BIOADSORBENTS - AN ECOFRIENDLY AND LOWCOST TECHNOLOGY FOR THE TREATMENT OF INDUSTRIAL EFFLUENTS

By

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Certified as Bonafide Research work.

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6.5.99.
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Signature of the
Guide

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INTRODUCTION

CHAPTER - I

INTRODUCTION :

Today the cry of “Pollution” is heard from all the nooks and corners of the globe and pollution has become a major threat to the very existence of mankind on this earth. It is the major challenge of our times. The pollution of various resources has gone to such an extent that we are unable to breath fresh air and drink fresh water. On one hand the advancements of Science and Technology have added to the human comforts by giving us automobiles, electrical appliances, supersonic jets, space crafts, better medicines, better chemicals to control harmful insects and other pests, etc., but on the otherhand, they have given us a very serious problem to face : Pollution.

In fact, it is not a new problem, except in dimensions which we see today. When man and other higher animals began their life on this earth, there was absolutely no sign of pollution. There was perfect balance in various natural processes. The air and water were pure and soil was fertile. The problem of pollution arose with the very civilization of man. As soon as man learned to use fire, the air pollution began. As human population increased, there was increase in our working sphere and with this also increased the pollution. The rapid un planed industrial progress added to our pollution problem.

I .1. WHAT IS POLLUTION ?

Pollution can be defined as an undesirable change in the physical, chemical or biological characteristics of the air, water, or land that can harmfully affect the health, survival or activities of humans or other living organisms. Note that according to this definition pollution does not have to cause physical harm.

It may merely interfere with human activities. For example, a lake may be considered polluted if it cannot be used for boating activities.

The problem with defining pollution is specifying what constitutes "Undesirable Change" which requires value judgements. For example, chemicals spewed into the air or water from an industrial plant may be harmful to humans and other organisms living near the plant. However, if expensive pollution controls are required, the plant may be forced to shut down. Thus workers who would lose their jobs may feel that the risks to them from contaminated air and water are not as serious as the benefits of having jobs.

Value judgements about short term versus long-term risks can also cause controversy. Building a world wide network of nuclear power plants may provide electricity for the present human generation, but it compels future generations to handle and store the radio active wastes produced for thousands of years, even if nuclear power is abandoned or exhausted as an energy source.

Thus we see that the determination of desirable versus undesirable effects of an environmentally altering is a very difficult and highly controversial process. The nature of tragedy as the philosopher Hegel pointed out long ago, is the conflict not between right and wrong but between right and right. Nevertheless, although defining pollution is a difficult, controversial process, it must be done in order to control pollution.

I.2. WATER POLLUTION :

Normally water is never "Pure" in a chemical sense. It contains impurities of various kinds, both dissolved and suspended. These comprise dissolved gases (eg. H_2S, CO_2 , NH_3, N_2) dissolved minerals (eg. Salts of Ca, Mg, Na), suspended impurities (eg, clay, silt, sand and mud) and microscopic organisms.

These are natural impurities derived from the atmosphere, catchment area and the soil but are in such a low concentration that they do not pollute the water normally rather their presence is sometimes essential for maintaining the potable and other useful properties of water. Polluted waters are turbid, not pleasant for drinking, sometimes smell bad, and are not suitable for bathing, washing or other human activities. They are generally harmful and diseases like typhoid, dysentry and cholera spread through polluted water (Agarwal, 1987).

Water pollution is any physical or chemical change in water that can adversely affect organisms. It is a global problem affecting both the industrialized and developing nations. The water pollution problems in the rich and the poor nations, however are quite different in many respects. Heat, toxic metals, sediments, animal and human wastes and synthetic organic compounds foul the water ways of developed nations. Human and animal wastes, sediment and pathogenic organisms head the list in the non-industrialized nations. In these countries, unsanitary water, and malnutrition account for most of the illness and death.

The term “water pollution” is referred to the addition to water of an excess of material (or heat) i.e, harmful to humans, animals, to desirable aquatic life or otherwise causes significant departures from the normal activities of various living communities in or near bodies of water. The national water commission stated (1973) that “Water gets polluted if it has been not sufficiently high quality to be suitable for the highest uses. People wish to make of it at present or in the future.

In reality, the term water pollution refers to any type of aquatic contamination between two extremes.

1. A highly enriched, over productive biotic community, such as a river, or lake with nutrients from sewage or fertilizer (cultural eutrophication), or

2. A body of water poisoned by toxic chemicals which eliminate living organism or even all forms of life.

The expression of "Water pollution" seems to be clear to all. Nevertheless, it is worth determining its real meaning as this has changed in the course of time. Felfoldy's (1982) precise definition is the following : "Water pollution" is every impact which changes the quality of our surface and subsoil waters to such a degree that its suitability either for human consumption or for the support of man's natural life processes with decrease or cease."(Trivedi et.al., 1992).

I.3. SOURCES OF WATER POLLUTION :

1) **Sewage and other oxygen demanding waste,** which contain decomposing organic matter and pathogenic agents.
2) **Industrial waste**, which contains toxic agents ranging from metal salts to complex synthetic organic chemicals.
3) **Agricultural waste**, which contains fertilizers, pesticides and biocides.
4) **Physical pollutants**, viz , heat(thermal pollution) and radio active substances.

Water pollutants are classified into 9 categories as given below :

1. Oxygen demanding wastes.
2. Disease causing agents.
3. Plant nutrients.
4. Synthetic organic compounds
5. Oil.
6. Inorganic chemicals and mineral substances.
7. Sediments.

8. Radio active materials.
9. Heat (Thermal pollution).

If untreated waste water is allowed to accumulate, the decomposition of the organic material it contains can lead to the production of large quantities of malodorous gases. In addition untreated waste water usually contains numerous pathogenic or disease causing microorganisms that dwell in the human intestinal tract, or that may be present in certain industrial wastes. It also contains nutrients, which can stimulate the growth of aquatic plants, and it may contