. Further, the culture is incubated at 25ºC under the light intensity of 1200 lux. After the growth period of 14 days, the cultured algae are inoculated in the Rice mill effluent (RME), collected from the rice mill industries located in Vellore district of Tamil Nadu. The various physico-chemical parameters of collected RME is presented in table 1. The study was conducted in 100ml conical flasks (lab scale) as well as 1 to 2 litres capacity poly bags (scale-up process) (Figure 1a) with an inoculum size of 20% (20ml of culture in 100ml RME v/v (volume /volume)) with an initial cell concertation of 1.45 x 10^5 cells ml^{-1}.

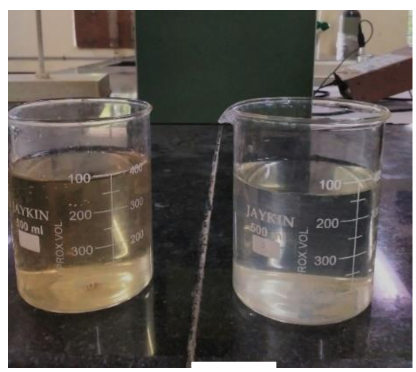
Table 1. Physico-chemical characteristics of RME

Parameters	**Rice Mill Effluent (RME)**
Colour	Dark yellow
Odour	unpleasant
pH	7.1
Turbidity (NTU)	17
Acidity (mg/l)	140
Total alkalinity mg/l	520
Total hardness mg/l	350
Total solids, mg/l	1800
Suspended solids, mg/l	400
Dissolved solids, mg/l	1400
Chloride mg/l	190
Sulphate mg/l	32
Phosphorous mg P/l	43
COD mg/l	1280
BOD (3 days at 27ºC) mg/l	473

Ammonical Nitrogen (NH_4- N) mg/l	274



(b)



(a) (c)

Figure 1. (a) Experimental set-up (b) Microalgae *Scenedesmus abundans* (c) RME before and after phycoremediation

Growth indicators such as chlorophyll-content, cell concentration (cells per ml of culture) and biomass dry weight were measured in alternate days of the growth period to understand the growth potential of *Scenedesmus abundans* in RME.

The chlorophyll-a content is determined by measuring the optical densities (OD) at 660nm and 642nm by UV spectrophotometer (Model: Hach DR6000). The formula used to calculate the chlorophyll content is given in equation 1 [10].

$$\text{Chlorophyll (mg/l)} = (9.90 \times \text{OD}_{660}) - (0.77 \times \text{OD}_{642.5}) \quad \text{--------------------- (1)}$$

The number of cells per ml of culture is determined by haemocytometer (Neubauer: improved) in which the average number of viable cells per square has been measured by considering five squares in a checkerboard pattern in the consecutive three rows. Further, the concentration or cell density is measured by using the below equation 2.

$$\text{Cell density (concentration)} = \text{Average no of cells per square} * \text{Dilution factor} * 10\text{^}4 \quad \text{--------------------- (2)}$$

Where the dilution factor is one when there is no dilution has been taken place.

Growth curve of a typical algal batch culture consisting of five phases namely, (i) lag phase (ii) exponential phase (iii) declining growth phase (iv) stationary growth phase and (v) death phase. During the exponential phase, the cell concentration increases as the function of time and it can be represented as the equation (3) given below.

$$C_t = C_o e^{mt} \quad \text{--- (3)}$$

Where, C_t – Initial concentration at time t; C_0 – Initial concentration at time 0 & m = specific growth rate. The specific growth constant (μ) of the exponential growth phase is calculated by using Equation (4)

$$\mu = \frac{log_{10}(N_1) - log_{10}(N_0)}{t_1 - t_0} \quad \text{--- (4)}$$

Where, $log_{10}N0$ is the log10 value of cell number at time zero (t_0) & $log_{10}N1$ is the log10 value of cell number at specific time (t_1).

The biomass dry weight is calculated by the difference in weight between the weight of an aliquoted vacuum filtered algal sample and the constant weight obtained after keeping the sample at 95ºC in a hot-air oven.

The excess nutrients or pollutants such as ammonical nitrogen and phosphorous as phosphates have been measured by the procedure followed in American Public Health Association (APHA) standard.

3. RESULTS AND DISCUSSION

3.1.Growth indicators

3.1.1. Chlorophyll a

Chlorophyll content of algae plays a key role in their growth metabolism as they are photosynthetic organisms [11]. The maximum chlorophyll content of 11.04mg l^{-1} has been achieved in lab scale whereas it is 9.968mg l^{-1} in the case of scale up process which is 10.76% lesser than the former one (Figure. 1).

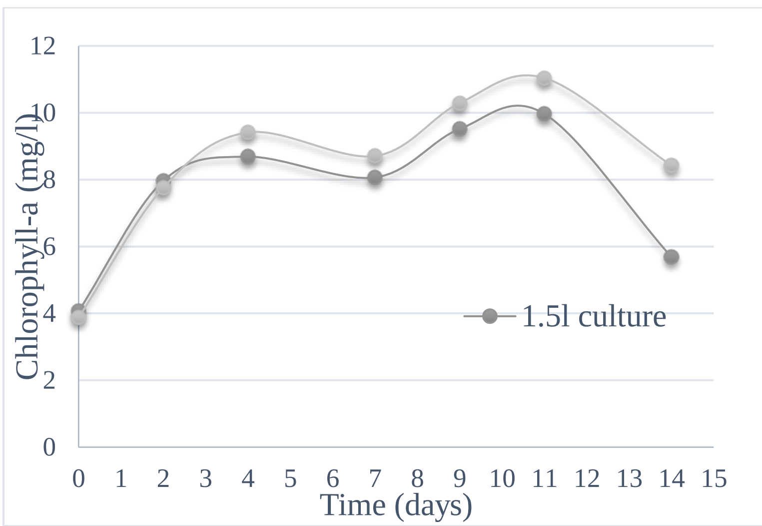


Figure 1. Comparison of chlorophyll-a content of *Scenedesmus abundans* in lab scale (100ml) and scale-up (1.5l) culture

3.1.2. Cell concentration or cell count per ml of culture

The growth curves of *Scenedesmus abundans* in 100ml and 1.5l RME are shown in figure 2. The initial concentrations of inoculated culture are measured as 3.32 x 10^04 and 2.68 x 10^04 respectively for the lab scale and scale up processes. This is mainly due to the dilution of RME as the inoculum is added on a volume basis. Initially, the growth curve has the short induction or lag phase as the liquid culture is used for the inoculum and reached its exponential phase in four days.

The specific growth rate is mainly dependent on algae species used, temperature and light intensity. Further, the phase of declining relative growth occurs in between four to seven days of culture period where the nutrients (nitrogen and phosphorous), pH, light, carbon dioxide and other physical and chemical parameters began to limit the growth of algae. There is no stagnant growth phase in 1.5l culture and the slight declination was identified in between nine to eleven days however it occurs in 100ml culture during the period. Finally, the algal growth reaches its death phase where the nutrients are depleted to the minimum value that will not support the algal growth and hence the cell density decreases rapidly and started collapsing. The specific growth rate constant of lab scale and 1.5l culture have been calculated as 0.279 and 0.272 respectively indicated that there is not the much significant difference between their growth rates.

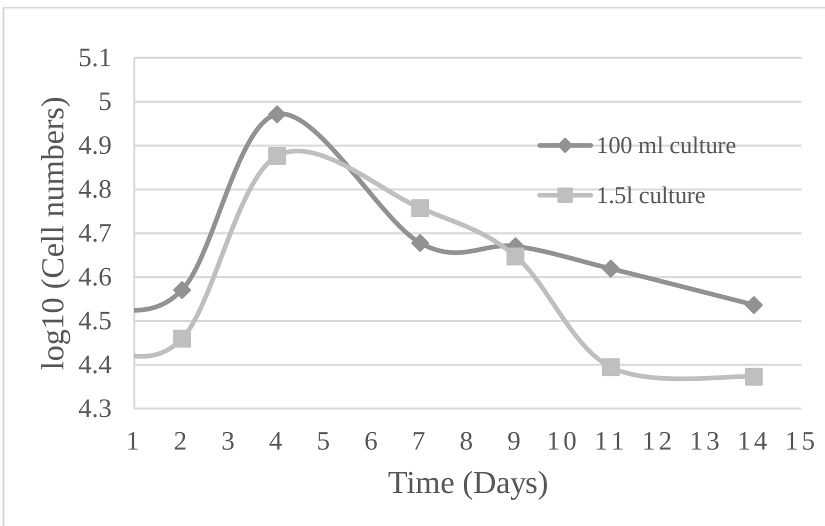


Figure 2. Growth curve of *Scenedesmus abundans* in lab scale RME and scale-up (1.5l) RME culture

3.1.3. Biomass dry weight

Biomass dry weight is another predominant indicator of algal growth. The biomass dry weight of lab scale increases with increase in time but there is a declination in between seven to nine days culture of 1.5l RME. Other factors such as light density, temperature and improper mixing of culture may inhibit the biomass value. The maximum biomass dry weight of 1.71g l^{-1} has been obtained in 11 days from a 1.5l culture which is merely 88% of the biomass obtained from the 100ml culture in lab scale (Figure 3). Further, the biomass value started decreasing due to the fact that the algal growth reaches its death phase.

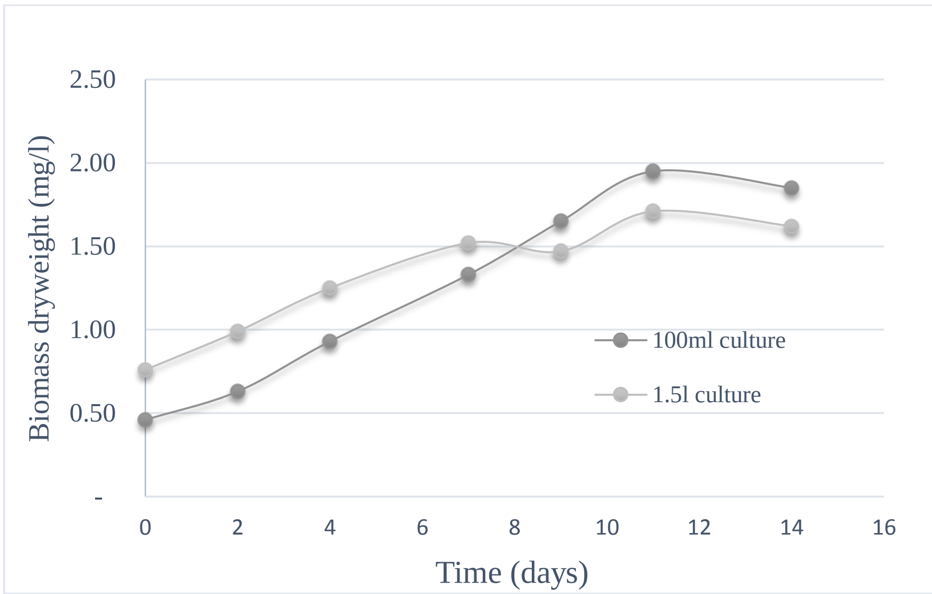


Figure 3. Biomass dry weight of *Scenedesmus abundans* in lab scale RME and scale-up (1.5l) RME culture

3.2. Pollutant / Nutrient removal

The optimum nitrogen to phosphorous ratio to enhance the growth of green algae is suggested to be in the range of 6.8-10.0 [12 - 14]. In this study, the N/P ratio (6.37) of RME (Table 1) supports the growth of microalgae, *Scenedesmus abundans* thereby acclimatize the nutrients from the wastewater.

3.2.1. Ammonical Nitrogen

Nitrogen is an important nutrient for all kind of photosynthetic organisms. Microalgae utilize the inorganic nitrogen in the form of nitrogen (NO_2^-), nitrate (NO_3^-) and ammonia (NH_4^+) in wastewater and converts into organic form by assimilation process. The accumulation of lipids and protein in the micro cell has been taken place during this process [15]. The ammonical nitrogen of 100ml and 1.5l inoculated RME are measured periodically to understand the nutrient uptake potential of *Scenedesmus abundans*. It was noted that both the cultures follow the same pattern of removal percentage nevertheless the maximum removal efficiency of 80.67% has been obtained in lab scale culture. Further, the scale up process (1.5l RME) utilized 74.32% of ammonical nitrogen in the treatment system (Figure. 4).

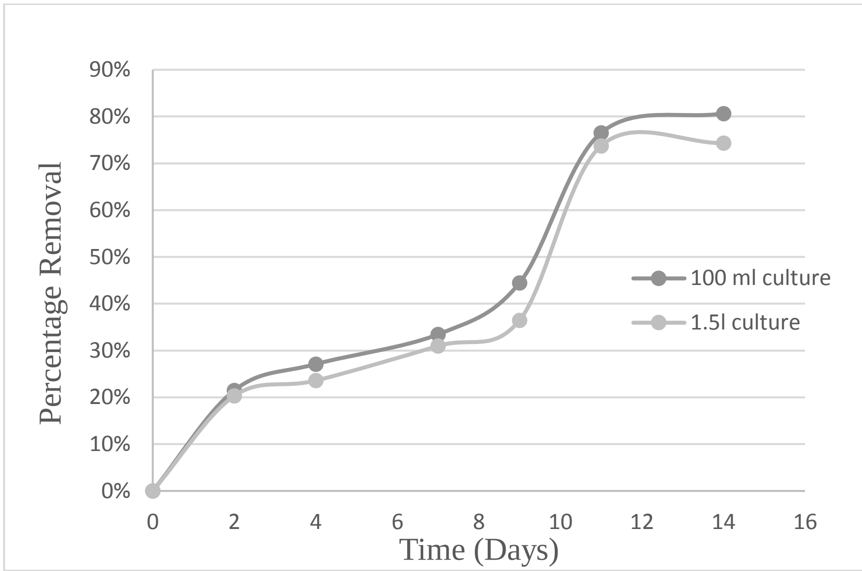


Figure 4. Percentage removal of ammonical nitrogen by *Scenedesmus abundans* in lab scale RME and scale-up (1.5l) RME culture

3.2.1. Phosphorous as phosphates

Phosphorous plays a vital role in the growth metabolism of micro algae. Phosphates in the form of mono hydrogen phosphate and di hydrogen phosphate in the treatment system are the main source of energy producers in the micro algal cell metabolism. The process, phosphorylation releases the high energy exchange medium in the cell, adenosine tri phosphate (ATP) by adding the third phosphate group to adenosine di phosphate (ADP) [15, 16]. Initially, 43.36% removal of phosphates has been achieved in 1.5l RME culture then increased gradually and reached the optimum value of 94.96% in 14 days. The phosphates removal efficiency of *Scenedesmus abundans* in 100ml RME culture increases suspiciously with the increase in culture period and reaches the maximum value of 99.45% at the end of period (Figure. 5).

3.3.Reuse potential of treated RME

The reuse potential of treated RME (Figure 1c) has been checked after harvesting the cultivated microalgae by centrifugation. It was identified that 95% of the reduction in phosphates has been achieved in the treatment. Further, 80 – 90% reduction in turbidity, alkalinity and BOD of the effluent have noticed in the system which may suggest the treated water can be reusable. Total hardness, ammonical nitrogen and COD of the RME have reduced to 66%, 74% and 75% respectively after the phycoremediation. Also, more than 30% reduction in other parameters has been noticed in the treated RME. Furthermore, the slight alkalinity has been noticed in the treatment system as the algae consume carbon dioxide during its photosynthesis, and this consumption is responsible for an increase in pH [17].

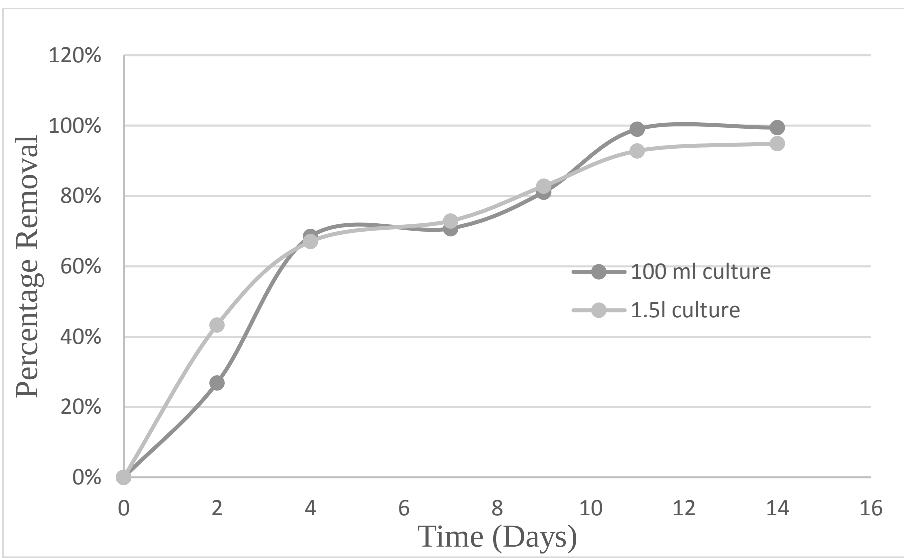


Figure 5. Percentage removal of phosphorous (PO_4) by *Scenedesmus abundans* in lab scale RME and scale-up (1.5l) RME culture

Table 2. Characteristics of RME after phycoremediation by *Scenedesmus Abundans*

Parameters	Value	Percentage reduction in physicochemical parameters
Colour	Nil	Clear water
Odour	Nil	Removes odour
pH	7.8	Slightly alkaline in nature

Turbidity (NTU)	3	82%
Acidity (mg/l)	20	86%
Total alkalinity mg/l	540	-4%
Total hardness mg/l	120	66%
Total solids, mg/l	1307	27%
Suspended solids, mg/l	220	45%
Dissolved solids, mg/l	1087	22%
Chloride mg/l	120	37%
Sulphate mg/l	21	34%
Phosphorous mg P/l	2	95%
COD mg/l	320	75%
BOD (3 days at 27ºC) mg/l	89	81%
Ammonical Nitrogen	70	74%

4. CONCLUSION

It is evident that the treatment efficiency decalins when go for scale up process. The phycoremediation of RME with *Scenedesmus abundans* in lab scale (100 ml conical flasks) given the maximum growth which was identified by measuring the growth indicators of chlorophyll-a (11.04 mg/l), cell concentration (9.36x10^04 cells/ml) and biomass dry weight (2.15 g/l). Further, the optimum removal efficiencies of 80.67% for ammonical nitrogen and 99.45% for phosphorous have been achieved in lab scale which is 8.54% and 4.73% more than the removal efficiencies of 1.5l RME culture in poly bags. Nevertheless, the specific growth constant of lab scale and scale up process not having a significant difference as it mainly depends on the cell concentration in the exponential phase of micro algal culture. The treated RME after phycoremediation has the considerable reduction in excess nutrients or pollutants which could recommend the water can be reusable in the industry. To conclude this study, even though the efficiency will reduce in case of scale up process, there is always in need of process optimization and improvement in employed technology to carry forward the lab scale to pilot scale, which is mostly applicable in industries.

ACKNOWLEDGMENT

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4.

Adsorption Of Organic Pollutant By Using Batch Process In Kinetic Studies

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ABSTRACT

Activated carbon was developed from coconut shell, characterized and used for theremoval of Rhodamine-B from wastewater successfully. The methylene blue number, iodine number and BET surface area of the prepared carbon were found to be 80 mg g^{-1}, 600mg g^{-1}, and 1200m^2 g^{-1} respectively. Rhodamine B is one of the water soluble, basic red cationic xanthene class dyes, a common water tracer fluorescent. Adsorption studies were carried out using Rhodamine B at different concentrations (150-400 mg g^{-1}), pH (2-12), and adsorbent dose (2-6 g l^{-1}). The adsorption data were correlated with both Langmuir and Freundlich models. The results indicated that the Freundlich model fitted the data (R^2: 0.9633) better as compared to the Langmuir model (R^2: 0.900).

Key words: Rhodamine B, Activated carbon, Isotherms, Adsorption.

INTRODUCTION

In recent years, pollution from dye wastewater has become a serious environmental problem due to the vast and increasing uses of a variety of dyes. Dyes are widely used in industries such as textiles, rubber, paper, plastics, cosmetics, etc., to colour their products. The dyes are invariably left as the major waste in these industries. Due to their chemical structures, dyes are resistant to fading on exposure to light, water and many chemicals and, therefore, are difficult to be decolourised once released into the aquatic environment (Sharma et al,2008). Many of the organic dyes are hazardous and may affect aquatic life and even the food chain. Release of these dyes in water stream is aesthetically undesirable and has serious environmental impact. Due to intense color they reduce sunlight transmission into water hence affecting aquatic plants, which ultimately disturb aquatic ecosystem; in addition they are toxic to humans also.

In an attempt to solve dye pollution problems, methods like reverse osmosis, membrane separation, coagulation, chemical oxidation, biological treatments, photodegradation and adsorption have been used; but the most efficient method has been through adsorption process.

Adsorption systems are rapidly gaining prominence as treatment processes that produce good quality effluentsthat are low in concentration of dissolved organic compounds, such as dyes. Regarding the selection ofadsorbents, a literature survey shows that materials such as commercially available activated carbons, zeolites, etc., have been used in the past for the treatment of textile effluents. Despite the prolific useof activated carbon for the wastewater treatment, carbon adsorption remains an expensive process, andthis fact over recent years has prompted a growing research interest into the production of low-cost alternativesto activated carbons. Various low-cost materials have been used for the removal of dyes from time totime. Such materials range from industrial waste to agricultural products. Various workers have exploitedsubstances such as peat, bagasse pitch, Fuller's Earth, lignite, coal, activated slag, activatedcarbon developed from fertilizer waste, bagasse fly ash, activated carbon fibers, wool carbonizing waste, clays, perlite, silica, wood meal, activated carbon developed from bamboo, alum sludge, and fly ash for this purpose.

Coconut shell is an agricultural solid waste, available throughout the year. We made an attempt to utilise an adsorbent from this low cost material for dye removal from aqueous solution.

Rhodamine B (RhB) is one of the water soluble xanthenes class dyes, a basic red cationic dye which is a common water tracer fluorescent. It is often used textile and food industries. It was an model pollutant to understand the adsorption capacity of the coconut shell carbon. This study is aimed at using a real world environmental process column study which requires little operator attention, easy inspection and cleaning for regeneration of adsorbent.

MATERIAL AND METHODS

Materials

Rhodamine B, is an cationic dye having IUPAC name as 9-(2-carboxyphenyl)-6-diethylamino-3-xanthenylidene]-diethylammonium chlorideand it was procured from S-D fine chemicals Pvt. Ltd, Mumbai and Coconut shell activated carbon was obtained from water system Pvt. Ltd, Villupuram. The stock solution was prepared in double-distilled water by dissolving 1g dye in it. All the test solutions were prepared by diluting the stock with double- distilled water.

ADSORPTION DYNAMIC EXPERIMENTS

Batch equilibration method

The known weight of adsorbent was added to 100 ml of thedye solutions with an initial concentration of 150 mg L^{-1} to 350mg L^{-1}. The contents wereshaken thoroughly using a mechanical shaker rotating with a speed of 120rpm. The solution was then filtered at preset time intervals and the residual dyeconcentration was measured by double beam UV-Visible spectrophotometer 548nm filters.

The amounts of dye adsorbed(q_e)and percent of removal (%R) can be calculated using the following equations:

$$q_e = \frac{(C_o - C_e)}{V_m} \quad (1)$$

$$\% R= \frac{(C_o - C_e)}{C_o} \times 100 \qquad (2)$$

Where qe is the amount of dye adsorbed (mg g^{-1}). C_e and C_e are the initial and equilibrium liquid-phase concentrations of dye (mg g^{-1}), respectively. V is the volume of the solution (l), and m is the weight of the sorbent used (g).

EFFECT OF VARIABLE PARAMETERS

Contact time

The effect of contact time on the removal of dye by the adsorbent was determined by keeping particle size, initial concentration, dosage, pH andconcentration at 150 mg L^{-1}, 2grm, 7pH and 30^0C, respectively.

pH

Adsorption experiments were carried out at pH 4, 7 and 12. Theacidic and alkaline pH of the media was maintained by adding the required amounts of 0.1N hydrochloric acid and sodium hydroxide solutions. The parameters like particlesize of the adsorbents, dye concentration, dosage of the adsorbent and contact time were kept constant at while carrying out the experiments. The pH of the sampleswas determined using a portable pH meter (Systronics Model).

Initial concentration of dye

Experiments were conducted withdifferent initial concentrations of dyes ranging from 150 to 400 mg L^{-1}. All other parameters werekept constant such as constant time, pH, temperature, adsorbents dosage were fixed at 3hrs, 7pH, 2grm and 30^0C, respectively.

Dosage of adsorbents

The various doses of the adsorbent 2,4,6(mg L^{-1}) were mixed with the dye solutions and themixture was agitated in a mechanical shaker. Other parameter such as initial concentration, contact time, pH, temperature at 150mg L^{-1}, 3hr, 7pH and 30^0C, respectively.

RESULTS AND DISCUSSION

Characterization of the adsorbent

The characterization of coconut shell activated carbon is presented in Table 1. As seen the carbon had high carbon content(30%), high surface area (1200m^2g^{-1}),good number of micropores and macropores.

Table 1. Characteristics of the adsorbent

PARAMETERS	VALUES
Surface area	1200m^2g^{-1}
Carbon content	30%
pH	8

Moisture	2%
Density	0.40-0.54 g cm^{-3}
Iodine number	600mg g^{-1}
Methylene blue number	80mg g^{-1}

Effect of contact time

The percentage Dye sorbed were estimated at different times keeping the other parameter fixed and the results are shown in fig.1. It was observed that the percentage of removal of Rhodamine B increase with respect to contact times. 3hrs was taken as the equilibrium time for subsequent experiments.

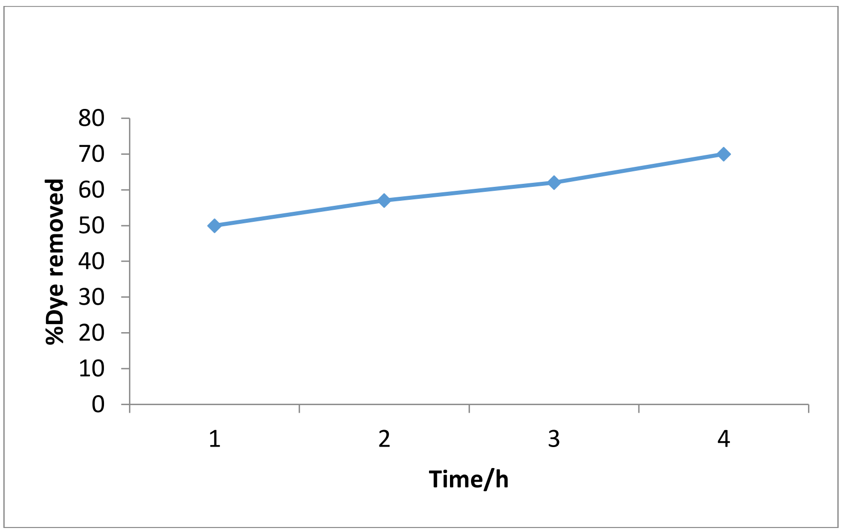


Fig 1. Effect of contact time on adsorption of Rhodamine-B onto activated carbon (Coconut shell activated carbon=1g, pH=Natural, Temperature=30^{0}C and initial dye concentration=150mg L^{-1})

Effect of pH

Because the initial pH of solution can significantly influence adsorption of dyes, the effects of pH on dye adsorption on the activated carbon was studied. The dye removal was maximum at acidic condition (< 7). Thepossible reason for such type of behaviour is due to the fact that Rhodamine B molecules are positively charged. As initial pH of the test solution increased, the number ofnegatively charged adsorbent sites increased and positively charged adsorbent sitesdecreased which favours the adsorption of positively charged dye cation due toelectrostatic attraction. Thus at higher pH, adsorption will be more and at lower pH,adsorption will be lesser.

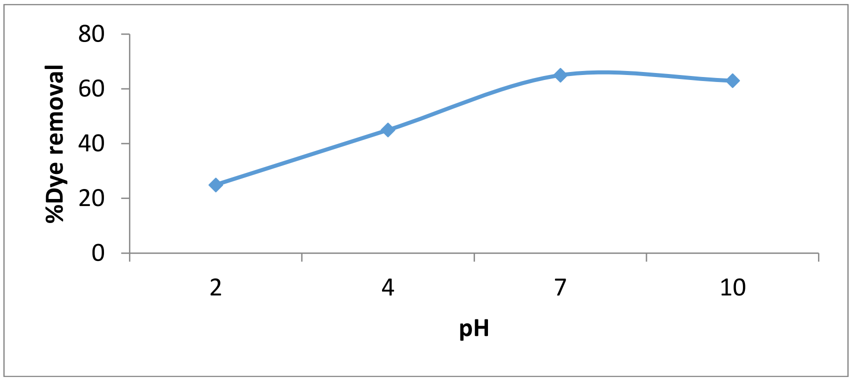


Fig 2. Effect of pH on adsorption of Rhodamine-B. (Coconut shell activated carbon= 1g, Equilibrium time =3hrs, Temperature=30^{0}C and initial dye concentration=150mg L^{-1})

Effect of Dye Concentration

The influence of dye concentration on percentage dye adsorbed was studied in the range of the effect of dye concentration was studied by keeping the adsorbentdose constant at 1g. The concentration of dye was in the range from 150-400 mgL^{-1}. As shown in Fig 3. there was regular decrease in percentage ofcolour removal when the concentrations of the dye were increased. A decrease in colour removal upto6% was observed when the concentration of RB was increased from 150-400mgL^{-1}. However, it had been seen that the decrease in percentage colourremoval was more pronounced at higher concentration.

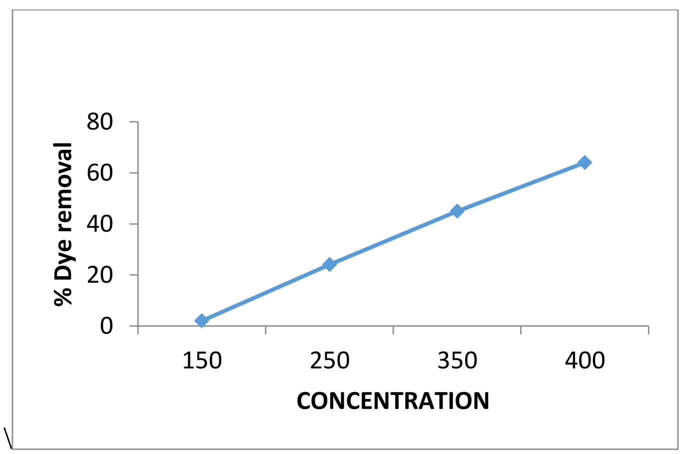


Fig :3 Effect of variation of concentration adsorption of the dye, Rhodamine-B.(pH=Natural, Equilibrium time=3hr, Temperture=30^{0}C and carbon 1gr)

Effect of sorbent dose

The effect of sorbent dose on the removal of the dye is shown in Fig 4. Thepercentage of the dye sorbed increased as the sorbent dose was increased over therange, 2-6 g. The adsorption of the dye increased from 40 to 75% with the increasein sorbent dose. This conveyed the idea that increase in dosage increase the availability of active sites to the dye molecules.

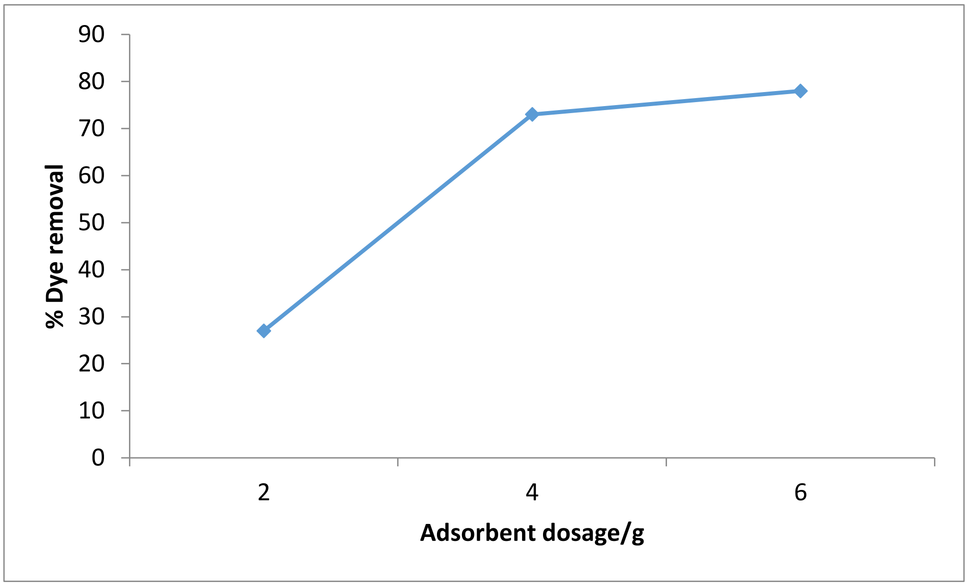


Fig:4 Effect of variation amount of coconut shell activated carbon on adsorption of the dye, Rhodamine-B. (pH=Natural, Equilibrium time=3hr, Temperture=30^{0}C and initial dye concentration=150mg L^{-1})

Freundlich adsorption isotherms

The data obtained from batch experiments were fitted to Freundlich and Langmuir adsorption isotherms.

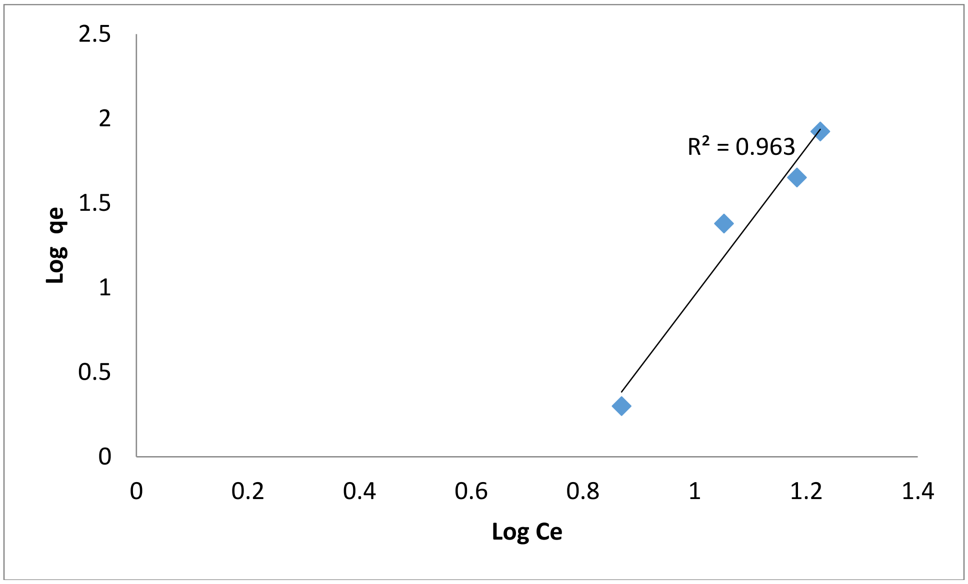
The Freundlich isotherms is represented as

$$q_e = KCe^{1/n}$$

The Linear form of Freundlich isotherm is represented as

$$logq_e = logK + (1/n)logC_e$$

Where q_e is the amount of dye sorbed per unit weight of the adsorbent, C_e is the equilibrium concentration (mg L^{-1}), K and n are the empirical constants and their values were obtained from the intercepts (log k) and slopes(1/n) of the linear plot of log q_e versus log C_e.



Langmuir Adsorption Isotherm

The Langmuir isotherm is represented as follows

$$\frac{1}{q_e} = \frac{1}{bC_m}\frac{1}{C_e} + \frac{1}{C_m}$$

Where C_e is the concentration of the dye solution at equilibrium, q_e is the mass of the dye adsorbed per gram of the adsorbent. C_m is the mass of the dye that 1gm of adsorbent can adsorb when the monolayer is complete and b is the isotherm constant for particular adsorbate-adsorbent combination. The Cm and b values were calculated from the intercept $(1/C_m)$ and slope $(1/bC_m)$ of linear plots of $1/q_e$ versus $1/C_e$.

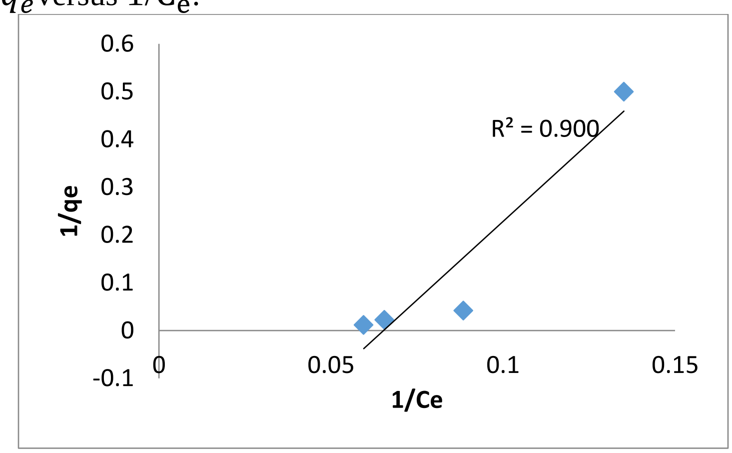


Table 2. Langmuir and Freundlich isotherms

Langmuir Isotherm		Freundlich Isotherm	
Cm	2.33	K	0.033
b	0.065	n	0.229
R^2	0.900	R^2	0.963

CONCLUSION

This study proved that activated carbon produced from coconut shell were effective adsorbent for Rhodamine B dye. Removal of Rhodamine B will be better at acidic pH(>6), moderate initial concentration (250 mg L^{-1}) and high adsorbent(>6 grm).

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5.

Application Of Various Management Strategies For Improvement Of Surface Water Quality

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1 NEED OF WATER QUALITY MANAGEMENT

1.1 The availability of good quality water resources will be paramount to the sustained socio-economic development of countries around the world. Water shortages and deteriorating water quality (WQ) have been continuing to place great pressure on India's water resources. Safe and adequate water supplies and environmental sanitation are vital for protecting the environment and improving health. According to various studies, an estimated 80% of all diseases and over one third of deaths are caused by consumption of contaminated water.There is a need for integrated water resources planning and management, covering all types of inter-related fresh water bodies, taking into consideration WQ and quantity. ***Many management technique may be required to solve one problem and one management technique may solve many problems***. Within this holistic framework, action should be taken to manage and improve the water use efficiency, prevent contamination of known resources and ensure that all potential water resources are identified and protected.

2 WATER RESOURCES IN INDIA

2.2 The great variety of climate and physiography in India gives rise to a very complex weather pattern in India, which influences the overall precipitation, the main sources of water in the country, in space and time. The rain fall various at 100 mm in Western most region to 11000 mm in Eastern most regions. The Annual average precipitation is 1170 mm. The average annual precipitation including snowfall is estimated to be of the order of 4,000 billion cubic meter (BCM) of which the monsoon rainfall during June to September itself is around 3,000 BCM. The average natural run -off as per the estimate of Central Water Commission (CWC) is 1869 BCM which is about 4 % of Global supply. The aerial distribution of the water resources in the country is highly uneven.

Classification	**Quantity (in BCM)**
Surface Water	690
Ground Water	432

Total	**1122**

2.4 India is blessed with large network of rivers comprising 12 major basins having combined catchment area of about 256 m. ha. Besides, there are 46 medium basins of sizes varying between 2,000 to 20,000 sq. km covering a total area of about 25 m. ha. Other water bodies including tanks and ponds cover an area of about 7 m. ha

2.5 Although, the average water availability in the country remains more or less fixed according to the natural hydrologic cycle, the per capita water availability is reducing progressively owing to increasing population. In 1955, per capita availability was 5, 300 cu. m which has come down to 2, 200 cu. m as of 1998 and by 2025, with the projected population growth, the availability will be only 1,500 cu. m as national average, while it will be much less in some of the regions/basins.

2.7 India is among the foremost countries in the world in exploring its river water resources. Remarkable achievement has been made in conserving the water resources for irrigation, generation of hydro-power and domestic water supply during the five decades of planned development of independent India.

3 LAKES/ RESERVOIRS IN INDIA

3.1 Indian lakes are distributed in different geographical region ranging from Himalayas in the North glaciated lakes, tectonic lakes and ox-bow lakes, to Deacon Plateau in the south. Many of these lakes have been formed through natural process while several other are manmade. The natural lakes in general are shallow basined compared to the lakes in other part of world. There are some lagoons and salt lakes also. However these lakes are critical importance to a large population depending upon these resources for drinking water, fishing, agriculture and unique recreational opportunities.

4 MAJOR PROBLEMS CONFRONTING LAKES IN INDIA.

4.1 Lakes constitute an important component of India's fresh water system. Due to pressures of various kind of human activities, a number of lakes are shrinking or getting polluted beyond the point of recovery. Many lakes in the urban area disappeared and lake area were converted in to concrete jungles. When the river is dammed and reservoir created water in it has many beneficial effects, besides many harmful effects

4.1 Siltation: Increasing soil erosion due to over use and mismanagement of arable, grazing, agriculture and forest lands causes siltation resulting in formation of large littorals colonized by dense macrophytes growth and shrinkage of lake area. The problem of siltation is predominant in the manmade reservoir. Study conducted by Central Water Commission shows some reservoirs are losing their service life due to siltation than the life considered while planning of those reservoirs. One of the reasons may be due to insufficient data during those periods regarding silt generated in the catchment area and silt inflow to reservoir.

4.2 Eutrophication: It is result of enrichment of stagnant water body with nutrients such as Nitrate and Phosphorous. The initial storm in the urban area carries heavy load of such nutrients and resulting in the formation of algal blooms, prolific growth of aquatic plants some of which reaches to nuisance proportions, oralteration of composition of flora and fauna. This also happens due to men's activities such as indiscriminate, unscientific use of chemical fertilizers, discharge of industrial effluents, municipal sewage, etcwithout any or sufficient treatment besides natural occurrence.

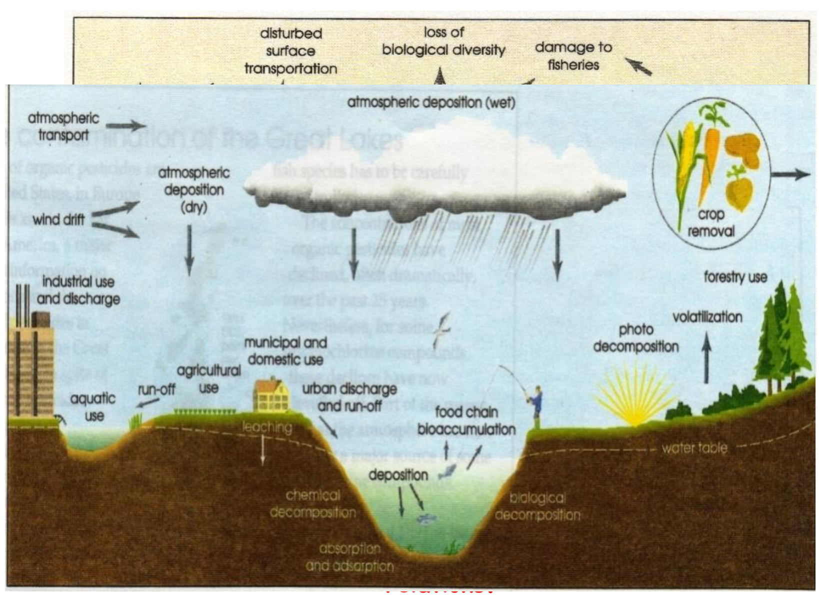
4.3 Exotic spices and weeds: The invasion of exotic spices by some natural or manual activities have profusely grown in some lakes posing a great threat to endemic species. Exotic weeds particularly any invasive weeds that covers the water surface, have the potential to create major environmental problem, principally through the creation of anoxic condition and the subsequent water quality problem that ensue. The floating water weeds also causes obstruction of weirs and channels, reducing hydraulic efficiency and increasing maintenance costs.

4.4 Aquaculture: In the coastal regions large area is converted in to aquaculture ponds leading to the problem of Stalinization, eutrophication and decrease of bio diversity. The unscientific way of planning and use of fish feed, manures, antibiotics etc. have result in formation of algal blooms and drastic reduction in oxygen concentration in the lakes causing serious threat to water quality.

4.5 Thermal stratification: Reservoir water is not well mixed and thus lead to vertical stratification which leads to many chemical action leading to an anaerobic condition, iron and manganese reduced and go to solution, Sulphate reduced to form Hydrogen Sulphide, lowering of pH and quality fall regarding colour, odor, temperature, dissolved oxygen etc. Thermal pollution also causes due to let out from thermal power stations.

4.6 Pollution: The inflow of chemicals from the fertilizers and pesticides in the catchment area, discharge of industrial, domestic and solid wastes deteriorates the lake water quality.

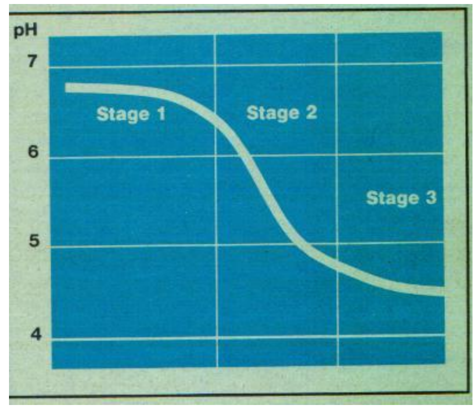
4.7 Encroachment: As lakes have a multiple value system, the surrounding area have been converted by the public without authorization for agriculture and other productive purposes resulting to the shrinkage of lake area damage to the eco system.



Pollution pathways and accumulation process

4.8 Heavy Metals: Mining and other extractive industries including mine water pumping, ore washing and effect of mine tailings will contaminate water with heavy metal such as lead, cadmium, chromium, copper, zinc, etc. The concentration of heavy metal in water will vary according to natural factors such as water run off patterns and occurrence of ore bodies and also according to pollution factors such as location of industrial and urban complexes.

4.9 Acidification: Airborne pollution from the automobiles and industries can affect the environment both directly and indirectly. Thus when Sulphur dioxide and nitrogen oxide gases are present in high concentration, they can cause damage to trees and lichens, affect people's health and corrode the historic monuments, structural material such as steel. These direct effects are often greatest in the vicinity of the emission sources. Sulphur dioxide and nitrogen oxide can however also form Sulphuric acid and nitric acid which may be carried with the winds over long distance before descending in rain or snow. Thus soil and water become acidified even far away from the source of emission.



Stages of acidification of lake water

4.10 Endocrine Disrupting Chemicals and Cyanotoxins: The effects of endocrine disrupters on the human body have been accepted, and investigation and research into these substances is proceeding in many countries. Many evidences of Endocrine disruption such as impotence leads to low population growth, fry mortality and abnormality in thyroid glands, imposex, immuno-deficiency, etc in fishes, wild lives have already been observed. The causes may be chemicals from pesticides, anti-fouling paints used for boats, fishing nets, marine structures, etc. This issue is to be viewed seriously to protect abnormal changes in the health of the aquatic and animal life.

Many pharmaceutical companies by research and development produce many new type of medicines for curing various deceases. But mostly they do not have any mechanism to know the effect on environment after the chemicals comes out from the human body/animals. This is one of the serious issue for the above problem. Even in the processes of raw water and waster water treatment the agencies fail to check the availability of hormone disrupting chemicals and environmental effect of such a wastewater after discharging out.

4.11 In addition to these, a list of causes would be somewhat as follows:

a) Over exploitation of ground water in coastal and semi-arid areas causing intrusion of slain water and depletion of groundwater level.

b) Destruction of wetlands, the natural filter of water.

c) Oil spills from oil transport and navigation systems in the major rivers and in coastal areas.

d) Non-availability of minimum flow in the rivers due to manmade structures reducing dilution capacity of rivers thus increasing pollution.

e) Water logging due to high irrigation intensity and poor drainage system.

f) The hidden chemicals stored in soils and sediments with the potential to be re-mobilized by land use change, dredging or climate change.

5 ENIVIRONMENTALMANAGEMENTTECHNIQUESFORLAKES AND RESERVOIRS

5.1 Physical and Legislative Restoration Measures For Lakes and Reservoirs

Some of the techniques that could be used for conservation of lakes and reservoirs are listed below

1. External Control measures

1.1 Protection of catchments area

a) Control of Hydrological Cycle and soil erosion. This involves afforestation in upstream areas, installation of buffer zone between agriculture land and lakeshore, contour cropping.

b) Land use regulation by stringent regulation of land use, moving of pollution source from the basin, ban on reclamation, control of pollution emitting factories.

c) Sewage treatment activities like construction of large scale treatment plant, construction of oxidation pond, small scale waste water treatment plant, use of septic tanks, diversion sewage outlets, livestockwaste treatment facilities, regulation of the use of agrochemicals, ban on toxic substance discharge.

1.2 Nutrient control in inflowing river water by use of wetlands for waste water treatment, establishment of coordination units for lake/river basin management, ban on phosphate containing detergents, control of waste discharge from enterprises, embankment for prevention of polluted water in flow, effective use of agriculture fertilizers, recycling of treated water to afforested area, night soil treatment facilities

2 Internal control measures

2.1 Physical measures

a) Mixing and thermal distratification by improvement of lake water turnover.

b) Aeration, hypo-oxygen inflation by lake bottom aeration, forced vertical mixing of reservoir waters.

c) Release prevention from sediments by sediment removal by dredging, sediment sealing with sand layer.

2.2 Biological measures.

a) Mechanical and chemical removal by harvesting water weeds, harvesting blue green algae, killing algae, killing water hyacinth.

b) Bio-manipulation and protection by manipulation of food chains, releasing of grazing fish for water weed control, growing of grasshopper for water hyacinth control, water level control for vegetation protection, lake shore vegetation protection, restriction of navigation to protect lakeshore vegetation

2.3 Chemical measures like liming.

5.2 Strom Water Management

5.2.1 Land Use Pattern

Land use directly effects water quality. In an undeveloped area, natural, physical, chemical, and biological processes interact to recycle most of the materials found in storm water. As human land use intensifies, the processes are disrupted and every day activities add materials to the land surface. Leaves, litter, animal wastes, oil, grease, heavy metals, fertilizers, and pesticides are washed off by rainfall and are carried by storm water to the lakes, rivers and bays. The improved storm water management will reduce pollutants loads from new developments.

5.2.2 First Flush.

Of primary importance to minimizing the effects of storm water on water quality is the first flush. In the early stages of the runoff the impervious surfaces like parking area, plat forms, streets, pavements are washed by storm water. This generates a huge loading of pollutants. A study in Florida have determined that the first one inch of runoff caries 90% of pollution from storm water. Treatment of this first runoff is needed to achieve the desired water quality benefit. This storm water quantity and need of the treatment depends on size of basin, land type, the amount of impervious surface, and type of receiving water.

5.2.3 Detention of storm water

Creation of landscape infiltration area that is permanent ponds and lakes, if planned and constructed properly, will provide many benefits include increased property value, recreation facilities, water for gardening, fire protection. This type of detention system will also provide flood protection. The basic components of a wet detention system should consist of permanent water pool, an overlying zone for temporary storage of peak runoff and a shallow littoral zone in which wetland plants biologically remove storm water pollutants like nutrients. During next storm the new water will replace the old water. This type of ponds could be used in series to with some pervious canal inter connections. The technical criteria can be established based upon the availability of land and need. Rock or concrete edging or toe wall could be provided to avoid the bank erosion.

5.2.4 Strengthen of field bund with a spillway system

Because of very small size of field bunds in the agriculture field, the storm water rapidly flows down with more velocity causing erosion to field surface. It also carries the valuable nutrients available on the agriculture field. Farmers should be advised to strengthen their field bunds with a spillway system made of stone/concrete pipes. This is embedded in the bund at certain level so that the water will flow over spillway or through pipe. The materials required for the strengthening should be borrowed from the field itself. This will increase the field water holding capacity and retention time, whichacts as small tank. This will result the deposition of sediment, and also increase the fertility of the soil, and high recharging of ground water.

5.2.5 Involvement of local government

Local government will play important roll particularly in the watershed management. These governments should prepare their integrated water shed management plan based on their comprehensive plan, with in purview of storm water master plan. The local government will have a dedicated sources of funds to build the required storm water infrastructure, public education, etc.

5.2.6 Vegetation

The vegetation provides several benefits. It observes the kinetic energy of falling raindrop results prevention of considerable erosion, increase the absorption of water by soil, increases the infiltration capacity. It reduces the discharge rate, the roots keeps the soil bonded.

5.3 Use of Bio Fertilizers

The farmers should be made aware by various media which are close to them, the importance of use of bio fertilizers instead of chemical fertilizers, slow soluble fertilizers. The long term effect of use of chemical fertilizers to human health, the eco system, and importance of protection of environment should be conveyed to the farmers. The use of fertilizers will certainly damage the precious eco-friendly insects like earthworms, which is very important for aeration of soil. The easier system to make bio fertilizers is to dig a pit of suitable size depending on the individual requirements and dumping the all the bio degradable wastes such as refuse from house, domestic animals wastes, weeds from fields, unwanted plants from the cultivable areas, unwanted vegetation, etc. Occasional filling of these pits with water gives better effect on decomposition of materials.

5.4 Night Soil and Domestic Waste Water Treatment System.

The domestic wastewater accounts for a large portion, about 70% of the all the organic pollutants. Domestic wastewater is relatively larger portion of the pollutants than industrial wastewater. In India the domestic wastewater is mostly discharged without sufficient or improper treatment. In the rural area, this generate huge non-point source pollution on the water resources. Still, in many villages, people follow the open-air defecation, which cause unhealthy living condition around the village and causes serious threat to health. Management of this wastewater and night soil is essential for improvement of living environment.

5.4.1 Combined wastewater treatment system.

Combined wastewater treatment system is effective in villages and small towns. The extended aeration process is used in many treatment tank units. For large-scale treatment tanks designed for more than 5,000 persons the conventional activated sludge process can be used.

The sewage treatment process always produces lots of sludge from the primary and final sedimentation tanks. For the sludge treatment, the plant can be equipped with gravity thickeners for thickening, filter press for dewatering. If necessary the sludge can be melted in a furnace after drying.

Slag after incineration

This will reduce the sludge volume, stabilizes the harmful substances. Slowly cooled slag has strength nearly equal to natural stone, and this would be used for verities of purpose like filling materials, construction material for making concrete blocks for pavement, etc. The sludge from community plants can also be used as bio fertilizers for agriculture purpose in the rural areas and horticulture purpose in the urban area.

5.5 Promotion of Public Awareness and Environmental Education:

5.5.1 Environmental education

Environmental education is one of the most effective means to increase public awareness. It will be more effective if children are taught at their early stages so that they become the integral part of the environmental protection system.

The UNESCO's definition (1987) environmental education is a permanent process in which individuals gain awareness of their environment and acquire the knowledge, values, skills, experience and also the determination which enable them to act individually and collectively to solve present and future environmental problems.

Including the environmental education in elementary and secondary level schools will alert the children to the world around them and the children will start to learn through and from the environment. Education at high school and University, shell include training to solve the problems. Encouraging the students by providing testing kits and manual, training to teachers and including environmental protection activities in the curriculum of teacher training schools and action oriented research will result better awareness.

5.5.2 Education for the decision makers

Keep informing the quality of aquatic environment with in a given region, involving them to acquire skills by attending workshops, seminars, short term professional courses and training.

5.5.4 Public participation

Public participation is concerned with involving, informing and consulting the public in planning, management, and other decision making activities which can be considered part of political process. An opportunity to express their views and encouragement for understanding our view is needed. Free and open access to information is necessary to understand the problems early.

Some specific objectives for public participation in decision making for control of lake and reservoir ecosystem are;

a) Obtaining public acceptance for the goal
b) Public control on implementation of schemes
c) Public involvement in implementing and monitoring industries,
d) Reinforcing the position of the local government as public entity responsible

The essential stage of process are;

a) Identification of people mass concerned with problem and selection of a representative for those group who has skills, position within community, connection with others, have respect of the group, ability to effective communication, acquire knowledge, commitment, moderate in their judgment and open to the view of others. He should be included as member of the various committees involved in the environmental protection work as applicable.
b) Organization of public involvement
c) Stimulation and integration of stakeholders could be done be using medias, demonstration, monitoring with direct participation and involving publics, training by doing themselves.
d) Involvement of scientific groups having knowledge on environmental problems, and NGOs as independent entities have great opportunity to increase the public awareness.

The identification of stakeholders can be done by screening existing organization/groups such as groups connected with fisheries, urban settlement, industries, farmers, institutions involved in water resources management, scientific community, environmental protection NGO, from the published materials, direct contact with organizations, using experience and knowledge of local communities and administrative authorities.

The public should be made to realize their responsibility for the quality of environment by providing knowledge on causes, effects, impacts and not to ignore the problem.

Importance of water resources development, compensatory afforestation, should be conveyed to the public. The awareness should be created to afford voluntary physical service for common cause like removal of silt from the lakes/rivers, monitoring the water quality by testing themselves with compact equipment, etc.The information should be made available to the widest audience through simple low cast visual aids, street dramas, display posters at prominent places, etc.

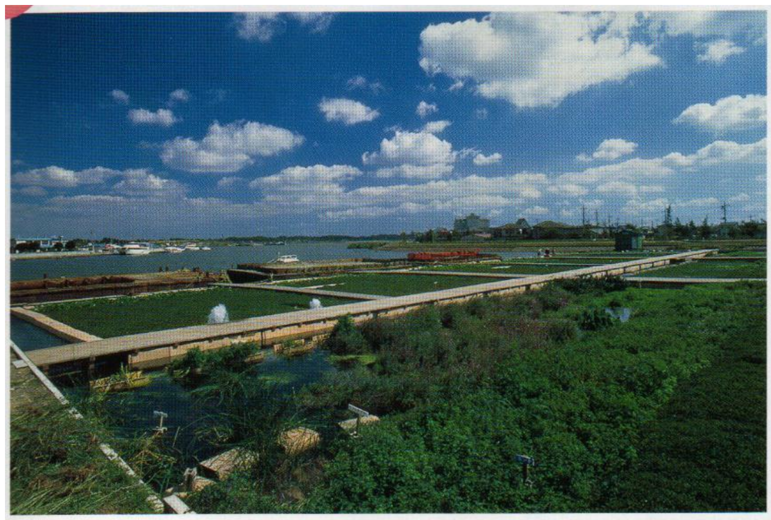
5.6 Water Quality Improvement by Construction of Bio Park

It is very simple effective method of removing the turbidity and fertilizers from the water. A natural field near the lake is created. The size is depending on the availability of land near the lake. The water is pumped up, and passed through the root system of cultivated vegetables and flowers plants. The roots of these aquatic plants spread like a mat and numerous micro-organisms live there. Suspended soil particle in the water containing the nitrogen and prosperous is made contact with the roots of aquatic plants and sinks. Micro creatures eat trapped phytoplankton and excrete nutrients which are eaten by larger organism for nourishment.

The small creatures such as dragon fly nymphs, losch and river shrimps eat these micro creatures for nourishment. Then, their excrement and dead bodies are decomposed by bacteria and serve as nutrition for aquatic plants.

Taking these aquatic plants that absorb nitrogen and prosperous as nutrition out from system helps to decrease eutrophication as well as the improvement of water transparency. The processed water is then discharged in to the lake.

The effect of water quality purification by this method is the removal ratio of about 70% of suspended solids and about 60%of the chlorophyll density which represents the volume of algae. By this method the transparency of lake water will also increase to great extent. About 40% of the nitrogen and phosphorous could be removed.

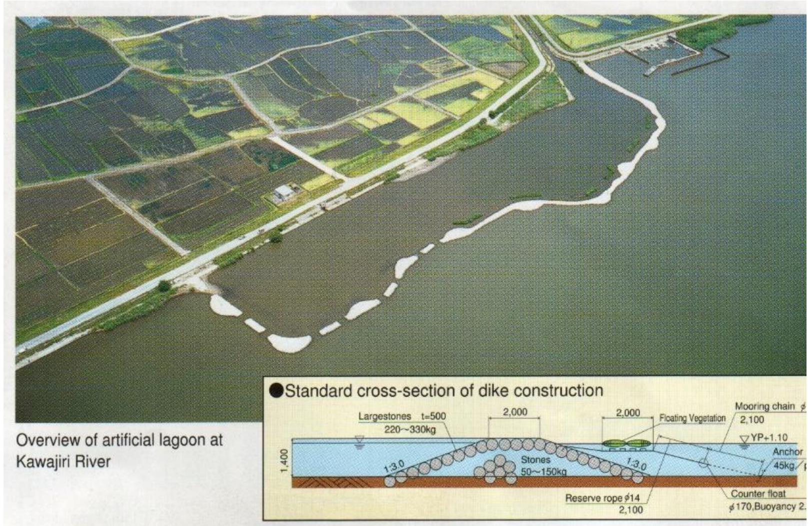


Construction of Bio Park

Local citizens group or NGO will come forward to maintain this system as it yields some products like flowers, vegetables, green leaves, etc. which can be used for their domestic purpose or sold in the market. The electricity for pumping water is a major component of maintenance.

5.7 Artificial Sediment Collection Lagoons/ Reservoirs

An artificial sediment collection lagoon is created by construction of Dike to the required height and size at the river mouth, which is vulnerable to sediment flow. The water from the river particularly in the rainy season carries heavy sedimentation is retained for some period. The sediments are deposited in this lagoon and only clear water is allowed to flow in to the lake. Growth of reed or other suitable plants in this reservoir will further reduce the nutrient in the water. This bio plant will also act as a breeding spot for the aquatic animals and environment for birds. The reeds, after growing to the desired height could be sold for making thatched roof. The dike will also act as wave absorbing structure and for some recreation purpose. Maximum sediment from the river is getting deposited near the bank of the lake the removal of these sediment will also be easy. The sediment can be used for construction material filling of low lying area, etc depending on the size of the grains.



Artificial sediment collection lagoon

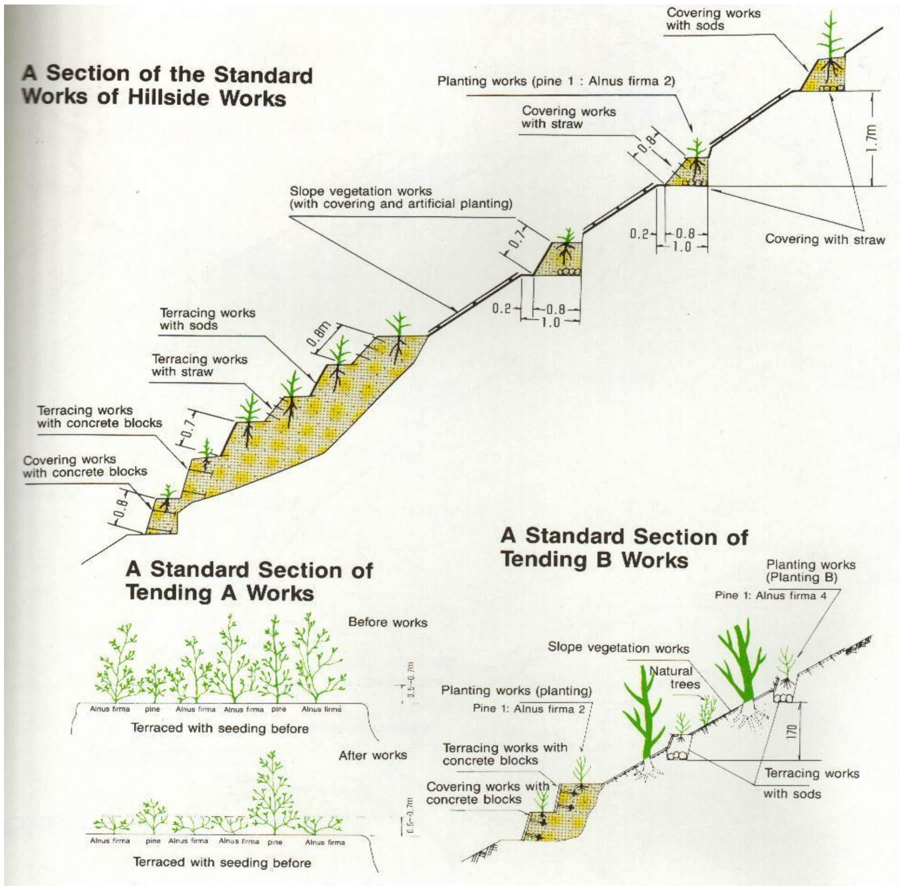
5.8 Erosion Control Work.

Hillside work shall be done to control the production of sediments, and to prevent the weathering of surface soil and management of erosion for the slop.

5.8.1 Dressing of slope surface. The existing slope will have irregular undulations, and some case very steep. The slope is made uniform and horizontally cut. It is like final marking / staking of ordinary construction work

5.8.2 Trenching for step work.With horizontal lines as markers, the terrace is trenched.

5.8.3 Terracing with ruble masonry.The ruble masonry is constructed in series and continuous. This works consists of constructing planting bed by making horizontal steps on the hillside to prevent erosion and preserve dampness in the soil for growth of plants. The bed excavation is carried out horizontally from the bottom to top on the prescribed lines. The dimensions are measured and inspected. During this operation the surplus soil is removed to the lower part. Plants which will grow to that environment and soil condition is planted at suitable interval. The plants which will have more tiny roots and leafs is more desirable because the roots will keep the soil bonded and leaves will observe the raindrop energy and retain some water. This will reduce the soil erosion considerably.Terracing with concave slop gradient is more desirable. It is desirable to use fertilizers for the growth of plants where the mountains having very low nutrient



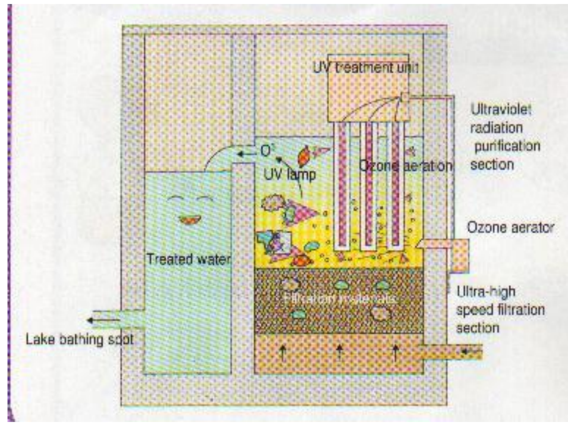
Hill side work for protection of soil erosion

5.11 Removal of Water Bloom.

A large volume of water bloom grows in summer due to eutrophication problem particularly in the shallow lakes. It turns the lake surface green, and when it decays, it produces unpleasant odors and significantly de grade the surrounding environment and scenery. At the same time the decayed water blooms changed into sediment and become cause for further eutrophication. The removal of water blooms is to be carried out using specialized boats which will work at shallow depth. The collected blooms are converted in to organic fertilizers and used for agriculture purpose.

5.9. *Water Cleaning Through Ultraviolet Radiation.*

The ultraviolet radiation destroys water bloom and other bacteria by decomposing their DNA. This facility aims to purify water in the specific water areas like bathing ghat, intake location for domestic purpose. This facility also serves to deodorize by oxidation using ozone and remove turbidity with filtering material.



Water purification by Ultraviolet radiation

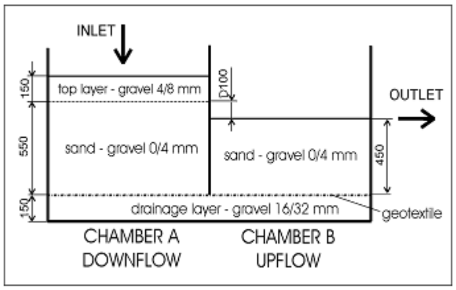
5.10 *Removal of Sediment from the Lake*

Sediment flow in the river water carries lot of nutrients like nitrogen and phosphorus released and deposited at the lake bottom. This not only reduces the capacity of lake gradually but also creates eutrophication problem in the lake. At certain interval, removal of this sediment is essential to maintain the lake eco system. The removal process is carried by mechanical system by means of dredger. The sediment so removed may have rich nutrients and can be used for reclamation of agriculture land, filling materials for low lying area, building material, etc depending on the type and size of particle. It may be pumped to a long distance through pipelines for various uses. A temporary floating wall can be constructed around the dredging area to protect the spread of suspended particle/turbidity to the adjacent area**.** Voluntary service of publics can be encouraged in this kind of work where their physical effort can be used.

5.12 *Construction of Wetlands.*

A sets of small scale or a medium scale plot is established beside lakes and each plot consists of two twin chambers (A and B), A is down flow chamber, B is up flow chamber, and they integrate at the bottom substrate, so the water can penetrate from A to B. Each small scale plots (SSP) chamber area may be $1\times1m^2$, medium scale plots (MSP) chamber may be $9\times9m^2$. The plain sketches of the wetland are shown in figure below.

Sketch of the Constructed Wetland



All the aquatic plants for the systems could be collected from the local region which will grow in this environment. They all have well developed roots, big biomass, certain anti-pest capacity and some have economic value.

The Running SSPs

15.12.1 Operation of wetland plants: The inflow water was pumped from Lake and stored at the pretreatment tank. When feeding, the stored water flush into buffer-tanks firstly, and then enter the chambers. For the chamber having reasonably bigger size the inflow is pumped from the Lake to a store tank. No buffer-tank may be necessary.This process removes Nitrogen, Phosphorus Organic pollutants, pathogenic bacteria, algae, Microcystins, heavy metalsfrom LakeWater.

5.13 Use of Remote Sensing and GIS Technique

Remote sensing technology has been greatly developed in many countries. This application combined with GIS is very vide. Today this technology will provide much needed information such as some aspect of water quality, land use details, vegetation cover over drainage area, aquatic vegetation cover the lakes, turbidity, monitoring of river morphology, sediment deposition in the reservoirs, assessment of flood effected area, etc. It is very effective where the accessibility is difficulty and large area need to be surveyed. Even encroachment over the banks of the lake or river by the publics, and mapping of surface distribution of pollution indicators could also be monitored using this technique.

Remote Sensing of water quality consists of correlation between the reflected and emitted radiation measured by the sensor and the water quality parameters obtained through laboratory analysis of samples collected in the field. The relationship is substantially influenced by the atmospheric effects, lake bottom reflectance, and contrasting special effects of suspended material (back scattering) and dissolved solids (absorption). Collection of water sample should be simultaneous with remote sensing measurements and standard preservation and analysis procedure need to be observed. The statistical modeling between remote sensing data and water sample data need to be consistent with our understanding of physical modeling of energy water interaction.

Various special field data available in the water shed such as population, land use details, location of various industrial units, meteorological data, etc can be stored in the GIS and the data can be manipulated in different ways and modeling can be generated for the decision making.

5.13.5 Sedimentation Analysis of Reservoir through Satellite Remote Sensing

The incidence of increased sediment yields in reservoirs in most cases poses serious threats to the storage capacity of reservoirs. Thus the need for assessing the loss of capacity due to sedimentation demands an approach to a host of unresolved problems. Remote sensing owing to the inherent benefits of synoptic coverage, cost effectiveness, repeatability, ability to map inaccessible areas, frequent enough to study most temporal phenomena, resolution (spatial/temporal) of the sensors being adequate (for both broad level and in-depth studies) is gaining popular use in reservoir sedimentation.

Remote sensing techniques make use of water spread of the reservoir between maximum and minimum operating levels during the observation period. Water spread observations below minimum draw down level (MDDL) are not possible as reservoir levels do not go below MDDL. Use of remote sensing is restricted to active/live storage zone only

5.14 Air Pollution and Acidification Management

Acidification of lakes and streams can be counteracted in the short term by liming. This raise the pH of the water, causes aluminum and other metals to precipitate, making them fall to the bottom, and leads to the decrease in the level of mercury in the fish. Liming must continue as long as there is an acid rain. Otherwise metals will again separate from the sediment, and then do more harm than before. Use of acidifying fertilizers and tree harvesting need to be limited so as to correspond to the ability of forest land to resists acidification. Acid ground water can be improved by placing a basic filter near the bottom of the well as a neutralizer. Alternatively the soil surrounding the well can be limed.

The main way to solve the problem of acidification in the long run is to reduce emissions of pollutants which can be achieved through using the best available technology for combustion and cleaning the flue gases, as well as through conservation of energy and other resources. Fuel and oil with low Sulphur content can be used.

Other methods like reducing the road traffic, lowering the speed limit, changing the modes of transportation, exhaust cleaning for instance by using 3-way catalyzers, modifying the engine design, fluidized-bed combustion gasification of solid fuels, using energy more efficiently, using renewable less polluting (or non-polluting) energy sources, reducing pollution from industries (Sulphur dioxide, nitrogen oxides, hydrocarbons) by altering methods and developing new methods for conservation technique.

5.15 Research and Development

Compilation of scientific data on water shed will help to develop environmentally sound management strategies for forests, rivers, lake fronts, wetlands, agriculture, urban and industrial lands, etc. Some research works, which will help for the effective decision making could be as under.

a) Assessment of climatological features, precipitation pattern, water and land use characteristics.

b) Study of urban, agricultural and industrial water uses and their implication in watershed management.

c) Assessment of amount and characteristics of surface and ground water runoffs

d) Establishment of hydrological characteristics of snow and snowmelt.

e) Recompilation of plant species data for the development of watershed vegetation map.

f) Examination of historical processes of shoreline landscape transformation

g) Assessment of paddy field nutrient runoff characteristic.

h) Study on the long term local residents use of and their association with lake waters

i) Study on the local residents awareness and sense of value on the preservation of lake environment.

j) Study on integration of environmental considerations in the river management policy and programs

k) Movement and mixing of water, bottom sediment and behavior and biochemical changes of nutrient in bottom sediment.

l) Distribution and decomposition of aquatic plants in lake water

m) Relationship between the change in the water quality and meteorological forces.

n) Wide application of Remote Sensing and GIS technique for environmental management.

5 *SUMMARY*

d) One of the main causes of eutrophication of lakes is discharge of domestic waste without proper treatment. Even after treatment also the effluents contains lot of nutrients. It is suggested that the construction of bio parks and wetlands are the efficient and environmentally sound process for water quality improvement and rehabilitation of aquatic ecosystems.Storm water contains lot of pollutants particularly from urban areas, need to be treated before discharging in to the water resources. It is necessary to create public awareness and include the environmental education in the primary level itself. Directly involving them as a part of the environmental monitoring and management activities will be more effective way to educate them.

e) More stress need to be given on the control of non-point source pollutions. Controlled irrigation management, producing the slow soluble chemical fertilizers, giving financial grants for production of bio-fertilizers to the farmers will considerably reduce the nutrients from the agriculture fields. Providing of community toilet system in each village and proper maintenance, will considerably reduce the nuisances caused by open air defecation and non-point source pollutions.

f) Construction of artificial sediment collection lagoons will also be more effective. Maximum sediment from the river is getting deposited near the bank of the lake, the removal of these sediment will also be easy. The reeds can be grown in this lagoon. These will some extent absorb the nutrients in the water. After growing to the desired height they could be sold for making thatched roof or some handy crafts.

g) The water resources management should be integrated in the natural system between land and water use, surface water and ground water, water quantity and quality, upstream and downstream, integration of human system such as mainstreaming water in the national economy, ensuing co-ordination between sectors, ensuing partnership between public and private sectors management and involving everybody

h) The existing law should be modified or if necessary new law should be enacted and strictly enforced to control the air pollution which is great threat of having acid rain and to protect the living organism from the endocrine disrupting chemicals and heavy metals, to meet the growing and future need. Polluters should be severely punished so that other can learn lesson.

i)

6 CONCLUSION

There may be many more techniques. Implementing best monitoring and suitable management technique which involves quality, quantity and integrity, needs considerable efforts from the government and people. ***Many management technique may be required to solve one problem and one management technique may solvemany problems***. As a decision makers choose the best, suitable, optimistic management technique. Polluters should realize the effect of environment for their present and future generation. Future generation should not be allowed to compromise their health for the present need. Planning for sustainable development with long term view for achieving friendly ecosystem is the need of the day. "***Prevention is better than cure".***

------------x----------------x------------

6.
Assessment and Prediction of Water Quality of Reservoirs Using CCME – WQI Method

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ABSTRACT

Reservoir water quality is the reflection of activities on its catchment which has a direct bearing on the reservoir water. The major source of water pollution is from human settlements, industrial and agricultural activities. These activities include unhygienic disposal and discharge of untreated sewage into reservoirs. This indicates towards deficient management, unsafe solid waste discharge. This paper presents a study on assessment and prediction of water quality of Panshet and Ujjani reservoirs. Data of physiochemical parameters collected from the field and laboratory analysis during the period March 2000 to November 2001 is used for prediction of water quality of the reservoirs for the period 2030 to 2031 and 2060 to 2061 by increase of failed variables. The Water Quality Index (WQI) suggested by Canadian Council of Ministers of the Environment (CCME) is applied in the study where quick detection of failed variables of physicochemical parameters is identified. The study shows the Panshet reservoir water quality degraded from Good-Fair to Fair-Marginal whereas Ujjani reservoir water quality degraded from Fair-Marginal to Marginal-Poor. The results of water quality analysis of physiochemical parameters obtained from CCME-WQI method are compared with acceptable limit of water quality for drinking purpose suggested by Bureau of India Standards guidelines and recommendations are made.

Keywords

CCME-WQI, Pollution, Physicochemical parameters, Reservoir, Water quality

INTRODUCTION

Reservoir water quality is the reflection of activities on its catchment which has a direct bearing on the reservoir water. Thus, all the problems of the reservoir water can be traced back to their activities in its catchments (Kodarkar et al., 2007). The major source of water pollution is from human settlements, industrial and agricultural activities. These activities include unhygienic disposal and discharge of untreated sewage into Mula-Mutha and Bhima rivers. This indicates towards deficient management, unsafe solid waste discharge. In the last few decades, there has been a tremendous increase in the demand for fresh water due to rapid growth of population and the accelerated pace of industrialization.

Upper Bhima basin with catchment area of 14500 km^2 having intense urban, rural, industrial and agricultural activities which has led to changes in its water quality over period of three decades after its completion about three decades ago. The urban discharges in the upstream of Ujjani reservoir are contaminating the water body. More than 86% of the untreated wastewaters discharged into the tributaries of river Bhima is sewage from the twin industrialized cities viz., Pune and Pimpri - Chinchwad having combined population more than 6 million (Sandeep Joshi, 2007). Ujjani reservoir water was tested for its suitability for various uses after commissioning of the project in 1982. Then the reservoir water quality was found good quality because its physical and chemical analysis indicated that the pH values, free carbon dioxide, total hardness, alkalinity, nitrates, nitrites, chlorides, sulphates, calcium and magnesium were within prescribed limits. Heavy metals, copper and lead were not present. However, during the rainy season, the iron content though high was found to be within permissible limits. Potassium and ammonia were within prescribed safe limits of acceptance for use of drinking, industrial and for fish propagation. However, it was found that that substantial quantity of the untreated sewage is discharged into the streams which flow into the Ujjani reservoir, particularly in the river stretch close to the Pune city.

Pune metropolitan area with number of industrial agglomerations in the upstream of the Ujjani reservoir affects Ujjani Dam. Analytical results have confirmed that the pollution from the Pune city has reached the distance of 200 km downstream to Ujjani reservoir - biggest in Bhima river basin in addition to 39 medium and small reservoirs - accelerating the growth of aquatic weeds in the water body. Highly polluted stretches of Mula-Mutha river are Vitthalwadi, Deccan, Kumbharwada, Bundgarden, Mundhwa, and Theur wherein the values of COD vary from 105 mg/L to 255 mg/L. Then, downstream of Theur, the organic pollution reduces to about 60 mg/L whereas Mula-Mutha river meets Bhima river. Speedy population growth and industrialization could not be matched by support civil systems in the Ujjani reservoir's huge catchment totalling about 14500 km^2. Wastes arising from such profusely populated areas finally find way down to Ujjani reservoir about 200 km downstream.

Water Quality

Water quality refers to the chemical, physical, biological, and radiological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. Bureau of Indian Standards (2012) guidelines for drinking-water quality ensure that public drinking-water supplies are as safe as possible. Central Pollution Control Board of India and World Health Organisation (WHO, 2004) worldwide establishes these standards and guidelines to know the suitability of water for designated uses such as drinking, recreation, agricultural irrigation or protection and maintenance of aquatic life. Continuous assessment of physical, chemical and biological parameters of water is an essential part of water quality control programs.

Panshet Reservoir

Panshet dam is built on river Ambi creates Panshet reservoir (also known as Tanajisagar reservoir) which is about 50 km southwest of the city of Pune and about 180 km from Mumbai in western India in the state of Maharashtra. The dam was constructed for irrigation and along with three other dams nearby, Varasgaon, Temghar and Khadakwasla, which supplies drinking water to Pune city (PMC, 2006). Panshet is one of the famous picnic spots of Pune and attracts many visitors from Mumbai. Panshet catchment area receives 400 cm to 600 cm rainfall annually with minimum human pressure and no industries in its catchment but has few villages with some agricultural activities. The locations of Panshet and Ujjani dams on Bhima river basin is presented in Figure 1.

Ujjani Reservoir

Ujjani dam is built on river Bhima creates Ujjani Reservoir (also known as Yashwantsagar reservoir), which is located near Ujjani village of Madha Taluk in Solapur district of the state of Maharashtra in India. Bhima River originates in Bhimashankar of the Western Ghats, and forms the Bhima Valley with its tributary rivers and streams. It has twenty-two dams built on it of which the Ujjani Dam is the terminal dam on the river and is the largest in the valley that intercepts a catchment area of 14858 km^2. The salient features of Panshet and Ujjani dams are presented in Table 1.

Fig. 1. Location of Panshet and Ujjani Dams on Bhima river basin

The project provides multipurpose benefits of irrigation, hydroelectric power, drinking and industrial water supply and fisheries development. The irrigation supplies benefit to about 500 km^2 of agricultural land, particularly in the Solapur district. Water supplied from the reservoir to irrigate agricultural areas primarily aims to reduce incidence of famines and scarcity during drought conditions. The reservoir operation also lessens threat due floods to cities such as Pandharpur. The basin above the dam has intense rural, agricultural, urban and industrial activities. The river basin, which has a slope from west to east has extreme physiographic and agro-climatic variations. The drainage basin has rich and fertile agricultural land, and several water resources development projects have been built on its river system.

Table 1. Salient Features of Panshet and Ujjani Dams

Salient Features	Panshet Dam	Ujjani Dam
Location	Velhe Taluk, Pune District	Madha Taluk, Solapur District
Latitude	18^o 23′ 15″ N	18^o 04′ 26″ N
Longitude	73^o 36′ 46″ E	75^o 07′ 12″ E
Year of Operation	1972	1969
Height	63.56 m (208.5 feet)	56.40 m (185.0 feet)
Length	1,039 m (3,409 feet)	2,534 m (8,314 feet)
Volume	4,190,000 m^3	3,320,000 m^3
Impounds	Ambi river	Bhima river

The basin experiences tropical monsoon climatic conditions. The rainfall is dictated by the southwest monsoon, which varies from 300 cm to 600 cm from the North - South trending mountain range of the basin and drastically drops to 70 cm within a distance of 70 km towards the east. The average annual precipitation of the basin above the dam in the Upper Bhima river basin has been assessed as 109.6 cm out of which 94.5 cm occurs during the four monsoon months (mid June to mid September). Thereafter, the basin falls under the rain shadow area towards east with rainfall incidence ranging between 45 cm to 60 cm and is thus under drought conditions quite frequently.

Most of rivers of Upper Bhima river basin are perennial. These rivers carry waste from urban areas. The situation is the worst in the Southern zone where Mula-Mutha, highly degraded rivers, carry sewage and industrial waste generated by Pune and Pimpri-Chinchwad urban areas, finally polluting Ujjani lake (Sayali Joshi and Sandeep Joshi, 2007). Pune city and its adjoining Pimpri-Chinchwad industrialized townships having combined population more than 6 million. The fast pace of urbanization and industrialization is putting increasing pressure on available water resources and while share of water for urban areas is increasing year after year, the same is decreasing in the case of irrigation sector. Degradation of rivers due to unplanned growth with unprecedented patterns is expected to grow continually and keep affecting water quality.

MATERIAL AND METHODS

In order to get correct representation of water pollution, surface water as well as water from various depths were collected from 18 and 29 locations of Panshet and Ujjani reservoirs respectively in well labelled clean polyethylene bottles rinsed by deionised water followed by reservoir water. Panshet reservoir water was sampled during March 2000, April 2000, August 2000, December 2000, July 2001 and November 2001. Ujjani reservoir water was sampled during April 2000, May 2000, September 2000, January 2001, March 2001 and October 2001. Analysis of physicochemical parameters was done as per with APHA (2005) guidelines.

Water Quality Index

Water Quality Index (WQI) is a single numerical expression, like a score or grade, which reflects the composite influence of significant water quality parameters. The index provides a meaningful and uniform method for assessing overall quality of a water body (lentic/ lotic systems), comparing quality conditions at different points in space and time, which is also a measure of water pollution abetment programs. Indices are used for different intended uses of water. WQI expresses water quality that offers a simple, stable, reproducible unit of measure and communicates information of water quality to the concerned citizens and policy makers; and therefore WQI becomes an important tool for the assessment and management of surface water. Horton (1965) at the middle of the past century, was the first researcher to suggest the advantages of calculating a WQI and since then, many studies concerning water indexes have been reported all over the world for lake and/or reservoirs. Brown (1972) applied WQI to study about the past, present and future state of the environment in the Vistula and Odra river basins.

CCME-WQI

In 1997, the Task Group of the Canadian Council of Ministers of the Environment (CCME) reviewed various existing techniques for calculation of WQIs. Their efforts led to the development of a standardized system i.e. a unified water quality index that has been employed in all parts of

Canada for the assessment of water quality (CCME, 2001). The CCME-WQI index is based on a combination of three factors F1, F2 and F3:

i) F1 (Scope) represents the percentage of variables that do not meet their objectives at least once during the time period under consideration (failed variables), relative to the total number of variables measured:

   F1 = (Number of failed variables/ Total number of variables) x 100

ii) F2 (Frequency) represents the percentage of individual tests that do not meet objectives (failed tests):

   F2 = (Number of failed tests/ Total number of tests) x 100

iii) F3 (Amplitude) represents the amount by which failed test values do not meet their objectives. The measure of amplitude (F3) is calculated in three steps.

   a) The number of times by which an individual concentration is greater than (or less than, when the objective is a minimum) the objective is termed an 'excursion' and is expressed as follows. When the test value must not exceed the objective:

      Excursion (i) = [(Failed test value (i)/Objective (j))-1] x 100

      For the cases in which the test value must not fall below the objective:

      Excursion (i) = [(Objective (j)/Failed test value (i))-1] x 100

   b) The collective amount by which individual tests are out of compliance is calculated by summing the excursions of individual tests from their objectives and dividing by the total number of tests (both those meeting objectives and those not meeting objectives). This variable, referred to as the Normalized Sum of Excursions (NSE) is calculated as:

$$\text{NSE} = \frac{\sum_{i=1}^{N} \text{Excursion (i)}}{\text{Number of tests}}$$

   c) F3 is then calculated by an asymptotic function that scales the normalized sum of excursions from objectives (NSE) to yield a range between 0 and 100.

      F3 = (100 x NSE) / (NSE+1)

Once the factors have been obtained, the index itself can be calculated by summing the three factors as if they were vectors. The sum of the squares of each factor is therefore equal to the square of the index. This approach treats the index as a three-dimensional space defined by each factor along one axis. With this model, the index changes in direct proportion to changes in all three factors.

The CCME-WQI is calculated by using the values of F1, F2 and F3, and given by:

$$\mathrm{CCME-WQI} = 100 - \left(\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732} \right)$$

The divisor 1.732 normalises the resultant values to a range between 0 and 100, where 0 represents the 'very poor' water quality and 100 represents the 'excellent' water quality.The assignment of CCME- WQI values to different categories is somewhat subjective process and also demands expert judgment and public's expectations of water quality. Depending on CCME-WQI value/score, the water quality is ranked in the following 5 categories (Table 2).

Table 2. CCME-WQI grades, values and description of water quality

S. No.	Rank	CCME-WQI value	Description of water quality
1	Excellent	95-100	Water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels.
2	Good	80-94	Water quality is protected with a slight presence of threat or impairment; conditions close to natural or pristine levels.
3	Fair	65-79	Water quality if usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
4	Marginal	45-64	Water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.
5	Poor	0-44	Water quality is almost always threatened or impaired; conditions usually depart from natural more desirable levels.

RESULTS AND ANALYSIS

The comparative summary of 22 physicochemical parameters for Panshet and Ujjani reservoirs depicting minimum, maximum, average, standard deviation values and percentage of compliances for three seasons, summer-2000, monsoon-2000 and winter 2000-2001 are presented in Tables 3, 4 and 5. Accepting water temperature during summer season and turbidity during monsoon season in both the reservoirs, BOD, COD, PO4, and Fe were found to be noncompliant almost all the months during study period. For Panshet reservoir, the EC value was found in the range of 55 μS/cm to 60 μS/cm which falls within the permissible limit of 300 μS/cm. Similarly, for Ujjani reservoir, the EC value was found in the range of 490 μS/cm to 570 μS/cm that is beyond permissible limit of 300 μS/cm. For both Panshet and Ujjani reservoirs, it was noted that the values of PO4-P and Fe are also deviated from their permissible limits. This can be attributed to draining of salts from their respective catchments during heavy showers.

Physicochemical parameters or variables which did not comply with objectives were termed failed variables indicated in yellow background with red fonts. Similarly the tests under each variable if failed were called as 'failed tests' and those tests were computed. The conversion of 22 physicochemical parameters into indicative value or grade, which is translated into one value vary from 0 to 100. This value indicates one of the five grades i.e. Excellent, Good, Fair, Marginal or Poor.

Water quality of Panshet and Ujjani reservoirs during 2000-2001
The computed CCME-WQI values using observed and analysed physicochemical parameters for Panshet and Ujjani reservoirs for the period 2000 to 2001 are presented in Tables 6 and 7. Panshet reservoir water quality was found as 'Good' in 83% occasions and 'Fair' in 17% occasions. For Ujjani reservoir, the water quality was found to be 'Marginal' in 33% occasions and 'Fair' in 67% occasions.

Water quality of Panshet and Ujjani reservoirs during 2030-2031
Predicted water quality of Panshet and Ujjani reservoirs for 2030-2031 is shown in Tables 8 and 9. The grade of water quality of Panshet reservoir was found as 'Fair' in 67% occasions and 'Good' in 33% occasions. From the analysis, it was also found that the water quality of Ujjani reservoir was found as 'Marginal' in 83% occasions and 'Fair' in 17% occasions.

Water quality of Panshet and Ujjani reservoirs during 2060-2061
The predicted water quality of Panshet and Ujjani reservoirs for 2060-2061 is shown in Tables 10 and 11. When the expected degradation of water quality of Panshet reservoir will be 'Marginal' in 33 % occasions and 'Fair' in 67% occasions whereas the water quality will be 'Marginal' in 67% occasions and 'Poor' in 33% occasions for Ujjani reservoir.

CONCLUSIONS
The physicochemical parameters are used as indicators of water quality as they reflect about the key elements of complex ecosystem in their catchment area. These indicators are thought to have meaning beyond the measures they represent and their trends are expected to yield valuable information about important aspect of the environment. All values except DO were found in higher range in Ujjani reservoir than Panshet reservoir. The study shows the DO value vary from 5 mg/L to 9 mg/L in Panshet reservoir and from 4 mg/L to 8 mg/L in Ujjani reservoir. Turbidity in both the reservoirs showed its high deviation from BIS limits during monsoon season July, August and September. The results of water quality showed its decline form viz., Good-Fair to Fair-Marginal for Panshet reservoir whereas Fair-Marginal to Marginal-Poor for Ujjani reservoir. This study indicated the decline of water quality in upstream located Panshet reservoir to lesser extent than

downstream located Ujjani reservoir. This is essentially due to huge human pressure in the downstream. The study also indicated the CCME-WQI could be used to assess the improvement of water quality.

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7.

Bioelectricity Generation Using Microbial Fuel Cell From Domestic Waste

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ABSTRACT

A Microbial Fuel Cell (MFC) is capable of generating electricity directly from a large variety of organic or inorganic compounds, using a microbe as a catalyst. MFC is a technology that uses a wide variety of substrates, materials, and is mainly developed to trap the energy from wastes. It has dual advantage, the microbes convert organic matter into electricity and the waste is treated simultaneously. In the present study, a cellulolytic bacteria was isolated from the compost and characterized as *Acinetobacter sp*. Optimization and characterization of cellulase enzyme was done and maximum activity was found to be 0.105U/ml. A lab scale MFC was set up and a potential difference was measured as 200mV from domestic organic waste.

KEYWORDS

Microbial fuel cell; bioelectricity; organic waste; bioelectrogenic microorganisms.

INTRODUCTION

Energy needs around the world, are rising at a pace yet unmatched by sustainable energy sources. Natural resources like oil will soon become scarce, and we need modifications in our current lifestyles if we wish to stretch the remaining oil reserves. Thus, all sorts of ideas and inventions for developing greener and more efficient methods of energy generation are increasingly being hailed across the globe (Deeksha; 2013). At the same time, India's garbage generation stands at 0.2 to 0.6 kilograms of garbage per head per day. In addition, large quantities of solid and liquid wastes are generated by industries. Waste generation in India is expected to increase rapidly in the future

Microbial fuel cells are devices which convert the chemical energy to electrical energy by means of electrochemically active bacterial decomposition. Bacteria require energy to survive and the consumption of energy occurs in two steps; oxidation which requires the removal of electrons from source of organic matter and reduction which gives electrons to the final electron acceptor i.e. oxygen. Certain types of bacteria respire by releasing the electrons into the surrounding medium. These released electrons pass through the semi permeable membrane or agar salt-bridge that connects the two chambers of the Microbial Fuel Cell (MFC). The transferred electrons generate a current and can be used to power devices (Zuraidah et al., 2016).

Moreover, MFCs have many distinct advantages over the conventional fuel cells. For one, they have higher efficiency, and produce little pollution. Some MFCs can even produce hydrogen along with electricity, conveniently solving the hydrogen problem as well, in a process called electrohydrogenesis. The MFCs may turn out to be highly effective as compared to conventional batteries, which need to be charged before usage, are environment unfriendly due to heavy metal content, and require electricity for powering those (Norilhamiah et al., 2016).

In the near future, MFCs may be developed to such a stage that they can give a reasonable and usable power output per unit the MFC volume. In such a viable scenario, a larger battery size could well be overlooked, provided the maintenance is easy and has a green and safe label. This eco-friendly fuel cell will then lead to several ground-breaking applications. As the amount of low-power devices implanted in the human body increases, the long term, stable power source used may well be the MFC (Deeksha; 2013).

The objective of this study was to isolate the cellulolytic microorganism from compost and generate electricity with the help of isolated bacteria using Microbial Fuel cell setup from waste.

Materials and Methods

Sample Collection

Samples were taken from the middle region of domestic compost pile consisting of food scraps, grass clippings, fruits, vegetables, grains, leaves, newspaper, curd and cow dung. The samples were collected in plastic bags and were stored at 4°C until used. Preparation of Compost One gram of compost was weighed and put in a conical flask containing 100ml of sterile water to make a suspension. Serial dilution was carried out by transferring 1ml of suspension into the first test tube and the next, and on up to the 5th of the sterile test tubes which contains 9ml of distilled water.

Isolation of cellulolytic microorganism

The CMC agar was used for isolation of cellulolytic bacteria at pH 7 for 24 hours of incubation at 37°C. Pure culture of bacterial colonies was obtained by repeated streaking. Purified cultures were further used for identification and screening for cellulase production. Screening on solid and liquid media 1% Congo red indicator was applied for screening of cellulolytic bacterial isolates. The plates were flooded with 1% Congo red indicator and left for 15mins followed by adding 1M NaCl solution and again left for another 15 min.

Filter paper screening for Cellulolytic Bacteria

The production medium was prepared for 100ml and 15cm diameter whatman filter papernNo.1 was folded into a cone and placed inside flask with the apex up. The flask was properly autoclaved at 121°C for 15min. One ml of the bacterial suspension was inoculated and incubated for 24hours. Positive flask, i.e., those with yellow and brown mottling/disintegration of filter paper was noted.

Biochemical Characterization

The isolate was characterized for various biochemical tests (James G.Cappuccino et.al., 2012)

ASSAY FOR CELLULASE:

Enzyme Assay by DNS Method:

CMCase Assay: CMCase activity was assayed using a standard method. Different concentrations of glucose in a range of 200μg/ml-1000μg/ml were reacted with Dinitro salicylic acid and Carboxymethyl Cellulose (CMC) in 0.1M Tris buffer at (pH 7) as substrate. The reaction was carried out at 50°C for 30 minutes. The amount of reducing sugar released in the hydrolysis was measured. One unit of CMCase activity was expressed as micromoles of glucose liberated per ml enzyme used per minute.

FPase Assay: A volume of 1ml of the crude enzyme supernatant was incubated for one hour at 50°C with 2m of 0.1M citrate buffer of pH4.8 containing 50mg Whatman filter paper. After incubation the reducing sugar were assayed by DNS method.

Protein was estimated by lowry’s method and the enzyme was partially purified by Ammonium sulphate precipitation. The optimum conditions like pH, Temperature and Incubation period was also carried out.

MFC construction and operation

Anode and cathode chambers with volume 200ml were connected by salt bridge (PVC pipe: 6cm). The H-shape Microbial Fuel Cell was constructed and Copper and Zinc electrodes were fitted into the lid of anode and cathode chamber. The entire assembly was surface sterilized with 70% ethanol and was exposed to

UV rays for 30 minutes in laminar air flow before inoculation. Multimeter was connected to the anode and cathode electrodes to record the readings in volts. The salt bridge was prepared by using 3% agar and 1M NaCl, autoclaved at 15 psi for 15 minutes. Sterile CMC medium was added into anode chamber. Paraffin film was used to seal anode chamber and maintain anaerobic conditions in anode chamber.

All operations were carried out at room temperature and at pH 7 for isolates. Readings were recorded after specific time interval.

Optimization of MFC parameters

MFC was optimized by using following parameters to increase potential difference between anode and cathode.

Effect of salt bridge concentration

Salt bridges were prepared with various Molar concentrations 1, 2M NaCl and with agar concentration of 3%. A dual chambered MFC with sludge as substrate was setup with above mentioned varying salt concentrations in salt bridge. The cells were run for one hour and readings were noted at regular intervals.

Effect of pH

pH of CMC medium was adjusted at different values (5, 6, 7, and 8) to check the efficacy of microbial fuel cell. The MFC was run and the voltage generation was recorded.

RESULT AND DISCUSSION:

ISOLATION AND SCREENING OF CELLULOLYTIC MICROORGANISM:

The isolate have been obtained, and was found to have cellulose hydrolyzing capacity which was confirmed on the basis of the plate staining method. The isolate showed clear zone around the colonies when stained with 0.1% Congo red dye and destained with 1MNacl. The isolate which showed positive for CMC screening was used for further studies.

Fig.1 *Acinetobacter species*

FILTERPAPER SCREENING: Disintegration of filter paper was noted in test culture, which determines that the organism was positive for the cellulase production.

BIOCHEMICAL TEST:

The isolate was found to be short, rod-shaped (coccobacillus) Gram negative bacterium. Based on the results the isolate was found to be *Acinetobacter species.*

CMCase Activity and FPase Activity:

The maximum CMCase activity was found to be 0.072U/ml, the results were on par with results of Sushi Singh et al., 2013 and FPase activity was found to be 0.1053U/ml.

OPTIMIZATION OF ENZYME PRODUCTION:

Effect of incubation period on cellulase production was determined. It was observed that 24hours was proved best incubation for the production of enzyme, and the activity was found to be 0.074U/ml. Reduction in the activity of the enzyme production was observed on increasing incubation period.

The temperature requirement of the organism is based on the nature of the organism. Cellulase production was carried out at different temperature and the higher cellulase activity was observed at 37°C and the activity was found to be 0.069U/ml.

Varying pH were analysed on cellulase production and maximum production of cellulase enzyme was found at pH 7. The activity was found to be 0.067U/ml. These results are on par with Otajevwo et.al (2011).

CHARACTERIZATION OF ENZYME:

The optimum pH for endoglucanase activity was found to be stable at pH 6.0 to 7.5. Increasing or decreasing pH beyond this resulted in decline in enzyme activity. Any change in pH caused changes in the enzyme active site. This range of pH is important for this enzyme, which can be used, in alkaline environments such as in processing of paper pulp (Irfan et al., 2012). cellulases showed optimum activity at 37˚C. On purification of enzyme, the activity increased and showed a maximum activity of 0.105U/ml for salt precipitate.

MICROBIAL FUEL CELL

1. Effect of salt bridge concentration

The effect of salt bridge concentration was determined and represented in the Fig 2.

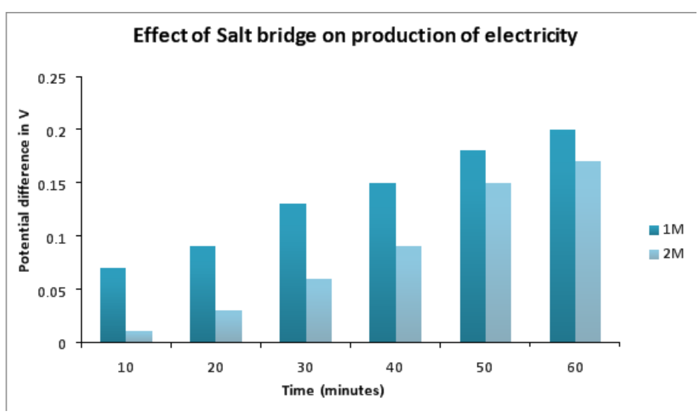

Fig 2: Effect of salt bridge concentration

In this experiment, 1M NaCl were used to transport H+ ions in the salt bridge. The voltage generation was recorded per ten minutes, for the inoculated sludge. The maximum generated voltage obtained with 1M NaCl and 2M was 0.20 V and 0.17 V respectively. The MFC was run for one hour and readings were noted at regular intervals

2. Effect of pH

The effect of pH was determined and represented in the Fig 3.

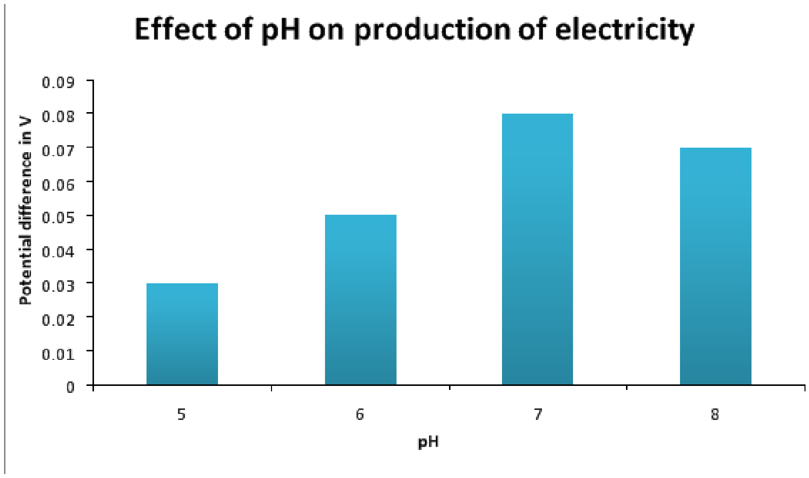

Fig 3: Effect of pH

Fig.4 Constructed Salt bridge MFC

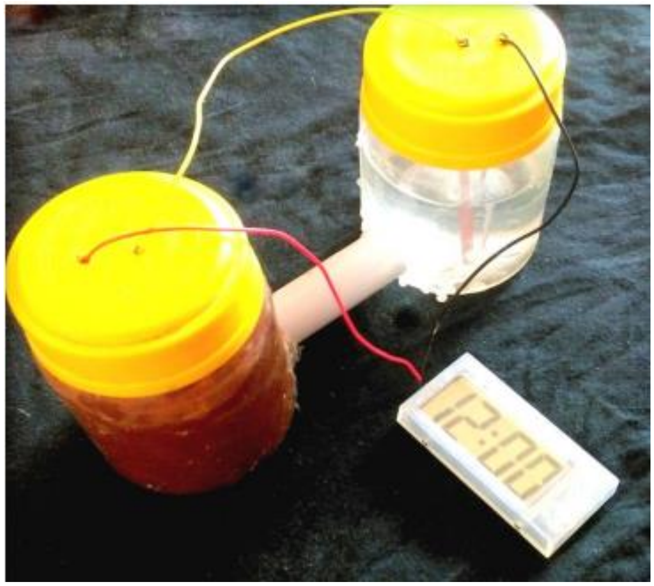

Fig.5 MFC powered Digital clock

SUMMARY & CONCLUSION:

In this present study, the cellulolytic bacteria was isolated from compost. Staining and biochemical characterization was performed. From the characterization studies, the bacteria isolated was found to be *Acinetobacter species*. Optimization of cellulase production was performed with various parameters like incubation period, temperature and pH. Since the enzyme has several applications in textile, food, paper industry and so on, the enzyme should be highly robust under the industrial conditions. The enzyme produced was characterized for thermal stability, pH stability and determination of Km and Vmax value with various substrates concentration. Partial purification of enzyme was carried out and the activity was found to be 0.105U/ml.

The isolated bacterium was used to generate electricity from compost using Microbial Fuel cell setup. The bacteria *Acinetobacter species* can produce 200mV from 50grams of compost. This can be developed as a house hold model for small electrical devices. Renewable energy is an increasing need in our society. The increase of energy cost, depletion of non-renewable energy sources like fossil fuels and intolerable changes in the climate have considerably motivated scientists to work on finding new alternative energy production approaches. The other by- product of development is, waste produced from different sectors. Hence Green energy is the need of the day.

MFC is a technology that uses a wide variety of substrates, materials, and system architectures with bacteria to achieve bioenergy production. These systems are mainly developed to trap the energy from wastes and have dual advantage. The microbes added convert organic matter into electricity and at the same time, the wastes are treated concurrently since energy is biologically extracted from them. As the effectiveness of operation of MFC anodic chamber on bioelectricity generation was observed high under neutral operating conditions, this eco-friendly fuel cell will then lead to several ground-breaking applications in domestic purposes such as to achieve a suitable current and power for the application in electrical devices with fabricated stacked MFC as power source.

The major goals for future MFC would be (1) Improvement in current MFC by trying with different electrode materials, electrode spacing, electrode area, membrane, catalysts and pH. (2) Connecting multiple MFCs in series to draw higher voltages suitable for practical applications. (3) Development of a continuous system to draw current continuously. (4) Study on impact of intermediate products formed by mixing substrates on voltage generated. It may be concluded that the organism *Acinetobacter sp* has the potential to produce electricity and could have potential application for wide range of industries and for domestic purposes.

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8.

Bioremoval of methyl red using *Aspergillus niger* from aqueous solutions

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ABSTRACT

Dyes are synthetic aromatic compounds which are predominantly used in textile sector and may cause lethal effects when disposed into aquatic and terrestrial ecosystem without proper treatment. In recent decades, attempts have been developed to formulate an efficient and sustainable method for the treatment of dyeing wastewater which is of scientific concern. Biosorption using fungi for the removal of dyes appears to be cost economic and ecofriendly remediation technique when compared to physico-chemical methods. The present study deals with the biosorptive prospective of *Aspergillus niger* for the removal of methyl red from the aqueous solutions. *Aspergillus niger* isolated from the textile effluent discharged soil was assessed for the removal of methyl red at various ranges of dye concentration (100 – 600mg/L), biosorbent dose (10-50g/L), pH (3,4,5,6,7,8), temperature (15ºC, 20ºC, 25ºC, 30ºC, 35ºC, 40ºC), incubation period (1-6 days), 1% carbon sources (glucose, sucrose, maltose, mannitol, galactose and starch) and nitrogen sources (ammonium chloride, potassium nitrate, sodium chloride, yeast extract, glycine, urea and peptone). The desorbing agent 0.1N HCl and 0.1N HNO_3 was used to remove the dye from the fungal biomass after biosorption. The results illustrate that under optimal conditions the maximum removal of methyl red (87%) was observed in the medium amended with 100mg/L of methyl red inoculated with 10g/L of biosorbent in pH 5 at 35ºC on 5th day of incubation using 1% glucose and peptone as carbon and nitrogen sources respectively. The desorbing agent 0.1N HCl desorbed 90% of dye from *Aspergillus niger* which reveals that the desorbed biomass can be reused for further sorption studies. The fungal biomass was subjected to FT–IR spectral analysis before and after biosorption and the results suggested that the dye binding sites on the fungal cell surface were most likely the hydroxyl and amine groups. Zootoxicity studies reveals that *Catla catla* survived in microbially treated methyl red and control, whereas the mortality of fishes increased in untreated dye as the time interval was increased. Hence, *Aspergillus niger* under optimized conditions efficiently removed the methyl red and may be exploited in the removal of pollutants from textile industrial effluent, which provides a clean and green ecofriendly approach to the society.

KEYWORDS: *Aspergillus niger*, Methyl red, Optmization, Biosorption, FT-IR, Zootoxicity

INTRODUCTION

Increasing human population has exerted an enormous pressure on the provision of safe drinking water especially in developing countries. The textile industry is one of the leading sectors in the Indian economy as it contributes nearly 14% to the total industrial production. Dyes used in textile industry are synthetic aromatic compounds which are widely used by many industries like textiles, cosmetic, plastics, paper, food, and pharmaceuticals (Saratale *et al*., 2011). Coloured wastewater contains more than 10,000 synthetic dyes and its accounts for approximately 10-15% of the total dyes used in the dyeing process (Jin *et al*., 2008).

Enormous volume of water is used throughout the operation process, such as washing of fibers to bleaching, mercerizing, dyeing and printing and washing of finished products. Effluents containing textile dyes are usually discharged in large quantities worldwide into natural water bodies on a daily basis (Meehan *et al*., 2000). The untreated textile wastewater can cause rapid depletion of dissolved oxygen if it is directly discharged into the surface water sources, due to its high BOD and COD values which are highly toxic to biological life (Imtiazuddin *et al*., 2012).The presence of dyes or their degraded products in water cause human health disorders, such as nausea, hemorrhage, ulceration of skin and mucous membranes. Presence of some toxic compounds resulted into severe damage to reproductive system, liver, brain and central nervous system (Ramachandran *et al*., 2013).

In the recent past, efforts have been made to develop efficient and sustainable methods for the treatment of dyeing wastewater, due to the rigorous Government legislations holding textile industries to increasingly higher standards of treatment regarding waste effluents (Corso and Almeida, 2009).

Methyl red, the candidate dye belongs to azo dye, is a dark red crystalline powder. It is a pH indicator which it is red in pH under 4.4, yellow in pH over 6.2 and orange in between, with a pka of 5%. It is investigated as promising enhancers of sonochemical destruction of chlorinated hydrocarbon pollutants. It is classed by the IARC in groups classified as the carcinogenic potential in humans.

A number of conventional physical and chemical wastewater treatment such as electrocoagulation, adsorption on activated carbon, ion exchange, flocculation, froth flotation, ozonation, membrane filtration and reverse osmosis have been suggested for decolourization of textile effluent. Although all these techniques were very versatile and useful, but they all end up in producing a secondary waste product which needs to be tackled further because of high cost and disposable problem (Lade *et al*., 2012)

Biosorption is potentially an attractive, alternative, ecofriendly and cost effective technology to remove dye from aqueous solution using biomass which are biological materials derived from living organisms. Biosorption is capable of removing traces of dyes and other elements from dilute aqueous solutions using algae, fungi and bacteria and produce less amount of sludge (Bohumil, 2007).

Hence, with this background an attempt has been made to study the ability and potential of *Aspergillus niger* towards remediation of methyl red dye under optimal conditions.

MATERIALS AND METHODS

Chemicals and Media

Methyl red (2 – (N, N – Dimethyl – 4 – aminophenyl) azo – benzenecarboxylic acid) is an indicator dye. Methyl red and the microbiological media used in the study were purchased from Himedia (Mumbai, India). The structure of methyl red is given in Fig.1

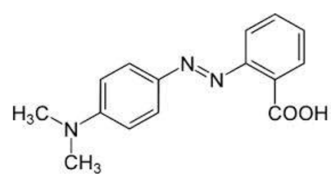


Fig 1. Structure of Methyl red

Collection of soil sample

For the present study, the soil sample contaminated with textile effluent was collected from the dyeing unit at Tirupur in a sterile polythene container. The lumps in the soil sample was crushed by using a porcelain mortar and pestle and stored at ambient temperature in cloth bags for subsequent analysis.

Isolation of methyl red decolourizing fungi

Ten grams of effluent contaminated soil sample was weighed and dispersed in 100 ml of sterile distilled water and stirred well. The sample was serially diluted upto 10^{-8} dilutions and 0.1ml of the sample was drawn from each dilution and spread plated on sterile Sabauroud dextrose agar medium. The plates were then incubated at room temperature (28º C) for 5 days. After 5 days of incubation, the well grown fungal colonies were isolated and the pure culture of each fungal colony was maintained on Sabauroud dextrose agar slants at 4º C for further study.

Preparation of Inoculum

One loopfull of the isolated fungal colony was inoculated into 100ml of Sabauroud dextrose broth (Peptone - 1g, Dextrose – 4g, distilled water – 100ml) separately. The broth was incubated for 5 days at room temperature for the fungal growth. The culture broth was used as inoculum for the decolourization study.

Screening and identification of isolated fungal colonies for their decolourization effect

To screen the fungal isolate which exhibited maximum decolourization 100 ml of Sabauroud dextrose broth amended with 0.01g methyl red was taken in 250ml Erlenmeyer flasks. 1g of each inoculum was inoculated into the broth separately and the contents were incubated for 5 days. After 5 days of incubation the per cent decolourization was determined by measuring the absorbance at 700nm in UV vis spectrophotometer (Chamunorwa *et al.,* 2008).

$$\text{Percent Decolourization} = \frac{\text{Initial absorbance} - \text{Final absorbance}}{\text{Initial absorbance}} \text{X100}$$

Based on the per cent decolourization, the fungal isolate which exhibited maximum decolourization percentage was selected for the present study and subjected to further identification by lactophenol cotton blue staining method (Cappuccino and Sherman, 1999).

Maintenance of the fungal isolate

The identified fungal isolate was subcultured on Sabauroud dextrose agar slants and incubated at room temperature. After sufficient growth was obtained, the slants were stored in refrigerator which served as stock culture. Subculturing of fungal isolate was routinely made for every month in the experimental work.

Optimization of different parameters for methyl red decolourisation

To evaluate the optimal conditions for methyl red decolourisation, the selected fungal colony was inoculated into a series of 250ml Erlenmeyer flask containing different concentrations of dye (100mg/l, 200mg/l, 300mg/l, 400mg/l, 500mg/l and 600mg/l) at varying inoculum concentrations (1%, 2%, 3%, 4% and 5%). The pH was set at different ranges from 3 to 8 (3, 4, 5, 6, 7 and 8) by adjusting with 1N HCl or 1N KOH. At each pH the fungal colony was inoculated and incubated at different temperature (15°C, 20°C, 25°C, 30°C, 35°C and 40°C) for various time intervals (1, 2, 3, 4, 5 and 6 days) to find out the optimum decolourisation activity. The carbon (glucose, sucrose, maltose, mannitol, galactose and starch) and nitrogen (ammonium chloride, potassium nitrate, sodium chloride, yeast extract, glycine, urea and peptone) sources were added at 1% level for effective decolourisation. At the end of the incubation period the samples were removed, centrifuged at 10,000 rpm for 10 minutes and the supernatants were analysed for the decolourisation activity. Under the optimal conditions the selected fungus was inoculated into methyl red solution and the textile dyeing effluent to determine the percentage decolourisation.

FT – IR spectral analysis

By interpreting the infrared absorption spectrum, the chemical bonds in a fungus can be determined before and after biosorption of methyl red dye. 50 ml of the fungal culture was pelleted by centrifugation at 6000 rpm for 15 min at 4°C and was lyophilized using an ice dryer. Methyl red loaded biomass was washed, dried and powdered after biosorption. One milligram of finely crushed biomass was then mixed with 400 mg potassium bromide. The mixture was ground into fine powder and translucent sample disks were obtained by using a manual hydraulic press at a pressure of 100 kg cm^{-2} for 10 minutes. The disk was then fixed in a FT – IR spectrometer (FT-IR 8400S SHIMADZU). FT-IR spectrum of the biomass unexposed and exposed to methyl red at concentration of 0.01 g/100 ml was obtained from 400 to 4000 cm^{-1}.

Zootoxicity Studies

An attempt was made to assess the impact of methyl red (untreated and treated) on the fresh water fish, *Catla catla.* Fresh water fish, *Catla catla* was collected from a fish farm in Coimbatore, Tamil Nadu. The fishes were transported to the laboratory in a polythene bag containing oxygenated water. They were kept in two large aquarium tanks and were acclimatized to laboratory conditions for a period of 15 days in non chlorinated water. Water was changed daily to provide sufficient oxygen and they were fed with fish feed regularly. Feeding was stopped one day prior to the start of the experiment. Three experimental tubs were setup and each tub was filled with tap water, untreated and treated effluent separately. Each treatment was replicated thrice. For each treatment five fishes were introduced and allowed to grow. The percentage mortality was recorded at one hour interval (9:30 a.m. to 4:30 p.m.), during the experiment period.

RESULTS AND DISCUSSION

Isolation, Screening and Identification of methyl red decolorizing fungi

Five different fungi which are capable of decolourising the dye was isolated from the textile dye effluent contaminated soil and screened for decolourisation. The percentage decolourisation by the selected fungal isolates

(1, 2, 3, 4 and 5) was recorded as 56%, 71%, 42%, 45% and 46% respectively. The fungal isolate 2 exhibited high per cent decolourisation and chosen for the further study. Based on the morphological, microscopic and cultural characters the selected fungus was identified as *Aspergillus niger*. On Sabauroud dextrose agar medium black colony with rapidly grown aerial hyphae was found. The spores are oval, black in colour, and the mycelium was aseptate which give rise to short conidiophores and terminal globose vesicle.

Optimization studies for methyl red decolourisation

The effect of various optimization parameters on the decolourisation of methyl red by *Aspergillus niger* was presented in Fig 1(a-g). The methyl red at the concentration of 0.01g showed maximum decolourization (72%) and minimum uptake (30%) was observed in the medium amended with 0.06g of dye by *Aspergillus niger* within 6 days of incubation. As the concentration of the dye is increased there was a decrease in the uptake of dye which indicates that the sorption sites in the fungal structure are saturated (Srivastava and Rupainwar, 2011), blockage of active binding sites of fungal degrading enzymes (Tony *et al*., 2009) or the sulfonic acid group (SO_3H) on the aromatic ring of the dye may inhibit the growth of microorganism (Chen *et al*., 2003). .

Increase in inoculum concentration from 1% to 5% decreased the percentage decolourization. *Aspergillus niger* at 1% inoculum concentration exhibited maximum decolourization of methyl red (73.2%). The effect of inoculum size on dye decolourization is an important factor as there is a direct relationship between inoculum size and dye decolourization. High performance decolourization was mostly due to dye sorption by fungi, as well as reduction of dye intensity in solution because of changes caused by them (Balan and Monterio, 2001).

Incubation time is an important parameter in all phenomenon including biosorption. Evaluation of time required for the fungal growth is important factor in biosorption to study the effect on the capacity of dye removal (Koyani *et al*., 2013). The rate of biosorption increased from 1st day to 5th day gradually with maximum decolourization of 73% on fifth day of incubation period. The results of the present study was in accordance with the findings of Raj and Gandhi (2009) who indicated that *Rhizopus microsporus* incubated with the synthetic textile dyes in potato dextrose broth showed remarkable breakdown action on green G and swiss pink within 5 days of incubation.

pH plays a major upshot on the efficiency of decolourization in biosorption and it also affects the interaction of dyes with biomass (Farah *et al.,* 2007). *Aspergillus niger* recorded maximum uptake of 71 per cent of dye at the optimum pH 5 and the minimum uptake was observed at pH 3 (35%) indicating the fact that the fungi can degrade the synthetic dyes mostly at acidic conditions. pH is one of the main variables affecting the biosorption process, influencing not only the surface charge of the sorbent, the degree of ionization of the material present in the solution and the dissociation of functional groups on the active sites but also the chemistry of dye (Crini *et al*., 2007 and Khatee *et al*., 2013).

Biosorption capacity of fungal biomass for methyl red increased with decrease in pH, because the presence of cell wall components such as polysaccharides, proteins, lipids, melanin along with several functional groups have the ability to bind with dye molecules and effectively decolourize the dye. The amino groups of the fungal cell wall components will also be protonated at acidic pH values (Ozer *et al*., 2006). Higher dye uptake obtained at lower pH values may be due to the electrostatic attraction between negatively charged dye anions and positively charged cell surface. The findings of present study showed that the optimum pH for *Aspergillus niger* was 5 which was in accordance with the reports observed in *Penicillium* at pH 5 (Sharma *et al*., 2009), *Aspergillus fumigatus* at pH 3-8 (Jin *et al*., 2007).

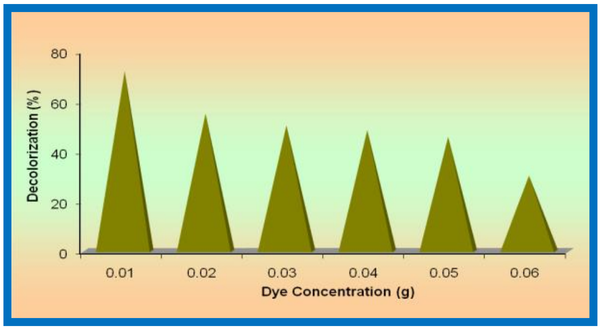
The effect of temperature on decolourization of methyl red exhibited maximum uptake of dye at 35º C (82.5%) and minimum decolourization was noticed at 20º C (28.2%). Temperature is a very important factor for all processes related with microbial vitality including the remediation of water and soil. It was also observed that the decolourization rate of synthetic dyes increases up to the optimal temperature, and afterwards there is a marginal reduction in the decolourization activity (Santos *et al*., 2007).Versatile textile dye effluent was produced at relatively high temperature therefore temperature was in important factor for the real application of the fungal biosorption. Removal of dyestuff at higher temperature by fungal biomass may be due to the increased surface active sites and kinetic energy of dye molecules (Kumari *et al*., 2007). Increase in temperature also increased the adsorption capacity, which indicates that the process was endothermic in nature. The enhancement in biosorption with temperature might be due to the increased mobility of the dye molecule with their increased kinetic energy and the rate of intra particle diffusion of adsorbate with the rise in temperature (Aksu *et al*., 2008).

Temperature affects the rate of dye adsorption based on the different dyes present in the solution. *Aspergillus foetidus* biomass was very efficient in decolourization of RB5 dye. The sorption capacity was maximum at 35ºC (Patel and Suresh, 2008). The results of the present study was also related with the findings of Anjaneya *et al*., (2009) who examined the biosorption capacity of acid violet dye using *Pencillium* species at 35ºC. Chen *et al.* (2008) recorded the optimum temperature for decolourization of crystal violet by *Shewanella* species at 35ºC. Majority of these reports indicate that biosorption capacity of the fungal biomass increases with increase in temperature.

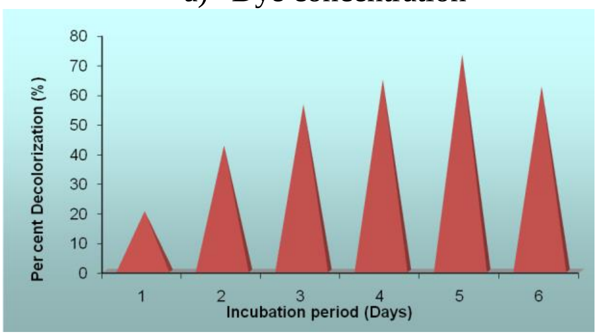
Dyes are deficient in carbon sources and the biodegradation of dyes without carbon source is very difficult (Khehra *et al*., 2005). *Aspergillus niger* exhibited maximum decolourization activity (83%) when glucose was supplemented in the medium as co-substrate. Glucose is an easily available and effective carbon source for fungus. It is frequently demonstrated that its addition improves the efficacy of dye degradation (Bardi and Marzona, 2010). Glucose serves as a source of carbon and energy and it also support the decolourization of dye. It plays a pivotal role in increasing decolourization (Kapdan *et al.,* 2000).

In case of azo dyes, the carbon sources are easily utilized and it acts as sources of electron donor, which are needed for azo bond cleavage (Mohanty *et al*., 2006). The ability to use azo dyes as sole energy and carbon source by fungus is to reduce the azo bond (Rai *et al.,* 2005). The results of present study coincides with the findings of Yesilada *et al.* (2003) who reported that the Astrazone Blue decolourization activity by *Funalia trogii* pellets showed maximum decolourization activity in glucose supplemented cultures. The decolourization rate of glucose supplemented cultures was higher when it was compared with glucose free cultures. Glucose also stimulates the digested spent wash decolourization activity of fungal cultures. Among all the supporting sources, glucose was noticed to be efficient decolourizing enhancers as carbon source.

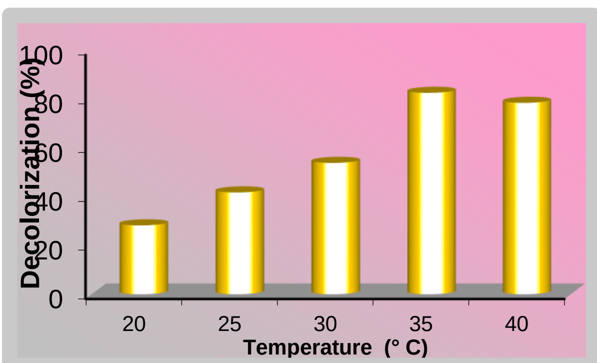
Biosorption of methyl red mainly depends on the nitrogen sources. Decolourization and mineralization of azo dyes have been reported to be enhanced in nitrogen sufficient culture. The result shows that peptone showed maximum decolourization (86.2%) of methyl red. During decolourization of azo dyes through reduction of azo bonds, reducing equivalents from different nitrogen sources are transferred to the dye (Saratale *et al*., 2009).



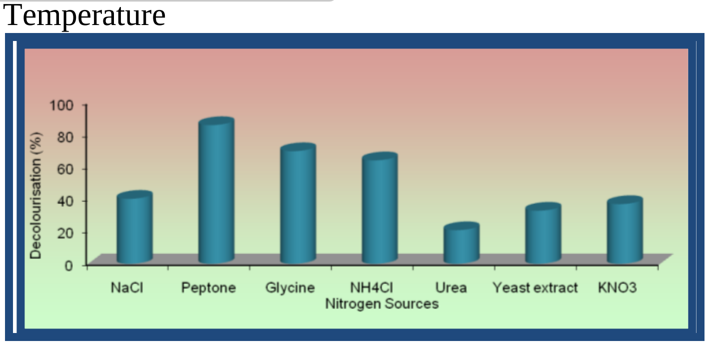
a) Dye concentration



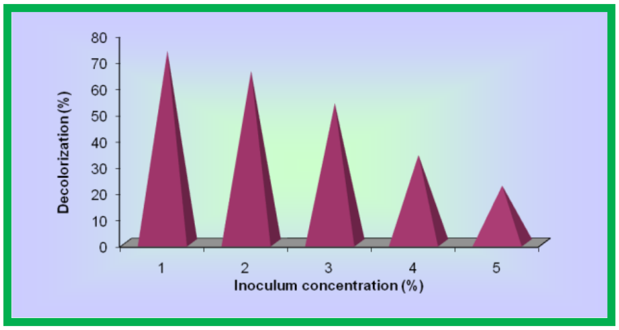
b) Incubation Period

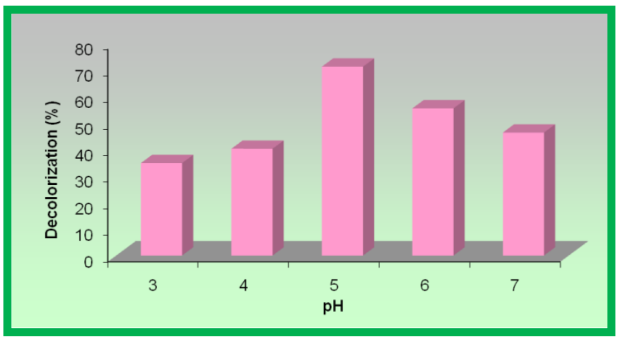


c) Temperature



d) Nitrogen Source





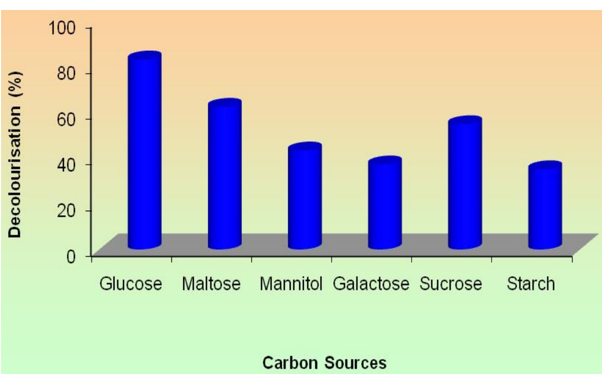


Fig 1 (a-g)- Percentage decolourization of methyl red using

***Aspergillus niger* at different optimal conditions**

The results of the present study coincides with Chang *et al.* (2000) who reported that organic nitrogen sources act as an electron donar for the reduction of azo dyes using microorganisms which results in effective decolourization. Levin *et al*. (2010) also reported that the peptone was the best nitrogen sources for laccase and manganese peroxidase production in the decolourization assay.

Aspergillus niger under optimized conditions degraded methyl red to 87%. For effective decolourization glucose and peptone (1g/100ml each), dye concentration (0.01g/100ml), inoculum concentration (1%), incubation period (5 days), pH (5) and temperature (35°C) should be in optimal level (Fig.2). Similarly 79% removal of colour from textile effluent was observed under pH 5, temperature (35°C) and biosorbent dose of 1g/ 100ml.

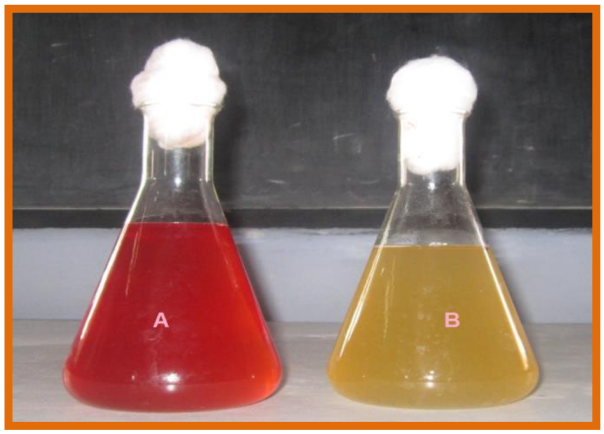


Fig 2 : Decolourization of methyl red dye using *Aspergillus niger* under optimal conditions

A- Untreated Methyl red, B- Treated Methyl red

FT–IR spectra of dye loaded and unloaded fungal isolates

To understand the involvement of the functional groups on the cell surface in adsorption of methyl red, biomass of *Aspergillus niger* before and after dye biosorption was examined using FT-IR spectroscopy. The vibrational spectra of the dye loaded and unloaded fungal isolate was shown in Fig 3a and 3b. The biomass of *Aspergillus niger* before and after biosorption shows shifting and intensification of some peaks after dye loading, indicating their involvement in dye biosorption, which were interpreted based on the standard wave number.

The peak at 3942.50 cm^{-1} shifted to a peak at 3441.01 cm^{-1} which seems likely due to the overlap of O-H and N-H stretching vibrations indicating the presence of both surface free hydroxyl groups and chemisorbed water on the biosorbent. The shifting and intensification of peaks from 1658.78 to 1728.22 cm^{-1} indicates CH symmetric stretching of the methylene groups ($-CH_2$) and deformation vibrations of methyl groups (CH_3) that are involved in the biosorption process. This peak observed in the dye loaded sample (1782.22 cm^{-1}) may be attributed to C=O stretching vibration of carboxylate (-COO) group. The peaks at 1149.57 cm^{-1} and 1080.14 cm^{-1} are visible mainly on dye loaded biomass which may be due to the C=O stretching vibration of ketones, aldehydes and carboxyl groups.

Thus, amide, hydroxyl, carboxylate, and methylene groups seem to participate in methyl red biosorption on the surface of *Aspergillus niger* causing shifts in wave numbers, due to change in bonding energy in the corresponding functional groups (Balaria and Shiewer, 2008).

On the basis of the change in the band, it was reasonable to assume that the peak value suggested the coordination of the dye with hydroxyl or carboxyl or amine groups, which may increase the hydrogen bondings or forms ligands between the dye and the cell wall. The peaks in the samples give the presence of functional groups such, carboxylic acids, amides, phenols and alcohols. This analysis had eventually confirmed the difference between functional groups in relation to biosorption of methyl red dye.

Hence, shifting of these peaks to another position from their original position indicated degradation of original structure of the dye. Similar changes in the peak of different dyes have already been reported by earlier workers (Dhanve *et al*., 2009 and Ghodake *et al.,* 2009). Thus, decolourization of methyl red was predominantly due to biosorption onto the biomass with little likelihood of any biodegradation of the dye during the process (Daneshvar *et al*., 2007).

Zootoxicity Studies

Despite the fact that untreated dyeing effluents might cause serious environmental and health hazards, they are being disposed off in water bodies and this water is being used for aquacultural purpose. Use of untreated and treated dyeing effluents in the aquaculture has direct impact on aquatic mammals. All the azo dyes which contains a nitro group were found to be mutagenic and highly toxicity. Therefore, toxicity of azo dyes and their metabolic intermediates

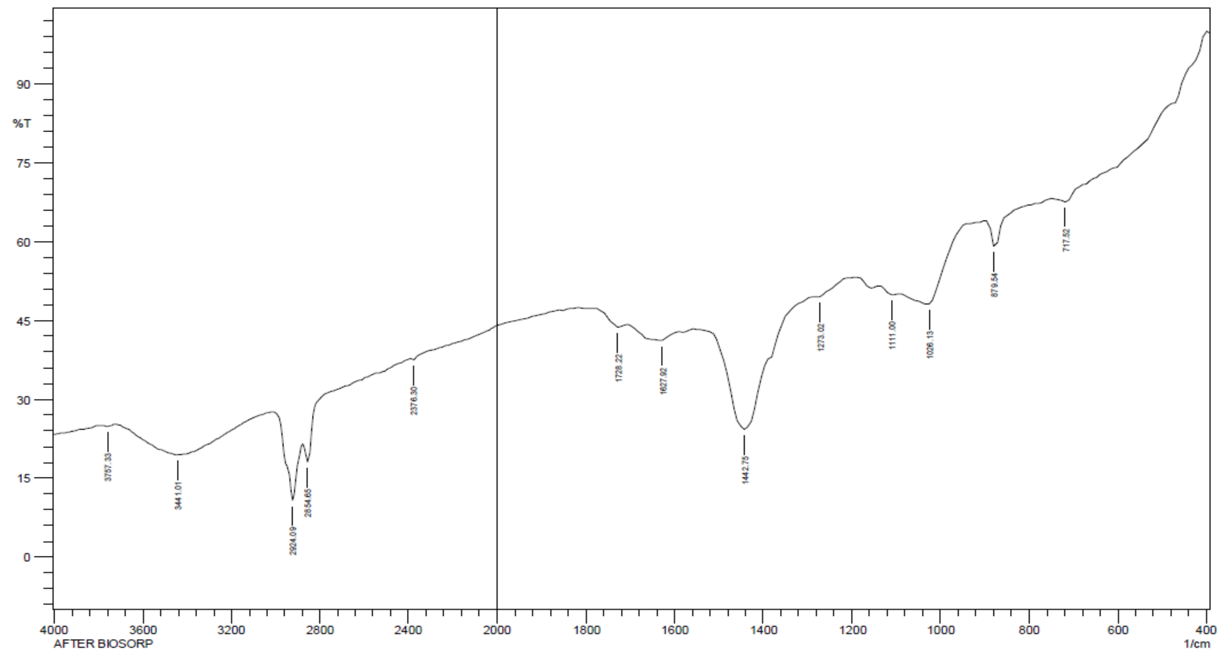


Fig 3a: FT-IR spectral analysis of *Aspergillus niger* unloaded with methyl red

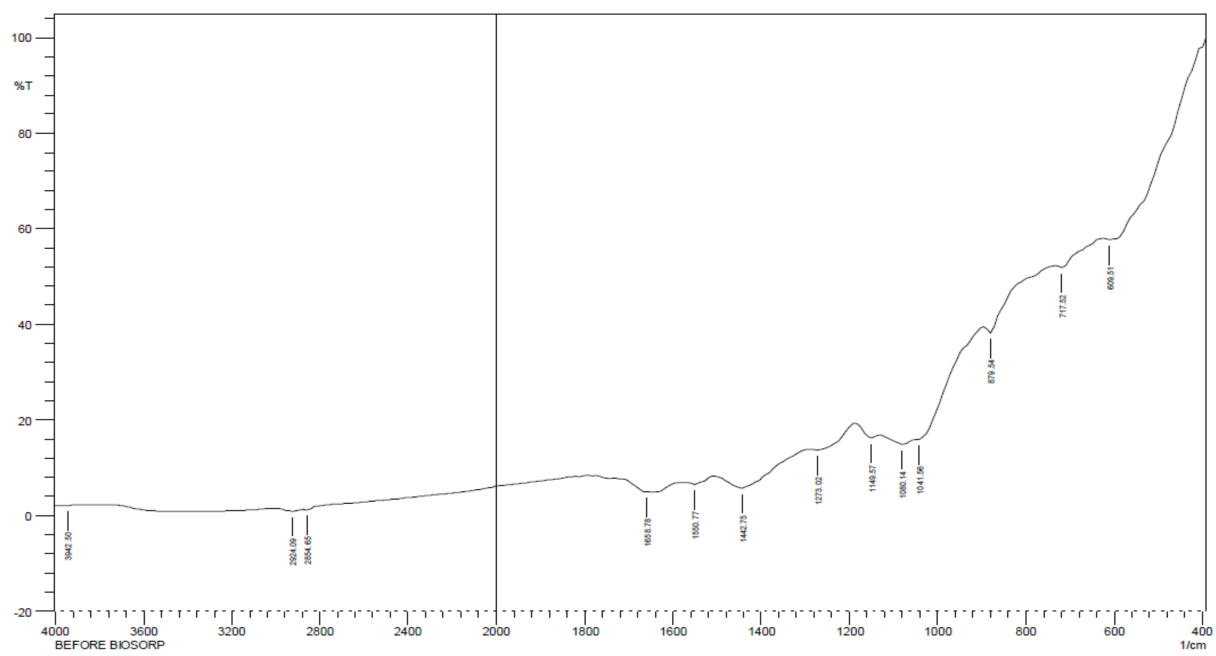


Fig 3b: FT-IR spectral analysis of *Aspergillus niger* loaded with methyl red

has been investigated by many researchers by assessing the microbial and zootoxicity of the sample before and after microbial treatment (Telke *et al*., 2008).

In the present study the fishes were treated with a particular concentration of methyl red (0.01 g) and the mortality of *Catla catla* was recorded at 1 hour time interval. The results indicates that all the fishes survived in the microbially treated dye solution when compared to control whereas in untreated dye solution when the time increase the mortality of fishes started to decrease (Fig 4).

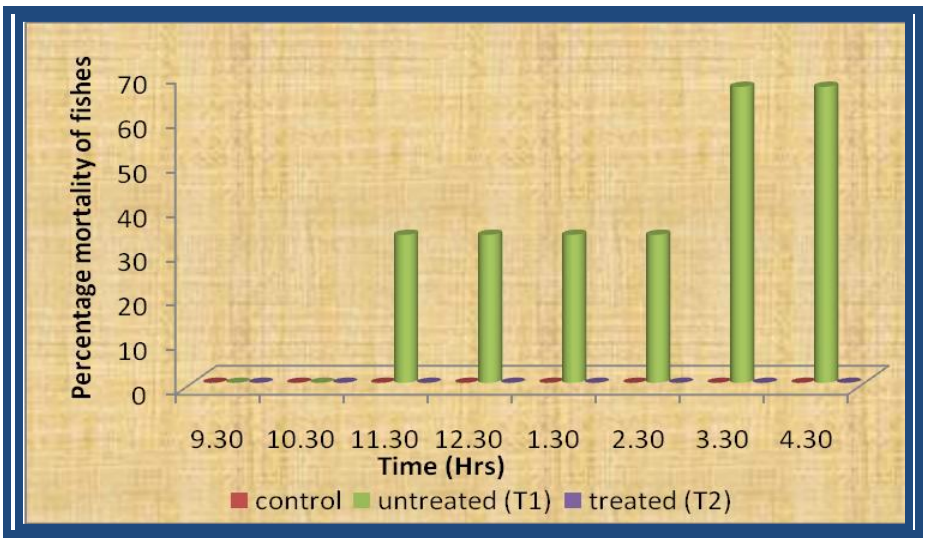


Fig 4 – Percentage mortality of *Catla catla* in the treated and untreated Methyl Red

The survival of fishes in microbially treated methyl red might be due to the sorption of the dye by the fungal isolate, *Aspergillus niger*. The results falls in line with the reports of Anandapandian *et al*. (2003) who cultured *Lepidocephalicthys thermalis* in dye house effluent treated with the species of *Aspergillus, Rhizopus* and *Geotrichum* and *Tilapia mossambica* in microbially treated effluent (Samyuktha *et al.,* 2006*).*

Thus *Aspergillus niger* can be exploited to develop a continuous treatment process for degradation and detoxification of textile effluent containing wide range of azo dyes. The treated dye could be utilized for agriculture and aquacultural purposes. It possessed high biosorption efficiency, reusability and stability and will form the basis for the development of inexpensive and ecofriendly technology for pollution free environment.

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9

Biosorption of textile dye effluent using dead biomass of *Circenella sp.*

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ABSTRACT

Textile processing industry is characterised not only by the large volume of water required for various operations but also by the variety of chemicals used for various processes. Coloured industrial effluents from the dyeing industries represent major environmental problems. Dye waste water discharged from textile and dyestuff industries have to be treated due to their impact on water bodies and growing public concern over the toxicity and carcinogenicity. Many different and complicated molecular structures of dyes make dye waste water difficult to be treated by conventional physico-chemical and biological processes. In recent years there has been considerable interest in the use of live and dead fungal biomass for decolourization of textile dye effluent. In the present study decolourization of textile dye effluent using dead fungal biomass was studied. Eight different fungal colonies were isolated from effluent discharged soil including *Fusarium sp.*, *Aspergillus sp.*, *Circinella sp.*, *Rhizopus sp.*, *Trichoderma sp.*, *Penicillum sp.*, *Trametes sp.*, and *Absidium sp.* The highest decolourization activity was observed with *Circenella sp*. Various parameters such as incubation time, dead biomass concentration, pH and temperature were optimized for decolourization of textile dye effluent using dead biomass of *Circenella sp.* Maximum decolourization was achieved at pH 6 with biomass concentration of 2% and incubation time of 4 days at 50°C. Optimization of different parameters increased the percent decolourization from 65 to 84 %. The present study reveals that dead biomass of *Circenella sp.* has the potential to remove colour from textile dye effluent.

KEY WORDS: Biosorption, dye effluent, optimization, *Circenella* sp.

1. INTRODUCTION

The Textile Industry is the second largest provider of employment after agriculture. The growth and development of textile industry has a direct impact on the economy of the nation. Textile industry is basically divided into dry and wet processing industries. The dry processing industries include ginning, spinning, weaving, knitting, preparing and processing of non-woven materials. The wet processing industries include processing, dyeing and finishing units. The textile wet processing industries consumes large volume of water and chemicals. As a result they generate a considerable amount of coloured waste water.

With the increased demand for textile products, the textile industry and its waste waters have been increasing proportionally, making it one of the main sources of severe pollution problems worldwide (1). Wastewaters from fabric and yarn printing and dyeing pose serious environmental problems because of their colour (2). Even small concentration of dye in water is highly visible. It affects not only the aesthetic merit of water, it also reduces water transparency which in turn affects the photosynthetic activity, thus causing severe damage to the ecosystem (3). Most of the dyes are very stable to light, temperature and other conventional treatment processes. In aquatic systems, the dyes undergo various reactions and the variations in their chemical structures result in the formation of new xenobiotic compounds, which may be more or less toxic than their parental compounds (4).

Wastewaters are usually treated to bring their dye concentrations down to nationally permitted levels, prior to their release. Some physical and chemical treatments such as adsorption, membrane filtration, photo catalytic degradations, ion exchange, precipitation, flocculation, floatation and ozonation are quite effective in decolorization of dyes (5). Each of these have some disadvantages which include excessive usage of chemicals, accumulation of concentrated sludge with obvious disposal problem, expensive plant requirements, high operative costs, unfriendly for nature or reliability in operation and sensitivity to variations in the waste water input (6).

Although decolorization is a challenge for textile industry as well as waste water treatment systems, there is a great potential for developing microbial decolorization systems with total color removal in some cases within few hours (7). Biological treatment methods are attractive due to their cost effectiveness, diverse metabolic pathways and versatility of micro-organisms (8). Both living and dead biomass can be used to remove the hazardous organics. Dead cells are obviously preferable for waste water treatment since they are not affected by toxic waste and chemicals and do not pollute the environment by releasing toxins

(6).They also do not require a continuous supply of nutrients and can be regenerated and reused for many cycles (9).

Hence, in present study, the feasibility of using dead fungal biomass for colour removal from textile dye effluent was examined.

2. METHODOLOGY

2.1 Screening and isolation of textile effluent decolorizing fungi

2.1.1 Collection of effluent and effluent discharged soil sample

The textile effluent from a selected industry at Erode was collected in a sterile polythene container. The container was rinsed with the sample before collection. The soil contaminated with textile effluent was collected from selected textile industry in a sterile polythene bag and stored at 4^{o}C until analysis was done (10).

2.1.2 Screening, isolation and identification of textile dye effluent decolorizing fungi

One gram of soil sample was mixed with 10ml of distilled water and serial dilution was made up to 10^{-9} on Rose bengal chloramphenical agar to isolate the fungal strains. The well-grown fungal colonies were screened for their dye decolorizing effect by inoculating them in 100 ml of textile dye effluent in 250 ml Erlenmeyer flask.

Per cent decolorization was determined by measuring the absorbance of the effluent at 290 nm in UV- visible spectrophotometer.

$$\text{Percent decolorization} = \frac{\text{Initial absorbance} - \text{Observed absorbance x 100}}{\text{Initial absorbance}}$$

The fungal strain which showed maximum decolorization percentage was selected for the present study. The selected fungal isolate was identified by lacto phenol cotton blue staining method.

2.2 Optimization of different parameters for decolorization of textile effluent using dead biomass of *Circinella simplex*

The mat formed by *Circinella simplex* grown in sabroud dextrose broth was separated by filtration. It was autoclaved and washed with distilled water to remove color and impurities and dried in an oven. The dried biomass was powdered. The powdered biomass obtained was used for the study (11).

2.2.1 pH

To determine the optimum pH for decolorization, the pH of the effluent was adjusted to 5.0-9.0 at an interval of one unit using 1N HCl and 1N NaOH and 0.1g of dead biomass of *Circinella simplex* was added to 100 ml of textile dye effluent and per cent decolorization was calculated.

2.2.2 Temperature

To determine the optimum temperature for decolorization, the inoculated tubes at optimum pH were incubated at different temperatures such as 30,40,50,60 and 70^{o}C for 5 days. After incubation period, the percent decolorization was determined.

2.2.3 Incubation period

To determine the effect of incubation period on decolorization, effluent containing 0.1gm of dead biomass of *Circinella simplex* was incubated for different time intervals (1, 2, 3, 4, 5, 6 and 7 days) at optimized temperature (50^{o}C) and percent decolorization was determined.

2.2.4 Dead biomass concentration

To determine the optimum biomass concentration for decolorization, textile dye effluent was added with varying concentrations (1%,2%,3%,4%,5%,6% and 7%) of dead biomass of *Circinella simplex* and incubated for 4 days at 50^{o}C under optimized conditions. After incubation period, the percent decolorization was determined.

2.3 Phytotoxicity Study

Phytotoxicity tests were performed in order to assess the toxicity of the untreated and treated dye. The phytotoxicity study was carried out by watering separately 5 ml of dye water and decolourized water to *Phaseolus mungo*. Control set was carried out using distilled water. Germination (%) and length of plumule (shoot) and radical (root) was determined after 7 days.

$$\text{Germination Per centage} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds sown}} \times 100$$

Vigor Index = Germination per centage X (root length+ shoot length)

3. RESULTS AND DISCUSSION

3.1 Isolation and identification of textile dye effluent decolorizing fungi

Seven morphologically distinct fungi were isolated from the textile dye effluent contaminated soil by serial dilution technique. Among them, the fungal isolate which showed highest per cent decolorization (Table 1) was selected.

Based on the colony morphology and staining, the fungal strain was identified as *Circinella* *simplex*. Mature colonies were green in texture and the surface was velvetty and the hyphae were sporulated.

Table 1

Decolorization of textile effluent by different fungal isolates

Fungal isolates	Decolorization(%)
Absidium sp	57
Fusarium sp	61
Circinella sp	**65**
Aspergillus sp	61
Rhizopus sp	50
Tricoderma sp	39
Trametes sp	45

3.2 Optimization of various parameters for decolorization of textile dye effluent using dead fungal isolate

Effect of pH

Per cent decolourization increased with increase in pH and reached maximum at pH 6.0 (Fig. 1). Above pH 6.0, there was a decline in per cent decolorization.

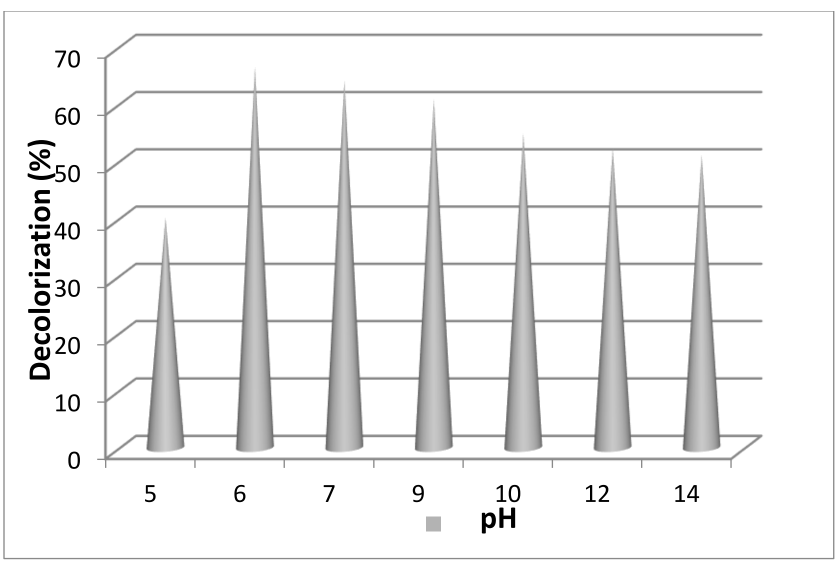

Fig. 1- Effect of pH on decolorization

Increase in pH decreased per cent decolorization which shows that sorption was maximum at acidic pH. The results were in agreement with Zhou and Banks, (1993) who reported that the biosorption of humic acid by *R.arrhizus* increased with decreasing pH (12).

Effect of temperature

The optimum temperature for decolourization was found to be at 50ºC (Fig. 2). Increase in temperature above 50ºC resulted in decrease in per cent decolourization. Similar trend was observed by Khalaf (2008) for biosorption of reactive dye from textile dye effluent by non-viable biomass of *A.niger* and *Spirogyra* sp. (3). Increase in temperature above 50ºC may alter the surface activity of biomass which results in a decrease in removal value.

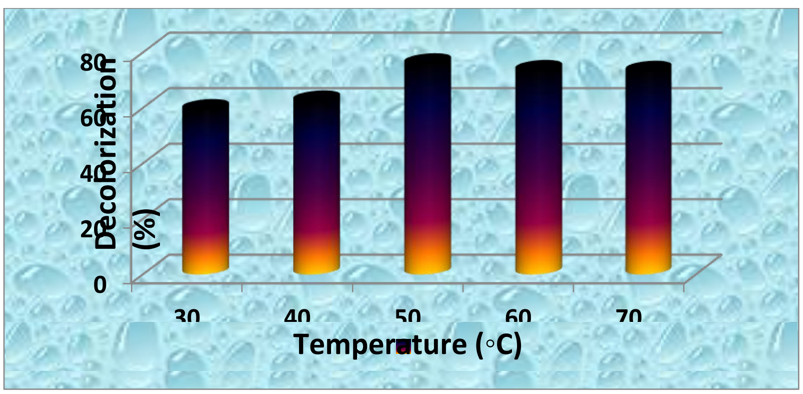

Fig.2-Effect of temperature on decolorization

Effect of incubation period

The effect of incubation period on decolorization of textile dye effluent by dead biomass of *Circinella simplex* is depicted in Fig. 3. Maximum decolorization (87%) was observed after 4 days of incubation. However, Prigione et al. (2009) have reported maximum decolourization at 24 h of incubation by autoclaved biomass of three mucorales fungi of *C.elegans*, *R. pusillus* and *R. stolonifera* (13).

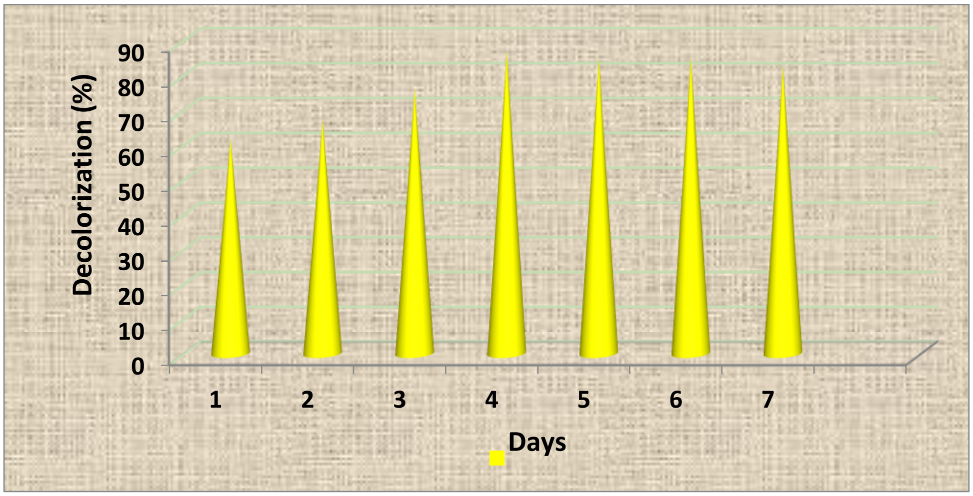

Fig.3-Effect of incubation period on decolorization

Effect of dead biomass concentration

Maximum decolorization was observed at 2% (w/v) of biomass concentration (Fig 4.). Further increase in biomass concentration did not increase per cent decolorization. This is due to the establishment of equilibrium between the dye molecules bound to the biomass and those remaining unabsorbed in the solution (14).

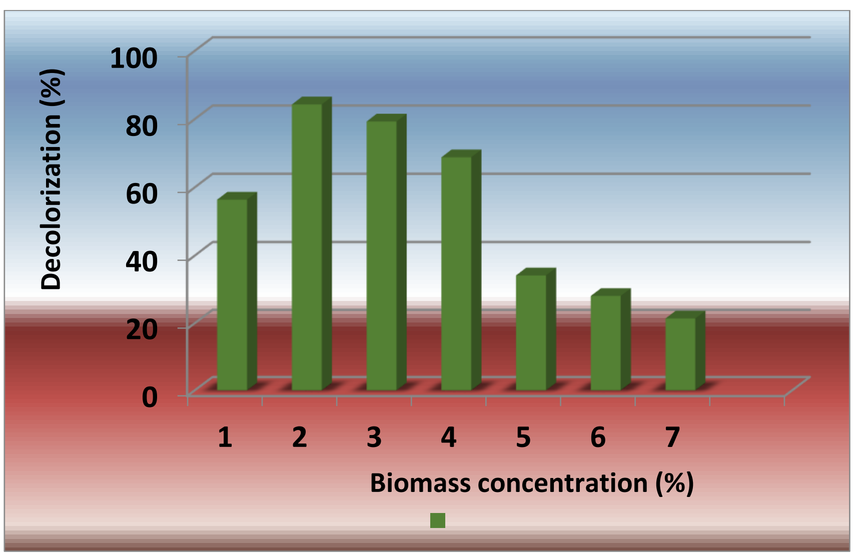

Fig.4–Effect of biomass concentration on decolorization

3.3 Phytotoxicity Studies

Use of untreated and treated dye effluents for agriculture has direct impact on fertility of soil. Hence, the impacts of untreated and treated dye effluents on the growth of *P.mungo* were studied. The plumule and radical length of *P.mungo* were 14.0 and 6.0 cm respectively in distilled water with 100% germination (Table 2).The germination as well as vigor index was drastically affected when watered with Untreated effluent. In contrast, the plumule and radical length of *P.mungo* were 13.0 and 4.0 cm respectively in treated effluent with 85% germination.The results revealed that the treated effluent resulted in good germination rate and vigor index.

Table 2 – Phytotoxicity Studies

Parameters studied	Distilled water	Untreated effluent	Treated effluent
Germination (%)	100	30	85
Plumule (cm)	14.0	5.0	13.0
Radical (cm)	6.0	3.0	4.0
Vigor index	2000	240	1445

CONCLUSION

The present study revealed the ability of the dead biomass of *Circinella simplex* to remove the reactive dye from textile dye effluent. The results obtained from this work showed that the fungal biomass possessed high decolourization efficiency. The findings offer potential for the development of a cost effective technology for biosorption of reactive dye effluents.

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10.

Centralized Automated Water Supply System For Kct Campus- A Model For Coimbatore Smart City

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ABSTRACT

Centralized Automated Water Supply System is the activity of planning, developing, distributing and managing the optimum use of water resources. Ideally, water resource management planning has regard to all the competing demands for water and seeks to allocate water on an equitable basis to satisfy all uses and demands, this is rarely possible in practice. It is an essential resource for all things like human beings,animals,etc..

Much effort in water resource management is directed at optimizing the use of water and in minimizing the environmental impact of water use on the natural environment. Management of any resources we requires knowledge of the resource available, the uses to which it may be put, the competing demands for the resource, measures to and processes to evaluate the significance and worth of competing demands and mechanisms to translate policy decisions into actions on the ground.

Centralized Automated water supply system is developed by Using Yokogawa centum VP DCS. We are developing DCS the remote location of the water tank and water sumps are monitoring and controlling in a centralized manner.

Keyword

Distributed control system(DCS) , Communication protocol, Level transmitter, PID controller, Yokogawa centum VP, Sensors, Actuators, cable.

I LITERATURE SURVEY

1.Microcontroller Based Automated Water Level Sensing and Controlling: Design and Implementation Issue
S. M. Khaled Reza, Shah Ahsanuzzaman Md. Tariq, S.M. Mohsin Reza

In this work there is an simple embedded logic involves. where as the water level is measured in terms of electrical conduction of water and it is given to the micro controller. Simple logic has been developed for an water management process.

2.Microcontroller based Automatic Water level Control System

Ejiofor Virginia Ebere (PhD), Oladipo Onaolapo Francisca (PhD)- In this paper the embedding a control system into an automatic water pump controller through the use of different technologies in its design, development, and implementation. The system used microcontroller to automate the process of water pumping in an over-head tank storage system and has the ability to detect the level of water in a tank, switch on/off the pump accordingly and display the status on an LCD screen.

3.Hua Jin et al, 2011- The DTMF shows the status on the mobile phone. The respective solenoid valve gets turn ON only if status of DTMF is 1. The status of DTMF reveals the image of the valve on the GLCD and this is used by GSM for sending SMS.

4.Rey, J.R.D et al, 2007 - The tank is automatically filled from the water resource with the help of AC pump. There is an level sensor which is inside the tank senses the level of water based on that simple ON and OFF logic has been developed.

5.By Paul F. Boulos and Amanda N. Wiley 2013 - Recent advances in smart water network technology have armed control room operators with a comprehensive set of decision-making capabilities that position operators as a major force for system improvement, regulatory compliance, and financial planning.

6.SHAMSUL ANUAR BIN ABD AZIZ 2013 - By applying the automation system such as SCADA with the integration of Fuzzy control to control water storage, the management of water distribution and monitoring can be improved thus resulting in reducing the level of water wastage and maintaining the supply of clean water.

7.Automated Town Water Management System

M.V.N.R. Pavankumar1, KumbharA(2014)- This projects deals about the automation in water distribution and management with technical advances. In this system the water level is sensed by the water level sensor. Depending upon the level of water the speed of the motor will be varied. The supply of water to different areas automated through the use of DTME The speed of the motor is controlled with respect to tank water level. This project deals about the mobile controlled water distribution different areas and distribution of water according to bill payment.

8.Literature Review for Automated Water Supply with Monitoring the Performance System N.B. BhawarkarȦ , D.P. PandeȦ , R.S. SononeȦ , Mohd. AaquibȦ , - The water theft and leakage are identified with the use of flow sensors. The controller calculates the difference in the flow rate of sensors. If the difference is an exceeds the set point like our preset value behind the first flow sensor and water distribution motor are turned off automatically using the GSM modem technology a message regarding the leakage or theft is delivered to responsible officer in the control room. This proposed system has been implemented through different controllers such as microcontroller 89S52 and relay, PIC controller, ARM controller and also using PLC & SCADA as mentioned in the further sections.

9.Santosh A. Tamble et al, 2008 - Hence supply of water has done separately to the different areas. It removes the manual requirement of man power. It is implemented for three different regions. When the system become ON it ask for the time setting to turn OFF & ON the water supply for particular area. As the same instant the clock timer will start for the specified time period. When the specified time limit reach the system will become OFF for particular area.

10.Gaikwad sonali ashok et al - The proposed system has been implemented using PLC/SCADA. The main objective of the atomization of the water distribution system is to avoid the wastage of water due to vandalism. To keep an eye on the vandal and the water theft the SCADA unit has initiated red alarm pop-ups.

11.Design and Implementation of a Fully Automated Water Level Indicator

Neena Mani , Sudheesh T , Vinu Joseph ,Titto V , Shamnas P.S - A liquid level sensor (transistor circuit) detects the present level of the liquid in the tank in terms of the voltage across transistor and feeds it to the microcontroller and the microcontroller generates a corresponding output text which in then displayed in the LCD. If the water level is full, then the circuits beeps through the buzzer notifying that the water level is full.

12.Muktha Shankari K , Jyothi K , Manu E O , Naveen I P , Harsha Herle 2013 - In this paper we have discussed about design and implementation of water level control system which is wireless, automatic, cost effective and reliable. It uses two Radio Frequency transceivers along with a controller each installed at the tank and sump. Radio Frequency transceivers are used for wireless communication. It is completely automated with the help of a micro controller. The system doesn't need any attention of the user unless the sump is empty. Installation cost is reduced since the system is wireless.

II INTRODUCTION

Optimization of water usage

This project brings the scientific study of water resources with practical planning and management skills. It's encourages to study water management from a multi-disciplinary perspective and to seek integrated solutions of applied research in the field of water management theory and practice. The Optimization of Water Management aims to develop knowledge, insight and skills required to design, implement and evaluate water management systems to achieve effective governance of water resources.

Problem Identification

Many regions of the world are increasingly facing challenges when it comes to managing water, and the nature of these challenges differs from one location to the next. It may relate to having too little water while water demands are growing explosively (water scarcity), too much water (flooding), and water of poor quality rendering them unfit to sustain the ecosystem or challenges related to providing water for people, industry and agriculture.

Objectives of the project

The main objectives of this proposal are

1.Optimization of water treatment of drinking water
2.Management of water resources
3.Management of flood protection
4.Management of irrigation

III DISTRIBUTED CONTROL SYSTEM

A distributed control system (DCS) is a control system is a centralized control scheme which is located in a distributed manner for a process or plant, like chemical industries paper, cement, sugar, etc..where the process variable and controlled variables are distributed throughout the process. This is in contrast to non-distributed systems, which use a single controller at a central location. In a DCS where the process elements are monitored and control in a centralized manner at centralized control room. A DCS typically uses custom designed processors as controllers and uses both proprietary interconnections and standard communications protocol for communication. Input and output modules form component parts of the DCS. The engineering station receives information from input modules and sends information to output modules. The input modules receive information from input instruments in the process (or field) and the output modules transmit instructions to the output instruments in the field. The inputs and outputs can be either analog signal which are continuously changing or discrete signals which are 2 state either on or off. Computer buses or electrical buses connect the processor and modules through multiplexer or demultiplexers. There is an buses used to connect between the field control station and human interface station.

Distributed control systems (DCSs) are dedicated systems used to control manufacturing processes that are continuous or batch-oriented. DCSs are connected to sensors and actuators and use to control the flow of material through the plant. DCSs are usually designed with redundant processors to enhance the reliability of the control system. Most systems come with displays and configuration software that enable the end-user to configure the control system without the need for performing low-level programming. DCSs may employ one or more workstations and can be configured at the workstation or by an off-line personal computer. There is an filed buses are used as a communication protocol between the plant and control room. A server and/or applications processor may be included in the system for extra computational, data collection, and reporting capability.

IV YOKOGAWA CENTUM VP (DCS)

Yokogawa is an one of the leading manufacturer and supplier of Distributed control system(DCS) and field instruments it offers centralized automation and control strategies, architectures, for every process industries application size and reduction of complexity. Their distributed control system (DCS) is designed for large, complex industrial processes, and geographically distributed applications. The DCS is an advanced control applications, it provides supervisory monitoring and control throughout the plant integrated information, configuring disparate systems into a holistic process overview and coordinated control strategy. A DCS utilizes a more distributed node topology and is often implemented with Yokogawa as a single source of responsibility.

Yokogowa Centum VP DCS is the advanced version of the CENTUM DCS series. Centum VP has an Field Control station (FCS) and one Human interface Station(HIS).The speed of operation is very faster than the other centum series.

Cpu modules – 2 nos 128MB RAM

Power supply modules 2nos

Control bus interface card

Analog input module 4-20ma 16 channel isolated

Analog output module 4-20ma 16 channel isolated

Digital input module 32 channel

Digital output module 32 channel

Human Interface station (HIS) and Console

Figure 4 Field control station(FCS)

V CAMPUS SURVEY

- The overall KCT campus water distribution system was studied.
- The major blocks are listed below
- 1. ACADEMIC BLOCKS
- 2. HOSTEL BLOCK(BOYS,GIRLS)
- 3. ADMIN BLOCK.

The project is going to implemented in ACADEMIC BLOCK.

Academic Block

In academic block region there totally seven blocks are available and totally seven overhead tanks are available for each block.

The tank capacity details are listed below.

S.NO	Block	Tank Capacity(L)
1	B-BLOCK OH TANK	50,000
2	A-BLOCK OH TANK	5,000
3	E-BLOCK OH TANK	5,000
4	D-BLOCK OH TANK	2,000
5	C-BLOCK OH TANK	1,000
6	ASC-BLOCK OH TANK	5,000
7	KORE OH TANK	5,000

Based on data B-BLOCK OH tank is a (major tank) process tank the other blocks tanks are parallel interlinked together also with the process tank.

The process tank (B-BLOCK OH) is to be monitored and controlled in a centralized manner with the Help of Yokogawa DCS Centum VP.

VI PROCESS FLOW

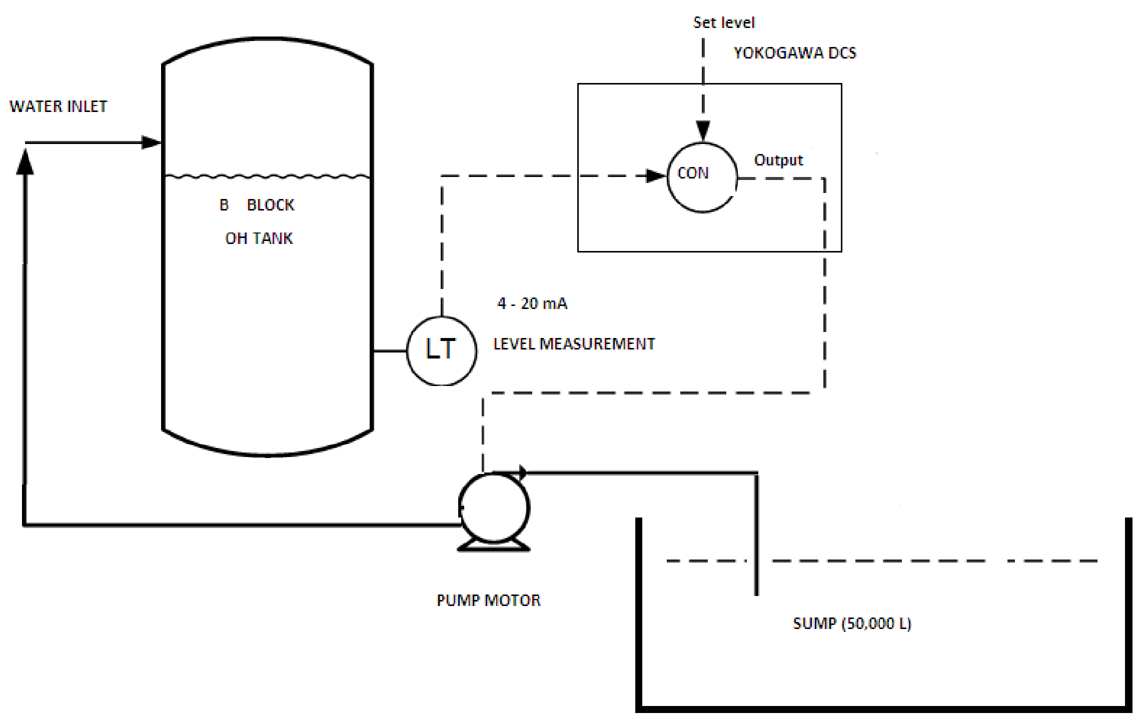

Figure 6.1 Overall Process flow diagram

The water reservoir (sump) which is located near B – Block which is having 50,000L.There is an 1HP pump motor is mounted used to pump the water from sump to B – Block tank (Process tank).

B- Block tank is an acted as a process tank remaining tanks is connected parallel interconnected together also having an overflow provision.

Sensor selection & erection

The tank is a fully closed concrete type tank. So hydro static level sensor has been chosen. It has been mounted outlet of the tank .it works on the principle of pressure difference, based on the tank level the pressure to be build on end of the sensor and another one is atmosphere pressure the output will be generated based on the pressure difference.

Figure 6.2 Sensor erection and mounting

Control Scheme

- Closed loop ON&OFF control logic is to be implemented in Yokogawa DCS.
- The Process Variable (Liquid level) of tank is measured using an Hydrostatic level transmitter which is interfaced with DCS. Level transmitter is calibrated 0.2M(min level) to 1.8M(Max level) in terms of 4-20 mA signal. Based on the transmitter signal the DCS will be operate the PUMP motor (ON&OFF**).**

VII PROJECT IMPLEMENTATION

Automated water supply system has been implemented in a yokogawa centum VP DCS both the hardware and software.

Software Implementation

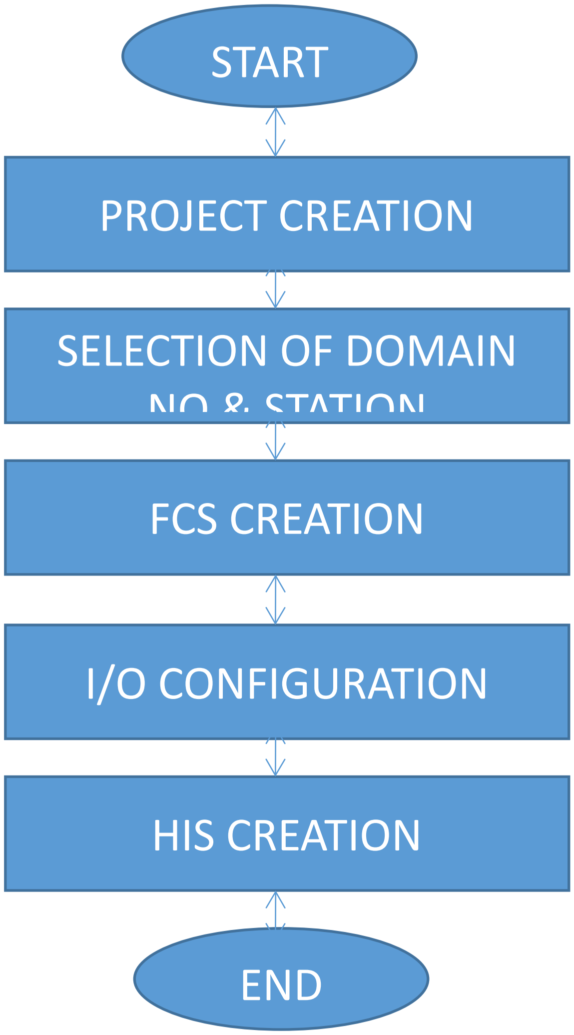

Figure 7.1 Flow chart of software implementation

Functional block

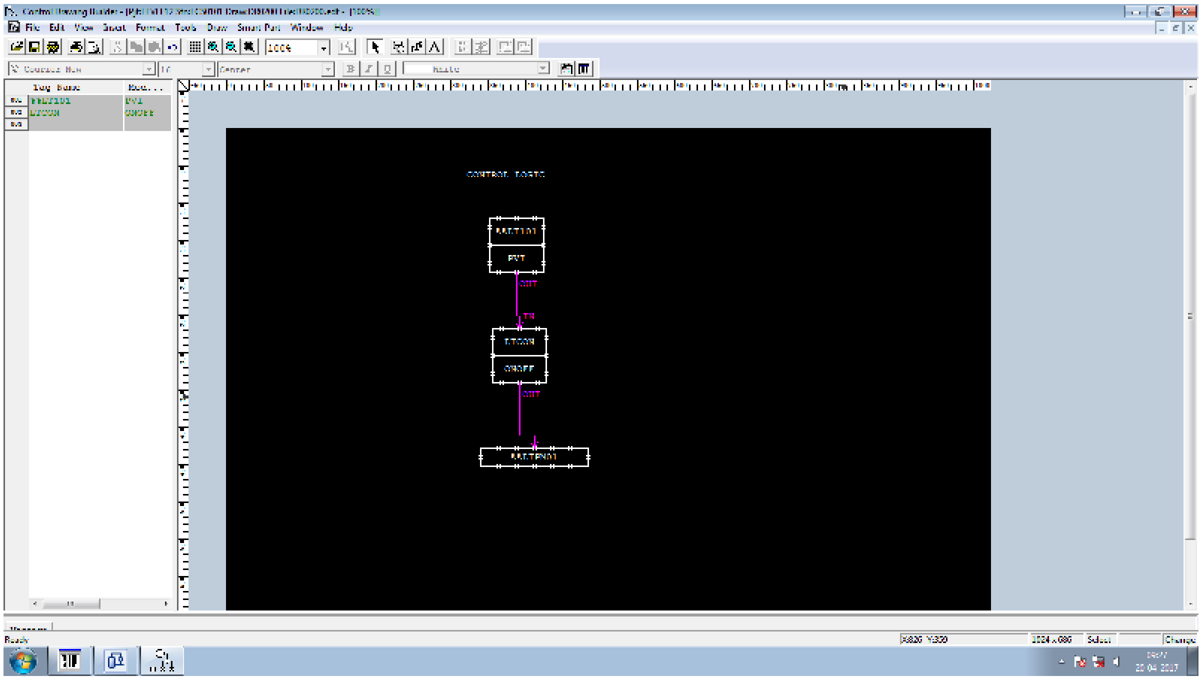

Figure 7.2 Functional block diagram

Human Interface Station

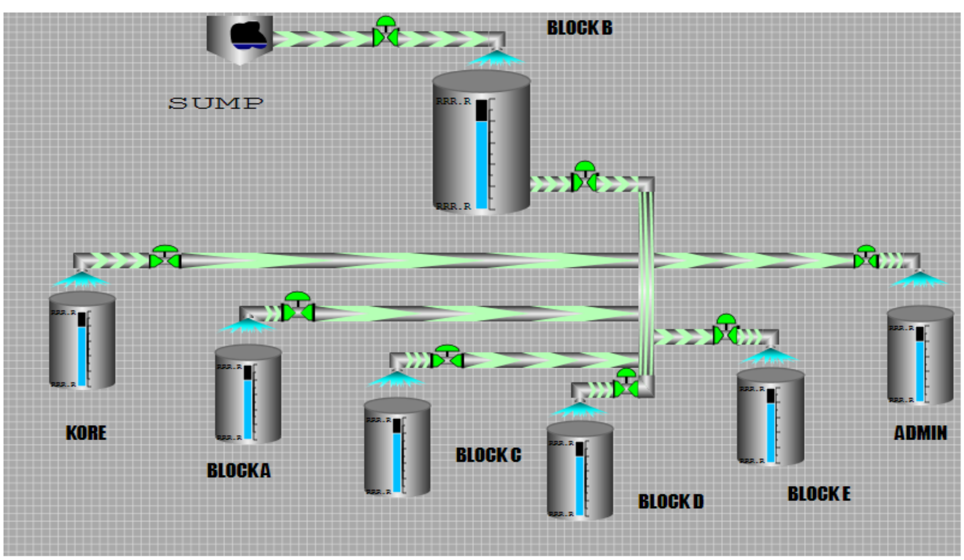

Figure 7.2 Graphical display

RESULT

This project has implemented with the help of Yokogawa Centum VP DCS. Where the B-Block over head tank has to be calibrated between 0.2M(High level) and 1.2M(low level).The sump operates between the two level through automatically.

CONCLUSION

Centralized automated water supply system achieved through yokogawa DCS. We can easily monitored and Controlled the tank by Distributed Control System. So that the wastage of water has to be controlled also electrical energy is reduced with the controlled operating of the sump motor.

Future enhancement

This work has to be further enhancement of regulating the water flow and energy conservation. Also scope for implementing in IOT with the help of wireless communication protocol.

11.

Congo Red Dye Removal From Aqueous Solution Using Adsorption Process And Membrane Seperation

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ABSTRACT

The objective of this work is the study of removal of Congo red from aqueous solution by adsorption followed by membrane separation.Removal of this dye from aqueous solution using potential activated carbon was prepared from Rice husk. Liquid phase adsorption experiments were conducted.Batch adsorption studies are carried out by observing the effect of experimental parameters, such as, pH, adsorbent dosage and contact time. From the study, it was found that maximum adsorption of 96% was obtained at pH of 8.15 with adsorbent dosage 150mg at 180 mins. After adsorptive removal of heavy metals, ions in the aqueous solution was further treated by membrane separation operation.

KEYWORDS

Congo red, Membrane separation, Adsorption, Heavy metals.

INTRODUCTION

Dyes have long been used in dyeing, paper and pulp, textiles, plastics, leather, cosmetics and food industries. Colour stuff discharged from these industries possess certain hazards and environmental problems.These coloured compounds are not only aesthetically displeasing but also inhibiting sunlight penetration into the stream and affecting aquatic ecosystem, Human body, and animals.The most common adsorbent materials are: alumina silica, metal hydroxides and activated carbon. As proved by many researchers, removal of dyes by activated carbon is economically favorable and technically easier

BASICS ON DYES

- A dye molecule consists of two key components: the ***chromospheres***, responsible for producing the colour, and the ***auxochromes***, which in addition to support the chromosphere, also render the molecule soluble in water and give enhanced affinity toward the fibers.

- TYPES OF DYES:

Acid dye, Basic dye, Disperse dye, Mordant dyes, Sulfur dyes, Reactive dyes, Solvent dyes, Vat dyes.

- Congo red is type of an acid dye. It is classified into two types.
- It is a type of diazo dye.

ADSORPTION PHENOMENON

- Sorption refers to the action of adsorption or absorption.

SORPTION

↓

ABSORPTION , ADSORPTION

- Adsorption is the physical adherence or bonding of ions and molecules onto the surface of another phase.

Eg:Reagents adsorbed to solid catalyst surface.

POTENTIAL HEALTH EFFECTS

INHALATION:

- Inhalation of dust may irritate the mucous membrance of the upper respiratory tract.

INGESTION:

- Results in symptoms nausea,vomiting,diarrhea,and abdominal pain.

SKIN CONTACT:

- May cause irritation.Can stain area of contacted skin.

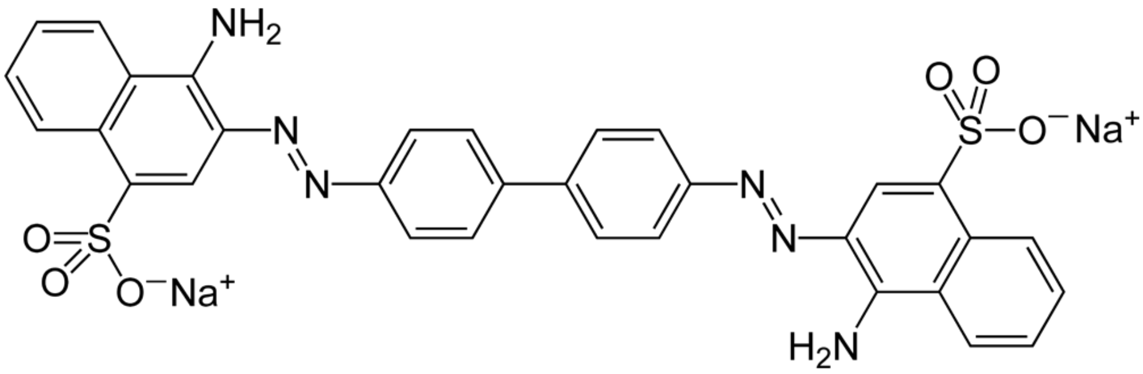
EYE CONTACT:

- Causes severe irritation. Contact may cause permenent eye damage.

ADSORBATE

- The Congo red dye was first synthesized in 1883 by Paul Bottinger who was working then for Friedrich Bayer Company in Germany.
- It is the sodium salt of benzidinediazo-bis-1-napthylamine-4-sulfonic acid.
- Formula: $C_{32}H_{22}N_6Na_2O_6S_2$; molecular weight: 696.66 g/mol).
- It is a secondary diazo dye. λmax=497nm

MOLECULAR STRUCTURE



ADSORBENT

- Rice husk activated carbon, is used as adsorbent for dye removal. It is a form of carbon that has been processed to make it extremely porous and thus to have a very large surface area available for adsorption or chemical reactions.

- Rice husk was collected and sundried. The husk was then washed with distilled water, filtered and finally dried overnight at 60c and crushed to an average size 0.3µ in a mortar and then activated by 0.1M H_2SO_4 in v/v ratio for 24 hrs.

- In the absence of oxygen the husk are burned up to 250◦C-300◦C without moisture content.

RICE HUSK TO CARBON

METHODS OF REMOVAL OF DYES

- There are various methods for removing of dyes using conventional methods including coagulation and Flocculation, oxidation of ozonation and membrane separation.

- However, these methods are not widely used due to their high cost and economic disadvantage. Electrochemical oxidations and coagulation are generally not feasible on large scale industries.
- An adsorption technique is by far the most versatile and widely used and has proven successful in removing dyes from aqueous solution.

Table-1
Effect of pH on removal of Congo red

Initial concentration: 25 ppm
Weight of adsorbent: 150mg
Initial pH: 8.15

Particalsize: 0-63µ
Temp: 30ºC±1

pH	Optical Density		CR % of adsorption
	Before Adsorption	After Adsorption	
1	8.15	0.02	99.754
2	8.15	0.04	99.509
3	8.15	0.02	99.754
4	8.15	0.01	99.877
5	8.15	0.01	99.877
6	8.15	0.01	99.877
7	8.15	0.01	99.877
8.10	8.15	0.01	99.877
9	8.15	0.01	99.877

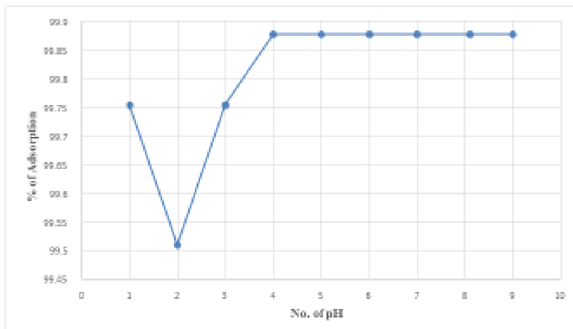


Table-2
Effect of Adsorbent Dosage on removal of Congo red

Initial concentration: 25 ppm
Partical size: 0-63µ
Temp: 30ºc±1
pH: 8.15

S.No	Weight of Adsorbent (mg)	Volume of CR (ml)	Optical Density		CR % of adsorption
			Before Adsorption	After Adsorption	
1.	50	50	0.32	0.16	50
2.	100	50	0.32	0.08	75
3.	150	50	0.32	0.04	96.8
4.	200	50	0.32	0.04	96.8
5.	250	50	0.32	0.04	96.8
6.	300	50	0.32	0.04	96.8

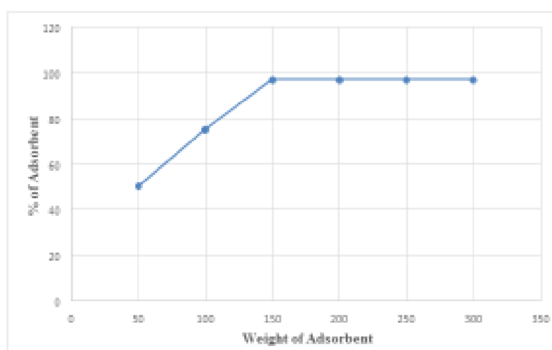


Table-3
Effect of contact time on removal of Congo red

Initial concentration: 5 ppm Partical size: 0-63µ
Weight of adsorbent: 150 mg Temp: 30ºc±1
pH: 8.15

S.No	Contact time(t) (Min)	Optical Density		CR % of adsorption
		Before Adsorption	After Adsorption	
1.	30	0.10	0.03	70.00
2.	60	0.10	0.03	70.00
3.	90	0.10	0.02	80.00
4.	120	0.10	0.01	90.00
5.	150	0.10	0.01	90.00
6.	180	0.10	0.01	90.00

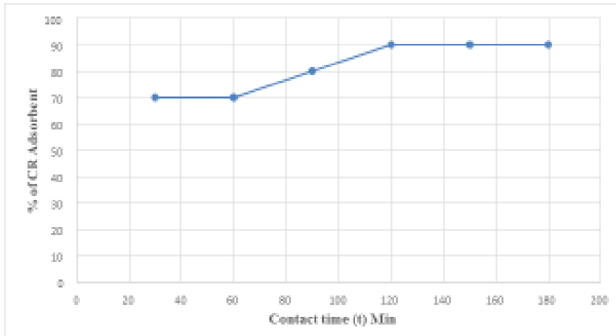


Table-4
Effect of contact time on removal of Congo red

Initial concentration: 25 ppm Partical size: 0-63µ
Weight of adsorbent: 150 mg Temp: 30ºc±1
pH: 8.15

S.No	Contact time(t) (Min)	Optical Density		CR % of adsorption
		Before Adsorption	After Adsorption	
1.	30	0.32	0.15	53.125
2.	60	0.32	0.13	59.375
3.	90	0.32	0.13	59.375
4.	120	0.32	0.12	62.500
5.	150	0.32	0.10	68.750
6.	180	0.32	0.07	78.125

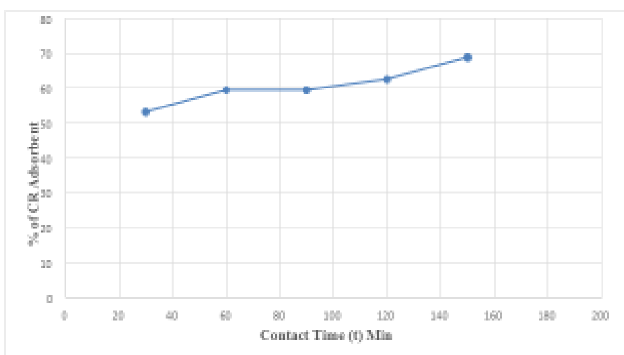


Table-5

Effect of initial Concentration removal of Congo red

Time: 30 Min

Weight of adsorbent: 150 mg

pH: 8.15

Partical size: 0-63μ

Temp: 30°c±1

S.No	Initial Concentration (ppm)	CR of Concentration (mg/l)
1.	5	3.500
2.	10	8.125
3.	15	8.8636
4.	20	12.800
5.	25	13.281

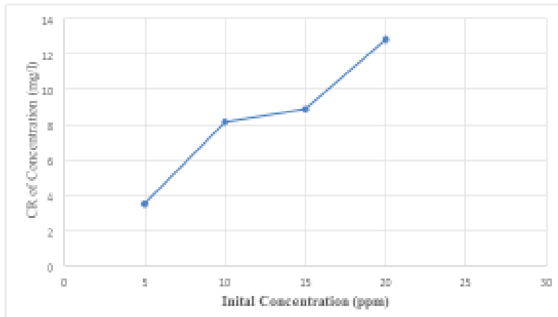


Table-6

Effect of initial Concentration removal of Congo red

Time: 180 Min

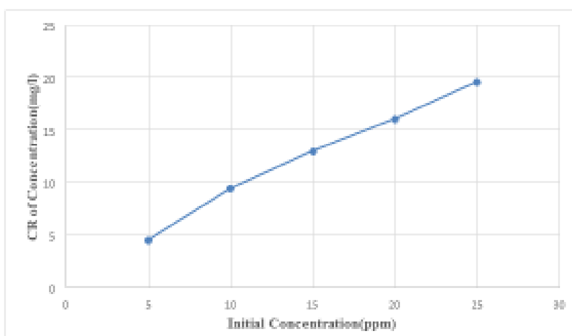
Weight of adsorbent: 150 mg

pH: 8.15

Partical size: 0-63μ

Temp:30°c±1

S.No	Initial Concentration (ppm)	CR of Concentration (mg/l)
1.	5	4.500
2.	10	9.375
3.	15	12.954
4.	20	16.000
5.	25	19.531



BATCH EXPERIMENT

- Batch equilibrium experiments were conducted by adding biomass to Erlenmeyer flask containing 50 ml of different test solution at desired pH conditions.

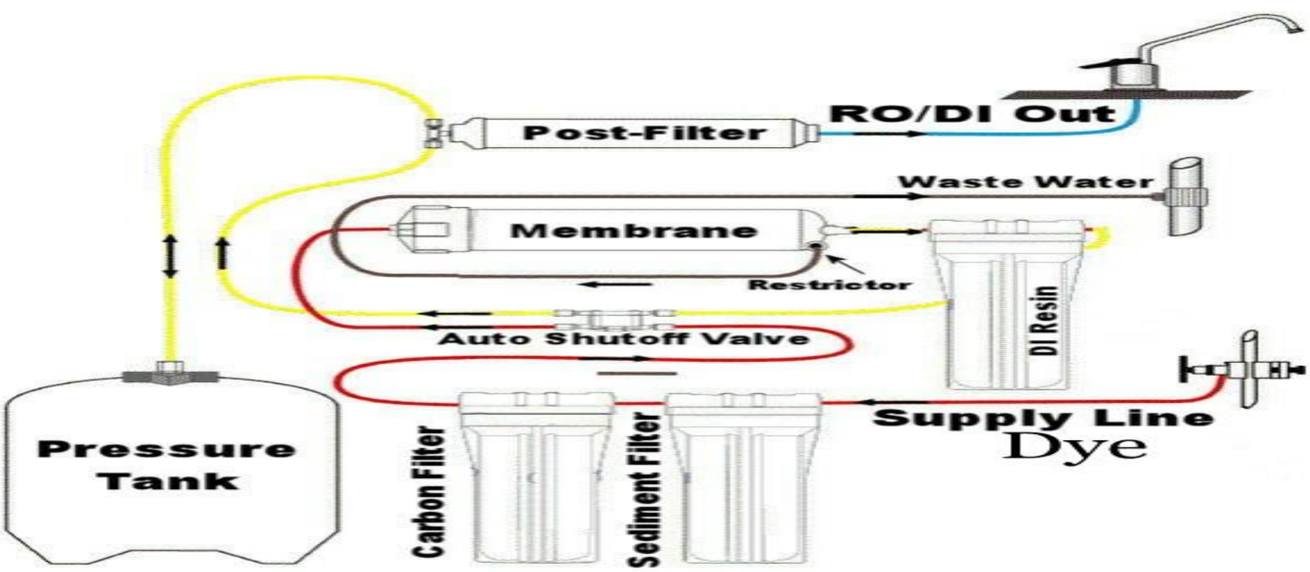
- The initial solution pH was adjusted by using 0.1 M HCl or 0.1 M NaOH. The flasks were agitated at 120 rpm in a rotatory shaker. After shaking process biomass was separated from the test solution by filtration.

- **% of CR dye removal** = $\frac{\text{Initial concentration-Final concentration}}{\text{Initial concentration}} \times 100$

MEMBRANE SEPRATION

- Reverse Osmosis is a technology that is used to remove a large majority of contaminants from dye by pushing the dye under pressure through a semi--permeable membrane.
- Activate Carbon filtration, as with any dye treatment method, is not capable of removing every possible type of contaminant. For example sodium, microbes, fluoride, and nitrates cannot be removed with activate carbon filtration.
- So after adsorption process the dye treated by reverse osmosis process to remove the sodium, microbes, fluoride, and nitrates. And reduce the TDS (total dissolved salts) in the dye. So increase the life time of membrane in the reverse osmosis process.

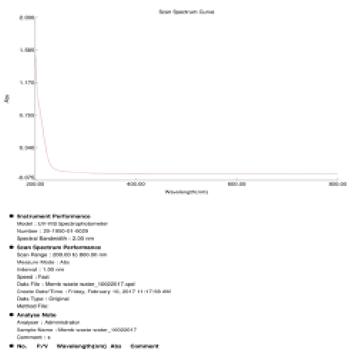
RO PROCESS

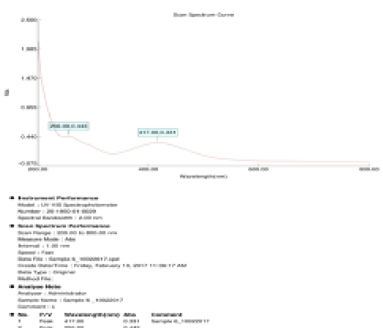


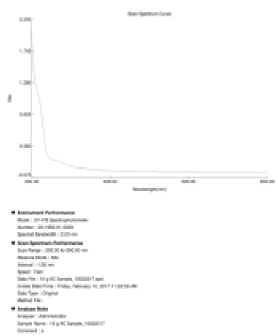
RESULT AND DISCUSSION

- The main objective of using reverse osmosis process for removal dye process is to increase the life time of membrane in the industry.
- To reduce the Total Dissolved Salts in the dye solution. So reduce the fouling of flowing pipes.

- To fully remove all the salts contents such as sodium, fluoride, nitrates.
- The below the table is comparison between the wave length vs absorbance for before adsorption process of dye solution, after adsorption process of solution and the treatment reverse osmosis process values are tabulated.







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12.
Design and Fabrication of Airlift Fluidized Biorector For Waste Water Treatment using *Novel adsorbents*

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ABSTRACT:

Safe drinking water is essential to humans and other life forms even though it provides no calories or organic nutrients. Currently, about a billion people around the world routinely drink unhealthy water. Placing untreated waste water directly into lakes and oceans can pollute these environments. Whether recycling will be appropriate in a given situation depends on the availability of additional water resources, a desire or necessity to conserve rather than develop water resources, careful economic considerations, potential uses for the recycled water. Waste water can be reused in many ways based on their economic norms. In the present study, a new Airlift fluidized Bioreactor has been designed and it is used for treating wastewater by using various novel adsorbent materials. This Bioreactor has been considered as three main qualities such as cost effective, substrate (adsorbent materials) and cost associated with separating and purifying the product. The main objective is to minimize the total costs of the process, and this usually requires compromises between various costs. It is the need for these compromises that makes correct bioreactor design. Emphasis is placed on this correct reactor design which can be made and it reduces the shape of the reactor, the method of aeration and the type, size, density and size distribution of the particles in the bed. It would be some consideration for choosing adsorbent materials in this bioreactor.

Key words: Airlift Fluidized Bioreactor, Adsorbent material, water purification

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INTRODUCTION

Water is the basic need of life. Water covers 71% of the earth's surface and makes up 65%of our bodies. It is important for the mechanics of human body. The body cannot work without it. Everyone wants clean water- to drink, for recreation, and just to enjoy looking at. Placing untreated waste water directly into lakes and oceans can cause eutrophication. Whether recycling will be appropriate in a given situation depends on the availability of additional water resources, a desire or necessity to conserve rather than develop water resources, careful economic considerations, potential uses for the recycled water, the strategy of waste discharge and public policies that may override economic and public health considerations or perceptions (Mantovani et al. 2001).

The traditional methods for municipal wastewater were based on biological treatments (Kelly, 1996).. In wastewater treatment, the cost of the 'substrate 'can be safely ignored, and the product separation is restricted to separating the biomass from clean water. It is the need for these compromises that makes correct bioreactor design so important and that has motivated the development of the fluidized –bed bioreactor. It has some consideration for choosing adsorbent materials in this bioreactor. Diatomaceous earth (adsorbent material) is used in chemistry as a filtration aid, to filter very fine particles that would otherwise pass through or clog filter paper. As far as diatomaceous earth (DE) was concerned, it was generally used as filter (Rees, 1990; zhang, 2002) and not as biomass carrier. It is also used to filter water, particularly in the drinking water treatment process. Thus, a novel diatomaceous earth-airlift-fluidized-bioreactor (DEALFB) process, which combined both physical-chemical and biological treatment mechanism for the removal of organic, nitrogen (mainly ammonium), phosphorous, and suspended solids in a single reactor, was first proposed by our research to treat municipal wastewater.

The application of airlift reactors for wastewater treatment addresses usually the conventional biological treatment (activated sludge, biofilm systems), but they are increasingly applied for advanced wastewater treatment (tertiary stage):nitrification-denitrification (Guo et al., 2005; Jianping et al., 2005), biological oxidation (Jianping et al.,2005; Pang et al., 2009), biodegradation of some refractory organic compounds (Liu et al., 2007; Liu et al., 2008; Mohanty et al., 2008), electro coagulation, electrofloculation

(Balla et al., 2010; Essadki et al.,(2008).The aim of the present study was to investigate the efficiency of Airlift fluidized bioreactor technology by using DE as suspended carrier. This innovative technology was applied for the treatment of sewage wastewater in laboratory-scale, continuous flow experiments. The effect of adsorption studies on DEALFB treating wastewater was also studied.

MATERIALS AND METHODS

1. Collection of the samples

1.1 Sewage water

The Sewage water samples were collected from Sewage Treatment Plant (STP), Bannari Amman Institute of Technology, Sathyamangalam, Erode District, and Tamil Nadu and transferred to the laboratory in closed Pet bottles and processed.

1.2 Diatomaceous Earth(DE)- Marine Algae

Diatomaceous Earth were purchased from Astrra Chemicals, Chennai and used as an adsorbent materials for water processing and treatment.

2. Analysis of the properties of sample before treatment

2.1. pH

Initial pH of water sample and after the treatment has to measure as per IS: 3025(Part 11): 1984.

2.2. Total Dissolved Solids (TDS)

TDS is measured in parts per million .TDS tell how many units of impurities there are for one million units of water. To determine the TDS of given water sample with the stipulations as per IS: 3025(Part 16):1984.

2.3. Total Suspended Solids (TSS)

TSS of a water sample is determined by pouring a carefully measured volume of water through a pre-weighed filter of a specified pore size, then weighing the filter again after drying to remove all water. To determine the TSS of given water with the stipulations as per IS: 3025(Part 17):2002.

2.4. Chloride test

To determine the chlorides of given water sample with the stipulations as per IS: 3025(Part 32):1988.Chlorides are widely distributed as salts of calcium, sodium and potassium in water and wastewater. In potable water, the salty taste produced by chloride concentrations is variable and dependent on the chemical composition of water.

2.5. Biological Oxygen Demand (BOD)

To determine Biological Oxygen demand in the given water sample with stipulations as per IS: 3025(Part 44):1993.BOD of water or polluted water is the amount of oxygen required for the biological decomposition of dissolved organic matter to occur standard condition at a standardized time and temperature. Usually, this time is taken as 5 days and the temperature is 20^{0}C.

2.6. Chemical Oxygen Demand (COD)

To determine Chemical Oxygen demand in the given water sample with stipulations as per IS:3025(Part 58):2006.COD determines the quantity of oxygen required to oxidize the organic matter in waste water sample, under specific conditions of oxidizing agent, temperature ,and time.

2.7. Total hardness as $Caco_3$

To determine total hardness in the given water sample with stipulations as per IS: 3025(Part 21):2002.

2.8. Turbidity

Turbidometer is used to measure turbidity of sample. In the Turbidometer, light shines through a sample of water. If the light strikes a colloid, the light is scattered, bouncing off the colloid and reflecting upward. If the light does not strike a colloid, it shines through the water sample. The meter measures how much light is reflected off colloids in the water. Clean water will reflect little light while turbid samples, like this one, will reflect large amount of light. To determine turbidity in the given water sample with stipulations as per: IS: 3025(Part 10):1984.

2.9. Total Alkalinity test

To determine the alkalinity of given water sample with the stipulations as per 13 of IS: 1964. Alkalinity is primarily a way of measuring the acid neutralizing capacity of water.

3. Design & Fabrication of Airlift Fluidized Bioreactor- Laboratory set up

Fig. 2(a): Airlift bioreactor with motor **Fig.2(b):** Thermometer attached with Bioreactor

Schematic Representation of Airlift Fluidized Bioreactor

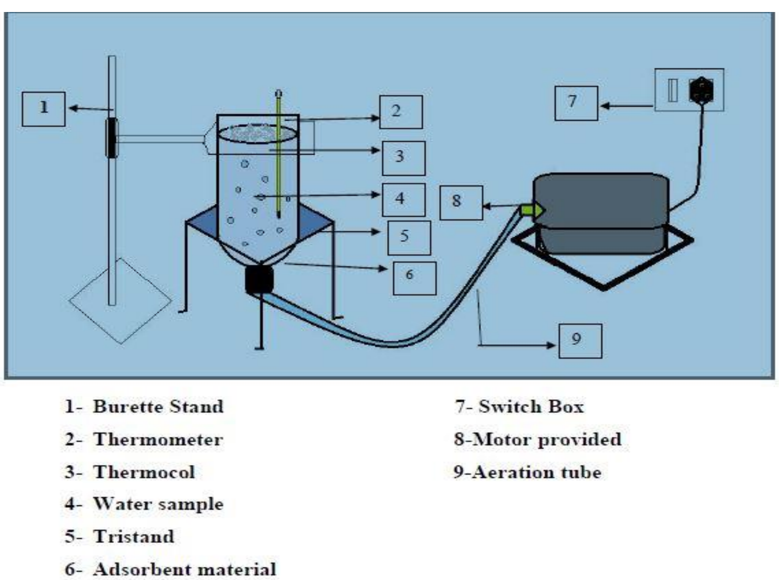

Fig.2(c): Airlift Fluidized Bioreactor with full setup

4. RESULTS AND DISCUSSION

4.1. Treatment of sample in Bioreactor

Air lift fluidized bioreactors are solid –liquid contacting device which are of particular importance in biotechnology industries. Fluidized- bed refers here to all beds in which the particles are not in continuous contact with each other due to the flow of a fluid up through them. An Airlift combined semi fluidized bed reactor for waste water treatment. In this reactor, Marine algae (Diatomaceous earth) were used as adsorbent materials to adsorb impurities of water. The bioreactor consisting of 2 litre pet bottle with a hole punched on the bottom of the cap. The inverted pet bottle is held with the burette stand. The tube from adaptor is sent through the hole for aeration purpose. A thermometer is partially placed inside the pet bottle which measures the temperature of the sample and a thermocol is prop the thermometer. 1 litre of sample is then poured inside the reactor and adsorbent material as diatomaceous earth were placed at the bottom of the reactor and comparison studies of various adsorbent materials were studied in detailed(Fig 2c). A reactor was made to run continuously for about 24 hours and sample was collected from the reactor for further analysis.

4.2. PROPERTIES OF WATER AFTER TREATMENT

After treating of sample in bioreactor, sample has been collected into 1 litre beaker and filtrate by using Filter paper. Adsorbent material were placed inside the reactor which changes sample properties and noticed. To further confirm the properties of water samples, were changed their physical and chemical properties has been analysed by above mentioned procedure.Properties of waste water has been analysed in SEEDS ENVIRO LABS, Coimbatore, No 1, Kamarajar Street, 6th Cross, K.K.Pudur, Coimbatore, before and after treatment of waste water using by Airlift Fluidized Bioreactor, with novel adsorbent material (Table 1). Renge et al (2012) used egg shell, chitosan, as absorbent material in the treatment process of heavy metals and the treatment efficiency were 100% by choosing the adsorbent amount precisely. Amuda et al (2006) and Ibrahim et al (2006) showed that coconut shell-based activated carbon was found to effectively adsorb organic matter. Amit Bhatnagar et al (2006) indicate that disposal of spent adsorbents in an environmental friendly way and found to be quite satisfactory. As a result, values obtained before and after the treatment of water sample using adsorbent material has changed. Before and after treatment the absorbent material were photographed using fluorescent microscope (Fig 3). From this obtained result, value of BOD, COD is negative due to laboratory conditions and processing of sample handling. The present novel method can be used in this bioreactor to enhance the properties of water and treated can be easily done. Therefore, in future the traditional methods of wastewater treatment may be replaced by this treatment.

Table 1: Changing of water sample properties before and after treatment

S.NO	**PARAMETER**	**RESULTS**	
		Before treatment	**After treatment**
1.	pH at 27° C	6.67	6.55
2.	Total dissolved solids	847.0 mg/I	568.mg/I
3.	Total suspended solids	60.0mg/I	30.0mg/I
4.	Chloride as Cl	212.70 mg/I	170.16 mg/I
5.	BOD	34.0mg/I	400.0 mg/I
6.	COD	240.0 mg/I	1620.0 mg/I
7.	Total hardness as Caco3	540.0 mg/I	425.0 mg/I
8.	Turbidity	6.0 NTU	4.0 NTU
9.	Total Alkalinity	600.0 mg/I	400.0 mg/I

Note:

- 1 mg/I = 1ppm/ BDL- Below detectable level(Detectable level -0.0001 mg/I)
- Limits source by: Source: CPCB, 1988, Pollution Control Acts, Rules, and Notifications thereunder. Volume I, pp.311-312. New Delhi: Central Pollution Control Board,MoEF.501

Fig 3. Microscopic View of Adsorbent Materials before and after treatment

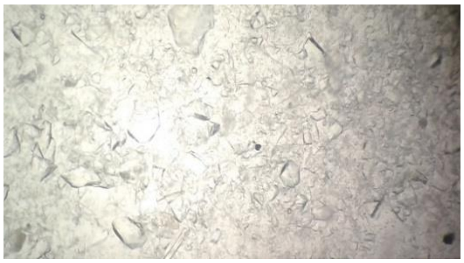

Fig.3(a): Before treatment

Fig.3 (b): After treatment

Acknowledgement:

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13.

Development Of Bacterial Biosensor For Arsenite Detection In Potable Water Samples From Gangetic Delta

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ABSTRACT

Arsenic has long held a position of ambiguity with regard to its activity in biological systems. Arsenic contaminationin deeper levels of groundwater, which became a high-profile problem in recent years due to the use of deep tube wells for water supply in the Ganges Delta. It causes serious arsenic poisoning to large numbers of people. Recent study found that millions of people in more than 70 countries are probably affected by arsenic poisoning of drinking water. Detection of arsenic levels in potable water can be done with development of whole cell bacterial biosensor using reliable and robust genetic engineering approaches. Isolated Pr-ABS-*arsR* gene was cloned in pUC18 and confirmed by agarose gel electrophoresis. Similarly reporter gene *gfp* was also isolated and cloned in pUC18-Pr-ABS-*arsR* construct. To reduce the background expression second copy of ABS inserted into pUC18-Pr-ABS-*arsR*-*gfp* and pUC18-Pr-ABS-*arsR*-ABS-*gfp* was obtained. This modified construct was then transformed into E.coli DH5α. These transformed cells can be developed as whole cell biosensor and applied in field.

KEY WORDS: Arsenite, ARS binding protein, whole cell biosensor

INTRODUCTION

Industrialization and new technologies have not only made life more convenient for humans, but have also created various environmental problems, potentially poisoning living organisms, including people. Heavy metals from industriesbioaccumulate in the aquatic food chain to the extent that the consumption of fish by birds and animals (Gbondo *et al.,* 1998). Organic compounds, originating from the widespread use of petroleum products, are highly toxic and causes concern about soil and drinking-water quality (Applegate *et al.,* 1998). Conventional chromatographic methods for evaluations are both expensive and technically complicated. They tend to overestimate the bioavailability of the pollutants, since metals and xenobiotics often exist in an insoluble form in the environment (Chaudri *et al.*, 1999; Sticher*et al.*, 1997). In recent years, bacterial whole-cell biosensors have been developed as tools to detect and quantify the toxicity of samples from different environments. They are all living cells producing a measurable gene product in the presence or absence of the investigated compounds. In all cases, detection of various xenobiotic compounds by the bacterial biosensors described in all other review requires direct interaction between the compound measured and the biosensor, which therefore gives a direct measurement of the impact on living organisms. In addition we hope to show that the use of biosensors is not limited to risk assessment of pollutants, but also has evolved to constitute a valuable tool in studying microbial ecology and gene expression in complex environments.

ARSENIC FORMS AND TOXICITY

Arsenic in the atmosphere was from sources, such as volcanoes (gas fumes), microbes, and human activities alikeburning fossil fuels.

Fig.1 Ars operon of *E.coli* R773

The toxicity of arsenite is due to the formation of strong bonds with functional groups, such as the thiols of cysteine residues and the imidazolium nitrogens of histidine residues from cellular proteins. In the case of arsenate, its toxicity is the result of the mimetic effect of arsenate (AsO_4^{3-}) and phosphate (PO^{3-}) which affects global cell metabolism (Tseng, *et al.*, 2004). In the present work, the fabrication of whole cell biosensor is carried out and used the green fluorescent protein as reporter protein (*gfp* gene).

MATERIALS AND METHODS

PLASMID ISOLATION

The plasmid pBGD 23 was isolated from *E.coli*R773 by alkaline lysis method. Agarose gel electrophoresis was adopted for elution of the gene of interest.

AMPLIFICATION OF REPRESSOR AND REPORTER GENE

Amplification of *arsR* gene with its promoter and *arsR* binding site with itsprimers PCR. The primers for *ArsR* are **5` ccc ttt cgt ctt c*aa cgt t*tc caag 3`**; 129 bp upstream of the start of *arsR* and introducing a *Hin*dIII site and *ArsR* rev **5` aac ata *tga att* cag gca aat ttt ttag 3`**, covering the stop codon of *arsR* and introducing a unique *Eco*RI site for amplifying *arsR*along with its promoter.The *gfp* gene present in the plasmid p*GFP*uv (from Clone tech. corporation, CA, USA) was amplified. The amplified reporter gene was cloned in downstream of sensing part (*arsR)* at appropriate restriction site in the MCS of pUC18-*arsR*. The resulting plasmid consists of *arsR* and *gfp* genes.Agarose (1%) gel electrophoresis was carried out for eluting repressor and reporter gene amplified through PCR.

Table 1. PCR specified conditions

Phase	Temperature(°C)	Time(seconds)
Denaturation	94	30
Annealing	55	30
Extension	72	30
Final extension	72	300
Final hold	4	-

RESTRICTION DIGESTION OF PUC18 VECTOR

Eluted *ArsR* andpUC18 vector were added with restriction enzyme buffer and one unit of the BamHI restriction enzyme. The reaction volume was made up to 40µl with sterile water. Thencontents were centrifuged and incubated at 37°C for 2 hr. The reaction was terminated by adding phenol/EDTA and the sample was frozen immediately.

LIGATION OF PR-ABS-*ARSR* GENE INTO PUC18 VECTOR

Restricted *Pr-ABS-arsR* and pUC18 vector were ligated by T_4 DNA ligase and the reaction volume was made up to 20µl. It was mixed thoroughly and incubated at 12°C for overnight.

TRANSFORMATION OF PUC18-PR-ABS-*ARSR* CONSTRUCT INTO *E.COLI* DH5A

E.coli competent cells and pUC18-Pr-ABS-*arsR* plasmid was added and mixed. It was then incubated in ice. A heat shock for 2 min was given at 42°C and again incubated in ice.The transformed cells (100 µl) were plated on selective plates (Luria agar containing 50 µg/ml of ampicillin) and incubated for 16 to 17 hr at 37°C.

INSERTION OF SECOND ABS IN CONSTRUCTED PLASMID

Background expression can be reduced by the insertion of second copy of ABS to the constructed plasmid. The steps involved are a) Amplification of ABS with given primer sequence in polymerase chain reaction b) Restriction with Eco RI enzyme and ligation using T_4 DNA ligase into constructed plasmid c)Transformation into *E.coli* DH5α cells

RESTRICTION WITH ECORI ENZYME AND LIGATION USING T_4 DNA LIGASE INTO CONSTRUCTED PLASMID

The restriction pattern was followed same as 3.1.6, with restriction enzyme as EcoRI and its corresponding buffer. The amplified and eluted ABS sequence was then ligated with pUC18-Pr-ABS-*arsR-gfp* construct. Transformation of pUC18-ABS-*arsR*-ABS-*gfp* was done.

AMPLIFICATION OF RESPONSE AND REPORTER GENE

The amplification of the repressor gene *arsR* and the reporter gene *gfp* was confirmed by agarose gel electrophoresis against marker DNA of 1kb size. The approximate size of insert gene was 0.7 kb. A Prominent band near 0.7 kb was observed under uv transilluminator. The amplified reporter gene was confirmed similarly which shows the size was approximately 1.1 kb.

RESTRICTION DIGESTION AND LIGATION OF PR-ABS-*ARSR* AND *GFP* TO PUC18

The restriction digestion of Pr-ABS-*arsR* and vector pUC18 using BamHI was confirmed by the presence of 0.7 kb and 2.9 kb linearized bands on the agarose gel. Similarly *gfp* gene also restricted using Hind III enzyme and confirmed through 0.6 kb size band.

CONFIRMATION OF PRESENCE OF SECOND COPY OF ABS

The constructed plasmid was modified by inserting second copy of ABS to reduce background expression and confirmed through PCR. The ABS amplifies the region between two ABS inserts and confirmed through agarose gel. The band obtained near 0.8 kb size as well as 0.3 kb showed the two copies of ABS in the modified construct pUC18-Pr-ABS-*arsR*-ABS-*gfp*.

SCREENING OF RECOMBINANTS

Through blue and white colonies growth was observed distinctly in 10^{-5} diluted plates. The white colonies were separated and patched in LB media with ampicilin (50 µg/ml). The transformants were isolated for modified plasmid and insertion of response and reporter gene was confirmed by restriction digestion by Hind III. Prominent band near 1.8 kb shows the presence of both genes in agarose gel electrophoresis under UV transilluminator.

ARSENITE DETECTION ASSAY

The arsenite measurement assay procedure was carried out for various river water samples and found to detect higher concentration of arsenite than that of ICP-OES. The ICP – OES found to quantify arsenite of 2 ppm concentration. The detection of arsenite was in the range of 7 µM to 50 µM for whole cell biosensor containing gfp as reporter gene. The fluorescence obtained for standard concentration of arsenite was shown in the figure below.Constructed pUC18 plasmid which can detect the arsenite in the potable water sample.

CONCLUSION

Arsenic has long held a position of ambiguity with regard to its activity in biological systems. Arsenic contaminationin deeper levels of groundwater, which became a high-profile problem in recent years due to the use of deep tubewells for water supply in the Ganges Delta. It causes serious arsenic poisoning to large numbers of people. Recent study found that millions of people in more than 70 countries are probably affected by arsenic poisoning of drinking water. Detection of arsenic levels in potable water can be done with develpoment of whole cell bacterial biosensor using reliable and robust genetic engineering approaches. Isolated Pr-ABS-*arsR* gene was cloned in pUC18 and confirmed by agarose gel electrophoresis. Similarly reporter gene *gfp* was also isolated and cloned in pUC18-Pr-ABS-*arsR* construct. To reduce the background expression second copy of ABS inserted into pUC18-Pr-ABS-*arsR*-*gfp* and pUC18-Pr-ABS-*arsR*-ABS-*gfp* was obtained. This modified construct was then transformed into E.coli DH5α. These transformed cells was developed as whole cell biosensor and assayed for the presence of arsenite. The developed sensor emits fluorescence which is exploited to show presence of arsenite.

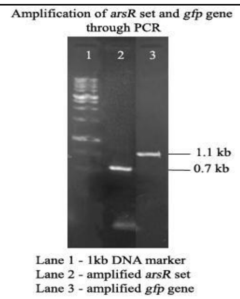

Fig.2 Agarose gel electrophoresis of amplified *ars*R gene and *gfp* gene.

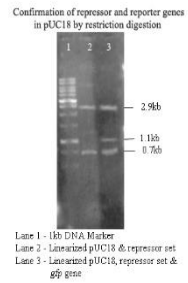

Fig.3 Agarose gel electrophoresis of repressor and reporter gene pUC18 by restriction digestion

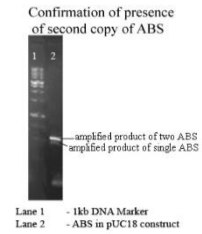

Fig.4Agarose gel electrophoresis of second copy of ABS

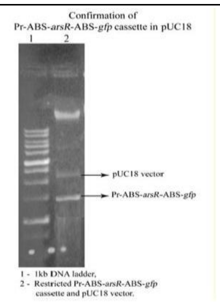

Fig.5Agarose gel electrophoresis of Pr-ABS-arsR-ABS-gfp cassette

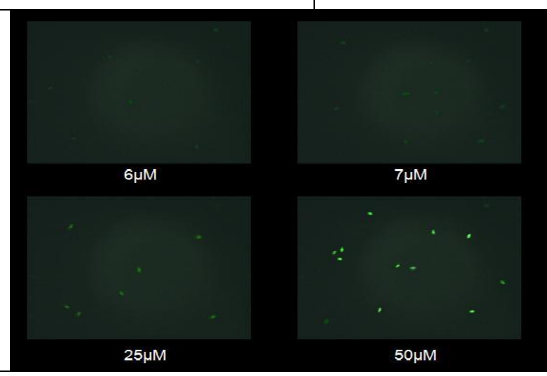

Fig.6 Detection of Arsenite through ICP-OES at different ranges

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14.

Eco-Friendly Fabric From The Leaves Of *Mimosa Pudica*

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ABSTRACT

Eco friendly processing aims at minimizing the negative effects of textile effluent on the environment. Medical textile is an emerging area with the numerous uses, Medical textile products are produced from high performance textile materials that are manufactured primarily for their functional and performance properties rather than their aesthetic or decorative properties. Studies have carried out in the present work to impact the properties of WOUND HEALING and antibacterial finishes in medical textiles producing a "MEDICATED HERBAL FABRIC "An eco-friendly natural finish has been prepared from the medicinal herb-extracts to achieve the properties of wound healing and antimicrobial finish. It have antibacterial, antifungal, antioxidant, anti-inflammatory, antiasthma tic, analgesic, and antidepressant activities. In the present study antimicrobial activity of mimosa pudica was extracted using water and the cotton fabric is dyed with this extract through eco-friendly processing. Mimosa pudica extract was directly applied on the cotton fabric by pad dry cure method. During synthetic dyeing process of the textile material about 10-25% of textile dyed are lost during the dyeing process and 2-20% is discharged as aqueous effluents. Presently there is an excessive use of synthetic dyes, estimated at around 10 × 106tons per annum, the production and application of which release vast amount of waste and unfixed colorants causing serious health hazards and disturbing the eco – balance of nature. Nowadays, fortunately, there is increasing awareness among people towards natural dyes. Many dyes and their breakdown products are carcinogenic and toxic to life .Dyes are mostly introduced into the environment through industrial effluent it leads to damage to the aquatic environment. Synthetic processing of textiles starting from preparatory processing to dyeing and finishing is important to improve the functional properties of the materials .These processes are consume more water, energy, and chemical intensive and cause serious environment pollution. Global warming is the serious problems of the world. Hence the scientific researcher focused their concentration towards safe environmentally friendly processing.

KEY WORDS

Medical textiles, Global warming, Eco-friendly, Antibacterial.

INTRODUCTION

Natural dyes are dyes or colorants derived from plants, invertebrates or minerals. The majority of natural dyes are vegetable dyes from plant sources roots, berries bark leaves and wood & other organic sources such as fungi and lichens. The word natural dyes derived from the natural sources like plants animals and minerals. Natural dyes are mostly non-substantive and must be applied on textiles by the help of mordants usually a metallic salt. For ready availability of pure synthetic dyes of different types/classes and its cost advantages most of the textile dyers/manufacturers shifted towards use of synthetic colorant.

Environmental issues are becoming more crucial all over the world .natural dyes due to their eco-friendly naturally serves a superior value to the textile material and apparel because of their bio- degradable nature which are safe to our skin. Naturally dyed materials have good resistance to moth invasion.

Most of the naturally dyed materials are non-toxic therefore non-hazardous to health Environmental issues are becoming more crucial all over the world. Natural dyes due to their eco-friendly naturally serves a superior value to the textile material and apparel because of their bio- degradable nature which are safe to our skin.

OBJECTIVES

- To select a suitable natural dye source and mordants.
- To Optimization of extraction and dyeing parameters.
- To study about the eco-friendly natural dye.

REASONS TO USE NATURAL DYES:

- ✓ Natural dyes are less destructive to the environment than the chemical dyes.
- ✓ Each plant provides an amazing diversity of shades, it may obtain 5-15 varying colours and shades.
- ✓ Colour created from natural elements lasts much longer than chemical dyes.
- ✓ It gives a healthier life.

ADVANTAGES OF NATURAL DYES

- ➢ It is more eco-friendly than synthetic dyes.
- ➢ Most of the natural dyes are antioxidants.
- ➢ Natural dyes cause no disposal problems as they are biodegradable.
- ➢ The shades produced by natural dyes / colorants are usually soft, lustrous and soothing to the human eye.
- ➢ Natural dyes can produce a wide range of colours.

DISADVANTAGES OF NATURAL DYES

- ➢ It takes time to extract the colours from the raw materials.
- ➢ It have limited availability.
- ➢ Natural dyes are obtained from plants and are dependent on growing seasons.

- Fabrics will fade quickly than fabrics colored with synthetic dyes when exposed to light and more laundering.
- Synthetic dyes usually cannot be dyed with natural dyes.
- Difficult to reproduce shades.

USES OF NATURAL DYES

- The use of natural dye for textiles dyeing purpose, decreased to a large extent after the discovery of synthetic dyes in 1856.
- As a result, with a distinct lowering in synthetic dye stuff costs, the natural dyes were virtually unused at the beginning of twenties century. Presently there is an excessive use of synthetic dyes, estimated at around 10 × 106tons per annum, the production and application of which release vast amount of waste and unfixed colorants causing serious health hazards and disturbing the eco – balance of nature. Nowadays, fortunately, there is increasing awareness among people towards natural dyes.
- Natural dyes find use in the colouration of textiles, foods, drugs, and cosmetics.

NATURAL SOURCE

Mimosa is known as a sensitive plant and it is a small short –lived shrub.

Mimosa belongs to the taxonomic group magnoliopsida and family mimosaseae.

SCIENTIFIC CLASSIFICATION

Kingdom: Plantae

Division : magnoliophyta

Class : magnoliopsida

Order : fabales

Family : fabaceae

Subfamily: mimosoideae

Genus : mimosa

Species M. pudica

DISTRIBUTION OF MIMOSA PUDICA

Mimosa pudica is native to South America and Central America. Mimosa pudica was first formally described by Carl Linnaeus in species plant arum in 1753. Mimosa is usually a short prickly plant with its branches growing close to ground. It grows up to a height of 0.5 m and spreads up to 0.3m. The stem of mimosa is erect, slender, prickly, and well branched. Leaves are bipinnate pale green in colour with a tendency of closing when disturbed. The leaflets are 15 – 25 pairs acute, bristly usually 9-12 mm long and 1.5mm wide. Flowering occurs from august to October in Indian conditions. Fruits of mimosa are pods, 1.5 – 2.5 cm long, falcate and closely prickly on sutures.

PRINCIPLE CONSTITUENTS OF MIMOSA PLANT

MIMOSINE: It is a toxic alkaloid present in m.pudica.

ADRENALIN: It is present in the extract of the leaves.

TANNIN : roots contain tannin up to 10 %.

BIOACTIVE COMPONENTS

Terpenoids, flavonoids, glycosides, alkaloids, quinines, phenols, tannins, saponins, and coumarins.

MEDICINAL PROPERTIES OF MIMOSA PUDICA

- **ROOT :** it is bitter, acrid, cooling, vulnerary, and used in the treatment of leprosy, dysentery, vaginal and uterine complaints.
- **DECOCTION OF ROOT:** It is useful in treating diarrhoea, amoebic dysentery, bleeding piles and fastens the wound healing process.
- It is mainly used in herbal preparations for gynaecological disorders.
- Recent researches show that the extract of this plant can be used for checking childbirth. It is used to relax the mind and relieve depression mental distress, irritability, amnesia.

OBJECTIVES

- To extract the dye source from leaves of mimosa pudica.
- To apply the dye on the cellulosic fabric.

- To test the dyed fabric.

SELECTION OF NATURAL SOURCE

The natural dye source is selected based on the easy application, affordable cost and colour. The leaves of mimosa pudica is selected for a study.The fresh leaves of ***mimosa pudica*** were collected from the botanical garden. Then the leaves of M.pudica washed with distilled water to remove dirt and soil, and were shade dried. Then the dried leaves were grind to make a powder, the powdered source were extracted using *dip & dry method*.

SELECTION OF THE FABRIC

Cotton is a soft, comfortable fibre and most widely used cellulosic material for apparel purposes. All the parts of the cotton plant are useful, the most important is the fibre or lint which is used in making cotton cloth. Cotton is widely used for apparels due to its high comfort.

PRE-TREATMENT OF THE FABRIC FOR DYEING

DESIZING

Desizing is the process of removing the starch from the fabric .In desizing the starch can be degraded into soluble substances using acids, oxidising agents and enzymes. Improper desizing results in improper dyeing.

OBJECTIVES OF DESIZING

- To remove the starch from the fabric.
- To increase the absorbency power of the fabric.
- To increase the affinity of the fabric.
- To increase the lustre of the fabric.

SELECTION OF MORDANTS

A mordant is a substance used to set dyes on fabrics by forming an insoluble compound with a dye .Mordant are metallic salt that facilitate the bonding of the dyestuff to the fibre. Colourfast dyeing usually requires a mordant. Both metallic salts and tannins.

Natural dyes need to use the mordants for colour fixation.

SELECTION OF MORDANT

Pomegranate rind was used for mordanting, these were collected from the garden and both were dried under sunlight.

Then grind them to make a powder and used as a mordant for this study.

SELECTION OF MORDANTING TECHNIQUE

There are three types of methods for application of mordants based on the time of usage they are as follows:

- Pre-mordant
- Simultaneous mordant
- Post-mordant

SELECTION OF EXTRACTION METHOD:

DIP AND DRY METHOD:

The leaves of mimosa pudica were air dried in the shade and ground into a fine powder. The powder was gradually dissolved in distilled water at a ratio 1:20 at room temperature. Extraction process is carried out at a temperature range of 80-85°c for 1 hour. The extract was collected by initially filtering with gauzes. The Colouring materials from the leaves are extracted to dyeing the fabric. Finally fabric was kept under the shade.

SUMMARY AND CONCLUSION

Eco friendly processing aims at minimizing the negative effects of textile effluent on the environment. Medical textile is an emerging area with the numerous uses, Medical textile products are produced from high performance textile materials that are manufactured primarily for their functional and performance properties rather than their aesthetic or decorative properties. Studies have carried out in the present work to impact the properties of WOUND HEALING and antibacterial finishes in medical textiles producing a “MEDICATED HERBAL FABRIC “An eco-friendly natural finish has been prepared from the medicinal herb-extracts to achieve the properties of wound healing and antimicrobial finish.

The textile dyeing industry consumes large quantities of water and produces large volumes of wastewater from different steps in the dyeing and finishing process, waste water from printing and dyeing units is often rich in colour containing residues proper treatment before being released into the environment. Nowadays, fortunately, there is increasing awareness among people towards natural dyes. Many dyes and their breakdown products are carcinogenic and toxic to life. Global warming is the serious problems of the world. Hence the scientific researcher focused their concentration towards safe environmentally friendly processing.

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15.

Effect of selected Agro-Waste (Corn Husk) for effluent treatment

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ABSTRACT:

Clean technology, eco mark and green chemistry are the need of the hour to tackle manmade environment hazards. The textiles industry is a very diverse sector in terms of raw materials, processes, products and equipments. The textile industry has always been regarded as a water intensive sector. Due to various chemical processing of textiles, large volumes of waste water with numerous pollutants are discharged. In order to protect and safeguard our surroundings from toxicological impact and pollution problem this study focuses to assess the physico chemical analysis of the reactive dye effluent before and after the treatment. The reactive dye effluent is decolorized using corn husk and reusability of treated effluent is assessed.

KEY WORDS: Eco mark, Toxicology, Pollutants, Effluent, Corn Husk.

INTRODUCTION:

Textile industry is a very diverse sector in terms of raw materials, processes, products and equipment and has very complicated industrial chain. The textile industry has always been regarded as a water intensive sector. It is well known that textile industry consume large volume of water for various processes such as sizing, desizing, scouring, bleaching, mercerization, dyeing, printing, finishing and ultimately washing. Textile industry waste water consists of BOD, COD, color heavy metals, total dissolved and suspended solids, and carcinogenic dye ingredients opine Tekoglu and Ozdemir (2010).

Various colour removal methods such as microbial degradation, coagulation chemical oxidation, membrane separation process, filtration, reverse osmosis have been proposed time to time. All of these methods suffered with certain limitation and none of these were successful in removing colour completely. So, the efficient treatment of the effluent is eco-friendly method for the treatment of textile effluent remark Murugalatha et al. (2010).

Adsorbents from agriculture by-products are particularly advantageous due to their low cost and high availability of materials such as cane waste, wood, lemon peel, barley husk, orange peel, rice husk, neem leaves,cane bagasse, coir pith de-oiled soya have been tested as adsorbent on remediation of contaminated water.

An attempt was made to study on "Effect of Selected Agro-Waste (Corn Husk) for Effluent Treatment" with the following objectives.

- To assess the physico-chemical analysis of the reactive dye effluent before and after the treatment.
- To screen and decolorize the reactive dye effluent using agro waste.
- To assess the reusability of treated effluent for irrigation.

SOURCE OF POLLUTION:

Dye pollution from the textile industry are important source of environment contamination. They pose serious environment problems because of their color, low biochemical oxygen demand (BOD) and high chemical oxygen demand (COD). They are mostly non-biodegradable and resistant to destruction by conventional wastewater treatments describe Kim et al. (2008). The release of coloured wastewater in the ecosystem is a remarkable source of aesthetic pollution, eutrophication, and per turbation in aquatic life (Aksu et al. 2007)

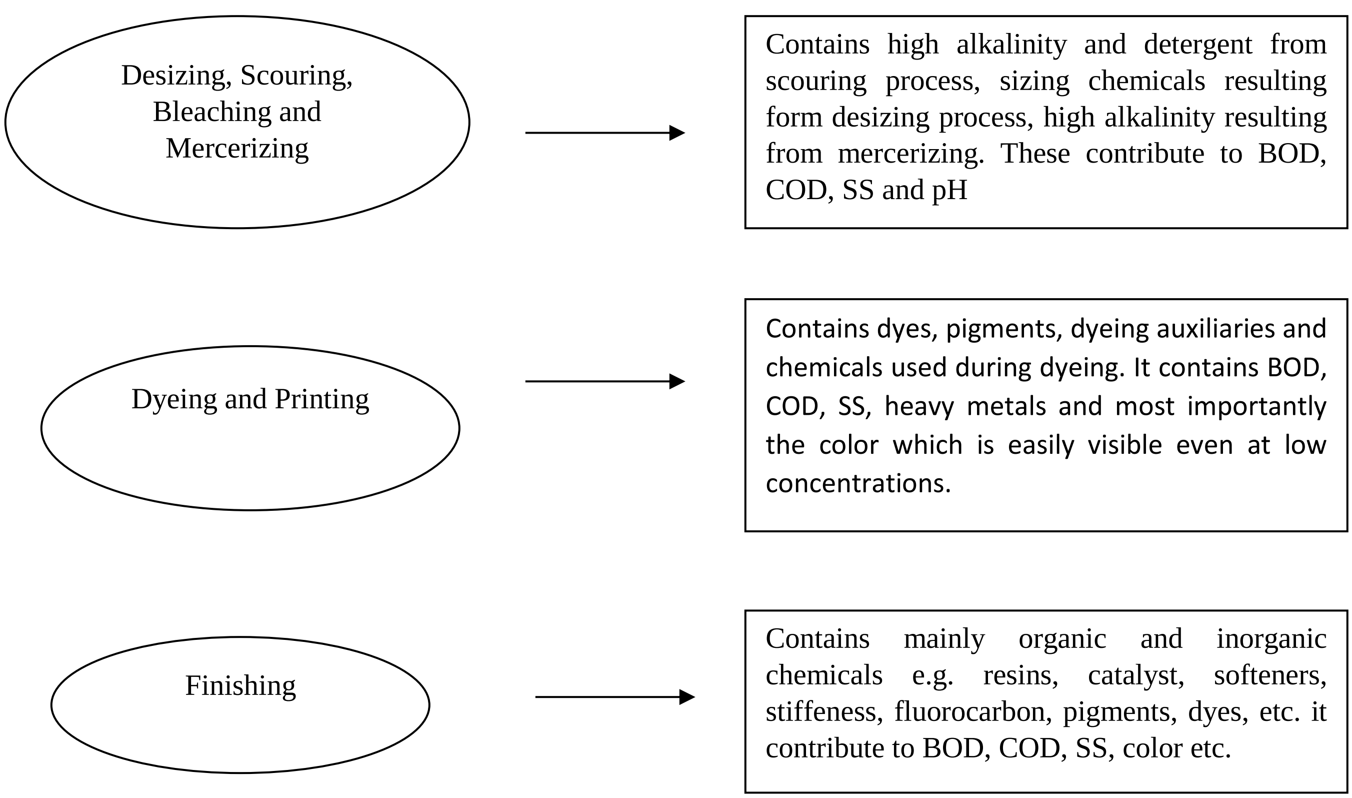

Figure I: Sources of pollution in textile processing

ENVIRONMENTAL AND HEALTH PROBLEM OF TEXTILE DYES:

Textile dyes improves the human lifestyle on a positive account. But on the same side at a negative point they are affecting the environment due to the pollutants given out by them. Tan et al. (2010) narrate synthetic dyes usually have a complex aromatic molecular structure such as benzene, naphthalene, anthracene, toluene, xylene, etc.

Reactive dyes have a high degree of wet fastness because the reactive dye molecule fixes itself to natural materials such as cotton, silk, wool or leather by a strong chemical bond. If reactive dyes are inhaled or ingested they can react in the same way within the body. Sometimes this can affect the body's immune system.

ROLE OF AGRO WASTE IN THE DECOLORIZATION OF DYE EFFLUENT:

Due to low biodegradability of dyes, a conventional biological wastewater treatment process is not very efficient in treating dye waste water. The elimination of colored substance in waste water is based mainly on physical or chemical methods. These methods have several disadvantages like high cost, incomplete removal, low selectivity and high energy consumption. After dye removal, activated carbon removes dyes from solution, they are then present in a more concentrated and toxic form and so their safe disposal increases the cost further. So, effective, more economically alternative and lower cost absorbents would be of great value.

METHODOLOGY

SELECTION OF EFFLUENT:

Textile manufacturers mostly uses the reactive dyes for the textile dyeing because it prevents fabric bleeding during garment washing or color-run-offs when adding treatments or finishes to products. Effluent containing reactive dyes is considered as a problematic waste of the textile industry report corso. Reactive dye effluents relatively produce heavily colored, contain high concentration of salt and exhibit high BOD and COD values. Hence the investigator selected reactive dye effluent for treatment to find a novel solution.

COLLECTION OF DYE EFFLUENT:

The reactive dye effluent from fabric dyeing unit at Tirupur was collected in a sterile plastic container and stored at $4^{O}C$ until analysis was carried out.

PRELIMINARY TRIALS FOR OPTIMIZATION OF ADSORPTION SOURCE:

In order to optimize the adsorption source, a pilot study was carried out to establish procedures and parameters as it saves tremendous amount of time and money, clarified instructions, determines the reliability and validity of independent variables. Hence, pilot study was done by taking 100 ml reactive dye effluent was treated using 10 grams each of dried raw corn husks, lemon peel, orange peel and banana peel, kept for decolourization. The present of adsorption of each agro-waste was calculated for 5 days using calorimeter.

Considering the results of the pilot study, the investigator decided to use dried corn husks for the study.

SELECTION AND COLLECTION OF CORN HUSKS:

Cotton husks were selected for the study due to the higher dye absorption qualities. Indian corn husks were selected for the study due to the availability of large amount in corn processing industry.

The collected corn husks were dried under sun. The collected and dried corn husks were taken and cut into small pieces. Then the dried corn husks were stored in clean white cotton bag at room temperature.

OPTIMIZATION PARAMETERS FOR DECOLORIZATION:

The optimum amount of cotton husk, time, pH, temperature for treating the optimum adsorption of corn husks for effluent treatment were determined for proper and effective process.

Effect of corn husk concentration of the decolorization of reactive dye effluent

To optimize the amount of corn husk to decolorize reactive dye effluent by taking different amount 1g, 1.5g, 2g, 2.5g, 3g, in 250ml beakers marked as A1, A2, A3, A4 and A5 respectively containing 100ml of effluent. Absorbance was measured at 600 nm for 5 days in calorimeter. The percentage of adsorption decolorization was calculated based on the results, 3g of corn husk concentration was considered as optimum for the further study.

ANALYSIS OF EFFLUENT AND TREATED EFFLUENT WATER:

The effluent and treated effluent water were analyzed for finishing out the toxic substance present in them and to know the pollution load of the water besides the quality of water. The analysis of effluent was carried out in bio – textiles lab, of our university.

RESULT AND DISCUSSION

Decolorization of reactive dye effluent by various agrowastes

Agrowaste	**Percentage Adsorption**

Cornhusk	92
Orange peel	75
Lemon peel	86
Banana peel	70

Among these agro – wastes, corn husk was found to be effective in the adsorption of reactive dye from its aqueous solutions and also it is an innovative source. Hence corn husk was selected for the study.

OPTIMIZATION OF DIFFERENT PARAMETERS FOR THE DECOLORIZATION EFFECT OF CORN HUSK CONCENTRATION ON THE DECOLORIZATION OF REACTIVE DYE EFFLUENT

The effect of corn husk concentration on the decolorization of reactive dye effluent was studied and the results are presented in Table I and Figure II

Table I

Effect of corn husk concentration on the decolorization of reactive dye effluent

S.No	Concentration of corn husk (g)	Percentage Adsorption
1.	1	72
2.	1.5	79
3.	2	85
4.	2.5	88
5.	3	94

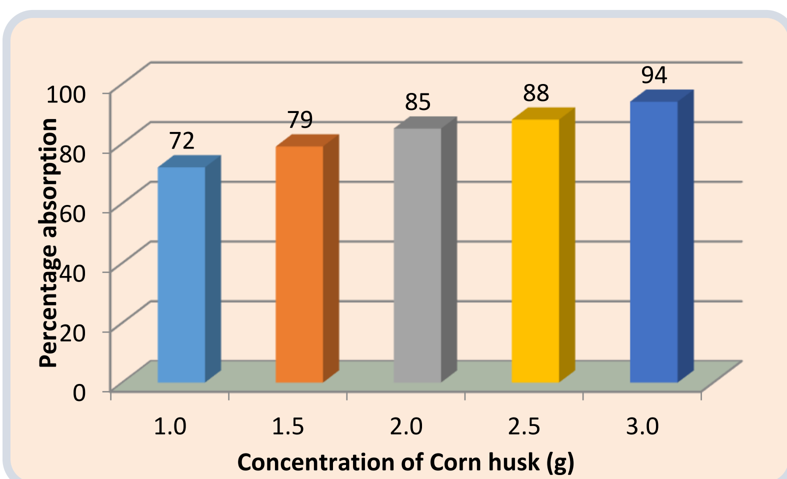

FIGURE II

From the Table III, and Figure II it is clear that the percentage of dye adsorption increased with increase in adsorbent concentration, the maximum percentage of dye adsorption (94%) was observed at 3g of corn husk. Hence this was considered as optimum amount required for treating reactive dye.

EFFECT OF PH ON THE DECOLORIZATION OF REACTIVE DYE EFFLUENT

The optimum results determined for the effective adsorption of reactive dye effluent, the adsorption capacities of all the adsorbents were studied at various pH range from 5 to 9 and the results are presented in Table II and Figure III

Table II

Effect of pH on the decolorization of reactive dye effluent pH

S.No	pH	Percentage Adsorption
1.	5	71
2.	6	85
3.	7	92
4.	8	62
5.	9	54

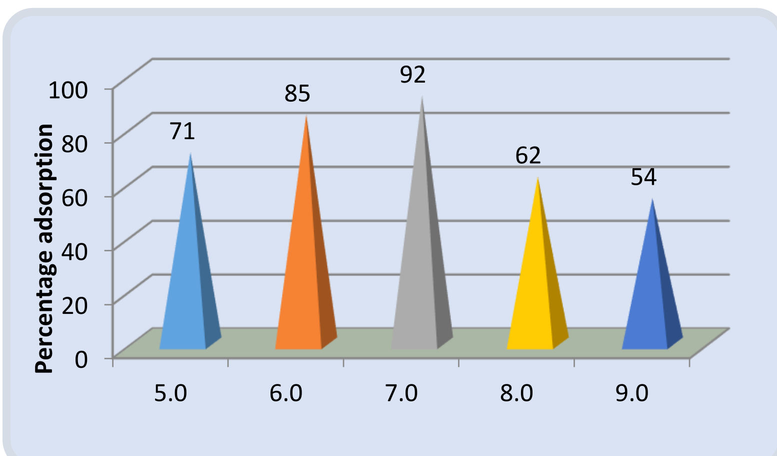

FIGURE III

From the Table IV and Figure III, it is clear that pH-7 shows a maximum dye adsorption of reactive dye using corn husk. Increase of pH results decrease in percent decolorization. Hence, further studies were carried out at a pH of 7.

EFFECT OF TEMPERATURE ON THE DECOLORIZATION OF REACTIVE DYE EFFLUENT

The effect of temperature on decolorization of reactive dye effluent was investigated at various temperature namely 30^{O}C, 40^{O}C, 50^{O}C, 60^{O}C and 70^{O}C maintaining pH of effluent and quantity of corn husk at optimum levels and presented in Table III and Figure IV

Table III

Effect of temperature on the decolorization of reactive dye effluent

S.No	Temperature	Percentage of decolorization (%)
1.	30	85
2.	40	65
3.	50	60
4.	60	54
5.	70	48

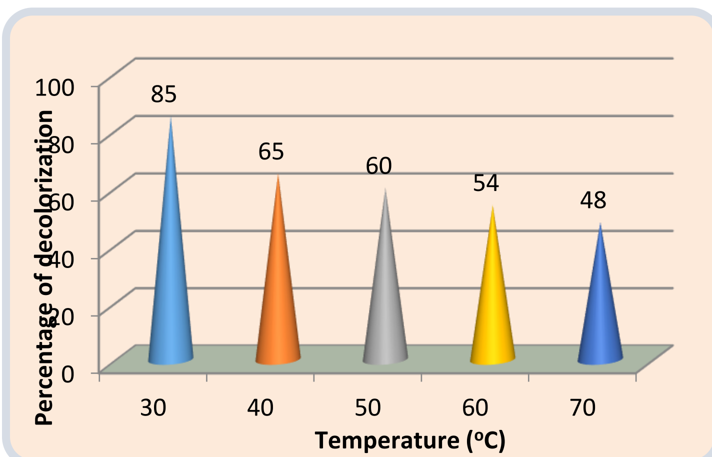

FIGURE IV

From the Table V and Figure IV, it is clear that the maximum dye adsorption was showed at 30^{O}C. However with increasing temperature, the adsorption rate of the corn husk has apparently decreased.

EFFECT OF CONTACT TIME ON THE DECOLORIZATION OF REACTIVE DYE EFFLUENT

The effect of contact time on the decolorization of reactive dye effluent was studied and the results are shown in Table IV and Figure V

Table IV

Effect of contact time on the decolorization of reactive dye effluent

S.No	Hours	Percentage Decolorization (%)
1.	24	52
2.	48	81
3.	72	65
4.	96	62
5.	120	58

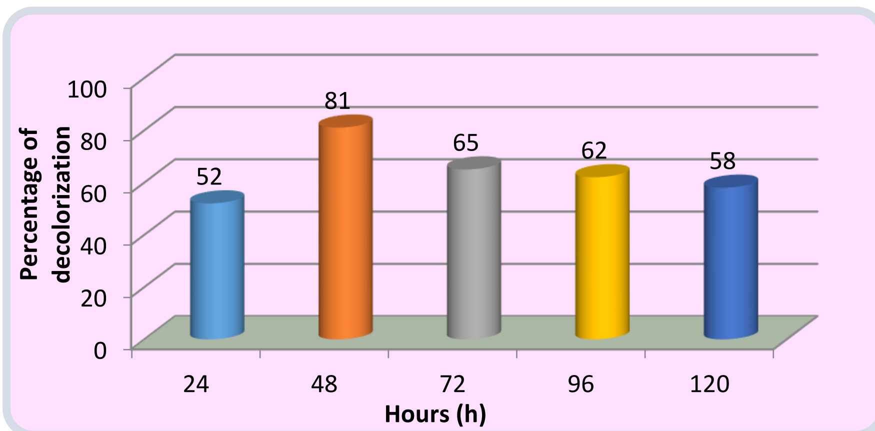

FIGURE V

From the Table IV and Figure V, it is obvious that maximum rate of adsorption was observed at 48 hours of incubation at room temperature because prolonged exposure to corn husks produced undesirable odour to the effluent. Hence this was considered as optimum amount (time) for treating reactive dye effluent. Hence this was considered as optimum amount required for treating reactive dye effluent.

PHYSICO CHEMICAL CHARACTERISTIC OF RAW AND TREATED EFFLUENT WATER:

The raw and treated effluent water samples were tested for various physical and chemical parameters and the results are presented in Table V

Table V

Analysis of Effluent and Treated Water

S.No	Parameter	Raw Effluent Water	Treated Effluent Water
1.	Colour	1.02	0.50
2.	pH	10.25	7

3.	Total Suspended Solids(mg/l)	6.2	4
4.	Total Dissolved Solids (mg/l)	11,500	4520
5.	Biological Oxygen Demand(mg/l)	80	15
6.	Chemical Oxygen Demand (mg/l)	620	120
7.	Total Hardness (mg/l)	190	42
8.	Total Alkalinity (mg/)	182	92
9.	Phosphate (mg/l)	3200	1230
10.	Sulphate (mg/l)	930	465

From Table VII, it is obvious that the decolorization efficiency was excellent after effluent treatment with corn husk.

Colour has been completely removed by the treatment pH has reduced from 10.25 to 7 TSS level of the effluent water was 6.2 mg/l before treatment and it has been reduced to 4 mg/l. TDS level of the effluent was maximum before treatment and it had been reduced to 4520 mg/l from 11,500 mg/l. Total hardness brought to 42 mg/l from 190 mg/l present in dye effluent before treatment. Similarly total hardness in treated effluent water was lower than that of the untreated effluent. In addition total alkalinity of the effluent was reduced by the treatment very effectively. Calcium, phosphate and sulphate content of the treated effluent water were also reduced remarkably. BOD of the effluent was reduced to 15 mg/l from 80 mg/l COD also reduced from 620 mg/l. It could be concluded that the corn husk treated water is safe, pollution free and protects the environment.

CONCLUSION:

Environmental pollution is one of the most challenging problems facing the human race. The impact of its atmosphere, hydrosphere and lithosphere by arthropogenic activities cannot be ignored. But we can reduce and avoid environmental harmful activities. Environmental negative impacts can be eliminated by economic eco-friendly process of decolorization of waste effluent by adsorption method using agro waste.

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16.

Effect on Implementation of Water Users Associations in Theni District of Tamil Nadu

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Abstract

Water Users Associations (WUAs) that involves farmers in the planning, operation and maintenance of the irrigation system is considered an effective way of enhancing the growth performance among source of irrigation water. In Tamil Nadu, Theni district best with Vaigai river basin which successful in activating water users association. Thus, the study focused on growth performance of area irrigated by different irrigation source in Theni district of Tamil Nadu State, to examine the existing cropping pattern in Theni districts and to analyze the growth performance of area, production and productivity of banana in Theni districts. The growth and instability in the net and gross irrigated by different sources as well as area, production and productivity of banana in Theni district was estimated using the compound growth function and Cuddy-Della Valle Index. The necessary secondary data were collected for a period of 35 years from 1978-1979 to 1995-1996 (before WUAs) and from 1996-1997 to 2013-2014 (after WUAs). The result revealed that net and gross irrigated by canals was found to be positive and significant with 2.14 per cent and 1.51 per cent, respectively after water users association formed. The overall net irrigated and gross irrigated area was negative and significant at one per cent level for before WUAs whereas positively significant for after WUAs. The highest instability in net irrigated area was observed before WUAs in open well with 23.41 per cent and the lowest was observed in canal (9.57 per cent) before WUAs formed. After WUAs formed, the highest instability in area was observed in net irrigated area by canal (15.43 per cent) and the lowest in open well (9.17 per cent) and in the case of net irrigated area by tank the instability was 3.06 per cent. Gross irrigated area by different source of irrigation for before WUAs formation, the highest instability was observed in area irrigated by tank (20.95 per cent), open well (19.44 per cent) and canal (13.38 per cent). The overall net irrigated was highest instability with 17.35 per cent and 17.62 per cent, respectively for before WUAs whereas lowest instability recorded for after WUAs with 5.71 per cent and 7.11 per cent, respectively. The result also revealed that cropping pattern in Theni district was banana cultivation under Water Users Associations. Therefore, growth in the area, production and productivity of banana showed negative and significant before WUAs whereas productivity of banana after WUAs formed showed positive and significant at one per cent level.

Key Words: Water Users Associations, Net and Gross Irrigated Area, Growth Rates, Instability Index.

INTRODUCTION

Water Users Associations (WUAs) that involves farmers in the planning, operation and maintenance of the irrigation system is considered an effective way of enhancing the growth performance among source of irrigation water. It is an important determinant factor of production of crops in agricultural sector. Intensive and extensive cultivation of land depends mainly on the availability of water. Thus, Water Users Associations was organization to save the quantity of water to improve the productivity of crops. Present statuses of WUAs in Tamil Nadu are majority of the farmers showed enthusiasm and willingness to involve themselves in the community activities like rehabilitation, water distribution and O&M activities. One third of the farmers are holders of EC membership at least in a year since WUA formed. Nearly 80 per cent of the farmers have contributed to the rehabilitation activities by way of either cash or labour or supervision of works. Those who worked as EC members alone informed that they are involved in the decision making with regards to water distribution. Nearly half of the respondents mentioned that they are involved in water distribution within their land limits. The rest 17 per cent of the farmers said that they are using the services of Neerkuttis or hired labourers to distribute water even to their own fields. Nearly 20 per cent of the farmers in the well functioning WUA sector mentioned that they are not at all involved in the O&M activities. However they regularly pay the annual fees. The rest of the farmers mentioned that they are involved by way of contributing labour and supervision activities.

In Tamil Nadu, Theni district best with Vaigai river basin which successful in activating water users association. In general, water distribution was mainly carried out by the Neerkattis with the direction from WUA members. Only in one WUA under Periyar Vaigai scheme in Theni district, individual farmers distribute water, but as per the instruction from the WUA. The rotational system is being adopted invariably in all schemes. WUA is involved only in the activities like (a) sluice operation, (b) water distribution, (c) maintenance and (d) rehabilitation works. Those associations which are not involved in water distribution are not functioning well such as Perinjakulam tank and Velliyanai tank. WUAs so far restricted their activities to the rehabilitation only in remaining districts in Tamil Nadu state. Thus, the study focused on growth performance of area irrigated by different irrigation source in Theni district of Tamil Nadu State, to examine the existing cropping pattern in Theni districts and to analyze the growth performance of area, production and productivity of principle crop in Theni districts.

DATA AND METHODOLOGY

The data on area irrigated by different irrigation source, cropping pattern and area, production and productivity of paddy, maize, cholam and banana in Theni district were obtained from various issues of season and crop report, published by Department of Economics and Statistics, Chennai.

GROWTH ANALYSIS

COMPOUND GROWTH RATE

The compound growth rate was worked out to examine the growth performance of area irrigated by different irrigation source as well as area, production and productivity of principle crops in Theni district were worked out by using the exponential growth function of the form

$Y = a\, b^t\, e_t$

Where,

Y = Dependent variable (area irrigated by different irrigation source, area. production, yield of principle crops)

t = time variable

e_t = Error term

a and b are unknown constants to be estimated

The unknown constants a and b were found by applying methods of least square by transforming the equation into logarithmic form

$\ln Y = \ln a + t \ln b$

Where,

ln Y is natural logarithm of Y, ln a and ln b are similarly defined.

The compound growth rate 'r' was computed by using the relationship

r = (Antilog of (ln b) – 1) x 100

Where, $$\ln b = \frac{\Sigma (t \ln Y) - (\Sigma t\, \Sigma \ln Y) / n}{\Sigma t^2 - (\Sigma t)^2 / n}$$

and n is number of time points

The significance of ln b was tested by t-ratio.

$$t = \left| \frac{\ln b}{SE(\ln b)} \right|$$

Where

$$SE(\ln b) = (SS_{\ln Y} - (\ln b)^2\, SS_t) / ((n-2)\, SS_t)$$

Where,

$SS_{\ln Y} = \Sigma (\ln Y)^2 - (\Sigma \ln Y)^2 / n$

and $SS_t = \Sigma t^2 - (\Sigma t)^2 / n$

The critical value is t- table value for n - 2 degrees of freedom.

INSTABILITY INDEX

To examine the extent of variability in the area irrigated by different irrigation source, area, production, yield of principle crops, the Cuddy-Della Valle Index is used (Cuddy and Della Valle 1978) using formula given below

$$\mathrm{IX} = \mathrm{CV}\sqrt{1 - \mathrm{R\ Squared}}$$

$$\mathrm{CV} = \frac{\mathrm{Standard\ Deviation}}{\mathrm{Mean}}$$

Where,

IX = Instability Index

CV = Coefficient of variation (per cent)

R squared = Coefficient of determination from a time-trend regression adjusted by the number of degrees of freedom.

The simple coefficient of variation over estimates the level of instability in time-series data characterized by long term trends whereas the Cuddy-Della Valle index corrects the coefficient of variation.

RESULT AND DISCUSSION

1. GROWTH RATES AND INSTABILITY INDEX OF AREA IRRIGATED BY DIFFERENT IRRIGATION SOURCE IN THENI DISTRICT

1.1. GROWTH RATES OF AREA IRRIGATED BY DIFFERENT IRRIGATION SOURCE IN THENI DISTRICT

The Compound Growth Rates (CGRs) and Cuddy-Della Valle instability index of net and gross irrigated area by different irrigation source for two periods 1978- 1995 (before water users associations) and 1996-2013 (after water users association) were estimated and are furnished in Table 1. The growth of net and gross irrigated area by open well, canal and tank irrigation in Theni district showed variations.

Table 1. Growth rate of area irrigated by different irrigation source in Theni district

(Per cent)

Sl. No	Variables	Before WUA	After WUA
I	**Net Irrigated Area (ha)**		
1	Open well	-4.50 * (-4.23)	0.17 NS (0.36)
2	Canal	0.68 NS (1.44)	2.14 * (2.69)
3	Tank	-5.93 * (-5.63)	-10.55 * (-7.66)
	Total Net irrigated area	-3.09* (-3.88)	0.70 ** (2.56)
II	**Gross Irrigated Area (ha)**		
1	Open well	-3.40 * (-3.80)	0.48 NS (0.96)
2	Canal	2.35 * (3.51)	1.51 *** (2.01)
3	Tank	-5.04 * (-5.29)	-11.38 * (-8.01)
	Total Gross irrigated area	-3.67 * (-4.61)	0.74 ** (2.18)

Note: Figures in parentheses indicate t values
Before Water User Association (WUA) - 1978-1979 to 1995-1996,
After Water User Association (WUA) - 1996-1997 to 2013-2014,
* Significant at 1% level; ** Significant at 5% level; *** Significant at 10% level; NS – Non Significant

The growth rate of net area irrigated after formation of water users association was positive and significant at one per cent level for canal (2.14 per cent) as compared to before water users association. The growth rates estimated for net irrigated area by tank was 10.55 per cent was negative and significant during 1996-2013. The growth rate of gross irrigated area by canal was statistically highly significant before WUAs formed whereas it was positive during 1996- 2013. Gross irrigated area by open well and tank was negatively significant at one per cent level. In general, total net irrigated and gross irrigated area was negative and significant at one per cent level during 1978- 1995 whereas positively significant during 1996-2013.

1.2. INSTABILITY INDEX OF AREA IRRIGATED BY DIFFERENT IRRIGATION SOURCE IN THENI DISTRICT

Cuddy-Della Valle Index was constructed to understand the instability in area irrigated by different irrigation source in Theni district. The instability indices are presented in Table 1. The highest instability in net irrigated area was observed during 1978- 1995 in open well and tank with 23.41 per cent 23.48 per cent and the lowest was observed in canal (9.57 per cent). During 1996- 2013, the highest instability in area was observed in net irrigated area by canal (15.43per cent) and the lowest in open well (9.17per cent), and in the case of net irrigated area by tank the instability was 3.06 per cent. In the case of total net irrigated area recorded the instability of 17.35 per cent during 1978- 1995 and 1996- 2013 (5.71 per cent). In the gross irrigated area by different source of irrigation during 1996- 2013, the highest instability was observed in area irrigated by tank (20.95 per cent), open well (19.44 per cent) and canal (13.38 per cent).

Table 2. Instability index of area irrigated by different irrigation source in Theni district

(Per cent)

Sl. No	Variables	Before WUA	After WUA
I	**Net Irrigated Area (ha)**		
1	Open well	23.41	9.17
2	Canal	9.57	15.43
3	Tank	23.48	3.06
	Total Net irrigated area	17.35	5.71
II	**Gross Irrigated Area (ha)**		
1	Open well	19.44	10.29
2	Canal	13.38	14.36
3	Tank	20.95	31.30
	Total Gross irrigated area	17.62	7.11

Note: Before Water User Association (WUA) - 1978-1979 to 1995-1996,
After Water User Association (WUA) - 1996-1997 to 2013-2014,
* Significant at 1% level; ** Significant at 5% level; *** Significant at 10% level; NS – Non Significant

2. CROPPING PATTERN UNDER IRRIGATED CONDITION IN THENI DISTRICT

An analysis on cropping pattern would provide an idea of the decision making behavior of the farmers on the crop-mix prevalent in the study area. Hence, cropping pattern in Theni district presented in Table 3.

Table 3. Cropping pattern under irrigated condition in Theni district

Sl. No	Crops	Area (ha)	Percentage
1	Paddy	12499	17.07
2	Maize	7998	10.92
3	Cholam	1826	2.49
4	Banana	2427	3.31
	Gross area irrigated	**73234**	**100.00**

Source: Season and Crop Report, 2013-2014.

It could be observed from the Table 3 that gross irrigated area was 73234 hectares in Theni district, of which 17.07 per cent has been accounted by paddy, followed by maize (10.92 per cent), banana (3.3.1 per cent) and cholam (2.49 per cent) to the gross irrigated area.

3. GROWTH RATE AND INSTABILITY INDEX OF AREA, PRODUCTION AND YIELD OF PADDY, MAIZE BANANA AND CHOLAM IN THENI DISTRICT

3.1. GROWTH RATE OF AREA, PRODUCTION AND YIELD OF PADDY, MAIZE AND BANANA IN THENI DISTRICT

The estimated compound growth rates in area, production and productivity of paddy, maize, cholam and banana in Theni district are presented in the Table 4.

Table 4. Growth Rate of Area, Production and Yield of Paddy, Maize, Cholam and Banana in Theni District

(Per cent)

Crops	Before Water User Association (1978-1979 to 1995-1996)			After Water User Association (1996-1997 to 2013-2014)		
	Area (ha)	Production (tonnes)	Yield (kg/ha)	Area (ha)	Production (tonnes)	Yield (kg/ha)
Paddy	-2.62 * (-5.27)	0.59 NS (0.57)	3.30 * (4.09)	-2.45 * (-5.54)	-0.64 NS (-0.86)	1.86 * (4.17)
Maize	8.51 * (4.01)	11.75 * (4.41)	2.98 *** (1.98)	7.20 * (6.02)	19.50 * (7.94)	11.47 * (5.74)
Cholam	-12.33 * (-7.47)	-9.29 * (-5.83)	3.47 ** (2.69)	-3.07 * (-3.82)	3.54 *** (1.94)	6.82 * (4.17)
Banana	-2.94 NS (-1.51)	-4.71 NS (-1.63)	-1.82 NS (-0.94)	0.25 NS (0.16)	0.05 ** (2.38)	4.91* (3.69)

Note: Figures in parentheses indicate t values
* Significant at 1% level; ** Significant at 5% level; *** Significant at 10% level; NS – Non Significant

Area under maize has registered positive growth of 8.51 per cent and 7.20 per cent during 1978-1995 and 1996-2014 respectively whereas area under paddy, cholam and banana has registered a negative growth during the period 1978-1995 and 1996-2014. Production of maize has registered positive growth of 11.75 per cent during 1978-1995 and 19.50 per cent during 1996-2014 at one per cent significant level. In fact, production of paddy registered a slight decline. In case of yield, paddy shows positive and significant at one per cent with 3.30 per cent during 1978-1995 whereas yield of paddy, maize, cholam and banana has registered positively significant at one per cent level with 1.86 per cent, 11.47 per cent, 6.82 per cent and 4.91 per cent respectively during 1996-2014.

3.2. INSTABILITY INDEX OF AREA, PRODUCTION AND YIELD OF PADDY, MAIZE AND BANANA IN THENI DISTRICT

Cuddy-Della Valle Index was constructed to understand the instability in area, production and productivity of paddy, maize, cholam and banana in Theni district. The instability indices are presented in Table 5.

Table 5. Instability index of Area, Production and Yield of paddy, maize and banana in Theni District

(Per cent)

Crops	Before Water User Association (1978-1979 to 1995-1996)			After Water User Association (1996-1997 to 2013-2014)		
	Area (ha)	Production (tonnes)	Yield (kg/ha)	Area (ha)	Production (tonnes)	Yield (kg/ha)
Paddy	10.77	20.09	16.72	9.08	15.09	9.31
Maize	44.26	45.33	28.55	23.07	47.96	47.93
Banana	37.99	57.47	38.36	36.59	40.86	26.55
Cholam	29.44	32.29	28.75	16.55	31.65	28.48

Note: Figures in parentheses indicate t values
* Significant at 1% level; ** Significant at 5% level; *** Significant at 10% level; NS – Non Significant

It could be seen from the Table 5 that the instability indices for area under paddy, maize, banana and cholam were less stable with 10.77 per cent, 44.26 per cent, 37.99 per cent and 29.44 per cent, respectively during 1978-1995 as compared to paddy, maize, banana and cholam with 9.08 per cent, 23.07 per cent, 36.59 per cent and 16.55 per cent, respectively during 1996-2014**.** Similar trends were noticed for production of paddy, maize, banana and cholam. Except yield of maize (47.93 per cent), instability index was stable for paddy, banana and cholam were stable with 9.31 per cent, 26.55 per cent and 28.48 per cent, respectively. It shows that lowest instability in area, production and yield of paddy was remarkable during 1996-2014 in Theni district.

CONCLUSION AND POLICY IMPLICATIONS

Compound growth rate analysis of different irrigation source namely canal, open well and tank in Theni district indicates that in 1996 to 2013 the growth rate of net irrigated area was positive and significant at one per cent level. Growth rate shows the negatively significant at one per cent level for both net and gross irrigated area during 1978-1995 and 1996-2014. The growth rates of almost all the variables were statistically highly significant. The instability analysis points out that the highest instability in net irrigated area of tank (23.48 per cent) during 1978-1995 and the lowest in net irrigated area of tank (3.06 per cent) during 1996-2014. Cropping pattern followed in Theni district under water user association was paddy, maize, banana and cholam. Compound growth rate analysis of paddy, maize, cholam and banana in Theni district indicates that in 1996-2014 growth rates shows the positive and significant in area of paddy, maize, cholam and banana. The highest instability in area under maize and lowest in area under paddy. In case of production the instability was high in banana during 1978-1995 and low in cholam during 1996-2013 in Theni district.

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17.

Environmentally Sound Disposal Of Tannery Sludge

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Abstract

The challenging problems faced by the tannery based countries are the safe disposal of the sludge generated by the effluent treatment plants. In this work, the disposal of the sludge at various generation points such as beam house (BHS) and after tertiary treatment process (TS) are studied. The FT-IR of the beam house sludge confirmed the presence of organic matter at 2880.31cm^{-1} and calcined products due the process of deliming. The TGA of BHS confirmed dominance of organic matter in the sludge with about 91.88% of residual mass at 292^{o}C, whereas the inorganic salts present in the TS lead to a residual mass of 32.92%. The characterization of various parameters such as pH, hardness, Chlorides, TDS, COD, BOD, TS for the leaching studies and mortar curing studies were also performed. The high values of hardness of the two sludge samples were due to the presence of calcium and magnesium salts. The EPTOX leaching studies of the raw sludges and the leachate studies from the mortar curing were also conducted. These results confirmed the unsafe disposal of tannery sludges. An effective disposal of the tannery sludge by composting and solidification/stabilization (S/S) is suggested and is to be carried out in future. The S/S of the raw tannery sludge without the addition of admixtures were tested for compressive strength. The 15 day compressive strength of BHS and TS were 1.1KN/m^2 and 1 KN/m^2.

Keywords: Beam house; FT-IR; Leaching; Tannery sludge; TGA

1. Introduction

Tannery industry has been characterized as one of the highly polluting industry and has adverse impact on the environment. Tanning is a process that stabilizes the protein of the raw hide or a skin by means of a series of chemical and mechanical process. Generally, water consumption is higher in tanning industry which is around 10 -100 litres of water per kilogram of skin/hide (Swarnalatha et al. 2006) When the tannery effluent is directly exposed to the environment without treatment, it becomes hazardous. Disposal of tannery sludge has also become as a challenging and burning issue in the society. The techniques such as land co-disposal, thermal treatment and anaerobic digestion are practiced for the disposal of solid wastes discharged from effluent treatment plant (Fernandez -sampere et al., 1997). The solid waste disposal is considered to be efficient if the energy involved is balanced in the overall recycle process. This balancing of energy supply and demand is a key concept in creating efficient recycling–based processes (Goto et al., 2005). Sludge from the effluent treatment can either be utilized as a replacement in construction or can be converted to manure by composting method. In this work, the authors are in the progressing stage of their work.

2. Materials and Methods

2.1 Materials

The sludge from Beam housing and after tertiary treatment was collected from E.K.M leather industries, Erode. The layout of the tannery processing industry are shown in fig.1. The collected sludges were dried were pulverized in a ball mill. The crushed sludges were sieved in a mechanical shaker and the sludges were collected for various sieve sizes such as 75µm, 300µm, 600µm and 1.18mm. The chemical reagents used were of Analytical grade and double distilled water was used for the laboratory testing of the sludge samples. Ordinary Portland cement of 43 grade, fine aggregate of size retained in 1.18mm and pulverized sludge were taken. A mould size of 100mm x 100mm x 100mm was used for testing.

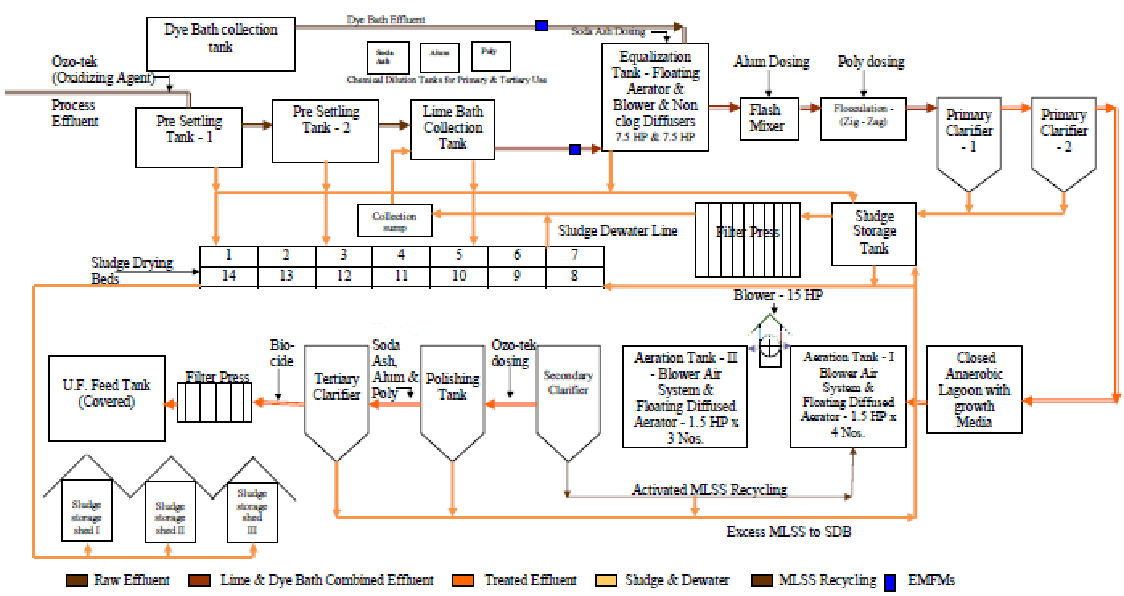

Fig.1. Layout of the tannery processing industry

Thermo gravimetric analysis (TGA) and Differential Gravimetric Calorimetry (DSC) NETZSCH STA 449 F3 and STA449F3A – 1100-M were carried out to determine thermal stability of sludge for a temperature range from 170°C to 700°C. The heating rate of the sludge sample was 10°C/min with a nitrogen atmosphere of 100mL/min flow rate. The sludge samples were replaced to 30% by the weight of Cement. The cement + sludge: Sand ratio was 1:3. The compressive strength of the mortar were tested for 7 and 14 days in Compression testing machine.

3. Results and Discussions

3.1 Characterization of tannery sludge

The physio- chemical characteristics of the tannery sludge and the aliquot of sample taken from the mortar cast for 7 and 14 days are shown in table 1. The pH of the tertiary sludge was 4.26 in the acidic range due to the presence of cationic salts and is confirmed by the FT-IR results. The casting of sludge along with cement resulted in a alkaline pH, tested for 7 and 14 days aliquot of the sample. The very high amount of the magnesium is due to the presence of the

Table 1. Characterization of the tannery sludge and the leaching samples after cube casting

Parameters	Sludge values (mg/L)		7 days aliquot (mg/L)		14 days aliquot (mg/L)	
	BHS	TS	BHS	TS	BHS	TS
pH	8.79 ± 0.05*	4.26 ± 0.02*	10 ± 0.02*	9.53 ± 0.02*	9.06± 0.00	9.04± 0.01
Total solids	1000 ± 0.00	1000 ± 0.00	857 ± 0.03	922 ± 0.03	963± 0.02	939± 0.0 0
Volatile solids	180 ± 0.05	330 ± 0.05	855 ± 0.04	461 ± 0.04	960± 0.01	943± 0.00
Fixed solids	820 ± 0.04	670 ± 0.04	20 ± 0.05	20 ± 0.00	34± 0.03	42± 0.01
Calcium hardness	-	-	20 ± 0.02	25 ± 0.00	31± 0.02	36± 0.03
Magnesium hardness	-		55 ± 0.0	460± 0.05	62± 0.02	483± 0. 04
Sulphate	-	-	298 ± 0.01	470 ± 0.02	± 0.04	± 0.05
Biochemical oxygen demand (BOD)	-	-	200 ± 0.01	450 ± 0.01	± 0.01	± 0.01
Chemical oxygen demand (COD)	-	-	600 ± 0.01	1400 ± 0.01	1000± 0.01	800± 0.00

- * pH as no units

Magnesium sulphate involved in the tertiary treatment process of the sludge. The high solids in both the beam house and tertiary sludge confirm the presence of organic and inorganic matters present in the sludge. The peaks of FT-IR of the sludge 2880cm^{-1} of the BHS denotes the presence of Chitosan linkages and at 1829.56cm^{-1} show the presence of biodegradable inorganic matter. The FT-IR spectroscopy of TS showed the abundant presence of water content in 3381.05cm^{-1} and the magnesium salts in 2140.46cm^{-1}.

The proposed future studies aims in the generation of ash from the tannery sludge generated. The change in mass of the sludge samples with varied temperature was conducted by thermogravimetry analysis (TGA). The TGA spectrum of BHS and TS are illustrated in fig.3 and fig.4. the TGA of BHS and TS had an steep declination in the mass reduction and the residual mass were 91.88% and 32.92 % respectively.

Table 2. Compressive strength of the sludge mixed cement mortar

Sample	Water/Cement + Sludge ratio	Compressive strength, N/mm^2	
		7 days	14 days
Beam house sludge (BHS)	1:2.3	1.1	2.2
Tertiary sludge (TS)	1:2.3	0.1	0.5

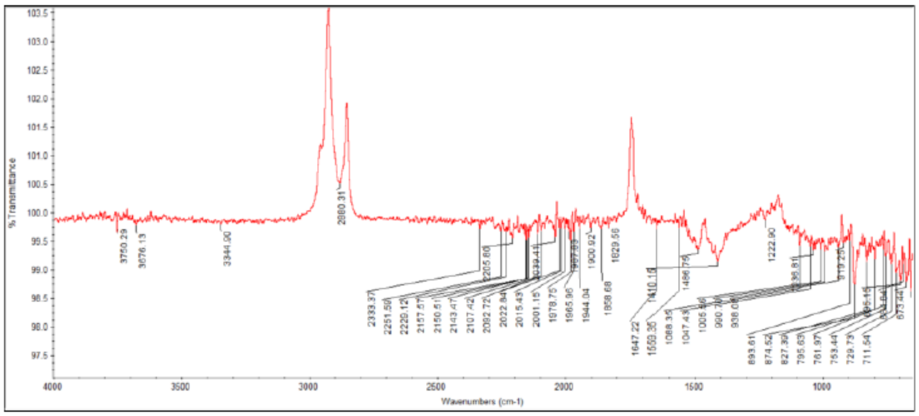

Fig.1. FT-IR spectroscopy of beam house sludge

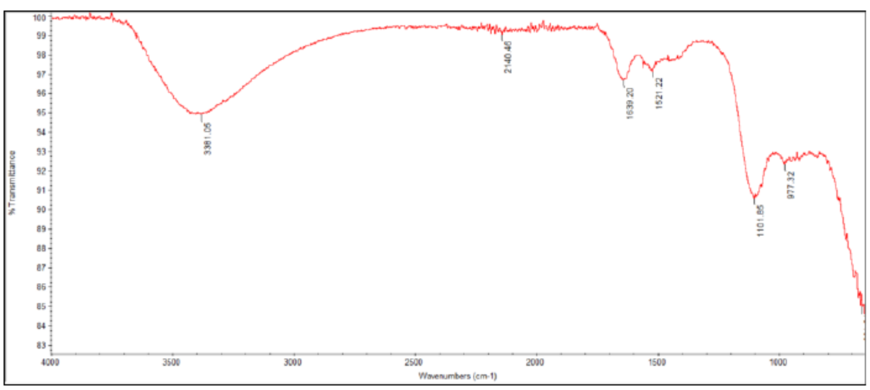

Fig.2. FT-IR spectroscopy of tertiary sludge

The compressive strength of the mortar cast is shown in table 2. The mortar cast was of very low compressive strength due to the mixing of raw sludge with the cement.

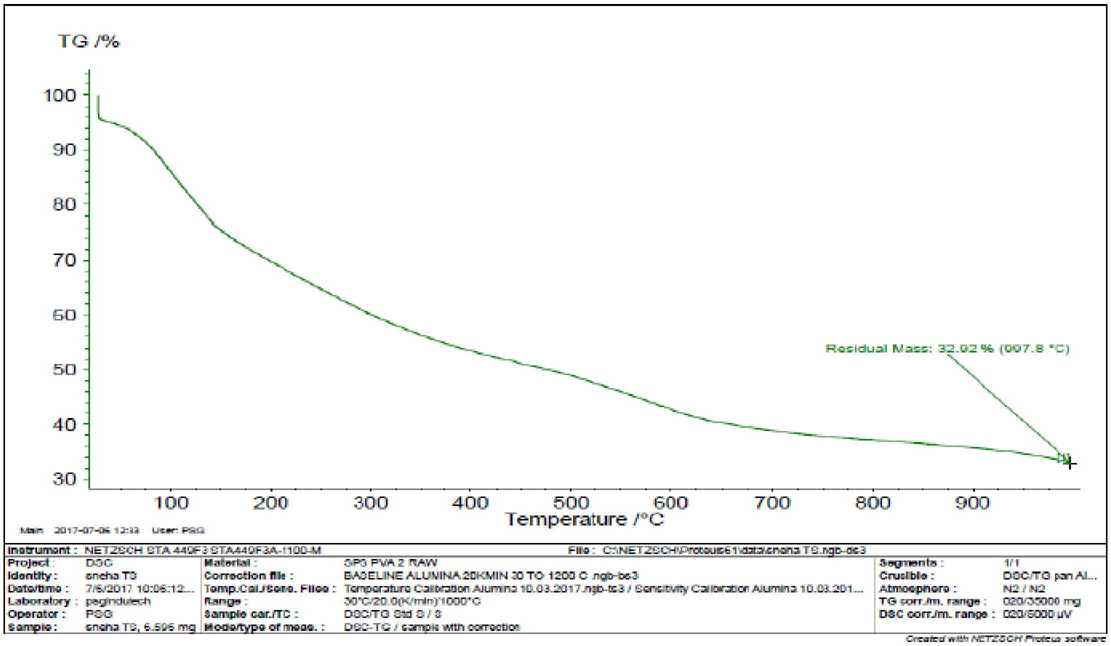

Fig.3.

TGA spectroscopy of tertiary sludge

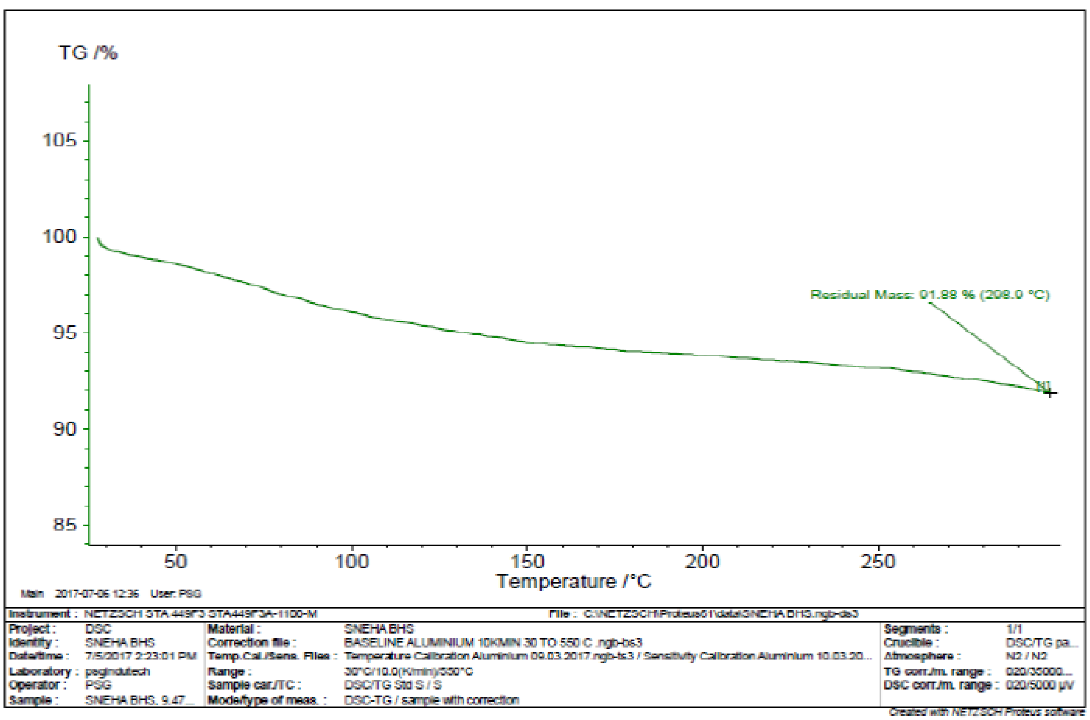

Fig.4. TGA spectroscopy of tertiary sludge

4. Conclusion and Recommendation

The raw tannery sludge collected from the beam housing showed the presence of organic matter and had a peak mass reduction from the initial of its thermo gravimetric analysis. The tertiary sludge had capability to withstand a temperature upto 600°C to 750°C. The presence of the magnesium salts upto 460mg/L and the FT-IR peak of 1880cm^{-1} confirmed the inorganic nature of the tertiary sludge. The very low compressive strength of the BHS and TS were 2.2 N/mm^2 0.2 N/mm^2 for 14 days respectively.

The disposal of the sludge in its present nature is not ecofriendly. The sludge is proposed to undergo an incineration/starved air combustion. The incinerated sludge ash is recommended and casted in the mortar mix in combination with certain admixtures in increasing the compressive strength. The S/S mortar causes the immobility of the contaminants and the leaching characteristics are planned to be studied for the S/S waste leading to safe disposal of the sludge.

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18.

Environment-Friendly Fabric Treated With *Acalypha Indica*

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ABSTRACT

Eco friendly dyes of natural origin seem to have promising use in the fields of textiles colouration has stated gaining impetus, the success which may be largely dictated by the development and availability of environmentally safe methods of application to textile substrate, designing eco-friendly dyes or artificial or manmade types. Natural dyes are dyes and pigments that are obtained from natural source without chemical processing. Natural dyes are aesthetically appealing, environment friendly, and bio – degradable, non – toxic and cost effective. With the world becoming more conscious towards ecology and environment, there is a greater need to revive our heritage. . In dyeing with synthetic dyes enormous chemicals are released in environment in the form of unused dye or industrial waste. Present increasing awareness about environment, pollution and ecology both nationally and internationally has revived the adoption of age old techniques of natural dye. In recent years a lot of awareness and concern has developed over the environmental issues. Health hazards caused by the synthetic dyes in particular continue to be serious problem. The natural dye was obtained from different solvent extracts of Acalypha indica and, its belongs to the family Euphorbiaceae, commonly known as Kuppaimeni in Tamil. It has been used in Ayurveda system of medicine for various alinments.The dye from natural source are non – pollutant, non-allergic, having rich shade etc. Acalypha indica plant held in high esteem in traditional Tamil siddha medicine as it is believed to rejuvenate the body. It is very good remedy in the treatment of skin eruptions, ring worms, eczema. The leave extract are applied to pustules, insect bites. The use of non –allergic, nontoxic and eco-friendly natural dyes on textiles has become a matter of significant importance due to the increased environmental awareness in order to avoid some hazardous synthetic dyes. The textile industries release large amount of effluents so we should pay great attention to eradicate the environment pollution from the effluent and save the environment.

KEY WORDS

Eco friendly, Bio-degradable, Natural dyes, Acalypha indica, Non –toxic.

INTRODUCTION

Textiles has become a part of every walk of life and occupies a premier position in the industrial economy of India in respect to employment .Textile industries are facing a challenging condition in the field of quality and productivity due to the globalization of world market .

In recent years a lot of awareness and concern has developed over the environmental issues. The textile dyeing industry consumes large quantities of water and produces large volumes of wastewater from different steps in the dyeing and finishing process. Increasing concern about environment, eco-friendly methods of natural dyeing are followed.

Natural dyes are dyes and pigments that are obtained from natural source without chemical processing .The use of natural dye are non –allergic, nontoxic and eco-friendly natural dyes on textiles has become a matter of significant importance due to the increased environmental awareness in order to avoid some hazardous synthetic dyes.

OBJECTIVES

- To select a suitable natural dye source and mordants.
- To Optimization of extraction and dyeing parameters.
- To Dyeing the sample using extracted dye solution.
- To study about the ecofriendly natural dye.

ECO FRIENDLY NATURAL DYE

Eco friendly dyes of natural origin seem to have promising use in the fields of food colouration, drugs and cosmetics. During last two decades natural dyes have witnessed a process of revival with the increasing awareness of consumers far eco textiles and need to preserve environment has led to the revival of old practice of coloration with natural dyestuff.

CLASSIFICATION OF NATURAL DYE

Natural dyes are classified into two groups as substantive dyes and adjective dyes. The adjective dyes are nothing but mordant dyes, which can apply on textile materials, mordanted with metallic salts. In substantive dyes, the colourants to which dye the fibres directly points out.

ADVANTAGE OF NATURAL DYE

- The colors are gentle, soft, and subtle and create a restful effect, the colour is enhanced with age and mellows to increasingly beauty.
- Natural dyes are used in the conservation and repair of historic times, better bio – degradability and generally higher compatibility with the environment. They also act as manure, enriching the soil.
- Natural dye have lower toxicity, are non – allergic and non – carcinogenic.

DISADVANTAGE OF NATURAL DYE

- Limitations of natural dyes that were responsible for their decline are availability complexity of dyeing process, colour yield and reproducibility of shades.
- There is great difficulty in blending of dyes, non- standardized inadequate degree of fixation, and inadequate fatness properties.

USES OF NATURAL DYES

The production and application of which release vast amount of waste and unfixed colorants causing serious health hazards and disturbing the eco – balance of nature. Nowadays, fortunately, there is increasing awareness among people towards natural dyes.

NATURAL SOURCE

Distribution of***ACALYPHA INDICA***

Taxonomic Classification

Kingdom :Planate

Class : Magnoliopsida

Order : Euphorbiales

Family : Euphorbiaceae

Sub family: Acalyphoideae

Genus : Acalypha

Species : Acalypha

MEDICINAL VALUE OF *ACALYPHA INDICA*

ACALYPHA INDICA has been used in avurvedic system of medicine for various ailments. It has been reported that this plant poses antibacterial, antifungal and used also check wound healing.

METHODS OF DYE EXTRACTION

The leaves of Acalypha indica were air dried in the shade and ground into a fine powder. The powder was gradually dissolved in distilled water at a ratio 1:20 at room temperature. Extraction process is carried out at a temperature range of 80-85°c for 1 hour. The extract was collected by initially filtering with gauzes. The Colouring materials from the leaves are extracted to dyeing the fabric.

COLLECTION OF NATURAL SOURCE

ACALYPHA INDICA plants are mostly available in roadside and wastelands. The leaves are collected from roadsides .The collected leaves are washed with distilled water for 5 minutes at room temperature for the removal of dust and soil particles.

SELECTION OF FABRIC

Cotton, natural, vegetable fibre of great economies importance as a raw material for cloth. It's wide spread use in largely due to the ease with which its fibre are spun into yarns.

PRE -TREATMENT OF THE FABRIC DYEING

The aim of preparatory process is improving the quality by removing impurities and foreign matters. Desizing plays a major and very important role in achieving a perfect fabric feel, Desizing is a process of removing impurities from the woven fabric.

SELECTION OF MORDANTS

A mordant is a substance used to set dyes on fabrics by forming an insoluble compound with a dye. Mordants are the materials that cause the natural dyes to band chemically with the cloth. Mordant is used as the fixing agents to the colours absorbed in the fabrics.

SELECTION OF MORDANTING TECHNIQUES

They are three types of methods for application of mordants based on the time of their usage they are

- Pre – mordanting
- Simultaneous mordanting
- Post - mordanting

SELECTION OF DYE EXTRACTION METHOD

CONVENTIONAL OR EXISTING METHOD OF EXTRACTION

ACALYPHA INDICA leaves were air dried in the shade and ground into a fine powder. The powder was gradually dissolved in distilled water at a ratio 1:20 at room temperature. Extraction process is carried out at a temperature range of 90°c for 1 hour with various concentration of dye source. The extract was collected by initially filtering with gauzes. The Coloring materials from the leaves powder are extracted to dyeing the fabric

SUMMARY AND CONCLUSION

The present study shows that the ***ACALYPA INDICA*** leave powder dyeing potential as a source for cotton dyeing. The dyed sample has good dye affinity in it. The synthetic dye has caused serious threat to the environment and hence nowadays synthetic dyes have been replaced by natural dyes .This natural dyeing process reduces the environmental impact and keeps the environmental clean.

Due to the nature of various chemical processing of textiles large volumes of waste water with numerous pollutant are discharged. Interest in ecological friendly wet processing textile techniques has increased in recent years because of increased awareness of environmental issues throughout the world.

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19.

Evaluation And Optimization Of Novel Plant Based Materials For Coagulation-Flocculation Process Of Palm Oil Mill Effluent (POME) Treatment With Response Surface Method (RSM)

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ABSTRACT

The ever-rising production of Palm Oil Mill Effluent (POME) has disabled the conventional treatment of aerobic and anaerobic ponding system to comply with the discharge limits set by Department of Environment (DOE), Malaysia. Addition of Coagulation-Flocculation process in POME treatment has proven to enhance the performance of the treated POME. The chemical coagulants have numerous pros but their potential to cause damage to the environment has shifted the interest of researchers to use of natural plant based coagulants and flocculants. This study focuses on use of okra (*Abelmoschus esculentus* L.) Moench, peanut (*Arachis hypogaea* L.), and wheat germ seeds (*Triticum aestivum* L.) as novel bio-flocculant and bio-coagulants. Two pairs of bio-coagulant and bio-flocculant (peanut seeds-okra and wheat germ seeds-okra) were formed and studied with respect to their removal efficiency of turbidity, TSS and COD. With the application of Design Expert®, a Central Composite Design (CCD) was constructed under Response Surface Method (RSM). The highest observed removal efficiencies of TUR, TSS and COD (92.49%, 86.58% and 34.83% respectively for PN–OK; 86.55%, 87.54% and 43.62% respectively for WG–OK) were obtained at optimum pH, coagulant and flocculant dosages (pH 11.57, 1000.05 mg/L and 135.46 mg/L respectively for PN–OK; pH 12, 1170.50 mg/L and 100 mg/L respectively for WG–OK). The natural coagulants and flocculant as well as POME solids were analyzed with Fourier Transform Infrared Spectroscopy (FTIR) and Energy Dispersive X-Ray Spectroscopy (EDX) for identifying the active components. The dewatering characteristics of the POME solids are obtained and calorific value of the solids is also calculated. The investigation suggests a zero-waste process as the treated water can be re-cycled and POME solids can be added in fertilizers or used as a soil-top-up.

KEYWORDS: Bio-coagulants; bio-flocculants; wheat germ seeds; POME; Design Experiment; FTIR; EDX

1.INTRODUCTION

The ever-increasing Palm Oil industry in Malaysia has gained immense attention over the years. The corresponding wastewater- Palm Oil Mill Effluent (POME) produced has increased as well. Conventional Ponding system treatment of POME requires large area of land and is time consuming. It also produces large amounts of methane, a harmful Green House Gas (GHG). Thus, this experiment focuses on treatment of POME with coagulation-flocculation process. Although, conventional coagulants and flocculants produce high amount of toxic sludge and are expensive. Therefore, this experiment focuses on use of plant based materials.

2. METHODOLOGY

2.1 EXPERIMENTAL METHODS

Raw Palm Oil Mill Effluent (POME) sample was collected from Seri Ulu Langat Palm Oil Mill Sdn. Bhd. in Dengkill, Malaysia. The samples were drawn from the facultative pond of the Waste Water Treatment Station of the above-mentioned plant. The samples were kept for 24 hours before proceeding with the experiment. The sample bottles are inverted few times before extracting for the conduction of the experiment. The typical characteristics of the collected POME sample are mentioned in table 1.

TABLE 1: TYPICAL CHARACTERISTICS OF COLLECTED RAW POME

Parameter	Unit	Range	Average Value
Turbidity (TUR)	NTU	197 – 394	299
Total Suspended Solid (TSS)	mg/L	370 – 762	525
Chemical Oxygen Demand (COD)	mg/L	1083 – 1359	1226

The Coagulants and Flocculant used for this experiment are Wheat Germ Seeds, Peanut Seeds and Okra, respectively. The coagulants, wheat germ seeds and peanut seeds were bought from a local supermarket in Semenyih, Malaysia and were later dried in an oven for 24 hours at 60°C. This ensures complete moisture removal from the coagulants. Then, the dried samples were grounded into solid powder using a domestic blender. Similar procedure for followed for okra pods, however, the pods were halved and seeds and fibre was extracted and the remaining skin was dried at a lower temperature of 40°C. Then the dried pods were grounded as well. The powdered samples are used for preparation of a stock solution with concentration of 50,000 mg/L. For coagulant stock solution, 25 grams of respective powdered coagulant is added to 500 mL of 1M brine solution and stirred on magnetic stirrer for 10 minutes with rpm of 700-

750. Whereas, for flocculant stock solution preparation 10 grams of okra is used, as opposed to 25 grams of the coagulants.

2.2 JAR TEST AND ANALYSIS

The most widely used process for coagulation and flocculation is Jar Test. The Jar Test is conducted for two pairs of Peanut seeds-okra and Wheat germ seeds-okra. The Phipps & Bird Jar-tester accommodates 6 beakers and contents of each beaker can be stirred at same speed with six-spindle of steel paddles. For this experiment, 500 mL beakers were filled with 300 mL of raw POME sample. The coagulant and flocculant stock solution were added according to the values obtained from Design Expert software. Then the impellers were immersed and stirred at 150 rpm for 2 minutes to ensure uniformity. Then, pH of the solution was adjusted with addition of 1M Sodium Hydroxide (NaOH) solution according to the values specified from Design Expert software. The impellers are immersed again and stirred for 5 minutes at 150 rpm followed for 30 minutes at 30 rpm. Then the impellers are removed and the solution is allowed to settle for 1 hour. The settled mixture contains supernatant fluid layer and settled sludge. The supernatant is collected for analysis of Turbidity (TUR), Total Suspended Solids (TSS) and Chemical Oxygen Demand (COD).

The initial TUR, TSS and COD of the raw POME samples were recorded and the removal percentages were calculated with reference to it. These values are added to the Design Expert software for further modelling.

The settled sludge undergoes Sludge Dewatering Characteristic test followed by Fourier Transform Infrared Spectroscopy (FTIR) and Energy Dispersive X-Ray Spectroscopy (EDX) followed by Calorific Value measurement. The results are discussed in the next section.

Response Surface Methodology (RSM) by Design Expert® Version 6.0.5 software (Stat-Ease Inc., Minneapolis, USA) was used for design, mathematical modelling, and optimization. The manipulative variables were Dosage of Coagulant and Flocculant and pH. Their respective removal efficiency of TUR, TSS and COD were added. The range for the manipulative variables was obtained via literature study and preliminary experiment. The selected rage was: 10-12 for pH, 1000-5000 mg/L for coagulant dosage and

100-500 mg/L for flocculant dosage. Based on the Central Composite Design, the Design Expert software produced 20 runs with different combinations listed in Table 2.

TABLE 2: TYPICAL CHARACTERISTICS OF COLLECTED RAW POME

Peanut Seeds - Okra							Wheat Germ Seeds - Okra						
Run	Factors			Response			Run	Factors			Response		
	A	B	C	TUR	TSR	CODR		A	B	C	TUR	TSR	CODR
1	10	1000	500	52.6	49.1	27.4	1	10	1000	500	52.6	49.1	27.4
2	10	3000	300	46.4	44.0	31.4	2	10	3000	300	46.4	44	31.4
3	11	3000	300	79.2	76.0	30.2	3	11	3000	300	79.2	76	30.2
4	12	3000	300	85.8	86.1	41.9	4	12	3000	300	85.8	86.1	41.9
5	12	5000	500	77.9	85.2	35.5	5	12	5000	500	77.9	85.2	35.5
6	11	3000	500	79.2	77.8	31.8	6	11	3000	500	79.2	77.8	31.8
7	11	3000	300	75.8	72.1	38.6	7	11	3000	300	75.8	72.1	38.6
8	11	3000	300	82.4	77.4	43.1	8	11	3000	300	82.4	77.4	43.1
9	12	1000	100	88.6	88.5	38.0	9	12	1000	100	88.6	88.5	38
10	11	3000	300	80.6	77.0	40.9	10	11	3000	300	80.6	77	40.9
11	10	1000	100	65.7	58.8	42.4	11	10	1000	100	65.7	58.8	42.4
12	11	3000	300	72.3	65.8	28.5	12	11	3000	300	72.3	65.8	28.5
13	11	3000	100	82.7	76.4	38.9	13	11	3000	100	82.7	76.4	38.9
14	11	5000	300	81.3	75.8	30.0	14	11	5000	300	81.3	75.8	30
15	10	5000	500	33.2	26.0	9.1	15	10	5000	500	33.2	26	9.1
16	11	3000	300	68.5	64.5	36.6	16	11	3000	300	68.5	64.5	36.6
17	10	5000	100	26.0	31.5	25.1	17	10	5000	100	26	31.5	25.1
18	12	5000	100	92.2	90.6	38.9	18	12	5000	100	92.2	90.6	38.9
19	12	1000	500	82.0	84.2	43.5	19	12	1000	500	82	84.2	43.5
20	11	1000	300	78.9	74.2	43.5	20	11	1000	300	78.9	74.2	43.5

In the above table, Factors A, B and C correspond to pH, coagulant and flocculant dosage respectively. The responses TUR, TSR and CODR correspond to TUR, TSS and COD removal percentage respectively.

3. RESULTS AND DISCUSSION

The interaction of independent variables of pH, coagulant dosage and flocculant dosage with the response variables of TUR, TSS and COD removal percentage were investigated with help of 3D plots of regression models. The plots produced via regression model are shown below in Figure 1 to 6.

EXPERIMENT 1: PEANUT SEEDS – OKRA PAIR

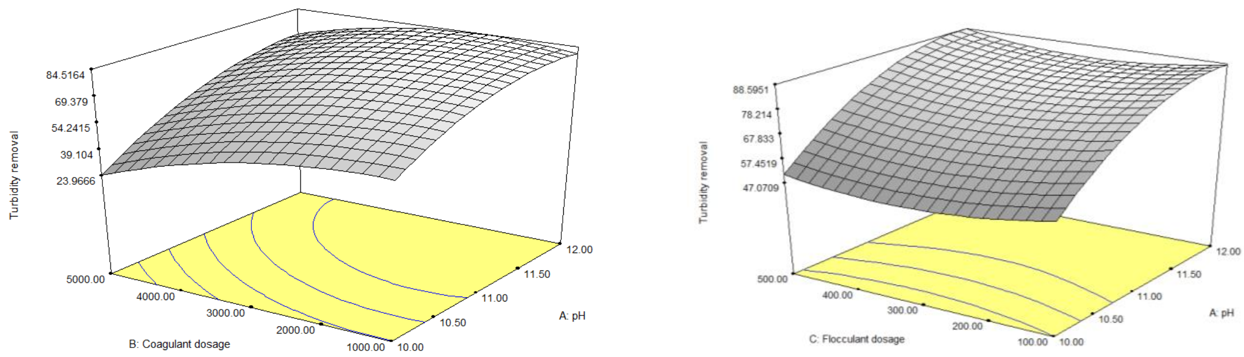

Figure 1-2: TUR removal percentage; relation of pH with coagulant and flocculant dosages

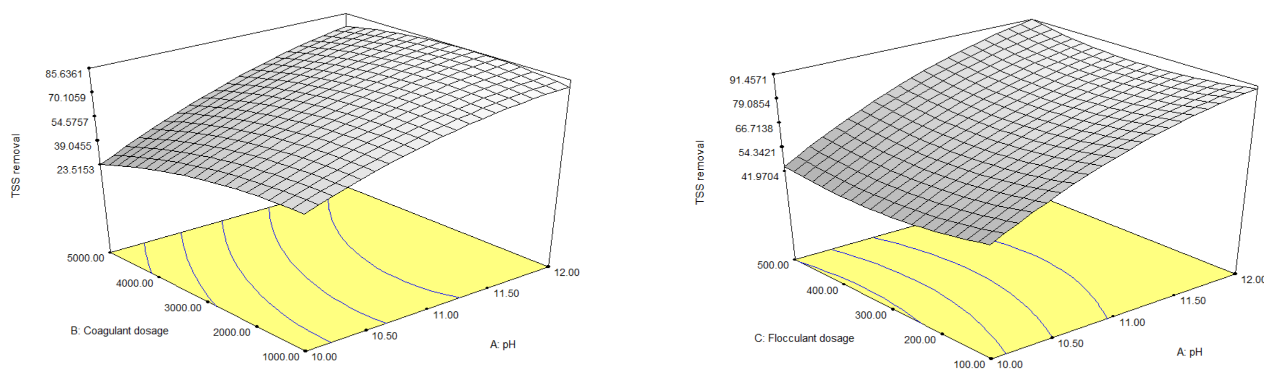

Figure 3-4: TSS removal percentage; relation of pH with coagulant and flocculant dosages

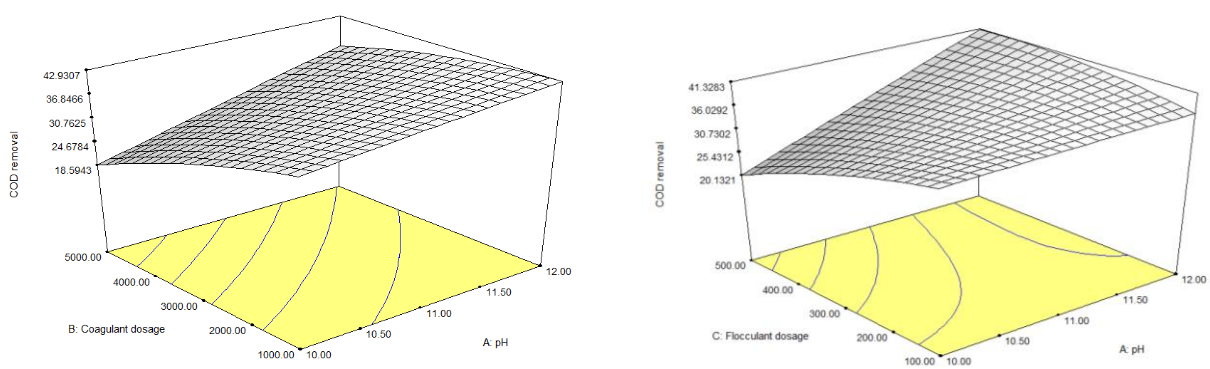

Figure 5-6: COD removal percentage; relation of pH with coagulant and flocculant dosages

EXPERIMENT 2: WHEAT GERM SEEDS – OKRA PAIR

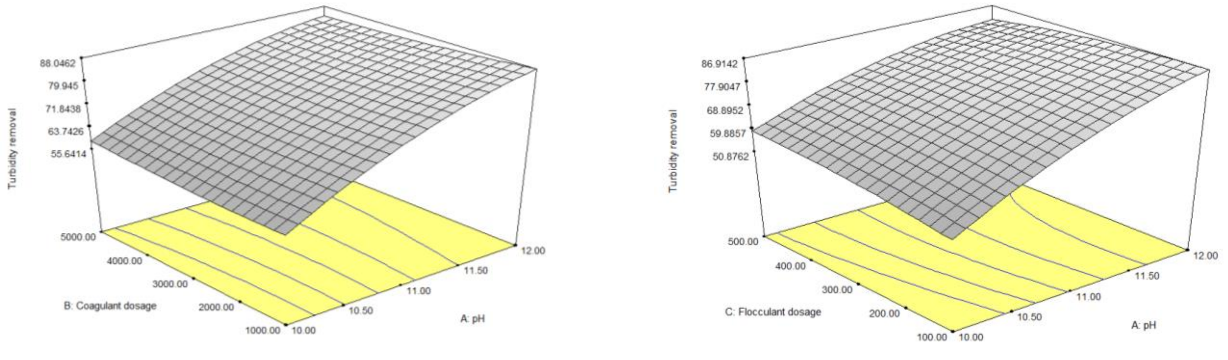

Figure 7-8: TUR removal percentage; relation of pH with coagulant and flocculant dosages

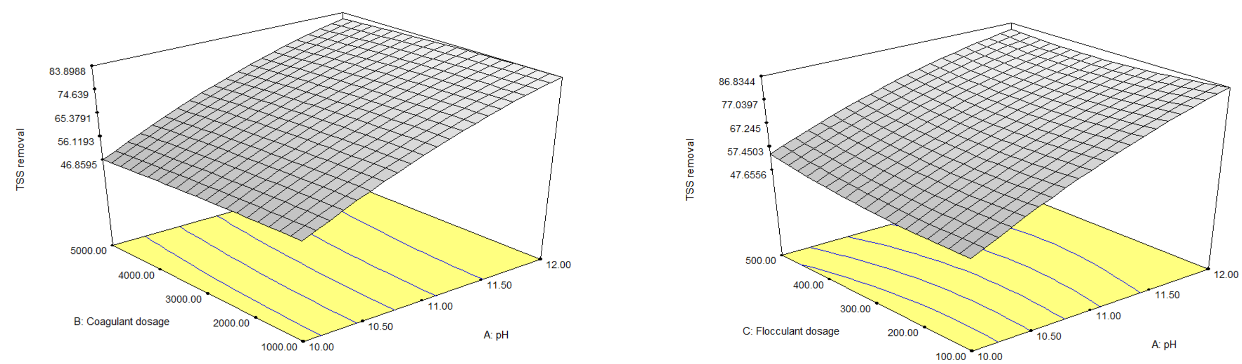

Figure 9-10: TSS removal percentage; relation of pH with coagulant and flocculant dosages

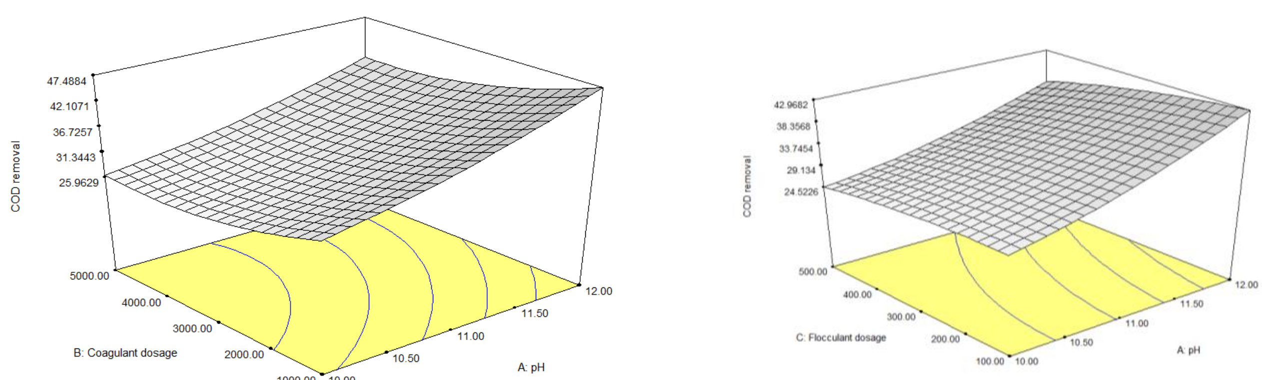

Figure 11-12: COD removal percentage; relation of pH with coagulant and flocculant dosages

The above figures depict the relation of manipulative variables with that of the factors. A trend can be observed in the first experiment. The removal efficiencies of TUR, TSS and COD are high at low coagulant dosage and high flocculant dosage. On the other hand, in second experiment, high efficiency is obtained at low coagulant dosage and low flocculant dosage.

The optimization studies conducted showed following values for the given dosages:

TABLE 3: Optimum parameters from Design Expert software

Variables	Peanut–Okra	Wheat germ–Okra
pH	11.57	12.00
Coagulant dosage (mg/L)	1000.05	1170.50
Flocculant dosage (mg/L)	135.46	100.00
Desirability	0.957	0.978

TABLE 4: Observed and Predicted values from validation experiment

Response Variables	Peanut–Okra		Wheat germ–Okra	
	Observed	*Predicted*	*Observed*	*Predicted*
TUR removal (%)	92.49	92.27	86.55	88.71
TSS removal (%)	86.58	86.79	87.54	86.35
COD removal (%)	34.83	36.33	43.62	46.81

The FTIR and EDX results confirms the presence of proteins and fatty acids in the natural coagulants and flocculants which is missing in the sludge samples. This ensures the use of these functional group for coagulation and flocculation of POME.

The analysis conducted on sludge depicts that the sludge obtained from POME coagulation and flocculation has very low solids content. The water removed via centrifugation is high thus producing less sludge volume. The bomb calorimeter calculated the calorific value of the sludge. Although, it is not enough to be used as a fuel alone. It needs to be enhanced.

4. CONCLUSION

The two pairs selected, (peanut seeds-okra & wheat germ seeds-okra) were evaluated and optimized with respect to the manipulative variables of TUR, TSS and COD removal percentages. The Design Expert software successfully constructed the model and optimized it according to the given conditions. The optimum operating parameters of coagulation–flocculation process by using PN–OK as coagulant–flocculant were pH 11.57, 1000.05 mg/L peanut dosage and 135.46 mg/L okra dosage in order to yield the maximum TUR, TSS and COD removal efficiencies of 92.49%, 86.58% and 34.83%, respectively. The optimum operating parameters using WG–OK as coagulant–flocculant were pH 12, 1170.5 mg/L WG dosage and 100 mg/L OK dosage in order to yield the maximum TUR, TSS and COD removal efficiencies of 86.55%, 87.54% and 43.62%, respectively.

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Evaluation of Household Waste Disposal Strategy in Different Areas of Salem.

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ABSTRACT

Municipal solid waste management and quality of community disposal strategy revolving in Salem typically meet state criteria for municipal solid waste reclamation. This paper endeavors an assessment of the current situation of municipal solid waste management (MSWM) in different areas of Salem. A manual survey was conducted through a questionnaire in 15 different areas of Salem district representing different taluks of Salem to account the primary household waste disposal strategy. Extensive investigations were carried out for community waste disposal quantification, analysis of physical composition, and characterization of MSW in each of the identified cities. The MSW management status (per the MSW Rules, 2000) has also been assessed, and an action plan for better management has been formulated; both are presented in this paper. Studies carried out with a structured questionnaire which interrogates the types of waste generated, amount of waste generated in a home per day and disposal methods, whether compost pit exist or not. In all the 15 areas at different locations around a sample 10 houses were surveyed. The collected data was analyzed thoroughly and profound existing strategies in all the 15 places were found out. This survey is taken for 15 different areas of Salem which are Pannangkattur, R.E.Quarters, Neethipuram, K.Pudur, Sauripalayam, Avarangapalayam, Kannangkurichi, Mullaivadi, Allikuttai, Suramangalam, Udayapatti, Alagapuram, Shevapet, Jagairammapalayam and Narayanapuram. To overcome the deficiencies in the existing MSWM systems, an indicative action plan has been presented incorporating strategies and guidelines.

Keywords: Manual survey, Structured Questionnaire, Waste Disposal Strategy

I. INTRODUCTION

Solid waste management is a challenge for the Salem authority in Tamilnadu mainly due to the increasing generation of waste, the burden posed on the municipal budget as a result of the high costs associated to its management, the lack of understanding over a diversity factors that affect the different stages of waste management and linkages necessary to enable the entire handling system functioning. We point out that as India moves towards stricter regulation of waste disposal techniques to control dumpsite pollution greater efforts required to reduce the risk to public health as toxic pollutants which are mainly colourless and odourless can be expected to be released into the ecosystems. Waste Disposal has become the most challenging task in developing countries. To include the hygiene & sanitation in common life style, we need to promote effective waste disposal system. Our paper describes the common primary household waste disposal strategies evolving in Salem. The methods may result in an ultimate disposal way in terms of community disposal or in terms of individual house disposal and their impacts on environment are discussed.

II. SALEM DISTRICT

Salem is located in the southern part of India at 11.669427°N. 140865°E at an average elevation of 278m (912ft). Salem is located about 340 kilometers (210 miles) southwest of Tamil Nadu. The area of Salem City is 134 Sq.km. 829,267 is the present population of Salem City. With such a vast land area population, it is becoming tougher to provide basic facilities in hygienic manner to people and also Environmental issues in Salem Corporation are getting increased day by day. Daily waste generation around 350tonnes of Municipal Solid Waste is approximates in Salem City.

Salem district has nine taluks. They are Mettur, Omalur, Salem, Attur, Edappadi, Sankari, Yercaud, Gangavalli, and Vazhapadi. Salem Municipal Corporation consists of 60 wards with an extent of 91.34 sq. km. Dumper bins are placed at suitable locations for collection of garbage. The garbage is collected and transported through the fleet of vehicles for disposal. Under the 60 wards around 21 divisions are privatized for primary collection and transportation of the garbage. The garbage is processed scientifically in the newly constructed, solid waste processing plant on BOOT basis in Chettichavadi as per the Solid waste management rules, 2000.

About 350 tones of wastes generated by the Salem City Municipal Corporation every day is being processed and converted into reusable materials. The processes involved in waste management are Tipping, Auto segregation, Separate processing of materials (Refused derived fuel, Remoulded plastics, Bio-composting), Sanitary land filling.The existing solid waste management system in Salem serves as an example of steer solid waste management system in a technical manner. The concept of solid waste management should originate truly right from the point of waste generation. To encounter the waste generation and disposal strategy we went on to a manual survey to different places of Salem with the questionnaire.The questionnaire reveals information about generation and disposal strategy in different parts of Salem. The survey is conducted in 15 different places of Salem to know the primary household waste disposal strategy. The rate of waste generation varies from area to area and based on population, standard of living etc.

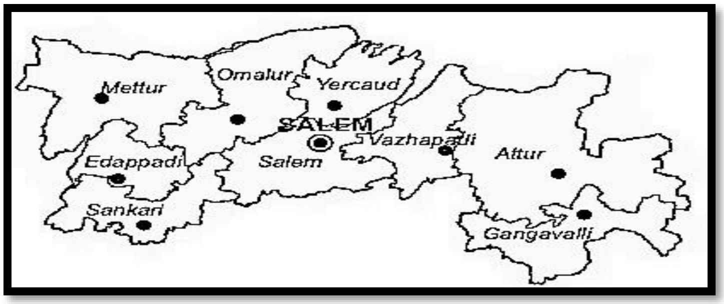


Fig1. Salem Taluk Map

III.METHODOLOGY

1. Manual Survey

A manual survey was conducted through a questionnaire in 15 different areas of Salem district representing different taluks of Salem to account the primary household waste disposal strategy. In all the 15 areas at different locations around a sample 10 houses were surveyed. The collected data was analyzed thoroughly and profound existing strategies in all the 15 places were found out.

i) Objectives of Manual Survey:

- Evolving existing primary household waste disposal strategies in each different areas of Salem.
- Around 10 individual houses were surveyed randomly ineach different areas of Salem.

ii) Questionnaire:

Our questionnaire is formulated to collect the information about the daily waste generation and primary individual household waste disposal strategies existing in different areas of Salem. The direct reply from the resident is accounted as original result.

Questionnaire

Present Disposal and Management of Solid Waste Strategy in Rural Areas of Salem

- ✓Taluk:
- ✓Name of the village:
- ✓Name of the resident:
- ✓Number of persons in your home:
- ✓Address:
- ✓Amount of waste generated per day in your home:
- ✓Solid waste (kg)
- ✓Types of solid waste
- ✓Disposal strategy:
- ✓Incineration/Burying/Dumping/Composting
- ✓Whether compost pit exist or not - yes or no

Fig2. Questionnaire

iii) The questionnaire reveals the following information

- ✓ Waste quantity generation in individual house fromeach different area of Salem.
- ✓ Composition of daily waste from individual house of each different areas of Salem.
- ✓ Primary waste disposal strategies revolving in each different areas of Salem.

S.NO	TALUK	AREA
1	Omalur	Pannangkattur
2	Mettur	R.E.Quarters Neethipuram
3	Edappadi	K.Pudur Sauripalayam
4	Sankari	Avarangapalayam
5	Yercaud	Kannangkurichi
7	Salem	Allikuttai Suramangalam Udayapatti Alagapuram Shevapet Jagairammapalayam
8	Gangavalli	Narayanapuram

Fig3. Surveyed Places in Different areas of Salem

IV.RESULTS AND DISCUSSION

i) Evolving Current Waste Disposal Strategy in different areas of Salem:

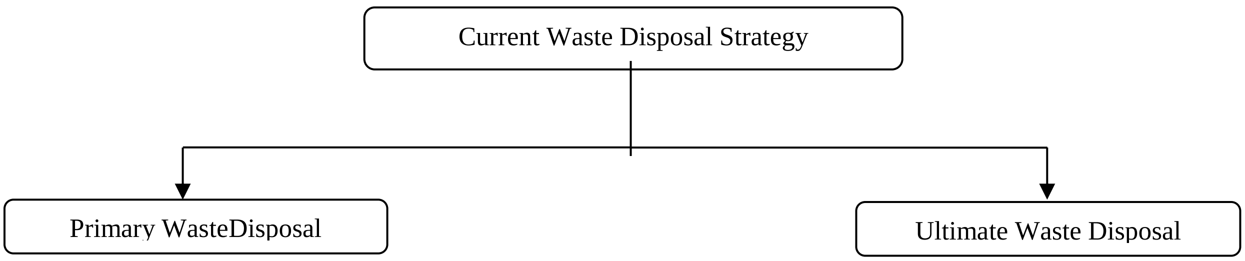
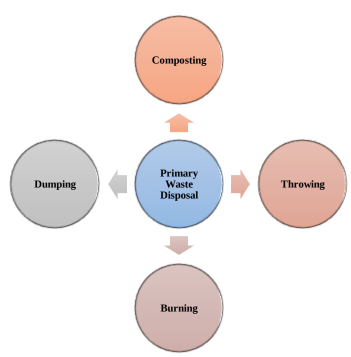
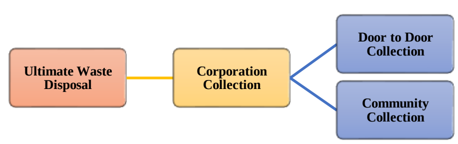


Fig4. Current Waste Disposal Strategy in different areas of Salem

Table1. Evolving Current Waste Disposal Strategy in different areas of Salem

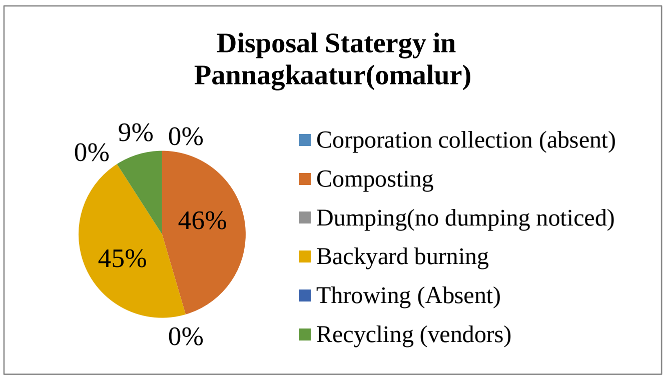
Current Waste Disposal	**Definition**
Primary Waste Disposal	*The primary practice of disposing the domestic waste nearby the individual houses in and around their Permises.* 
Composting	Composting is a form of waste disposal where organic waste decomposes naturally under oxygen-rich conditions. Although all waste will eventually decompose, only certain waste items are considered compostable and should be added to compost containers. Food waste, such as banana peels, coffee grinds and eggshells, are great items to compost.

	
Throwing	*The disposal of waste by simply throwing near the compound wall or at the edge of house. This may also cause breeding of mosquitoes, rodents which cause disease to human.*
Burning	*Burning of waste materials converts the waste into ash, flue gas and heat. The ash is mostly formed by the inorganic constituents of the waste, and may take the form of solid lumps or particulates carried by the flue gas.* 

Community Burning	Process of Collecting the waste from each house at the end of the street and converting it into ash, flue gas and heat.
Backyard Burning	*Backyard burning is a waste treatment process that involves the combustion of organic substances contained in waste materials in their own house. Backyard burning and other high temperature waste treatment systems are described as "thermal treatment".* 
Dumping	Dumping is one of the most poorly rendered services by Municipal authorities in developing countries as the system applied are unscientific, outdated and in-efficient.
Community Dumping	The domestic wastes from all the individual houses of an area are dumped in a common place of a street.
Permises Dumping	The domestic wastes from the individual houses are dumped nearby their permises. 
Ultimate Waste Disposal	*The domestic waste is collected from each house by the corporation for further treatment and disposal of waste which is away from the town.* 
Door to Door Collection	The domestic waste is collected from each house by the person from door to door with the help of vehicle in a regular cycle.

Community Collection	A common bin is kept for a single street at the edge of the street. If there is delay in removing waste the wastes are thrown outside the bin. Hence this disposal causes impact to people due to foul odors, mosquitoes, flies, etc.

Ii Comparison of Current Waste Disposal Strategy in different areas of Salem:



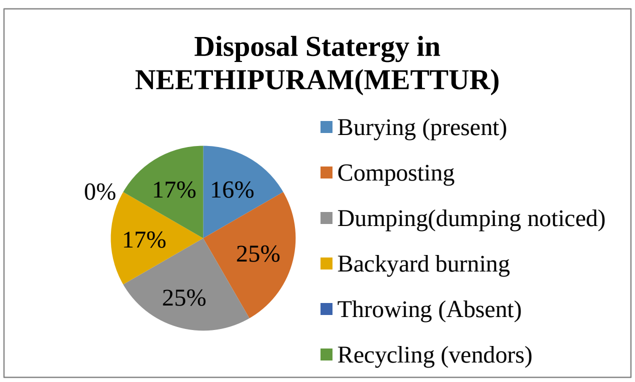
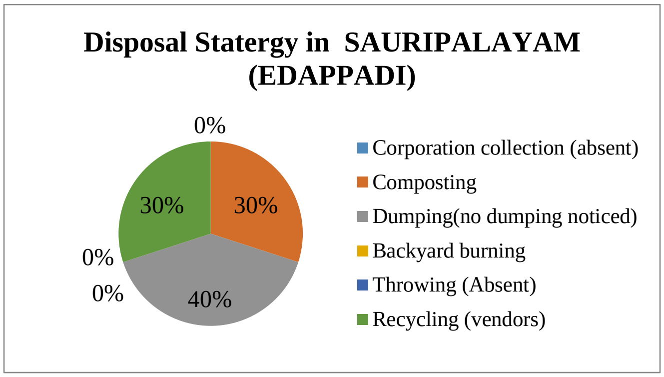


Fig6. Disposal Strategy in Omalur

Fig7. Disposal Strategy in Mettur



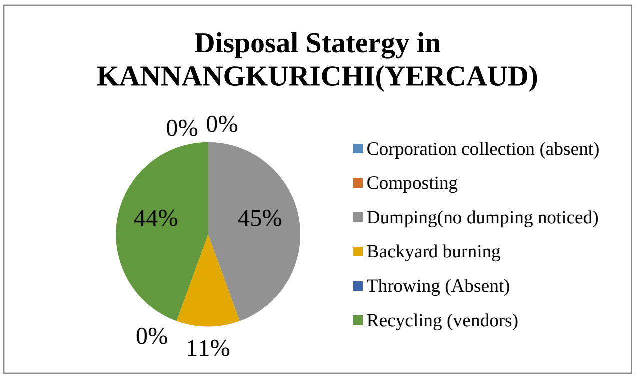
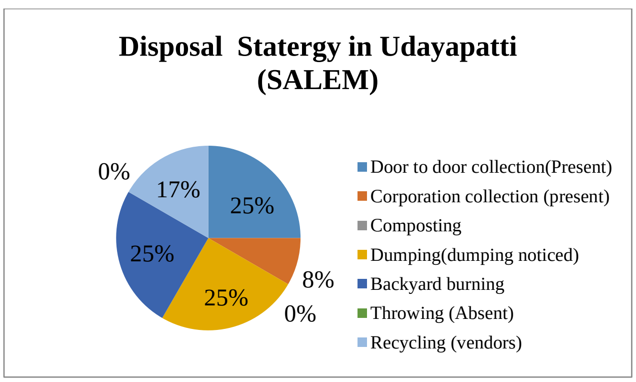


Fig8. Disposal Strategy in Edappadi

Fig9. Disposal Strategy in Yercaud



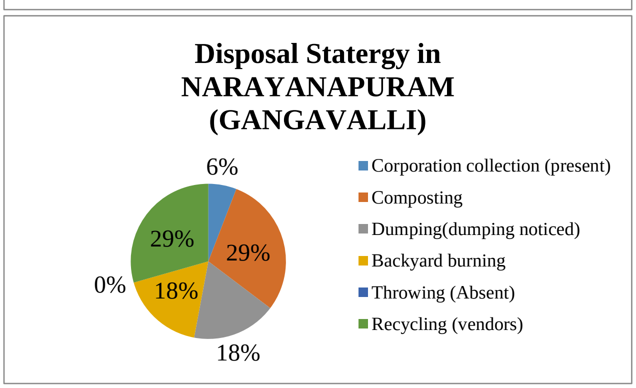


Fig10. Disposal Strategy in Salem

Fig11. Disposal Strategy in Gangavalli

V.CONCLUSION

The prediction we made from the above analysis is the current disposal strategies profoundly existing throughout Salem which can be classified as primary and ultimate waste disposal. Among the surveyed places the majority people in the rural areas likepannagkaatur(omalur), neethipuram(mettur),sauripalayam (edappadi),and narayanapuram (gangavalli) were effectively following composting as a waste disposal method and belongs to Green House(Economy generation, pollution free, eco friendly) whereas the people living in the areas kannangkurichi(yercaud) and narayanapuram (gangavalli) were following recycling as a waste disposal method and belongs to Yellow house (Economy Generation, pollution free).

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21.

Experimental And Growth Kinetics Studies Of Bacterium Isolated From Waste Automobile Engine Oil Contaminated Soil

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ABSTRACT: The release of oil or hydrocarbons into the environment whether accidentally or due to human activities is a major cause of water (both surface and groundwater resources) and soil pollution. Several gallons of waste engine oil are generated daily from automobile workshops and discharged carelessly into the environment. Several components of engine oil such as aliphatic hydrocarbons and polycyclic aromatic hydrocarbons (PAHs) are carcinogenic in nature. Safe disposal of these wastes is a serious problem and has gathered the attention of the researchers' world over. None of the available conventional disposal methods is environment-friendly. Biological methods have been well reviewed and acknowledged for remediation of petroleum hydrocarbon contaminated waste such as waste engine oil (WEO). The primary objectives here are to investigate the microbial degradation of waste engine oil by isolating the oil-degrading bacteria from the waste engine oil contaminated soil. The soil samples were collected from the oil contaminated sites (nearby garages) and were utilized to obtain the oil-degrading bacterial species. Mixed microbial culture isolated from contaminated soil was grown using standard medium, with engine oil as a sole carbon source. The growth kinetics of mixed microbial culture and pure strains were analyzed by using the UV-VIS spectrophotometer (Thermo Scientific™ Evolution 201) and plate count methods for two different contaminated soil samples. The increase in absorbance at 600 nm (OD_{600}) and CFU count (CFU/ml) are indicative of bacterial growth with waste engine oil as substrate.

KEY WORDS: Hydrocarbon, Waste Engine Oil, Soil Pollution, Bioremediation, Growth Kinetics.

INTRODUCTION

Soil contamination occurs when hazardous compounds mixwater or soil. There are two primary ways by which contaminants contact with the soil, either spillage into soil or burial into soil directly. The usage of hydrocarbon products increases the soil contamination with used engine oil which is the major environmental problem. According to the analysis done by the International Tanker Owners Pollution Federation Ltd., it has been found that three oil spills of 700 tons or more occurred in year 2013 only (Abioye *et al.*,2012). The oil spill accidents, have received great attention of the world, due to their catastrophic effect on the environment. The environmental protection agency (EPA) USA estimates that only about 10% of all wastes are disposed of safely.

The conventional techniques used for remediation of hazardous wastesand its safe disposal are direct burning and landfilling. These methods can become highly expensive when the amounts of contaminants are in larger quantities. Some of the above methods are efficient but thebyproducts produced during the process have negative impacts on the environment and as well as on health of society.A better approach is to fully destroy the pollutants if at all possible, or to transform them to innocuous substances. One such possibility is the use of bio based techniques such as bioremediation. Bioremediation is the application of microorganisms to degrade contaminants from an area. The precise definition is the use of biological degradation procedures to reduce the concentration of the pollutant from the contaminated sites. It uses relatively low-cost, low-technology techniques, which is generally accepted by people and mostly carried out in situ. Even though the method employed is not technically complex, little bit of experience and expertise is required to design and implement an efficient bioremediation, due to the need to completely assess a site for suitability and for optimization of conditions to achieve a satisfactory result. Bacteria play vital role in execution of bioremediation. The enzymatic capabilities possessed by these creatures allow them to use environmental pollutants as the food source. In situ bioremediation, can be regarded as the natural process taking place for billion years breaking down plant and animal wastes.

The success of process of bioremediation depends on three factors: type of microorganism, type of contaminant and geological conditions. Bioremediation have applied to a very limited extent in cleaning up larger range of contaminants, mostly hydrocarbons, as far as commercial applications are concerned (National Research Council, 1993). Two important factors in use of organic contaminants by microbes are:i) They provide carbon source; ii) They provide electrons which are used in their oxidation. The basic mechanism is the redox reaction that takes place during bioremediation (Zahed *et al.,*2010). It's a type of reaction involving transfer of electrons between two species. The reducing agent loses its electron and oxidization takes place, the oxidizing agent gains electron and the reduction takes place.

In this paper bioremediation of the waste engine oil(WEO)by the bacterium isolated from WEO contaminated soil is discussed. The focus is majorly on the growth kinetics studies of oil degrading bacteria with WEO as the sole carbon source. The bacteria that are already present in the soil seems to have evolved to survive in the extreme conditions by degrading oil and using it as an energy source. If such strains of bacteria are identified and cultured, they can be used for remediation of the contaminated soil on a large scale, thereby reducing pollution.

MATERIAL AND METHODS

Sample collection and chemicals—Contaminated sub-surface soil samples and waste engine oils were collected from nearby garages in Pilani, India. All the chemicals used were of Analytical Range (AR) grade and procured from Sigma Aldrich. The media were taken from Hi Media laboratories.

Materials and methods—The WEO and WEO contaminated soil samples were stored in the freezer (-4^{o}C) for later use in the experiment. The soil sample (10 g) was dispersed in distilled water (100 ml) and vortexed. The supernatant (5 ml) was collected and used as inoculum.Two different types of media, Lysogeny Broth (LB) and Bushnell Haas (BH), were used for enrichment of bacterial cultures. The purpose of a medium is to provide the nutrients necessary to supplement the growth of bacteria without having a carbon source.Two types of solutions (abiotic and biotic)were prepared to study the bacterial growth for each medium.All the glasswares used for preparation of solutions and cultures were autoclaved at 121^{o}C.

Selection of suitable media for study—The comparative batch study of growth of microbes was carried out using LB and BH media. The inoculum and WEO (2% v/v) was added to the flask as a carbon source and was analyzed for the growth of microbes for 7 days. At the end of batch study, it

was observed that the microbes have shown better growth potential in LB media.

Measurement of Bacterial Growth—For measuring the bacterial growth over time optical density (OD) and colony forming units (CFU) in the given solution (CFU/ml) is used.

Optical Density (OD)—Spectrophotometry is a technique used for the measurement of the amount of light that is absorbed or that passed through (is transmitted) the sample solution or mixture. The result provided by the spectrophotometer is in two forms: percent transmission and absorbance. Each individual cell within a sample will absorb light at particular wavelength. The most commonly used wavelength for bacterial samples are 600 nm (Ssonko *et al.,* 2015). An absorption spectrum is generated by measuring the absorbance at various dilutions. The one used for the experimental purpose was the UV visible spectrophotometer(Thermo scientific UV evolution-201).

CFU/ml count—The colony forming unit is a measure of a total viable microbial cell. In OD_{600}, all cells dead and alive are counted, but CFU/ml gives us the count of viable cells only.Pour plate technique is used for the measurements of colony forming bacteria in the culture solution. The serial dilution is an important step and is measured in CFU/ml count. The fixed amount of the culture solution usually 100 micro liters of culture is taken by a pipette and is diluted with 900 micro liters of sterile distilled water. This makes 10^{-1} dilution. Fig. 1, shows the serial dilution process. The reason for making the serial dilution is that the total number of viable cells on a plate should not be so high that their counting becomes difficult. The usual range of TVC for plating is 30-300 colony forming units. The molten and cooled NB agar media (around 20 ml) is poured in a Petri plate. The serially diluted inoculum in a volume of 100 micro liters is then placed on to a Petri plate in a canter using sterile pipette.The inoculum is then spread uniformly over a plate using a L-shaped rod. After solidification of agar, the plate is inverted and incubated at 37^{o} C for 24 hours. The CFU/ml count is obtained by multiplying the number of colonies formed with the volume of culture used per unit of dilution factor.

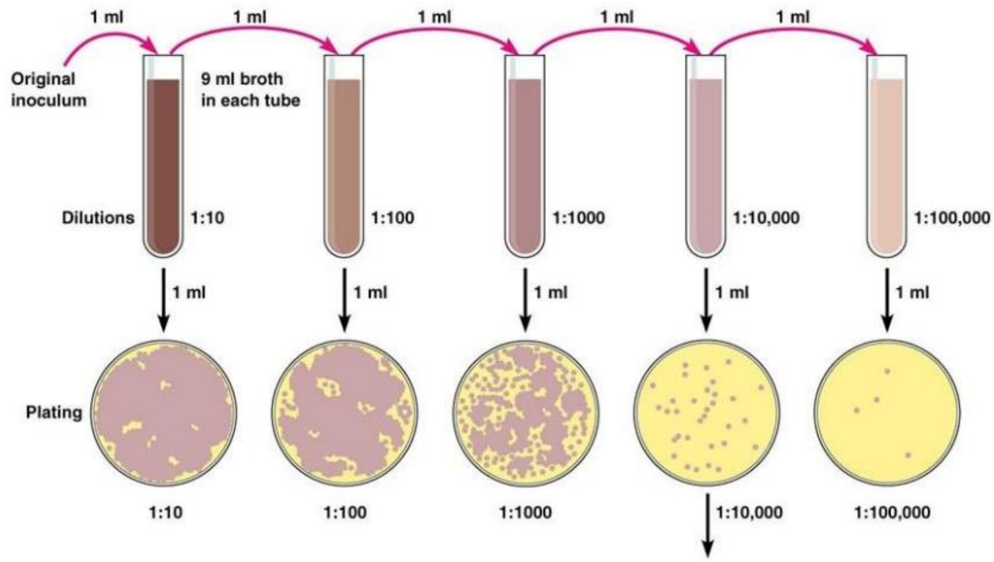

Fig 1: Serial dilution for the colony forming units (http://microbeonline.com/pour-plate-method-principle-procedure-uses-dis-advantages/(Retrieved on 19/5/17 6:58 pm)

Laminar hood chamber—The whole procedure explained above is done strictly in a laminar hood chamber to avoid any type of contamination.Laminar hood chamber provides the aseptic work area using high efficiency particulate air (HEPA) filter through which an air is blown from inside to outside towards user.The surface of the working area in a hood is cleaned using 70% ethanol.This way the contamination and contact of outside environment with work area is avoided.The UV lamp is given and supposed to be used to sterilize the interior of chamber before use. The running time for UV lamp is usually 20 minutes.The laminar hood chamber used for the experimental purpose was of a make Macro scientific works(MSW 101).

Fluorescent microscopy—A fluorescence microscope, uses a light source of higher intensity which excites a fluorescent species in a sample.The xenon lamp is used as a light source.The microbial species in a sample is illuminated by the light of certain wavelength usually in visible range which excites them and they emit light of higher wavelength.The emission filter separates the illumination light from the emitted fluorescence, which goes to detector and the fluorescent image is formed.

Preparation of abiotic control—The abiotic control group was prepared in an Erlenmeyer flask using oil and medium without the supernatant.A 50 ml of solution with 1% (v/v) waste engine oil in the LB medium was prepared.The abiotic control groups were prepared to check for possible contamination by any external species. Because of the sterilization, and absence of supernatant, there should be no microbial growth in the bioreactors. If there is a bacterial growth in an abiotic control group, it implies the existence of contamination in the solution.

Preparation of biotic control group—The biotic control groups were prepared by mixing the supernatant (5 ml), LB medium (100 ml) and glucose (2 ml of 1000 ppm).The glucose acts as an energy source.The control groups were prepared for both the sets of experiments to find out if the bacteria are able to survive in the medium. In the scenario where the bacteria are not able to survive in the culture, the cause might be the oil or the medium. The control groups ensure the compatibility of bacterial strains to the chosen media. All the flasks were incubated for 7 days at 37^{o} C and 100 rpm to observe the growth of bacteria in the culture medium of biotic control group.

Kinetics Study

Analysis of growth kinetics of bacterial strains is an important factor to understand the capability of the strain to use WEO as their food source. Therefore, we are growing them under controlled laboratory conditions with a defined media and known carbon source. The growth curve is then developed by measuring the rate of bacterial cell growth over a time. It is important to know their growth kinetics when we are targeting to use them for a purpose of biodegradation. The biodegradation potential of bacteria usually corresponds to their specific growth rate.Bacterial growth is the process which involves numerous anabolic and catabolic reactions in which synthesis and breakdown of cell constituents take place. The biosynthesis reactions result in cell division.In a culture medium, under ideal conditions, the cell division time can be as little as 10 minutes whereas it has been 100 years in some subsurface terrestrial environments (Pimda*et al.,*2010). This slower growth is the result of many factors including the poor nutrient environment.

The study of growth under such controlled conditions can be done by two different approaches: batch culture and continuous culture. In a batch culture the growth of microorganisms is analyzed using a defined medium having known amount of carbon source or food. In continuous culture, steady influx of growth medium is maintained.Generally, to understand the growth of microbial species,cells are placed in a liquid mediumincontrolledenvironmental conditions. If

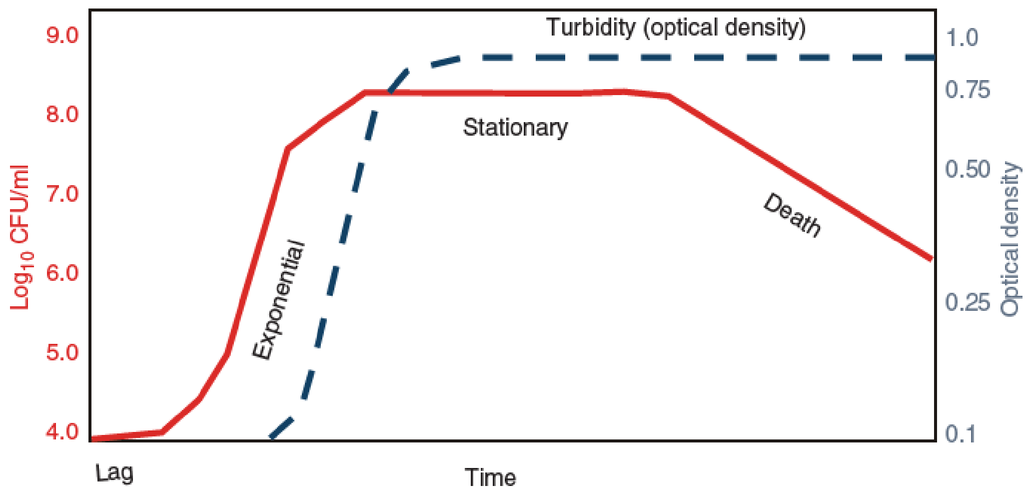

Fig 2: A typical growth curve for bacteria (Diphare *et al.*, 2013)

the medium supplies all the necessary nutrients essential for growth and physical parameters are optimal, the increase in cell number can be measured as a function of time which gives the growth curve. A typical batch growth curve has four distinct growth phases which can be observed within a growth curve as shown in Fig. 2 (Diphare *et al.,* 2013).

Experimental procedure—There are various direct and indirect methods used to determine progressive growth in microbial cultivation. Direct methods include biomass measurements and CFU/ml whereas indirect methods include optical density measurements (Arpa et al., 2010). Both of these methods, OD_{600} and CFU/ml methods were used for determining bacteria growth over time. For this purpose, isolated species taken from petri plates were allowed to grow in a conical flask of 250 ml volume.LB media was used as a culture solution which will provide the necessary nutrients for their growth.WEO was used a sole carbon source (2% v/v).The flasks were kept in a rotary incubator shaker at 37^{o}C and 100

rpm (Mittal et al., 2013).The batch study was carried out and OD_{600} and CFU /ml were measured every 24 hours.

Specific growth rate and generation time—During the exponential phase of growth, the bacteria follow first order kinetics which is given by following equation:

$$\frac{dN}{dt} = kN \tag{1}$$

Where,*k*-specific growth rate; *N*- Concentrations of cell; *t*-time. The specific growth rate is expressed as a reciprocal of time.

Alternatively, Eq.(1) can be rewritten over a finite time interval as:

$$ln\frac{N_2}{N_1} = k(t_2 - t_1) \text{ or } log\ N_2 - log\ N_1 = \frac{k(t_2 - t_1)}{2.303} \tag{2}$$

Plot of log "CFU/ml" versus"Time" generates a straight line and its slope is the specific growth rate "k".

Calculating generation time(g)—Generation time is the time taken by bacteria to double its population i.e. grow by a factor of 2. It is given by the Eq. (3) as (Dhage et al., 2017):

$$g = \frac{\ln 2}{k} \tag{3}$$

Using Eqs. (2) and (3), the specific growth rate(*k*)and generation time (*g*) for all 5 species and mixed culture were calculated.

Results and Discussion

Kinetics study—The batch growth study for mixed culture for both the samples and 5 isolated species was carried out using OD_{600} and CFU/ml measurements. Fig 3 and Fig 4 shows the optical density and CFU/ml values obtained for different species and mixed culture respectively. The absorbance value in optical density measurement is directly proportional to the total number of cells, i.e., dead cells and viable cells. The increasing trend is observed for the absorbance values which indicate that total number of cells is also increasing. But as said earlier, it also includes dead cells. So, we cannot rely on optical density measurements alone to understand the growth. CFU/ml gives the total number of viable cells in culture. Now, when we observe the trend of CFU/ml values, we see the ascending behavior with respect to time which indicates that there is increase in viable cell count in a culture. The declining nature in the graph depicts the death phase of species which can be due to depletion of carbon source. Therefore, the absorbance values are increasing continuously but there is fall in CFU/ml values due to death of cells.

The specific growth rate (*k*) was calculated using the equations described in section III. The exponential phase of growth was considered for the calculation of specific growth rate and log values of CFU/ml were plotted against time. The growth was found to be following the first order kinetics. The graphs plotted below are shown for all 5 species and mixed cultures as well.

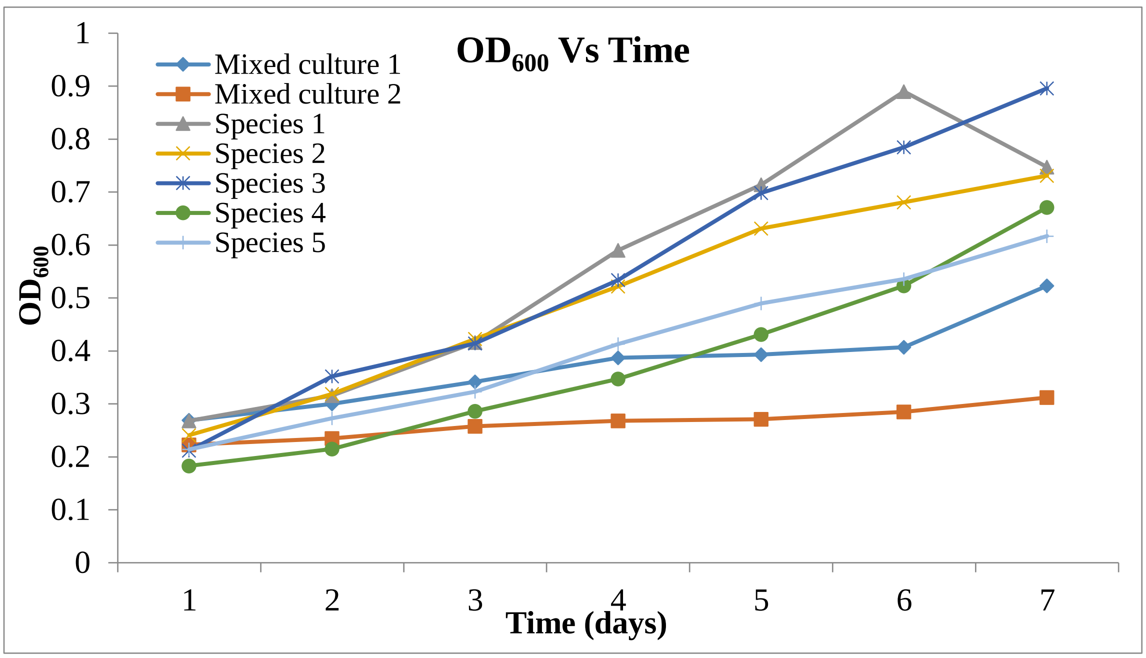

Fig 3: Optical Density (OD_{600})Versus Time (days) graph of Species 1-5 and Mixed Culture 1-2.

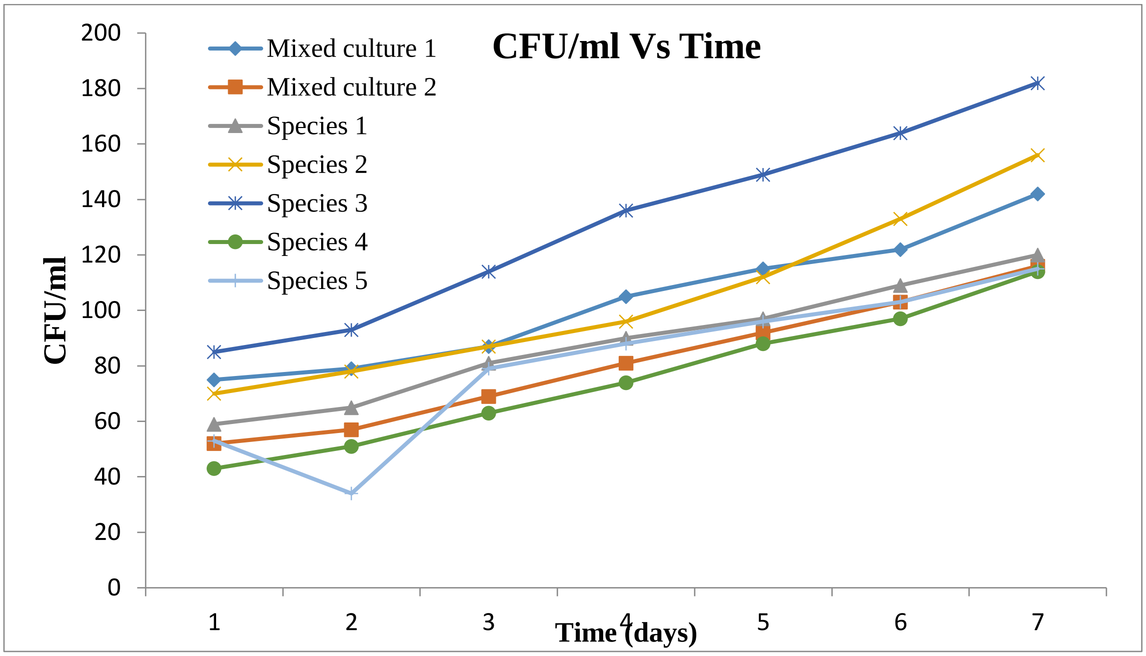

Fig 4: CFU/ml Versus Time (days) graph for Species 1-5 and Mixed Culture 1-2.

Table 1. Specific Growth Rate and Generation Time

Species	Specific growth rate (hr^{-1})	Generation time(min)
Sp. 1	1.28	32.48
Sp.2	1.39	29.74
Sp. 3	1.41	29.48
Sp.4	1.62	25.2
Sp. 5	1.26	33
Mixed culture 1	1.17	35.59
Mixed culture 2	1.42	29.19

Table 2. Morphology of the Isolated Species

Species	Form	Colour	Elevation	Edge
1	Circular	Brown	Flat	Entire
2	Irregular	Green	Convex	Undulate
3	Spirochete	Green	Raised	Entire
4	Filamentous	Dark green	Flat	Filiform
5	Circular	Green	Flat	Entire

The Table 1. gives the values of specific growth rate and generation time for isolated species and mixed cultures. For the purpose of calculating the specific growth rate and generation time, only the exponential phase of the growth was considered. It's because the exponential phase generally follows first order kinetics. The generation time is the period in which the number of bacterial cells grows into double. It may vary from as short as 12 minutes to 24 hours. The generation time obtained for all species is within the range of some minutes, which indicates the rapid growth of microbes on WEO as a carbon source. The mixed culture samples also shoe shorter generation times which states the symbiotic behavior of species in mixed cultures.

Morphology of isolated species—Bacterial species show tremendous growth rate when they are provided with ample amount of food. Different type of strains tends to produce different-appearing colonies. The distinction may be on the basis of colour, shape, elevation, margin, edge, pigmentation etc. the species were differentiated based on their color, shape, elevation, edge. The morphological structure of 5 isolated species was obtained fluorescent microscope and the same are shown in the Fig 3 & 4. The obtained structures are reported in the Table 2. The genetic information of the species will be obtained after 16S rDNA gene sequencing.

Conclusion and Future Work

Based on the results obtained in the present study, following conclusions are drawn: i) The growth of microbes was analyzed using OD_{600} and CFU/ml. The plot of OD_{600} and CFU/ml Vs Time shows the growth of microbes in the culture as linear function of time during the exponential phase; ii) The microbial species were able to survive on WEO as their primary food source. The generation time was found to be between the range of 30 to 60 minutes for eachspecies which shows that there is rapid growth of microbes using WEO as a sole carbon source;iii) Morphological analysis shows the presence of atleast five-distinct species. It is required to perform 16S rDNA Gene sequencing for precise information about the species type and their genetics;iv) Since this study was limited to the analysis of microbial growth with WEO as a sole carbon source. Further, the GC-MS analysis of the treated WEO will be able to confirm the biodegradation WEO components and products form.

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22.

Filtration And Discoloration Of Industrial Waste Water Using Agricultural Waste

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ABSTRACT

The waste water generated by the industries is very toxic to the environment and has to be treated before disposal. The textile industry release colored waste water due to the dissolved chemicals which are toxic in nature and has to be treated. The air pollution consisting of oxides of nitrogen is one of the global threats. This project aims in treating and filtering the waste water generated by the textile industry by the application of agricultural waste. The various agricultural wastes used are sugarcane bagasse, corn waste and crushed coconut shells. These agricultural wastes form a great medium for adsorption. The agricultural elements are provided at different intervals inside the disposal pipe with the help of a wire mesh. This structure is detachable and the wastes can be easily replaced periodically. These wastes are biodegradable and can be disposed away at a minimal cost. The waste water is toxic in nature and is healthy medium for pathogens to grow. The above agricultural wastes are available on a large scale and can be used effectively and economically, to treat and remove the color of the wastewater generated by the textile industry. This will be a great solution for treatment of water in the developing countries. Also, with the addition of photocatlytic compounds on the surface of the pipes, the air pollutants can be effectively absorbed and converted into harmless precipitates. These precipitates can be easily washed away to a tank. These precipitates can be used as flocculants, which are used in the flocculators of the water treatment plant. The wastewater contains a large amount of urea in the form of urine. Thus, this model will also have a urine electrolysis center, where the urea will be electrolyzed to get hydrogen gas. This hydrogen gas can be used as a fuel for zero emissions vehicles and aircrafts, to heat homes and offices and to produce electricity. Thus, this will solve the problem of fast exhaustion of fossil fuels. This model has to be implemented in most of the developing countries. This will give a solution for the water and air pollution, as well as, find a source of energy. Hence this model is economical, ecological, efficient and effective.

Keywords
Sugarcane bagasse, bio-adsorption, discoloration, photocatalysis, titanium dioxide.

INTRODUCTION

Waste management strategies adopted in India have failed to keep pace with the industrial growth and urbanization. Most of the industries in India are situated along the river banks for easy availability of water and also disposal of the wastes. These wastes often contain a wide range of contaminants such as petroleum hydrocarbons, chlorinated hydrocarbons and heavy metals, various acids, alkalis, dyes and other chemicals which greatly change the physico-chemical properties of water. All these chemicals are quite harmful or even fatally toxic to fish and other aquatic populations. It is found that one-third of the total water pollution in India comes in the form of industrial effluent discharge, solid wastes and other hazardous wastes. Although all the Indian industries function under the strict guidelines of the Central Pollution Control Board (CPCB) but still the situation of environmental pollution is far from satisfactory. Different norms and guidelines are given for all the industries depending upon their pollution potentials. Most of the major industries have treatment facilities for industrial effluents. But this is not the case with small scale industries, which cannot afford enormous in-vestments in pollution control equipment as their profit margin is very slender. Consequently, the water pollution problem particularly due to toxic heavy metals has become menacing concern. The effluents generated by the textile industries have high pollutant potential due to dyes consumption in the tinting stage and the consumption of additives the pre-tinting and storage stages.

Owing to the adverse environmental effects, some processes to remove the color and filter the particles from the industrial waste water have been evaluated including the use of agricultural wastes as bio-adsorbents. The agricultural wastes used here are the sugarcane bagasse, crushed coconut shells and maize corn waste. These materials are easily available in the agricultural sector and is available at a minimal cost. These wastes are also available on a large scale and can be replaced very easily. The use of such agricultural wastes filters the waste water to an extent and the water is decolorized due to adsorption of chemicals on the surface of the materials. A solution for the air pollution by traffic can be found in the treatment of the pollutants as close to the source as possible. Therefore, photo-catalytic materials like Titanium Dioxide (TiO_2) can be added to the surface of pipelines and surface of wastewater tank surface. In combination with light, the pollutants are oxidized, due to the presence of the photo-catalyst and precipitated on the surface of the material. The harmful pollutants are oxidized to harmless precipitates which can be washed off easily on the application of rain water. These precipitates can be used as flocculants in the flocculation and coagulation tank of the wastewater treatment plant. This will result in self cleaning and environmental friendly cement pipelines.

OBJECTIVE AND STUDY AREA DETAILS

Objective:

To filter the waste water produced from different industries using agricultural wastes like sugarcane bagasse, crushed coconut shells and maize corn waste. Also these wastes are used for discoloration of the wastewater produced from the industries specifically from the textile industry by the process of adsorption. To absorb air pollutants and convert them into harmless precipitates by the process of photocatalysis using titanium dioxide coated as plaster on the pipelines and the tanks of the waste water treatment plant.

Scope:

This project aims in filtering the waste water produced from the various industries and decolorizing the waste water with the help of agricultural wastes, which are available on a large scale at a minimal cost. This will reduce the water pollution to an extent and the environment will be greatly effected in a positive way. With photocatalysis the air pollution will be considerably reduced and also the precipitate produced act as flocculants in wastewater treatment plant.

Study Area:

Different water samples were taken from the outlet pipes of the industries. Main samples were taken from the Subramanyapura Area where the wastewaters were generated by a textile industry as well as a cement industry. Also, water samples were collected from the Kumaraswamy Layout and ISRO Layout surroundings. The test for nitrogen dioxide was carried out in closed controlled condition in Dayananda Sagar College of Engineering, Bengaluru.

Materials used

Sugarcane Bagasse:

Sugarcane Bagasse are long fibrous substances that are left out after a sugarcane stalks are crushed to extract their juice. They are available on a very large scale with the local vendors and merchants.

Maize corn waste:

Maize corn wastes are basically the stalks which are left out after the grains on the maize are taken out either for domestic purpose or industrial purpose. This is also highly available with local vendors and farmers, and also with the small scale industries which manufacture corn flour.

Crushed coconut shells:

The hard covering which is left when the outer layer of coconuts are removed and also the flesh is taken out are called as shells. These shells are made to crush thoroughly so that crushed sample is made to be available at a standard size of 4-10 mm.

D. Titanium Dioxide (Chemical):

Titanium dioxide appears in remarkable extent in nature. The anatase form of Titanium Dioxide is used which is produced by sulphate process.

Methodolgy

Preparation of filtrates:

The agricultural waste viz. sugarcane bagasse, crushed coconut shells and maize corn wastes, are brought on a very large scale. The sugarcane bagasse are cut of lengths not more than 6cms. The corn waste are cut and made into cubes of side 10mm. The coconut shells are crushed properly and are retained on10mm IS sieve. It is made sure the cubes do not pass the 4.75mm IS sieve. These materials are later thoroughly washed in clean water and left to dry for at least 48 hours. These agricultural wastes are stuffed in wire meshes to form a neat filter mesh consisting of materials in 3 layers. The bottom layer will be of crushed coconut shells. The middle layer is filled with maize corn waste. And the uppermost layer is filled with compressed sugarcane bagasse. This forms the filtrates and filters which are used in the model.

Waste water sample collection:

The waste water is collected safely from different outlet pipes of the industries or from the sewage near the industries. The volume of these samples should be at least 2 liters so that they can be sufficiently usedfor various tests conducted in the laboratory.

Filtration of the waste water:

The waste water collected from the industries are made to pass through the filtrates provided at the pipes with the support of a wire mesh. Several samples are made to pass through various filtrate layers. The minimum layers to be provided are 12. The filtered water and the original wastewater solution are taken to the laboratory and several tests are performed and values are compared.

D. Design of the plaster mix:

Assume radius of pipe = 0.75m
Circumference = 2 x 3.14 x 0.75 = 4.71m
For 1m length, Area= 4.71 x 1 = 4.71 m^2

For 1” thichness plaster, Quantity= 4.71x 0.0254 = 0.1196m^3

Density of mortar = 2200kg/m^3
Ratio mix = 1:6

For 1 m^3,
Cement = (1/7)x 2200= 315 kg
Sand = 2200-315= 1885kg

For 0.1996 m^3,
Cement= 37.674kg
Sand= 225.446kg

4% of Titanium Dioxide = 263.12 x 4% = **10.52kg/m/1.5m dia**

E. Application of the plaster mix on pipes:

When 10g of 80% pure copper (Cu) fillets are added into the 1:1 concentration nitric acid (HNO_3), it liberates 100 ml of nitrogen monoxide (NO) and nitrogen dioxide (NO_2) gasses. Variation of temperature was between 24^0 to 27^0c during the experiment.

$4HNO_3 + Cu \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

When these gases reacts with titanium dioxide molecules available at the surface of the cement plaster of the pipelines and tanks to form nitrate (NO_3^-), nitrate got deposited on to the surface of the concrete block by forming calcium nitrate $CaNo_3$ compound with calcium available in concrete block. Nitrate deposition on the surface was due to the photo-catalytic reaction of titanium dioxide particles available on the surface, along with nitrate deposition. The surface has to be washed or cleaned frequently. The sample collected was later given for nitrate analysis test.

DATA ANALYSIS

1. Determination of the various parameters of the untreated effluent samples. Analysis was done as per standard procedures.

Table 1 : Sample A

Parameter	Before Filtration	After Filtration
pH	10.43	8.53
COD	612	423
Chlorides	95.14	81.35
TSS	638	501.2
TDS	2806	1908
BOD	19.2	16.5
Turbidity	476	320.5

Table 2 : Sample B

Parameter	Before Filtration	After Filtration
pH	11	9.06
COD	360	343
Chlorides	79.53	80.05
TSS	1260	1215
TDS	6930	6203
BOD	11.8	10.2
Turbidity	320	296

Table 3 : Sample C

Parameter	Before Filtration	After Filtration
pH	7.23	7.05
COD	544	387
Chlorides	90.88	81.38
TSS	726	591.0
TDS	8684	5909
BOD	23.7	18.7
Turbidity	514	388

All units are in mgl^{-1} except pH, turbidity (NTU)

COD = Chemical oxygen demand,

BOD = Biochemical oxygen Demand,

TSS = Total suspended solids,

TDS = Total Dissolved Solids

2. NITRATE ANALYSIS TEST:

Nitrate analysis test is conducted for the collected samples. The different amount of nitrate produced for different time periods and different percentage of TiO_2 added is shown below:

Table 4: Nitrate analysis test results

TiO_2 (%)	Final NO_3^- (mg/l) 1 DAY	Final NO_3^- (mg/l) 3 DAYS	Final NO_3^- (mg/l) 7 DAYS
0.5	9	9.2	10
1	9.9	10.4	10.5
1.5	10.9	11.1	11.6
2	11.7	11.9	11.9
2.5	13.8	14	14.2
3	13.8	14.2	14.2
3.5	14	14.2	14.2
4	14	14.2	14.5
4.5	14.1	14.2	14.5
5	14.1	14.2	14.6

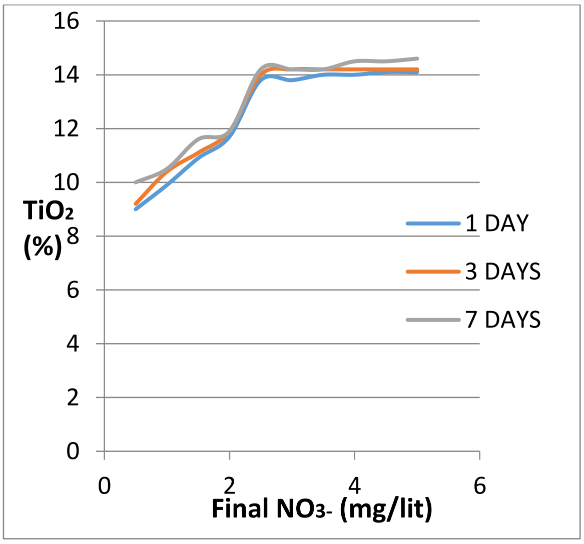

Fig 1: Nitrate analysis test results

RESULTS

From the determination of various parameters for the original solution before filtration and the filtrated solution, it is clearly seen that the values are considerably decreased. The decrease in the turbidity is an indication of decreasing color content of the wastewater or the effluent. Hence discoloration of the waste water takes place. Also decrease in the number of solids in the form of total suspended solids and total dissolved solids indicate the reduction of chemical content of the wastewater. The reduction in the hardness and pH of the wastewater will allow it to be treated smoothly and easily. Hence the overall process of filtration of the wastewater with the agricultural waste is successfully carried out. The nitrogen oxides were successfully absorbed by the Titanium Dioxide and converted into calcium hydroxide.

CONCLUSION

Agricultural wastes like sugarcane bagasse, crushed coconut shells and maize corn waste are abundantly available at a minimal cost. They act as effective adsorbents and efficiently filter the industrial waste water and also decolorize the waste water produced majorly from the textile industry. The laboratory test values are evident for the reduction of chemicals in the form of chlorides and sulphates. The reduction of organic matter is shown by the reduction in COD and BOD values.

Hence, the agricultural wastes act as powerful filtrates and decolorizing agents by the process of bio-adsorption. The waste water filtered and decolorized are less harmful and makes the process of further treatment easy. The plants and trees nearby the water body are also not affected. The color of the wastewater is also toxic for the soil making it non-fertile and non-usable. These complexities are overcome by the discoloration of the wastewater by the agricultural waste.

The addition of Titanium Dioxide can be restricted to 3%, as the further increment in Titanium Dioxide content will not be economical. Addition of Titanium Dioxide to cement up to 5%, did not affected the properties of cement. The consumption of NO_2 increases with increasing percentage of Titanium Dioxide chemical up to 3%. If there is further increase in the chemical, it remains constant. Whiteness of the concrete block remained for longer time. Therefore Titanium Dioxide can be used to improve architectural view. Therefore, by considering the above results and testimony we can conclude that, photo catalytic materials like Titanium

Dioxide, in the presence of sunlight, can effectively absorb pollutants like Nitrogen Dioxide and convert it into nitrates which can easily be washed away by rainwater. These are also used as flocculants in the flocculation tank. Hence this helps in attaining environmental friendly and self cleaning concrete pipelines and tanks in the waste water treatment plants.

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23.

Growth Performance And Eco-Physiological Behaviour Of Different Tree Species Irrigated With Treated Domestic Sewage Water At Ukkadam Sewage Plant, Coimbatore, Tamil Nadu

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ABSTRACT

Treatment of domestic sewage water and subsequent utilization of treated sewage water as irrigation for forestry crops (Trees) helps in reducing the demand for fresh water irrigation. To address this phenomenon, the field study was conducted in Ukkadam sewage plant (10°58'00" N and 76°58'00"E), Coimbatore city, Tamil Nadu under Department of Environment (DoE), Government of Tamil Nadu funded project for testing the biometric attributes (Height and collar diameter) and eco-physiological behaviour (Photosynthesis rate and Transpiration rate). Five fast growing tree species *viz.*, *Neolamarckia cadamba*, *Dalbergia sissoo*, *Eucalyptus tereticornis*, *Melia dubia* and *Acrocarpus fraxinifolius* were planted in Randomized Block Design and irrigated with treated domestic sewage water. Among the five fast growing tree species, the highest photosynthetic rate (11.41 μ mol.$m^{-2}s^{-1}$), height (218.42 cm) and collar diameter (48.57 mm) were observed in *Melia dubia* and highest transpiration rate (6.53 m mol. m^{-2} s^{-1}) in *Dalbergia sissoo*. Whereas, *Neolamarckia Cadamba* exhibited lowest photosynthetic rate (6.63 μ mol. m^{-2} s^{-1}), transpiration rate (3.15 m mol. m^{-2} s^{-1}) and height (118.51 cm) after 6 months of growth. On concluding the study, *Melia dubia* and *Dalbergia sissoo* performed well under treated domestic sewage water interms of growth and ecophysiological attributes.

KEYWORDS: Treated domestic sewage water, Growth performance, eco-physiological behaviour, Trees, *Melia dubia*

INTRODUCTION

Water is a vital resource for the existence of all living organisms, and is limited in most countries. This valuable water resource is increasingly being threatened by anthropogenic activities throughout the globe. Total utilizable water resource in the country has been estimated to be about 1123 BCM (billion cubic meters), which is just 28 % of the water derived from precipitation (Camposeo *et al.,* 2011). A large number of river stretches are severely polluted as a result of discharge of domestic sewage. Treatment of domestic sewage and subsequent utilization of treated sewage water for irrigation can prevent pollution of water bodies, reduce the demand for fresh water in irrigation sector and result in huge savings in terms of nutritional value of sewage in irrigation (Camposeo *et al.,* 2011). Irrigation with TSE has been used for three purposes: (i) complementary treatment method for wastewater, (ii) use of marginal water as an available water source for agriculture; (iii) use of TSE as nutrient source associated with mineral fertilizer savings and high crop yields. In order to address the above issues, the current study was designed to compare the suitability of tree species irrigated under treated domestic sewage water.

Application of TSE in forest plantations have become a popular alternative of water reuse because of not being part of the food chain, providing a green image, a higher water use than other crops N and C storage in biomass (mainly in wood) over the long-term that represents the major mechanism for retention of the elements in the ecosystem. Reuse of wastewater is one such effort, being practiced in many countries for agricultural irrigation. Pollution caused by sewage water discharged from cities and towns is the primary cause for degradation of major water resources. The use of treated sewage in irrigation was emphasized in the Water (Prevention and Control of Pollution) Act, 1974. In order to address the above issues, the growth (Biometric) performance and ecophysiological behaviour of trees species under treated domestic sewage water was studied in sewage treatment plant, Ukkadam, Coimbatore.

MATERIALS AND METHODS

A field experiment was conducted at the sewage treatment plant, Ukkadam Coimbatore in Tamil Nadu with the geographical coordinates of 10°58’00” N Latitude and 76°58’00”E Longitude, at an altitude of 420 m above mean sea level (MSL). The species selected for studying the growth performance and eco-physiological behaviour under treated domestic sewage water were *Neolamarckia cadamba, Dalbergia sissoo, Eucalyptus tereticornis, Melia dubia* and *Acrocarpus fraxinifolius.* Six months old seedlings were planted in the field with the spacing of 3m x 3m. To assess the biometric attributes, the following plant height (cm) and plant collar diameter (mm) were recorded at 6 month after planting (MAP). The ecophysiological parameters was recorded using a Portable Photosynthesis System (PPS, model LCpro + Photosynthesis System CO_2 gas analyzer, UK) to assess the physiological behaviour of trees grown under treated domestic sewage water. The ecophysiological attributes *viz*., photosynthetic rate (μ mol. m^{-2} s^{-1}) and transpiration rate (m mol.$m^{-2}s^{-1}$) were measured on a sunny day between 10.00 AM to 11.00 AM.

The data were analyzed using AGRES software developed by Tamil Nadu Agricultural University (TNAU) Coimbatore. The data on every parameter were analyzed separately in single factor analysis, using AGRES software. Then the values of critical difference (CD) at 0.05 level and standard error deviation (SEd) were given in the respective tables.

RESULTS AND DISCUSSION

i) BIOMETRIC PARAMETERS

In tree height, *Melia dubia* attained the maximum height of 218.42 cm followed by *Eucalyptus tereticornis* (183.33 cm) and the lowest height of 118.51 cm was observed in *Neolamarckia cadamba* at 6 month after planting (Table 1). Similar to the present study, use of municipal waste water as a source of irrigation increased the height growth of olive (*Olea europaea*) trees was also reported by Aghabarati *et al.* (2008).

Table 1. Biometric parameters (Growth performance) of tree species under treated domestic sewage water

Sl.No	Species	Height (cm)	Collar diameter (mm)
1.	*Neolamarckia cadamba*	118.51	24.22
2.	*Dalbergia sissoo*	165.45	40.06
3.	*Eucalyptus tereticornis*	183.33	41.17
4.	*Melia dubia*	218.42	48.57
5.	*Acrocarpus fraxinifolius*	151.00	30.29
	SEd	5.868	1.32
	CD(0.05)	12.259	2.76

Among the tree species studied, the maximum collar diameter was recorded in *Melia dubia* (48.57 mm) followed by *Eucalyptus tereticornis* (41.17 mm) and the least collar diameter was recorded in *Neolamarckia cadamba* of 24.22 mm (Table 1). The significant increase in collar diameter was probably due to the availability of increased organic matter and nutrients especially the available nitrogen present in the municipal sewage water.

ii) ECO-PHYSIOLOGICAL BEHAVIOUR

Photosynthetic rate which was a measure of productivity showed significant variation among the selected tree species in Table 2. The result evidence showed that *Melia dubia* and *Dalbergia sissoo* showed very high photosynthetic rate of 11.41 µ mol. m^{-2} s^{-1} and 10.70 µ mol. m^{-2} s^{-1} respectively and eventually resulted with the highest productivity. Similar kind performance was also reported by Rao (2005) by analyzing five tree species namely *Albizia lebbeck, Dalbergia sissoo, Leucaena leucocephala, Shorea robusta* and *Tectona grandis*.

Table 2. Eco-physiological attributes of tree species under treated domestic sewage water

Sl.No	Species	Photosynthetic rate (µ mol. m^{-2} s^{-1})	Transpiration rate (m mol. m^{-2} s^{-1})
1	*Neolamarckia cadamba*	6.86	3.34
2	*Dalbergia sissoo*	10.85	6.71
3	*Eucalyptus tereticornis*	8.59	5.75
4	*Melia dubia*	11.57	4.94
5	*Acrocarpus fraxinifolius*	6.94	4.76
	SEd	0.197	0.432
	CD(0.05)	0.411	0.903

Availability of water to plant and the ability of plants to regulate water potential under varied climatic condition would help to adapt species (Rouhi *et al*., 2007). The transpiration rate was the highest in *Dalbergia sissoo* (6.71 m mol. m^{-2} s^{-1}) followed by *Eucalyptus tereticornis*
(5.75 m mol. m^{-2} s^{-1}).

CONCLUSION

The overall observation of the study helps to conclude that *Melia dubia, Eucalyptus tereticornis* and *Dalbergia sissoo* showed highest performance in terms of biometric parameters and ecophysiological attributes irrigated with treated domestic sewage water. The study also explained that *Neolamarckia cadamba* had shown poor performance under irrigated treated domestic sewage water.

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24.
High Performance Membrane Based Capactive Deionization Unit (Mcdi) With Nano Graphene Oxide Coated Electrodes In Treatment Of Textile Dyeing Effluent

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"Capacitive Deionisation may solve water problems in India" - Rajan Dash and Lawrence Weinstein- Techno-Commercial Professional, Water Supply Strategy

Textile industries are rapidly increasing by numbers in most of the countries which discharge huge amount of effluent containing dye and salts. There are about 9000 knitting, 736 dyeing and bleaching, 300 printing units, 100 embroidery units and 200 units catering to compacting, raising and calendaring in the last two-decades in and around Kongu region discharging effluent depleting both surface and groundwater resources in the area. The conventional methods of physico chemical and biological methods consume lot of chemicals, high energy and are not sufficient to break down azo double bonds of reactive dyes. The production of secondary products or sludge becomes more difficult to be disposed off. Also, huge amount of reject from Reverse Osmosis is another major problem. There is lack of techno-economically viable option available for treating the effluent from small units which is one of the social challenges of all developing nations like India. So, an efficient and cost-effective treatment method for textile industrial effluent is required to treat the dyes and salts coming out of the small scale industries. Main challenges existing in the treatment of textile industrial effluent are:

- Recycling and reuse of treated effluent
- Removal of dye and reduction of Total Dissolved Solids (TDS) in the treated effluent
- Treatment of contaminated groundwater with salts and dyes

The membrane filtration is one of the treatment techniques which plays a vital role in rejection of salts and dyes. It is a very efficient and economical way of separating the components that are suspended or dissolved in the liquid. Membrane is a physical barrier that allows certain compounds to pass through, depending on their physical and chemical properties. The membranes commonly consist of a porous support layer with a thin dense layer on top that forms the actual membrane. The membrane filtration includes microfiltration, ultrafiltration, nanofiltration and reverses osmosis membrane. The Membrane based Capacitive Deionization Unit (MCDI) is one of the electrochemical methods is a well efficient and economically feasible technique that has got its own advantages such as no fouling of electrodes, no secondary pollution, less energy consumption, capable of addressing most of the ionic contaminants etc. which can be easily applied to solve the water problem in developing countries like India through reuse and recycling. This is a well-efficient electrosorption technique to remove ions from salt solutions. The salt ions are adsorbed on to the electrical double layer region (EDL) when the electrode is charged electrically through a DC power supply. When the aqueous solution is passed through the porous carbon electrodes the ions get adsorbed to the porous surface material whereas, when the applied potential is zero, regeneration of ions takes place in the electrodes. This process is reversible and has its unique advantages over other desalination technique such as low consumption of energy, economic and cost effective and it does not produce any chemical waste during regeneration.

This paper presents the application of Industrial MCDI unit (composed of a pump, a feed cell that provides two consecutive cells (containing each over 100 carbon aerogel electrodes) with the appropriate amount of water) in removal of dye and salts from contaminated textile dye effluent.

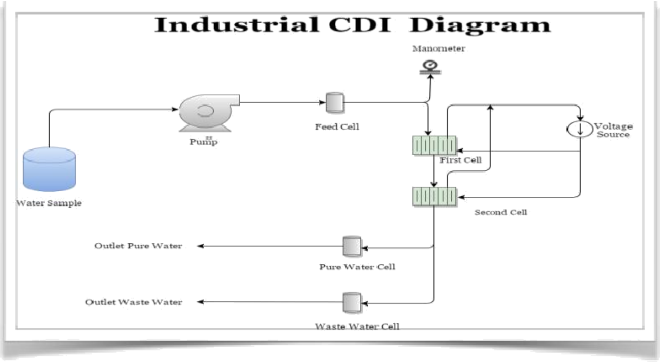

Fig 1. Schematic Diagram of Industrial CDI Unit

From the observed results, it was identified that the Total Dissolved Solids decreased from an average of 1580mg/L to 350mg/L, i.e.to 77% of total removal. Moreover, more than 90% removal of fluoride and chloride was observed during experimental investigations. To observe the efficiency of MCDI unit in the long run, the experiments were run for 20 consecutive cycles, in a period of three hours. To improve the performance of MCDI unit in salt removal, nano graphene oxide electrodes were prepared at Water Institute and the characterisation studies were carried out using Cyclic Voltametry method to identify the improvement in specific capacitance to remove salts from the effluent. A laboratory cell was also assembled and its performance efficiency in treatment of groundwater was studied.

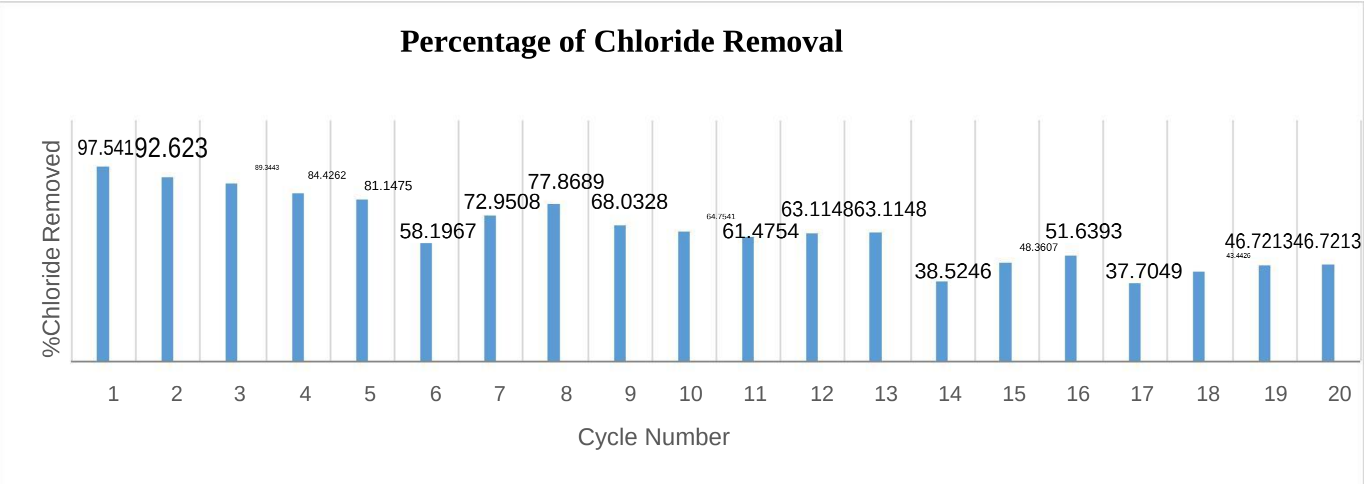

Fig 3. Percentage of removal of Chloride using MCDI

25.

Natural Dyeing For Eco Friendly Textiles

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ABSTRACT

In the current scenario of growing concern on the environment, the major problem faced by the textile dyers is the treatment of used dye effluent. Huge amount of unused and unfixed synthetic dyes are released into the water bodies that creates a serious pollution problems. There is a growing interest in the revival of natural dyes as these offers no effluent or disposal problems. Today natural dyeing is done in small scale. The possibilities of using natural dyes for textiles dyeing and printing in regular basis need to be explored. For successful commercial use of natural dyes standardized methods and techniques need to be optimized for the selected dye sources.

India has abundant dye source and there is ample scope to explore and rebuild the traditional dyeing methods to meet the needs of the consumers. Though natural dyes have some limitations such as availability, fastness , dyeing process and reproduction of shades, they have their own place in the market.

Not only dyes but the pretreatments, process, and mordantsused in preparation also need to be eco safe. This study has been for extracting coloring materials from selected plant materials and use of natural mordants, pretreatments for a pollution free dyeing process.

KEYWORDS:Natural dye; Plant materials; Natural mordants; eco pretreatments; pollution free

1. INTRODUCTION

The alarming increase in pollution level demands us to immediately alter for ecofriendly products. People the world over are increasing consciousness about ecology, and preference for natural dyes is increasing.. This drives us back to nature that is developing ecofriendly processes and finishes. Natural sources such as plants and animals , algae, bacteria and fungi not only provide us eco friendly products for textile finishing but also posses bio-degrable properties.

India has abundant dye source and there is ample scope to explore and rebuild the traditional dyeing methods to meet the needs of the consumers. Though natural dyes have some limitations such as availability, fastness , dyeing process and reproduction of shades, they have their own place in the market.

Not only dyes but the pretreatments, process, and mordantsused in preparation also need to be eco safe. This study has been for extracting coloring materials from selected plant materials and use of natural mordants, pretreatments for a pollution free dyeing process.

This study attempts to evaluate the eco finishing and dye ability of cotton with flowers of Peltophorumpterocarpum. This could further the use of eco finishing and dyeing on larger scale.

2. SELECTION OF FABRICS

Cotton is an ideal fabric for wear in all seasons and also possess number of suitable technical qualities like high tensile strength , good dyeabilityand hence cotton fabric was used for the study.

2.1. Fabric pre treatments

The woven fabric was desized by soaking the material in boiling water for fifteen minutes. Later the fabric was washed in five percent detergent solution and thoroughly rinsed in soft water.

Treating the fabric with butter milk is traditional method of treatingfabrics.[3] The desized material was soaked in buttermilk for 24 hours forpretreatment. The fabric was then rinsed thoroughly and dried.

3. DYEING

3.1. Pilot Study

A pilot study was carried out with regard to the selection of mordants, mordanting techniques and dyeing procedure. Flowers of Peltophorumpterocarpum (Tamil :Iyalvakai) were collected dried in the shade and powdered.

Mordanting techniques used were pre, post and simultaneous mordanting. The natural dyes having limited substantively for the fibre, require use of the mordant which enhances the fixationof the natural colorant on the fibre by the formation of the complex with the dye .[1]. The metallic mordants produce bright and fast colours, but are not always eco-friendly. Some of the metallic mordents are hazardous[2]. . Considering the same points natural mordants namely tamarind rinds and myrobalon were selected for the study.

3.2. Selection of mordants

Based on the visual inspection results the following mordants and mordanting techniques were selected for optimization

Table 1. Selection of Mordanting Techniques

S.No Mordants Mordanting Technique

1.

2.. Tamarind rinds

Myrobalon Post-mordanting

Post-mordanting

3.3. Dyeing procedure

The weighted quantityof dye powder was dissolved in 100ml soft water. Mordanting solutions were prepared with the selected mordants in 100ml soft water.

The main objective of optimization was to standardize the different variables involved in dyeing. This included optimization of mordant concentration, mordanting technique, dyeing time and mordanting time.

The optimum concentration of dye source was found by varying dye concentration. Five and ten grams of dye powder/100ml of soft water were taken . The soaking time was kept constant for all concentration. The samples were visually inspected and based on the results ten percent was decided as the optimum dye concentration.

Table 2 .Parameters Optimized For Dyeing

PARAMETERS OPTIMIZED PARAMETER

Dye Concentration in %

Dye extraction time in min

Dyeing time in min

Mordant concentration in %

Mordanting time in min 10

60

60

5

45

Based on the optimization results the material was dyed using the dye source, mordants and mordantingtechnique.

All the samples were soaked in soft water prior to dyeing. Later they were taken out, squeezed and shaken to avoid crease formation. The dye powder was dissolved in the required quantity of soft water and boiled for the specified temperature. The wet material was boiled at the chosen temperature for the specific duration with occasional stirring. The mordanting solution was prepared by dissolving the mordants in water. The material was mordanted following the suitable technique selected. Each dyed sample was rinsed thoroughly in soft water and dried in the shade.

3.4. Selection of washing Method

Vast majority of people still do their washing manually . Hence the samples were given hand washing by using kneading and squeezing method.

The samples were soaked in detergent solution for ten minutes and washed by kneading and squeezing. It was rinsed in three changes of soft water and dried in the shade.

3.6.7.Nomenclature of Samples

Nomenclature of the dyed and washed samples are given as follows.

O-Original; T- tamarind rinds mordant, M- myrobalon mordant, P - Flower dye. 3 - Post Mordanting; W - Washed samples.

3.7. EVALUATION

The dyed and washed samples were visually evaluated and rated for their eveness of dyeing, texture, luster and general appearance.Objective evaluation includes fabric thickness, tear strength, and colour fastness

4. RESULTS OF THE STUDY

4.1. Visual Inspection

The visual examination reveals that the samples were evenly dyed. They had maximum luster and medium texture. The general appearance was rated to be fair.

4.2. Objective evaluation

4.2.1. Fabric Thickness

Dyeing increased the thickness of all samples but washing reduced the same slightly. Sample T3PW had a maximum decrease of eighteen percentage.

4.2.2. Tear Strength

Dyeing reduced the tear strength of all samples in the warp direction. Sample T3PW had a maximum loss of ten percent. While sample M3P had a minimum loss of less than one percent. Washing further reduced the strength of all dyed samples. Dyeing improved the tear strength sample M3P by nine percent in the weft direction. Washing reduced the tear strength of all dyed samples.

4.2.3. Colourfastness

Table.3. COLOUR FASTNESS

S.No	Samples	Sunlight colour change				Washing		Pressing		Crocking	
		Colour change		Staining		Wet	Dry	Wet	Dry		
				Colour change		Staining		Colour change		Staining	
	Colour change	Staining		Colour change		Staining					
1.	M3PW ¾	¾	4	4	¾	5	4/5	4	4	4/5	4
2.	T3PW ¾	¾	4	4	¾	5	4/5	4	4	4/5	4

Note : 1 - very poor ½ - 2 - poor ¾ - Fair 2/3 - 3 – Moderate 4 - Good 4/5 Very good 5 - Excellent

As regards colourfastness samplesM3PW andT3PW had fair fastness to sunlight. Staining test proves that samples were good to colour fastness.

In wet pressing samples T3PW and M3PW had good fastness and excellent colour fastness to dry pressing. Staining tests also proved that all samples had very good fastness. Samples had good fastness to wet crocking. very good fastness to dry crocking.

5. CONCLUSION

It may be concluded that natural dye can be used for dyeing cotton as it reduces the effluent. Though the fastness properties are only fair further treatments and research may improve the dye ability . This also reduces the chemical usage in fabric pre treatments and can produce eco friendly fabrics.

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26.

Nutrient Removal from Fertilizer Industry Wastewater Using Microalgae

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ABSTRACT -*Wastewaters from chemical fertilizer industry mainly contain organics, alcohols, ammonia, nitrates, phosphorous, heavy metals such as cadmium and suspended solids. The nature of effluent streams varies in terms of its constituents and complexity. Removal of nutrients from those wastewater effluents is important because their discharge to surface waters can lead to eutrophication by stimulating the growth of phytoplanktons. Effective wastewater treatment by microalgae depends on its ability of growth in the wastewater. To achieve this, bioreactor is developed so as to cultivate the algal species- (Chlorella sp & Scenedesmus sp) and which is inoculated into the fertilizer wastewater in the ratio (1:9). In which Algal growth rate and parameters like COD, total kjeldahl Nitrogen, Nitrite and Phosphate were monitored. The COD of the samples were observed to be 468.2 mg/L and the TKN, Nitrite and Phosphate was found to be around 16.8 mg/L, 100 mg/L and 260 mg/L. The findings of the study in treating the wastewater of fertilizer plants using microalgae showed that removal efficiency of Chlorella sp. is higher than Scenedesmus sp.*

KEYWORDS – *Eutrophication, Chlorella sp., Scenedesmus sp.*

1. INTRODUCTION

Fertilizer industry is very important manufacturing sector, especially for India due to its agricultural based economy. The growth of agricultural sector is significant and is fuelled by variety of fertilizers that includes nutrients such as nitrogen, phosphorous and potassium (N, P, K- nitrogenous, phosphoric and potassic fertilizers). Wastewater treatment is a major problem in such complex fertilizer plant from environmental pollution point of view as variety of wastes are discharged from the Fertilizer plant as water pollutants in the form of (1)Processing chemicals like Sulphuric acid,(2)Process intermediate like Ammonium, Phosphoric, (3)Final products like urea, Ammonium sulphate, Ammonium phosphate etc. Thus, the wastewater generated from various plants includes different contaminants such as acids, alcohols, salts and is characterized having significantly high values of COD and Ammoniacal nitrogen depending upon the source of generation have been reported[19].

Microalgae have been at the focus of attention in recent years as an alternative system for biological wastewater treatment with several applications in wastewater treatment. Microalgae are photosynthetic microorganisms that can grow rapidly and live in harsh conditions due to their unicellular or simple multicellular structure. They provide a way for contaminant removal (nitrogen, phosphorus and carbon) from wastewater while producing biomass that could find use for the production of high-value chemicals. The biomass of microalgae contains three main components: proteins, carbohydrates and lipids. To achieve the maximum benefits from microalgae cultivation, it is essential to pay attention to the selection of suitable species. The cultivation conditions, including (1) liquid media with adequate pH and temperature, (2) necessary nutrients and (3) CO_2 dosed in a controlled manner in the presence of sunlight, are also required for microalgae cultivation.

The main mechanism for the removal of organic matter and nutrient by microalgae include the use of organic matter as energy source and the uptake of nutrient into the cells. The advantage of using microalgae for nutrient removal from wastewater include low operational cost, the potential of using the assimilated nutrients (N and P) as a fertilizer, and the discharge of oxygenated effluent into water bodies [13].In addition, after treatment, algae can be harvested and used to produce biofuels or co-digested with sludge to increase the biogas generation at treatment plants. Both would increase the revenues for the treatment plant and produce green energy.

2. MATERIALS AND METHODS

2.1. Preparation of Synthetic Fertilizer Wastewater

Wastewater is prepared by dissolving ammonium sulphate, potassium di-hydrogen phosphate and sodium nitrite reagents to make the desired influent concentrations of nitrogen (NH_4^+ and NO_2^-) and phosphate[14] which is autoclaved and preserved for further use.

Table 1. Synthetic Fertilizer Wastewater Composition

S.No	Constituent	Composition(mg/l)
1.	$(NH_4)_2SO_4$	330
3.	$NaNO_2$	345
3.	$CaCl_2.2H_20$	300
3.	$MgSO_{4.}7 H_20$	200
5.	$NaHCO_3$	1050
6.	KH_2PO_4	25
7.	EDTA	6.25
8.	$FeSO_4$	6.25

2.2.Preparation of Algae Culture Medium

The species was obtained from algal culture collection, CAS, University of Madras. Bolds Basal Medium was selected which is suitable for fresh water Microlagae i.e., *Chlorella sp.* and *Scenedesmus sp*[2]. The growth characteristics of *Chlorella sp, Scenedesmus sp, and* concentration of pigments viz., chlorophyll-a, chlorophyll-b and total carotenoids was studied.

Table 2. Composition of Bolds Basal Medium

Chemical	Composition
$NaNO_3$	250 mg/l
$CaCl_{3.}2H_2O$	25 mg/l
$MgSO_{3.}7H_2O$	75 mg/l
K_2HPO_4	75 mg/l
KH_2PO_4	175 mg/l
NaCl	25 mg/l
Micro nutrients	1 ml

Fig 1: Algal Species **Fig 2: Bold's basal medium**

2.3. Algal Culture of Chlorella and Scenedesmus

The algal species was collected in 10ml test tube from Centre for Advanced Studies in Botany, Madras University. The species was inoculated in 100-ml Erlenmeyer flasks containing 50ml BBM medium in the ratio of (1:9). Flasks were provided with Trulite (18Watts) at room temperature of 30±1°C. Algae growth was monitored by measuring the green contents like chlorophyll a, chlorophyll band total carotenoids by taking the samples from algae cultivated. The full growth of those species is achieved after 21 days [2].

Fig 3: Algal Growth In 21st day

2.4. Experimental Setup

Cultivation bottles of 1000ml is equipped with trulite lamp (18 watts), and experiments were carried out under continuous lighting for a period of 28 days. The algae is inoculated in the ratio of 1:9 (i.e) 450 ml wastewater and 50ml culture. The pH of the incubated samples was maintained at 7.5, and no additional carbon dioxide (CO_2) was supplied to the samples other than the diffusion of CO_2 present in the ambient air. The flasks were stirred manually. The algae utilises the nutrient present in the synthetic waste water during the photosynthesis of algae. Analysis of various parameters like chlorophyll a, chlorophyll b, total carotenoids, COD, TKN, Nitrite and Phosphate were done at regular intervals of every five days once.

Fig 4: Experimental setup Setup 1-*Chlorella sp.*, & Setup 2- *Scenedesmus sp.*,

2.5.Analytical Methods

The parameters like pH, COD, TKN, Nitrite and Phosphate were determined for the synthetic fertlizer industry wastewater. The parameters were analyzed by standard methods (APHA, 2005).

2.6. Cell Count

The cell count of algal species i.e *Chlorella sp.* and *Scenedesmus sp.* is measured using haemocytometer. One ml of sample was taken from the culture, and poured in the haemocytometer using micropipette. Then it was observed at 10x through microscope and the number of cells were counted. In case of *Scendesmus sp*, lucasyrin was added to avoid the movement of cells.

2.7.Chlorophyll Content

Accurately 5ml sample mixture was centrifuged for 5,000 rpm for 15min. The supernatant were separated and 0.5ml of it is mixed with 4.5ml of the respective solvent (i.e 80% Acetone). The solution mixture was analyzed for Chlorophyll-a, Chlorophyll-b and Carotenoids content in spectrophotometer. The equation used for the quantification of Chlorophyll-a, Chlorophyll-b, and Carotenoids are given below:

$$\text{Ch-a} = 14.7\, A_{663} - 4.69\, A_{645} \quad \ldots 1$$

$$\text{Ch-b} = 24.9\, A_{645} - 4.68\, A_{663} \quad \ldots 2$$

$$C\ x{+}c = (1000A_{470} - 1.82Ch_a - 85.02Ch_b)/198 \quad \ldots 3$$

A = Absorbance, Ch-a = Chlorophyll a, Ch-b = Chlorophyll b, and C x+c = Carotenoids

3 RESULTS AND DISCUSSION

3.1. Characterization of Wastewater

The wastewater sample prepared is characterized for the following parameters:

Table 3. Characterization of Wastewater

S.No	Parameters	Value (mg/l)
1.	pH	7.5
2.	COD	468.2
3.	TKN	16.8
4.	Nitrite	100
5.	Phosphate	260

3.2. Cell Count of Algal Species

The cell count of algal species i.e *Chlorella sp.* and *Scenedesmus sp.* was measured using haemocytometer. The cell count observed on the 21st day was 1007.5 x 10^4 cells/ml for *chlorella sp.*and 655 x 10^4 cells/ml for *scenedesmus sp*.

3.3.* Structure of *Chlorella Species

Chlorella is a genus of single-cell green algae belonging to the phylum chlorophyta. It is spherical in shape, about 2to10μm in diameter, and without flagella. *Chlorella* sp. contains the green photosynthetic pigments chlorophyll-a and chlorophyll-b in its chloroplast. The structure of *chlorella* sp. was seen through microscope as well as zoomed picture is shown.

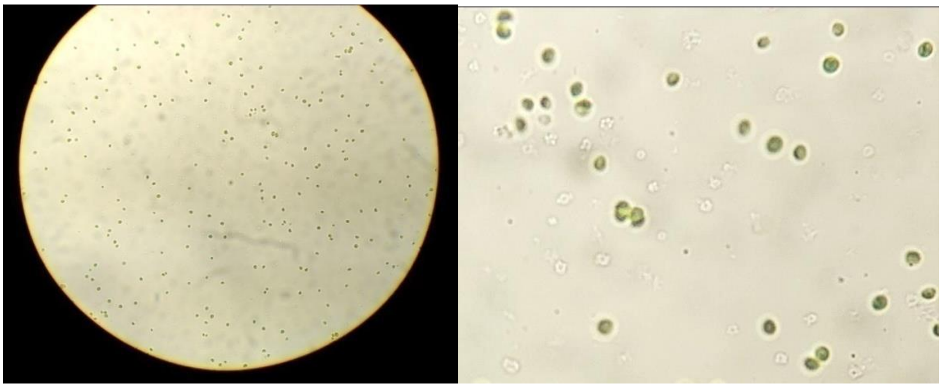

Fig 5: Structure of Chlorella sp.

3.4. Structure of *Scenedesmus species*

*Scenedesmus*is a genus of green algae, in the class chlorophyceae. They are colonial, non-motile and arranged with two or more cells in a row. The structure of *Scenedesmus*sp. was seen through microscope as well as zoomed picture is shown.

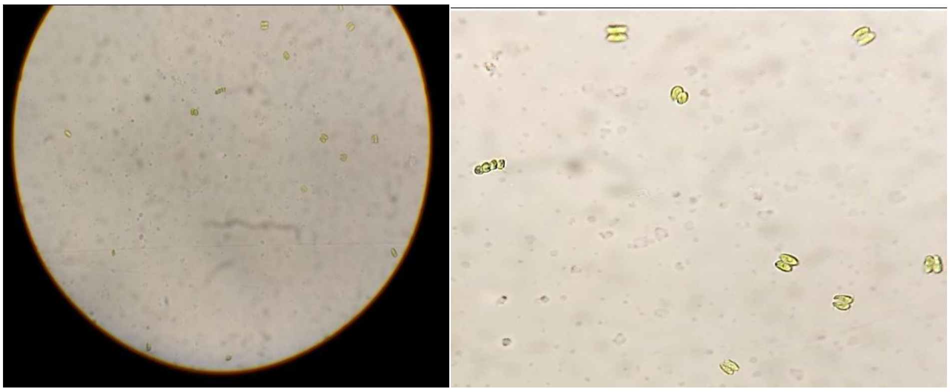

Fig 6: Structure of *Scenedesmus sp.*

3.5. Chlorophyll Concentration of Chlorella Species

The initial chlorophyll concentration of *Chlorella* microalgae in the Bold's basal medium was 1.605, 0.811 and 0.511 µg/ml respectively. Experiments were carried out continuously for a period of 28 days. Samples were taken from the setup periodically during the experiment and the concentrations of the microalgae were measured.

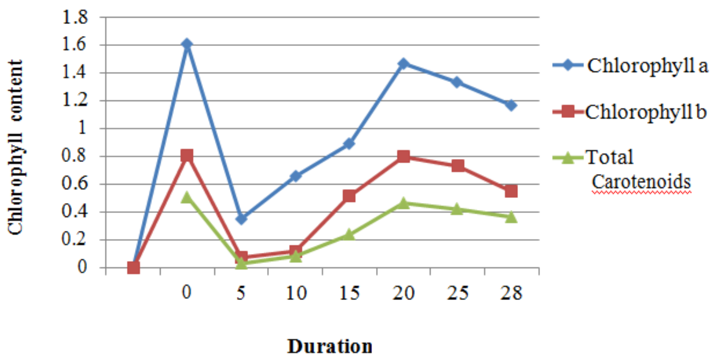

Fig 7: Concentration of chlorophyll-a, chlorophyll-b and total carotenoids in setup1

The lag phase occured in the first 5 days, this was followed by an exponential growth phase upto 20th day, where the algae chlorophyll concentration increased to a maximum of 1.468µg/ml,0.798 µg/ml and 0.465 µg/ml. After this peak the algae concentration decreased. The data observed was an indication of optimum mean cell residence time for the microalgae under the present operating conditions lies between 5–20 days.

3.6. Chlorophyll Concentration of Scenedesmus Species

The initial chlorophyll concentration of *Scenedesmus sp.* microalgae in the Bold's basal medium was 10.332 µg/ml, 4.714 µg/ml and 4.161µg/ml respectively. Experiments were carried out continuously for a period of 28 days. Samples were taken from the setup periodically during the experiment and the concentrations of the microalgae were measured.

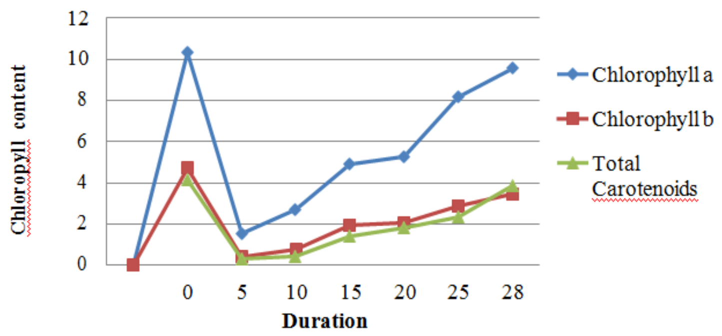

Fig 8: Concentration of chlorophyll-a, chlorophyll-b and total carotenoids in setup2

The lag phase occured in the first 5 days, this was followed by an exponential growth phase up to 28th day, where the algae concentration increased to a maximum of 9.554µg/ml 4.465µg/ml and 4.867µg/ml. However, the data observed was an indication of optimum mean cell residence time for the microalgae under the present operating conditions lies between 5–28 days.

The graph showing that difference between the growth rate of algal species in the bolds basal medium and the synthetic fertilizer wastewater (i.e Chlorophyll Content of *chlorella sp* and *scenedesmus sp* measured in wastewater was less than the Chlorophyll Content in bolds basal medium).

3.7. Concentration of COD in the Culture Medium

The feed which is the synthetic fertilizer wastewater has an average concentration of 468.2mg /L over the duration of the experiments. After the process the COD concentration was between 132 and 89 mg /L.The results of the study showing the decrease of COD values because the samples were centrifuged and digested. Marhaini *et al* [13] indicated that there is an accumulation of organic materials in the wastewater resulting from the growth of microalgae *Chlorella pyrenoidosa* and *Nannochloropsis sp* resulted in increased levels of COD.

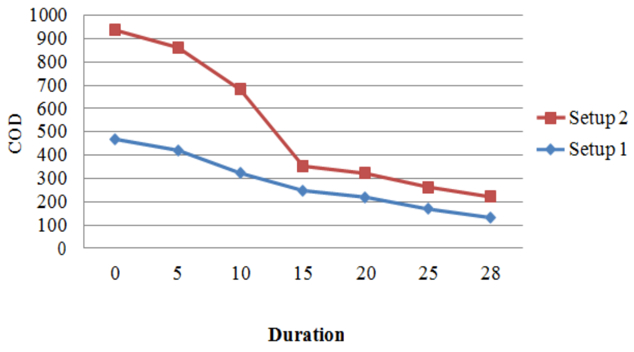

Fig 9: Concentration of COD in the culture medium

The removal efficiency of COD in setup1 was found to be 71.8% (*Chlorella sp.*) and 80.9% in setup 2 (*Scenedesmus sp.*). The removal of COD was found to be higher in setup 2 (*Scenedesmus sp).* And it was found to be 34.33% removal from the study of nutrient utilization from wastewater by algae *tanmayee et* al [18].

3.8. Concentration of TKN in the Culture Medium

Microalgae are able to assimilate nitrogen from a variety of nitrogen sources including ammonium, nitrate, nitrite and urea Azianabiha *et al* [2] although ammonium is the preferred nitrogen source. In this study, the TKN parameter was measured which was the sum of organic nitrogen and ammonium in the wastewater sample. The concentration of TKN at pH 7.5 in wastewater sample on 0^{th}day was 16.8 mg /L. On 28^{th} day concentration of TKN in sample added with algal culture was reduced to nil in setup 1 and 9.7mg/L in setup 2 respectively.

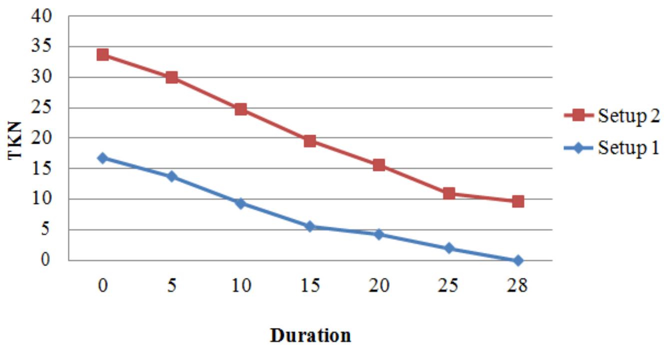

Fig 10: Concentration of TKN in the culture medium

3.9. Concentration of Nitrite in the Culture Medium

The concentration of Nitrite at pH 7.5 in wastewater sample on 0thday was 100 mg /L. On 28th day concentration of Nitrite in the sample added with algal culture was reduced to 10mg/L in setup1 and 15mg/L in setup2 respectively.

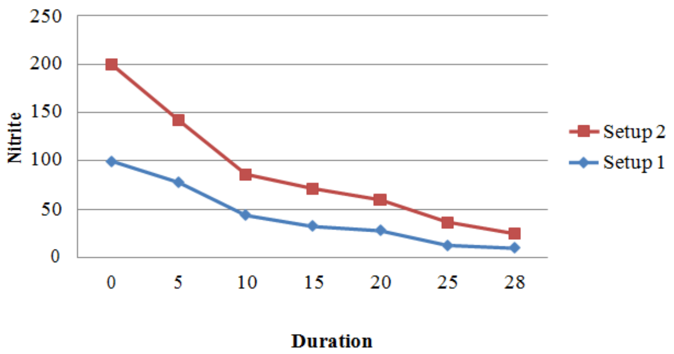

Fig 11: Concentration of Nitrite in the culture medium

Martinez *et al* [12] have been reported that the microalgae *C. vulgaris* and *S. obliquus* showed preferences for ammonium to any other form of nitrogen present in wastewater. The treatment of the wastewater of urea fertilizer plant was done by means of combining chemical and bilogical methods, the use of microalgae *Chlorella pyrenoidosa* absorbed nitrate and nitrite as much as 99% and *Nannochloropsis sp.* as much as 84% (Marhaini et *al* [13].

3.10. Concentration of Phosphate In The Culture Medium

The concentration of phosphate at pH 7.5 in wastewater sample on 0thday was 260 mg /L. On 28th day concentration of phosphate in the sample added with algal culture was reduced to 10mg/L in setup1 and 211mg/L in setup2 respectively.

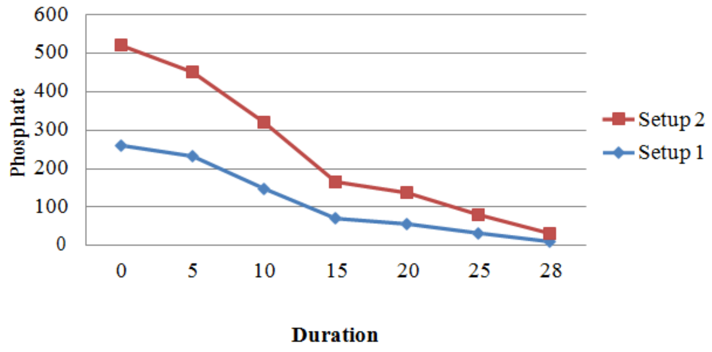

Fig 12: Concentration of phosphate in the culture medium

At the temperatures of 15 and 25ºC, [10] have been reported that the average total nitrogen and phosphorus removal extents ranged from 72 to 83% respectively. In this study at temperature of ±30ºC, the removal efficiency of TKN, Nitrite and Phosphate in setup1 (*Chlorella sp.*) was found to be 100%, 90% and 96.15% as well as in setup2 (*Scenedesmus sp.*) was found to be 42.26%, 85% and 91.9% respectively.

4.CONCLUSION

Wastewaters from fertilizer industries are a serious environmental hazard. In this study, an attempt was made to remove the nutrients from fertilizer wastewater by using microalgae *Chlorella sp.* and *Scenedesmus sp*. The fertilizer wastewater is synthetically prepared and it was characterized as per standard methods for the examination of wastewater (APHA 2005) for the parameters such as pH, COD,TKN, Nitrite and Phosphate.

The finding implied that application of these two species with wastewater in which adaptability of *Chlorella sp.* has promoted faster growth. Highest cell count of Chlorella sp., was

1007.5(10^4 cells/ml) obtained in this study which was greater compared to previous literatures using comparable culture conditions. The maximum amount of pigment chlorophyll-a (1.468 & 9.554µg/mL) chlorophyll-b (0.798 & 4.465µg/mL) and concentration of total carotenoid (0.465 & 4.867µg/mL)was produced on the algal culture medium. Results indicated that the removal efficiency of COD in setup1 was found to be 71.8%(*Chlorella sp*) and 80.9% in setup 2 (*Scenedesmus sp*). And also the removal efficiency of TKN, Nitrite and Phosphate in setup1 (*Chlorella sp*) was found to be 100%, 90% and 96.15% as well as in setup2 (*Scenedesmus sp.*) was found to be 42.26%, 85% and 91.9% respectively.

The study concluded that algae can consume the nutrients in the fertilizer wastewater sample and can be cultivated at pH 7.5 which was optimum for algal growth. The data collected provides an indication that an optimum mean cell residence time for the microalgae i.e, *Chlorella sp.* under the present operating conditions lies between 5–20 days and for *Scenedesmus sp.* it lies between 5- 28 days. Based on which, the removal efficiency of nutrients were found to be higher in setup 1 (*Chlorella sp.*).

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27.

Performance Evaluation of Electrodes TiO_2/Zn and zinc in the Treatment of disperse dye by Electrocoagulation Process – A Comparative Study

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ABSTRACT:

This work primarily deals with the treatment of textile dyeing waste water followed by the utilization of waste material. The aim of the proposed study is to evaluate the performance of electrocoagulatiuon process using TiO_2/Zn electrodes by thermal decomposition of $TiCl_3$ and to compare the performance with Zn - Zn. The process was investigated for color removal and energy consumption. The effects of the relevant key operating conditions such as applied current and electrolysis time, pH, electrolyte were studied in order to evaluate the performance of electrodes. The surface morphology and crystalline studies of the electrode was studied using SEM (Scanning Electron Microscope and) and XRD (X-Ray Diffraction) analysis. The synthetic disperse dye was obtained from Devi Industries in coimbatore, Tamilnadu. The operating parameters were compared for both electrodes, where the decolourisation of disperse dye with newly developed TiO_2/Zn electrode at pH 7.5 with the applied current 0.05A achieves high dye removal efficiency (98%) with less reaction time and energy in the coagulation process.

KEY WORDS: Electrocoagulation, disperse dye, newly developed TiO_2/Zn electrode, reaction time

INTRODUCTION

Technological advancements have resulted in a greater demand for water from various types of industries. The quantity of water generated and discharged as waste from these industries has been hastily increasing containing wide variety of pollutants. Treatment of these waste waters before release into the environment has become a grand challenge. Textile industry is one of the major water consuming sectors in developing countries and amid all industries. Although textile and apparel manufacturing has largely shifted to developing countries, textile wastewater remains a big concern both in developed and developing countries. The size of India's textile market is expected to expand at a CAGR of 10.1 per cent over 2009-21. India is the major manufacturer of textiles which constitute 83 composite mills and 2241 semi composite processing units [1]. Hence, it can be said that India may be the major contributor of textile wastewater in South Asia. The textile industries in India are mainly located in Mumbai, Surat, Ahmedabad, Coimbatore, Ludhiyana and Kanpur [2].

When colored wastewaters are discharged into the environment without treatment, they can affect aquatic ecosystems in different ways [3]. Color removal is possible via different physical, chemical, and biological methods or a combination thereof. Physical methods include such as adsorption, absorption, membrane filtration, and ultrasonic waves; chemical methods include ion exchange, electrolysis, coagulation, conventional, and advanced oxidation; and biological methods using algae, fungi, and bacteria can be mentioned [4, 5, 6]. In chemical coagulation, electrostatic gravity between the dye solution and polymeric molecules with opposite loads generate coagulation. The disadvantages of this method are high sludge production and high dissolved solids in treated wastewaters and polymeric molecules with opposite loads generate coagulation. Chemical coagulation is efficient for sulfurous and disperse dyes. Acidic, direct, vat and reactive dyes coagulate with this method but do not settle, while cationic dyes do not even coagulate. [7] The electrochemical method is a better treatment method with high efficiency for treating textile wastewaters which contain a high concentration of dye. This method has advantages over others for decolorization, such as the need for simple equipment, higher performance, and shorter retention time to remove contaminants, easier operation, and less need for chemicals [8]. This challenge towards rising demand for quality water can be resolved by the application of certain sophisticated scientific techniques for the conversion of waste water into reusable water. A wide range of wastewater treatments are currently known to people. With the recent technology development in electrochemical field, a new technique has been introduced in the industry, named as electrocoagulation.

EC has been successfully used for decades in order to treat the wastewaters of textile [9, 10] food and protein [11] phosphate [12] tannery wastewater [13] restaurant wastewater [14] [and defluoridation [15].

One of the main challenges that this technology is likely to encounter is that of high electricity consumption while treating the wastewater. As it directly affects the operating costs, more research into the ways and means of reducing the power consumption would help in rapid acceptance of this technology [16]. Firstly since electrical energy requirements are a direct function of treatment time, electrocoagulation with conventional electrodes like aluminium resulted in two-fold electrical energy consumption (17 kWh/m^3 wastewater) as compared with energy consumption using stainless steel electrodes (8 kWh/m^3 wastewater) [17]. Although conventional electrode materials (Al and Fe) can offer high coagulation efficiency, they both generated high O_2 evolution over potential and are anodically soluble with low durability. Reports on novel electrode materials remain very scarce in the literature. So Need for novel cost effective electrode material/ Hybrid EC reactor which consumes less current and time.

Secondly no previous studies have attempted to comprehensively investigate electrocoagulation using sacrificial Ti electrodes, so there is a Need for improving the economical efficiency of Titanium electrode. [18]

Based on these research, the aim of the present study is to prepare TiO_2 coated zinc electrodes from the thermal decomposition method of $TiCl_3$ and examine the efficiency of electrocoagulation process in which EC performance were evaluated for pollutant dye removal of disperse dye using TiO_2/Zn –TiO_2/Zn and compared with Zn - Zn. The two technical criteria which are of primordial importance are color removal and electrode efficiencies. The two criteria which may directly influence the process efficiency and economy, especially operational costs, are energy and electrode consumptions. The method was tested under various parameters including applied current, pH, time, dye concentration and of supporting electrolyte. The main target was to determine the optimum operating conditions, with the aim of applying this method to a real wastewater.

2. MATERIALS AND METHODS:

2.1 Preparation of TiO_2/Zn Electrode:

In general the experimental procedure recommended by Beck and Co- workers [19, 20] was adopted for the preparation of TiO_2/Zn electrode by the thermal decomposition of $TiCl_3$ by the following procedure. Precursor solution was prepared using $TiCl_3$ (0.15N), HNO_3 (5.0%v/v) and isopropyl alcohol (Merck). In this solution the concentration of HNO_3 and isopropyl alcohol were kept constant. A stable clear yellow solution is obtained. This solution was sprayed over pretreated zinc substrate strips. And the adherent film was dried in an oven at 100-110^{0}C. The metal strip was placed in a muffle furnace for 25 minutes at 600^{0}C. This procedure was repeated at least six times to get a good coating of TiO_2 on zinc substrate. The electrodes were prepared with dimensions of 9cm × 3.2cm ×.5cm.

2.2 Morphological and structural analysis

The morphological and structural analysis of the coatings was performed by using SHIMADZU-6000 X-Ray diffractometer. Surface morphology of TiO_2/Zn electrodes was carried out by Scanning Electron Microscope (SEM) using JEOL 6390 instrument

2.3 EC PROCESS

2.3.1. Synthetic dye solution

Disperse dye was obtained from one of the textile industry in Coimbatore, Tamil Nadu. (Commercial name; color index number not known) The simulated wastewater was prepared by dissolving a given amount of disperse dye in distilled water at initial dye concentrations of 0.03, 0.04, 0.05, 0.06 and 0.07%. The experimental device is schematically shown in Fig 1.The EC unit consists of an electrochemical reactor which is a glass beaker with magnetic stirring, a D.C power supply and two sets of EC process were run with TiO_2/Zn – TiO_2/Zn and Zn – Zn. (Hereafter these electrodes will be represented as 'A' (TiO_2/Zn – TiO_2/Zn) and 'B' (Zn – Zn))

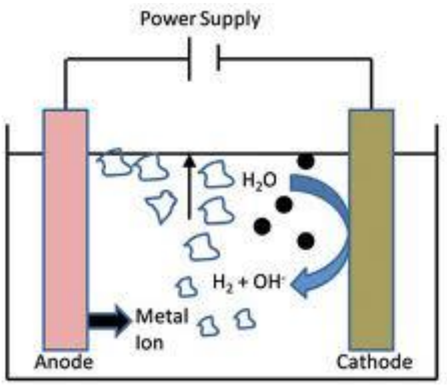


Fig 1: Schematic representation of EC process (Source: http://pubs.sciepub.com)

The electrodes were used with dimensions of 9cm × 3.2cm ×.5cm. The total effective electrode area was 28.16 cm^2 and the spacing between electrodes was 3cm. The electrodes were connected to a digital dc power supply (var tech) providing a current ranging from 0.05 to 0.3A. 500ml electro coagulation cell that contained the 250 ml test solution and a magnetic stirrer was used to stir the solution, thereby enhancing the efficiency. The applied current was adjusted to a desired value and the coagulation was started. In each run, 250 ml of dye solution was placed into the electrolytic cell. Before each run, electrodes were washed with water and dipped in 15% hydrochloric acid in order to remove dust from the electrode plates and thus weigh the electrodes after drying. At the end of each run, the electrode plates are washed with water, dried and finally weighed. The subsequent treated sample was filtered using whattman filter paper and filtrate was used for the characterization. In this study, individual effects of electrolysis time and applied current were quantified on color removal efficiency (CRE). The pH was adjusted by adding 0.5N HCl or 0.5 N NaOH. The conductivity of solutions was raised and adjusted to different values by the addition of NaCl. All experiments were carried out at constant temperature of 25 °C. Two sets of EC process were carried out with 'A' and 'B' electrodes with operating parameters like pH, EC time, dye concentration, addition of electrolyte NaCl and applied current for optimization to achieve higher Color Removal Efficiency (CRE%). On the basis of the initial

experiments, other parameter rates were considered constant. The ultraviolet-visible spectrophotometer (Jasco V-670 spectrophotometer) was used to measure the wavelength (542 nm) of dye. The calculation of color removal efficiencies (CRE %) after electrocoagulation treatment was performed using this formula:

Colour removal efficiency (CRE%) $=100*(A_0-A_t)/A_0$ (1)

Where A0 and A_t were the absorbance of the dye in solution before electrocoagulation and at the time *t*, respectively. The electrical conductivity and pH of different dye concentration were measured by using conductivity meter (Elico CM180) and pH meter (Eutech)

The energy consumption per volume of treated wastewater was estimated and expressed in kWh/m^3. The average cell voltage, during the electrolysis, is taken for calculating the energy consumption, as follows:

The electrical energy consumed per unit volume of treated wastewater was determined using the equation

$$EEC = V\ I\ t/v \qquad (2)$$

where *EEC* is the electrical energy consumption (kWh/m^3), *V* is the potential (V), *I* is the current (A), *t* is the time (h), and *v* is the volume of solution (m^3).

3 RESULTS AND DISCUSSION

3.1 Characterisation of electrode

3.1.1 X-ray diffraction analysis

The phase purity and composition of the particles obtained by the thermal decomposition method was examined by XRD. Fig 2 shows a typical XRD pattern of Zn and TiO_2/Zn. A number of Bragg reflections with 2θ values of (32, 35, 47, 56, 63, 68) were observed corresponding to (104) (110) (024) (018) (300) (208) planes, shows a typical XRD pattern of TiO_2 particles. Same way a number of Bragg reflections with 2θ values of (36, 43, 54, 70, 78) were observed corresponding to (002) (100) (101) (102) (103) (004) planes, shows a typical XRD pattern of zinc substrate. The data was compared with the standard JCPDS card no: 71- 1059 for TiO_2 and 65-3358 for Zn. No other impurity peak was observed in the XRD pattern and TiO_2 is found with good crystalline in nature of the sample. From the XRD results it has been found that Ti is in the form of Ti^{2+} on zinc.

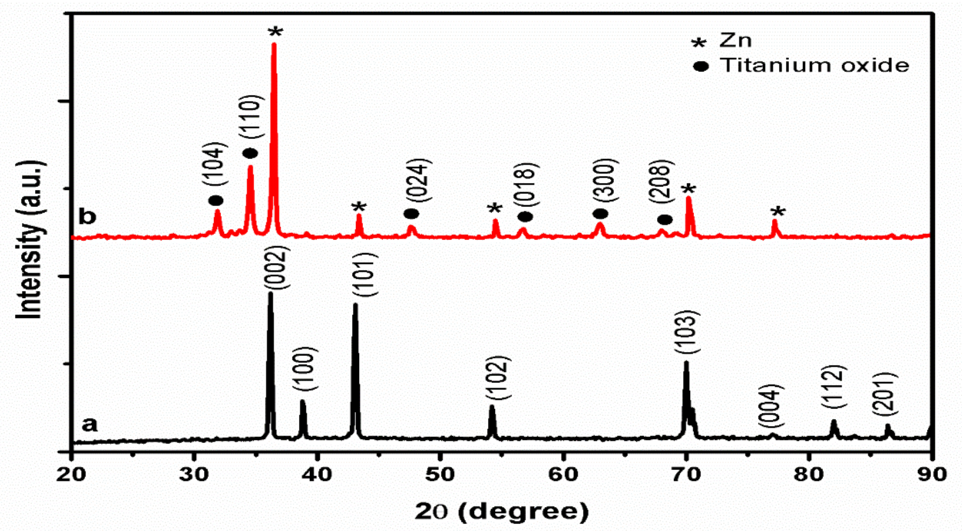


Fig 2: XRD Pattern a- Zn, b- TiO_2/Zn

3.1.1.2 SEM Analysis:

Fig 3 represents the SEM micrograph of zinc substrate (Fig 3a) and TiO_2/Zn (Fig 3b). From the SEM micrographs, the TiO_2 particles are irregular in shape and appeared in an agglomerated state. Fig 3b shows the zinc substrate with TiO_2 particles as small crystallites covering the entire surface with smaller tubular structures spread over the zinc substrate. The average particle size shown from SEM micrograph is 200 - 294 nm. The coating of TiO_2 on zinc substrate has increased the surface roughness which in turn resulted in more contact area. And the increase in more contact area resulted in increasing the efficiency of dye removal as well as in less consumption of electrical energy in the case of TiO_2/Zn compared with Zn electrodes in the EC process. (Fig 9, Table 6)

(a) (b)

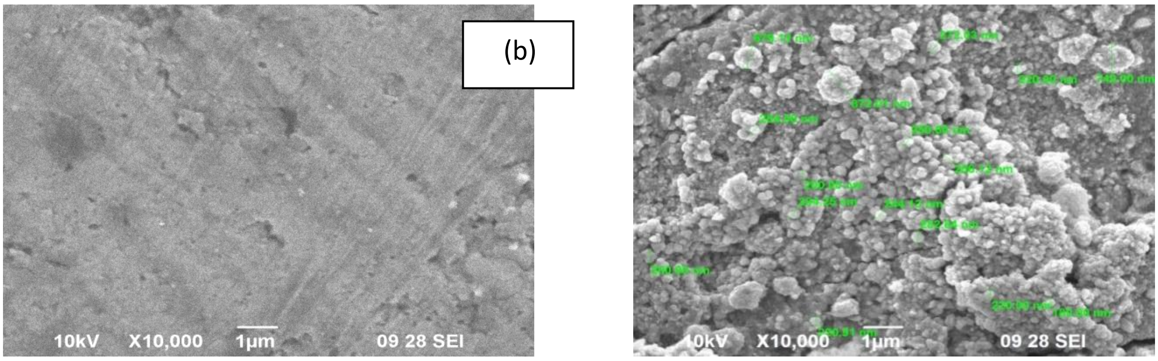


Fig 3: SEM image of (a): Zn, (b): Ti^{2+}/Zn

3.2 OPTIMIZATION OF OPERATIONAL PARAMETERS

3.2.1 Effect of pH:

The pH is one of the most important parameters in the performances of EC process in order to achieve a compromise between best coagulation and best flotation. The optimum range may however vary as a function of electrode material and dye structure. And the fact is that pH determinates the metallic ions speciation, the chemical state of other species in the solution, and the formed products solubility.[5] Hence the optimum pH is necessary to minimize environmental remediation costs and make the process more efficient. To investigate this effect in this work, a series of experiments were performed using synthetic disperse dye solution.

Experiments were carried out at various values of pH (4.5, 5.5, 6.6, 7.5, 8.5 and 9.5) under which the applied current was kept at 0.05A for electrode 'A' and 0.15A for electrode 'B'. The pH was adjusted to a desirable value using NaOH, or $H_2SO_4$and varied in the range 4.5 to 9.5. The treated sample is collected and filtered and the % of CRE estimated. The obtained results are shown in Fig 4 and Table 1.

It can be noticed that decolorization was most effective in a pH range between 4.5 to 8.5 for coated and 4.5 for zinc electrodes and removal of CRE% reached values between 90.5 to 95.3 for the coated and 80.4 for Zn electrodes. This corresponds to the region where positively charged $Ti(OH)^{2+}$ and $Ti_2(OH)^{2+}$, and insoluble $Ti(OH)_3$ species prevailed. Cations are able to conduct primarily charge neutralization, as colloidal particles are usually negatively charged, while insoluble species favor coagulation by immediate precipitation. On the other hand, above pH 8.5, % of CRE fell when soluble $Ti(OH)_4{}^-$ anions become predominant at high pH [21]. At an initial pH of 4.5, dye process was completed within 5 minutes with high efficiency. And also at pH 4.5, the dye separated well from solution and the sludge floated with high % of CRE removal in the case of electrode 'A', and the separation was clear and high % of CRE removal as the pH was increased from 4.5 to 7.5 may be due to the formation of more monomeric and polymeric insoluble Ti species.

Table 2. Effect of pH on CRE (%)

	CRE %	
pH	A	B
4.5	90.56	80.49
5.5	94.82	68.67
6.5	92.95	59.31
7.5	95.60	41.70
8.5	95.32	36.03
9.5	87.95	25.25

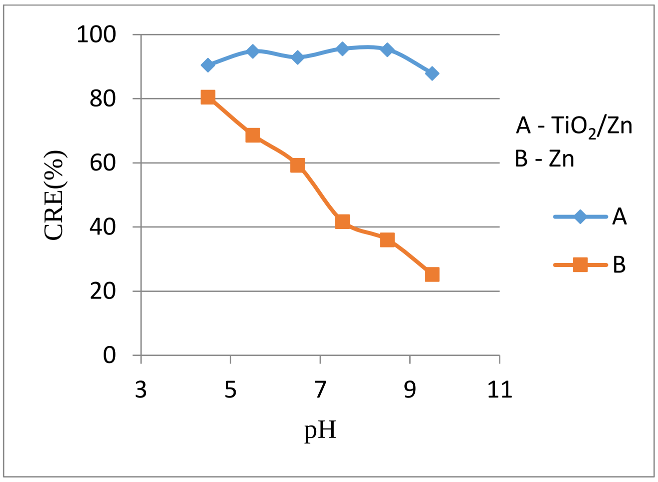


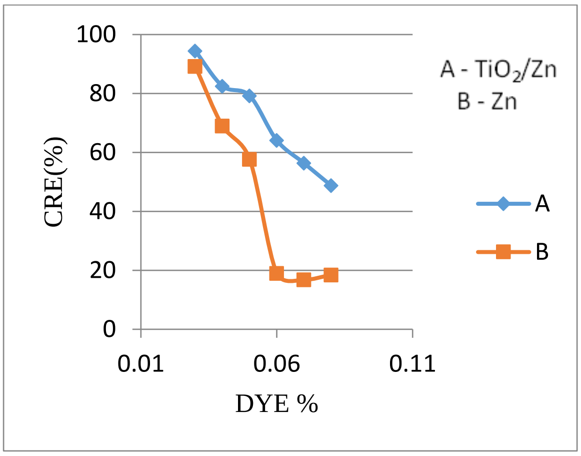
Fig 4: Effect of pH on CRE (%)

In the case zinc electrodes at pH 4.5 the % of CRE was 80.49, as the pH increased from 4.5 to 9.5 there was a gradual and sudden abatement in % of CRE, this may be due to the formation of more soluble $Zn(OH)_2$ than insoluble species of zinc ion which can favor coagulation and thereby precipitation.

3.2.2 Effect of Dye Concentration

To determine influence of initial dye concentration on color removal efficiencies during electrocoagulation, different initial concentrations of disperse dye in the range of 0.03 to 0.08% were treated for the electrodes 'A' and 'B' under the optimized conditions of other parameters. Results obtained are shown in Fig 5 and Table 2. From the results it is observed that when dye concentration increased from 0.03 to 0.08%, removals efficiencies decreased. One of the most important pathways of dye removal by electrocoagulation is adsorption of dye molecules on metallic hydroxide flocs. The adsorption capacity of flocs is limited and specific amount of flocs is able to adsorb specific amount of dye molecules. So, with increasing of dye concentration, amount of produced flocs is insufficient to adsorb all dye molecules, therefore on increasing dye concentration, CRE decreases for electrode 'A' the percentage is 94%, but for 'B' 89%.

Table 2. Effect of dye conc on CRE (%)



	CRE %	
Dye conc (%)	**A**	**B**
0.03	94.47	89.28
0.04	82.54	69.03
0.05	79.27	57.76
0.06	64.13	19.05
0.07	56.40	16.83
0.08	48.77	18.43

Fig 5: Effect of dye conc on CRE (%)

3.2.3 Effect of Electrolyte:

The increase of the conductivity, by the addition of supporting electrolyte, is known to decrease the cell voltage (*U)* at constant current density due to the decrease of the ohm resistance [21] of the solution. Energy consumption, which is proportional to *UI*, will therefore be reduced. NaCl is generally used to increase the solution conductivity by electrocoagulation treatment. It also allows decreasing the passivity of the electrodes by removing the passivating oxide layer formed on electrode surface due to its catalytic action [22]. Chloride ions could significantly reduce the adverse effects of other anions (due to their oxidation), and increases the availability of metal hydroxide in the solution. Thus, this parameter should have a significant impact on removal efficiencies of pollutants. The ability of pollutant removal at certain conditions depends on the rate of coagulant generated which is related to the conductivity of the media. In this process, NaCl is added to increase the conductivity of the waste water to be treated and the increase in the salt concentration increase the ion concentration in the solution and hence reduces the electrical resistance of the solution, as a result the resistance between the electrodes. Greater the electrical conductivity means higher electrical conductivity of the solution, and for creating a fixed current conductivity, a higher voltage is needed. Therefore, for creating a fixed current conductivity, less NaCl is needed compared with other electrolytes like Na_2SO_4, or Na_2SO_3, Moreover NaCl has a higher ionization speed and mobility due to the lower radiuses of Na and Cl as a result, and more current passes through wastewater and by increasing passing current, the speed of anode dissolution increases. On the other hand, producing acidic species such as HCl and ClO^- enhances the desirability of revival conditions. Therefore, using NaCl as electrolyte has advantage for lower price. Also, textile and dying industries use plenty of NaCl and wastewaters of these industries include ions of this salt NaCl, because it is cheap and the solution containing this salt has high conductivity thus it need low voltage for electrocoagulation and so it is economical in industrial scale.

To study the effect of wastewater conductivity on dye removal, various experiments were performed using NaCl as the electrolyte in the range of 0.1-0.35g/L and the CRE removal efficiencies observed during EC process are given in Fig 6 and Table 3.

It is believed that the main pollutant removal mechanism observed during electrocoagulation is adsorption and entrapment onto the amorphous titanium and $Zn(OH)_2$ precipitate formed due to the anodic reaction at maximum rate at pH 7.5 and 4.5 for ‘A’ and ‘B’ electrodes [23].

$$Ti(s) \rightarrow Ti^{3+}(aq) + 3e^- \quad (3)$$

$$Zn \rightarrow Zn^{2+}(aq) + 2e^- \quad (4)$$

Table 3. Effect of NaCl on CRE (%)

	CRE %	
NaCl (g/L)	**A**	**B**
0.10	96.83	98.19
0.15	97.44	88.35
0.20	82.93	61.31
0.25	87.28	33.13
0.30	82.24	42.02
0.35	79.12	40.12

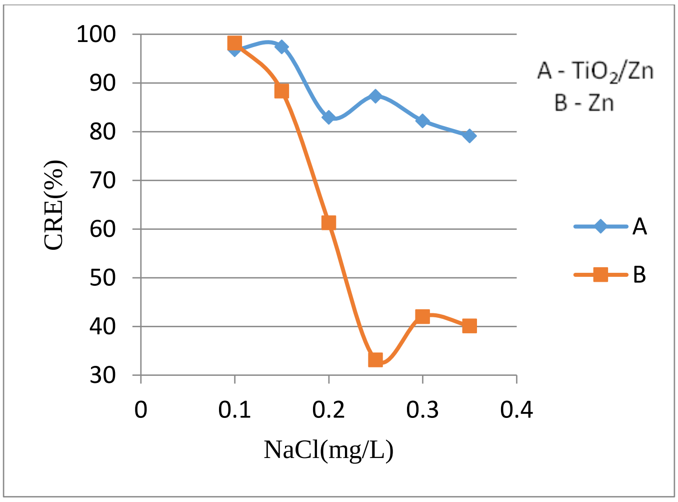


Fig 6: Effect of NaCl on CRE (%)

As is evident in Fig 6 increasing the electrolyte concentration from 0.1 to 0.35 g/L the high % of CRE reducing rates (97.4 for electrode 'A' and for 'B' 98.1), the increase in the removal efficiency of CRE may be attributed to a change in the ionic strength due to the increasing conductivity of aqueous medium and a further addition of NaCl up to 0.35 g/L resulted in a moderate but significant retardation of treatment efficiencies in terms of CRE removals in the electrode 'A'. But in the case of Zn electrodes there was a sudden decrease in the CRE as the electrolyte concentration is increased from 0.1g/L (from 98% sudden abatement in % of CRE) a further increase of electrolyte concentration did not improve, these results can be explained by the fact that when the NaCl concentration increased, the conductivity of the electrolyte was enhanced correspondingly. This was probably, because the Cl^- anions can destroy the passivation layer and increase the anodic dissolution rate of metal, either by the incorporation of Cl^- into the oxide film or by the participation of Cl^- in the metal dissolution reaction [24]. In both the electrodes, further increase of NaCl concentration showed negative degradation and formation of salt film on the electrode surface, which would block the contact between electrode and wastewater. Hence, the probability of effective contact between the organic pollutants and OH free radicals was decreased.

3.2.4 Effect of Applied Current:

It is well known that EC is strongly affected by the applied current [25]. This effect can be explained by the fact that an increase in anodic dissolution of metal ions, occurs with increased applied current, which results in the formation of high amounts of precipitate for the removal of pollutants. Operating current density is critical in batch electrocoagulation as it is the only operational parameter that can be controlled directly. Upon increasing the current, the amount of oxidized metal ions increased and amounts of metal hydroxide compounds for precipitation and adsorption of the pollutants were also increased [26]. Furthermore, the rate of production of hydrogen bubbles increases and their sizes decrease as the applied current increases. All these effects are important for effective removal of dye. Operating at high current may cause other side reactions in the vicinity of the anode, such as the direct oxidation of one of the constituents of the contaminant or the formation of oxygen, which limits the effectiveness of electrocoagulation. Conversely, a high current causes passivity of the cathode by reduction, leading to a high consumption of energy. Especially regarding energy and electrode consumptions, the best conditions correspond to a low applied current and an important electrolysis time. To overcome the unnecessary generation of $Ti(OH)_n$ or $Zn(OH)_n$ in wastewater, it is ultimately important to avoid working at too high current. The efficiency of contaminant reduction depends on Ti (IV or III) and Zn (II) production by the anode so that high electrolysis duration would cause higher production of these titanium hydroxide or zinc hydroxide, which is in turn responsible for the coagulation process. To optimize the parameter applied current in EC process, experiments were carried out at various applied current from 0.05 to 0.30A under other optimized parameters and the results are given in Fig 7 and Table 4.

As the applied current increased from 0.05 to 0.30A, the anodisation followed by floc formation with the Ti^{n+} ions increased, the % CRE was 96 at 0.05A and thereafter slight reduction in removal efficiency in the case of electrode 'A' and in Zn - Zn electrodes as the applied current increased there was a steady increase in the CRE removal, maximum CRE was 86% at 0.15A. This may be explained in electrode 'A' the flocculation was due to the dissolution of both Ti^{3+} and Zn^{2+}, whereby at lower applied current highest CRE removal was obtained, moreover it could be observed that increasing the applied current above the optimum value decreases the CRE is due to undesirable side reaction such as electrolysis of water and oxygen evolution from OH free radicals [27]. However energy consumption leads to be higher for increased applied current and indicates that increase in current density led to less efficient process.

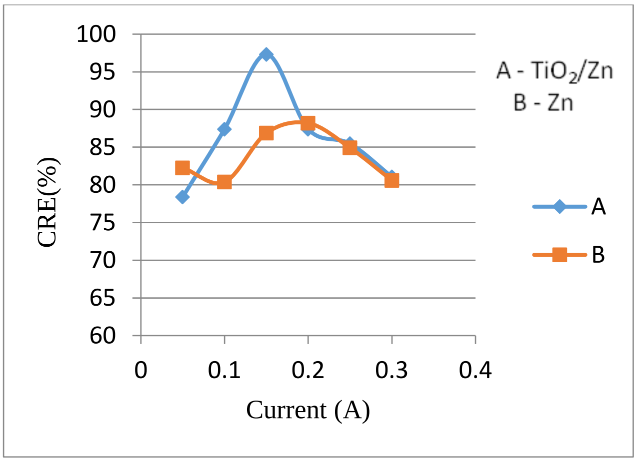


Fig 7: Effect of current on CRE (%)

Table 4. Effect of current on CRE (%)

	CRE %	
Current (A)	**A**	**B**
0.05	78.40	82.26
0.10	87.39	80.37
0.15	97.32	86.87
0.20	87.39	88.18
0.25	85.46	84.91
0.30s	81.06	80.59

3.2.5 Effect of Time:

The percentage color removal efficiency depends directly on the concentration of ions produced by the electrodes. This can be achieved by parameter like EC time. Because the formation of metal ions and concentration of the metal hydroxides play an important role on pollutant removal, this depends on operation time. To study its effect, the EC time was varied for different time intervals i.e., 5, 10, 15, 20, 25, 30 min and the other optimized parameters were kept constant. The results obtained are illustrated in Fig 8 and Table 5. The H_2 and O_2 release and flocs formation increased over time and the foam became thicker.

A plot is drawn between time verses % CRE for two different electrodes as shown in graph, it was clearly known that as the time increases the percentage of CRE increased in the case of electrode 'A' at 10 mins was 96.23 and then there was slight reduction in CRE. Whereas in the case of electrodes 'B' there was a gradual increase of CRE from 50 to 92% and high % of CRE was achieved at 30 minutes which will be with more of energy as well electrode consumption compared to the electrodes 'A'. (Fig.8, Table 5.)

Table 5. Effect of time on CRE (%)

	CRE %	
Time (min)	**A**	**B**
5	90.27	50.34
10	96.23	70.44
15	96.01	84.22
20	95.14	88.05
25	93.89	90.60
30	94.12	92.03

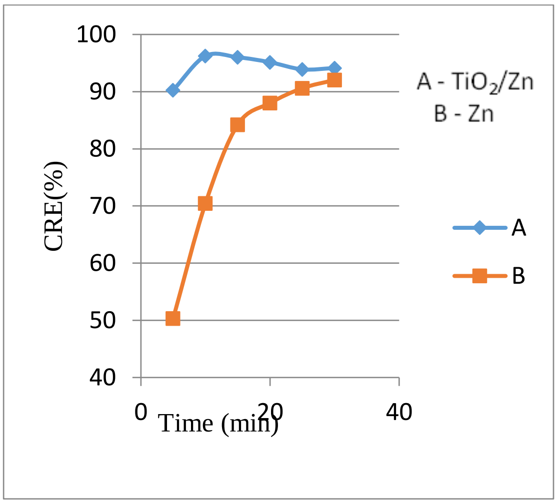


Fig 8: Effect of time on CRE (%)

In the EC process, the anode produces metal ions during electrochemical reaction. Metal ions are destabilization agent. If the charge loading were low, the metal ion released from the anode would not be sufficient to destabilize all the colloidal and suspended particles, so dye removal was not efficient in the case of zinc electrodes at applied current 5A. When EC time changed from 5 to 30 minutes the energy consumption increased from 0.0004966 to 0.00174 kWh/m^3in the case of electrode 'A' and 0.000843 to 0.005227 kWh/m^3 for Zn electrodes (Fig 9, Table 6). From these results it is shown that % CRE removal is high with less energy consumption in the case TiO_2/Zn than zinc electrodes. Treatment time is related with energy consumption and wastewater treatment performance. It is well known that the removal efficiency did not improve much after 25 min electrolysis, but the prolonged time would increase the electrochemical treatment cost. The results indicate that the optimum electrolysis time for best removal efficiencies is 10 min for TiO_2/Zn and 30 min for Zn electrodes.

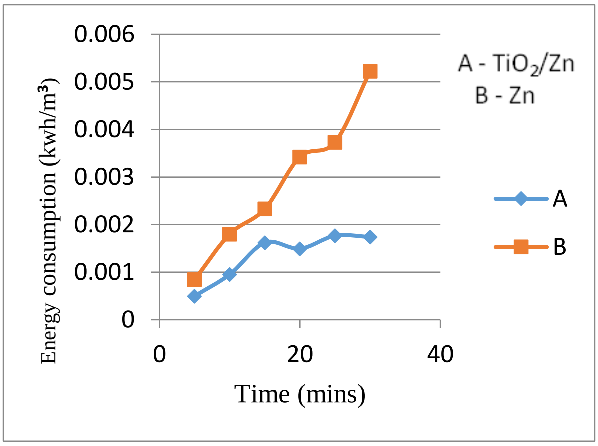


Fig 9: Energy consumption on time

Table 6. Energy consumption on time

	kWh/m^3	
Time (min)	**A**	**B**
5	0.000496	0.000843
10	0.000953	0.001800
15	0.001620	0.002330
20	0.001493	0.003423
25	0.001766	0.003733
30	0.001740	0.005227

4. CONCLUSION

The results obtained in this study shows that the color can be eliminated with high percentages and efficiencies can be achieved using the newly prepared TiO_2/Zn electrodes compared with Zn in EC process. The effect of applied current on CRE% can clearly be understood. As the applied current increased the removal of organic matter also increased. In all the experimental parameters, dye removal efficiencies were in short period of operational time was observed in TiO_2/Zn. It is also known that, the increase on the applied current means the increase on energy consumption. So an optimum current density has to be considered due to local discharge limits, energy and electrode consumptions, local energy unit prices and some other limiting factors. In addition, this study showed that the original pH of the wastewater was the best which was observed with high CRE% at the optimized pH 7.5 in the case of TiO_2/Zn but 4.5 for Zn electrode. Overall, high removal efficiency of disperse dye was obtained using newly modified TiO_2/Zn. The EC process has the potential to treat the textile dyeing wastewater and thus to reduce the contamination of the environment by the dye molecules as the real time textile dyeing waste water can be treated with this newly developed TiO_2/Zn by the thermal decomposition of $TiCl_3$.

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28.
Performance Study For Treatment Of Institutional Wastewater By Activated Sludge Process

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ABSTRACT - Treatment of waste water involves a variety of methods. Biological treatment using aerobic activated sludge process has been in practice over a century. Conventional Activated Sludge Process (ASP) is the most common and oldest bio treatment process used to treat municipal and industrial wastewater. Typically wastewater after primary treatment i.e. suspended impurities removal is treated in an activated sludge process based biological treatment system comprising aeration tank followed by secondary clarifier. The aeration tank is a completely mixed bioreactor where specific concentration of biomass (measured as mixed liquor suspended solids (MLSS) is maintained along with sufficient dissolved oxygen (DO) concentration (typically 2 mg/l) to effect biodegradation of soluble organic impurities measured as biochemical oxygen demand (BOD 5 days). The Hydraulic Retention Time (HRT) is varied in the range 3 - 8 hrs. The maximum BOD removal efficiency obtained was 93.7% and turbidity removal efficiency was 87.6% in the 8 hrs HRT.

KEYWORDS: Activated Sludge Process, Removal Efficiency, BOD, COD, MLSS

INTRODUCTION

The organic material present in the primary effluent, which overflows the primary settling tanks exhibits certain characteristics which require additional forms of treatment. This organic material is comprised of dissolved and finely divided suspended or, colloidal solids which account for the turbid appearance of the primary effluent. By nature, the dissolved organic material present in the influent will remain in solution in the liquid flow during primary treatment. The colloidal solids present are very small in size and mass and do not settle during primary treatment. It is not possible or practical to increase the detention time of the wastewater in the primary tanks in an effort to remove these colloidal solids. Increased detention times would promote the development of septic conditions within the settling tanks and solids removal efficiencies would actually decrease. To treat the primary effluent waste stream a secondary biological treatment process is used known as the activated sludge process. The shortage of water and accumulation of waste urges a demand in the treatment of waste water. Also there is a need in producing more pure water for drinking purpose and reuse of treated water. The Institutional waste water is from the source of domestic waste, which contains high amount of organic and inorganic impurities such as BOD, COD, and Turbidity. The treatment of waste water involves removal of BOD and Turbidity.

WASTE WATER TREATMENT PROCESS

PRIMARY TREATMENT

In the primary sedimentation stage, sewage flows through large tanks, commonly called "pre-settling basins", "primary sedimentation tanks" or "primary clarifiers". The tanks are used to settle sludge while grease and oils rise to the surface and are skimmed off. Primary settling tanks are usually equipped with mechanically driven scrapers that continually drive the collected sludge towards a hopper in the base of the tank where it is pumped to sludge treatment facilities.

SECONDARY TREATMENT

Secondary treatment is designed to the treat the settled sewage liquor using aerobic biological processes. To be effective, the microbes require both oxygen and food to live. The bacteria and protozoa consume biodegradable soluble organic contaminants (e.g. sugars, fats, organic short-chain carbon molecules, etc.) and bind much of the less soluble fractions into floc. Secondary treatment systems are classified as fixed-film or suspended-growth systems.

TERTIARY TREATMENT

The purpose of tertiary treatment is to provide a final treatment stage to further improve the effluent quality before it is discharged to the receiving environment (sea, river, lake, wet lands, ground, etc.). More than one tertiary treatment process may be used at any treatment plant. If disinfection is practiced, it is always the final process. It is also called "effluent polishing."

BIOLOGICAL PROCESS

Biological treatment is an important and integral part of any wastewater treatment plant that treats wastewater from either municipality or industry having soluble organic impurities or a mix of the two types of wastewater sources. The obvious economic advantage, both in terms of capital investment and operating costs, of biological treatment over other treatment processes like chemical oxidation; thermal oxidation etc. has cemented its place in any integrated wastewater treatment plant. Biological treatment using aerobic activated sludge process has been in practice for well over a century.

Types of Biological process

1. Activated sludge
2. Aerated lagoon
3. Aerobic granulation
4. Constructed wetland
5. Membrane bioreactor
6. Rotating biological contactor
7. Sequencing batch reactor
8. Trickling filter

To use less space, treat difficult waste, and intermittent flows, a number of designs of hybrid treatment plants have been produced. Such plants often combine at least two stages of the three main treatment stages into one combined stage.

CONVENTIONAL ACTIVATED SLUDGE PROCESS

Conventional biological treatment of wastewater under aerobic conditions includes activated sludge process (ASP) and Trickling Filter. The activated sludge process consists of an aeration tank, where organic matter is stabilized by the action of bacteria under aeration and a secondary sedimentation tank (SST), where the biological cell mass is separated from the effluent of aeration tank and the settle sludge is recycled partly to the aeration tank and remaining is wasted Recycling is necessary for activated sludge process. The aeration conditions are achieved by the use of diffused or mechanical aeration.

Diffusers are provided at the tank bottom, and mechanical aerators are provided at the surface of water, either floating or on fixed support. Settled raw wastewater and the returned sludge enter the head of the tank, and cross the tank following the spiral flow pattern, in case of diffused air aeration, or get completely mixed in case of completely mixed reactor. The air supply may be tapered along the length in case of plug flow aeration tank, to match the quantity of oxygen demand. The effluent is settled in the settling tank and the sludge is returned at a desired rate.

TYPES OF ACTIVATED SLUDGE PROCESS

CONVENTIONAL AERATION

In conventional ASP the flow model in aeration tank is plug flow type. Both the influent wastewater and recycled sludge enter at the head of the tank and are aerated for about 5 to 6 hours for sewage treatment. The influent and recycled sludge are mixed by the action of the diffusers or mechanical aerators. During the aeration period the adsorption, flocculation and oxidation of organic matter takes place. The F/M ratio of 0.2 to 0.4 kg BOD/kg VSS.d and volumetric loading rate of 0.3 to 0.6 kg BOD/m3.d is used for designing. Lower mixed liquor suspended solids (MLSS) concentration is maintained in the aeration tank of the order of 1500 to 3000 mg/L and mean cell residence time of 5 to 15 days is maintained. The hydraulic retention time (HRT) of 4 to 8 hrs is required for sewage treatment. Higher HRT may be required for treatment of industrial wastewater having higher BOD concentration. The sludge recirculation ratio is generally in the range of 0.25 to 0.5.

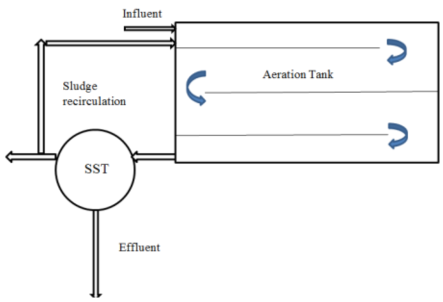

Fig 1.Conventional Aeration

TAPERED AERATION

In plug flow type aeration tank BOD load is maximum at the inlet and it reduces as wastewater moves towards the effluent end. Hence, accordingly in tapered aeration maximum air is applied at the beginning and it is reduced in steps towards end, hence it is called as tapered aeration. By tapered aeration the efficiency of the aeration unit will be increased and it will also result in overall economy. The F/M ratio and volumetric loading rate of 0.2 to 0.4 kg BOD/kg VSS.d and 0.3 to 0.6 kg BOD/m3.d, respectively, are adopted in design. Other design recommendation are mean cell residence time of 5 to 15 days, MLSS of 1500 to 3000 mg/L, HRT of 4 to 8 hrs and sludge recirculation ratio of 0.25 to 0.5. Although, the design loading rates are similar to conventional ASP, tapered aeration gives better performance.

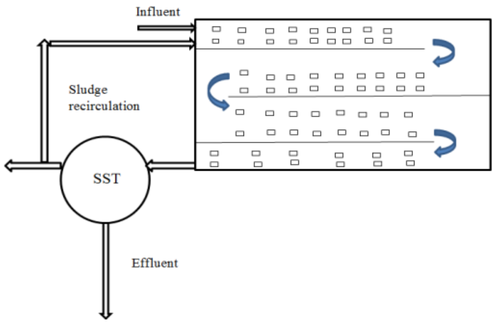

Fig 2.Tapered Aeration

STEP AERATION

If the sewage is added at more than one point along the aeration channel, the process is called as step aeration. This will reduce the load on returned sludge. The aeration is uniform throughout the tank. The F/M ratio and volumetric loading rate of 0.2 to 0.4 kg BOD/kg VSS.d and 0.6 to 1.0 kg BOD/m3.d, respectively, are adopted in design. Other design recommendation are mean cell residence time of 5 to 15 days, MLSS of 2000 to 3500 mg/L, HRT of 3 to 5 hrs and sludge recirculation ratio of 0.25 to 0.75. In step aeration the design loading rates are slightly higher than conventional ASP. Because of reduction of organic load on the return sludge it gives better performance.

METHODOLOGY

Sample collection from institutional treatment plant

↓

Characterization of Institutional wastewater

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Setting up of lab-scale ASP reactor

↓

Effect of various aeration time (3, 4, 5, 6, 8hrs) at constant fill, anoxic, settling and decant time

↓

Treated Effluent Characterization such as BOD, pH, Turbidity

↓

Optimization of operating variables of ASP

CHARACTERISTICS OF WASTE WATER

Table 1. Characteristics of Waste Water

S.NO	PARAMETER	OBTAINED VALUE	CPHEEO 2012 (Permissible limit for irrigation)
1	pH	8.7	5.5-9.0
2	Turbidity	650 NTU	200 NTU
3	BOD	630 mg/l	100 mg/l
4	COD	940 mg/l	-
5	Chlorides	1780 mg/l	-
6	Sulphates	960 mg/l	
7	Ammonical nitrogen	400 mg/l	-
8	Total hardness	1250 mg/l	-
9	Calcium Hardness	1015 mg/l	-

REACTOR SETUP

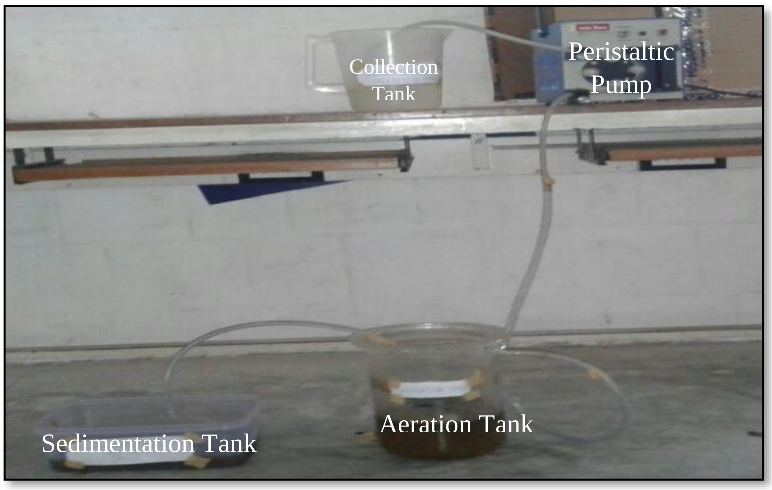

Fig 3. Reactor Setup

The waste water is pumped to the aeration tank by peristaltic pump from the collection tank. The waste water is filled in the tank by leaving the freeboard space. The air is supplied by using the diffuser. After the aeration process, the waste water is moved to the sedimentation tank. The sludge which settled down in the sedimentation tank is then recirculated into the aeration tank for the next process for maintain the MLSS concentration .The process is continued till the maximum efficiency is attained by varying the run time. The BOD and Turbidity is tested for the treated water at various runtime.

RESULT AND DISCUSSION

CHARACTERISTICS OF TREATED WASTE WATER

Table 2 Characteristics of Treated Waste Water

Parameters	Reaction time				
	3 Hrs	4 Hrs	6 Hrs	7 Hrs	8 Hrs
pH	8	7.9	7.9	7.2	6.8
Turbidity (NTU)	570	490	385	240	80
BOD (mg/l)	495	444	335	195	40

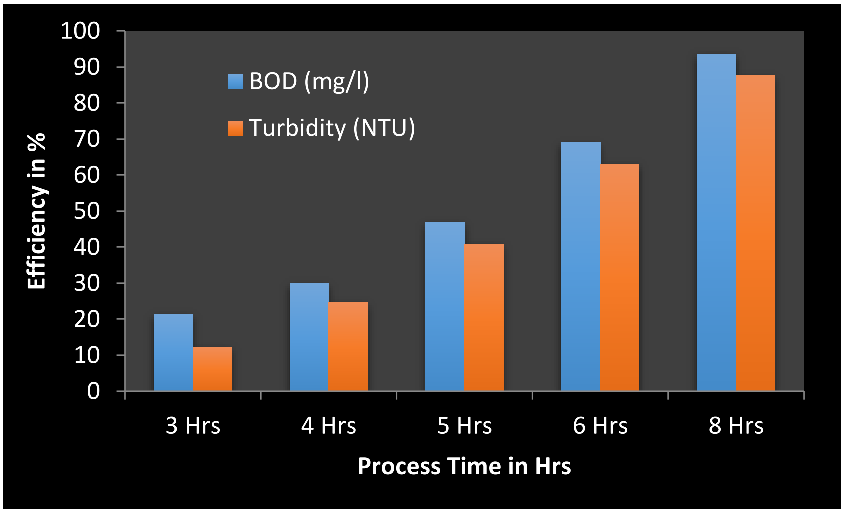

Fig 4 .Removal Efficiency

CONCLUSION

Based on this work on treatment of waste water by Activated Sludge Process, the following results are concluded: After the treatment process the treated water characteristics like pH, Turbidity, BOD were found to be within the limits specified by the CPHEEO 2012.The characteristic like BOD was reduced to 40 mg/l at 93.7% efficiency and Turbidity was reduced to 80 NTU at 87.6% efficiency (The specified limit as per CPHEEO 2012.). Thus treatment of Institutional wastewater using Activated Sludge Process for BOD and Turbidity reduction is found to be a very effective and economical method.It is suggest that the Institutional Waste water can be treated by ASP for 8 hrs process, so that it can be used for Irrigation and Gardening purpose.

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29.
Pollution Free Plasma Processing To Enhance Comfort Properties Of Bamboo/Cotton Treated Fabric

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ABSTRACT

Recent development in the plasma treatment of textile materials has revealed that it has an enormous potential as an alternate technology for the textile processing in terms of cost saving, water saving and eco friendliness. The main aim of this research work is to study the comfort properties of Bamboo/Cotton blended plasma treated fabrics. The blending of bamboo/cotton is carried out during carding itself and fibers are converted into yarn using ring spinning method to 40'sNe count. Then yarns are tested for Tenacity, elongation, imperfection and friction. The yarns were converted to woven fabric using lab model Rapier weaving machine and the fabric is tested before and after plasma treatment with Nitrogen gas to find the improvement in comfort properties like air permeability, water permeability, thermal resistance and spray rating .Based on the results obtained blended fabric will be chosen for making the apparels.

Key words: Bamboo, Cotton, yarns, fabrics, Nitrogen gas, plasma and testing.

INTRODUCTION

Using the plasma is an approach that three reduce air, water and land pollution in comparison to conventional methods of wet chemistry. Plasma surface treatment used to modifying the functional properties of fibers possesses advantages in comparison with traditional techniques. Plasma includes less water usage and energy consumption, with very small fibre damage, then making plasma process very attractive. It will be used to enhance the quality of textile products in fabric preparation and in dyeing and finishing methods. The textile industry must go towards sustainable technologies, developing environmentally safer methods of processing and finishing fabrics. Moreover to reduce energy consumption, chemicals, and time waste in textile processing, the use of multi-purpose dyes and finishing agents. Optimization of bulk and surface properties of materials can represent a promising approach for meeting technical and economical requirements. Because of costs related to study and production of new fibers, polymer researchers now focus on modifying existing fibers to impart the desired aesthetic or functional properties. Conventional fibre modification methods include various thermal, mechanical, and chemical treatments. Another important method to modify the fibre, to increase the uptake of dyes and finishes or to impart unique functionality, is performed through the plasma treatment. Characteristics that can be improved include after plasma treatment wet ability, flame resistance, adhesive bonding, printability, electromagnetic radiation reflection, surface hardness, hydrophilic hydrophobic tendency, dirt-repellent and antistatic properties. Plasma treatments can answer the demand of textile industry. Besides the base function of dressing people, textiles contribute to human health and safety, protecting from exposure to dangerous environments.

The Bamboo fiber is one of the regenerated cellulose fibers and it is produced from bamboo pulp, processed from bamboo culms. It looks like cotton in its un-spun form. Bamboo fiber have very thin when compared to hair and it has a round and smooth surface which makes it abrasion proof better. Then the bamboo fiber present naturally antibacterial, antifungal and anti-static properties. Bamboo has a unique anti-bacteria and bacteriostasis bio-agent which bonds tightly with bamboo fiber the cellulose growth will be normal. Bamboo fiber contain it naturally anti-bacterial, UV protective, green & biodegradable, breathable & cool, strong, flexible, soft and has a luxurious shiny appearance. This feature gets retained in bamboo fabrics too. When many tests have been conducted for bamboo fiber which show the results over 70% death rate after bacteria was incubated on bamboo fiber fabric.

Cotton is the most widely used fiber. Almost one half of total world fiber demand is for cotton. The cotton has good strength fiber with good abrasion resistance. Because cotton is an absorbent fiber, it is comfortable to wear in hot, humid weather. The fiber is most often spun into yarn or thread and used to make a soft, breathable textile.

MATERIALS AND TESTING METHOD

The bamboo and cotton yarns were spun on a miniature ring frame with 22 twists per inch.

Table 2.1 shows the properties of bamboo and cotton spun yarns.

Sl. no	Cotton		Bamboo	
1	Fibre length	28 mm	Fibre length	36 mm
2	Fibre uniformity ratio	49.58 %	Moisture regain	11.42%
3	Fibre fineness	4.52 ug/in	Elongation	21.2%
4	Fibre maturity	82.53%		
5	Trash content	0.19 %		

Table 2.2 Fibre blends ratios of Bamboo and Cotton yarns

Sl. no	Fibres	Blending Ratios
1	Bamboo	100%
2	Cotton	100%
3	Bamboo/ Cotton	50:50

Table 2.3 Fibre Properties Testing Method Standard

Sl.no	Fibre properties	Instrument for testing	Standard
1	Length	Hand stapling method	ASTM D5103 - 07(2012)
2	Strength	Stelometer	ASTM D1445 / D1445M - 12
3	Elongation	Stelometer	ASTM D1445 / D1445M – 12
4	Fineness	Micronaire instrument	ASTM, D1445

The Bamboo and Cotton yarn, which are used for this work, properties have been studied using standard testing method using appropriate testing instrument as shown in Table 2.4.

Table 2.4 Yarn Properties Testing Method

Sl.no	Yarn Properties	Instrument for testing	Standard
1	Yarn strength	Electronic Count Balance	ISO/TC 38/SC 23, British Standard
2	Yarn elongation	Uster Tensorap	ASTM D-5034:1995
3	Yarn Tenacity	Electronic tensile tester	In house method SITRA/YP/01:2015
4	Yarn imperfection	Uster tester	ASTM D 1425/D 1425M: 2014
5	Yarn friction	Yarn Friction (L & H) (Metal to yarn)	(ASTM-D-3108/D 3108 M-13)

Methodology

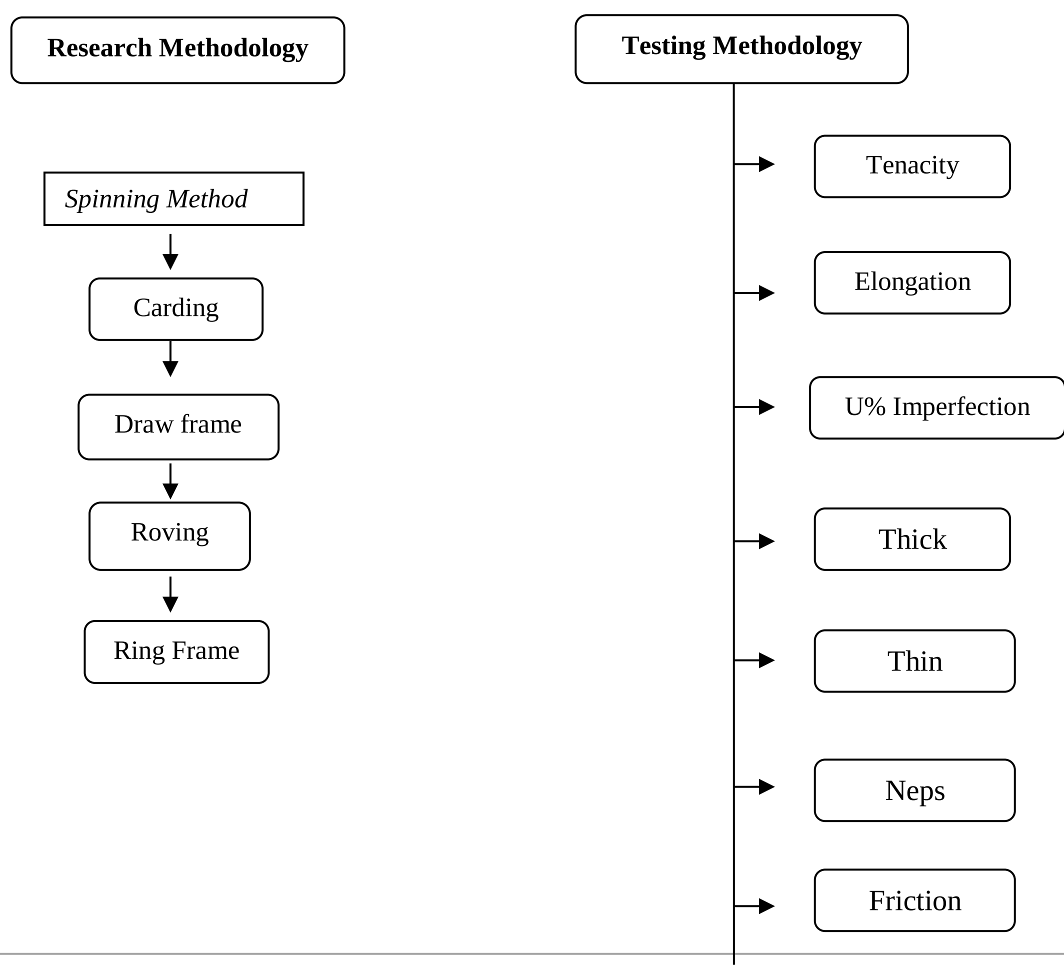


Table 2.5 Fabric Comfort Properties Testing Method

Sl.no	Fabric Testing Method	Instrument for testing	Standard
1	Air permeability	Air-Tronic Permeability Tester	ASTM D737
2	Water permeability	SDL Atlas M261	BS7209
3	Thermal resistance	Czechkoslovakia (skin model)	ISO 11092
4	Spray method	SDL Atlas (UK) -M232	AATCC Photographic scale. ISO 139

Table 2.6 Development of woven fabrics (plain weave) using the above developed blended yarns.

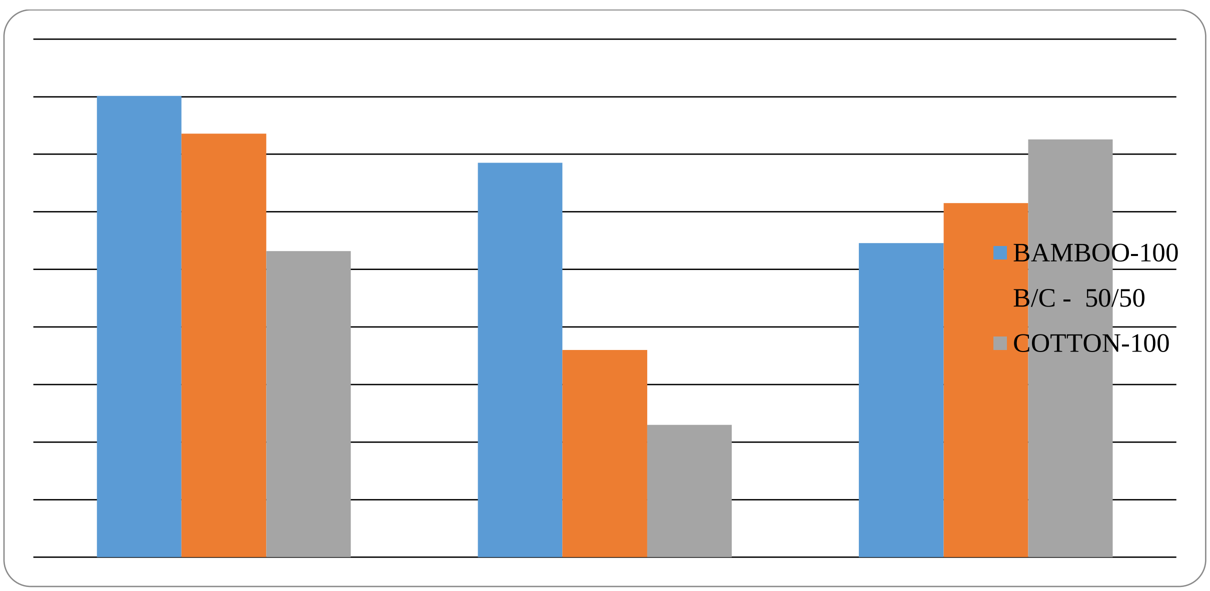
Sl no	Parameters	Determined
1	Count	40s
2	EPI	80
3	PPI	76
4	Cover factor	19.2
5	Thickness	0.36 mm

RESULTS AND DISCUSSION

The three varieties of blend of yarns samples were developed and tested their physical properties such as tenacity, elongation, , imperfection, thick, thin, neps and friction are rating and their quality analysis are given below.

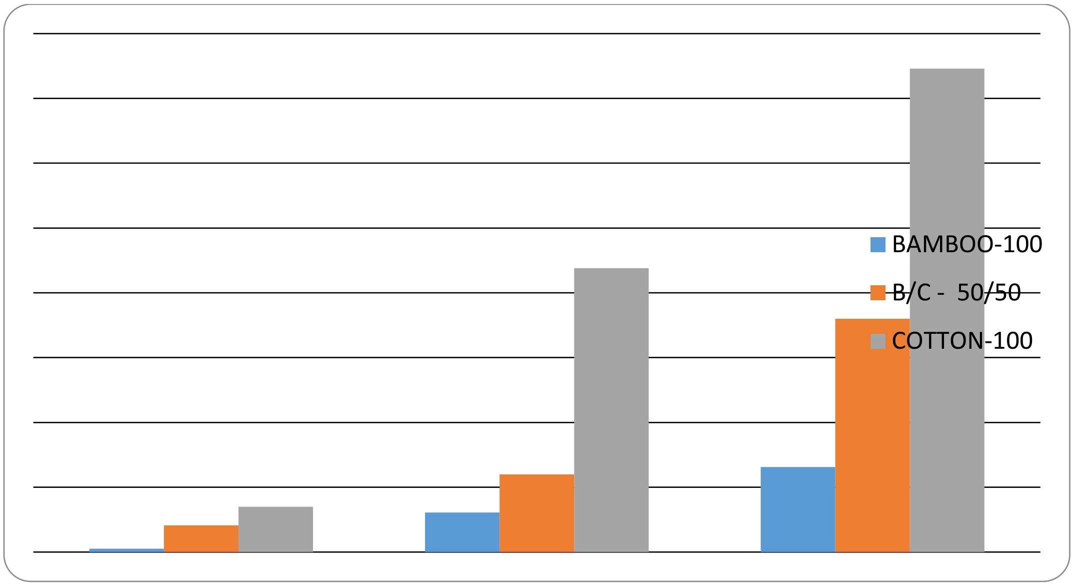
Table 3.1 Yarn Testing Report

Sl.no	Blending Ratio	Tenacity (g/tex)	Elongation (%)	U%	Thin (M)	Thick (M)	Neps	Friction
1	Bamboo-100	16.03	13.7	10.91	5	61	131	O.25
2	B/C - 50/50	14.72	7.2	12.3	41	120	360	O.25
3	Cotton-100	10.64	4.6	14.52	70	438	746	0.3



Graph 3.1 Tenacity,Elongation and U%

Graph 3.1 shows the result of Tenacity 100% cotton 15.45(g/tex) is higher value than other blends yarn. So the result gives cotton yarn has higher attributes value. Elongation 100% bamboo 13.7 (g) is higher value than blends yarn. So the result gives bamboo yarn has higher attributes value. U% Imperfection 14.6% mean 100% cotton yarn is higher value than other blends yarn. Because other blend yarn has containment is less.

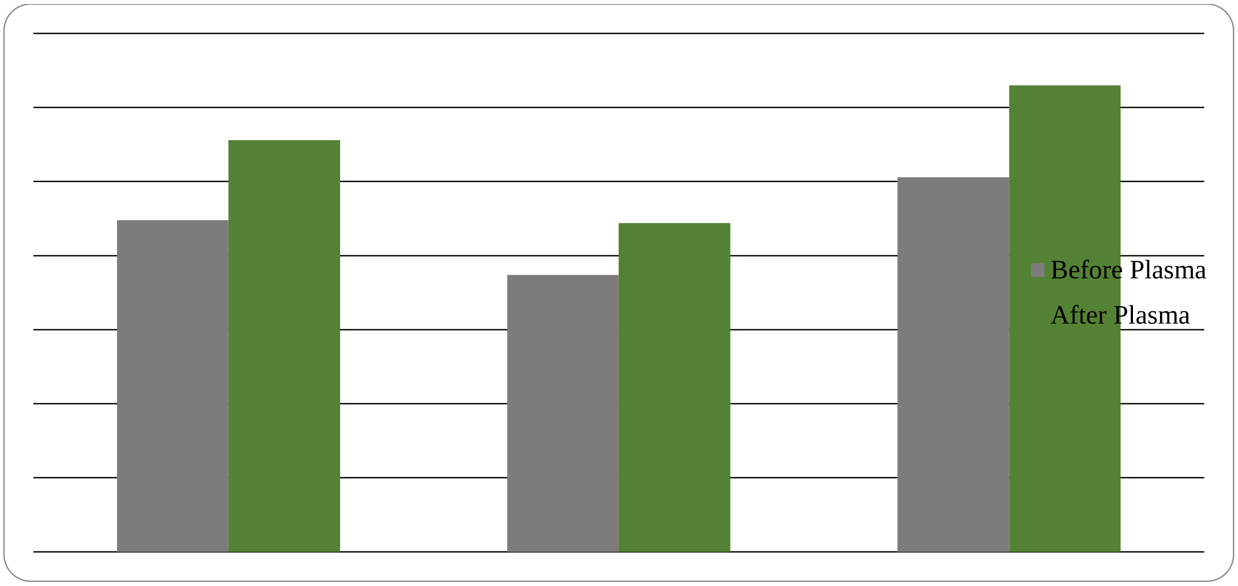


Graph 3.2 Thin, Thick and Neps

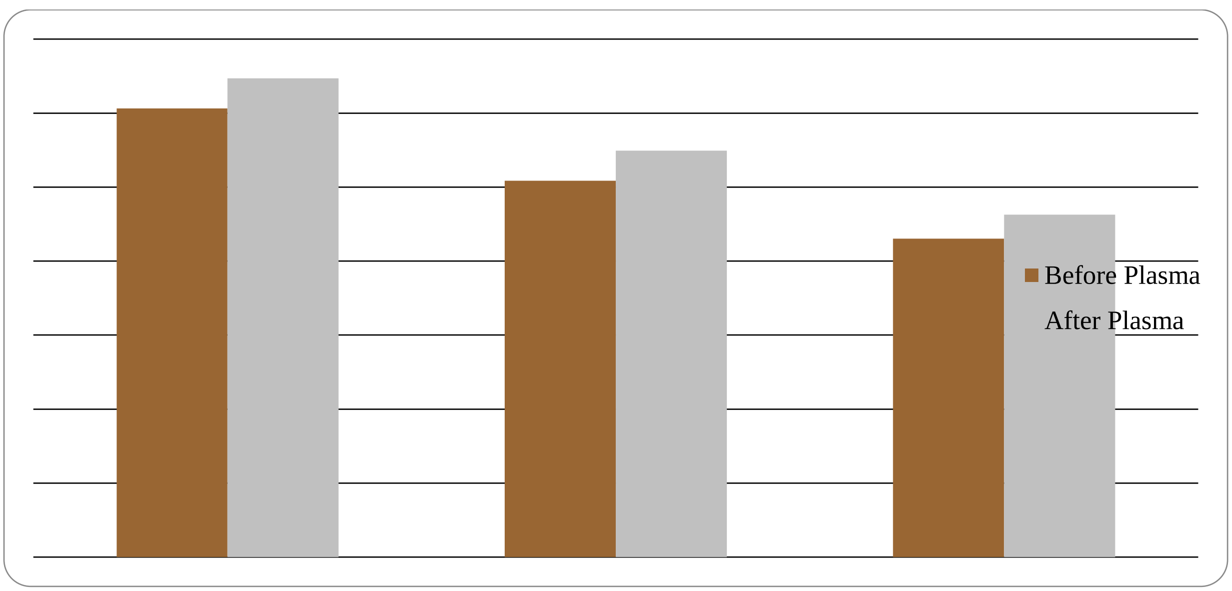
Graph 3.2 shows the result of Thin 100% cotton 70/1000M is higher than all blend yarn. So the result gives cotton yarn has higher attributes value s.Thick 100% cotton 438 of 1000m is higher than all blend yarn. So the result gives cotton yarn has higher attributes value. Because of more uneveness in cotton present in blended yarn. And neps 100% cotton is higher compared to 100% bamboo. Because of the more contenament present in cotton fibers.

Table 3.2 Fabric Comfort properties testing Report

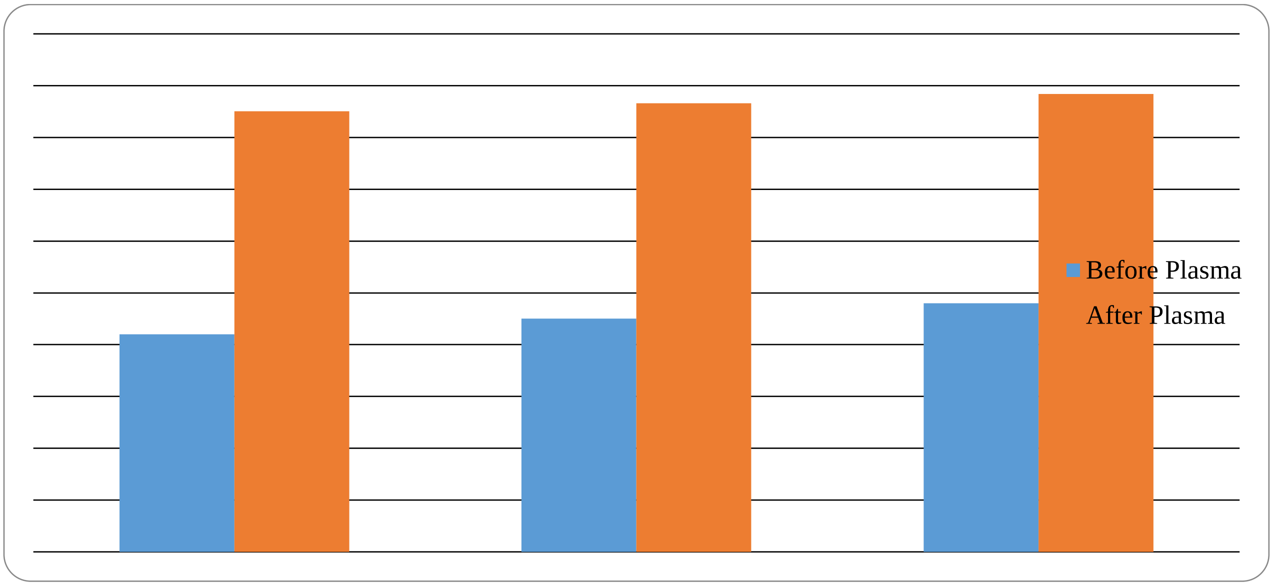
		Air Permeability l/min/20cm2		Water Vapour Permeability (g/m2/day)		Thermal Resistance (m2.mk/w)	
Sl.no	**Blending Ratio**	**Before Plasma**	**After Plasma**	**Before Plasma**	**After Plasma**	**Before Plasma**	**After Plasma**
1	Bamboo 100%	22.4	27.8	3032	3234	42	85.04
2	Bamboo/Cotton 50/50	18.7	22.2	2542	2747	45	86.6
3	Cotton 100%	25.3	31.5	2151	2314	48	88.4



Graph 3.3 Shows the result of Air Permeability of bamboo cotton different blends of fabric the 100% cotton fabric gives higher air permeability before (25.3 l/min/20cm2) and after plasma (31.5 l/min/20cm2) treatment using nitrogen gas, where compared to other blend fabric.



Graph 3.4 Shows the result of Water vapour permeability of 100% bamboo is higher vapour penetrate before plasama(3032 g/m2/day) and (3234 g/m2/day) after plasma. Where compared to other blend fabrics.



Graph 3.5 Thermal Resistance shows the result of 100%Bamboo before plasma is 42(m2.mk/w) is lower compared to after plasma is 100% cotton is 88.4 (m2.mk/w) is higher attribute value.

CONCLUSION

- The elongation of blended yarns increases when bamboo content increase.
- Evenness, friction & U % showed improvements where bamboo content is high.
- The Bamboo and Cotton fabric of average testing result of comfort properties such as air permeability 100% cotton fabric allows more air to pass in materials.
- The water vapour permeability 100% bamboo is higher vapour to penetrate in fabric.
- Plasma treatment is good to substitute for pollution free to processing the comfort properties.
- Plasma treatment with nitrogen gas gives higher surface modification on materials.
- Hence plasma treatment gives less pollution for processing. It helps to save water like processing, dyeing and finishing.

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Qualitative Analysis Of Waste Water In Textile Industries

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ABSTRACT

Water pollution has become a major crisis in the Modern world. It has created a great impact on the Environment. The wastewaters that are produced by the Industries are very toxic in nature and cause many ill effects to Human beings and Environment. Toxic Effluents are produced from Industries such as Dyeing, Tannery, Steel, Paper Mills, etc. It contains Heavy Metals, Dyes, Toxic Compounds and many more pollutants. The Conventional methods prove to be very expensive and also not effective. The remedy for this problem is that a methodology should be adopted such that it is Effective in removing the toxic Pollutants and also Cost Efficient.

A dye mixed solution of water is taken. Different compounds in the water are measured and cross-checked with the natural water readings. Then a mixture of Sodium carbonate and Sodium Hydroxide is added to the Wastewater collected in a tank. Again the compounds in the solution are measured after 8 hours. Three different readings are then compared and analyzed for indicating the toxic substances present in the polluted wastewater.

KEYWORDS — toxic effluents, COD, pH

INTRODUCTION

Water pollution has become a major crisis in the Modern humankind. It has been created a great impact to our environment system. The wastewaters that are produced by the industries are very toxic in nature and cause many ill effects to human beings and environment system. Toxic Effluents are produced from industries such as dyeing, tannery, steel, paper mills etc. It contains heavy metals, dyes, toxic compounds and many more pollutants. It is estimated that over 10,000 different dyes and pigments are used industrially and over 735 tons of synthetic dyes are annually produced worldwide. Textile materials can be dyed using batch, continuous or semi-continuous processes. The kind of process used depends on many characteristics including type of material as such fiber, yarn, fabric, fabric construction and garment, as also the generic type of fiber, size of dye lots and quality requirements in the dyed fabric.

TEXTILE PRINTING AND DYEING PROCESS

Textile Printing and dyeing processes include pre-treatment, dyeing / printing, finishing and other technologies. Pre-treatment includes desizing, scouring, washing, and other processes. Dyeing mainly aims at dissolving the dye in water, which will be transferred to the fabric to produce colored fabric under certain conditions. Printing is a branch of dyeing which generally is defined as 'localized dyeing' i.e. dyeing that is confirmed to a certain portion of the fabric that constitutes the design. It is really a form of dyeing in which the essential reactions involved are the same as those in dyeing. In dyeing, color is applied in the form of solutions, whereas color is applied in the form of a thick paste of the dye in printing. Both natural and synthetic textiles are subjected to a variety of finishing processes. This is done to improve specific properties in the finished fabric and involves the use of a large number of finishing agents for softening, cross linking, and waterproofing. All of the finishing processes contribute to water pollution.

TEXTILE DYEING WASTEWATER RISK

Discharged wastewater by some industries under uncontrolled and unsuitable conditions is causing significant environmental problems. The importance of the pollution control and treatment is undoubtedly the key factor in the human future. If a textile mill discharges the wastewater into the local environment without any treatment, it will have a serious impact on natural water bodies and land in the surrounding area. High values of COD and BOD, presence of particulate matter and sediments, and oil and grease in the effluent causes depletion of dissolved oxygen, which has an adverse effect on the aquatic ecological system. Effluent from textile mills also contains chromium, which has a cumulative effect, and higher possibilities for entering into the food chain. Due to usage of dyes and chemicals, effluents are dark in color, which increases the turbidity of water body. This in turn hampers the photosynthesis process, causing alteration in the habitat.

A. STANDARDS FOR WATER POLLUTANTS

As the wastewater is harmful to the environment and people, there are strict requirements for the emission of the wastewater. However, due to the difference in the raw materials, products, dyes, technology and equipment, the standards of the wastewater emission have too much items. It is developed by the national environmental protection department according to the local conditions and environmental protection requirements which is not fixed. It varies according to the situation in different regions. Therefore, the nature of emission targets is priorities of the points.

Table 1.1, Textile Industry Standards for Water Pollutants

S.No	Parameters	WHO
1	pH	6.5 to 8.5
2	Temp., °C	NA
3	TS, mg/L	2030
4	TDS, mg/L	2000
5	TSS, mg/L	30
6	Total Hardness, mg/L	600
7	Total Alkalinity, mg/L	600
8	BOD, mg/L	50
9	COD, mg/L	70
10	Nitrate Nitrogen, mg/L	10
11	PO_4, mg/L	5.0
12	Ca, mg/L	75
13	Mg, mg/L	50
14	Cu, mg/L	1.0

15	Zn, mg/L	5.0
16	Fe, mg/L	0.3
17	Mn, mg/L	0.5
18	Pb, mg/L	0.5
19	Cr, mg/L	0.5

COD MEASUREMENT

Chemical Oxygen Demand is an important water quality parameter because, similar to BOD, it provides an index to assess the effect discharged wastewater will have on the receiving environment. Higher COD levels mean a greater amount of oxidizable organic material in the sample, which will reduce dissolved oxygen (DO) levels. A reduction in DO can lead to anaerobic conditions, which is deleterious to higher aquatic life forms. The COD test is often used as an alternate to BOD due to shorter length of testing time.

If effluent with high COD levels is discharged into a stream or river, it will accelerate bacterial growth in the river and consume the oxygen levels in the river. The oxygen may diminish to levels that are lethal for most fish and many aquatic insects. As the river re-aerates due to atmospheric mixing and as algal photosynthesis adds oxygen to the water, the oxygen levels will slowly increase downstream. The drop and rise in DO levels downstream from a source of COD is called the DO sag curve.

A common method for Chemical Oxygen Demand analysis is oxidation. The method involves using a strong oxidizing chemical, potassium dichromate $K_2Cr_2O_7$, to oxidize the organic matter in solution to carbon dioxide and water under acidic conditions. Often, the test also involves a silver compound to encourage oxidation of certain organic compounds and mercury to reduce the interference from oxidation of chloride ions. The sample is then digested for approximately 2 hours at 150°C. The amount of oxygen required is calculated from the quantity of chemical oxidant consumed.

HARDNESS AND CHLORINE DETECTION

Water hardness is the traditional measure of the capacity of water to react with soap, hard water requiring considerably more soap to produce lather. Hard water often produces a noticeable deposit of precipitate in containers. It is not caused by a single substance but by a variety of dissolved polyvalent metallic ions, predominantly calcium and magnesium cations, although other cations like aluminium, barium, iron, manganese, strontium and zinc which also contribute. Hardness is most commonly expressed as milligrams of calcium carbonate equivalent per litre. Water containing calcium carbonate at concentrations below 60 mg/l is generally considered as soft, 60–120 mg/l - moderately hard; 120–180 mg/l - hard; and more than 180 mg/l - very hard. Although hardness is caused by cations, it may also be discussed in terms of carbonate (temporary) and non-carbonate (permanent) hardness.

Hardness of water is found by titrating the solution against EDTA. Sample solution is mixed with a 2ml solution of buffer and 2 drops of EDTA is added to it. The sample solution is then titrated against standard solution of EDTA till wine-red color changes to blue. The volume is calculated and the hardness is calculated. Soap consumption by hard water causes economic loss to water consumers. Precipitated foam by hard water adheres to surfaces of tubs, sinks etc and may stain clothing, dishes or other items.

Chlorine is a naturally occurring element. It is very dangerous toxin that has many uses, from disinfecting to bleaching. In small quantities, liquid and gas forms can be poisonous. In its gas form, chlorine is a pale green color and has a smelly odor and makes your breathing labored. In its solid form, it is more of a yellow green color. It is abundant in nature in its chloride ion form found in many of the salts that are in the earth.

Chlorine has long been used to disinfect our drinking water because it controls the growth of such unwelcome bacteria as Ecoli. The long-term exposure to chlorine leads to the production of free radicals within the body. Free radicals are carcinogenic, and cause tremendous damage to our cells. Chlorine can irritate severely, even burn, skin exposed directly to it. It can irritate and burn the eyes and throat as well.

PH AND IRON DETECTION

pH is a measure of the amount of free hydrogen ions in water. Specifically, pH is the negative logarithm of the molar concentration of hydrogen ions. pH = - log[H+]. Because pH is measured on a logarithmic scale, an increase of one unit indicates an increase of ten times the amount of hydrogen ions. A pH of 7 is considered to be neutral. Acidity increases as pH values decrease, and alkalinity increases as pH values increase. Most natural waters are buffered by a carbon-dioxide-bicarbonate system, since the carbon dioxide in the atmosphere serves as a source of carbonic acid.

The pH of water affects the solubility of many toxic and nutritive chemicals; therefore, the availability of these substances to aquatic organisms is affected. As acidity increases, most metals become more water soluble and more toxic. Toxicity of cyanides and sulfides also increases with a decrease in pH (increase in acidity). Ammonia, however, becomes more toxic with only a slight increase in pH.

Most often used pH electrode is the glass electrode. It is made up of glass tube ended with glass bubble. The electrode is filled with buffered solution of chlorides in which silver wire covered with silver chloride is immersed. pH of internal solution varies-for example, it can be 1 (or) 7.Active part of the electrode is the glass bubble. While tube has strong and thick walls, bubble is made to be as thin as possible. Surface of the glass is protonated by both internal and external solution till equilibrium is achieved. Both sides of the glass are charged by the adsorbed protons, this charge is responsible for potential difference. This potential is inversely proportional to the pH difference between solutions on both sides of the glass.

The Environmental Protection Agency considers iron in water as a secondary contaminant, which means it does not have a direct impact on health. The Secondary Maximum Contaminant Level set out by the EPA is 0.3 milligrams per liter, but this is merely a guideline and not a federal standard. Typically around 15 mg/L, Idaho’s well water does contain quite high amounts of iron, but the level is still not enough to cause physical harm.

Consumption of high concentration of iron can cause liver diseases. Iron in excess of 0.3mg/k causes stains to washbasin and steel containers. Iron also promotes the growth of Iron bacteria, they gives a rusty appearance to the water. Iron content in the water can be calculated by using Spectrophotometer. By analyzing the absorbance of known concentration of Iron in Spectrophotometer, the concentration of iron in dye water can be calculated.

RESULT

Thus by analyzing the textile dye, the following concentration of the compounds present in the dye water is calculated

Table 1.1, Water Pollutants in Dye water

Compounds	Water	Dye Water
COD	-	32 mg/l
pH	7.4	8.3
Hardness	55 mg/l	755 mg/l
Iron	0.1 ml	0.5ml
Chloride	4.25 ml	37.233 ml

VII.CONCLUSION

Reduction of waste is very important as it decreases pollution and production costs. This review has shown that various methods can be applied to treat textile effluent and thus minimizing pollution load. Technologies based on membrane systems are the best alternatives methods that can be used for large-scale ecologically friendly treatment process. Advanced oxidation process represents a powerful treatment for refractory or toxic pollutant in textile wastewaters. This methodology has great potential in photo reduction of dyes in effluents and this method is applied commercially in treatment of textile effluent.

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31.

Reinforced Nonwoven Filter Press Media As An Alternative For Woven Filter Media For Sludge Dewatering

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ABSTRACT

This paper reports on the development of scrim reinforced nonwoven fabric by needle punching technique for filter press application in textile effluent treatment plant. The nonwoven fabrics were developed by using different denier polyester fibers and changing stitch density. For filter press development, the nonwoven fabric was reinforced with the nylon scrim as the central layer in order to withstand the filtration pressure. The filtration parameters such as filtration efficiency and cake discharge properties of the developed nonwoven filter were evaluated and compared with existing woven fabric filter media. The developed nonwoven fabrics were subjected to calendaring treatment and the influence of calendaring on the cake discharge properties of the nonwovens was also studied.

The results of this study show that the developed nonwoven fabrics have 40% higher weight per unit area and 20% higher thickness compared to commercial woven fabric filter media. The bursting strength and air permeability values are equivalent to woven filter media. It was observed that developed nonwovens have 8% higher filteration efficiency and lower cake discharge properties compared to the existing woven fabric fiter media. It was found that calendered nowoven filter fabrics have improved cake discharge property compared to un-calendered nonwoven fabrics.

Key words: cake discharge, filter press, filtration, reinforced nonwoven, pore size

INTRODUCTION

A filter press is a conventional device specifically used in solid - liquid separation using principle of pressure drive. Sludge dewatering using filter presses has become accepted as a reliable and efficient method of dewatering effluents and sludge from industrial and municipal waste treatment processes. They are used to remove water from liquid waste water residuals and produce a non-liquid material referred to as "cake". Dewatered cake varies in consistency from that of custard (12 to 15 percent solids) to moist soil (20 to 70 percent solids). The cycle time depends upon the type of sludge and sludge feed concentration. In general, the higher the sludge feed concentration, the shorter the cycle time. One of the most essential requirements in a filter press is the filter press cloth. The commercial filter press cloths are woven fabrics made of monofilaments, multi filaments or spun yarn. The woven structure can filter particles which are larger than 15 microns only.

Nonwoven technology has been preferred to develop the filter media due to its multilayer filtering effect on dust particles which gives better filtration efficiency. Nonwovens have played a significant role in dust and liquid filtration due to their loftiness, porous structure and lower cost of manufacturing. The design considerations for the filtration media depend upon the basic properties of fibers, fiber arrangement (i.e. structure of the fabric) decided by the technology employed, air, gas or liquid velocity and flow rate, mechanical, thermal and chemical properties of the medium, extent of filtration required, filtration mechanism, environmental laws and the mode of application, for example, disposability versus durability. The needle punching technique selection provides better structural stability to withstand high pressure application in the filtration process [1].

Thangadurai et al analyzed effect of fiber fineness and areal weight on air permeability, tensile strength, bursting strength and compressibility of micro denier polyester needle punched nonwovens and observed that air permeability decreases with the increase in areal weight of the nonwoven [2]. Kothari et al studied effect of processing parameters on filtration efficiency of composite needle punched nonwovens. They observed that an initial rise and then subsequent fall in filtration efficiency values with incremental punch densities in case of layered fabric made from fine fibres. But in case of coarse fibre, filtration efficiency values continue to increase with punch density [3].

An analysis on scrim-woven and nonwoven fabrics performance on air filters has performed by Saleh. It has been reported that nonwoven with scrim woven industrial fabric filters have different performance compared with the filters that are produced from only nonwoven fabrics in terms of air permeability, compression properties, tensile strength and tear resistance [4]

. Anandjivala and Boguslavsky have studied the influence of needle punching process parameters on air permeability, mechanical features, and pore size distribution and filtration efficiency of flax nonwoven fabrics. They also examined effect of calendaring on filtration efficiency of nonwovens. It was observed that overall improvement in all filtration characteristics because of the calendaring operation [5].

This study investigated the development and characterization of scrim reinforced needle punched polyester nonwoven for filter press applications. The effects of fiber denier and punch density on the structure development were examined. Filtration parameters such as filtration efficiency and cake discharge properties of developed filter fabrics were evaluated and compared with existing woven filter fabric. Furthermore, the effect of calendaring process on cake discharge properties of nonwoven filters was evaluated.

MATERIALS AND METHODS

Polyester fibers having 64 mm length with deniers 3, 6 & 15 were sourced from Reliance fibers ltd, India for the development of nonwoven fabrics. The filtration performance of the nonwoven filter medium are primarily influenced by raw material parameters like fibre fineness, fibre length and processing parameters like fabric weight (GSM), punch density (punches/cm^2) and depth of needle penetration (mm). In this work, nonwoven fabrics were developed by maintaining fabric weight of 250 GSM and depth of needle penetration of 10 mm and totally 9 different nonwovens were produced by varying fibre fineness (3, 6 &15 deniers) and punch density (200, 400 & 600) at three levels. Plain woven nylon scrim having GSM: 160, ends per inch (EPI): 14 and picks per inch (PPI):14 was incorporated in nonwovens to improve the integrity, strength and stability of the nonwoven filter. The scrim acts as reinforcement to the filter.

Calendaring is a finishing process that modifies the surface characteristics and rectifies the permeability of filter fabrics. Since the cake formation is important in filter press, the developed nonwoven filter fabrics were passed through Tasker calendaring machine at 140º C with a pressure of 6 bar (6.1 Kg/cm^2) in order to disperse the cake uniformly on the filter and release the fabric easily.

Characterization methods

The developed nonwoven fabrics were tested for the fabric weight per unit area (grams/m^2) according to ASTM D 3776. The thickness of the filter fabrics were measured in fabric thickness gauge at a pressure of 200 grams /cm^2. The fabric air permeability was measured with Textest FX 3300 air permeability tester as per ASTM D 737 standards. A diaphragm bursting strength tester was used to evaluate the fabric bursting strength in (kg/cm^2) in accordance with ASTM D 3786. The pore size and pore distribution of the developed nonwoven fabrics was evaluated using liquid extrusion porometry as per ASTM F-316. The performance of the developed filters for textile effluent treatment process was carried out in Sukra Processing Mills, Tamilnadu, India.

Evaluation of the filtration efficiency

The filtration efficiency was evaluated in terms of reduction in the total suspended solids (TSS) as the filtration process is capable of removing only the suspended particles and not the dissolved particles. The reduction in TSS due to the filtration by the filter fabric can be calculated using the following formula:

$$\text{TSS reduction (\%)} = \frac{\text{TSS in the sludge (g/l)} - \text{TSS in the filtrate sample (g/l)}}{\text{TSS in the sludge (g/l)}} \times 100$$

Evaluation of cake discharge properties

The cake discharge properties refer to the ease with which the cake drops from the filter fabric at the end of the filtration cycle. Filter cake which adheres to the fabric inevitably leads to a reduction in process efficiency, either by way of a reduction in process efficiency, either by way of a reduction in effective filtration area or where the cakes require to be removed with manual assistance, a longer and hence more costly cycle time [6]. The cake discharge in terms of percentage is calculated as follows:

$$\text{Cake discharge (\%)} = \frac{\text{Mass of cake discharge from fabric}}{\text{Total mass of cake formed}} \times 100$$

RESULTS AND DISCUSSION

Physical properties of nonwovens

Table 1. Physical properties of filter fabrics

S.No.	Sample	Areal density (g/m^2)	Thickness (mm)	Density (g/m^3)
1	Woven filter fabric	474	1.09	0.435
2	3D-200PD	669	2.69	0.249
3	3D-400PD	673	2.56	0.263
4	3D-600PD	675	2.29	0.294
5	6D-200PD	668	3.24	0.206
6	6D-400PD	630	2.44	0.258
7	6D-600PD	656	2.41	0.278
8	15D-200PD	648	4.35	0.149
9	15D-400PD	665	4.25	0.152
10	15D-600PD	674	3.73	0.181

The physical properties of the developed nonwovens are shown in Table1. In sample ID 3D-200 PD, D denotes fiber denier and PD denotes punch density. It was observed that, the density of reinforced nonwoven fabrics slightly increases as the punch density increases. Theoretically, it is expected that the mass per unit area should stay constant regardless of the punch density due to the fact that any increase in punch density does not affect the fibers present on the nonwoven fabric. It was noticed that the dimension of the filter was getting narrow as the punch density increased. As the dimension of the filter getting narrowed due to the shrinkage of nonwoven, the mass per unit area is getting higher as the punch density increases.

It was observed that the thickness of the nonwoven fabric filter is getting finer as the punch density is getting higher. This may be due to increased interlocking of fibers at higher punch density. This, in turn, resists the fibers to bounce back to their original position when the needle is withdrawn. The woven filter fabric has the least thickness of 1.09 mm. Since the reinforcement is an additional layer added to the filter, the thickness of the reinforced filter is thicker than woven filter fabric. The increase in thickness of the nonwoven filter fabric will cause a small decrease in the cake holding capacity of the recessed filter plates in the filter press. During filtration, the filtration pressure will further compact the nonwoven fabrics, thereby reducing the thickness. Hence the increased thickness of the nonwoven filter fabric becomes negligible. Two samples of reinforced nonwoven fabrics (3D-600PD and 6D-400PD) were selected for bursting strength, air permeability and pore size characterization.

Bursting strength of nonwovens

It can be seen from the Table 2 that the nonwoven fabrics without reinforcement have a bursting strength of approximately two-third of the bursting strength of the woven filter fabric. The nonwoven fabrics reinforced with the scrim have very high bursting strength compared with existing woven fabric filter fabric. Incorporation of scrim, which is a light weight, open weave and coarse fabric, into the center of the web provides additional strength.

Table 2. Bursting strength of filter fabrics

Sample	Bursting strength (kg/cm^2) (without reinforcement)	Bursting strength (kg/cm^2) (with reinforcement)
3D-600PD	22.0	48.0
6D-400PD	21.0	56.0
Woven fabric filter	30.6	

Table 3. Air permeability of filter fabrics

Sample	Air Permeability (cm^3/cm^2/sec)
Woven	9.1
3D-600 PD	13.3
6D-400 PD	33.8

Air permeability

Air permeability is an important factor for filters. The air permeability of the woven filter fabric and the selected non-woven filter fabrics is given in Table 3. The 3D-600PD nowoven fabric had an air permeability of 13.3 $cm^3/cm^2/sec$ which is close to that of the woven fabric and lower than 6D-400 PD nonwoven fabric. This is because with increase in fineness, there is an increase in total number of fibers present, which, in turn, increases the total surface area of fibers, exposed to the flowing air. Thus nonwoven fabric made from 3 denier fibers has lower air permeability value than nonwoven fabric made from 6 denier fibers. The air permeability value also decraeses with the increase in punch density because of the increasing entanglements. These results are in line with Kothari et al. studies, who also confirmed that the air permeability varies inversely in relation to the punch density and the propotion of fine fibres in the nonwoven.

Pore size and pore size distribution

The performance of needle-punched nonwoven fabrics in filtration application is mainly determined by the pore size and its distribution [7]. The liquid extrusion porometry is often used to characterize the pore structure of nonwovens. Specimens of each sample were subjected to extrusion flow porometry for the measurement of pore sizes and their distribution. In this technique, a wetting liquid with known surface tension of 15.9 dynes/cm filled the pores spontaneously and was then removed by pressurized non reacting gas. The results on pore size measurement of scrim reinforced nonwoven fabrics 3D-600PD and 6D-400 PD and existing woven filter fabric are shown in Table 4. Scrim reinforced nonwoven fabrics (3D-600PD and 6D-400 PD), showed significant difference in terms of pore size in comparison to woven filter fabric. This may be attributed to the less dense and more porous structure of nonwovens.

Table 4. Minimum, mean and maximum pore diameters of filter fabrics

Sample	Minimum pore diameter (µm)	Mean flow pore diameter (µm)	Maximum pore diameter (µm)
Woven fabric	36.35	88.64	206.46
3D-600PD	8.95	36.4	92.57
6D-400PD	14.4	56.3	142.15

Filtration efficiency

The filtration efficiency indicates the extent to which the solid particles have been removed from the feed sludge. The filtration efficiency was evaluated in terms of reduction in total suspended solids (TSS). The filtration efficiency is a function of the porosity of the fabric. Higher the filtration efficiency better will be the filtrate clarity. The filtration efficiency of the woven fabric and the developed nonwoven filter fabrics are shown in Figure 1.

It can be observed that the woven filter fabric offers a TSS reduction of 90.19%. The nonwoven fabrics namely, 3D-400PD, 3D-600PD, 6D-400PD, 6D-600PD have a higher TSS reduction of 96.98%, 97.38%, 95.11% and 92.45% respectively. As this filtrate is further treated in the effluent treatment plant, this improvement in the TSS reduction % provided by the nonwoven filters will help to reduce the sludge load in the further steps. The poor performance of the other nonwoven fabrics made of 15 denier fibers is possibly due to the larger pore size which cannot entrap the very fine particles. The better particle retention of the 3D-400PD, 3D-600PD, 6D-400PD, 6D-600PD nonwoven filters is primarily due to the larger number of pores and surface area available in the nonwoven filter and the random distribution of the pores.

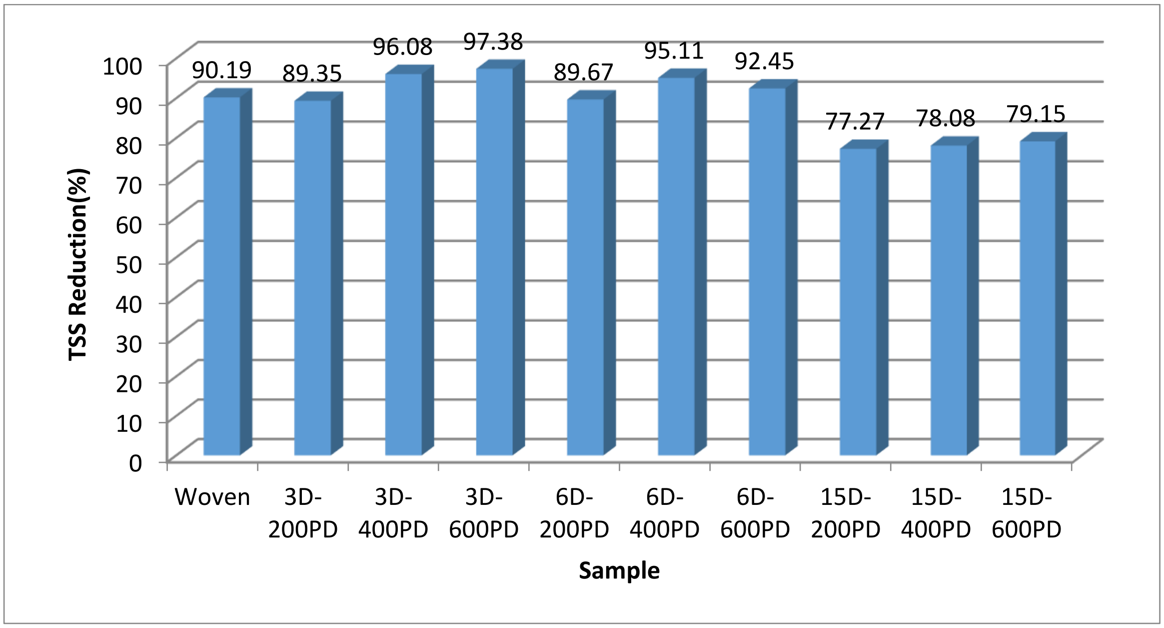

Fig 1: Comparison of the filtration efficiency

Cake discharge properties

The ease with which the cake drops from the filter fabric at the end of the filtration cycle has been analyzed as cake discharge %. It is important for the filter fabric to facilitate easy discharge of the formed cakes in order to save time and to prevent abrasion of the fabric surface due to scrapping.

Figure 2 shows the comparison of the cake discharge properties of the woven fabric, nonwoven fabric and calendared nonwoven fabric. It is observed that the woven fabric has an average cake discharge of 76.4%. The nonwoven fabric has a cake discharge of 10.1% which is very poor compared to woven filter fabric. This is due to the irregular fabric surface of nonwovens compared to woven fabrics. The higher number of protruding fibres in nonwoven fabric increases the frictional contact which enhances the adhesion of the cakes to the fabric. The cake discharge % of nonwoven fabrics improved to 37.1 % after calendaring. The microscopic images of nonwovens before and after calendaring are shown in Figure 3. It was observed that calendared nonwoven fabric has better surface smoothness and less number of protruding fibres compared to un-calendared nonwoven. Hence filter media clogging was reduced and cake release property was improved in calendared nonwoven fabrics.

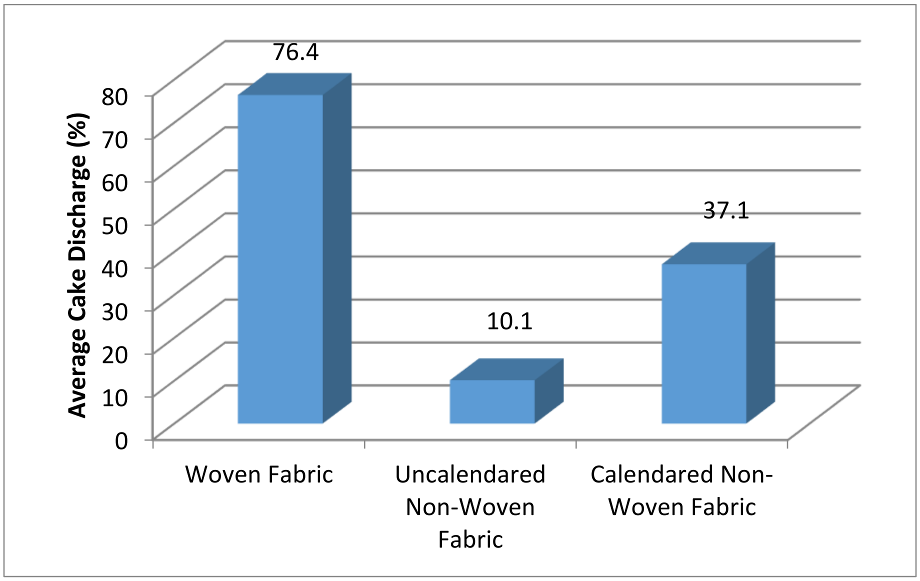

Fig 2: Comparison of the cake discharge properties

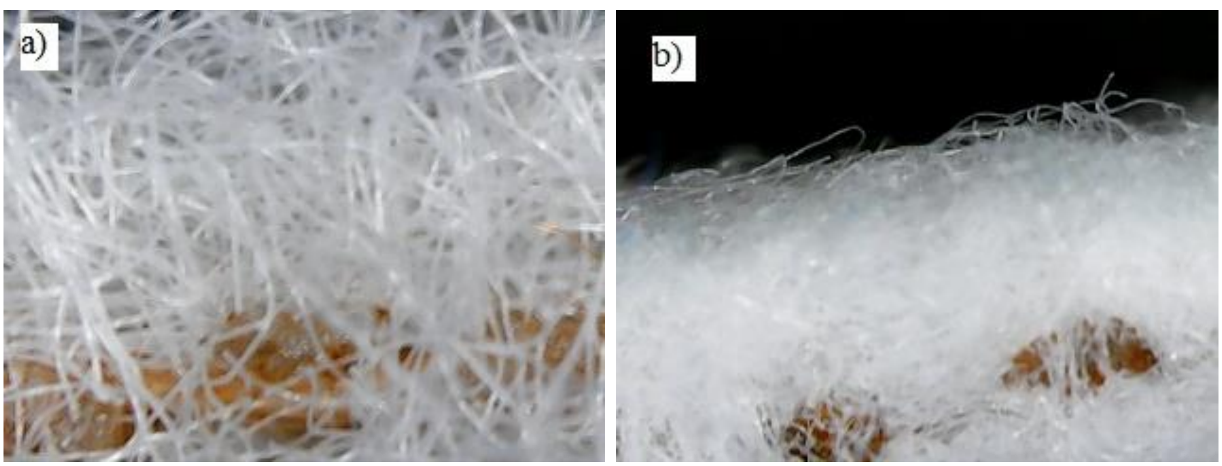

Fig 3: Calendaring treatments on nonwoven fabric a) before calendaring b) after calendaring

CONCLUSIONS

In this study scrim reinforced polyester needle punched nonwoven fabrics were developed by varying the fiber denier and punch density. The developed nonwoven filter fabrics were characterized in terms of physical properties and filtration performance and the results were compared with commercial woven fabric filter. In terms of physical properties, the developed nonwoven fabrics had about 40% higher weight per unit area and 20% thicker. But their bursting strength and air permeability was equivalent with the woven filter fabric. While considering the filtration performance, the developed nonwoven fabrics offered superior filtration efficiency (8% higher) and lower cake discharge properties compared to woven fabric. Calendaring was found to increase cake discharge properties of the nonwoven fabrics by improving surface smoothness.

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32.

Removal of Ammonia from Dam Water using Natural Zeolite of Heulandite type as an Ion Exchange Membrane

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ABSTRACT

Ammonia found in the samples taken from Kelavarapalli Dam originates from various sources which include domestic and industrial effluents mixing upstream of the river before it reaches the Dam reservoir. Excess ammonia present will produce an adverse effect on health & biodiversity like eutrophication, harming aquatics etc. For the removal of ammonia, there are many methods proposed which include Ion Exchange, electrochemical methods, Biological Methods, Break-Point Chlorination etc. Natural Zeolite of Heulandite type has a very high cation sorption capacity and also readily available in most parts of India. In this work, a Membrane bed made with Heulandite which acts as an activated zeolite bed is used. Initially, standard lab solutions of ammonia with known concentration and pH were taken and tested for removal of ammonia through Langmuir & Freundlich isotherm. Then the raw dam water is analysed for the initial concentration and a peak separation of 89.6% is achieved. Based on the result it can be concluded that Heulandite can be a promising material for the removal of ammonia from reservoir water.

KEYWORDS

Heulandite Zeolite, NH_3 Removal, Ion Exchange Membrane.

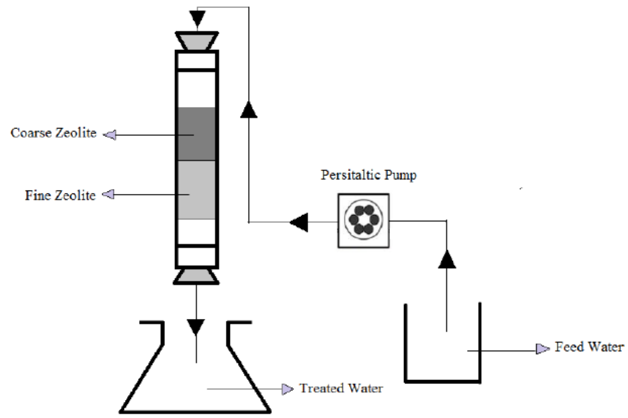

Figure: Experimental Setup

INTRODUCTION

Water forms an essential part of our life. But defamation of water resources like lake, ponds, streams, rivers etc is done on a mass scale due to industrialisation and urbanization. The alarming increase in the demand of water and pollution of already depleting water sources forms the most important point for researchers and policy makers all over the world for the past two decades. International policies and key research thrust are given to these areas of removal of effluents mixed with water. Our college is situated in the southern part of the metro city Bengaluru and the chief water supply for our town (Hosur) is essentially from two resources The Cauvery River and South Pennaiyar River. The Kelaverapalli reservoir is situated 10 km from our home town Hosur on the South Pennaiyar river. From our laboratory analysis, we confirmed that the water in the reservoir has more amount of Ammonia and BOD which is very much higher than the allowable threshold prescribed by TWAD (Tamilnadu Water supply And Drainage Board).

The Kelavarapalli Reservoir is contaminated due to the local

& industrial wastewater from Bengaluru entry into the dam water through Pennaiyar River.

Nitrogen and Phosphorous compounds are an essential elements for living organisms. However, when they are more than needed, they can lead to eutrophication. European Association for drinking water has provided the maximum limit for the ammonia in the water was approximately 0.5 mg l^{-1} and also guide level was given as 0.05 mg l^{-1} [1, 2], therefore the dam water with high concentrations of ammonia should be treated before it reaches the people. A variety of biological and physicochemical methods and technologies have been proposed for the removal of ammonia from the environment and industrial waste water systems. Removal of ammonium can be accomplished through the use of air stripping, breakpoint chlorination, ion exchange, and biological nitrification and denitrification [1, 3]. The orthodox method for the removal of ammonia from the municipal and industrial waste water is biological methods [4] but ion exchange offers a number of advantages including the ability to handle shock loadings and the ability to operate over a wider range of temperatures. The biological method does not respond well to shock loads of ammonia. The ion exchange method usually employs organic resins, which are very selective. However, they are very expensive [5]. Ion exchange with natural zeolites is more competitive because of its low cost and relative simplicity of application and operation. Natural Zeolites are the most important inorganic cation exchangers that exhibit high ion exchange capacity, selectivity and compatibility with the natural environment [6]. Zeolites are most effective ion exchange membranes which are used in various fields of engineering and research. The discovery of natural zeolites deposits has lead to an increasing use of these minerals for the purpose of eliminating, or at least reducing, many long-standing pollution problems [7]. Both natural and synthetic zeolites have the ability for removing several cations from solutions concerning adsorption and ion exchange capacity, adsorption, porous structure, molecular sieve, dehydration and rehydration, low density and silica compounds [6, 8]. One ion exchanger with a high affinity for ammonium ion is Heulandite a naturally occurring zeolite.

Among the natural zeolites, Heulandite occurs most frequently in India in specific heulandite is a silica-rich zeolite and has an Empirical formula $Ca_{3.57}Sr_{0.05}Ba_{0.06}Mg_{0.01}Na_{1.26}K_{0.43}Al_{9.37}Si_{26.7}O_{72\cdot 26}.0_2(H_2O)$. Heulandite has been chosen as the material for the removal because of its high cation exchange capacity as show in table 1.1 [9] and due to its selectivity order [10].

$Cs^+>Rb^+>K^+>NH_4^+>Ba^{2+}>Sr^{2+}>Na^+>Ca^{2+}>Fe^{3+}>AI^{3+}>Mg^{2+}>Li^+$

Furthermore, there are impurities like quartz in most of the heulandite deposits. These factors reduce the uptake of ammonium into onto natural heulandite. Fusion with sodium hydroxide prior to natural materials to high cation exchanger. In addition to ion exchange capacity, selectivity is also an important character for zeolites. Although the ion exchange capacity of heulandite is lower than some other zeolites, it generally exhibits a high selectivity for the NH_4^+ ion. The removal of ammonia from dam water by ion exchange method varies depending on the occurrence of other cation in the aqueous phase and early ammonia concentration.

Table 1.1 Categorization and Characterization of Natural Zeolites

Zeolite	Void space	Cation exchange capacity

Analcime	18	4.54
Chabazite	47	3.84
Clinoptilolite	34	2.16
Erionite	35	3.12
Heulandite	39	32.91
Laumontite	34	4.25
Mordernite	28	2.29
Phillipsite	31	3.31

2. MATERIALS AND METHODS

2.1 MATERIALS

Waste water used in experiments was collected from Kelavarapalli reservoir. Heulandite Zeolite (4 Kg) was used as packing material for the removal of ammonia from dam water, Sterilized Glass wool (0.5 Kg) for removing pathogens, Aqueous NaCl (2 lit) for the activation of Heulandite, was purchased from Mark chemicals, Mumbai. Methyl Orange (100 ml), Concentrated Hydrochloric acid (1 l), Nessler's reagent (100 ml), Distilled water (10 lit), Whatman Filter paper was purchased from Eswar Scientific Glass Wares, Trichy.

2.2 EXPERIMENTAL SETUP

Fig 2.1: Experimental setup

The setup consists a Column made up of Teflon with 15 cm in length and 50 mm in diameter. Peristaltic Pump used for the transfer of liquid at the required flow rate to the column. Feed tank and a Conical Flask to store raw water and to collect the treated water respectively.

2.3 EXPERIMENTATION

2.3.1 PREPARATION OF HEULANDITE ZEOLITE NA

Heulandite zeolite was grounded and sieved into different sizes of 0.3 mm, 0.25 mm, and pan and then washed with distilled water to remove the non-adhesive impurities. The washed zeolite was dried in an oven at 100˚Cfor 24 hours and then made into fine powder. The dried powder and aqueous solution of sodium chloride should be prepared for different conditions.

Sodium chloride concentrations were varied from 0.5 to 2 mol/lit with zeolite solution per solution ratio maintained at 1 g per 10 ml. Suspension was stirred in a conical flask using magnetic stirrer water bath at 100 rpm and 80˚C for 2 hours, subsequently the suspension was filtered, washed and dried at 60˚C in an oven for 24 hours and used in batch adsorption experiment at initial ammonia concentration of 100 mg/lit with pH of 7 at room temperature and stirring time of 24 hours.

2.3.2 BATCH EXPERIMENTS

In batch studies, the effects of time and ammonium concentrations on ammonium removal efficiency by zeolite were examined by using Dam Water

2.3.2.1 EFFECT OF TIME

In order find the optimum time for the removal of ammonia activated Heulandite zeolite of all the sizes as mentioned above was packed into the column in different layers and then the column was filled with raw Dam Water by means of Peristaltic Pump and batch process has been carried out at room temperature.

2.3.2.2 ADSORPTION ISOTHERM

Ion exchange reaction is a process which purely depends on the stoichiometric coefficients of the reaction that take place, where one equivalent ion of the solid phase is swapped by one equivalent ion of the solution phase. This process can be explained by the reaction given below,

$$\mathbf{Na_{(z)}^{+} + NH_{4(s)}^{+} \Leftrightarrow Na_{(s)}^{+} + NH_{4(z)}^{+}} \quad (2.1)$$

z- Zeolite; s- Solution

Equilibrium of an ion in solid phase with the concentration of the ion in solution was characterized by ion exchange isotherms. Batch isotherms for the removal of ammonia was studied. Batch isotherm was determined in 250 ml conical flask. Heulandite-Na zeolite of weight (1-5 g) was introduced into the 5 conical flasks, to which the 200ml of ammonium buffer solution (synthetic solution) with fixed concentration of 1200 mg/l of NH_4^+ at the pH of about 7.5

were added. The conical flask was shaken for 11 hours using a shaker device.

Possible experimental conditions at room temperature for the removal of ammonia by ion exchange isotherms by using Heulandite-Na zeolite is represented by graphs obtained. For the effective utilization of a Heulandite zeolite as an ion exchanger, it is essential to have chemical bonds that help to describe accurately NH_4^+- N equilibrium. Empirical equations such as the Freundlich isotherm and Langmuir isotherm were fitted to the experimental data. The amount of ammonia accumulated on the Heulandite Zeolite was calculated by the following equation as the difference between initial ammonia concentration in the solution and equilibrium concentration of the ammonia.

$$Q = \frac{(C - C_e)\,V}{M} \qquad (2.2)$$

Where,

Q (mg/g) is the amount of ammonia adsorbed

C (mg/l) represents initial ammonia concentrations

C_e (mg/l) represents equilibrium ammonia concentration

V (l) is the volume of solution

M (g) is the mass of Zeolite

2.3.3 COLUMN STUDIES

Teflon column with length 15cm and inner diameter 50mm is used for the column studies. The Heulandite-Na Zeolite bed height and the volume of the columns were 130mm and 25cm^3, respectively. The column is filled with four layers of zeolite (Four different sized zeolites). Operation and Regeneration parameters of Heulandite zeolite were investigated. Peristaltic Pumps were employed to transfer the raw water to the column at the flow rates required. The outlet ammonium concentrations of the samples were observed by volumetric titration method.

Effects of flow rate, surface area are also studied in this paper. From the literature studied the decrease in the flow rate increases, the percentage removal of ammonia and decrease in the size of the packing material increases the surface area of contact which in turn increases the percentage removal of ammonia from the Dam Water.

2.3.3.1 EFFECT OF FLOW RATE

Contact time or residence time of the water inside the column is controlled by the flow rate by the use of a peristaltic pump. The effect of flow rate on percentage removal of ammonia from dam water was studied by feeding the column with dam water at different flow rates say 2, 4, 6, 8, 10 ml/min at the room temperature and constant pH.

2.3.3.2 EFFECT OF SURFACE AREA

To check the Effect of Surface Area on the removal efficiency of ammonia from Dam Water, Zeolite of size 0.4mm is loaded into the column and raw dam water was passed through the column at the flow rate of 2 ml/min, the same process has been carried out for the other sized zeolites say 0.3, 0.25mm and less than 0.25mm.

3. RESULT AND DISCUSSION

3.1 BATCH EXPERIMENT

3.1.1 EFFECT OF TIME

Ammonia removal, depending on the time is given in Fig.3.1. As shown in the Fig.3. after 6 min of the time, the removal efficiency did not change considerably. The optimum value of time for the reaction was found to be 6 min.

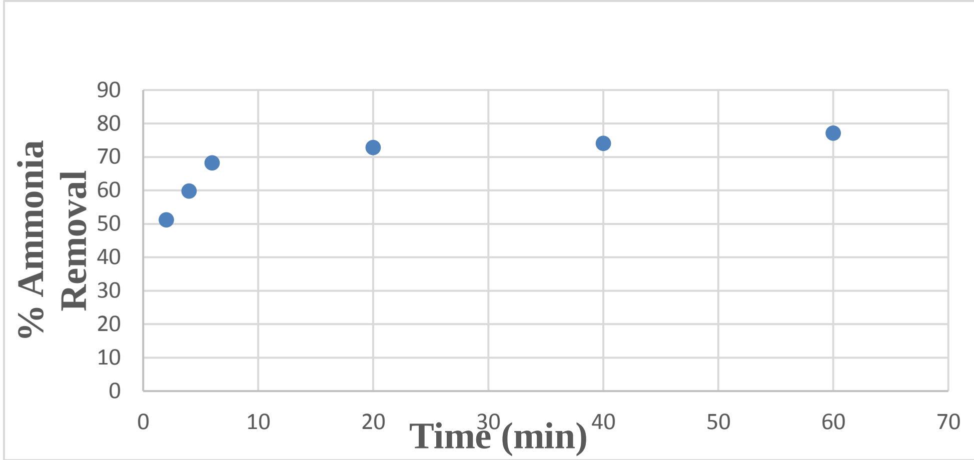

Fig 3.1: Effect of time on % Removal of ammonia

3.1.2 ADSORPTION ISOTHERMS

Interaction of ammonium ions (NH_4^+-N) with Heulandite zeolite can be described by Adsorption Isotherm and are also useful to optimize the use of Zeolite as an adsorbent. Therefore empirical equations such as Langmuir isotherm and Freundlich isotherm are important for the adsorption data analysis and calculations. Both Langmuir and Freundlich models were used for the evaluation of experimental results.

The Langmuir Isotherm model is as follows [11]:

$$Q_e = \frac{K_L C_e}{1 + aC_e} \qquad (3.1)$$

Where,

Q_e is the amount absorbed,

C_e is the equilibrium concentration of adsorbate,

K_L, a are the Langmuir isotherm constant.

K_L = 0.0838, a = 0.005121, R^2 = 0.7894.

Langmuir Isotherm Equilibrium for ammonia removal can be represented by the following equation

$$Q_e = \frac{0.0838 C_e}{1 + 0.005121 C_e} \qquad (3.2)$$

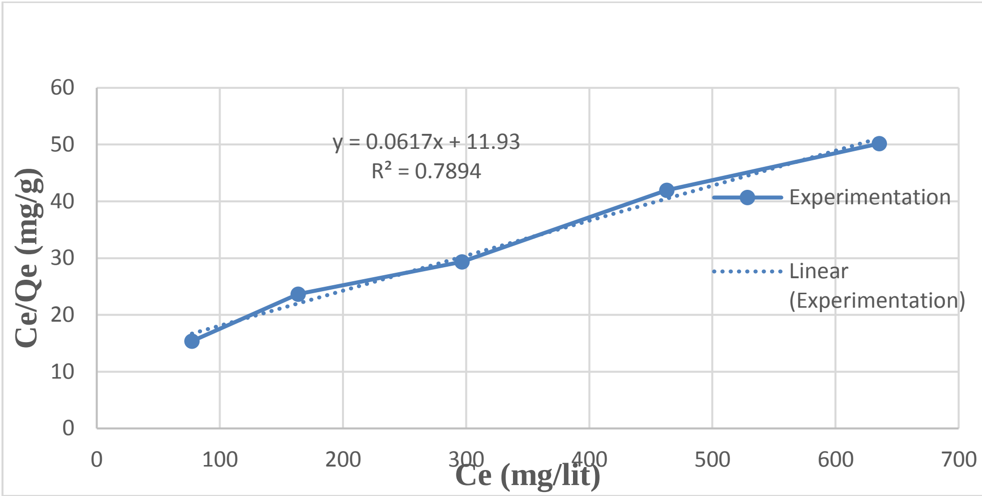

Fig 3.2: Langmuir adsorption Isotherm curve at room temperature.

The Freundlich Isotherm model is as follows [12]:

$$Q_e = K_F C_e^{\left(\frac{1}{n}\right)} \qquad (3.3)$$

Where,

Q_e is the amount absorbed,

C_e is the equilibrium concentration of adsorbate,

K_F, 1/n are the Freundlich Isotherm constants.

K_F = 1.2504, 1/n = 0.655, R^2 = 0.9927.

Freundlich Isotherm Equilibrium for ammonia removal can be represented by the following equation

$$Q_e = 1.2504\ C_e^{0.655} \qquad (3.4)$$

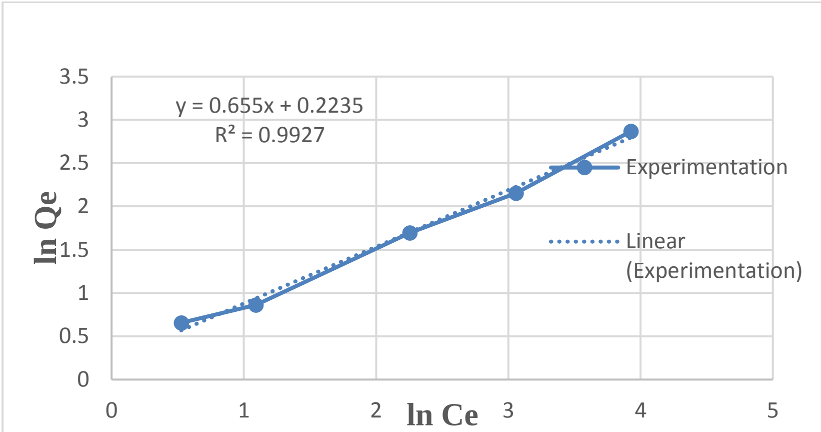

Fig 3.3: Freundlich adsorption Isotherm curve at room temperature.

As shown in Fig 3.2 and 3.3 and above equations both isotherms can't be used, because Regression coefficient (R^2) value for Langmuir model is low when compared to Freundlich model. Hence Freundlich model should be employed for the experimental data. Regeneration of the Zeolite bed is easy because the experimental data fits into Freundlich model which indicates that Physical adsorption takes place.

3.2 COLUMN STUDIES

3.2.1 EFFECT OF FLOW RATE

Based on the experimental results, the adsorption capacities of the Zeolite at various flow rates are studied as shown in Fig.3.4. The experimental data proves that flow rate is one of the important parameters in column design. When compared with one achieved at 10ml/min, it was observed that the adsorption capacity is increased by 30% when the flow rate is decreased to 2 ml/min. This shows that the decrease in the flow rate increases the residence time which in turn increases the removal efficiency of Ammonia. The optimum flow rate was found to be 2ml/min.

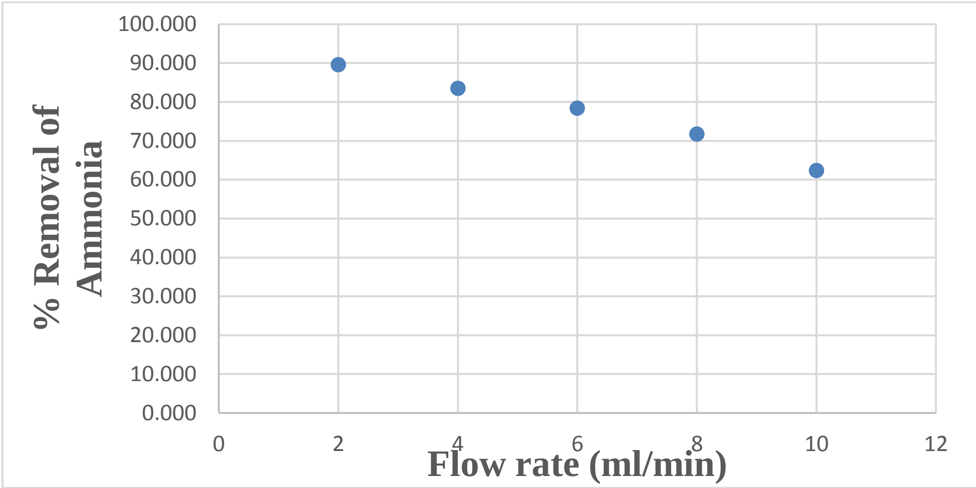

Fig 3.4: Effect of Flow rate on % Removal of ammonia

3.2.2 EFFECT OF SURFACE AREA

Adsorption capacity determined at sizes 0.4, 0.3, 0.25, 0.2 mm and 2ml/min flow rate were calculated to be 51.258, 59.686, 65.771, 73.378% respectively. This shows that at the constant flow rate decrease in the size of the bed particle increases the surface area which in turn increases the removal efficiency. Thus it was considered that the optimum size of the particle for the preparation of bed is 0.2mm.

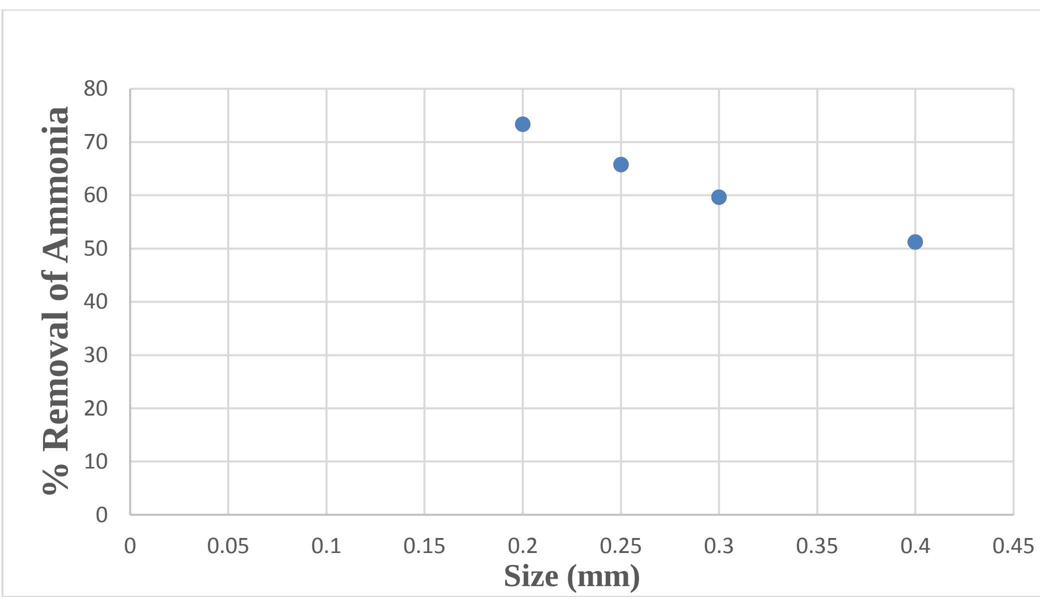

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Fig 3.5: Effect of Surface area on % Removal of ammonia

4. CONCLUSION

In this study, batch and the continuous process have been carried out to estimate the adsorption capacity of ammonia from aqueous solution by using Heulandite Zeolite. Our Selective ion exchange process for removal of ammonia by using zeolite has been achieved in our experiment.

The data obtained from the tests were applied to Langmuir and Freundlich isotherms. The Freundlich isotherm gives the satisfactory correlation coefficient value compared to the other also proves that regeneration is easier in this process.

The results obtained from the column studies showed that total exchange capacity of the Heulandite Zeolite for the removal of ammonia for different flow rates was obtained between 62.381 and 89.615%. This indicates that Flow rate plays a major role in the ion-exchange process, lowering the velocity of the aqueous solution, increases the hydraulic residence time of the solution inside the column resulting in higher removal efficiency. As the particle size of the zeolite is decreases, the surface area increases resulting in the higher removal capacity of the material. Maximum efficiency is obtained at the flow rate of 2 ml/min and 2 mm particle sized zeolites.

As a summary ammonium ion can be removed from Dam water by using Heulandite Zeolite as ion exchange membrane. Perhaps, it can be concluded that the selectivity of natural zeolites for the particular ion, such as ammonium ions is very much dependent on the origin as well as on the type ions already present in the structure.

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33.

Removal Of Dyes From Textile Dyeing Effluents By Liquid-Liquid Extraction Using Isoamyl Alcohol And Cationic Surfactant

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ABSTRACT

Dyebath effluents and wash liquor effluents are generated during dyeing of fresh fabrics and washing of dyed fabrics, respectively. The dye concentration in these effluents differs due to the process. Synthetic dyes from textile dyeing effluents were extracted by solvent extraction using isoamyl alcohol as a diluent and cetyltrimethyl ammonium bromide (CTAB) as a surfactant. Various parameters such as pH, contact time, surfactant concentration, diluents and its concentration were optimized. Among the sixteen solvents screened, isoamyl alcohol showed highest dye extraction of dyes from the textile dyeing effluents. The effect of pH, solvent volume, CTAB concentration and contact time were studied for the extraction of dyes from both dyebath effluent and wash liquor. The optimum pH, solvent volume, CTAB concentration and contact time for the removal dyes from dyebath effluents were 7, 3µl/ml, 50 µl/ml, and 10, respectively. The optimum pH, solvent volume, CTAB concentration and contact time for the removal dyes from wash liquor effluents were 4, 300µl/ml, 200 µl/ml, and 60, respectively.

KEYWORDS: Dye bath, wash liquor, CTAB, iso amylalcohol and solvent extraction.

INTRODUCTION

For coloring the products, dyes are widely used in various industries like textiles, leather, plastic, paper and cosmetics. Dyeing process involves desizing, scouring, bleaching, dyeing , printing and finishing unit operations and these steps in textile industries generate huge quantity of waste water [1]. Azo dyes are the largest group of dyes used in textile industry for dyeing. The term azo dye is applied to synthetic organic colorants that are characterized by a nitrogen-to-nitrogen double bond: -N=N- [14]. Durability of azo dyes causes pollution to the environment. Besides, some azo dyes are toxic and mutagenic. Methyl red is an anionic azo dye, it is used in paper printing, textile dyeing and it causes irritation of the eye, skin and digestive tract if inhaled/swallowed.The discharge of polluted effluents and use of various raw materials may cause contamination of soil, ground water and surface water which may have adverse consequences on environment in general and local population in particular. The effluents generated from the textile dyeing industry are of utmost concern because of their high volume and pollution potential. The release of colored wastewater from the industry may present eco-toxic hazard and may eventually affect human life through food chain if it is accumulated [2]. Color interferes with the transmission of sunlight into the stream and therefore reduces photosynthetic action so it is essential to treat the textile wastewater prior to discharge [3].

Various methods have been used to remove dyes from textile dyeing waste water. Adsorption, coagulation, photocatalytic degradation, ozone treatment, and electro Fenton's and hypochlorite treatment are the most widely used methods for the removal of dyes [15-24]. The physical methods are non-destructive and merely transfer the pollutants from one medium to another, thus giving secondary treatment [25]. Chemical methods are not economically viable due to high chemical dosage (e.g. FeSO4, lime and polyelectrolyte) and production of a large quantity of sludge [26-28].

Now-days, much attention has been focused on a separation technique such as solvent extraction or liquid-liquid extraction (LLE) and liquid membrane. LLE is based on the principle that a solute can distribute itself in a certain ratio between immiscible solvents, and the extraction process depends on its mass transfer rate. The advantages of LLE methods are: the method lends itself to rapid and very selective separations that are usually highly efficient, the composition of the organic phase and the nature of complexing (or) binding agents can be varied so that the number of practical combinations is virtually unlimited and it can be performed with simple equipment, but can also be automated [4]. The key factor for liquid-liquid extraction process is the chemical reaction which causes the extraction of desired chemical species [5]. The reaction mainly depends on the pH of the solution. The mechanism of the extraction is

$$[R3PH]^{+}_{org} + (Dye)_{aq}Na^{+} \longleftrightarrow [(R3PH)(Dye)]_{org} + Na^{+}_{aq}$$

Cetyltrimethylammonium bromide (CTAB) is a cationic surfactant, is widely used as topic antiseptics, and may be found in many household products such as shampoos, hair conditioning product and cosmetics. According to the Directive 67/548/EEC, CTAB chemical is not classified. As with most surfactants, CTAB forms micelles in aqueous solutions. It is clear water white liquid of moderate volatility and has the highest narcotic effect among all the amyl alcohols. It was first derived from Fusel oil, a byproduct during the production of Ethyl alcohol by fermentation of molasses. It was then derived from the chlorination of Pentanes followed by hydrolysis.

2. METHODS AND MATERIALS

The extraction process was carried out using textile dyeing effluents (dye bath and wash bath) collected from Perundurai Common Effluent Treatment Plant, (PCETP), Tamil Nadu. Isoamyl alcohol was used as solvent for extraction process. Sodium hydroxide and HCl were used for pH adjustments. UV-Visible spectrophotometer (Shimadzu) was used was used to measure the absorbance of the dye. The pH of the aqueous solution was measured by a pH meter. pH of the effluent was adjusted to 7 . Solvent and the surfactant were added to the effluent in a separating funnel; contents were stirred thoroughly and allowed to settle for 24 h to form two clear phases: organic phase and aqueous phase. Organic phase is believed to contain solvent, dye and surfactant while the lower the aqueous phase contain residual dyes in water. Sample from the aqueous was collected, and used for absorbance measurement. The percent dye extraction was calculated by the following formula:

$$E = \frac{C_i - C_f}{C_i} \times 100$$

Where C_i is the initial dye concentration of aqueous phase (mg/L),

C_f is the dye concentration of aqueous phase after extraction (mg/L).

3. RESULTS AND DISCUSSIONS

3.1 EFFECT OF PH

3.1.1 WASH BATH

The effect of pH for the extraction of dye from the wash bath was studied. The actual pH of the wash bath was found to be 8 hence pH of the wash bath was varied from acidic pH 4 to alkaline pH 12, but maximum extraction of dye was found to be at acidic pH 4. From Fig 2. maximum percentage of extraction 75% was observed at pH 4 and there is decline in the extraction process at alkaline pH.

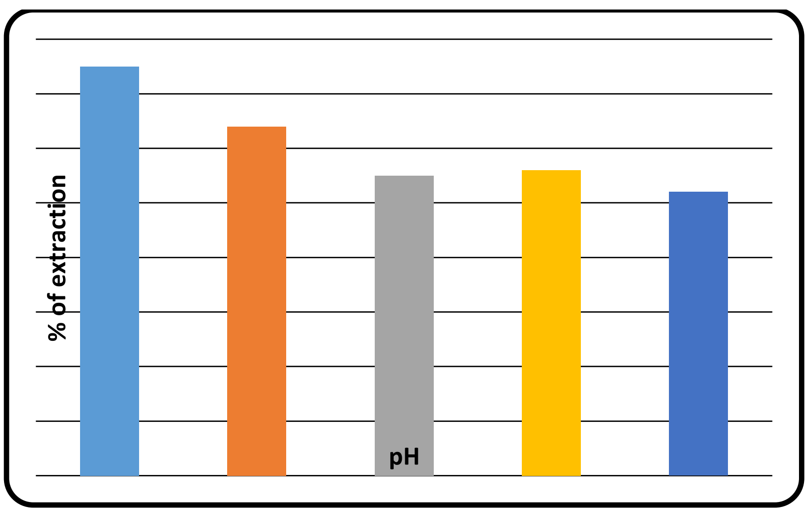

Fig 1: Effect of pH on percent dye extraction from wash bath (A/O phase ratio 1:1; solvent, 0.5 ml; contacting time, 10 min; room temperature)

3.1.2 DYE BATH

pH of the extraction solution is considered one of the most important factors affecting the extraction process. The initial pH of the effluent was varied from 5 to 12 using sodium hydroxide and hydrochloric acid to investigate the extraction process. It is evident from Fig. 1 that the maximum percent extraction of dye was observed at pH 7 was 81%. The changes in the behavior of the dye could be attributed to the hydrolysis or aggregation at these pH conditions [6]. It is clear from Fig. 1 that the dye extraction increased steadily from pH 5 to 7 and was insignificant at pH 9, 10 and 12.

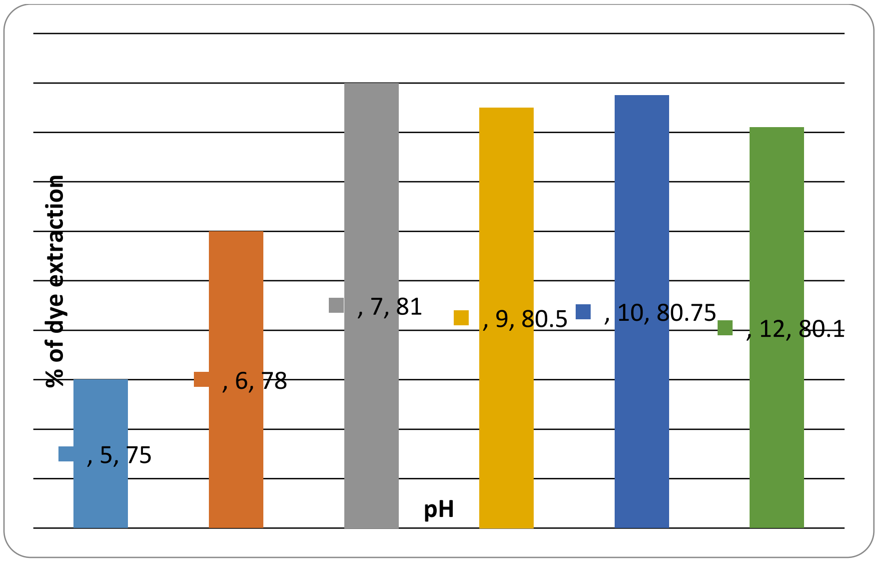

Fig 2: Effect of pH on percent dye extraction from textile dyeing effluents (A/O phase ratio 1:1; solvent, 50 µl/ml; contacting time, 10 min; room temperature)

3.2 EFFECT OF CONTACT TIME

3.2.1 WASH BATH

Contact time between the aqueous and the organic phase was tested at 5, 15, 30, 45 and 60 minutes. The extraction process increase with increase in contact time of 60 minutes and remain constant. Fig 4. shows that the percentage of extraction at different time intervals. The extraction efficiency of dye increased with an increase in contacting time from 5th min to 60th min. About 82% dye was extracted at 60th min.

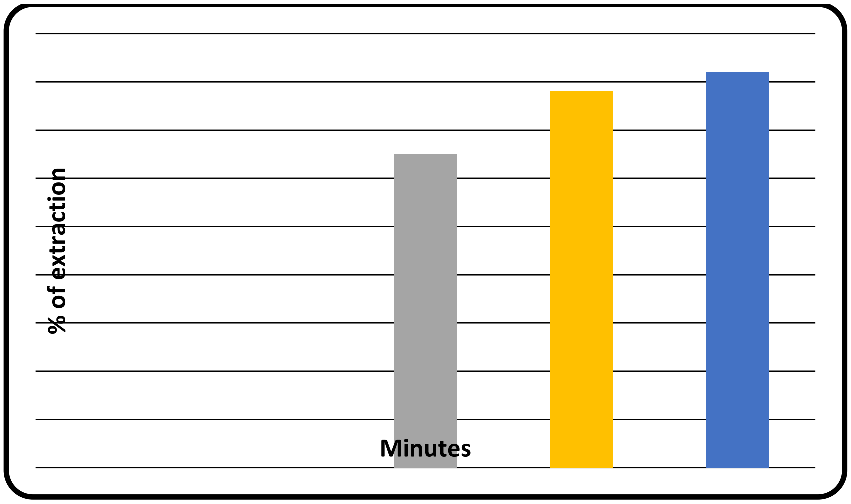

Fig 3: Effect of contact time on extraction of synthetic dyes from wash bath (A/O phase ratio 1:1; solvent, 0.5 ml; contacting time, 60 min; room temperature

3.2.2 DYE BATH

The effect of equilibrium time on the percentage of dye extracted was studied at 5, 10, 30, 45, 60, 120 and 300 min. Fig. 2 shows that the percentage of extraction at different time intervals. The extraction efficiency of dye increased with an increase in contacting time from 5th min to 10th min (Figure 3). About 82% dye was extracted at 10th min. Any further increase in contact time beyond 10th min did not show significant increase in percent extraction of dyes up to 300 min. process. Hence, contacting period of 10 min. is recommended for the extraction of dyes and was used for further experiments.

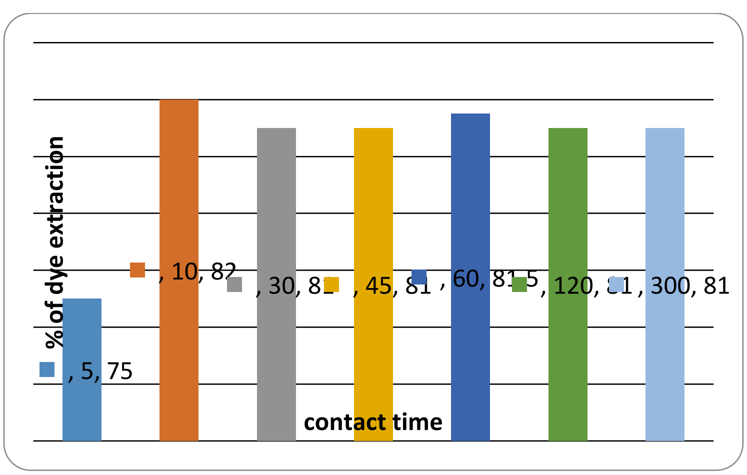

Fig 4: Effect of contact time on extraction of synthetic dyes from textile dyeing effluents (A/O phase ratio 1:1; solvent, 50µl/ml; contacting time, 10 min; room temperature).

3.3 EFFECT OF SUFACTANT CONCENTRATION

3.3.1 WASH BATH

Extraction of dye from the wash bath was tested with varying the surfactant concentration in the range from 1 % to 10 %. Fig. shows effect of CTAB on percent dye extraction. It is observed from the Fig 6. that the percentage dye extraction is maximum when the concentration of CTAB is 2 %,further increase in CTAB concentration led to decrease in percent dye extraction due to number of reverse micelle formation[29]. Therefore, CTAB at 2 % was used in the subsequent experiments.

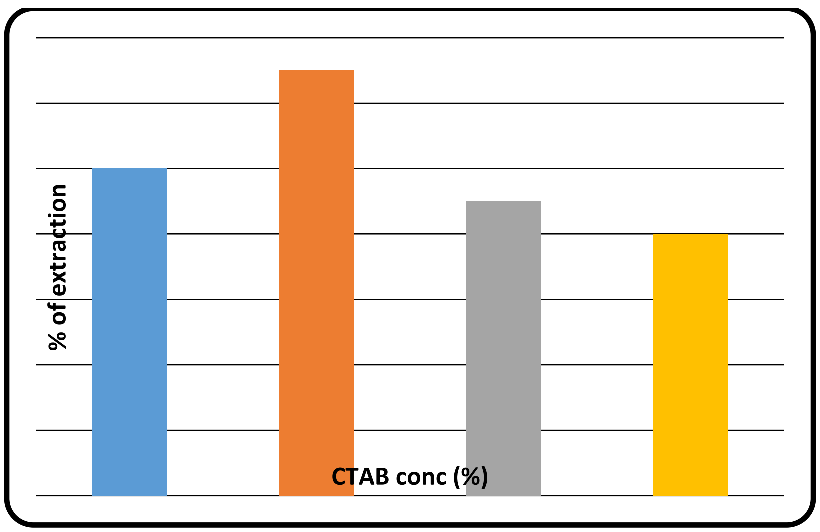

Fig 5: Effect of surfactant concentration on percent dye extraction from wash bath (A/O phase ratio 1:1; solvent, 0.5 µl/ml; contacting time, 60 min; room temperature).

3.3.2 DYE BATH

The effect of cetyltrimethyl ammonium bromide on percent dye extraction from textile dyeing effluents was investigated in the concentration range from 10 to 100 µl/ml. Fig. 5 shows effect of CTAB on percent dye extraction. It is observed from the Fig.3 that that the percentage dye extraction increased from 5th min and reached 84% at 50µl/ml. It is evident from Fig. 5 that any further increase in CTAB concentration beyond 75 µl/ml. led to decrease in percent dye extraction. Therefore, CTAB at 50µl/ml was used in the subsequent experiments.

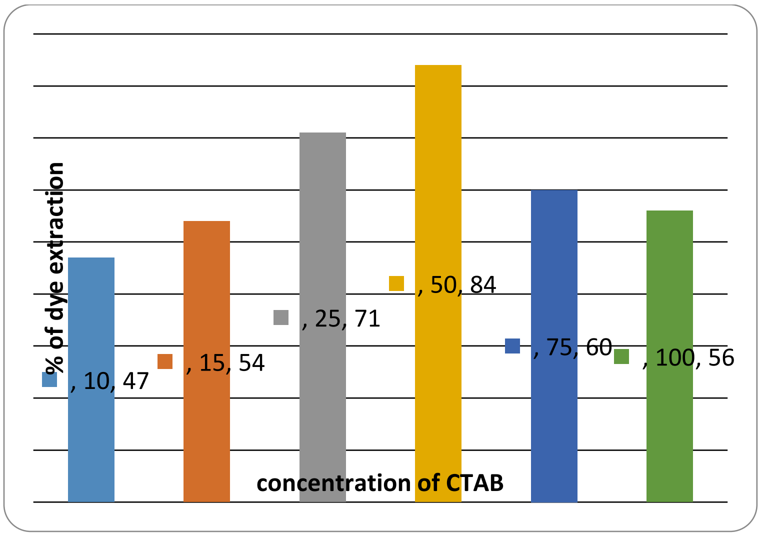

Fig 6: Effect of surfactant concentration on percent dye extraction from textile dyeing effluents (A/O phase ratio 1:1; solvent, 50 µl/ml; contacting time, 10 min; room temperature).

3.4 EFFECT OF DILUENT CONCENTRATION

3.4.1 WASH BATH

Iso amyl alcohol was used for the extraction of dye from the wash bath. The volume of iso amyl alcohol was varied from 0.1 ml to 0.5 ml. The optimal volume was found to be 0.3 ml of Iso amyl alcohol for the maximum dye extraction from the wash bath. The extraction percentage was found to be 79 % at 0.3 ml of Iso amyl alcohol.

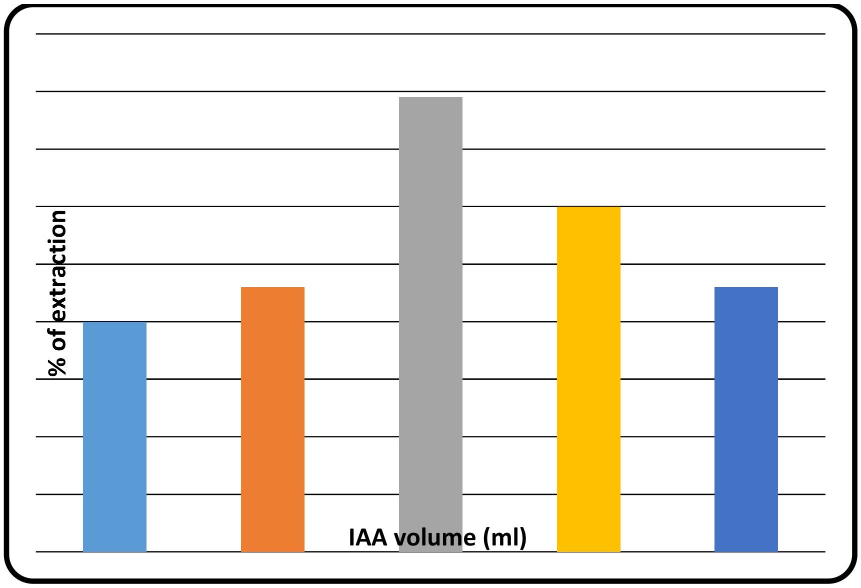

Fig 7: Effect of solvent level on the extraction of dyes from textile dyeing effluents (A/O phase ratio 1:1; solvent, 0.3 ml; contacting time, 60 min; room temperature

3.4.2 DYE BATH

Among the sixteen solvents tested for the extraction of dyes from the effluents, isoamyl alcohol was found to be the best for the extraction process and used as diluent for further investigations. The extraction of dyes was studied by varying the concentrations of the solvent from 10 to100 µl/ml. It is clear from Fig. 7 that extraction of dyes increases with an increase in solvent level from 10 to 30 µl/ml. Maximum percentage of extraction (80%) was observed at the concentration of 30µl/ml. On the contrary, dye extraction process decreased with an increase in solvent level from 40 to70 µl/ml.

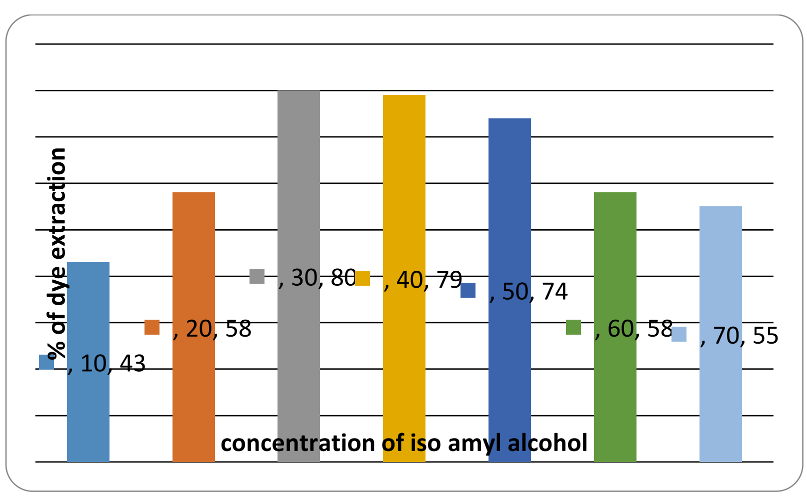

Fig 8: Effect of solvent level on the extraction of dyes from textile dyeing effluents (A/O phase ratio 1:1; solvent, 50µl/ml; contacting time, 10 min; room temperature).

3.5 EFFECT OF TEMPERATURE

3.5.1 WASH BATH

Extraction of dye was done at different temperatures (20°C, 30 °C, 40 °C, 50 °C, 60 °C and 70 °C).The optimum temperature for the extraction process was found to be 40 °C and the percentage of extraction is 65 as shown in Fig. 9. Further increase or decrease in temperature the extraction process is insignificant.

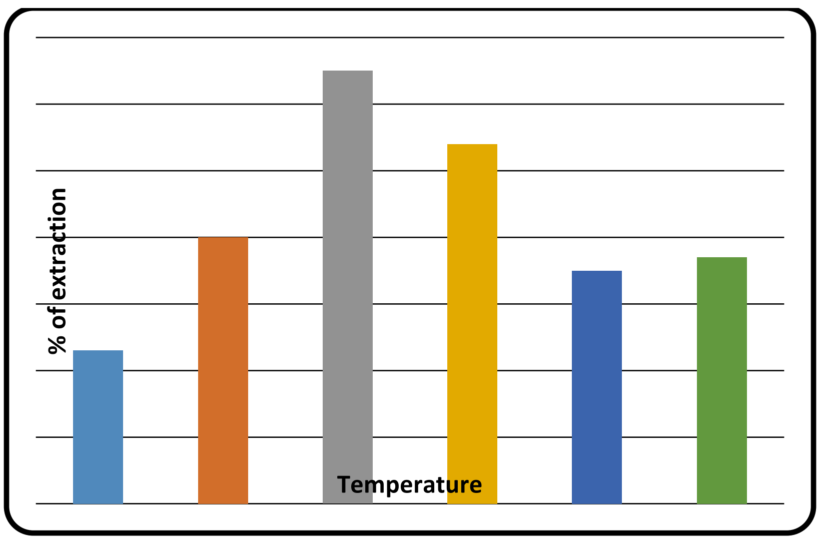

Fig 9: Effect of solvent level on the extraction of dyes from textile dyeing effluents (A/O phase ratio 1:1; solvent, 0.3 ml; contacting time, 60 min).

3.5.2 DYE BATH

The effect of temperature was tested at 20°C, 30 °C, 40 °C, 50 °C, 60 °C and 70 °C. The percentage of extraction was found to be 89 % at 30°C and further increase in temperature reduction in the percentage of extraction was observed, might be due to the evaporation of solvent at high temperatures [2].

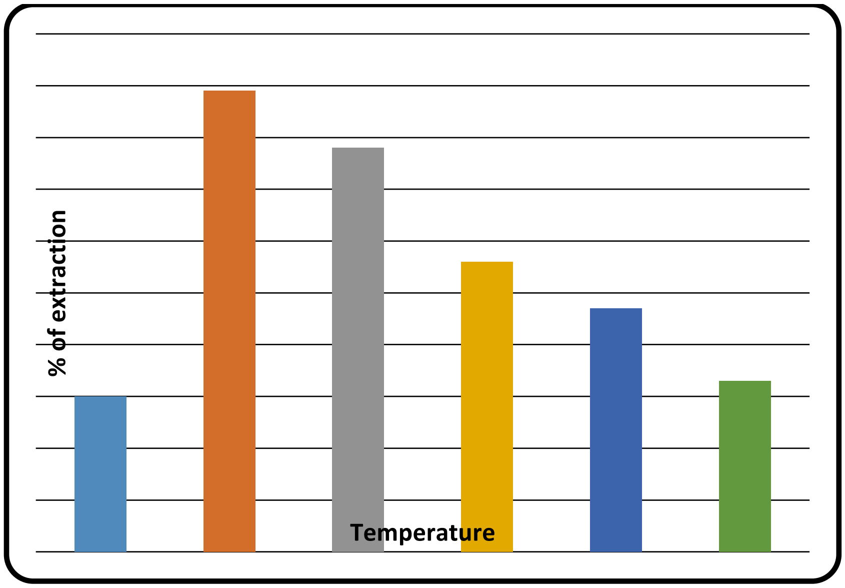

Fig 10: Effect of Temperature on the extraction of dyes from textile dyeing effluents (A/O phase ratio 1:1; solvent, 50µl/ml; contacting time, 10 min).

Based on the above results, scale up was done for 50 ml and 500 ml of effluent (dye and wash bath), treated under optimal conditions for phase separation. Then, an aliquot of aqueous phase was withdrawn and analyzed using spectrophotometer. The percentage of the dye extraction was found to be around 80%.

4. CONCLUSION

Dyes from the textile effluent both wash bath and dye bath were removed by liquid-liquid extraction using isoamyl alcohol as the solvent and cetyltrimethyl ammonium bromide as the surfactant. The parameters like pH, contacting time, surfactant concentration, solvent level and its concentration for efficient extraction were optimized and the extraction process was investigated. At pH 7 maximum extractions was observed with the contacting time of 10 min. The surfactant concentration at 50 µl/ml and 30µl/ml of isoamyl alcohol level extracted maximal dye from textile dyeing effluents and for the wash bath the optimum parameters were found to be acidic pH 4, contact time of 60 minutes, CTAB concentration at 2% and volume of isoamyl alcohol is 0.3 ml.

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34.
Retreatment Of Toxic Industrial Effluent By Microalgae Cultivation For Potential Biofuel Production

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ABSTRACT

Industrial effluent having Organic & Inorganic chemicals which were released into the environment as a result of domestic, agriculture and industrial water activities lead to environmental pollution, The process have been used to treat the industrial effluents to eliminate the easily settled organic chemicals present in effluent and which is reused for beneficial purpose. This effluent is however loaded with some inorganic chemicals like N_2 & P and causes eutrophication, longer term problems because of the heavy metals that are released. Microalgae are the third generation source provides a valuable way for treatment of effluents, because they provide a tertiary bio treatment along with the production of biofuel. Microalgae have the ability to utilize inorganic N_2 & p as a nutrient for their growth. And also, capacity to use heavy metals as well as some toxic chemicals. In this present study, the industrial effluents were treated by *Chlorella sp., Scenedesmus sp., Desmococcus sp.,* coupled with biofuel production. The species (*Chlorella sp., Scenedesmus sp.,*) were collected from Phycospectrum Environmental Research Centre and the *Desmococcus sp.,* was isolated from nearby drainage areas and the effluent was collected from various dye industry and match industry. The collected species were subjected to screening for the effective utilization of nutrients from effluent. And also the growth was observed in the addition of Macronutrients, Micronutrients and effluent. The bio treated effluent was undergone for physico-chemical properties. From this study we concludes that the *Chlorella sp., and Desmococcus sp.,* shows the maximum growth and highlighted on effective utilization of organic & inorganic substances and should be used for biofuel production.

KEYWORDS: Effluents, Inorganic N_2&P, Microalgae, Macro & Micronutrients, Biofuel Production.

INTRODUCTION:

Now days, due to overpopulation the earth atmosphere get increased by the emission of excessive greenhouse gases and carbon derivatives. Due to the pollution created by the industrial activities the living beings get affected. Also the waste water from the various industries is directly released into the environment with or without treatment. The effluents which are not treated within the industry causes various diseases to the human like respiratory problem by in healing the polluted air and by drinking the water the digestive system also get disturbed. Due to the over emission of carbon di oxide, the Ozone layer also get depleted which leads to the UV rays directly to enter into the earth. Most of the diseases are commonly due to the contamination of drinking water. It also diminishes the nutrients present in the soil which can be used for the cultivation. The pollution control board insist the industry should have the Waste water treatment plant based on the volume of effluent get released into the environment. So there is a need for the efficient system to treat the effluent in a less expensive and should give the beneficial activities towards the environment. Various generations are available for the production of biofuel. They are first generation, second generation and third generation biofuel. In every industry there will be the emission of waste water which may contain more toxic compounds. This waste water when released into the cultivable land causes land pollution which may affect the growth of commercial and cash crops.

2. MATERIALS AND METHODS

2.1. Sample collection: *Desmococcus species* were obtained from drainage areas confirmed by photographic view and the *chlorella species & Scenedesmus species* were purchased from Phycospectrum Environment Research Centre, Chennai.

2.2. Chemicals and medium : Calcium chloride, Sodium chloride, Sodium bi carbonate, Sodium nitrate, Dipotassium hydrogen phosphate, Potassium sulphate, Magnesium sulphate hepa hydrate, Ferrous sulphate, Calcium acetate are the chemicals used for the preparation of medium. The prepared medium was CFTRI Medium, BBM Medium, Industrial effluent (Match industry effluent, coloring dye effluent Dye industry effluent 1, 2).

2.3. Pre-inoculum Preparation: Microalgae were collected from the drainage areas and cultivated in 250mL Erlenmeyer flasks containing 100mL of CFTRI medium and Micronutrients:(10ml each /940 ml)$NaNO_3$ (10g/400ml), $CaCl_2.2H_2O$ (1g/400ml) , MgSO4.7H2O(3g/400ml) , K2HPO4(3g/400ml) , KH2PO4(7g/400ml) , NaCl (1g/400ml), EDTA (1ml/lit): EDTA (50g/lit , KOH(31g/lit) ,Iron (1ml/lit): FeSO4.7H2O (4.98g/lit, H_2SO_4(1.0ml/lit), Macronutrients(per liter): 4.98 $ZnSO_4.7H_2O$, 1.44g MnCl2.4H_2O , 0.71g MoO3 , 1.57g $CuSO_4.5H_2O$, 0.49g Co(NO3)$_2$.6H_2O. The composition of the CFTRI medium was as follows (perliter):4.5g NaHCO3, 0.5g K2HPO4, 1.5g NaNO3, 1.0g K2SO4, 1.0 NaCl, 0.2g MgSO4.7H2O, 0.04g CaCl2, and 0.01g FeSO4.The flasks were subjected to direct sunlight and optimum temperature until they reached sufficient growth.

2.4. Effluent treatment with microalgae: The effluents was treated with *Chlorella sp* and *Scenedesmus sp* in a boiling tube with varying volume of effluent and CFTRI medium was taken also act as control. The growth was measured at regular time interval using Hemocytometer. The specific growth rate was calculated as per the cell count.

2.5. Observation of growth by addition of nutrients: The various micronutrients such as organic, Inorganic and SAP (fertilizer) to the effluents in the concentration of 0.5g/lit in a 250ml of Erlenmeyer flasks and treated with the *Chlorella sp* .The cell count was taken till 15th day and the specific growth rate was calculated.

2.6. Screening of medium by micro algae: The different medium includes nutrients (carbon, nitrate, phosphate) for the effective utilization of micro algal species. It was done by varying the volume of BBM medium which was made up to 10ml with the effluent (food coloring dye) and 1ml of inoculum was added to each boiling tube for which the initial cell count was made on the day of inoculation till 10th day. The specific growth rate was calculated.

2.7. Comparative study with existing work: The Three species of micro algae were cultivated in the optimized effluent (ie..Match industry effluent) in a boiling tube by varying volume of CFTRI Medium and made up to 10ml with effluent. The growth was measured in a periodic interval of time and the specific growth rate was calculated and the cell count was done with Hemocytometer.

2.8. **Specific growth rate:** The specific growth rate was calculated for the day on which the cell count was made by using the formula, **ì = ln ì2-lnì1/2t.**

2.9. Biomass recovery: The biomass was recovered on 15th day and centrifuged at 5000 rpm for 10 minutes. The supernatant was collected in a separate vessel for analysis physico-chemical properties and used for biochemical test. The recovered biomass was allowed to dry in a direct sunlight for 20 minutes. The dry cell of microalgae was weighed.

2.10. Analytical methods: **Physico-chemical parameter analysis:** The different physico-chemical parameter of a medium was estimated using TWAD manual protocol. The parameter such as Appearance, odor, Turbidity NT units, total dissolved solids, Electrical conductivity, Color, P^H, Alkalinity, Total hardness, calcium , Magnesium, free ammonia, Nitrate, Chloride, Fluoride, Sulphate, Phosphate, Tidy`s test 4hrs., COD , BOD were monitored.

3. RESULTS AND DISCUSSION:

3.1. Preparation of seed inoculum: *Desmococcus species, Chlorella species and Scenedesmus species* was cultivated in Erlenmeyer flask containing 250mL of CFTRI Medium. The cultures were maintained at a temperature of 16ºC. The Light and Dark cycles was maintained at 8hrs. The culture was used as a seed inoculum for further studies.

3.2. Cultivation of micro algal species in different effluents for the effective utilization of chemicals: The three different species was cultivated in 250mL Erlenmeyer flasks containing 100mL of different effluent. The cultures were maintained at a temperature range of 16ºC, Dark and light cycle period. The cultures were placed in light intensity of 2000 lux in light period.

3.3. Growth curve analysis: The 1mL of seed inoculum was inoculated into different effluents and the cell growth was continuously monitored at 4th and 8th day. Among these two species the *chlorella sp*., shows the maximum growth due to effective utilization of inorganic nitrate and phosphate in food coloring dye as shown in the figures.

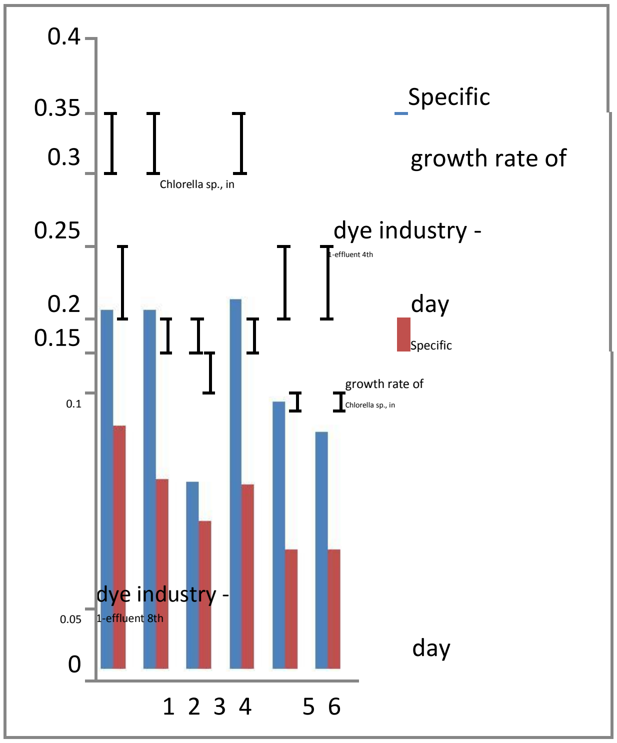

Fig 1: Specific growth rate of *Chlorella sp.*,in *sp.*,dye industry-1- effluent

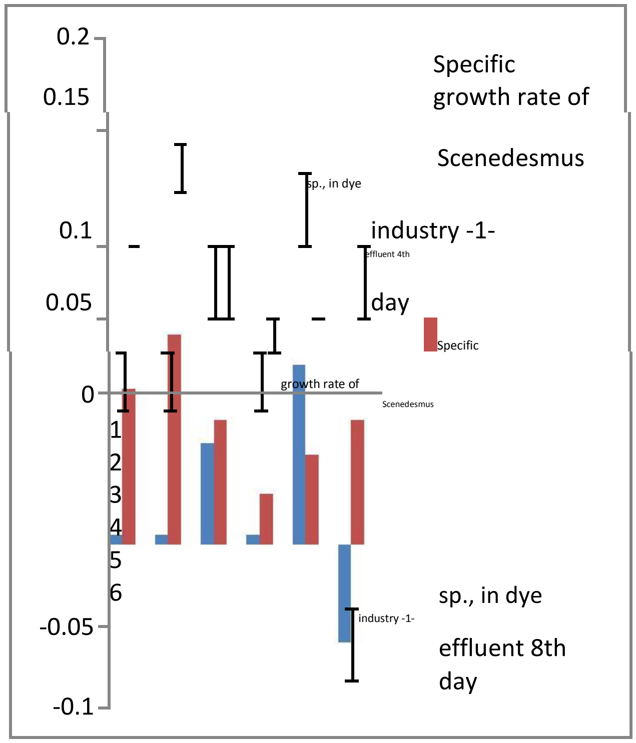

Fig 2: Specific growth rate of *Scenedesmus* in dye industry-2-effluent

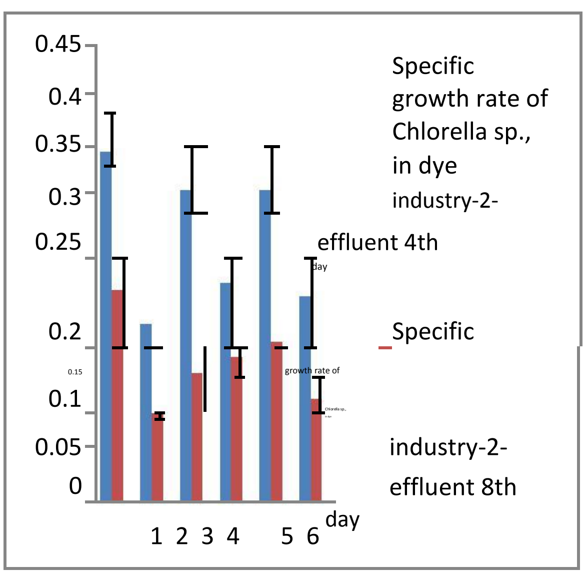

Fig 3: Specific growth rate of *Chlorella sp.*, in *sp.*, in dye industry-2-effluent

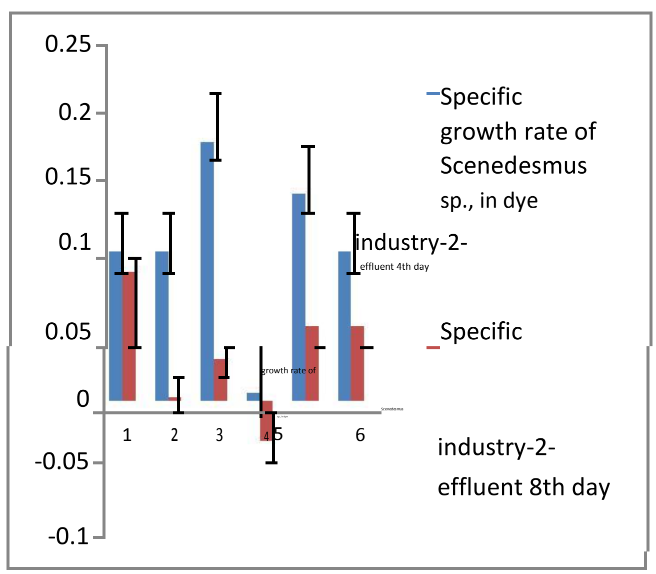

Fig 4: Specific growth rate of *Scenedesmus sp.*,dye industry-2-effluent

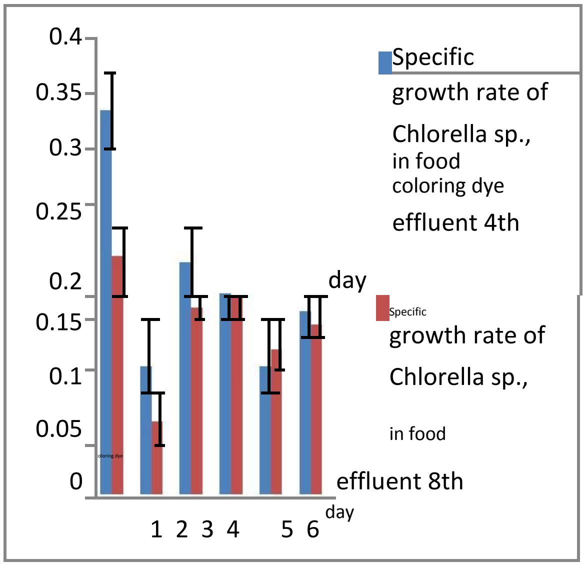

Fig 5: Specific growth rate of *Chlorella sp.*, in food coloring dye effluent

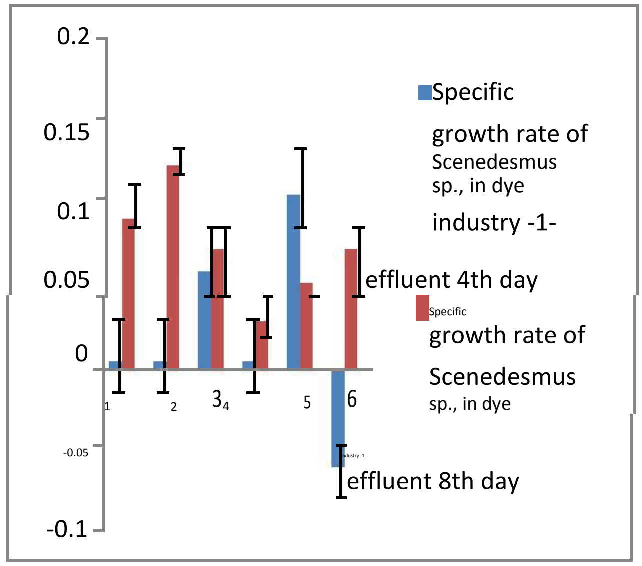

Fig 6: Specific growth rate of *Scenedesmus sp.*, in food coloring dye effluent

3.4. Growth curve analysis by the addition of micronutrients: 250ml Erlenmeyer flask containing 100ml of effluents and 10ml of seed inoculum was added with organic , inorganic and SAP(fertilizer) in the concentration of 0.5g/lit in every flask. The *Chlorella sp.*, shows a maximum specific growth rate of 0.224(day)$^{-1}$, 0.276(day)$^{-1}$, 0.276(day)$^{-1}$ in dye industry-1-effluent, food coloring dye effluent, dye industry-2-effluent by the addition of inorganic, SAP, organic micronutrients to the different effluents as shown in figures.

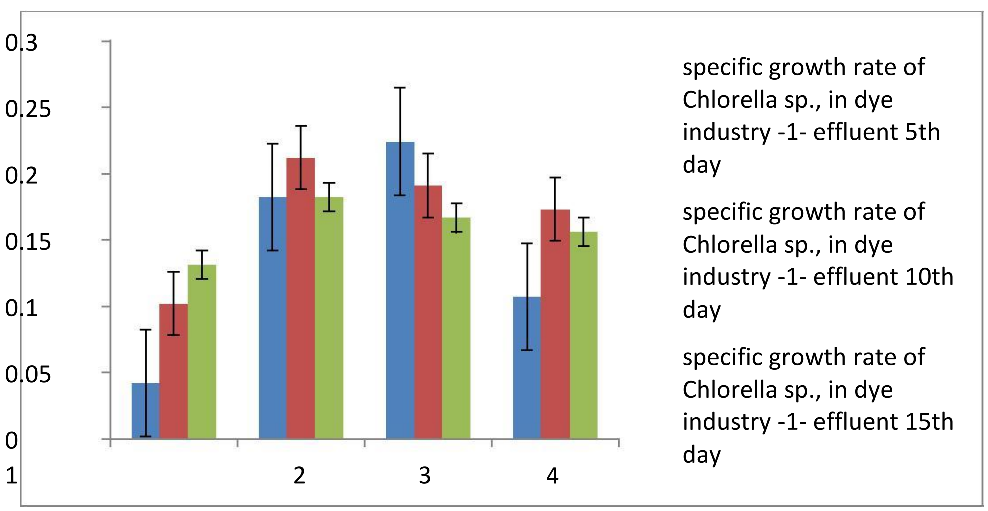

Fig 7: Specific growth rate of *Chlorella sp.*, in dye industry-1-effluent

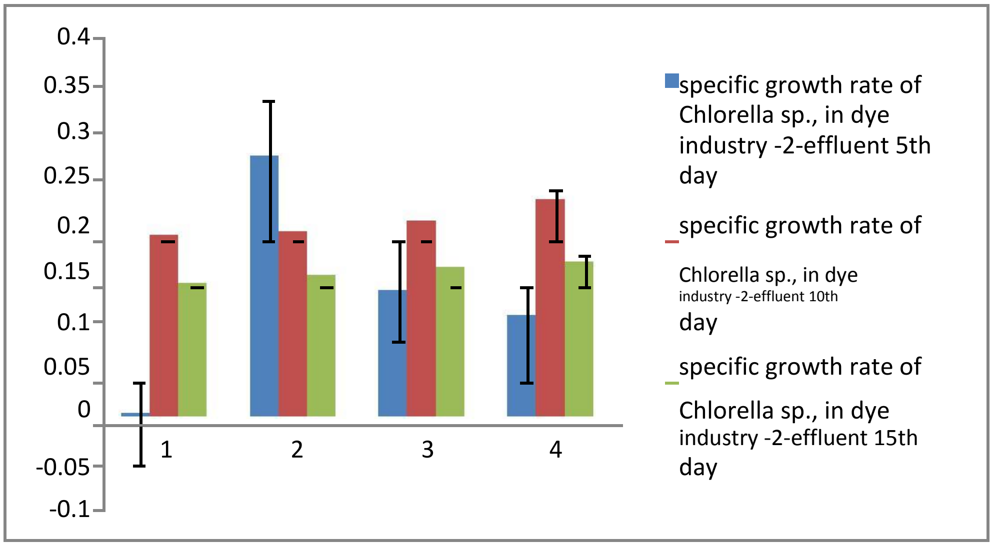

Fig 8: Specific growth rate of *Chlorella sp*., in dye industry-2-effluent

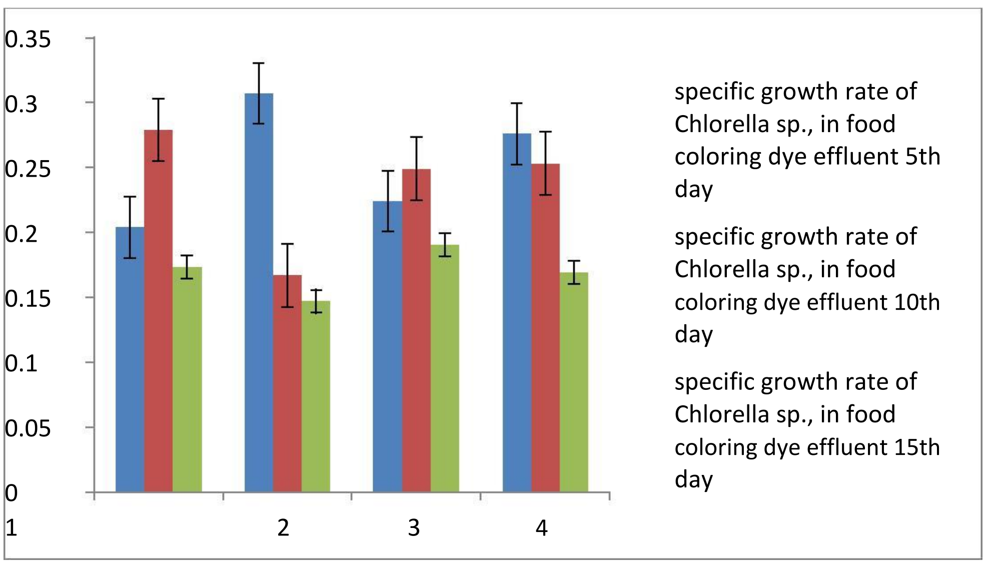

Fig 9: Specific growth rate of *Chlorella sp*., in food coloring dye effluent

3.5 Screening of media by microalgae: 1ml of seed inoculum of three microalgae species was added with varying volume of effluent (2ml, 4ml, 6ml, 8ml, and 10ml) was made up to 10 ml with BBM Medium. The *Chlorella sp.*, & *Scenedesmus sp.*, shows the maximum growth on 5th day and the *Desmococcus sp.*, shows the maximum growth on 9th day in food coloring dye effluent containing urea, phosphate and nitrate. The growth of microalgae depends on the macronutrients like carbon, Nitrogen and Phosphorus (Larsdotter et al, 2006). The graph was plotted between the specific growth rate (day)$^{-1}$ and the varying volume of effluent as shown in table.

Table 1: Specific growth rate of *Chlorella sp.*, on food coloring dye effluent in Nitrate, Urea, Phosphate on 5th day

S.No	Effluent rate in ml	Specific growth rate of *Chlorella sp.*, on food coloring dye effluent		
		Nitrate on 5th day	Urea on 5th day	Phosphate on 5th day
1	Control(BBM)	**0.11**	**0.230**	**0.21**
2	2	**0.16**	**0.150**	**0.25**
3	4	**0.16**	**0.200**	**0.22**
4	6	**0.21**	**0.200**	**0.15**
5	8	**0.11**	**0.120**	**0.16**
6	10	**0.25**	**0.270**	**0.15**

Table 2: Specific growth rate of *Scenedesmus sp.*, on food coloring dye effluent in Nitrate, Urea, Phosphate on 5th day

S.No	Effluent rate in ml	Specific growth rate of *Scenedesmus sp.*, on food coloring dye effluent		
		Nitrate on 5th day	Urea on 5th day	Phosphate on 5th day
1	Control(BBM)	**0.088**	**0.21**	**0.24**
2	2	**0.039**	**0.1**	**0.21**
3	4	**0.073**	**0.16**	**0.13**
4	6	**0.1**	**0.073**	**0.2**
5	8	**0.16**	**0.18**	**0.1**
6	10	**0.17**	**0.24**	**0.26**

Table 3: Specific growth rate of *Desmococcus sp.,* on food coloring dye effluent in Nitrate, Urea, Phosphate on 9th day

S.No	Effluent rate in ml	Specific growth rate of *Desmococcus sp.,* on food coloring dye effluent		
		Nitrate on 9th day	Urea on 9th day	Phosphate on 9th day
1	Control(BBM)	**0.44**	**0.32**	**0.38**
2	2	**0.43**	**0.46**	**0.48**
3	4	**0.46**	**0.43**	**0.47**
4	6	**0.45**	**0.41**	**0.47**
5	8	**0.43**	**0.31**	**0.45**
6	10	**0.37**	**0.45**	**0.32**

3.6. Comparative study with the existing work: In previous work, the bio treated effluent was optimized as match industry effluent for the cultivation of *Desmococcus species.* It was compared with the growth of *Chlorella sp.,* and *Desmococcus sp.,* 1ml of seed inoculum of *Chlorella sp.,* was added with varyin6g volume of match industry effluent and it was made up to 10ml of CFTRI medium in a boiling tube. The specific growth rate was measured on a regular time interval (3rd, 5th, 7th, 9thday). Maximum growth of *Chlorella sp.,* and *Desmococcus sp.,* was compared and tabulated. The graph was plotted between the specific growth rate $(\text{day})^{-1}$ and varying effluent rate (ml).

Table 4: Specific growth rate of microalgal species in match industry effluent

Effluent rate in ml	Specific growth rate of microalgal species in match industry effluent					
	Initial count of *Chlorella species*	Count of *Chlorella species* on 5th day	Initial count of *Scenedesmus species*	Count of *Scenedesmus species* on 7th day	Initial count of *Desmococcus species*	Count of *Desmococcus species* on 9th day
Control (CFTRI)	17	0.239	14	0.127	2	0.611
2	17	0.316	14	0.111	2	0.444
4	17	0.208	14	0.188	2	0.369
6	17	0.232	14	0.093	2	0.423
8	17	0.232	14	0.17	2	0.515
10	17	0.239	14	0.127	2	0.512

• **CONCLUSION:** Three micro algal species (*Chlorella sp., Scenedesmus sp., Desmococcus sp.,*) was used as an agent for bioremediation of industrial wastewater. The bio treated effluent contains the biomass of *Desmococcus sp.*, 0.45g/lit. Level of Inorganic Nitrate and Phosphate reduced in the bio treated effluent was Nitrate-96.96% and phosphate-42.49%**.** The Optimized match industry effluent from existing work has compared with food coloring dye effluent to cultivate different microalgae species to obtain maximum growth.

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35.
Simultaneous Adsorption Of Multi Heavy Metal Ions From Municipal Solid Waste Leachate Using Fly Ash

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ABSTRACT

Investigations were carried out on simultaneous adsorption of multi heavy metal ions present in MSW leachate using lignite based coal fly ash. Municipal solid waste leachate samples were collected from Mayiladuthurai municipal solid waste open dumping site, Nagapattinam District, Tamil Nadu, India. Leachate samples were analyzed for its physic-chemical characteristics and for the presence of multi heavy metal ions Cu, Zn, Pb, Cr and Ni. The lignite based coal fly ash used for this study has been obtained from the Neyveli Lignite Corporation, a Public sector company located at a distance of 210km south of Chennai, the capital city of the state of Tamilnadu. Fly ash applicability for adsorption of multi heavy metal ions present in MSW leachate was studied using two Multicomponent adsorption isotherm models namely Extended Langmuir Isotherm model and Langmuir - Freundlich Isotherm model. Experimental equilibrium metal uptakes were compared with calculated values. The performances of the model were studied based on the coefficient of correlation.

Key words: Fly Ash, Municipal solid waste leachate, Extended Langmuir Isotherm model, Langmuir - Freundlich Isotherm model

INTRODUCTION

Urban solid waste includes house hold garbage and rubbish, street sweeping, construction and demolition debris, sanitation residues, trade and industrial refuse and bio-medical solid waste[1]. The waste generation is increasing day by day with rapid growth in population and urbanization and the situation becomes critical[2]. The per capita waste generation in the India is ranging between 0.2 to 0.7kg per day. With growth of urban population ranging between

3 to 3.5% per annum the annual increase in overall quantity of solid waste is assessed at about 5% and it translates to 260million tones per year by 2047[3].

About 90% of wastes are open dumped in landfills[1]. The major objectives of land filing is to remove from general circulation the materials that are no longer in use, and to make the waste not to cause any impact on environment and on human health. The present practice of open dumping of waste cause severe impact on all the environmental medias and on human health [4,5,6,7,8]. As the waste is disposed on earth's mantle without any precaution the handling, management and disposal of municipal solid waste (MSW) throw a formidable challenge specifically in all metropolitan cities[9].

As the time progresses the open dumped solid waste undergo aerobic decomposition during the initial stages and due to the absence of molecular oxygen anaerobic conditions gets initiated. During the latter stage of anaerobic decomposition based on the availability of substrate, waste reduction is achieved by formation of methane[10].

Due to liquefaction, precipitation and due to increased snowfall the open dumped waste leaches and the leachate infiltrates into soil beneath leading to contamination of ground water. Leachate contains dissolved, suspended and microbial contaminants from solid waste. Leaching occurs as a consequence of bio-chemical reactions taking place at the scale of the individual waste particles as well as of the contaminant transport processes via the fluid moving through the solid particles. The complex issue associated with the landfilling of the waste is its potential risk of leaching, particularly inorganic salts, heavy metals and toxic organic compounds[15]. Many researchers has approximated the quantity of leachate from uncovered or sparely vegetated MSW landfills between 15 to 60% of yearly rainfall[11,12,13,14]. The heavy metal concentration in preliminary phase of waste degradation may be higher and its presence in the leachate will vary widely [16,17,18]. The extent of impact depends on the rate at which leaching occurs[15]. The prevention of leachate migration in sanitary landfill will be achieved by natural or synthetic liner and a leachate collection system.

Fly ash is the inorganic pozzalonic residue obtained from lignite after its combustion in boilers. It mainly consists of silica, alumina, and calcium oxide. The lignite and sub bituminous coal on combustion produce class C fly ash, while anthracite and bituminous coal under similar process generate Class F fly ash. The sum of SiO_2, Al_2O_3 and Fe_2O_3 content in fly ash should be greater than 70% for class F fly ash whereas CaO content should be less than 5%. The class C fly ash are those fly ashes having less than 50% of SiO_2, Al_2O_3, Fe_2O_3 combined. CaO content varies from 20% to 30% for such fly ash. The lignite fly ash has predominantly quartz, anorthite, genlenite, hematite and mullite as major crystalline phases[19]. Table1 gives the characteristics of leachate used for the study. The typical characteristics of lignite fly ash are given Table 2.

Shaobin and Hongwei, (2006) [20] reported the technical feasibility of utilisation of fly ash as a low-cost adsorbent for various adsorption processes for removal of pollutants in air and water systems. Instead of using commercial activated carbon or zeolites, a lot of researchers have conducted the experiments using fly ash for adsorption of NO_x, SO_x, organic compounds, and mercury in air, and cations, anions, dyes and other organic matters in waters. It is recognised that fly ash is a promising adsorbent for removal of various pollutants. Chemical treatment of fly ash will make conversion of fly ash into a more efficient adsorbent for gas and water cleaning. Investigations also revealed that unburned carbon component in fly ash plays an important role in adsorption capacity[21].

In the present investigation an attempt has made to study the applicability of fly ash, for adsorption of multi heavy metal ions in leachate. The Multi component adsorption isotherm models namely Extended Langmuir isotherm model and Langmuir-Freundlich isotherm model were used for modeling the equilibrium data of multi heavy metal ions such as Cu, Zn, Pb, Cr and Ni in leachate by fly ash as adsorbent.

MATERIALS AND METHODS

The MSW leachate obtained from the open dump site was analyzed as per the procedure given in APHA 2005[23] at room temperature and characteristics of leachate is given in Table 1.. The collected fly ash C was oven dried at 105°C for a period of two hours**.** The oven dried adsorbent was under gone for the preliminary physicochemical analysis and tested for the presence of initial heavy metal concentration and the its characteristics has been given Table 2. The heavy metal analysis in MSW leachate was carried out using Atomic Absorption Spectrophotometer (AAS - Make Thermo fisher - Chemito, Model 201). 100 ml of MSW leachate stock solution was taken in 250ml conical flask along with 0.2gms of fly ash and kept in rotary shaker for a period of maximum of 4hours in order to reach equilibrium. The shaker is maintained at constant rpm of 60. For a periodic time interval of 0, 30, 60, 90, 120, 150, 180, 210 and 240minutes the samples were collected. The samples were centrifuged and the supernatant were tested in AAS and the absorbances were noted at respective wave lengths. The concentration of multi heavy metal ions is calculated from the absorbance using the calibration curve. The amount of metal ions adsorbed on to the fly ash is calculated using mass balance equation 1.

$$q_{eq} = \frac{V}{M}\left(C_i - C_{eq}\right) - - - -(1)$$

Where qeq (mg/g) = uptake of metal ions at equilibrium conditions. Ceq (mg/l) = Concentration of metal ions at equilibrium condition. V (l) = Volume of solution taken for analysis. M (g) = Mass of adsorbent used. Ci (mg/l) = Initial concentration metal ion in MSW leachate. The same procedure is repeated with varying fly ash dosage of 0.4, 0.6, 0.8, 1.0 and 1.2g. All the experiments and analysis were carried out at a room temperature of 30°C. The solution pH is maintained at 7 in all experiments.

The scanning electron microscopy (SEM) is widely used to study the formation and morphology of adsorbent. The major advantage of SEM is its ability to study the heterogeneity of materials to visualize various mineral components in their distinct growth forms and their relation in terms of overall micro fabric and texture. The SEM micro graph of the fly ash show spherical morphology of the fly ash particles. It is constituted by compact spheres of different sizes; on the sphere surface the existence of solid deposits or small crystals is also observed. The fly ash is mostly free on the surface. The SEM analysis was performed both before and after adsorption and the pictures were given in Figure 1 and Figure 2.

RESULTS AND DISCUSSION

Adsorption Isotherms

Adsorption Equilibria provides the fundamental physicochemical information to assess the applicability of the adsorption process. Moreover the Adsorption Equilibria is the essential to analysis and design of the adsorption process. It describes the phenomenon governing the mobility of a substance from the aquatic environments to a solid-phase under equilibrium condition at a constant temperature and pH[24,25,26].

Adsorption equilibrium is established when an adsorbate containing phase has been contacted with the adsorbent for sufficient time, with its adsorbate concentration in the bulk solution is in a dynamic balance with the interface concentration[24,27,28]. The mathematical correlation, which provides an important role towards the modeling, design and applicability of the adsorption systems, is usually described by graphically and expression of adsorbate concentration in the solid-phase against liquid phase[24,29].

` The nature of interaction between adsorbate and adsorbent at the time of equilibrium could be determined by the correlation of experimental data with equilibrium isotherms. Various single component isotherms like Langmuir, Freundlich, Dubinin-Radushkevich, Temkin, Toth, Redlich-Peterson, Sips, Khan and Hill models have been studied but unexpectedly no one would be a successful, due to the presence of multi heavy metals in the leachate used in this investigation. This unfit nature is the account of presence of other metal ions which may either interact with adsorbate of interest or compete for same binding sites of adsorbent. Due to these constraints, the amount of adsorbent adsorbed either increase, decrease or remain unaltered in the presence of other heavy metal ions. A number of alternates have been proposed to evaluate the multicomponent adsorption. In the present investigation two multi component adsorption isotherms namely Extended Langmuir isotherm, Langmuir-Freundlich isotherm has been used to assess adsorbate - adsorbent interactions and nature of adsorption[30]. Table 3 gives the equations and parameters of multicomponent isotherms investigated for the present study.

Extended Langmuir Isotherm

When two or more adsorbable components exist with the possibility of occupying the same adsorption sites, isotherm relationship become more complex. The simplest is the extension of Langmuir type isotherm by assuming no interaction between adsorbate[31]. During the adsorption of a component from the liquid solution containing n number of components, certainly one can increase, decrease or have no influence on the adsorption of other component, depending upon the interactions of the adsorbed molecules. Mohan and Chander, (2001)[32]; Aksu and Gilen, (2002)[33], Bhumica and Chandrajit, (2013)[34] reports the three effects of competitive adsorption. Presence of two or more than two components in aqueous systems may have three types of effects: synergism - that is the effect of the mixture is greater than that of each of the individual effects of the constituents in the mixture, antagonism - that is the effect of mixture is less than that of the each of the individual effects of the constituents in the mixture and non-interaction - that is the effect of the mixture is neither more nor less than that of each of the individual effects of the constituents in the mixture. Many models have been published in the literature to describe the equilibrium relationship between adsorbate and adsorbent for single component system but unfortunately very least for multicomponent system. One of the most important model is Extended Langmuir Adsorption model which has permitted the calculation of $q_{eq,i}$ the amount of adsorbate i adsorbed per unit weight of adsorbent in the presence of another adsorbing adsorbate. The simple theoretical treatments to the extension of the Langmuir equation by neglecting such an interactions and assumes that the only effect is the reduction of vacant surface area to the adsorption. The extended Langmuir isotherm model was applied to determine the adsorption of multi heavy metal ions in leachate onto the fly ash adsorbent.

The extended Langmuir isotherm model is shown in Table 3. The extended Langmuir parameters k_i and b_i can be obtained by using the fminsearch tool in Matlab10a Version. Table 4 shows the constants and parameters of Extended Langmuir isotherm for adsorption of Multi heavy metal ions in leachate by fly ash solid adsorbent. The coefficient of correlation for Extended Langmuir isotherm is found to be good. Figure 3 shows the plot q_{eq} experimental against q_{eq} by extended Langmuir isotherm. The coefficient correlation R^2 indicates that the experimental equilibrium uptake and calculated equilibrium uptake concur with one another. Hence the Extended-Langmuir Adsorption isotherm is found to be the best fit for adsorption of multi heavy metal ions in MSW leachate by lignite based coal fly ash. To evaluate the interaction effect of more than two adsorbents, the ratio of adsorption capacity of one adsorbate (q_{mix}) in the MSW leachate to that of same adsorbate when present alone (q_o) was calculated for the following conditions as reported by Mohan and Chander., (2001)[32] and Bhumica and Chandrajit.,(2013) [34] i.e., qmix/qo > 1, synergism; qmix/qo = 0, non-interaction and qmix/q0 < 1, antagonism.

For all the heavy metals, considered in this study, the value of qmix/qo is greater than zero indicating that the non-interaction between the adsorbent and adsorbate never occurred and a healthy competition between the metal ions present in the MSW leachate exists, due to the presence of more active sites. This is further confirmed by the values obtained for qmix/qo in which synergism is followed by antagonism. Table 5 shows the qmix/qo values for Extended Langmuir adsorption isotherm. It is also observed in Table 5 that the Nickel ion shows a higher synergism to adsorb on to the fly ash for all values of adsorbent dosage and it is followed by Chromium up to a dosage of 0.8 gms of fly ash. Up to a dosage of 0.2 gms of fly ash, Pb and Zn ions shows the synergism since qmix/q0 is greater than 1, later antagonism is observed for both metal ions. For Cu, synergism exists up to an adsorbent dosage of 0.4 gms of fly ash later it turns out to be antagonism.

Langmuir-Freundlich Isotherm

A combination of Langmuir and Freundlich isotherm models makes a new model called the Langmuir-Freundlich isotherms model. The Langmuir Freundlich isotherm model parameters Ki, bi and ni are obtained by using the fminsearch tool in Matlab10a Version. Table 6 shows the constants and parameters of Langmuir Freundlich adsorption isotherm. The coefficient of correlation obtained for the comparison of qeq experimental with qeq Langmuir Freundlich isotherm is found to be least for all heavy metal ions present in leachate. It indicates that Langmuir-Freundlich Adsorption isotherm model for competitive adsorption of metal ions has least significance since the R^2 values are less. Figure 4 shows the graphical representation for the plot of q_{eq} experimental with q_{eq} Langmuir - Freundlich isotherm.

Conclusions

The present study reveals that fly ash, the pozalonic material can be used for adsorption of multi heavy metal ions in MSW leachate. Among the two isotherms Extended Langmuir adsorption isotherm model shows a greater fit, rather than Langmuir-Freundlich Adsorption isotherm model, the coefficient of correlation R^2 found to be high for all the metal ions by Extended Langmuir adsorption isotherm model.

For all the heavy metals, considered in this study, the value of qmix/qo is greater than zero indicating that the non-interaction between the adsorbent and adsorbate never occurred and a healthy competition between the metal ions present in the MSW leachate exists, due to the presence of more active sites, this is further confirmed by the values obtained for qmix/qo in which synergism is followed by antagonism. Table 5 shows the qmix/qo values for Extended Langmuir adsorption isotherm. It is also observed in Table 5 that the Nickel ion shows a higher synergism to adsorb on to the fly ash for all values of adsorbent dosage and it is followed by Chromium up to a dosage of 0.8 gms of fly ash. Up to a dosage of 0.2 gms of fly ash, Pb and Zn ions shows the synergism since qmix/q0 is greater than 1, later antagonism is observed for both

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TABLE 1
Properties of MSW Leachate

Constituent in MSW Leachate	Concentration
pH	7.61
EC (mmhos/cm)	5.64
Chlorides	1640
Hardness	1040
Turbidity	47
Sulphate	295
Fe	27.96
Ammonia	50
Na	98
Ca	282
K	45
Phosphate	14
COD	3920
Acidity	70
BOD	1224
Cu	1.22
Zn	2.86
Pb	2.62
Cr	1.5
Ni	0.65
Cd	BDL

All values are in mg/l except pH and EC

TABLE 2

Characteristics of Fly ash used for this study

Sl.no	Parameter	Percentage
1.	Silica as SiO_2	62.6
2.	Iron as Fe_2O_3	4.04
3.	Alumina as Al_2O_3	24.41
4.	Calcium as CaO	0.35
5.	Magnesium as MgO	0.54
6.	Sulphate as SO_3	0.85
7.	Loss on Ignition	1.27
8.	pH	8.12

9.	EC	0.44
10.	TDS (mg/l)	286
11.	Chlorides (mg/l)	24
12.	Hardness (mg/l)	2250
13.	Ca (mg/l)	198.50
14.	Na (mg/l)	41.55
15.	K (mg/l)	6.15
16	SO_4 (mg/l)	108
17.	p (mg/l)	0.0
18.	Fe (mg/l)	BDL
19.	Cd (mg/l)	0.04
20.	Cu (mg/l)	0.03
21.	Zn (mg/l)	BDL
22	Pb (mg/l)	0.03

TABLE 3

Equations and parameters of Multicomponent isotherm

Model	Equation	Parameters
Extended-Langmuir Isotherm Model[25, 25a 25b 25c 25d]	$q_{eq,i} = \frac{k_i\, C_{eq,i}}{1+\sum_{i=1}^{n} b_i C_{eq,i}} --(1)$	k and b
Langmuir-Freundlich Isotherm[26,27]	$q_{eq,i} = \frac{k_i\, C_{eq,i}^{n,i}}{1+\sum_{i=1}^{n} b_i\, C_{eq,i}^{n,i}} --(2)$	k, b and n

TABLE 4

Extended Langmuir Adsorption isotherm for adsorption of Multi heavy metals in leachate by fly ash

Heavy Metal	Extended Langmuir Adsorption Isotherm Parameters and Constants		
	K	b	R^2
Cu	0.4479	0.400	0.899
Zn	0.135	0.421	0.902
Pb	0.144	2.312	0.857
Cr	0.207	2.065	0.923
Ni	0.582	0.358	0.897

TABLE 5

Calculated values of q_{mix}/q_o for Extended Langmuir Adsorption Model

Adsorbent dosage	Cu q_{mix}/q_o	Zn q_{mix}/q_o	Pb q_{mix}/q_o	Cr q_{mix}/q_o	Ni q_{mix}/q_o
0.2	8.684	1.001	7.101	18.25	8.593
0.4	1.495	0.181	1.001	2.77	1.777
0.6	0.945	0.124	0.597	1.70	1.360
0.8	0.468	0.080	0.305	1.00	1.085
1.0	0.265	0.032	0.175	0.65	0.997
1.2	0.150	0.038	0.086	0.37	1.169

TABLE 6

Langmuir-Freundlich Adsorption isotherm for adsorption of Multi heavy metals in leachate by fly ash

Heavy Metal	Langmuir-Freundlich Adsorption Isotherm Parameters and Constants			
	K	b	n	R^2
Cu	1.374	3.053	0.236	0.806
Zn	6.228	2.468	0.536	0.064
Pb	2.855	3.631	1.124	0.776
Cr	1.035	2.171	0.399	0.805
Ni	1.433	1.419	0.551	0.548

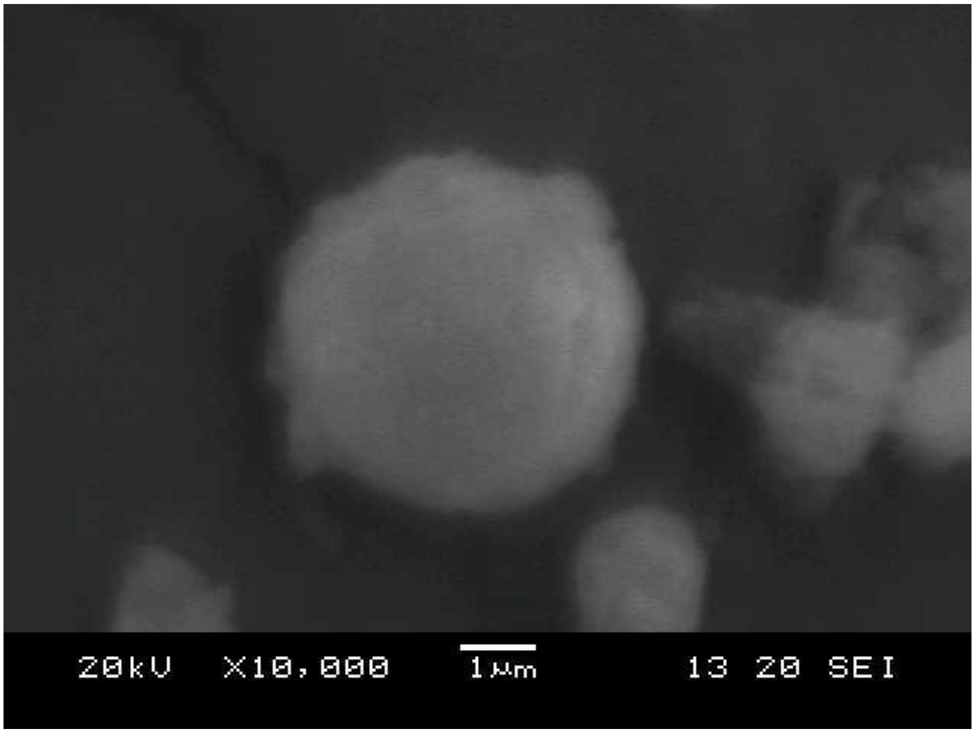

Figure 1**SEM image of Individual fly ash before adsorption**

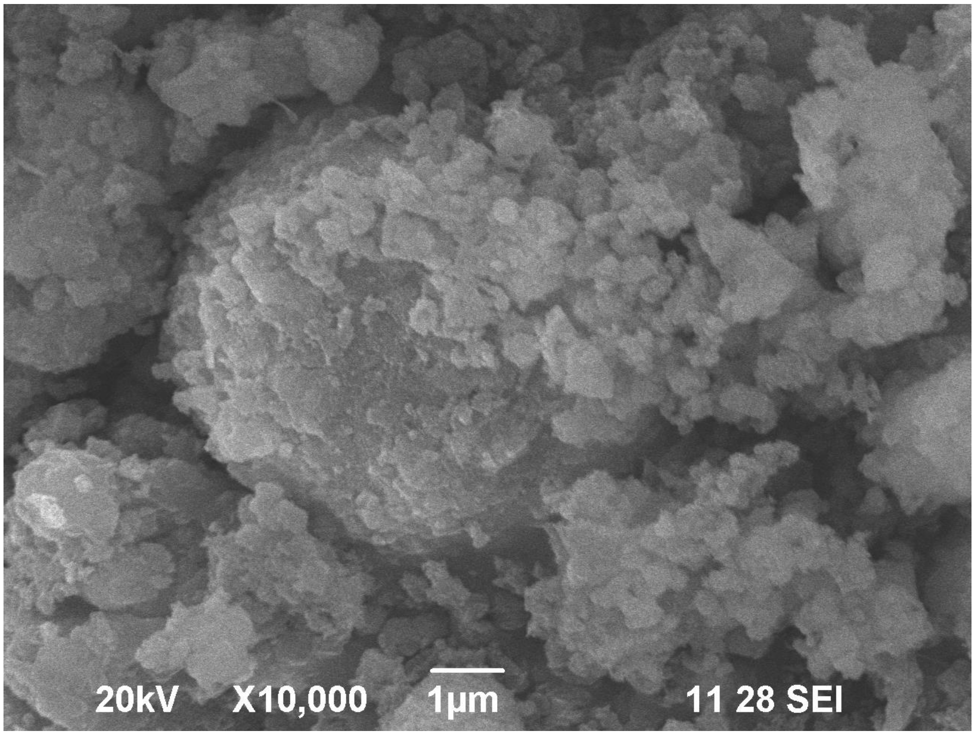

Figure 2 **SEM image of fly ash after adsorption**

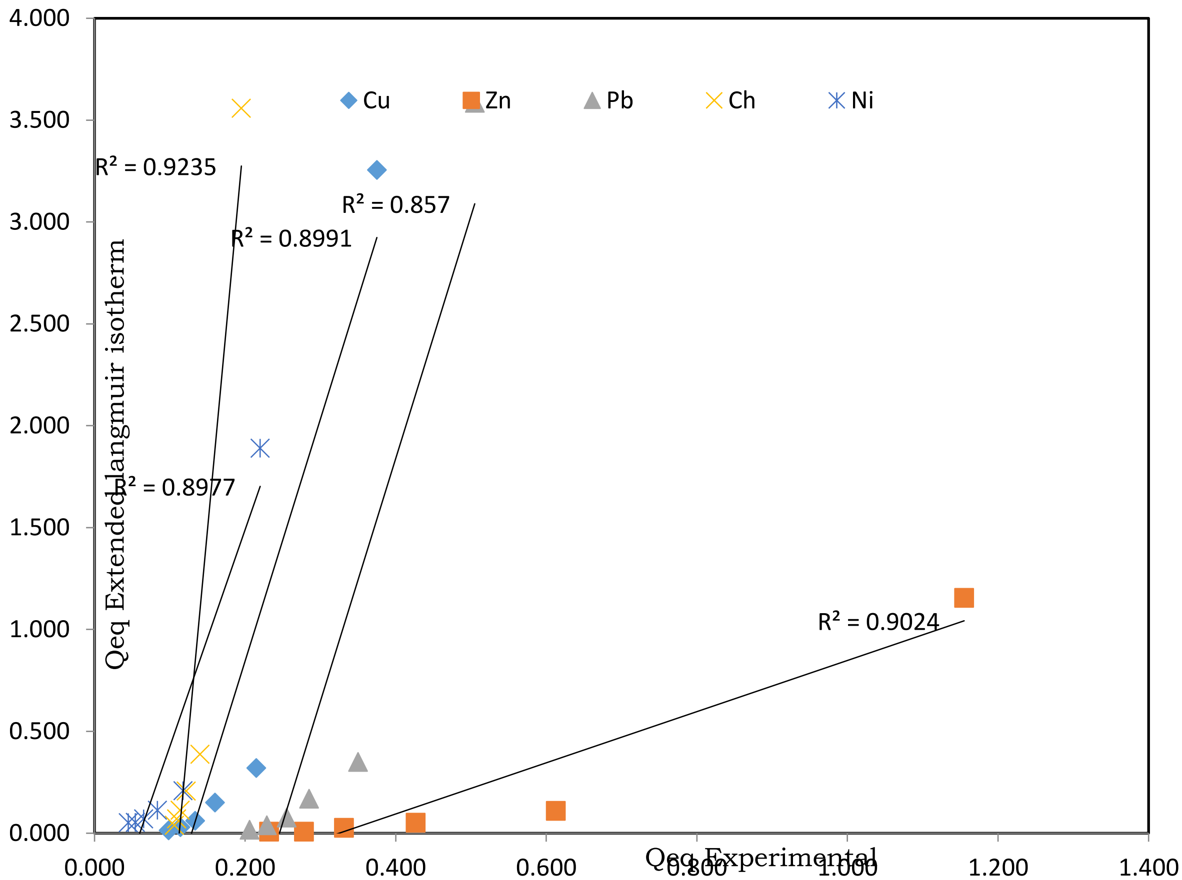

Figure 3 **Extended Langmuir Adsorption isotherm for adsorption of Multi heavy metals in leachate by fly ash**

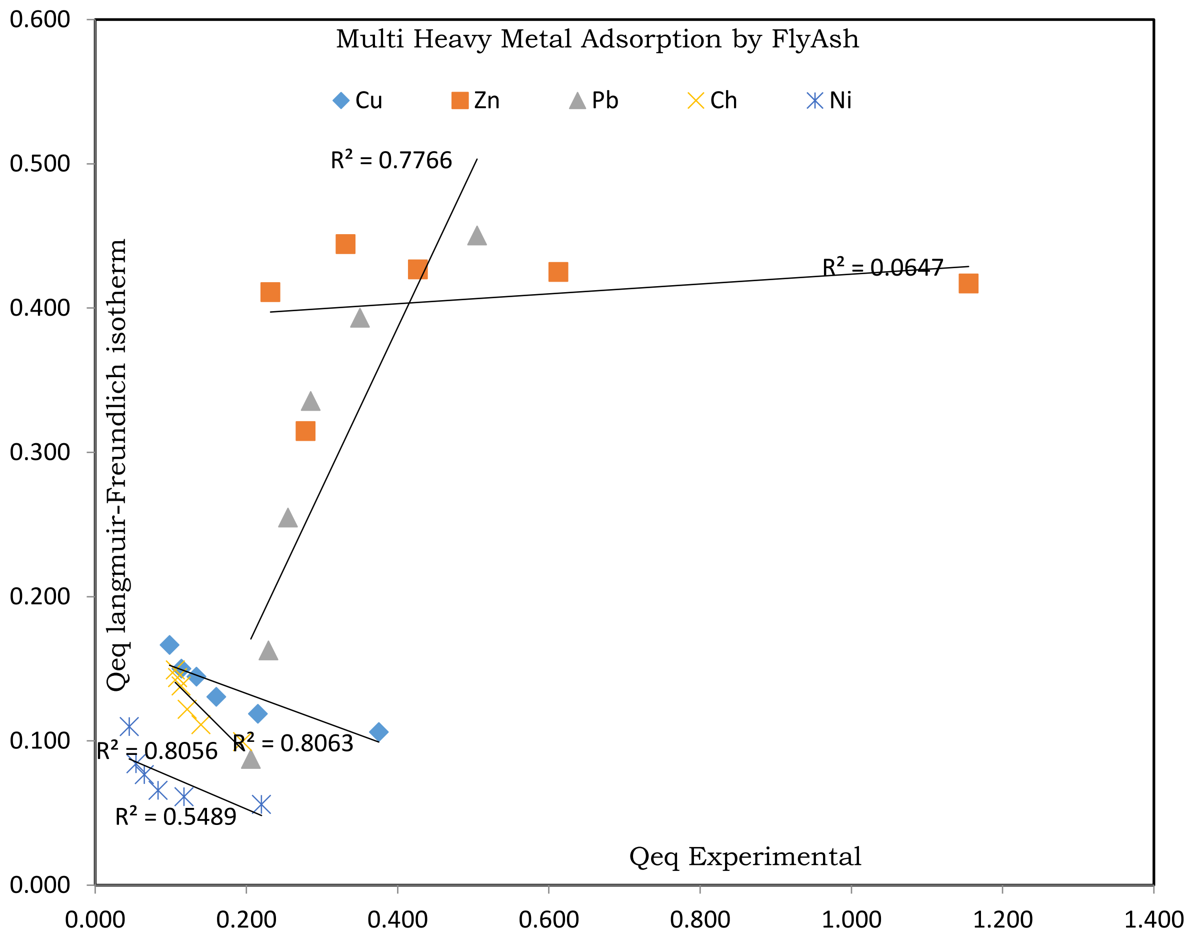

Figure 4 **Langmuir-Freundlich Adsorption isotherm for adsorption of Multi heavy metals in leachate by fly ash**

36.

Studies On Decolorisation Of Textile Dye By *Aspergillus Sp.,*

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ABSTRACT

Consequent to the invention of synthetic dyes, several forms of dyes are being widely used in textile and dyestuff industries. A dye or dyestuff is usually a colored organic compound or mixture that may be used for imparting color to a substrate such as cloth, paper, plastic or leather in a reasonably permanent fashion. The present study deals with the decolorization of textile dyes by aspergillus sp. Paper yellow dye was used for degradation studies. The degradation of dyes in limited condition of nitrogen, phosphate and sucrose were studied. Other parameters such as pH and biomass for degradation of the dye were carried out. Dye was decolorized by Aspergillus sp., upto 93% within 5 days of incubation and maximum growth was observed. Decolonization was found to be highest when the pH was adjusted to 10 and the biomass was also high.

KEY WORDS: Dye Decolorization, Yellow Dye, Aspergillus sp., Optimization

INTRODUCTION:

Dyes are released into the environment in industrial effluents from two major sources, the textile and the dye stuff industries. A necessary criterion for the use of these is that they must be highly stable in light and during washing. They must also be resistant to microbial attack. There is a limited study on microbial degradation of azo and reactive dyes. Therefore, they are not readily degradable and are typically not removed from water by conventional waste water treatment systems. Maximum number of dyes undergoes degradation through reduction.Degradation of black liquor pulp mill effluents by the strains of *Pseudomonas putida*. Some anaerobic bacteria, *Streptomyces* and fungi (eg, *Phanerochaete chrysosporangium*) have been characterized for decolorization of chromogenic dyes. Enzymes involved in dye degradation are lignases (lignin peroxidase). These enzymes are well associated with lignin degrading system. Based on the chemical structure of chromophoric group, synthetic dyes are classified as azo dyes, anthraquinone dyes, and triaryl methane dyes etc. azo dyes are the largest class of dyes with the greatest variety of colours. Azo dyes are not typically degraded under aerobic conditions, the azo linkage can be reduced to form aromatic amines which are colorless but which can be toxic and carcinogenic. Azo dye compounds are linked to bladder cancer in human and to hepatocarcinoma and nuclear anomalies in the intestinal epithelial cells in mice. Thus, a number of azo dyes have been classified as carcinogenic (Hartman et al., 1978). The ability of intestinal microflora of human and other animal species to reduce the azo groups of xenobiotic compounds has been known for many years. However, the specific organisms of the intestinal microflora participating in azo dye reduction are poorly understood (Brown, 1981). When azo dyes enter the body through ingestion, they are metabolized to aromatic amines by intestinal microorganisms. Reductive enzymes in the reductive cleavage of the azo linkage to produce aromatic amines. The intestinal azo reductase may be more important than the liver enzymes in azo reduction. The first catabolic step in the reduction of azo dyes, which is accompanied by a decrease in the visible light absorbance of the dye and the decolorization of the dye, is the reduction of azo bridge to produce aromatic amines. Aromatic amines, which are known human carcinogens, have been found in the urine of dye stuff workers and test animals following the administration of azo dyes. The present study deals with the decolorization of textile dyes by aspergillus sp. Paper yellow dye was used for degradation studies. The degradation of dyes in limited condition of nitrogen, phosphate and sucrose were studied. Other parameters such as pH and biomass for degradation of the dye were carried out.

MATERIALS AND METHODS:

Effluent soil sample was collected from **HANUMAN DYEING UNIT, ERODE** and used for isolation of fungi and its decolorization studies. The effluent soil sample was collected in the sterile container and stored in the ice box till it was transported to the laboratory.

ENUMERATION OF MICROBIAL POPULATION IN THE EFFLUENT SOIL:

The microbial population present in the effluent soil sample was enumerated by serially diluting the effluent soil in a sterile saline. For the enumeration of bacterial population, nutrient agar medium was used; for the enumeration of actinomycetes, starch casein agar medium was used and for the enumeration of fungi, potato Dextrose agar medium was used.

ISOLATION OF COLOR DEGRADING FUNGI:

For the isolation of color degrading fungi, the effluent soil was serially diluted and plated on a Czapek Dox agar medium containing 10 mg / 100 ml of dye (paper yellow). The plates were incubated at 30°C for five days. Fungal colonies which were able to decolorize the dye was selected and purified.

ABSORPTION MAXIMA OF THE DYE:

The dye obtained was in powder form and it was soluble in water. The absorption maxima for the dye were found out using spectrophotometer.

MICROSCOPICAL EXAMINATION:

A small block of PDA was placed on a glass slide. Then the culture was inoculated on the agar surface and a cover slip was placed over it. Slides were kept for incubation at 30°C for 10 hours. After incubation, the cover slip was placed on the slide with lacto phenol cotton blue staining solution and observed under microscope.

DECOLORIZATION EXPERIMENT

Czapek Dox broth of about 100 ml was prepared with 10 mg of the dye. After sterilization, the fungal mycelial was added to the broth and kept for incubation at 30°C for five days. The decolorization process was monitored about 11 days. The biomass produced and the percentage color removed was determined on alternative days. The color removal percentage was then computed as follows

$$\textbf{Color removal percentage} = (C_1 - C_2) / C_1 * 100$$

Where, C_1 is the initial color unit, C_2 is the color unit of the fungal treatment.

EFFECT OF pH ON DECOLORISATION:

In order to examine the effect of pH on decolorization of the dye, broth was adjusted with different pH levels 6, 7, 8, 9 and 10. the percentage of color removal and biomass produced was recorded after five days incubation. Select the pH at which maximum decolorization taken place.

EFFECT OF SUCROSE CONCENTRATION ON DECOLORISATION:

To study the effect of sucrose concentration on decolorization, various concentration of sucrose (1, 2, 3 g / 100 ml and without sucrose) were tested. Results were recorded after five days incubation.

EFFECT OF NITROGEN SOURCE ON DECOLORISATION:

To study the effect of nitrogen source on decolorization process, various concentration of nitrogen (0.003 g / 100 ml; 0.3 g / 100 ml) were tested. Various nitrogen sources such as urea (0.023 g / ml), ammonium nitrate (0.017 g / 100 ml) and ammonium chloride (0.013 g / 10 ml) were also tested. Results were recorded after five days incubation.

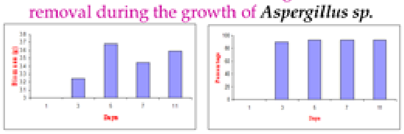
EFFECT OF PHOSPHATE SOURCE ON DECOLORISATION:

To study the effect of phosphate source on decolorization process, various phosphate concentrations (0.025 g / 100 ml; 0.05 g / 100 ml; 0.1 g / 100 ml; 0.125 g / 100 ml; 0.15 g / 100 ml) were tested. Results were recorded after five days incubation.

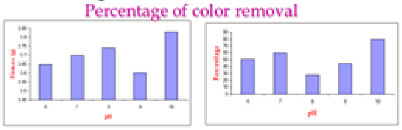
RESULT AND DISCUSSION:

Aspergillus sp., was isolated from effluent soil. The textile dye, paper yellow was found to be degraded by aspergillus species. Dye was decolorized by aspergillus sp., upto 93% within 5 days of incubation and maximum growth was observed.

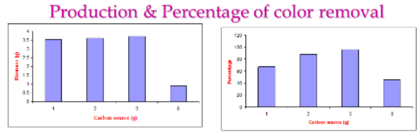
Biomass Production & Percentage of color removal during the growth of ***Aspergillus sp.***



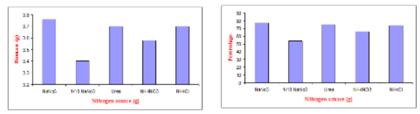
Effect of **pH** on the Biomass Production & Percentage of color removal



Effect of **CARBON SOURCE** on the Biomass Production & Percentage of color removal



Effect of **NITROGEN SOURCE** on the Biomass Production & Percentage of color removal



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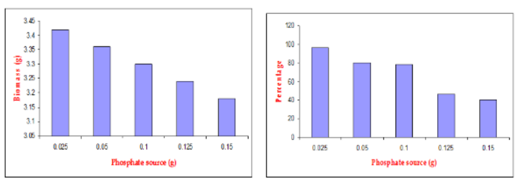
Effect of **PHOSPHATE SOURCE** on the Biomass Production & Percentage of color removal



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Decolorization was found to be highest when the pH was adjusted to 10 and the biomass was also high. CD broth was supplemented with various concentrations of sucrose and without sucrose. Dye was decolorized upto 96% with sucrose and without sucrose decolorization was only 45%. Biomass produced was more in high sucrose concentrations.

Dye was added to CD broth with 1 / 10 th of nitrogen and various nitrogen source. In nitrogen limited conditions dye was decolorized upto 54% to the normal condition was 77%. Urea decolorizes the dye upto 75%. Biomass produced depends upon the percentage of decolorization. Various concentrations of phosphate source shows dye decolorization upto 95% in case of limited phosphate source. When the phosphate source increased beyond the normal condition the decolorization declines and the biomass produced was vice versa.

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37.
Study of Polluted River Stretches of Bhima River and Treatment of Waste Water for Irrigation

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ABSTRACT

Water is essential for sustenance of life and needs to be preserved and protected from all type of pollutant. The human body and other living organisms require it, but in its pure form apart from any type of contamination. But, the natural water system is being polluted by the addition of industrial wastes, urban wastes, pesticides and related pollutants. In India, water law is made of different components. It includes international treaties, federal and state acts. It also includes a number of less formal arrangements, including water and water-related policies as well as customary rules and regulations. This paper presents a comprehensive study on domestic pollution for the assessment of polluted river stretches of Bhima river. In the polluted stretches of Indrayani, Pawana, Mula-Mutha and Bhima, there are two major cities of Pune and Pimpri Chinchwad having total population of 60 lakh people. Apart from Pune and Pimpri-Chinchwad, other cities like Alandi, Dehu, Pune cantonment and Khadki cantonment didn't have any treatment facility for treatment of sewage water. Similarly, all the small towns and villages have not provided any collection and treatment system and its absence leads to river pollution. The study suggests the treated waste water of 53 million litres per day could be used for irrigation purposes as it has no industrial contamination.

Keywords

Bhima river, Domestic pollution, Irrigation, Sewage treatment, Waste water

INTRODUCTION

Water is essential for sustenance of life and needs to be preserved and protected from all type of pollutant. The human body and other living organisms require it, but in its pure form apart from any type of contamination. But, the natural water system is being polluted by the addition of industrial wastes, urban wastes, pesticides and related pollutants. In India, water law is made of different components. It includes international treaties, federal and state acts. It also includes a number of less formal arrangements, including water and water-related policies as well as customary rules and regulations. Pollutants of water come in many forms (Pathak, 2013), including:

i) Deoxygenating materials – For example, sewage and other organic wastes, such as silage, farm wastes from a number of heavily polluting industrial processes (e.g. food processing and the production of smokeless fuel, textiles , paper and dairy products).
ii) Nutrient enrichment by such things as fertilizers, which may give rise to eutrophication, causing an accelerated growth of plants and algae and leading to a decline in water quality.
iii) Solids, which may impede flows or block out light for growth.
iv) Toxic materials - heavy metals, pesticides or nitrate are toxic to humans, animals, plants, or all three, often depending on the level of the dose received.

v) Materials which cause an impact on amenity, such as car tyres or shopping trolleys, or old boots in canals.
vi) Disease – carrying agents such as bacteria.
vii) Heat, which may affect biological conditions and also deoxygenates water.

The effect of any potential pollutant will vary according to the size, temperature, rate of flow and oxygen content of the receiving waters, as well as the local geology and the presence of other pollutants and any resulting synergistic effects. The use made of a stream is also a enormous importance in deciding whether it can be said to be polluted, and third factor has a large impact on the attitude of the regulatory bodies towards the setting of standards and their enforcement. It is not sufficient to look only at pollution of surface waters, since 30 percent of public water supply is taken from ground waters. As a result the control of water pollution encompasses the control of liquid discharges to land.

The study on domestic pollution includes (i) identification of major outfall points with their locations; (ii) quality and quantity of municipal waste water discharging in a water body; (iii) identification of extend of pollution control needed in view of critical flow condition and comparing with desired quality criteria; and (iv) utilization of waste water and volume of waste water used for agriculture (Angelakis and Snyder, 2015). The paper details a study on polluted river stretches of Bhima river due to domestic pollution and the adoption of treatment of waste water for irrigation use.

Bhima River

The Bhima river originates near Bhimashankar temple in the Bhimashankar hills in Khed Taluka on the western side of the Western Ghats, known as Sahyadri, in Pune District. The latitude and longitude of Bhima river basin is 19° 04′ 03″ N and 73° 33′ 00″ E respectively. Bhima flows southeast for a long journey of 861 km^2, with many smaller rivers joining it as tributaries. It flows through Bhimashankar Wildlife Sanctuary where it enters Khed Taluka and is soon joined by its tributary, the Aria river from the right (west) which flows into the Chas Kaman reservoir. The Chas Kaman reservoir is impounded by the Chas Kaman Dam, the most upstream dam on the Bhima river. Some 5 km along the river below the bridge on the Bhima at Chas, the Kumandala river enters from the right. From there, it is 8 km along the river to the railroad bridge at the town of Rajgurunagar on the left bank. In 18 km further along the river, the Bhima River enters from the right just above the village of Pimpalgaon on the left bank. After leaving Khed Taluka, the Bhima forms the boundary between Haveli Taluka on the right (south) and Shirur Taluka on the left (north).

The Bhima river, the Indrayani river and the Mula-Mutha river are the major tributaries of the Bhima that drain western Pune. After the Indrayani, in about 4 km downstream the Dhomal river enters from the right, at the village of Wadhu Budruk. Shortly, thereafter (3.5 km) the Bhima passes under the SH 60 bridge at the town of Koregaon Bhima. From Koregaon going east, downstream 16 km, is the confluence with the Vel River from the left (north) and the village of Vittalwadi. The Vel River also arises in Ambegaon Taluka, east of the Bhima, and flows through Khed Taluka and into Shirur Taluka before flowing into the Bhima. With Vittalwadi on the left, the right side of the river leaves Haveli Taluka and enters Daund Taluka. From Vittalwadi the Bhima meanders northwest and 14 km after the Vel River enters from the left, the Kamania River enters from the left at the village of Parodi. After the Kamania River enters, the river meanders back southeast for 23 km to the confluence with the Mula-Mutha River from the right at the village of Ranjangaon Sandas. From This point onwards it is known as Bhima river. Figure 1 presents the location map of the Bhima river and Figure 2 represents the river flow path of Bhima river at Koregaon site.

Figure 1: Location Map of Bhima River

Figure 2: Bhima at Koregaon

Domestic Pollution

Since Bhima basin is a fertile region it is populated from Lonavla to Pargaon (study area). There are numerous small towns with a population of less than 1000 people to big municipal corporations of Pimpri Chinchwad and Pune with a total population of 6 million people. As there is plenty of water available, these cities generate sewage and in the absence of proper collection and treatment, domestic effluent is discharged into the river with treated/partially treated/untreated leading to the river pollution (Paranychianakis et al., 2015). In the major cities of Pune and Pimpri Chinchwad only 60 to 70 percent of the collected sewage is treated whereas in remaining towns sewage is discharged to river without any treatment. This is indicated by the sample analysis at various locations in all the rivers. This also indicates that to make river clean, it is necessary to properly collect, treat and dispose of domestic sewage (Asano et al., 2007).

In the polluted stretches of Indrayani, Pawana, Mula, Mutha, Mula-Mutha and Bhima there are two major cities of Pune and Pimpri Chinchwad having total population of 60 lakh people. Apart from Pune and Pimpri-Chinchwad, other cities like Alandi, Dehu, Pune cantonment and Khadki cantonment didn’t have any treatment facility for treatment of sewage water. Similarly, all the small towns and villages have not provided any collection and treatment system and in its absence leads to river pollution.

Identification of Major Outfall Points and its Locations

The locations of major outfall points and its locations in Bhima river along with discharge and treatment plant capacity are presented in Table 1. Maharashtra Industrial Development Corporation (MIDC) has constructed a 4 MLD (Million Litres per Day) capacity Common Effluent Treatment Plant (CETP) at Talegaon. At present this plant receives 1 MLD capacity of industrial waste and domestic sewage which is treated and used in high rate transparency system. In addition, various industries in Talegaon MIDC have constructed their own Industrial as well as Domestic waste water treatment plants. Treated water is used in the campus of the factory for gardening.

Hinjewadi MIDC is developed for Information and Technology (IT) industry. Here, in Phase 1, domestic sewage generation is 2.5 MLD which is treated in MIDC’s treatment plant having capacity of 0.8 MLD. The capacity of this plant is being increased to 4 MLD which will be complete shortly. Various industries in MIDC's in Chakan, Pimpri-Chinchwad, Bhosari etc. have constructed their own treatment plants for Industrial as well as domestic sewage. After treatment treated water is used for gardening within the campus of each industry.

Table 1. Identification of Major Outfall Points and its Locations

Sl. No.	Location	Discharge (MLD)	Treatment plant capacity (MLD)
1	Lonavla	12.3	3.7
2	Talegaon	7.0	0
3	Dehu	0.3	0
4	Dehu cantonment board	8.2	0
5	Alandi	2.4	0
6	Junnar	2 .0	0
7	Shirur	4.2	0
8	Pimpri Chinchwad Municipal Corporation (Kiwale, Walvhekar wadi, Gokhale park, Thergaon, Gawade colony, Link road, Bhat nagar, Nashik phata, Sandvik, Sangvi gaon, Delux nalla)	255	207
9	Pune Municipal Corporation (Hinjewadi, Bopodi, Balewadi, Pashan, Baner, Malwadi- Warje, Vadgaon (B), Vadgaon (D), Manik, Vithhalwadi, Erandwana, Kothrud, Nagzari, Ambil odha, Tanaji wadi, Bhairoba, Mundhwa-1, Mundhwa-2, Nagar Road, Wadgaon (S), Mental Hospital, Kalas)	744	612
10	Khadki cantonment Board (Range hill nalla, Nalla near K.N. Bajaji Udyan, Pachwada Nalla, Sapras Nalla, Rajiv Gandhi Vasahat, Khadki Bazaar Nalla, Gavaliwada Nalla)	6.0	9.2
11	MIDC Areas		
	Talegaon	1.6	4.0
	Chakan	4.8	4.8
	Talawade	1.6	1.6
	Bhosari (Pimpri-Chinchwad)	80	80
	Hinjewadi	2.5	0.8

Various industries which are located outside MIDC area have constructed their own industrial effluent and Sewage treatment plants and treated water is used within the campus of the industry for gardening. For some major industries, Maharashtra Pollution Control Board (MPCB) has given permission to treat the effluent as per specified standards and then discharge the treated effluent into the nearest water course. MPCB regularly monitors the quality of river water by analysing the samples were treated effluent is discharged as per consent.

Apart from these major cities there are about 23 small towns having total population of 57722 people generating sewage flow of 28133 m^3/day.

Quality and Quantity of Municipal Waste Water Discharging in a Water Body

The raw sewage quality of various nallah of the Bhima river basin is presented in Table 2. The details of water consumption and sewage generation along with population in two Mahanagar Palikas, five cities, three cantonments (Dehu, Khadki and Pune) and Villages on the bank of the river are presented in Table 3.

Table 2. Raw Sewage Quality of Various Nallah

Corporation/ Municipality	Name of nallah	pH	DO	BOD	COD	SS	SO_4	Cl	NO_3	Hardness
Pune Municipal Corporation	Tanajiwadi	8.2	1.52	45.7	132	36	25.3	-	0.192	140
	Ambilodha	8.2	2.11	21.6	60	45	26.8	44	0.281	104
	Yerawada	8.2	2.35	20.4	60	28	26.2	66	0.281	110
	Mhatre Pool	8.0	0.0	48.9	140	28	35.1	60	0.508	100
	Vithhalwadi	8.1	3.32	16.7	48	55	19.8	66	0.216	156
	Varje Malwadi	8.2	2.62	13.9	40	32	19.0	88	0.181	158
	Bhairoba	8.1	1.06	57.5	164	85	37.9	84	0.298	150
Pimpri Chinchwad Municipal Corporation	Kiwale	7.9	4.28	8.5	28	16	63.1	90	0.862	296
	Valhekar	7.8	2.78	37.5	108	22	31.0	84	0.926	146
	Gokhale Park	7.6	0.00	43.5	124	25	72.1	105	0.728	148
	Thergaon	7.6	0.66	56.0	160	24	69.5	90	1.280	180
	Garware colony	7.7	3.20	18.5	52	17	35.1	76	0.668	140
	Link Road	7.7	3.10	16.3	48	18	64.7	90	0.572	180
	Garware Nalla	7.7	3.98	13.8	40	16	75.7	84	0.602	210
	Nullah	7.7	3.26	16.7	48	24	146.4	110	0.772	200
	Bhairoba	7.6	0.79	52.8	148	164	73.2	112	1.420	244
	Nashik Phata	7.5	3.35	15.5	44	27	13.9	64	0.446	140
	Sandvik	7.2	1.86	48.3	140	40	29.7	96	1.280	152
	Sangvi gaon	7.6	1.24	41.9	120	23	53.5	84	1.120	160
Talegaon	Katvi	7.6	2.50	29.5	128	16	108.6	46	0.110	-
Dehu Cantonment	Shelarwadi	7.8	0.00	35.0	100	22	41.2	66	0.194	-
	Kiwale	7.6	0.00	75.0	208	20	28.0	126	0.149	-
	Kinhe	7.8	0.00	60.0	172	26	58.6	118	0.268	-
Pune Cantonment	Morwade	7.6	4.79	4.2	12	30	16.2	50	0.102	90
	Manik	6.6	0.0	25.3	72	44	19.8	45	0.158	130
	Bhairoba	6.7	0.0	36.2	104	68	50.0	72	0.279	164
Khadki Cantonment	Civil area Ammi-nuation factory	7.1	0.0	23.7	68	116	44.6	7	0.337	344
	STP civil area	6.9	0.0	22.9	64	82	35.3	47.5	0.229	124
	G.E. Office	6.9	0.0	46.5	132	96	27.7	62.5	0.332	204
	Bajaj Park	7.2	0.0	20.9	60	34	56.7	52.5	0.253	236
	C.B. office	7.7	4.0	9.8	28	24	148.7	0.393	340	64
	Saiprus	7.4	0.9	14.2	40	30	28.2	32.5	0.192	116
	Hindu crematorium	7.0	0.0	67.0	204	106	38.3	156	0.356	240

	Rajiv Gandhi colony	6.9	0.0	186.0	568	76	37.8	168	0.65	260
	Gadi adda	7.4	0.0	55.8	168	114	92.1	112	0.296	264
	Gawli wada	7.3	0.0	127	388	266	44.4	145	1.164	234
DO: Dissolved Oxygen; BOD: Biochemical Oxygen Demand; COD: Chemical Oxygen Demand; SS: Suspended Solids; SO_4: Sulphate; Cl: Chloride; NO_3:Nitrate										

From Table 3, it is noted that the total water supply for domestic purpose is 1519.72 MLD and 1074.48 MLD of sewage is generated in the Bhima river basin. Out of this sewage, 713.69 MLD of sewage is treated by providing primary, secondary and in some cases, tertiary treatment and then used for gardening to the maximum extent and remaining treated water is discharged into the river. With this analysis it is seen that 364.79 MLD (33.9%) of sewage is still discharged into the river untreated. Of the 364.79 MLD untreated waste water discharged into the Bhima river or its tributaries 247 MLD is from Pune city (67.8 %) and 48 MLD from Pimpri Chinchwad area (13.2%), 27.19 MLD from 5 Municipalities (7.5%), 28.8 MLD from various Cantonment boards (7.9%) and 13.8 MLD from various villages on the bank of rivers (3.8%).

Table 3. Details of Water Consumption and Sewage Generation along with Population

Sl. No.	Name of City/ Town	Population	Water Supplied (MLD)	Sewage Generated (MLD)	STP Capacity (MLD)	Quantity of Sewage untreated (MLD)
Mahanagar palikas						
1	Pimpri Chinchwad	20,00,000	360	255	207	48
2	Pune	40,00,000	1,050	744	497	247
	Sub-total	60,00,000	1,410	999	704	295
Cities						
1	Lonavla	49,865	21.8	16.00	3.69	12.31
2	Talegaon	56,025	9.0	6.72	0	6.72
3	Alandi	40,000	4.0	2.40	0	2.40
4	Junnar	24,741	2.2	1.76	0	1.76
5	Shirur	40,000	5.0	4.00	0	4.00
	Sub-total	2,10,631	42.0	30.88	3.69	27.19
Cantonments						
A	Dehu					
1	Civilian residence	46,921	9.0	8.2	0	8.2
2	Army	14,000	1.9	1.5	0	1.5
B	Khadki					
1	Civilian residence	77,473	11.3	6.0	6.0	0
2	Army	16,026	2.9	1.6	0	1.6
C	Pune					
1	Civilian residence	79,865	12.8	8.0	0	8.0
2	Army	70,000	10.0	9.5	0	9.5

Sub-total		3,04,285	47.9	34.8	6.0	28.8
Villages on the bank of river						
1	Haveli (35 villages)	1,70,070	6.80	4.70	0	4.70
2	Indapur (19 villages)	24,897	0.99	0.70	0	0.70
3	Shirur (11 villages)	26,753	1.07	0.74	0	0.74
4	Mawal (63 villages)	1,31,259	5.25	3.67	0	3.67
5	Khed (35 villages)	1,42,783	5.71	3.99	0	3.99
Total for 163 villages		4,95,762	19.82	13.80	0	13.80
Grand total		70,10,678	1519.72	1078.48	713.69	364.79

Water Quality

Table 4 presents the details of water quality of river Bhima near Koregaon Bridge for the period of twelve months from January to December. From Table 4, it is noted that the Dissolved Oxygen (DO) of Bhima river vary from 2.38 to 7.05 mg/l. Also, from Table 4, it is noted that the BOD vary from about 4.8 to 12.8 mg/l and faecal coliforms organisms vary from 65 to 275 per 100 ml. This water can be used for drinking purpose with proper treatment followed by disinfection (Escher and Leusch, 2012; WMO, 2004).

Table 4. Water Quality of Bhima River near Koregaon Bridge

Month	pH	Dissolved Oxygen	BOD	COD	Nitrates	Faecal Organisms
January	8.54	3.50	8.5	20	1.7	65
February	8.22	4.80	7.5	20	1.3	225
March	7.90	4.60	9.2	28	2.4	250
April	8.59	5.20	6.8	20	3.7	110
May	8.23	5.10	7.4	24	6.5	225
June	8.52	2.38	12.8	36	0.4	250
July	8.59	5.29	6.0	20	2.2	85
August	8.34	4.33	5.1	16	1.5	130
September	7.89	7.05	4.8	24	1.4	275
October	NA	Not Applicable (NA)	NA	NA	NA	NA
November	NA	NA	NA	NA	NA	NA
December	NA	NA	NA	NA	NA	NA

Identification of Extent of Pollution Control

Identification of extent of pollution control is needed in view of critical flow conditions and comparing with desired quality criteria. Pollution control systems will be required in all aspects starting from sewage collection, treatment and disposal (European Commission, 2011; Tzanakakis et al., 2007). The details are as follows:

Sewage Collection: This is the first step and based on water supply figures even Pune and Pimpri Chinchwad towns are not collecting all their sewage. Similar situation is in other towns like Pimpri Chinchwad, Alandi, Talegaon and other towns/cities. Therefore, sewage need be properly collected for treatment.

STPs: In the cities where sewage treatment is provided still, 30 to 40 percent of the collected sewage is released to the river untreated. This need be addressed on priority basis. This quantity prima facia collectively is more than 300 MLD.

Providing STPs: For the villages provide bund to the nallah and pump sewage to nearby fields or provide septic tanks followed by soak pit to group of residents (Gill et al., 2009). The sewage water needs to be treated by Activated Sludge Process (ASP) treatment, as the procedures presented in Figure 3. The treated sewage water could be used for industrial and gardening purposes to some extent.

Criteria for the Selection of the Site for Waste Water Treatment

i) Proximity to an important river - as close as possible- treated water must be adequately diluted.
ii) Situated near the zones to be served - allows the economic regrouping of the water sewers in order to reduce the construction costs of the planned sewers.
iii) Access to the site by an existing road - as close as possible to avoid the construction costs of an access road.
iv) Presence of housing or protected forest - avoid zones to be protected.
v) A river in close proximity to the site - avoid affecting a river.
vi) Site outside a flooding zone - avoid flooding that may affect water treatment.
vii) Zoning - respect existing municipal zoning.
viii) Land acquisition - economic impact.
ix) Control of odours, noise and lighting.
x) Architecture: (i) respect for the architectural surroundings and (ii) integrate and harmonize with the existing architecture.
xi) Construction of conduits, collectors and outlets - shortest possible distance in order to reduce costs.
xii) Area of the site - area required for natural treatment for small towns- area required for biological rector.
xiii) Topography of the site must be relatively flat to facilitate construction.
xiv) Type of soil - lends itself to the construction of a treatment plant at a reasonable cost.
xv) Geotechnical stability of the site - soil must be stable.

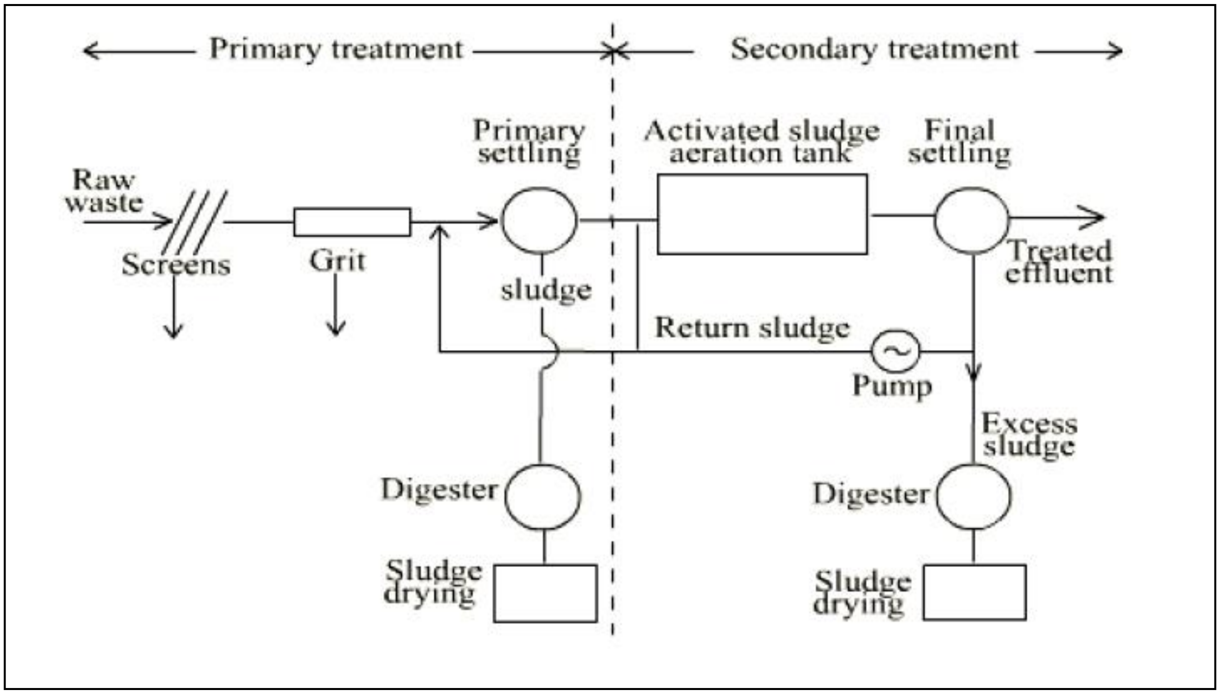

Figure 3: Schematic Diagram of ASP Treatment

Utilization of Waste Water and Volume of Waste Water used for Agriculture

Based on available data, total waste water generated is 25 MLD from 3 cities and about 28 MLD from all villages combined i.e. 53 MLD. After treatment this can be easily used for agricultural purpose since it has no industrial contamination (Tchobanoglous et al., 2014).

CONCLUSIONS

This paper presented a comprehensive study on domestic pollution for the assessment of polluted river stretches of Bhima river. From the experimental data analysis, the following conclusions were drawn from the study:

i) In Pune and Pimpri Chinchwad, only 60 to 70 percent of the collected sewage is treated whereas in remaining towns sewage is discharged to river without any treatment.
ii) The total water supply for domestic purpose is 1519.72 MLD and 1074.48 MLD of sewage is generated in the Bhima river basin.
iii) Out of this sewage, 713.69 MLD of sewage is treated by providing primary, secondary and in some cases, tertiary treatment and then used for gardening to the maximum extent and remaining treated water is discharged into the river.
iv) Of the 364.79 MLD untreated waste water discharged into the Bhima river or its tributaries viz., 247 MLD from Pune city, 48 MLD from Pimpri Chinchwad, 27.19 MLD from 5 Municipalities, 28.8 MLD from various Cantonment boards and 13.80 MLD from various villages on the bank of rivers.
v) The DO of river Bhima is found to be 3.5 to 7.05 mg/l and BOD is about 4.8 to 12.8 mg/l with faecal coliforms organisms 65 to 275 per 100 ml.

vi) Based on available data, total waste water generated is 25 MLD from 3 cities and about 28 MLD from all villages combined i.e. 53 MLD. After treatment this can be easily used for agricultural purpose since it has no industrial contamination.

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Sustainable Income For Mulberry And Silkworm Rearing Waste, Larva Water (Litter) Utilized For Vermicomposting, Seri Composting And Biogas Production In Tamilnadu

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Abstract

India is developing as potential silk producing and Sericulture is one of the rural-based agro industries with global reach, which had been focusing on silk production previously, switched its market for supplying food supplements and raw materials for medicine and compost (vermicomposting, seri composting, biogas production) production. Integration of various agricultural enterprises viz., cropping, animal husbandry, fishery, sericulture, horticulture, mushroom, vermicomposting, biogas, etc. Have greater potential in the agricultural economy. Integrated farming system not only enhances the net income of the farm. But also provides good opportunity for recycling of crop residues animal wastes as organic sources of nutrients sericulture will be a most promising and more viable component is the integrated farming system under garden land conditions. The silkworm litter can be used as a good source of biogas production along with cow dung the effect of incorporation of sericultural wastes for biogas production is high. **The silkworm larval water (litter) incorporated along with cow dung and old slurry in the proportion of 1:2:2 (v/v) gave the maximum quantity 15299cc of gas/day on an average of period of 12 weeks.** The silkworm cocoon wastes and generate 910 and 1000cc of gas/day respectively. When compared to control of 972cc/day quantity of macro and micro nutrients for the preparation of compost. Sericultural farm wastes can be filled layer by layer in pits 4.5x 1.5 x 1.0 mtr. Size the pits should be closed after adding 200-300g of single super phosphate ash cow dung solution and sufficient quantity of waste for each and every layer. Mussorie rock phosphate @ 20kg/ ton can also be added to increase the phosphorus contents of the compost. **The compost will be ready by four months. A quantity of 180-200kg nitrogen, 90-100kg phosphorus and 150-180kg potash can be made available to the soils through application of 10 MT of sericompost.** In this way sericulture as a component in integrated farming system can be a born to farmers to produce good quantity silkworm cocoons at reduced cost and to improve their earning. Sericulture waste materials can be used in recycling and further developed and finally reborn into a real biotechnology- based sericulture in the future.

Key words: Mulberry, Silkworm, Compost, Cocoon

Introduction:

A farming system is the result of complex interactions among a number of inter-dependent components, where an individual farmer allocates certain quantities and qualities of four factors of production, namely land, labour, capital and management to which he has access. Farming systems research is considered a powerful tool for natural and human resource management in developing countries such as India. This is a multidisciplinary whole-farm approach and very effective in solving the problems of small and marginal farmers. The approach aims at increasing income and employment from small-holdings by integrating various farm enterprises and recycling crop residues and by-products within the farm itself.

Sericulture is defined as a practice of combining mulberry cultivation, silkworm rearing and silk reeling. Sericulture is a recognized practice in India. India occupies second position among silk producing countries in the world, next to China. The total area under mulberry is 188 thousand ha in the country. It plays an important role in socio-economic development of rural poor in some areas. In India more than 98% of mulberry-silk is produced from five traditional sericultural states, viz., Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu, and Jammu and Kashmir.

Design of Study

Moriculture: Cultivation of mulberry plants is called as 'moriculture'. There are about 20 species of mulberry, of which four are commonly cultivated. They are *Morus alba*, *M. indica*, *M. serrata* and *M. latifolia*. The crop can yield well for 12 years, after which they are pulled out and fresh planting is done. Yield of mulberry leaves is 30-40 t/ha/year.

Silk worm rearing: There are four types of silk worm viz.

(i) Mulberry silk worm – *Bombyx mori*
(ii) Eri silk worm – *Philosamia ricini*
(iii) Tassar silk worm – *Antheraea mylitta*
(iv) Muga silk worm – *Antheraea assami*

Rearing and maintenance:

The fertilized moth is covered with an inverted funnel or cellule and eggs are allowed to be laid over a cardboard. Parasites may be removed by brushing the egg masses with a fine brush. This will also enable to obtain a uniform hatch. In a bamboo tray rice husk is spread. Tender chopper mulberry leaves are added to the tray. The hatched out larvae are transferred to the leaves. It is important to change the leaves every 2-3 hours during the first 2-3 days. The cocoon is constructed with a single reelable thread of silk. If the moths are allowed to emerge from the cocoons, the silk thread is cut into pieces. Hence the pupa are killed 2-3 days before the emergence of moth and processed. The cocoons required for further rearing are kept separately and moths are allowed to emerge from them.

Result and Discussion

Mulberry cultivation, silkworm rearing and fish farming complement each other in the man-made ecosystem. However, irrespective of whether in Pearl River delta or Taihu basin, such ecosystem is rather incomplete. Most of them have not incorporated silk reeling industry. If silk reeling factory is established within the “mulberry plot-fish pond” ecosystem and pupae, worm dregs and waste water from the factory can be adequately and effectively channeled into the ponds, thus enabling a more complete, recycling of organic waste. The establishment of the factory reduces transportation cost and instead increases the rate of economic returns. This is the real type of “mulberry plot-fish pond” integrated fish farming model.

The actual yield from a 6 mu “mulberry plot-fish pond” belonging to Jinwan Brigade is shown in Table 2. The actual produce from the farm was 107.7 kg of cocoons, valued at 330 yuan; worm dregs as fertilizers for producing woffia which produced 20,400 summer fingerlings (5 cm carps) valued at 57.12 yuan (28 yuan/10,000 fingerlings). The total value of both products were 387.12 yuan.

The cost of producing 1217.5 kg of food fish is shown in Table 3. Among the feedstuff and fertilizers, 282 man-days have been spent to collect 70,500 kg of aquatic plants from Taihu lake for feeding the fish, in addition, 150 kg of rape-seed cake, 2,000 kg of pig and sheep manure, 500 kg of have to be bought. Apparently, there is no close coordination between mulberry cultivation, silkworm rearing and fish farming. The only close integration is the use of pond humus/mud - the base manure for mulberry cultivation. As it is the production cost per kilogram of fish is 1.216 yuan. one yuan = 50.5 US cents.

Production is able to freely utilize the mulberry residues and worm dregs and waste water to raise food fishes by constructing a silk reeling factory, then 107.7 kg of cocoons will yield 14 kg of raw silk and the side products of 86.15 kg of pupae, 4308 kg of waste water and 850 kg of worm dregs can be used to produce 170.8 kg of fish. This supplies 14% of the feeds and fertilizers inputs. Besides the scrappy silk obtained from silk reeling after further processing can be used for making blankets, cushins and pillows. The scrappy silk together with silkworm moulds and sericin make up 7% of the total cocoon weight.

From the economic stand point, the production of raw silk compared with the sale of cocoons alone will increase income by about 29.4%. Thus the establishment of a mulberry cultivation-silkworm rearing-silk reeling-fish farming integrated farming system not only enable a closer integration of the recycling of matter within the "mulberry plot-fish pond" ecosystem, but also creating a more compact and complete energy flow whereby the dikes of the pond are used for mulberry cultivation; the mulberry leaves for silkworm culture; cocoons for silk reeling and its by-products consisting of worm dregs, pupae and organic waste water for fish farming. From socio-economic view point, it is essential to economize on fish farming expenditure (based on the production cost per kilogram of fish according to Table 3 and total fish yield in Table 4, a saving of 207.75 yuan can be obtained) so as to increase the income from mulberry cultivation and silkworm rearing, creating new production industry and increase employment opportunity. The silkworm larval water (litter) incorporated along with cow dung and old slurry in the proportion of 1:2:2 (v/v) gave the maximum quantity 15299cc of gas/day on an average of period of 12 weeks.

The silkworm cocoon wastes and generate 910 and 1000cc of gas/day respectively. When compared to control of 972cc/day quantity of macro and micro nutrients for the preparation of compost. Sericultural farm wastes can be filled layer by layer in pits 4.5x 1.5 x 1.0 mtr. Size the pits should be closed after adding 200-300g of single super phosphate ash cow dung solution and sufficient quantity of waste for each and every layer. Mussorie rock phosphate @ 20kg/ ton can also be added to increase the phosphorus contents of the compost. The compost will be ready by four months. A quantity of 180-200kg nitrogen, 90-100kg phosphorus and 150-

180kg potash can be made available to the soils through application of 10 MT of sericompost. In this way sericulture as a component in integrated farming system can be a born to farmers to produce good quantity silkworm cocoons at reduced cost and to improve their earning. Sericulture waste materials can be used in recycling and further developed and finally reborn into a real biotechnology- based sericulture in the future. The basis of integration of mulberry cultivation-sericulture and fish farming model in Taihu basin and Pearl River delta in Table 1.

Table 1. The basis of integration of mulberry cultivation-sericulture and fish farming model in Taihu basin and Pearl River delta.

Items	Jinwan production brigade	Taihu basin	Pearl river delta
Mulberry leaves (kg/mu)	875	1000–1500	2400–2500
Cocoons (kg)	44.88	80–120	160–200
worm dregs (kg)	354.15	300–450	1200–1250
	(44.25)**	(37.50–56.25)	(150–156.2)
Pupae (kg)	35.90	64.96	128–140
	(17.95)	(32–48)	(64–70)
Waste water from silk extraction (kg)	1795	2500	2500
	(8.95)	(12.5)	(12.5)
Raw silk (kg)	5.85***	5.6–8.4	11.2–14
Total fish produced (kg)	***71.20***	***82–116.75***	***226.5–238.75***

Research Needs

Although integrated farming has now been proved to be highly profitable, its practice remains very limited in scale. This is because the relevant scientific and technological information on diversification of methods is unavailable to farmers. To remedy this, there must be a bridge between the information sources and the farmers, perhaps through extension services. A multidisciplinary approach is needed, including technological, economic, social and political aspects which are interrelated. Any approach must, however, be relevant to national economics, social and environmental conditions and to the farmers need.

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Sustainable Management Practices for Mixed Municipal Wastes using Aerobic Composting

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ABSTRACT

Improper handling and disposal of solid waste materials originating from domestic sector is increasing at an alarming rate in the current scenario of accelerated urbanisation. Effective reuse of waste materials to provide an alternative and sustainable solution to this waste management problem is highly demanding. In the present study, we propose a methodology for preparing nutrient rich manure by composting a blend of waste materials like faecal-rich sewage sludge and organic rich undigested green waste along with inorganic materials like paper etc. Different combinations of proportions (based on carbon: nitrogen ratio) were tried to optimize the stability and maturity of compost. The physic-chemical characteristics of the compost are monitored for a period of 40 days to ensure its maturity based on stable nutrient composition. The compost thus prepared is ready to use as organic manure in agricultural fields. Apart from treating the unmanaged domestic and agricultural waste materials, this provides an additional benefit of detoxifying faecal-rich sewage sludge and enhancing the nutrient (carbon: nitrogen ratio) of the compost.

Keywords

Agricultural waste, Compost, Municipal waste, Organic matter, Sewage sludge

INTRODUCTION

There are numerous questions posing concern over the sufficiency of the existing waste management systems in developing countries, their associated environmental, economical and social implications in the context on ever-increasing population and urbanization (Mengistu et al. 2018). Sustainable waste management strategies are becoming increasingly important due to the need to conserve and recycle nutrients for agriculture (Tognetti et al. 2011). The concept of recycling waste nutrients and organic matter back to agricultural land is feasible and desirable in lower income countries, where technology is not in place. Composting is a low-cost and sustainable technology to prepare value-added amendments from municipal solid waste (MSW) materials thereby helping to mitigate their open disposal problem to a large extend. Moreover, it improves the quality of the end product, reduces odor emission by decreasing the concentration of volatile compounds and also reduces the impact of greenhouse gases on the environment (Tognetti et al., 2011; Morales et al., 2016). Application of organic manure (compost) has been shown to improve the soil organic matter content, water infiltration and retention and the available water content of soils by 58–86% in the root zone and increase the yield production (Adamtey et al. 2010). Being a natural process, it can minimize the duration of decomposition and strengthen the soil stability as well as provide pathogen-free, matured compost which can be used as bio-fertilizer.

Faecal sludge (FS) in India is generated either from open defecation (accounts for about 58% of total FS) or on-site sanitation systems. Currently, the focus is changing from fecal sludge (FS) disposal to reuse with fertilizer and soil amendments being among the most common reuse options. The human excreta is relatively rich in nitrogen (N), phosphorus (P), potassium (K) and moisture, whereas the MSW is comparatively high in organic carbon (OC) content and has good bulking property. Ideally, both these waste materials can be combined (co-composting) to produce good quality compost (with high C: N ratio). Generation of high temperature in composting process are found to be effective in inactivating excreted pathogens available in the FS thereby converting both wastes into a hygienically secure soil conditioner-cum-fertilizer (Strauss et al. 2003).

In co-composting, the selection of a co-substrate to the original material (main substrate) is crucial to achieve sustainable balance in the original properties of main substrate. Co-substrates could be also useful to regulate the moisture content and to balance the biochemical composition of the main substrate (Ruggieri et al. 2008; Cofie et al. 2016). During co-composting, it is crucial to select suitable bulking agents to maintain sufficient mixing and aeration while eliminating the chance of 'mud-ball' formation and preferential pathway for moisture distribution. In the context of sustainable waste management, the present study focuses on utilization of available waste materials from a small residential campus to prepare aerobic compost to be promoted as bio-fertilizer. The objective of the study is to identify the right combination of co-substrates to yield safe and matured compost in minimum time duration.

MATERIALS AND METHODS

Study Area

The study was carried out at the Bannari Amman Institute of Technology, Sathyamangalam (11.5048°N, 77.2384°E) in Erode district of Tamil Nadu. The average temperature in the campus environment varies from 26°C to 33°C. The municipal wastes in the campus were classified as polythene covers, paper, cardboard, leaves, food wastes and vegetables etc, which are mostly generated from academic block, mess, hostels and staff quarters. As a sustainable technology towards "Swachh Bharat" mission, we propose the aerobic bin-composting for the effective reuse of the organic wastes. Along with the organic composting materials, the dewatered sludge from the sewage treatment plan was also added and is used as effective manure.

Selection and Preparation of Substrates

In this study, the selected substrates were vegetable wastes, news papers, cardboards, green leaves and grass (Table 1). The vegetable waste consists of unused vegetables like lady's finger, cabbage leaves, beetroot tops and onion wastes. The news papers and cardboards were cut into an average size of 2.5 by 2.5 cm. The yard waste such as grass and dry leaves were collected from the horticulture area of the campus. The sewage sludge is dewatered by simultaneous evaporation and draining in the sludge drying beds.

Table 1: Individual C- N ratio for various co-substrate materials

S. No.	Types of waste	Major nutrient composition	Expected C:N ratio	References
1	Vegetable waste	Nitrogen	25:1	www.planetnatural.com
2	Green leaves	Nitrogen	20:1	

3	News paper	Carbon	175:1	
4	Cardboard	Carbon	350:1	
5	Dry leaves	Carbon	60:1	

Experimental Composting Procedure

Three different mixes were set-up for composting experiments and they were conducted in three bins (Table 2). The first mix (bin 1) consisted of dewatered sewage sludge, food wastes (vegetable wastes), green leaves and shredded news papers. The second mix (bin 2) and the third mix (bin 3) differ from the first mix in the proportion of the sewage sludge addition (30%, 50% and 70% of initial volume-volume basis). The sizes of three bins were 110x100x50cm, 110x100x50cm and 110x100x50cm respectively. The compost mixtures were turned and mixed once in two-week basis to ensure adequate aeration (Fig. 1). The bins were specifically kept partially under shades in order to enhance the solar irradiation for the sewage sludge. These composting bins were monitored for a period of 40 days and the temperature was monitored daily.

Table 2: Selection of co-substrate for preparing the composting

S. No.	Substrate	Source of waste	Quantity	Average particle size (cm)	Height of filling (cm)
1	Vegetable waste	Mess and staff quarters	18.328kg	2.5	10
2	Green waste	BIT campus	6.88kg	2.5	10
3	Dry waste	BIT campus	5.360kg	2.5	10
4	Sewage sludge	BIT STP	15.5kg	---	20

Figure 1: Filling up of composting bin and temperature measurement

Data Collection and Analysis

The materials used for composting is collected from the college campus and the mixing has done based on their available individual C: N ratio. The effect of physicochemical parameters such as temperature, moisture content, volume reduction, pH and electrical conductivity were evaluated periodically in the laboratory by following the standard methods of analysis. The temperature was measured *in situ* using a thermometer by dipping at various places in the bin to a depth of 8-10cm. The moisture content was calculated by gravimetric (oven-dry) method.

RESULTS AND DISCUSSION

pH

Generally, pH follows certain pattern in composting as decline in the early stages of composting and elevation in the later stages (Fig. 2). It is an important parameter in the composting process as it affects microbial activities during composting. At neutral pH, the organic acids were completely decomposed further pointing out a range of optimum pH as 7.0 – 8.0 (Chan et al. 2016). In this study, pH value was found to be increasing from 6.0 to 8.0 with maturity of composting, thus indicating the accumulation of ammonia from the microbial degradation of organic matter (Hachicha et al. 2009). The final pH values for the three mixtures obtained in this study were

8.05, 8.21 and 8.34. Further, it is interesting to note that pH has a direct influence of temperature attributing to the existence of different microbial groups during the progressing stages of compost.

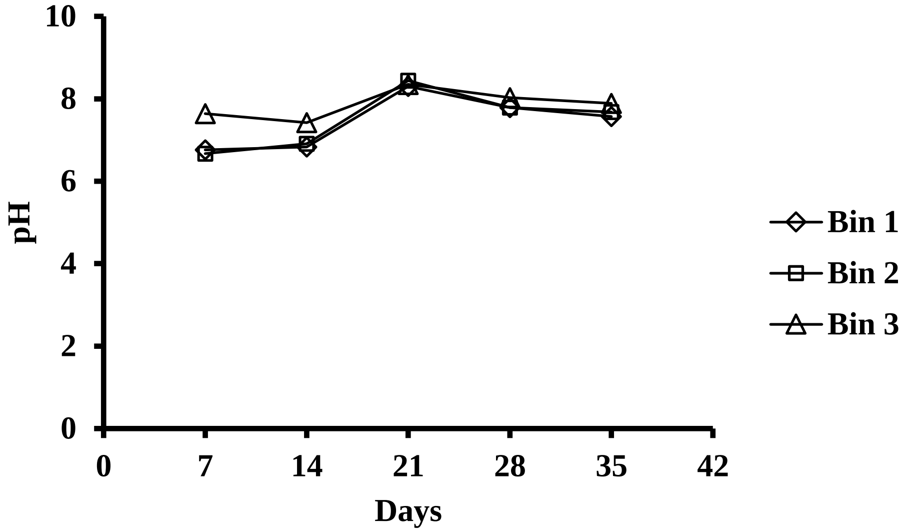

Figure 2: Variation of pH with time for the three combinations of composting (Bin 1, Bin 2 and Bin 3)

Electrical Conductivity (EC)

During composting, concentration of salts increases unavoidably due to the decomposition of complex organic matter. The EC indicates the total salt content of compost reflecting the quality of compost to be used as a fertilizer. The value of EC for the three mixtures on 7th day was observed as 129, 117 and 102 mS/cm respectively, which decreased to 35, 36 and 32 on 35th day (Fig. 3). This could be explained based on the volatilization of ammonia and the precipitation of mineral salts during the composting process during the study period. Compost with low EC value will be beneficial for supporting the plant growth (Yang et al. 2015).

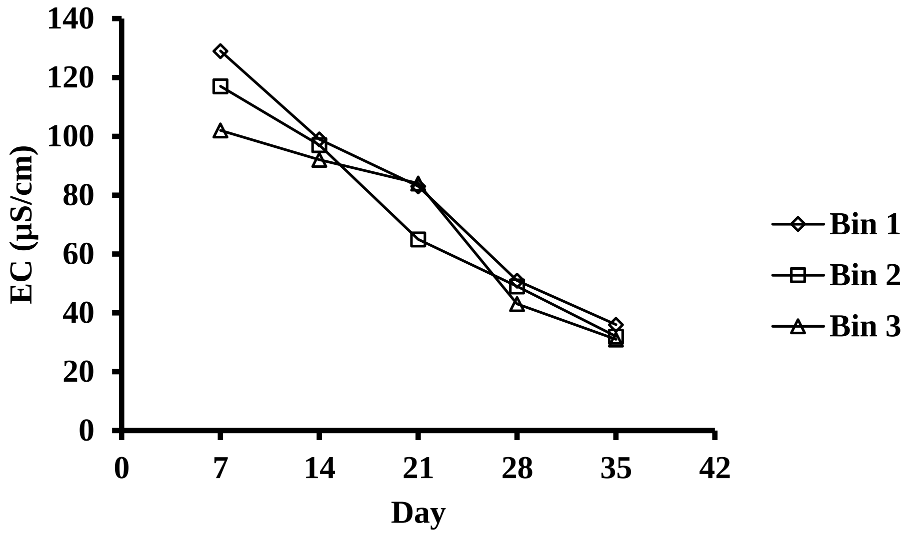

Figure 3: Variation of electrical conductivity (EC) with time for the three combinations of composting (Bin 1, Bin 2 and Bin 3)

Temperature

The temperature profile of all three composting bins (Bin 1 to 3) was measured from the day of set-up of the process until the completion of stabilization. Temperature variation for composts of three treatments is presented in Fig. 4. Temperature in composting is directly affected by the microbial biomass and its enzymatic activity for degrading process, which is dependent on availability of energy in the composting material (Meng et al. 2016). The initial temperature was on an average of 33, 33 and 42 °C for Bin 1, 2 and 3 respectively. As a result of accelerated biodegradation of organic compounds, the temperature of all treatments rapidly increased from the mesophilic phase and reached the thermophilic range (40 - 50 °C) during the first 11 days. The maximum temperatures achieved in treatment Bin 1, 2 & 3 were 47.33, 50.33 and 46.0 °C, respectively. The thermophilic phase can be attributed to the liberation of heat on the sides of the bins as an indication of the biological decomposition process. The apparent decrease in temperature in the middle stage was due to the moisture addition which can alter the microbial activity for a short period of time (Awasthi et al. 2014; Pandey et al. 2016).

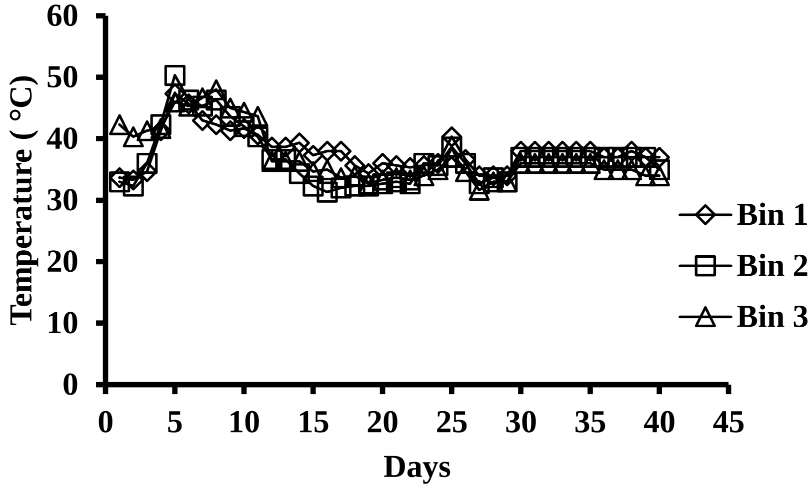

Figure 4: Variation of temperature with time for the three combinations of composting (Bin 1, Bin 2 and Bin 3)

Moisture content

The moisture content (MC) influences the oxygen uptake rate, free air space, microbial activity, and temperature of the composting process. The optimum MC required for biological activity during composting is between 40 - 70% of the compost weight (Petric et al. 2012). As the experiments were conducted in summer, water loss was relatively high. In order to maintain perfect biological activity, water was sprayed twice a week into all the bins to keep 40 - 70% moisture content. However, when the moisture content exceeds 70% the rate of gas diffusion declines, uptake of oxygen rate becomes inadequate in meeting the metabolic demands of the microorganisms and the process may tend towards anaerobic due to restricted activity. MC of the mixtures in the bin 1, 2 and 3 were observed 70.88%, 63.42% and 58.12%, respectively, at 5th day of compost (Fig. 5). At the end of 40th day, 70% and 62% of MC was observed in Bins 1 and 2, respectively and 48% was observed in bin 3. Although the proportion of sludge was higher in this particular mixture, due to the effective dewatering in the initial days, moisture content reduced significantly due to the high activity of microbes available in the sludge.

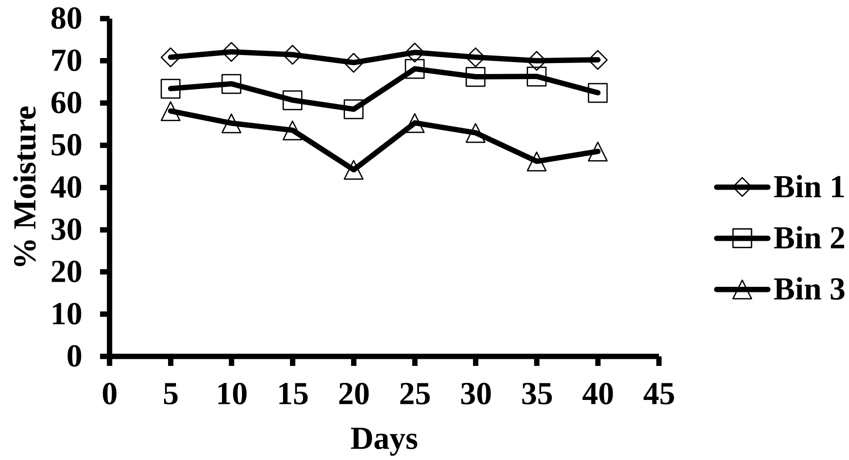

Figure 5: Variation of moisture content (MC) with time for the three combinations of composting (Bin 1, Bin 2 and Bin 3)

C/N ratio

The C/N ratio has been projected as one of the best indicators of compost maturity. However, it cannot be used as an absolute indicator of compost maturity due to its large variation that is dependent on the starting materials (Cofie et al. 2016). The C/N ratio was found to be decreasing, especially at the beginning of the composting process when the OM degradation was greatest; and then stabilized to reach values close to 20 (Table 3). The C/N ratio on 14th day was fallen sharply in all the bins at the beginning of decomposition. Final values of the C/N ratio values were 10.95:1, 11.31:1 and 9.19:1 in Bins 1, 2 and 3, respectively. It is suggested that all composts had reached an acceptable degree of maturation, since all the C/N ratios were close to 12, the limit accepted for mature compost (Parades et al. 2000). A recommended C/N ratio for use of compost is below 16 to avoid nitrogen barriers due to competition between microorganisms and plants. A well moisten soil has C/N ratio nearer to 10 and the additional compost materials with a C/N ratio below 16 may not alter the microbiological equilibrium of the soil (Cofie et al. 2016). In this study, the C/N ratio at the end of 35th day satisfied the above recommended limits and can be considered as mature and suitable for addition to soil.

Table 3: Variation in C/N ratio for three combinations of composting (Bin 1, Bin 2 and Bin 3)

Compost unit	**C/N Ratio**			
	Day 14	**Day 21**	**Day 28**	**Day 35**
Bin 1	1.30	6.32	4.66	10.95
Bin 2	1.06	6.47	5.75	11.31

Bin 3	1.45	2.31	5.76	9.19

Reduction in Volume

Composting aimed to reduce the volume of waste organic materials reaching the landfills but to recycle them to facilitate as a source of nutrients and soil conditioner in the field. The initial compost volume for Bins 1, 2 and 3 were 0.408 m^3, 0.414 m^3 and 0.414 m^3, respectively. The volume reduction is a result of the organic matter degradation and break down of structural organic components during the composting process. Other factors such as waste composition, turning frequency, particle size and pile size can also favor the volume loss in composting process. Volume losses in Bins 1, 2 and 3 after 40 day were 0.115 m^3, 0.13 m^3 and 0.088 m^3, respectively (Fig. 6). It can therefore be inferred that during thermophilic phase, compost can reduce the solid waste volume by 40 – 50%. In this present study, the volume reduction occurred above 40 % in all the bins.

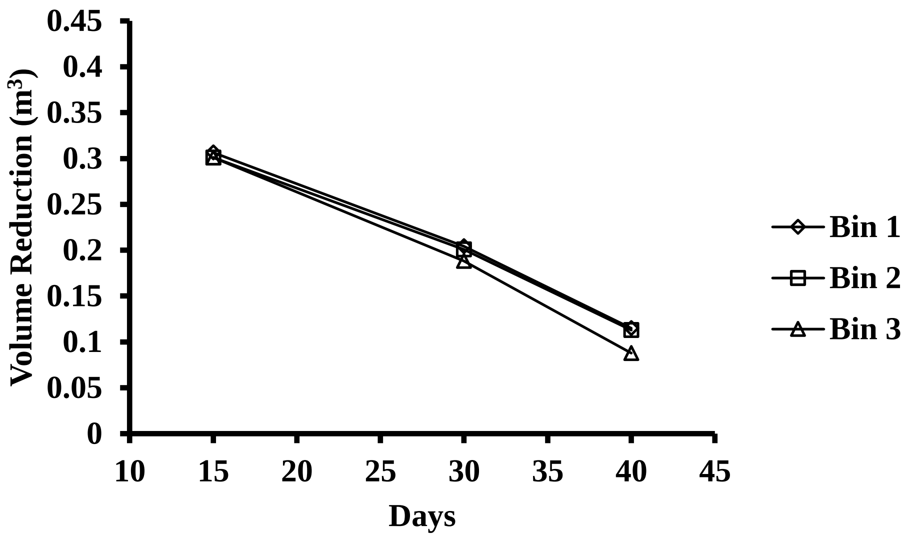

Figure 6: Variation of reduction in volume with time for the three combinations of composting (Bin 1, Bin 2 and Bin 3)

Conclusions

Present study deals with effective management of domestic solid waste by incorporating various co-substrates for the preparation of aerobic composting. The co-substrates mainly included refuse green waste, uncooked vegetable waste, inorganic refuse like paper, bulking agents like saw dust and faeccal-rich sewage sludge. The results indicate that there is sufficient decomposition of mixed domestic wastes within a period of 40 days caused by the surviving inoculums of microbes from the sludge. However, the necessity of sterilization was met by the increased temperature within the compost mass due to the controlled ventilation and solar radiation.

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40.

Synthesis Of Zinc Oxide Nano Particle From *Coco Nucifera* Coirfor Environmental Applications

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ABSTRACT

Nanotechnology is the production and use of materials at the nanoscale. Nanotechnology has considerably improved and revolutionized several technology and industrial sectors including medicine, food safety, and many others. Nanoparticles are used immensely due to its small size, orientation, physical properties, which are reportedly shown to change the performance of any other material which is in contact with these tiny particles. These particles can be prepared easily by different chemical, physical, and biological approaches. But the biological approach is the most emerging approach of preparation, because, this method is easier than the other methods, ecofriendly and less time consuming. The present study reports the synthesis of ZnO nanoparticles by biological method. Highly stable and hexagonal phase ZnO nanoparticles were synthesized using Coco nucifera coir (coconut) extract and were characterized confirmed by UV–vis and FT-IR spectroscopy. Therefore, the study reveals an efficient, ecofriendly and simple method for the synthesis of multifunctional ZnO nanoparticle using synthetic approach. The particles synthesized were of the size ranging from 90-500 nm.

KEY WORDS:*Coconucifera* (coconut fibre/coir), Nanoparticles, Zinc oxide nanoparticle, UV-vis and FT-IR spectroscopy.

INTRODUCTION

Nanotechnology emerges from the physical, chemical, biological and engineering sciences where new techniques are being developed to probe and maneuver single atoms and molecules for multiple applications in different field of scientific world. In nanotechnology, a nanoparticle is defined as a small object that behaves as a whole unit in terms of its transport and properties. The science and engineering technology of nanosystems is one of the most exigent and fastest growing sectors of nanotechnology. In the recent years, due to the advancement in Science and technology researchers have attempted to synthesize nanoparticles within the size range of 100 nm and this extensive research and concern on nanoparticles is widening due to their potential application in wide areas of science and technology.Metal oxide nanoparticles have been intensively studied in the past decade. Nanosized materials have been an important in basic and applied sciences. Biological process for nanoparticle synthesis using microorganisms, enzymes, plants and alga have been proposed as feasible ecofriendly alternatives to chemical and physical methods, because they are hazardous and costly . The synthesis of metal and metal oxide nanoparticles have attracted considerable attention in physical, chemical, biological, medical, optical, mechanical and engineering sciences because it has a high surface area. The metal oxides have high fraction of atoms and they have responsible for their fascinating properties such as antimicrobial, magnetic, electronic and catalytic activity .The progress of technology and quality of life of mankind has always been closely knit with the progress in material science and material processing technology. Most techniques applied in material processing are based on breaking up large chunk of a material into desired shapes and sizes, inducing strain, lattice defects and other deformations in the processed material. Recent developments and findings in nanotechnology and the demonstration based on various quantum size effects in nanoscale particles, reveals that most of the novel work and devices of the future will be based on properties of nanomaterials. Each nanoparticle contains only about 3- 107 atoms/molecules. The traditional material processing techniques that induce lattice defects and other imperfections will no longer be diluted for synthesis of nanoparticle by unmitigated number of atoms. Furthermore, the application oftraditional approach imparts difficulties for synthesis of such small particles in a desirable size range. Alternative synthetic technique for nanoparticles involves controlled precipitation of nanoparticles from precursors mixed and dissolved in a solution. A micro suspension can also be formed using surfactants between two immiscible liquids, with thereactionary isolated inside a colloid, throughhydrophobic versus hydrophilic forces. The resultant nanoparticles form a micro colloidal suspension. Various factors such as thermodynamic determinant as well as van der Waal"s forces induce particle growth and accumulation, resulting in bigger particles that settle down over time. A contingency in utilizing colloidal nanoparticles is that its stability is 2 maintained in colloidal suspension. The mechanism involved in stabilization of nanoparticles can be categorized as a) electrostatic stabilization: involving the creation of a double layer of adsorbed ions over the nanoparticles resulting in a coulombic repulsion between approaching nanoparticles; or b) Steric hindrance: achieved by adsorption of polymer molecules over the nanoparticles. Polymer molecules coated with nanoparticles feel osmotic repulsion when these particle approach each other which occurs due to localized increase in their concentration and hence keeps them (along with the nanoparticles) well separated. Nature has devised various processes for the synthesis of nano and micro- length scaled inorganic materials which have contributed to the development of relativelynew and largely unexplored area of research based on the biosynthesis of nanomaterials. Synthesis using bio-organisms is congruent with the green chemistry principles. "Green synthesis" of nanoparticles makes use of environmental friendly, non-toxic and safe reagents.

ZINC OXIDE NANO PARTICLE

Zinc oxide nanoparticles is attracting tremendous attention due to its stimulating properties like wide direct band gap of 3.3 eV at room temperature and high excitation binding energy of 60 meV . ZnO belongs to the class of metal oxides, which is characterized by photo catalytic and photo-oxidising capacity against chemical and biological species. Furthermore, ZnO nanoparticles strongly resist or prevent a microorganism and some reports show considerable antibacterial activity of CaO, MgO and ZnO . They are attributed to the generation of reactive oxygen species on the surface of these oxides.

BENEFITS OF ZINC OXIDE NANO PARTICLE

Zinc oxide nanoparticles (ZnO-NPs) are among nanoscale materials displaying exponentially growing production due to their applications in the field of cosmetology, medicine, as antibacterial agent and catalyst. The ZnOnanomaterials release into the aquatic ecosystems through domestic and industrial wastewaters has the potential to induce pernicious effects on fish and other organisms. Increasing concerns on the environmental hazard to aquaticbiota have been highlighted by the toxic potential of some metal-based nanomaterials. Several characteristics of ZnO-NPs (e.g.

size, shape, surfacecharge andagglomeration state) play a central role in biological effects such as genotoxic, mutagenic or cytotoxic effects. Overall, Zn bioaccumulation, histopathological, and hematological changes with oxidative and cellular stress have been reported in ZnO-NPs exposed animals.

COCO NUCIFERA (COCONUT COIR)

The coconut tree (*Cocosnucifera*) is a member of the family Arecaceae (palm family) and the only species of the genus*Cocos*. The term coconut can refer to the whole coconut palm or the seed, or the fruit, which, botanically, is a drupe, not a nut. Coconuts are known for their great versatility, as evidenced by many traditional uses, ranging from food to cosmetics.They form a regular part of the diets of many people in the tropics and subtropics. Coconuts are distinct from other fruits for their large quantity of water (also called "juice") and when immature, they are known as tender-nuts or jelly-nuts and may be harvested for their potable coconut water . When mature, they can be used as seed nuts or processed to give oil from the kernel, charcoal from the hard shell, and coir from the fibrous husk.

THE CHEMICAL COMPOSITION OF COCO NUCIFERA

The coconut fiber is nothing but the husk present around the coconut shell.Coconut husk has high amount of lignin and cellulose, and that is why it has a high calorific value of 18.62MJ/kg. The chemical composition of coconut husks consists of cellulose, lignin, pyroligneous acid, gas, charcoal, tar, tannin, and potassium. The predominant use of coconut husks is in direct combustion in order to make charcoal, otherwise husks are simply thrown away. Coconut husk can be transformed into a value-added fuel source which can replace wood and other traditional fuel sources. In terms of the availability and costs of coconut husks, they have good potential for use in power plants.

Chemical Composition of Coconut / Coir Fiber:

- Lignin……………...............…45.84%
- Cellulose………….............…43.44%
- Hemi-Cellulose……………...............00.25%

- Pectin's and related Compound…………03.00%
- Water soluble…………….........05.25%
- Ash……………………...........02.22%

PROPERTIES OF *COCONUCIFERA*(COCONUT COIR)

Coconut fibre is extracted from the outer shell of a coconut. The common name, scientific name and plant family of coconut fibre are coir, cocosnucifera and arecaceae (Palm), respectively. There are two types of coconut fibres, brown fibre extracted from matured coconuts and white fibres extracted from immature coconuts. Brown fibres are thick, strong and have high abrasion resistance, while white fibres are smoother and finer, but also weaker. Coconut fibres are commercially available in three forms, namely bristle (long fibres), mattress (relatively short) and decorticated (mixed fibres). These different types of fibres have different uses depending upon the requirement.

- Length in inches…………6-8
- Density (g/cc)…………………….1.40
- Tenacity (g/Tex)………………10.0
- Breaking elongation%..............30%
- Diameter in mm………….0.1 to 1.5
- Rigidity of Modulus……….1.8924 dyne/cm2
- Swelling in water (diameter)…………5%
- Moisture at 65% RH…………10.50%

USES OF COCONUT FIBRE

Coconut fibre is a natural fibre extracted from the husk of coconut andused in products such as floor mats, doormats, brushes and mattresses. Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut.In agriculture and horticulture, coir is a substitute for sphagnum (peat moss) and peat because it is widely available and environmentally friendly. Many sources of coir however are heavily contaminated with pathogenic fungi, and the choice of the source is important. Coir is also useful to deter snails from delicate plantings, and as a growing medium in intensive glasshouse (greenhouse) horticulture. Coir fibre pith or coir dust can hold large quantities of water, just like a sponge. Coco fibre can be re-used up to three times with little loss of yield. Coco fibre from diseased plants should not be re-used.

MATERIALS AND METHODS

MATERIALS

Coco nucifera (Coconut fibre) were collected from Coimbatore , Tamil Nadu, India. Zinc nitrate hexahydrate [Zn(NO3)2 _ 6H2O] were purchased from Merck, India Pvt. Ltd. Deionised water was used throughout the reaction process.

PREPARATION OF EXTRACT

Coco nucifera (coconut fibre)were collected and it is washed several times with water to remove the dust particles and then to remove the residual moisture. The extract used for the reduction of zinc ions (Zn2+) to zinc nanoparticles (ZnO) was prepared by placing 50g of washed dried fine cut of *Coco nucifera* (coconut fibre) in 250 mL glass beaker along with 100 mL of sterile distilled water. The mixture was then boiled for 60 minutes until the color of the aqueous solution changes from watery to light yellow. The extract was cooled to room temperature and filtered using filter paper. The extract was stored in a refrigerator in order to be used for further experiments.

SYNTHESIS OF ZINC OXIDE NANOPARTICLES

For the synthesis of zinc oxide nanoparticle 50 ml of *Coco nucifera*(coconut fibre) extract was taken and boiled to60-80 degree Celsius using a stirrer heater. 5 gramsof Zinc Nitrate was added to the solution as thetemperatures reached 60 degree Celsius. Thismixture is then boiled until it reduced to adeepyellow colored paste. This paste was then collectedin a ceramic crucible and heated in an air heatedfurnace at 400 degree Celsius for 2 hours. A lightwhite colored powder was obtained and this wascarefully collected and packed for characterization purposes. The material was mashed in a mortarpestleso as to get a finer nature for characterization.

RESULT AND DISCUSSION

CHARACTERIZATION OF ZINC OXIDE NANOPARTICLES UV-VIS SPECTRA ANALYSIS

Electromagnetic radiation such as visible light is commonly treated as a wave phenomenon, characterized by a wavelength or frequency. Wavelength is defined on the left below, as the distance between adjacent peaks (or troughs), and may be designated in meters, centimeters or nanometers (10-9 meters). Visible wavelengths cover a range from approximately 400 to 800 nm.Optical properties of the as-prepared ZnO nanostructure sample was revealed by UV–Vis spectrum atroom temperature. It can be seen from the Figure No.1 that there was intensive absorption in the ultraviolet band of about 300-1100 nm. The absorption wavelength at about 208 and 215 nm of ZnO suggested the excitonic character at room temperature. Photoluminescence (PL) studies were performed to emphasize its emission properties as shown in Figure No.1. The photoluminescence of ZnO sample suggested emitting bands, 208 and 215 been observed in as-prepared ZnO sample. The PL of the ZnO sample in our case is considerably different from the typical observation in ZnO crystals.

FTIR SPECTRA ANALYSIS

2mg of ZnOnanoparticales were prepared by mixing with 200 mg of spectroscopic grade KBr. FTIR spectra were recorded using a Nicolet 520P spectrometer with detector at 4000-400 cm-1 resolution and 20 scans per sample. FTIR Spectra of aqueous Zinc oxide nanoparticles prepared from the *Coco nucifera*(Coconut fibre) extract was carried out to identify the possible biomolecules responsible for capping and efficient stabilization of the metal nanoparticles synthesized by using coir.(Figure No.2)

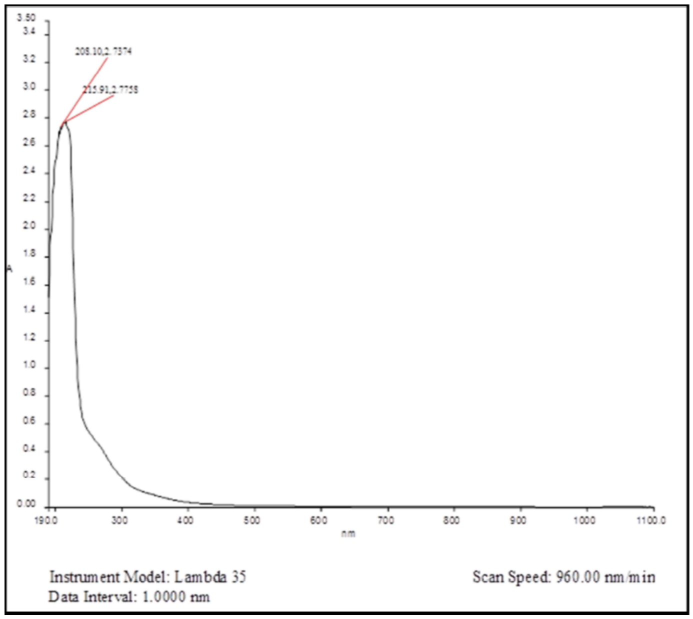

Fig 1.Graphical representation of analysis of Zinc oxide nanoparticle from *Coco nucifera* (coconut coir) using UV-vis spectroscopy.

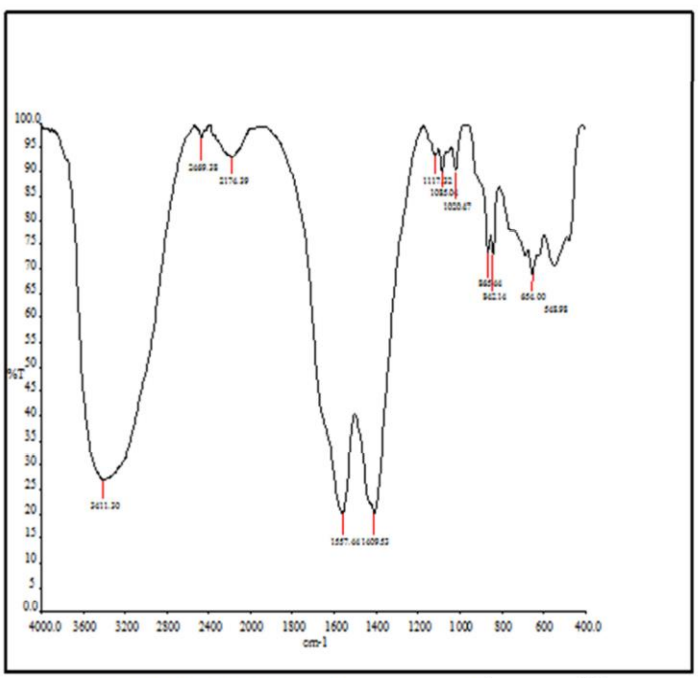

Fig 2.Graphical representation of analysis of Zinc Oxide nano particles from *Coco nucifera* (coconut coir) using FT-IR spectroscopy.

CONCLUSION

To conclude we have used unreported, inexpensive, nontoxic, ecofriendly and abundantly available *Coco nucifera*(coconut fibre) for the rapid synthesis of ZnO nano particles in the range of 9-10nm.Thus by the analysis of FT-IR and UV-vis spectroscopy the conformation of Zinc oxide nano particles have been analysed and confirmed. The Zinc Oxide nanoparticles have extensive applications in waste water treatment and other environmental pollution management system.

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41.

Technical Efficiency Of Water Users' Association On Water Use Efficiency In Theni District Of Tamil Nadu

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Abstract: Water is the elixir of life, a precious gift of nature to mankind and millions of other species living on the earth. It is fast becoming a scare commodity in most part of the world. Water resources comprising of surface water (river and lakes), ground water and marine and coastal waters, support all living things including human beings. A water user's association (WUA) is an organization of water users administered on the principles of cooperation and its role is to implement water institutions, and in the process to achieve a fair water allocation across different locations. Given the existing water supply scenarios, the demand management strategies will be considered more relevant for the efficient management of the available supplies. Therefore, what is needed is the clear understanding of the value of water in alternate uses as well as the incentive to allocate the water among competing crops and uses in different river basins. This will also help to work out the performance of both irrigation and agriculture sectors at basin level. Accordingly, the following objectives are set forth: to discuss the characteristics of WUAs and the impact of such characteristics on the water use efficiency of the selected farms. to examine the participation of farmers under WUAs in the selected area The deliverables will be a boost for water users' association and find a way possible ways for the water use in a economic prospects.

Key Words: Water User's Association, Participation, Water Use Efficiency, Periyar-Vaigai River Basin

Introduction:

In recent years, management reforms can be observed in Tamil Nadu, by Participatory management through water users associations (WUAs) and contracting out of irrigation canal management to individuals. To promote Participatory Irrigation Management (PIM), the Governments of Andhra Pradesh (Nikku, 2002) and Tamil Nadu have enacted 'Andhra Pradesh Farmers Management of

Irrigation System Act of 1997' and the 'Tamil Nadu Farmers Management Irrigation System Act of 2000', respectively These policy reforms emphasize "Irrigation Management Transfer" from the State Department to Water User Association / Water User Cooperative Society – a paradigm shift from state management to user institutions. A high participation in off-farm employment among WUA members, and hence a low reliance on agricultural production, may reduce the incentives of group members for improving agricultural water use efficiency. The impact of WUAs on farm production, income and water savings is examined by Wang et al. (2005, 2006, 2010). These studies find that WUAs have not been universally successful in either saving water or improving farm incomes, and link the performance of water management systems to the incentives that these new institutions provide to water managers. Empirical research that identifies the relative importance of different factors influencing water use efficiency through user-based water management is needed to underpin such policies.

OBJECTIVES:

1. to discuss the characteristics of WUAs and the impact of such characteristics on the water use efficiency of the selected farms.
2. to examine the participation of farmers under WUAs in the Periyar-Vaigai river basin.

METHODOLOGY

Based on the coverage of Water Users' Association Theni District have been purposefully selected for studying their impacts, user group and characteristics of WUAs. In this area Periyar-Vaigai river basin have been selected. To fullfil the objectives, the study focused on 60 farmers under WUAs and 40 famers under Non-WUAs which is covered under this river basin and thus making the total sample size to 100 farmers. Cluster analysis was used to classify explanatory variables which group together signifying a unified dimension to classify objects of analysis to relatively homogeneous groups called clusters. Objects in each cluster tend to be similar to each other and dissimilar to objects in the other clusters. Set of variables or characteristics representing the objects to be clustered were used to calculate the similarity between objects.

Results and Discussion:

The results of the DEA of banana farms are given in Table 1. The estimated technical efficiency ranged from 0.59 to 1.00 and 27.14 per cent of the farms were operating at the technical efficiency range of above 91-100 per cent. The mean technical efficiency range of 0.82 for all the farms indicates that the output can be raised by 18 per cent by following efficient crop management practices without increase in the level of application of inputs.

Table 1. Efficiency level of overall Technical efficiency, Allocative efficiency and Cost efficiency of Banana farms

Sl.No	Efficiency Range	Technical Efficiency		Allocative Efficiency		Cost Efficiency
		Mean TE efficiency	**No of farmers in per cent**	**Mean TE efficiency**		
1	Less than 60	0	0.48	0	0	5.71
2	61-70	0	18.10	0	0	33.80
3	71-80	0	28.57	0.47	0	26.66
4	81 - 90	0	25.71	40.47	0	28.09
5	Greater than 90	0	27.14	59.04	0	5.71
	Mean TE	**0**	**0.82**	**0.91**	**0**	**0.75**

Source: David Chella Baskar (2014)

Similarly, the allocative efficiency score ranged from 0.80 to 1.00 with mean efficiency score of 0.91. About 59.04 per cent of the sample farmers were allocatively efficient in the range of 91-100 and no farms were noticed below the range of 70 per cent. This result revealed that 9 per cent of the resources were inefficiently allocated relative to the best- farmed practices producing the same output and facing the same technology in the study area. This advocated that allocative efficiency among the respondents could be increased by 9 per cent in the study area through the better utilization of resources in optimal proportions for crop production with the current state of technology. This would enable farmers to equate the marginal revenue product of input to the marginal input cost, thereby improving the farm income.

Table No:2 Characteristics of WUA based on their command area in Periyar-Vaigai River Basin:

S.No	Characteristic of the Association	Association Below the Command area (Below 1500 acres) Number of Association-19	Association Above the Command area (Above1500 acres) Number of Association-11
1	Area under Paddy during summer season in %	30.5	26.7
2	Percentage of membership (%)	57	42
3	Number of farmers in the societies area	198	156
4	Total fund available with the society per farmer (Rs.)	280	185
5	Number of borewells in the command area (No.)	10	11

Source: David Chella Baskar (2014)

From the Table No.2 it could be inferred that the associations below 1500 acres cultivate paddy during summer which covers of 30.5 per cent and the water release form the command area were distributed towards these area for effective utilization of water during summer season. As the participation of the farmers were more in numbers (198) the strength of the association show a positive impact on the water distribution and allocation. Even though the association below the command area possesses more financial contribution, but the participation on cultivating the paddy was high when compared to the associations which are below 1500 acres.

Table.No:3 Zero-order correlation of characteristics of respondents with their efficiency of water use for Banana:

Variable No	Independent variables	Correlation coefficient
X1	Age	0.112*
X2	Education	0.314**
X3	Occupation	0.58

X4	Farm Size	-0.006 NS
X5	Farming Experience	0.213*
X6	Annual Income	-0.023NS
X7	Cropping Intensity	0.046NS
X8	Irrigation Intensity	0.124*
X9	Productivity	0.031NS
X10	Source of Irrigation	-0.002NS
X11	Social Participation	-0.054NS
X12	Risk Awareness	0.063*

** Significant at 1 per cent
* Significant at 5 per cent
NS Non-significant

Out of the twelve independent variables taken for analysis, age, education, farm size, farming experience, irrigation intensity and risk awareness were found to have positive significant relationship with the efficiency of water use in the selected area.

Farming experience showed a positive and highly significant relationship with the efficiency of water use for paddy crop. Most of the respondents were having high to medium level of experience. This might have influenced them to greater water use efficiency in paddy farming. As the farming experience increases their experience made them efficient to use the available water.

Irrigation intensity showed a positive and highly significant relationship with the efficiency of water use for paddy crop. As the irrigation intensity increases the efficiency of water use also increases because they get water from different sources. This result showed parallel with the findings of Vignesh (2006).

As far as Age is concerned it showed a positive and highly significant relationship with the efficiency of water use for paddy crop. As the age increases their experience influenced them to use the available water in a efficient way.

Educational status was found to have positive and highly significant relationship with the efficiency of water use for paddy crop. Obviously, educated respondents develop a positive attitude towards efficiency of water use.

Risk Awareness showed a positive and highly significant relationship with the efficiency of water use for paddy crop. Risk orientation develops the respondent's ability to face the odds in farming. Thus, increase in risk awareness increases the efficiency of water use of respondents.

Conclusion:

This study has analyzed the characteristic and participation of water users association formed in Periyar-Vaigai River Basin of Theni District of Tamil Nadu. Most of the WUAs showed an active participation in the allocation and distribution of river water but there is lacuna in conducting meetings regarding the general body. The association however contributing to resolve the conflicts between the farmers but showed a least interest in conducting the meetings. The WUAs functionaries perform their activities under the supervision of the president on periodical basis. With all the odds being faced by the association, the study has revealed the potential of water users' association in canal water distribution in the selected area.

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42.

Thematic Representation Of Sediments Distribution In Pichavaram Mangrove Forest

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Abstract: The purpose of this study was to present the substance classification of heavy metals of Riversediments at Pichavaram Mangrove Forest Lakein the Chidambaram, Tamilnadu, India. The quality of water commonly reflects the force of seawater and the uppanru estuary encroached by evaporation and in situ energy content which is accumulated during a given period of time. The biological process controlling the exhaustion and oscillation of dissolved silica. Nitrate and phosphate are derived from fertilizer input which is being used in nearby agriculture fields. Deforestation and re deferment processes causes the unreliable range of Total Suspended matter (TSM). Sand and silt occupies 80-93% of the total sediments. The fluctuations of chemical concentrations were identified in the water and the sediments combination. Unique chemical behaviour of sediments can be seen from heavy metals enrichment of the samples. To show the distribution of heavy metals in the area, thematic process was carried out by using ARC GIS 9.1 software.

Keywords: Heavy Metals, Biological Process, Total Suspended Matter, Arc GIS 9.1.

INTRODUCTION

The mangrove eco system are a group of trees and shrubs that live in the coastal intertidal zone and also holds and stabilize the atmosphere from erosion. Mangroves will act as a safeguard zone between land and sea to protect land from natural disasters such as cyclone, Tsunami etc in a sea shore. The protected baggy water circumstances in the mangrove eco system allows thedeposition of fine particles typically enhanced with metals,high in organic matter and minerals. This pichavaram mangrove forest provide a suitable spot to study a number of progressions thatare significant in understanding hydrogeochemical processessuch as water and sediments chemical exchange between them, mixing , dissolution and evaporation. In a tropics and sub tropics region the mangrove forest will occur worldwide mainly between 25⁰ N and 25⁰ S. The total mangrove forest area of the world in 2000 was 137,800 square kilometres (53,200 sq mi), spanning 118 countries and territories

(Wikipedia). Sediments can be formed by three process. They are Bed load, Suspended load and wash load. In our study area suspended load takes place.Pichavaram mangroveis specifically encircled by ten fishing villages, agriculturalland and prawn culture ponds as wellas habituallyfascinatinga large number of tourists. The mangrove system experiences physiochemicalchanges remaining to the contribution of rivers Coleroonand Vellar and seawater, along with catching fish,population increasing, and other pollutions originating from human activities. The plant communities and bacterial profusionof pichavaram mangrove forest have been clearly studied. There is no other meticulous practical evidenceon the environmental geochemistry of the Pichavarammangroves; hence, the present work reveals in detail the variation of sediment characteristics and chemistry. Sediments will affect the penetration of light, transport of nutrients, shoreline morphology and other coastal processes.So that we are in the need to estimate and to reduce the concentration of suspended sediments along the pichavaram mangrove forest.

STUDY AREA

Pichavaram is located in Chidambaram region under Cuddalore District, Tamilnadu,between latitude 11°20' to 11°30' north and longitudes 79°45' to 79°55' east. Pichavarammangrove forest is located between two noticeable estuaries, the Vellar estuary in the northdirection and Coleroon estuary in the south direction. Pichavaram forest has been declared as areserved forest by the Forest Department, Government of Tamilnadu on 15th December 1987.The total area of pichavaram mangrove creek is about 2335.5 ha and which about only241 ha is occupied by dense mangrove forest. Pichavaram Mangrove creek has been divided into three zones Agricultural zone, wetland zone, vegetated and non-vegetated zone. There areplentiful creeks, gullies and canals circumnavigating the mangroves with a dispersion fluctuatingfrom 0.5 to 1.5 m and discharging freshwater into the system. The mangrove soil usually consistsof alluvium derived from the mangrove plants. In our study area 10% of the area is covered bymud flats, sandy and salty soils, 50% of the area covered by forest and the rest 40% of the areacovered by water. The land use of pichavaram mangrove creek are listed below. (Government ofIndia- Report on visit to Pichavaram in Tamilnadu. A compact vegetation of mangroves of Rhizophora apiculate Blume, A. officinalis L.,Bruguiera cylindrical L. (Bl.) and Ceriops decandra (Griff.) Ding Hou are found in this area. TheAtmosphere temperature varied from 20.0°C to 34.0°C. The Rainfall varied from 10 mm *to 936.6mm. Surface water temperatures varied from 27ºC to 38ºC and from 26ºC to 37ºC (Ashok PrabuV et.al.)*

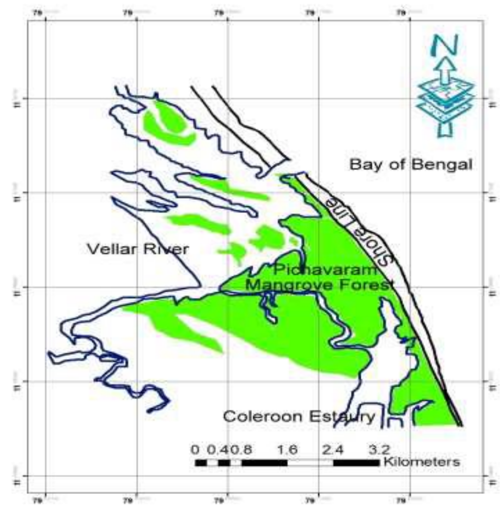


Fig 1. Study Area

MATERIALS AND METHODS

The periodic and spatialchangeability in a number of parameters has been studied by using sampling strategy. Consequently, to betterunderstand of the several progressions operating in thistropical ecosystem, sampling was carried out in the Pichavaram mangrove forest during the month of January 2016. In polyethylene bottle, ten water samples end surface sediments, seven suspended sediments and two coresample were collected in direction to inspect the naturaland anthropogenic impacts of mangrove water was collected. Immediately after the collection of samples, pH and alkalinity were measured by using portable pH meter. From the dry part of the mangrove channel, the surface sediments were collected very near in the river body. The top layer was removed and the representative samples was taken for the analysis. For the analytical work, the major sediment sample was expurgated into sectors of 0-7 cm. By the use of 0.45-mm celluloseacetate membranes, the water samples were filtered. At 47ºC in acold room within a week of sampling, suspendedand surface sediments were conserved. Standard sieving can be used to separate the sediments by size fractions.Attenburgcylinder method based on Stokes' law will be used to separate the fraction of 37m sediments.X-ray diffraction (Systronics) with CU-Ka radiation utilizing an Nifilter can be used to determine themineral compositions. Arc GIS 9.1 was used for the thematic representation of sediments which is evenly distributed along the mangrove eco network.

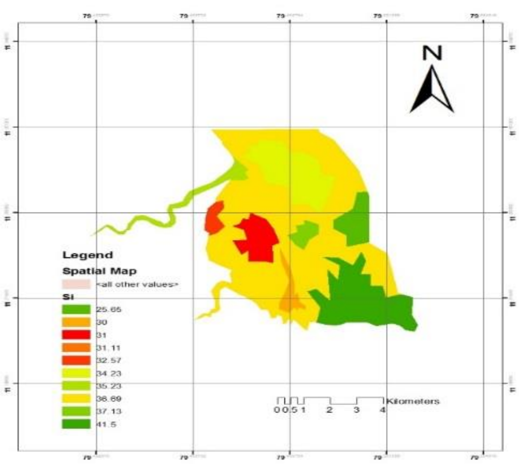
Topographic map downloaded from USGS earth explorer has been georeferenced and digitized before the derivation of the Thematic distribution map.

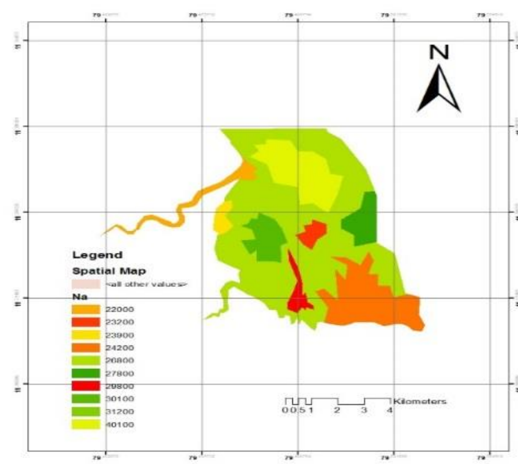
RESULTS AND DISCUSSIONS

Sample	Si	Na	K	Ca	Mg	Cd	P	Ni	Mn	Fe	Cl	Cu	Zn	Pb	Al
A I	36.69	26800	7980	9647	4272	6	291	80	385	29100	89	24	50	8	18.16
A II	31.11	31200	9942	9762	4900	7	301	44	860	35400	122	26	63	10	18.00
A III	34.23	40100	7173	8922	4164	9	361	38	943	29300	182	47	95	11	16.32
A IV	30.00	29800	6943	8840	4092	8	120	65	909	27600	131	48	88	12	16.11
A V	41.50	24200	6021	9100	5200	7	353	71	708	23400	120	64	110	15	22.10
A VI	31.00	30100	9600	9022	4092	6	361	57	687	24600	162	69	81	12	15.48
A VII	37.13	23200	5900	9421	4547	5	215	50	866	20300	186	4	102	14	20.10
A VIII	25.65	27800	7640	8740	4061	3	350	49	119	31000	43	7	52	8	18.12
A IX	35.23	22000	5100	7621	5112	4	378	84	121	16200	42	11	59	9	25.62
A X	32.57	23900	5622	8061	3892	2	181	86	86	25900	46	20	68	3	14.01

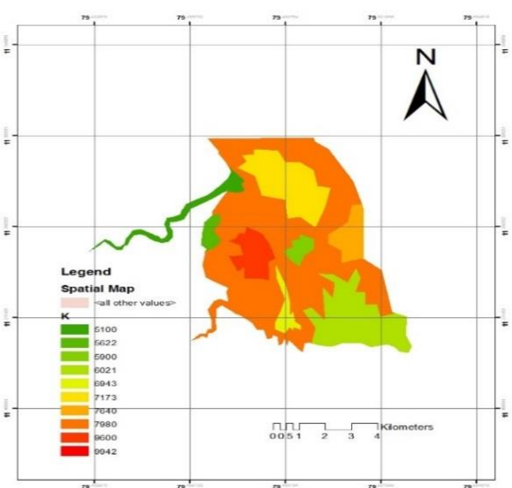
Table 1. Chemical composition of sediments in Pichavaram mangrove [µg/g except for Si, Al (%)]

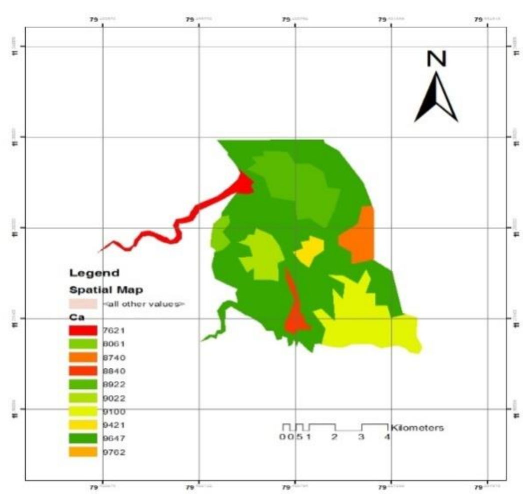
Table 1 summarizes the configuration of the surface water which have been taken for the analysis. Figure 2, shows the thematic representation of the chemical parameters of the surface water. From the results it is observed that pichavaram mangrove forest is alkaline in nature without any seasonal changes in it. The reason for higher value of pH is the mixing of sea water with estuarine river water and shifting of high alkalinity is due to the mangroves photosynthetic activity which utilizing co_2 *for their mechanism. Chloride and sulphate subsidize 75% of the total ions in the mangrove water sample. Higher chloride concentration due to the saline soils and saline ground water in the drainage areas. Sodium values ranges from 20100 to 40100 mg/ltr produced from the earth's crust and the mixing of sea water into the estuary of river. Silica is naturally occurring compound found in sand and quartz and its* *values are ranges from 30 mg/ltr to 41.50 mg/ltr. Organic matter (OM) concentration ranges from 5.5% to 15.4%. Organic Matter content is higher inthe inland channels.Organic matter* *substances of the Vellar and uppanaru estuaries are comparatively lesser than themangrove sediments.*



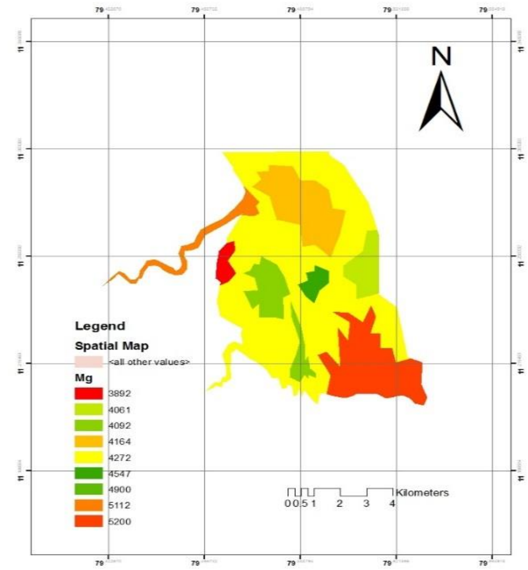


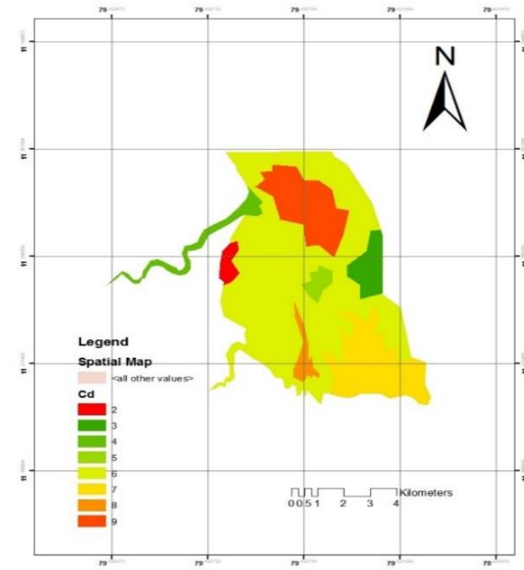
a) Si map ***b)Na map***



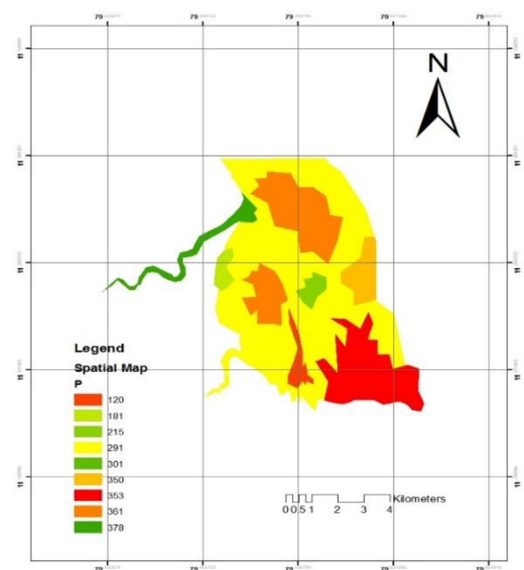


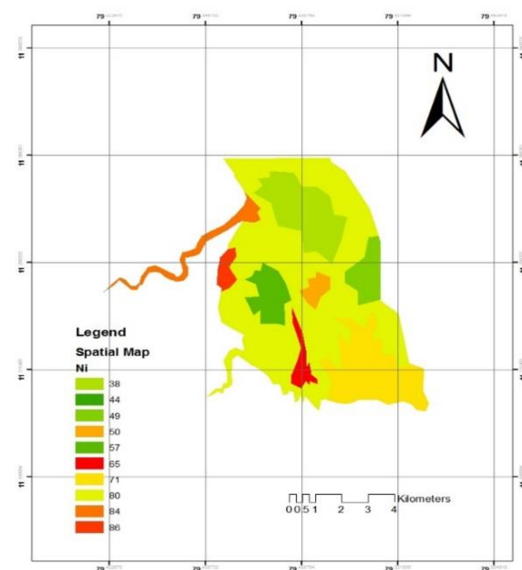
c) K mapd) Ca map



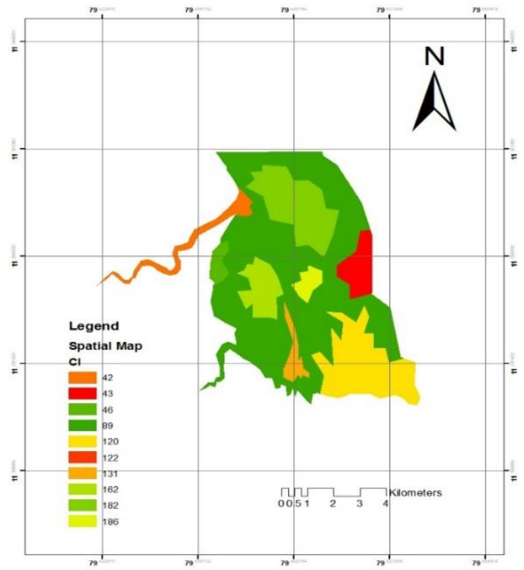


e)Mg map ***f)Cd map***

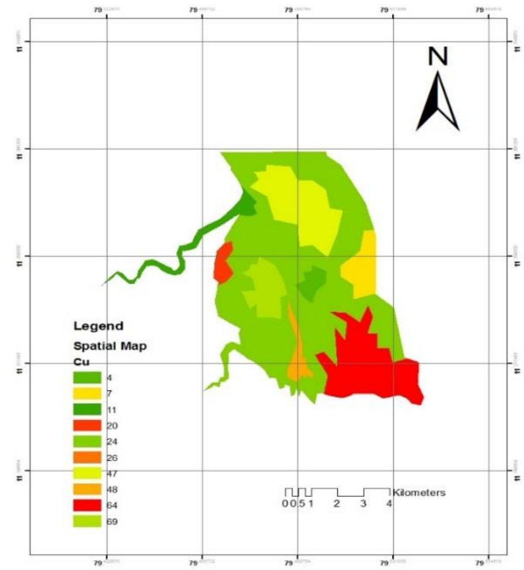




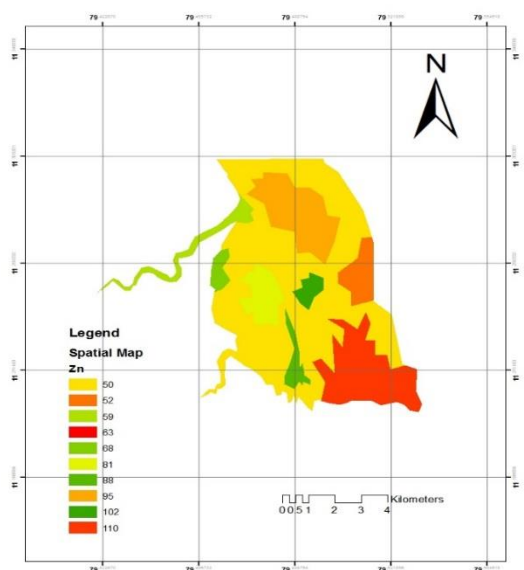
g) P map ***h) Ni map***



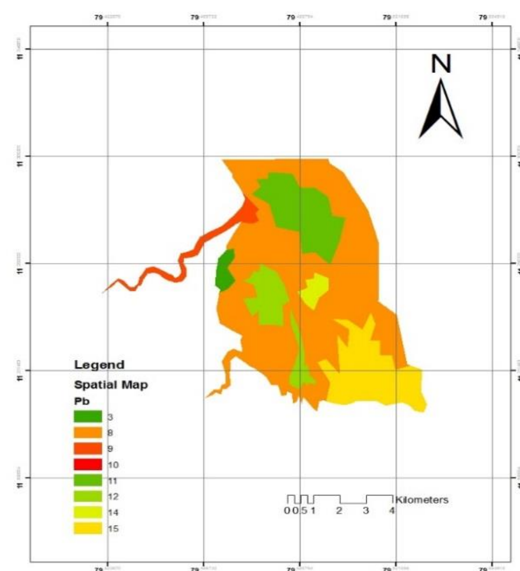
i) Cl map



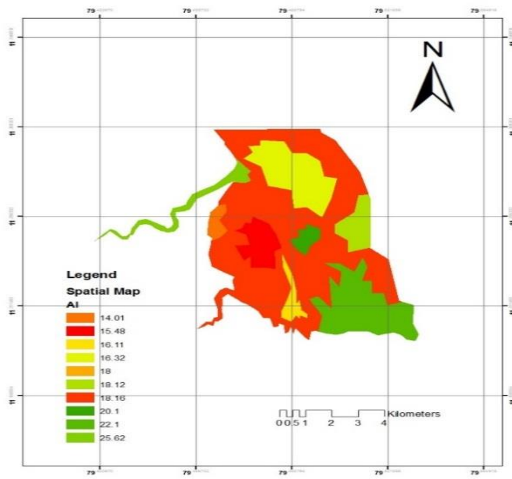
j) Cu Map



k)Zn map



l)Pb map



m) Al map

Figure 2. Spatial Maps of Various components of Sediments Pichavaram Mangrove Forest

The spatial variations of the Si, Na, K, Ca, Mg, Cd, P, Ni, Mn , Fe, Cl, Cu, Zn,Pb, in the mangrove and in themanipulating zones of the inlet, especially near Uppanaru,were significantly different.This perceived that the higher concentration of Fe in the mangrove sediments is a consequence of the textural and mineralogical appearancesof the mangrove sediments. From this experiment the dominant species were identified as that of clays and feldspar present in the sand and silt size populations of the sediments due to its characteristics.

Variable	Analyzed results	Permissible limits (For Irrigation)
Si	34 %	1.05 % (10500 PPM)
Al	17.6 %	0.0020 % (20 mg/ltr)
Mg	4.672 mg/ltr	10 mg/ltr
Fe	32.48 mg/ltr	20 mg/ltr
Zn	0.093 mg/ltr	10 mg/ltr

Pb	0.011 mg/ltr	10 mg/ltr
Cd	0.0066 mg/ltr	0.05 mg/ltr
Ni	0.062 mg/ltr	2 mg/ltr
Co	0.0353 mg/ltr	5 mg/ltr
Cr	0.1496 mg/ltr	1 mg/ltr
Cu	0.0435 mg/ltr	5 mg/ltr
Na	28.205 mg/ltr	70 mg/ltr
K	8.246 mg/ltr	20 mg/ltr
Mg	4.672 mg/ltr	25 mg/ltr
P	0.3056 mg/ltr	0.4 mg/ltr
Mn	0.941 mg/ltr	< 0.2 mg/ltr

Table 2. Comparison of Analyzed results with irrigation permissible limits

Mn is thenext profuse heavy metal followed by Cr, Zn and othermetals such as Na, Ca, P and Ni.The meditations of heavy metals in this study werenormally below the levels found in permissible limit of irrigation water usage. Even though, certainlocations in the privileged undistributed channels have difficult deliberations of metals. The difficult deliberationswere irregular and vary from one metal to another. This supports the exceptional chemical behavior of themangrove sediments.To determine the textural and depositional characteristics, grain size measurement was useful. The chloride content is conservatively acting with the metals concentrations of the surface sediments because of the fluctuation of metals present in the suspended sediments producing deposition and metal enhancement in the chemical comportment. To find the impact of agriculture, urban and other man made activities in the recent past inthis ecosystem, the alluvial core chemistry has been studied.Si, Al, P and Cd show an increasing movement and Fe, Cu and Pb shows a decreasing movement withpenetration of its capacity.

CONCLUSION

Silica in the mangrove is to be controlledby genetic processes. From all those results it was observed that theNitrate and phosphate aresubsidized from manmade sources. Sodium isthe foremost cation followed by Mg, Ca and K.Deforestation,tidal and airstream action is the reason for the behavior of unreliable TSM.Sand and silt found 69.5 ± 92% of the mangrove sedimentsfollowed by clay. Chemical analysis of the sediments suggestthat the mangrove is *relatively unpolluted, withunique chemical behavior.The fundamental sediment interactionrecommends that the lesserinvolvement of metals is associated with detrital due to barrierconstruction.The study exposesthat the slighter impact of manmadesignatures in the Pichavaram mangrove eco network.*

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43.

Waste Water Treatment Using Membrane Bioreactors – A Review Study

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ABSTRACT

This review study will demonstrate the importance of MBR in treatment of wastewater. With the increase in harmful effluent discharge into water, reducing contaminants is the need of the hour. Biological methods like MBR are the most economical and environment-friendly. Membrane bioreactors(MBR) consist of a combination of membrane separation technology and biological treatment. It has been used in the treatment of industrial wastewater, pharmaceutical wastewater, municipal wastewater, household wastewater among others. MBRs can be used to produce high quality effluent which has the potential to be reused. This is advantageous over the conventional activated sludge processes of wastewater treatments as this ensures better water quality by strengthening the function of the bioreactor through increasing the concentration of the activated sludge. MBR allows conventional plants to become single step processes. This review will shed light on the various studies involving industrial waste water management using MBR and it also includes the strategies to achieve enhanced biodegradation of industrial pollutants using MBR.

KEYWORDS

Membrane bioreactor, Wastewater treatment, MBR, Membrane fouling, Membrane

CHAPTER 1.1

INTRODUCTION

There is no infinite source of utilisable water. The discharge standards of effluents into water has been strengthened. Reducing pollutant discharge into water is the need of the hour.

Various conventional processes like activated sludge processes have disadvantages and are not reliable. Biological treatment methods are the most economical and environment friendly. So the latest technology, MBR uses membranes to filter and separate contaminants from water.

1.1.1 NEED FOR THE REVIEW

There have been several studies using MBR for the treatment of industrial wastewater, municipal wastewater, pharmaceutical wastewater, dyeing and printing wastewater, household wastewater among others. There has also been research done extensively in the treatment of pharmaceutical wastewater using conventional treatment methods in combination with MBRs.

If treatment of water using MBR as a single stage was possible, then this would be a major breakthrough in the treatment of waste water treatment. This review substantiates some of the researches done on this topic and provides a scope for future projects.

1.1.2 OBJECTIVE OF THE REVIEW

The objective of this review was to shed light on the various studies involving industrial waste water management using MBR and it also includes the strategies to achieve enhanced biodegradation of industrial pollutants using MBR.

1.1.3 MEMBRANE BIOREACTORS

Membrane bioreactor technology is a modern technology used for wastewater treatment over activated sludge processes [1]. It is a combination of membrane separation technology and new bioorganic wastewater treatment technology (biological treatment) [2].

Organic molecules are trapped in place of the secondary settling tank. This increases the concentration of the activated sludge and ensures better water quality, thereby strengthening the function of the bioreactor. Operating as an MBR allows activated sludge plants to become single step processes, hence producing high quality effluent potentially suitable for reuse. [3]

Table 1.1 Overview of various types of wastewater investigated by MBRs

Type of wastewater	Author/year
Beverage and Food Wastewaters	Sridang et al. (2006), Matošićet al.(2009)
Dyeing and Printing Wastewaters	Zheng and Liu (2006), Yun et al. (2006)
Household Wastewater	Yeom et al. (1999)
Industrial Wastewater	Khor et al. (2006)
Mineral Oil Wastewater	Bienati et al. (2008)
Municipal Wastewater	Huang et al. (2001), Pollice et al. (2004), Kimura et al. (2005), Laera et al.(2005), Wang et al. (2006), Kim et al. (2007), Pollice et al. (2007), Qin et al. (2007), Choi and Ng (2008), Ferraris et al. (2009), Malamis et al. (2009), Qu et al. (2009)
Petrochemical and Polymeric Wastewaters	Chang, CY., et al. (2006), Qin et al. (2007 a)
Piggery wastewater	Kornboonraksa and Lee (2009), Prado et al. (2009)
Pharmaceutical Wastewater	Benitez et al. (1995) Chang et al. (2008) Chen et al. (2008)
Textile Industry Wastewater	Yigit et al. (2009)

CHAPTER 1.2

MBR TECHNOLOGY

Membrane bioreactors are used for wastewater treatment in which a permeable selective membrane is integrated with a biological process of treatment – a bioreactor

1.2.1 MEMBRANE

A membrane is a semi permeable material which allows certain physical and components to pass more readily than others. Hence it is a semi-permeable membrane, those which pass through readily are called ‘permeate’, while those retained are called ‘retentate’. Figure 1.1 shows the evolution of membranes in a bioreactor.

1.2.2 WHY MBR IS BETTER

MBR technology has several advantages over the activated sludge processes. Some of them are: [4]

- High quality effluent
- Shorter hydraulic retention time (HRT)
- Higher volumetric loading rates
- Longer solid retention time (SRT)
- Potential for simultaneous nitrification
- Less sludge production

1.2.3 ADVANTAGES OF MBR

Excellent effluent quality (reusable)

Independence between HRT and SRT

High loading rate

Small foot print

No sludge bulking risk

Low sludge production

Possibility to grow specific microorganisms

Treat wastewater under extreme conditions

Flexible modular design

1.2.4 DISADVANTAGES OF MBR

High capital cost, no economy scale

Complicated control system

Inevitable membrane fouling

Low oxygen transfer efficiency

1.2.5 MEMBRANE FOULING

Membrane fouling refers to the adsorption of materials on or within the pores. It is one of the most common problems faced in all filtration processes. This is a costly process problem. Fouling can cause a loss of permeate quality and detoriation of the membrane. This could be caused by suspended solids, colloids, deposition or growth of microorganisms or scaling by salt precipitation [5].

There are four different kinds of fouling. Figure 1.2 shows the different types of fouling.

Figure 1.1: Evolution of membrane use in conjunction with bioreactor.(S. Fazal et al)

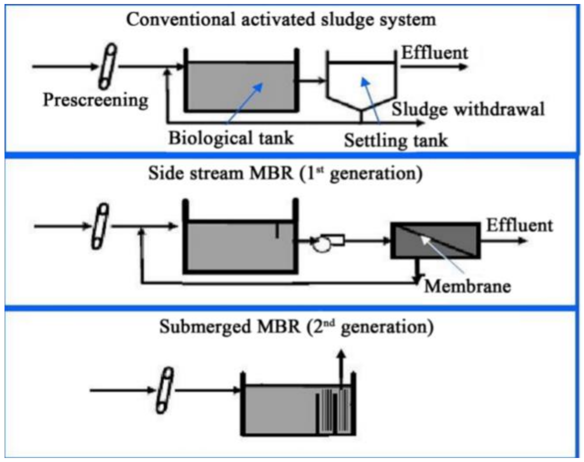
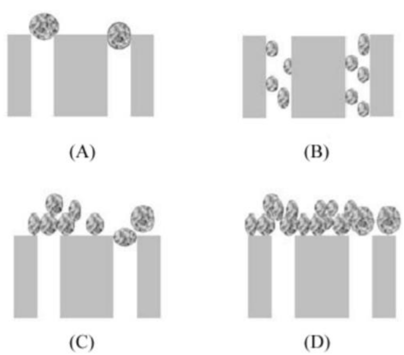


Figure 1.2 Schematic diagram of the fouling mechanism: (A) Complete blocking; (B) Standard blocking; (C) Intermediate blocking; (D) Cake filtration (Jiang, T, 2007)



CHAPTER 1.3

TREATMENT OF WASTEWATER USING MBR

1.3.1 DYEING AND PRINTING WASTEWATER

A research team used a laboratory-scale MBR, which was fitted with a gravity drain for treating dyeing and printing wastewaters from a wool mill. An anaerobic tank was added to improve its efficiency and decolorization of the wastewaters.

Membrane used was made of polyvinylidene fluoride (PVDF). The average concentrations of BOD, COD, turbidity and colour in the effluent were 3.7 mg/L, 36.9 mg/L, 0.2 NTU and 21 dilution times (DT), respectively. It was concluded that due to the compact design, simple operation and easy maintenance, the system had low energy consumption and was cost effective to build and operate. [6]

1.3.2 MUNICIPAL WASTEWATER

Another group of researchers worked on and treated municipal wastewater using a bench scale MBR, using a hollow fibre membrane. This reactor was operated for 60 days. It was concluded form their study that the reactor showed fast start-up and the removal efficiency of COD averaged between 87-94% [7]

The long-term investigation of biological processes and biomass characterisation was done using a Zenon hollow membrane for 366 days by Laera et al. Substrate removal efficiencies and biomass related parameters were measured to study the biological processes. This MBR showed good removal efficiencies (SS > 99%, COD 86%, total nitrogen 98% and ammonia 99%) and reached equilibrium conditions. This study showed that the equilibrium condition was able to hold for 150 days confirming that equilibrium had been established between metabolism, biomass growth and inorganic materials. [8]

1.3.3 BEVERAGE WASTEWATER

The results from treating wastewater from the bottling of water and soft drinks using a pilot-plant MBR with a hollow membrane was reported by Matošić et al. they concluded that the MBR removed pollutants successfully from the wastewater measured as COD, BOD and TOC with an efficiency of over 90%. [9]

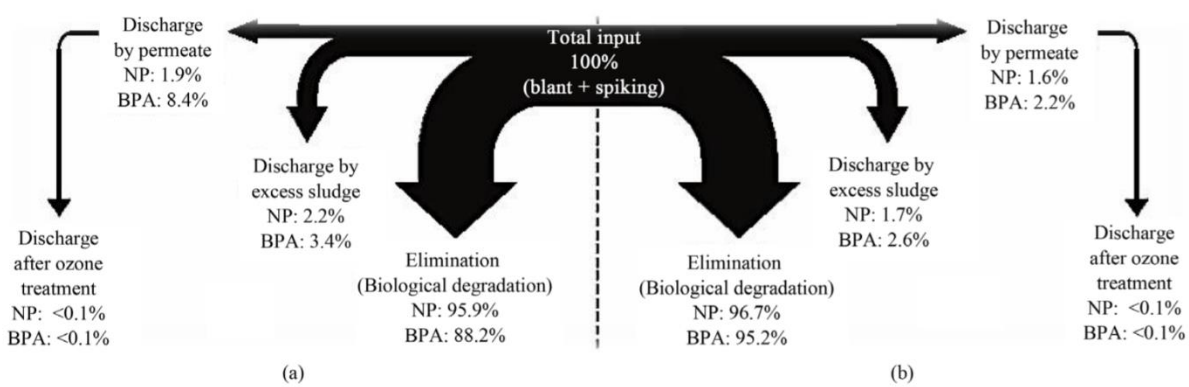
1.3.4 INDUSTRIAL WASTEWATER

The performance of MBR in the removal of EDC was investigated by another group. Endocrine disrupting chemicals are potentially harmful chemicals that are generated during wastewater reclamation. One good example is Bisphenola (BPA), which is used to synthesize flame retardants and dental sealants. BPA removal using a submerged MBR was studied and the results showed that biodegradation dominated the BPA removal process. [10]

Figure 1.3 shows the comparison of the removal of two EDC using conventional methods and MBR methods.

Figure 1.3 Mass flow chart demonstrating the fate of two micropollutants [4-nonylphenol (NP) and bisphenol A (BPA)] during treatment by **(a)**conventional, **(b)**MBR process, and after subsequent O3 treatment steps.

Source: S. Fazal et al



In another study using a pilot scale MBR, the authors concluded that MBR was more effective in removing cholesterol, stigmasterol and BPA to low ng/l levels when compared to a full-scale conventional activated sludge process which received the same wastewater. They collected their result that the lower effluent concentration was because of the efficiency of the membrane. [11]

1.3.5 PHARMACEUTICAL WASTEWATER

The treatment of industrial pharmaceutical wastewater was studied using a pilot-scale submerged MBR with a hollow fibre membrane having a pore size of 0.1µm. It was demonstrated that the system removed 99% and 95% of BOD and COD respectively. [12]

Benitez et al. studied the combined stabilisation and dewatering of industrial pharmaceutical wastewater using a microfiltration unit inside a bioreactor using a hollow membrane of pore size 0.1µm. the experiment was carried out for 62 days and the average COD removal during the experiment was found to be 63%, which maximised at 86%. [13]

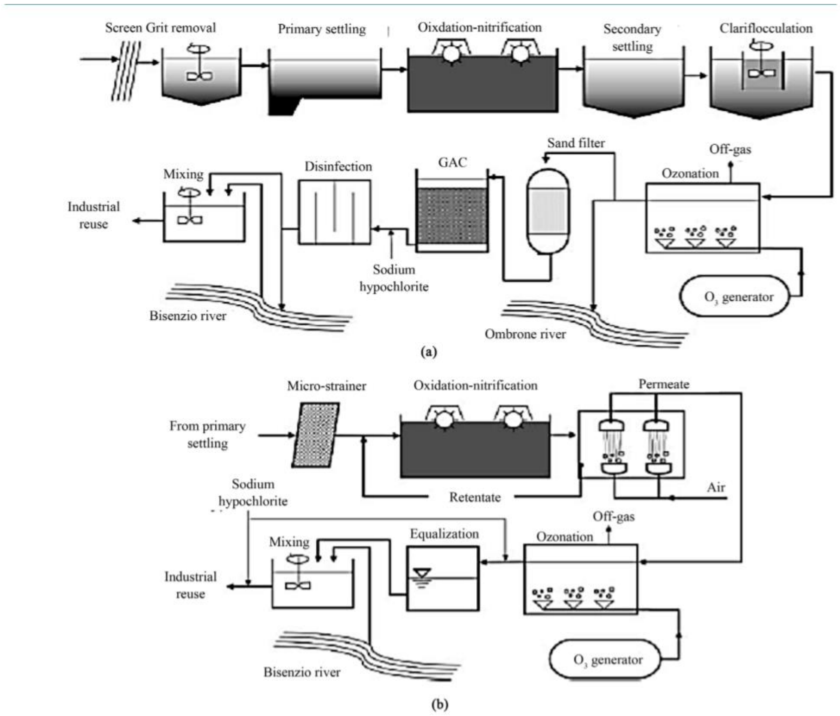
1.3.6 TEXTILE INDUSTRY WASTEWATER

The performance of a pilot-scale MBR in the treatment of concentrated wastewater generated from wet processes of dyeing, finishing and sizing was studied by a group of researchers in a denim producing textile industry. The MBR had a submerged hollow membrane of pore size 0.04 µm and the reduction in COD was found to be in the range of 13 – 60 mg/L from the influent value of 686 – 2278 mg/L. [14]

Figure 1.4 shows the comparison of the treatment processes of textile wastewater using conventional process and MBR process. The MBR process is more compact.

Figure 1.4: Schematic of two textile wastewater treatment options: **(a)** Conventional elaborate process **(b)** MBR based compact process

Source: S. Fazal et al



1.3.7 TANNERY AND WINERY WASTEWATER

Using a Zenon submerged membrane bioreactor, Artiga et al. studied its performance in treating winery wastewater. The influent range of COD was of the range 1000-4000mg/l. The COD removal efficiency in less than 10 days after the start-up was 97% lesser. [15]

1.3.8 HOUSEHOLD WASTEWATER

Using a submerged MBR with a hollow membrane made of polyethylene with pore size of 0.1µm, Yeom et al. treated household water including toilet flush water. It was studied that 96% total chemical oxygen demand 100% SS from the household wastewater and the total average efficiency was reported to be 83%. [16]

CHAPTER 1.4

1.4.1 CONCLUSION

Based on the literature review, the following conclusions have been made:

1) MBR is extensively being used in many developed countries for the treatment of various kinds of wastewaters. Though not very common, it is being studied and used in developing countries like India.
2) There have been cases where MBR has been used in combination with other conventional activated sludge processes. The result has been significantly better than using only MBR or only conventional methods.
3) Using MBR as a single stage process for the treatment of pharmaceutical wastewater is still under study and research is on in this field of study.
4) Studies have been carried out in the treatment of municipal wastewater, tannery and winery wastewater, household wastewater, textile industry wastewater, beverage wastewater and dyeing wastewater. But not much extensive studies have been carried out in treatment of pharmaceutical wastewater.

1.4.2 FUTURE SCOPE

Based on the review conducted, it has been observed that there is a great potential for research on treatment of wastewater generated from any source using MBR technology.

MBR technology could be the future of wastewater management and treatment in the world as it produces reusable water and the process is very compact compared to the conventional processes of activated sludge.

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CHAPTER 1.6

APPENDICES

1.6.1 LIST OF FIGURES

1.6.2 LIST OF ABBREVIATIONS USED

S.No.	Abbreviation	Full Forms	S.No.	Abbreviation	Full Forms
1	BOD	Biological Oxygen Demand	**7**	MBR	Membrane BioReactor
2	BPA	Biphenola	**8**	NP	4-nonylphenol
3	COD	Chemical Oxygen Demand	**9**	NTU	Nephelometric Turbidity Unit
4	DT	Dilution Time	**10**	PVDF	Polyvinylidene Fluoride
5	EDC	Endocrine Damaging Chemicals	**11**	SRT	Solid Retention Time
6	HRT	Hydraulic Retention Time	**12**	TOC	Total Organic Content

44.

Water Hyacinth As Natural Source For Waste Water Treatment

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ABSTRACT

Water hyacinth (*Eichhornia crassipes*) is a free floating perennial aquatic plant. An investigation was conducted by using water hyacinth aquatic plants as a post-secondary wastewater treatment process. The plant has a high capacity for the uptake of heavy metals which could be make it suitable for the bio-cleaning of industrial waste water. It removes cyanide which is environmentally beneficial. It removes arsenic from arsenic contaminated drinking water and keeps water clean. It can remove pesticides from contaminated water. It can be used for removing radioactive contaminants from nuclear power plant waste water. These systems substantially reduced ammonia concentrations by more than 70% in non-aerated ponds and 99% in a pond with supplemental aeration. Total nitrogen reductions were approximately 55 % and 70% for the non aerated and aerated ponds, respectively. Using water hyacinth in waste water treatment is a suitable ecotechnology due to reduced footprint, energy savings, and increased quality effluent. Water hyacinths can be cultivated for waste water treatment.

KEY WORDS: water hyacinth, aquatic plant, aeration, energy saving

INTRODUCTION

One of the most serious threats to the ecosystem is Sewage wastewater discharge. A proper treatment is needed before the waste water is released in to the environment [1]. A large number of technologies, such as oxidation ponds or activated sludge processes, have been applied for domestic wastewater treatment but most of these practices are expensive to erect and run [2]. Accordingly, there is a need for a substitute system to overcome these drawbacks and achieve a high elimination rate of pollutants. In recent years, the application of constructed wetlands (with rooted, emergent and free-floatingaquatic plants), and facultative ponds treating domestic sewage have attracted considerable attentionbecause they offer an environmentally sound approach [3–6]. The mechanisms of pollutant removal inconstructed wetlands involve an interaction between the bacterial metabolism, plant uptake andaccumulation [7]. The impurities are removed in facultative ponds entirely by natural processesinvolving both algae and bacteria [8]. In that order, vegetation is considered as a dominant feature ofconstructed wetlands, and acts as an important biotic factor in the treatment process [9]. Among thefree-floating species, the water hyacinth (*Eichhornia crassipes*) appears to be a promising candidatefor pollutant removal owing to its rapid growth rate and extensive root system [10–12]. The waterhyacinth lagoon functions as a horizontal trickling filter, where the submerged roots provide physicalsupport for the bio-film bacterial to growth [9]. Nevertheless, despite the efforts made worldwide, theconstruction of aquatic systems, particularly the water hyacinth treatment process, has not gainedmuch popularity due to the requirement of a large land area and considerable capital investment [5].

ABOUT WATER HYACINTH:

Water hyacinth (*Eichhorniacrassipes*) is a free floating perennial aquatic plant (fig. 1), native to South America. Water hyacinth is a popular water garden plant because of the beauty of its large, purple to violet flowers located on a terminal spike and its interesting floating vegetation. Many plant nurseries and big box stores sell it as an ornamental pond plant that can grow to a height of 3 feet. The dark green leave blades are circular to elliptical in shape attached to a spongy, inflated petiole. Underneaththe water is a thick, heavily branched, dark fibrous root system. The common water hyacinth is a vigorous grower known to double its population in two weeks.

Fig.1water hyacinth

WASTE WATER TREATMENT WITH HYACINTH:

“Water hyacinth has the potential to clean up various contaminated waters. It can be used to treat waste water from dairies, tanneries, sugar factories, pulp and paper industries, palm oilmills, distilleries etc. The plant can absorb into its tissues large quantities of heavy metals fromthe water column and grows very well in water polluted with organic contaminants and highconcentrations of plant nutrients. In the Ologe Lagoon, Nigeria, water hyacinth that was notdeliberately introduced into the lagoon to absorb heavy metals did so, even when theconcentration of the heavy metals in the water column was very small. While water hyacinth'scapacity to absorb nutrients makes it a potential biological alternative for treatment of agroindustrialwastewater,oneof themajorchallengesis howto properlydisposethe vastamountoftheplantmaterialswhichmayhaveto be consideredastoxicwaste."

TEXTILE WASTE WATER TREATMENT

Waste water is the major environmental issue of textile industries besides other minor issues like solid waste, resource wastage and occupational health and safety. Textile industry (and especially its part focused on the dyeing process) belongs among important sources of contamination responsible for the continuous pollution of the environment as the Textile wastewater contains substantial pollution loads in terms of chemical oxygen demand (COD), biological oxygen demand (BOD), total suspended solids (TSS), total dissolved solids (TDS) and heavy metals. These mechanisms can result from complexation, metal chelation, ion exchange, adsorption and micro precipitation. Phytoremediation is one of the waste water treatment methods by using plant based systems for removing the contaminants from various natural sources. To clean up the contaminated water, selection of an appropriate and efficient plant system is highly essential. Those plant systems should have high uptake of both organic and inorganic pollutants, grow well in polluted water and be easily controlled in quantitatively propagated dispersion.

Garg et al (2004) conducted a case study on the use of water hyacinth in treatment systems for textile mill effluents. The study was monitored for a period of one year on various pollution physiochemical parameters at the Veyangoda textile mill in Srilanka. The authors could achieve a substantial reduction in volatile solids 72.6%, dissolved solids 60%, suspended solids 46.6%, 75% BOD and 81.4% COD. An increase in organic nitrate ion concentration was seen suggesting nitrification of organic nitrogen in the medium.

Kannadasan et al., 2013 studied the effectiveness of a natural coagulant derived from a cactus species for turbidity removal from dye industry effluent. Other parameters such as pH as well as colour were also studied. High turbidity removal determined indicates that cactus (Opuntia) and water hyacinth (*E. crassipes*) have the potential to be utilised for waste water treatment applications. Similarly Shah et al., 2010 observed water hyacinth as a remediation tool for dye effluent pollution. The authors reported significant decrease in the pH, TDS, conductivity, hardness, DO, BOD, COD, nitrate nitrogen and ammonium nitrogen in various concentrations of wastewater, where the water hyacinth performed well in 25–50% wastewater and not in 75–100% wastewater. Thus the authors concluded that the water hyacinth can be utilised for treating dye waste water after dilution.

Although various physical, chemical and biological processes like reverse osmosis, flocculation, activated carbon adsorption, and microbial treatment are involved as dye treatment techniques, adsorption process plays a major role and was preferred as an promising and efficient method for the treatment of dyes and dye effluents. Various studies are reported in the literatures using different adsorbents like alumina, zeolite, and polyurethane foam etc. The disadvantages of advance technology entail high operating cost, makes them ineffective to treat the wide range of effluents. Industrial and agricultural wastes (coir pith, sun flower stalks], rice husk, neem leaves, mango seed kernel, modified saw dust, peanut hulls, pineapple stem, banana pith, orange peel, guava leaf, wheat shell, wheat bran, egg shell, corn cobs and barley husk, treated wood shavings, almond, lemon peel, degreased coffee bean, rubber wood, jute fibre carbon) as low cost adsorbents are highlighted as an economic mode of dye effluent treatment nowadays. However the adsorption capacities of the low cost adsorbents mentioned above remain elusive and are not satisfactory. Thus still the search for simple, economic, ecofriendly, and highly effective adsorbents is continuing.

E. crassipes being one of the worst weeds in the world as a vigorous grower which is known to double its population within two weeks was worked out as a cheap and easily available adsorbent for dye and effluent treatment by various researchers. The weed and its various forms, modifications have been studied for increased efficacy. However much more detailed study on various textile dyes and different modified forms will establish water hyacinth as a simple, best and economic source for dye effluent treatment in the near future.

Conclusion

Water hyacinth, the worst aquatic weed was found to be highly impossible to eradicate from the water ways, though its quest for nutrients has given a possible way for its usage in phytoremediation. In the last few years great interest has been shown for the research of water hyacinth as a good candidate for pollutant removal or even as a bio-indicator for heavy metals in aquatic ecosystems. In this present article the detailed bio-sorption efficiency of the water hyacinth in the removal of various pollutants present in textile waste water was enumerated. In conclusion, water hyacinth has high removal rates for various dye stuffs and heavy metals like iron (Fe), zinc (Zn), copper (Cu), chromium (Cr), cadmium (Cd), manganese (Mn), mercury (Hg) and arsenic (As) from aqueous solutions. Very few reports are available in the literature on the direct application of water hyacinth and its derived products in removal of dyes and heavy metals from textile effluent as well as from wastewater. This may be due to the complexity of the textile effluent and its wastewater with the various numbers of chemicals being used in the dyeing and processing units. More research is needed to achieve a greater efficiency in contaminant removal with respect to certain modifications in its functional group or various treatment procedures of the plant and its parts that can be focused upon in near future.

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45.
Water Less Dyeing Technology – A Pollution Free Dying Method

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Abstract:

Water is known as much valuable resource for existing in the entire world for its multifunctional properties. So, Scarcity of water and increased environmental awareness are world-wide concerns and that causes a sharp rise in prices for drinking and removal of water. It is well known that the textile industry is one of the largest consumers of water. Conventional textile dyeing uses huge amounts of fresh water and which then is disposed as waste water containing dyestuff chemicals. Elimination of the water process and chemicals will be a real and significant advance for the textile dyeing industry. This new process utilizes by-product carbon dioxide (CO_2) for dyeing textile-materials. It is a completely waterless dyeing process using recycled carbon dioxide in certain temperature and pressure. The supercritical fluid is used extensively, especially in substance extraction. The extraction of many substances has reached the economic-scale industrial bulk production stage. This paper discusses the development situation of supercritical fluid dyeing technique, and described the evolution of stock dyeing, measurement of solubility of dye, studies of dyeing kinetics and instrument application studies, in order to provide related data for relevant studies in further development of this technique.

Key points: Supercritical fluid, CO_2, stock dyeing, kinetics

1. INTRODUCTION

Water is known as much valuable resource for existing in the entire world for its multifunctional properties. So, Scarcity of water and increased environmental awareness are world-wide concerns and that causes a sharp rise in prices for drinking and removal of water. It is well known that the textile industry is one of the largest consumers of water. Conventional textile dyeing uses huge amounts of fresh water and which then is disposed as waste water containing dyestuff chemicals. Water is used as a solvent in many pre-treatment and finishing processes in the textile industry, such as washing, scouring, bleaching dyeing and finishing. So the experts are tried to develop a new technology to dye the textile material without using water (waterless dyeing technology). Elimination of the water process and chemicals will be a real and significant advance for the textile dyeing industry. This new process utilizes by-product carbon dioxide (CO2) for dyeing textile-materials. It is a completely waterless dyeing process using recycled carbon dioxide in certain temperature and pressure.

It is noticed that the textile industry is one of the biggest consumer of water. Every day the industry is using huge number of water for coloration the textile material. Coloration involved

• Pretreatment,

• Dyeing process and

• After treatment (Finishing).

On average an estimated 100- 145 liter of water is needed to process 1(one) kg of textile material. Water is used as a solvent in many pretreatment and finishing processes as well as coloration process, such as washing, scouring, bleaching, dyeing and to impart some special finishing effects into the textile material. Although there have been efforts to reduce the water input such as altering conventional equipment, recycling water and reusing wastewater—water usage is still high in the textile industry. So, for solving this problem the experts are trying to invent a new technology. The experts tried to find out a chemical that is capable to be liquid as well as gas in certain environment (certain temperature and pressure). Final the dream come true, a new technology has been introduced to dye the textile material without water called Supercritical Fluid Dyeing Technology. For this CO2 is used, that has capacity to be liquid and gas state in certain pressure and temperature.

As a green, safe and environmentally friendly medium, supercritical carbon dioxide fluid, which was introduced at the first time in textile dyeing as an alternative to traditional water bath by E. Schollmeyer et al., in 1988 (Bach et al., 2002) and further developed by Knittel, has been worldwide investigated and tried for textile dyeing and other applications due to its essential advantages. Dyeing in supercritical carbon dioxide has been applied on synthetic fibers and especially on polyester fabrics. As the method has gained success on polyesters, the other fibers have begun to be applied too. Natural fibers, firstly cotton, than wool and silk fibers have been dyed in supercritical carbon dioxide. Supercritical fluid CO_2 enables polyester to be dyed with modified disperse dyes. It causes the polymer to swell, allowing the disperse dye to diffuse and penetrate the pore and capillary structure of the fibres. The viscosity of the dye solution is lower, making the circulation of the dye solutions easier and less energy intensive.

Table 3. Comparison b/w conventional dyeing and supercritical dyeing

Conventional Water-Dyeing	***Dyeing in*** **supercritical carbon dioxide**
High volume of water required	Completely avoids the use of water
Produces huge effluent	No waste water at all
Wastage of valuable dyestuffs	Unreacted dye remains as powder
Requires huge chemicals and auxiliaries	No need for dispersing and leveling agents
High energy requirements	Requires only 20% energy of conventional dyeing
Dyeing, washing and drying times are 3-4 hours per batch	Only 2 to 2.5 hours per batch
Drying is required after dyeing process	Not required as CO_2 is released in gaseous state
After treatment is a compulsory step	No after treatment is required.
Water treatment (ETP) and recycling is difficult and costly	CO_2 can be easily recycled upto 95%
Dyeing factory need to establish where water is sufficiently available	Dyeing factory can be established where water is not available
Overall cost comparing to $scco_2$ is high	Machine cost is high

1.2 ADVANTAGES

- Elimination of water consumption
- Elimination of wastewater discharges
- Wastewater treatment process eliminated
- Elimination of drying and dryer effluent
- Reduction in energy consumption
- Approximately 95% of CO2 can be recycled

- Dyeing time significantly reduced
- Another advantage of this process is the non-existent drying times, which makes the process twice as fast as water-based dyes.
- This technique Improves the sustainability efforts and in turn reducing the harmful effects to people, animals and the environment that water-based dye processes have had in the past.
- Lower viscosities enabling the circulation of dye solutions easier.
- CO_2 causes the polymer fiber to swell slightly that gives a faster diffusion within the polymer.
- Faster penetration of voids between fibers because of no surface tension and the miscibility of CO_2 with air under pressure.
- Higher diffusiveness in the fluid resulting in faster mass transfer in the fluid.
- Supercritical CO_2 is ecologically harmless, non-toxic and nonexplosive.

2. SUPERCRITICAL FLUID

Supercritical fluids are highly compressed gases which possess valuable properties of both a liquid and gas. Any gas above its critical temperature retains the free mobility of the gaseous state but with increasing pressure its density will increase towards that of a liquid. The properties which are intermediate between gases and liquids are controlled by pressure. Supercritical fluids do not condense or evaporate to form a liquid or a gas. The fluids are completely miscible with permanent gases, which leads to higher concentrations of dissolved gases than can be achieved in conventional solvents. Supercritical fluids offer advantages in textile processing as they combine the valuable properties of both a gas and liquid. These fluids have solvating power or the ability to act as a solvent as well as a solute, making them desirable in the dyeing process in which disperse dyes are utilized. Carbon dioxide is the most investigated and used gas in the supercritical fluid dyeing process. It is a naturally occurring, chemically inert, physiologically compatible, relatively inexpensive and readily available for industrial consumption.

The supercritical state is sometimes referred to as the fourth state of matter. A supercritical fluid can be defined as a substance above its critical temperature and pressure. Under these conditions the fluid has unique properties, in that it does not condense or evaporate to form a liquid or a gas. Referring to the idealized pressure–temperature diagram for a pure substance shown in Figure 1, it is observed that the supercritical state exists at temperature and pressure conditions above the so-called critical point. As the critical point of a substance is approached, its isothermal compressibility tends to infinity. Correspondingly, the specific volume or density of the substance changes dramatically. In the critical region, a substance that is a gas at normal conditions exhibits liquid-like density and a much increased solvent capacity. This behaviour occurs because increase in density decreases mean intermolecular distance resulting in an increase in the number of interactions between the solvent and solute. Even though liquid like densities are observed for supercritical fluids, other properties are similar to those of gases. For example, viscosity values are relatively low while diffusivity values are relatively high. Low viscosity results in supercritical fluids being easier to pump, but also somewhat more easily diverted. High diffusivity generally results in improved mass transfer.

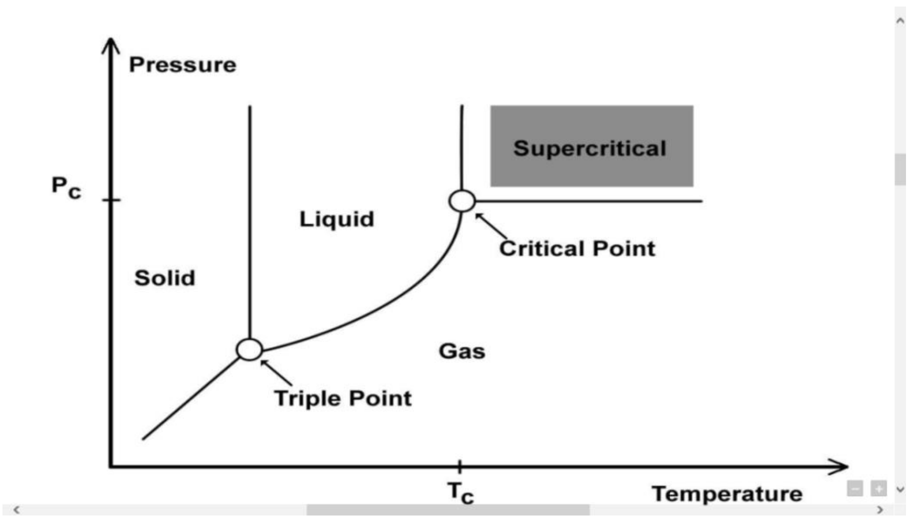


Fig No.1: Different stages of phases from solid to super critical

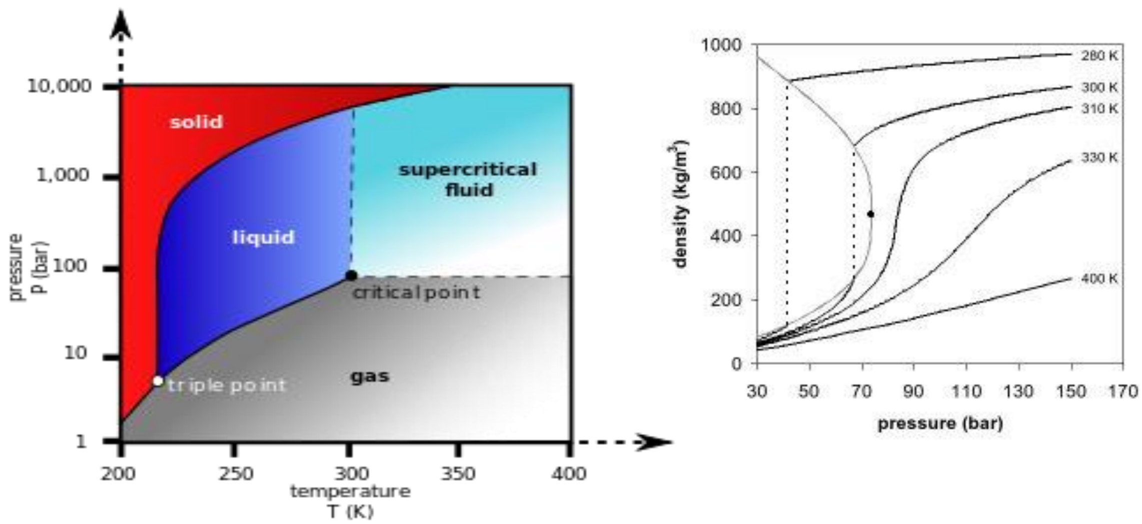


Figure: CO_2 pressure-temperature & density-pressure phase diagram

Table 2. Properties of Carbon dioxide (CO_2)

Solvent	Molecular Weight	Critical Temperature	Critical Pressure	Critical Density
	G/mol	K	Mpa (atm)	G/cm^3
Carbon dioxide (CO_2)	44.01	304.1	7.38 (72.8)	0.469

2.1 ADVANTAGES OF CARBON DIOXIDE

Carbon dioxide is also considered the best supercritical fluid for the dyeing process. It is naturally occurring, chemically inert, physiologically compatible, relatively inexpensive and readily available. Other attributes of carbon dioxide are:

- It is an inexhaustible resource.
- Its use does not release volatile organic compounds (vocs).
- It is biodegradable as a nutrient for plants.

- There are no disposal issues. It can be recovered and reused from the dyeing process.
- It is non-flammable and non-corrosive.
- It is non-toxic and low cost.
- The critical point of the carbon dioxide is well within the manageable range (31C and 73 bar).

3. PRINCILPES OF DYEING

The principle of dyeing with CO2 was invented in Germany twenty-five years ago. Developing a well functioning machine, however, turned out to be too expensive.' dyecootextile Systems' parent company, Feyecon, began tackling this issue ten years ago in partnership with the Delft University of Technology and Stork. This ultimately resulted in dyecoo(which was formed in 2008), which literally means dyeing with CO2.

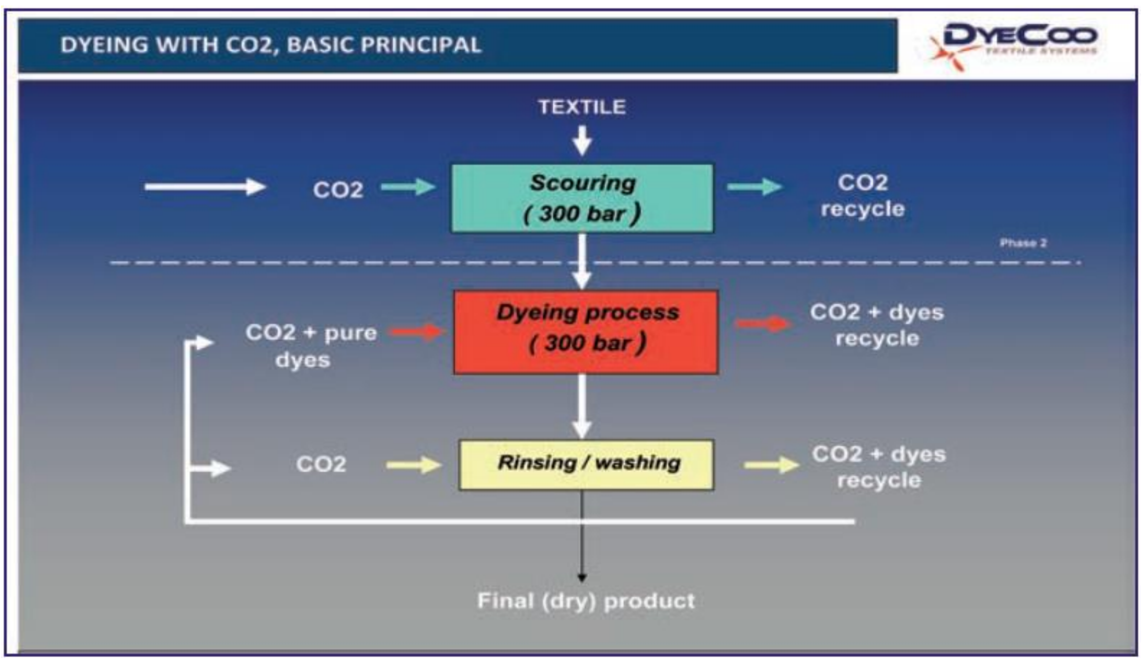


Fig No.2: Basic principle of dyeing with CO2

3.1 DYEING IN SUPERCRITICAL CARBON DIOXIDE

The application of scfs, especially supercritical carbon dioxide (SC-CO_2), in the textile industry has recently become an alternative technology for developing a more environmentally friendly dyeing process. Carbon dioxide, has so far been the most widely used, because of its convenient critical point (Tc=31◦C and Pc=74 bar), cheapness, chemical stability, non-flammability, stability in radioactive applications and non-toxicity. On account of its solvating ability towards nonpolar or slightly polar organic molecules in the supercritical phase, CO_2 can be used to transport disperse dyes to polyester fibres, without having to use the traditional aqueous medium, thus avoiding pollution problems. Since polyester fibres typically have a very compact structure and high crystallinity, the choice of dyes for them is limited to the disperse dye range.provides an order of magnitude comparison of physical properties typical for gas, liquid and supercritical fluid state. Above the critical point, carbon dioxide has properties of both a liquid and a gas. In this way supercritical CO_2, has liquid-like densities, which is advantageous for dissolving hydrophobic dyes, and gas-like low viscosities and diffusion properties, which can lead to shorter dyeing times compared to water. Compared to water dyeing, the extraction of spinning oils, the dyeing and the removal of excess dye can all be carried out in one plant in the carbon dioxide dyeing process which involves only changing the temperature and pressure conditions; drying is not required because at the end of the process CO_2 is released in the gaseous state. The CO_2 can be recycled easily, up to 90% after precipitation of the extracted.

The dyestuff/supercritical carbon dioxide/fiber system will in this respect represent a three component/ three-phase system. The three components are the gas, the dyestuff and the fiber polymer. In their solid state, dyestuff and polymer are present in the form of three separate phases besides the supercritical mixture. The dyestuff is dissolved in the supercritical fluid, transferred to, absorbed by and diffused into the fiber. Supercritical carbon dioxide is known to reduce considerably the glass transition temperature for many polymers, resulting in an increased mass transfer rate inside the polymeric matrix. In the first approximation the system is described as the distribution equilibrium of the dyestuff between fluid and fibers. A more exact definition of the thermodynamic processes involved in this system will have to consider the solubility of carbon dioxide in the polymer and in the solid dyestuff as well as the solubility of the polymer in the fluid. For the sake of simplification, the dyestuff will be considered as pure component, whereas the solubility of carbon dioxide and polymer in the solid dyestuff can be neglected. The solubility if the polymer in the fluid is so low that it can be neglected as well. All other mixtures can, however, significantly affect the dyeing process.

A simple apparatus for dyeing in supercritical carbon dioxide. It consists of a temperature controller, a vessel heater which surrounds the vessel, a stainless steel dyeing vessel, a manometer, a carbon dioxide pump and a cooler for cooling the head of the carbon dioxide pump. The sample to be dyed is wrapped around a perforated stainless steel tube and mounted inside the autoclave around the stirrer. The apparatus is then sealed and heated to the working temperature and during this time carbon dioxide is pumped into the autoclave. The pressure rises to 350 bar, an isochoric process achieved by heating to 130◦C . Following a dye time the pressure within the autoclave is reduced to atmospheric temperature within about 2-3 minutes, the carbon dioxide being routed through a separating vessel in order to recuperate precipitated residual dye stuff. Dyestuff order is placed in the bottom of the vessel; the apparatus is sealed, purged with gaseous carbon dioxide, and preheated. When it reaches working temperature, carbon dioxide is isothermally compressed to the chosen working pressure under constant stirring. Pressure is maintained for a dyeing period up to 60 minutes and after wards released.

S.-K. LIAO, P.-S. CHANG

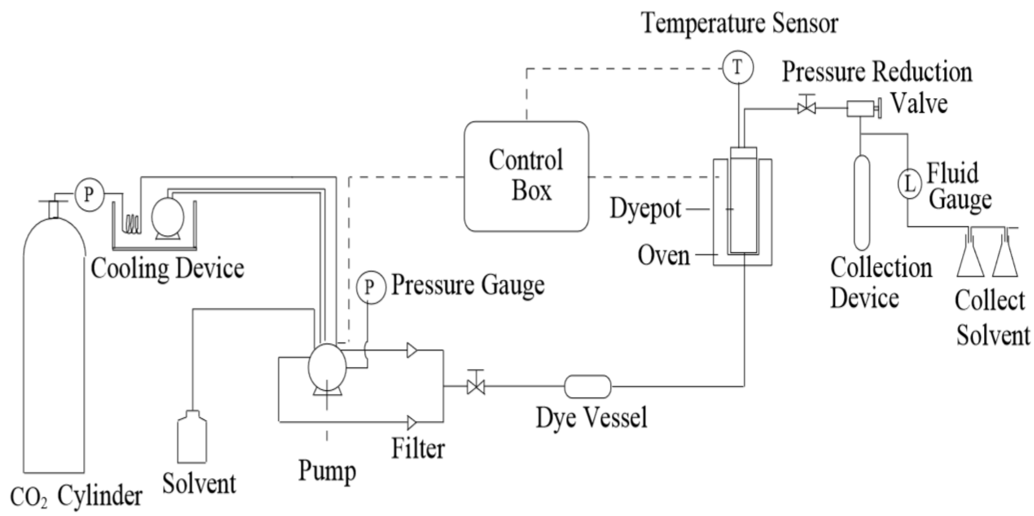


Figure 1. Schematic diagram of supercritical fluid dyeing [36].

4. DYEING AND FUNCTIONAL FINISHING OF NYLON 6 USING SUPERCRITICAL CARBON DIOXIDE

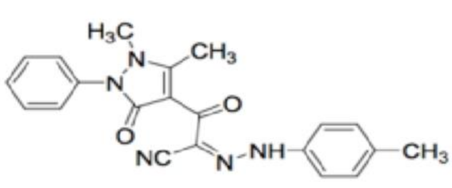
Polyamide fibers have particular properties such as high tensile strength, elasticity and good mechanical and chemical resistance, etc. Correspondingly, polyamide fabrics are utilized in considerable applications of the textile industry. The dye ability of synthetic hydrophobic fibers such as polyamide, polyester, polyacrylonitrile and polypropylene in scco2 poses a great challenge to dyestuff chemists. As a consequence in the last few decades, various researchers focused their efforts on the synthesis of new dyes for these fibers. The success of dyeing synthetic textiles, particularly polyester, with disperse dyes in scco2 prompted research application of this technique to other synthetic fibers such as polypropylene, and aramid fibers or alternative natural fabrics like cotton.

The dyeing of nylon 6-6 with hydrophobic-reactive and disperse-reactive dyes using supercritical carbon dioxide as a solvent was reported; a covalent force was formed successfully between the terminal amine group of nylon6 6 and the vinylsulphone group of the dye molecule. The work indicated that both solubility and affinity have an effect on the dye uptake of nylon 6-6 with hydrophobic reactive and disperse-reactive dyes using supercritical carbon dioxide as a solvent system. Light fastness was acceptable for common applications and washing fastness was superior. We explored the dyeing of polyester fabrics with antibacterial disperse–azo dyestuffs which were synthesized in our program, employing a supercritical carbon dioxide dyeing technique. Working with antibacterial dyes in textiles integrated the dyeing and finishing process and resulted in a more effective technique in terms of water and energy management. The obtained result showed that this process was absolutely as adequately efficient as the typical procedure and led us to study the behaviour of the synthesized dyes on other synthetic fabrics. In this context, the purpose of this work was to provide a one-step dyeing and finishing process for nylon 6 fabrics with antimicrobial disperse dyes through supercritical processing.

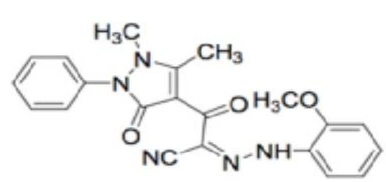
4.1 FABRIC AND DYES

A 100% polyamide 6 plain plane weave fabric (70 g/m2) supplied by Shikisen-sha company (Osaka, Japan) was used as dyeing substrate. Figure 1 shows the chemical structure of dyes

dye	Name (IUPAC)
1	2-(1,5-dimethyl-3-oxo-2-phenyl-2,3-dihydro-1H-pyrazol-4-yl)-2-oxo-N'-(p-tolyl) acetohydrazonoyl cyanide
2	2-(1,5-dimethyl-3-oxo-2-phenyl-2,3-dihydro-1H-pyrazol-4-yl)-N'-(2-methoxyphenyl)-2-oxoacetohydrazonoyl cyanide
3	2-([1,1'-biphenyl]-4-yl)-N'-(1,5-dimethyl-3-oxo-2-phenyl-2,3-dihydro-1H-pyrazol-4-yl)-2-oxoacetohydrazonoyl cyanide
4	N'-(2-chloro-4-methylphenyl)-2-oxo-2-(p-tolyl) acetohydrazonoyl cyanide
5	N'-(2-chlorophenyl)-2-oxo-2-(p-tolyl) acetohydrazonoyl cyanide



1



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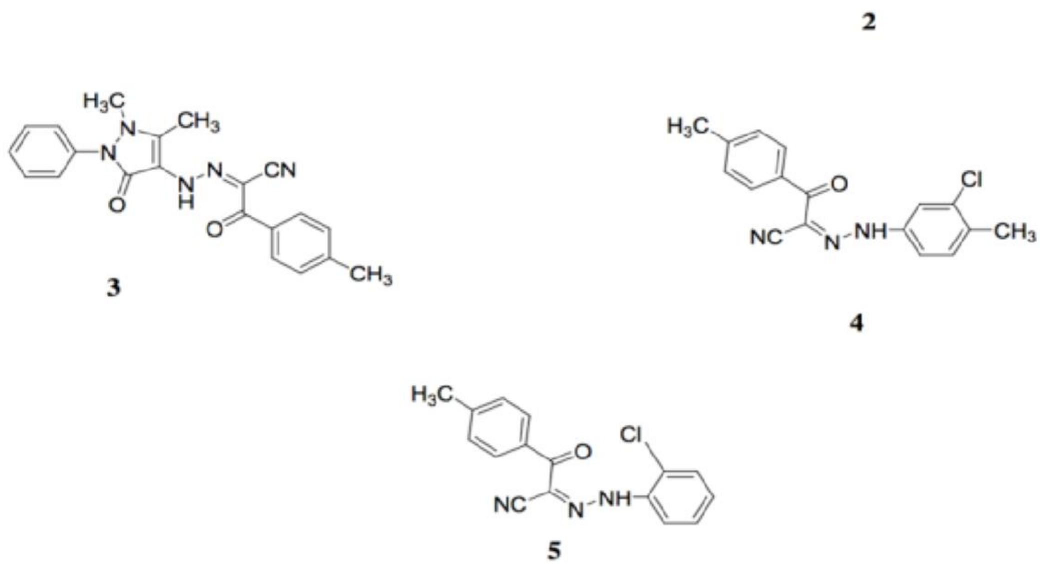


Figure 1. The chemical structure of dyes.

4.2 DYEING APPARATUS

Figure 2 is a diagram of the whole apparatus. The liquefied CO2 departing from the cylinder moved inward to a cooling unit and was infused into a high-pressure syringe pump (model Jasco Pll-2880 plus, Jasco, Easton, PA, USA). High-pressure CO2 ultimately ran out into a dyeing autoclave. The dyeing autoclave as shown in Figure 2 is a 50 cm3 stainless steel autoclave outfitted with a steel screw-tube, a pressure sealed magnetic stirrer, and a quick-release cap.

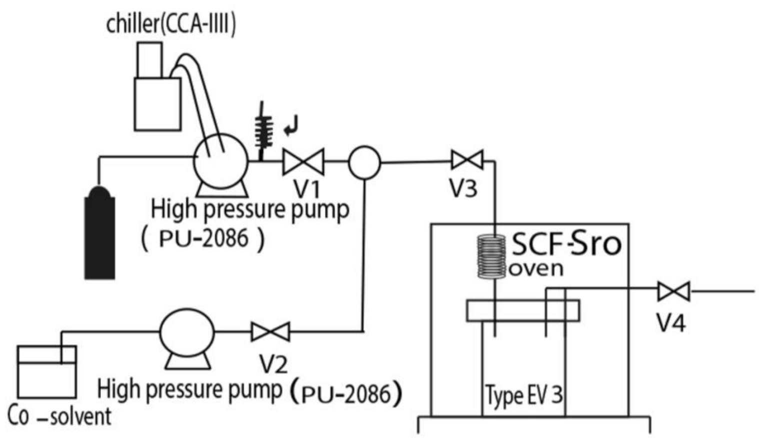
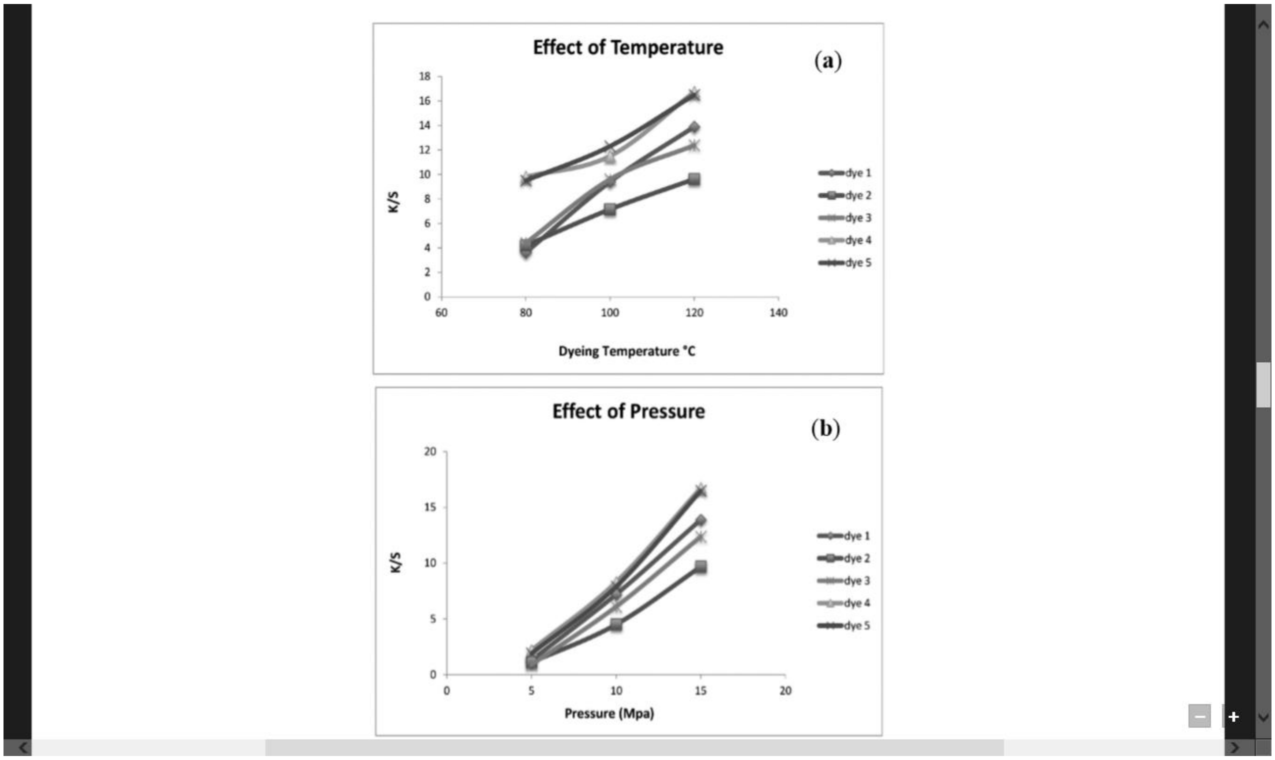


Figure 2. Supercritical CO_2 apparatus.

5. SUPERCRITICAL CARBON DIOXIDE DYEING

Polyamide 6 fabric (usually 3 × 10 cm) was wrapped around a stainless steel cylinder coil bearing perforated holes (0.5 cm diameter) and seated inside the autoclave. The purified dye was loaded on the base of the surface of the cylinder, and the amount of dye used varied from 2% to 6% owf. The autoclave was then sealed and heated to the desired temperature. At the same time, CO2 was pumped through into the vessel and kept at a working pressure by stirring. The head temperature of the pump was maintained at −5 °C using a chiller. The circulation system was activated as the pressure reaches 10 mpa. The stream of the fluid was introduced using the magnetic drive under the column at 750 rpm. The fluid flowed from the inside to the outside of the cylinder. After a definite reaction time (1 hand 3 h), the CO2 released by shutting off the valve slowly until the pressure of the dyeing vessel reached atmospheric pressure. After dyeing, the fiber was removed, soaped at a temperature of 60 °C for 15 min, and then rinsed with water.



5.1. EFFECT OF DYEING PRESSURE

As shown in Figure, the dye uptake expressed as the color strength K/S was remarkably improved with an increasing system pressure. This behavior could be made clear by the fact that increasing system pressure led to an increase in the density of supercritical carbon dioxide fluid, which consequently increased its solvent power. Hence the dyes could be readily dissolved, as well as enhancing swelling of the nylon fibers in the supercritical dyeing medium, resulting in a higher dye adsorption and enhancement in c olor strength value .

5.2. EFFECT OF DYEING TIME

The relationship between dye adsorption and dyeing time (1hand3h) in scco2 is demonstrated in Figure 7a–c. It is seen that dye uptake expressed as color strength (K/S) increased with increasing dyeing time, at all dye concentrations (2%, 4% and 6%). The improvement in K/S values reflected the positive impact of increasing dyeing time which led to an adequate and uniform adsorption of the dye by the fibers, as well as uniform penetration and diffusion of the dye into the fabric, which resulted in the enhancement of the uptake of the dye into the fabric]. However, this result was not consistent with all dyes, since the K/S value of the fabric dyed with dye 2 for 1 h is higher than that of the fabric dyed with dye 2 for 3 h as shown in Figure 7a. This may be attributed to the decomposition of the dye with prolonged heating leading to a lower K/S value.

5.3 ADVANTAGES OF SUPERCRITICAL CARBON DIOXIDE DYEING

- Elimination of usage of water, water treatment and water pollution
- Elimination of a drying step, thus reduces energy cost
- Elimination of auxiliaries, such as, dispersing agent, leveling agent
- Rapid diffusion and potential for high degree of dye exhaustions
- Dyeing occurs with high degree of levelness
- No after treatment is required
- Time required for dyeing is very less
- Gives good rubbing fastness
- Dyeing houses may be started on sites where there is water scarcity
- No air pollution due to recycling of CO_2 is accomplished
- Economical and environmentally friendly.

6. COMPARATIVE ENERGY REQUIREMENTS

	Conventional	**Scco$_2$**
Pretreatment	**4555**	**4555**
Dyeing	**45250**	**30625**
Post Treatment	**3800**	**0**
Total	**53605**	**35180**
Energy Savings		**34.37%**

7. DISADVANTAGES/LIMITATIONS

- Initial investment is high.
- High pressure and high temperature are required for dye solubility during the process.
- It is a batch process. So processing of long length fabric (continuous) is not possible.
- During polyester dyeing, the trimer is produced. This is removed using aqueous cleaning waterless $scco_2$ as a problem to eliminate.
- There is little data available about dyestuff solubility in $scco_2$.
- At present, $scco_2$ dyeing is confined to synthetic fibers.

8. CONCLUSION:

Dyeing with super critical CO2 is still at its early life. It has been proved time and again that it's successful at laboratory scale. Large amount of research input is needed for system integration. Dyeing with this system has been found successful with synthetic as well as natural fibers. With evolution of time Supercritical CO2 dyeing would be popular one day by concerning save environment (free from polluted water).

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46.

Water Quality Prediction Using Clustering Algorithms For Cauvery River

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ABSTRACT

The objective of this study is to analyze the various water quality parameters of the Cauvery River and to find similarity between them so as to suggest some decision plans or policies to predict or classify the water quality. In this study we find an approach to water quality prediction through clustering of between various water quality parameters. There are different cluster algorithm among which Hierarchical cluster algorithm, K-means cluster algorithm, EM algorithm, DensityBased clusteralgorithm are used to find and extract the similarities between various water quality parameters for Cauvery River.

KEYWORDS: Water Quality Prediction, Water Quality Parameter, Clustering Algorithm

1. INTRODUCTION

The Cauvery River is a bigIndian Waterway. The beginningof the reveries atTalakaveri, Kodaguin Karnataka and the river flows from south Karnataka,east Karnataka and Tamilnadu. The Cauvery stream measure is 81,155 square kilometers (31,334 sq mi) with a substantial number tributaries including those Shimsha, Moyar River, the Hemavati, the Arkavati, Honnuhole, LakshmanaTirtha, Kabini, Bhavani River, those Lokapavani, those Noyyal and the Amaravati River.

Water resource as an essential part in ecological development and also include human survival with the society. The previous problem in water quality prediction is the large datasets have difficult to fix their monitoring stations and pattern from the water quality data sets. This proposed work using clustering algorithm to monitoring stations in the water quality prediction of Cauvery River datasets.

2. METHODOLOGY

2.1 CLUSTERING ALGORITHMS

Clustering is on figure out those innate grouping over a situated from claiming unlabeled information.Clustering might a chance to be “the transform from claiming arranging objects under bunches whose parts need aid comparative on some way”. A group is, therefore, an accumulation from claiming objects which would “similar” the middle of them add more need aid “dissimilar” of the objects having a place should other groups.

2.1.1 HIERARCHICAL CLUSTERING ALGORITHM

Hierarchical clustering algorithm begins with every last one of information focuses allocated to a group of their own. That point two closest groups would be consolidated under those same bunch. In the end, this algorithm terminates the point when there is just an absolute bunch left.Provided for a set for N items with be clustered, anda N*N separation (or similarity) matrix, the fundamental procedure from claiming hierarchic clustering.

1. Begin Eventually of perusing relegating each thing on a cluster, there about that though you have N items, you right away haven clusters, each holding just one thing. Tell the distances (similarities) between the groups the same concerning illustration the distances (similarities) the middle of the things they hold numerous.
2. Discover the closest (most similar) one sets from claiming groups and blend them under a single cluster, thus that presently you have you quit offering on that one cluster less.
3. Compute distances (similarities) the middle of those new group and each of the old groups.
4. Repeatable steps 2 and 3 until the greater part things would be bunched under a single bunch from claiming size N. (*).

2.1.2 K-MEANS ALGORITHM

K-means clustering aims to partitionN observations into K clusters in which each observation belongs to the cluster with the nearest mean, serving as a prototype of the cluster. This results in a partitioning of the data space into Voronoi cells.

The algorithm is composed of the following steps:

1. Place K points into the space represented by the objects that are being clustered. These points represent initial group centroids.
2. Assign each object to the group that has the closest centroid.
3. When all objects have been assigned, recalculate the positions of the K centroids.
4. Repeat Steps 2 and 3 until the centroids no longer move. This produces a separation of the objects into groups from which the metric to be minimized can be calculated.

2.1.3 EXPECTATION MAXIMIZATION ALGORITHM

EM algorithm is an iterative strategy to finding greatest probability alternately greatest a posteriori (MAP) estimates about parameters over statistical models, the place the model relies looking into surreptitiously idle variables. Those EM cycle alternates between performing a desire (E) step, which computes those desire of the log probability assessed utilizing those current evaluate for the parameters, and expansion (M) step, which computes parameters expanding the expected log probability found on the e venture. These parameter estimates are afterward used to focus the conveyance of the idle variables in the following e step.

2.1.4 DENSITYBASED CLUSTER ALGORITHM

This strategy may be dependent upon that idea about density. The fundamental thought will be proceed with developing those provided for bunch likewise in length as those density in the neighborhood surpasses a percentage threshold, for each information point inside an provided for cluster, those span of a provided for group need with hold in any event a least amount for focuses.

3. STUDY AREA AND DATA

Ahmed Barakat, Mohamed El Baghdadi, JamilaRais, BrahimAghezzaf, Mohamed Slassi[1] hasapplied multivariate statistical techniques to assess the spatial and seasonal water quality variation of OumErRbiaRiver in Morocco within the period from 2000–2012 from fourteen sampling stations. The water quality parameters used were TEMP, pH, EC, turbidity, TSS, DO, NH4+, NH3–, TP, BOD5, COD and F. coli.That water caliber information was broken down utilizing multivariate Statistical methods including Pearson's correlation, PCA, and CA. PCA is used to compare the factors and patterns.CA is indicated generally spatial and seasonal transforms done surface water quality, which will be generally indicators of contamination with rainfalls or other sources.

C. K. Tay, E. K. Hayford,, I. O. A. Hodgson [2] has projected The provision about multivariate Factual system for hydrogeochemical evaluation from claiming groundwater inside the more level Pra Basin, Ghana. Spearman's Correlation matrix and PCA specifies the relationship between Cu^{2+} and Zn^{2+}.Find the total variance in the hydrochemical data specified in three components. There are i) to delineate those primary characteristic processes ii) to delineates the incongruent disintegration about silicate/aluminosilicates, iii) to delineates that pervasiveness from claiming contamination.

M. FarhadHowladar, Md. Abdullah Al Numanbakth and Mohammed Omar Faruque [4] has done An application of Water Quality Index(WQI) and multivariate statistics to evaluate the water quality around Maddhapara Granite Mining Industrial Area, Dinajpur, Bangladesh.thay used 24 water quality parameters. Multivariate statistical methods were adopted for determining the water quality and their sources of contamination. Cluster analysis confirms that three main groups of water samples where cluster I includes 70.97% of water samples, cluster II and cluster III includes rest 22.58 and 6.45% of the water samples respectively. Factor Analysis/Principal Component Analysis (FA/PCA) illustrates five factors extracted which explain 75.89% of the total variance. This research work was estimating the major sources of contamination in different areas within the framework of activities intending to improve the quality of water.

M. G. Khublaryan, T. I. Moiseenko [5] has describe Water Quality, the causes of water quality Degradation and drawbacks Of assessment methods, studies on water quality formation Under contemporary conditions, studies of biological systems' Responses and water quality Assessment criteria, and main principles Of preserving water purity.

Mingzhong Xiao, QiangZhang,Vijay P. Singh, Xiaohong Chen [6] has proposed Probabilistic forecasting of seasonal deficiency behaviors in the Huai River basin, China. Huai River data collected from 1960 to 2013 at 41 monitoring stations. The copula works on model the hold on in property about drought, the probabilistic occasional dry season determining models need been based in the Huai stream bowl.Droughts were monitored toward those Standardized Precipitation Evapotranspiration Index (SPEI) for the time scales about 3, 6, furthermore 9 months, and their composite event likelihood need been used to figure those regular dry season.

MuhteremDemiroglu [7] has done identifying the groundwater basin boundaries used Environmental isotopes. This examines shows the utilization from claiming Ecological isotope information should translate and right groundwater bowl limits. Giving the concerning illustration a sample the Yenic¸ıkrı bowl inside the primary Sakarya bowl.

P.K. Srivastava, S. Mukherjee,M. Gupta, S.K. Singh [8] has done Characterizing Monsoonal Variation on Water Quality Index of River Mahi in India Using Geographical Information System. They have used 8 water quality parameters. The water quality index, cluster analysis and pointing numerical error seem useful for the technical. The numerical error which was arose due to mistakenly omitting the powers of 10 for the weighting factors during the final submission. However, the final WQI values reported are correct.

S BrinthaRajakumari, C.Nalini [9] has done the identification Of Lead Contaminant in River Water Quality Data. The river dataset collected from 2011 to 2013. This work applied cobweb, EM, simpleKMean and Hierarchical clustering algorithm to aggregation the information Furthermore compared the long run taken should bunch the lead information also shown the most elevated lead done waterway water caliber dataset.

WeihuiDeng,Guoyin Wang [11] has proposed a novel water quality data analysis framework based on time-series and data mining techniques. This work analysis on weekly used dissolved oxygen time series data from five monitoring station on Yangtze River, China within the period from 2005 to 2014 years. They have developed two component i) 2D-NCR and similarity Measurement ii) three time series data mining tasks are similarity search, anomaly detection and pattern discovery.

Yi Luo, Kun Yang,ZhenyuYu,JunyiChen,YufeiXu,XiaoluZhou,Yang Yang [12] has worked Dynamic monitoring and prediction of Dianchi Lake and also find the cyanobacteria outbreaks in the context of rapid urbanization. In the lake monitor the water quality used wireless sensor network and geographic information system. It was measured in the macro scale and meso scale. Also used historical real time water quality and weather condition data. This model combination of prediction using adaptive gray model, back propagation artificial neural networks and can forecast cyanobacteria outbreaks.

This study used the water quality monitoring data from twenty-nine stations located in the CauveryRiver in India. In each station , the ten water quality parameters were measured in a yearly basis; Temperature Min, Temperature Max, D.O Min, D.O Max, PH Min, PH Max, B.O.D Min, B.O.D Max, Conductivity Min,Conductivity Max. Water quality monitoring data of these stations from 2006 to 2014 is available.

S.No	Station Code	Places
1	1198	NapokuluBdg (D/S)
2	1195	Kushal Nagar U/S (Near Baichanahalli)

3	33	KrsDam,Balamurikshetra
4	1386	D/S Of Karekuara Village,
5	1171	Sri Rangapattanna,D/S Of Road Bdg
6	34	Sathyagalam Bridge
7	2773	Bannur Bridge
8	2774	Ranganathittu
9	50	Mettur
10	1322	1km. D/S Of Bhavani River Confl
11	51	Pallippalayam
12	1320	Erode Near Chirapalayam
13	1323	Velore Near Kattipalayam
14	3015	Pugalur, Karur
15	1324	Mohanur Near Pattaipalayam
16	1451	Thirumukkudal-Confl. Pt.Of R. Amravati
17	31	Musiri
18	3016	Pettaivaithalai, Trichy
19	1202	Tiruchirappalli U/S
20	1325	Tiruchirappalli D/S
21	1203	Trichy,GrandAnaicut
22	1206	Thanjavur, Tamilnadu
23	3018	Mayiladuthurai, Nagapattinam
24	3012	Komarapalayam, Namakal
25	3013	Urrachikottai, Erode
26	3014	Vairapalayam, Namakal
27	3017	Kumbakonam, Thanjavur,
28	1326	Coleroon
29	1327	Pitchavaram

Table 1: Water Quality Monitoring Stations

4. APPLICATIONS AND RESULTS

In the below figure 1 represent the process of the water quality prediction using various clustering algorithm.

The water quality data collected from the Cauvery River with 29 monitoring station and having 10 parameters. There are many preprocessing techniques available in data mining are noise filtering, data filling and data integration. There are any missing values in the datasets use the ReplaceMissing with constant method to fill the values. Also have any redundant data is available to remove from the dataset.

The preprocessed datasets apply the hierarchical clustering algorithm to form a two cluster are cluster 0 contain 220 instances with 98% and cluster 1 contain 5 instances with 2% in the execution time was 0.31 seconds.

The Expectation Maximization Clustering Algorithm To Form a 6 Cluster Are Cluster 0 Contain 60 Instances With 27%, Cluster 1 Contain 59 Instances With 26%, Cluster 2 Contain 18 Instances With 8%, Cluster 3 Contain 20 Instances With 9%, Cluster 4 Contain 38 Instances With 17% And Cluster 5 Contain 30 Instances With 13% In The Execution Time Was 15.8 Seconds.

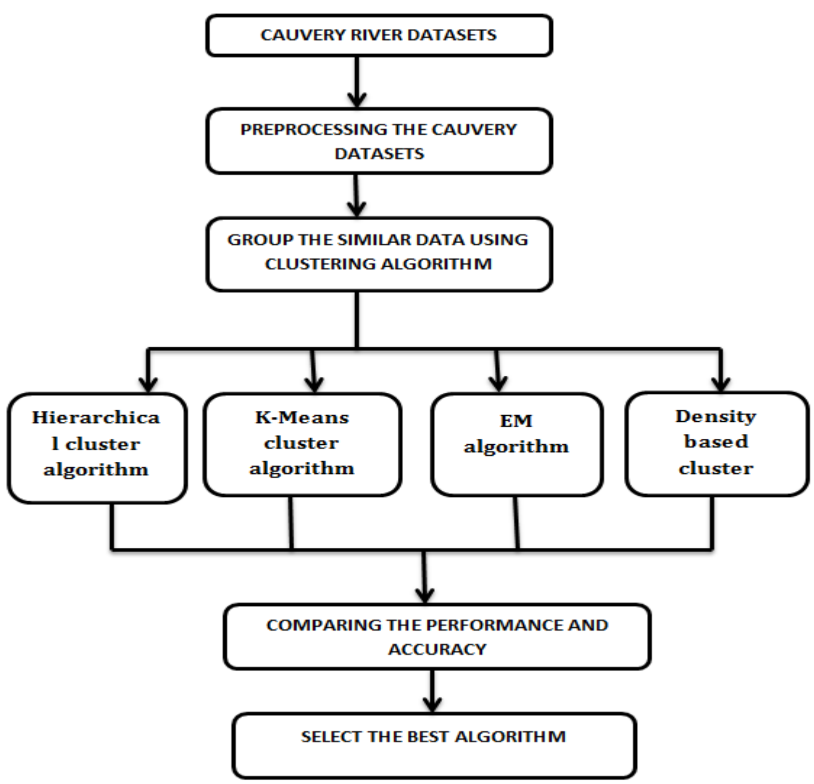

Figure 1: Flow Diagram for WQP

Water Quality Parameter	Description	Unit
Temperature	Water temperature can be defining the measurement of average kinetic energy of the atoms and molecules. Also WT is specifying hot water or cold water.	°C
PH	Its measure of the hydrogen ion concentration. PH<7---Acidic PH>7—Basic PH 6.5 to 8.5 Surface water PH 6 to 8.5 Ground water	number
BOD[Biochemical Oxygen Demand]	Determine the amount of dissolved oxygen using aerobic microorganism.	(mg/l)
DO[Dissolved Oxygen]	Measure the amount of gaseous oxygen and dissolved in water. $CO_2+H_2O \rightarrow O_2+C_6H_{12}O_6$	(mg/l)
Conductivity	Water estimate the totalamount of solids dissolved in water. It depends on WT and display of total salinity.	µmhos/cm

Table 2: Water Quality parameter, description and unit

The K-Means Clustering Algorithm To Form a Two Cluster Are Cluster 0 Contain 44 Instances With 20% And Cluster 1 Contain 181 Instances With 80% In The Execution Time Was 0.02 Seconds.

The Density Based Clustering Algorithm To Form a Two Cluster are Cluster 0 Contain 44 Instances With 20% And Cluster 1 Contain 181 Instances With 80% In The Execution Time Was 0.04 Seconds.

Finally Compare The Performance Of Four Clustering Algorithm Is Better One Is Hierarchical Cluster Algorithm Is 98% Of Similarity Of Instance With 0.31 Seconds.

Table 3: Comparison the Performance of Clustering Algorithms

S.No	Algorithm	Total Cluster instance	Number of Iterations	Number of Cluster Instance and performance Percentage	Execution Time
1	EM Cluster	6	1	Cluster 0 60(27%) Cluster 1 59(26%) Cluster 2 18(8%) Cluster 3 20(9%) Cluster 438 (17%) Cluster 5 30 (13%)	15.8 Seconds
2	Hierarchical Cluster	2	1	Cluster 0 220 (98%) Cluster 1 5 (2%)	0.31 seconds
3	Density Based Cluster	2	4	Cluster 0 44 (20%) Cluster 1 181 (80%)	0.04 seconds
4	K-Means Cluster	2	**4**	Cluster 0 44 (20%) Cluster 1 181 (80%)	0.02 seconds

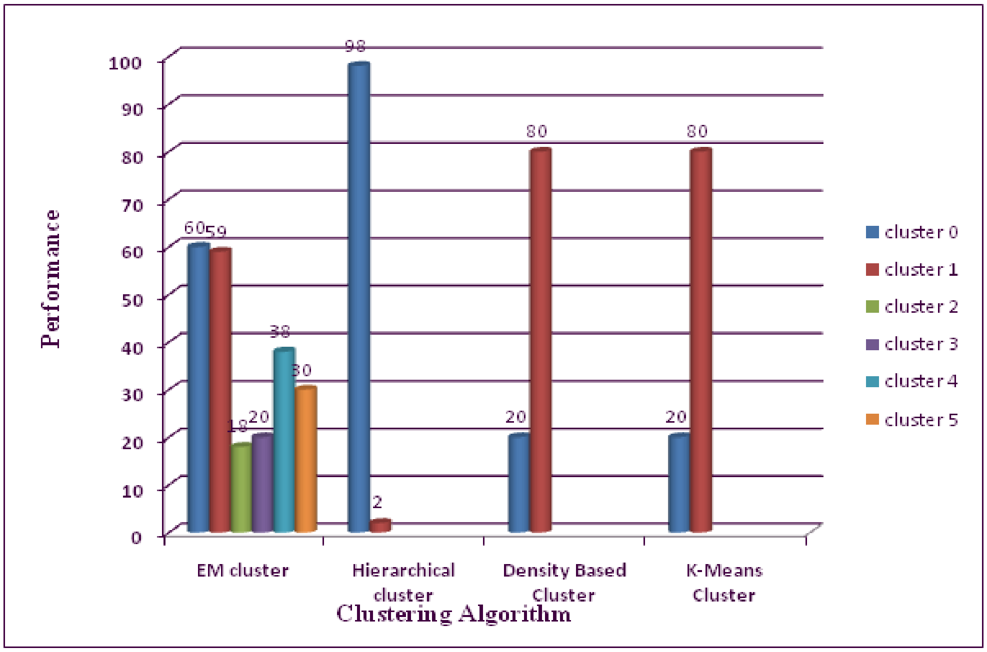

Figure 2: Comparison Result in Cluster Algorithms

5. CONCLUSION

In this study, used a clustering method that EM cluster, Hierarchical cluster, Density based cluster, K-Mean cluster to assess the water quality variation in the Cauvery River datasets. Then compared the performance of above four algorithms to produce the Hierarchical algorithm is 98% of performance is better than other algorithm. For future work apply various method and techniques used to predict the water quality prediction.

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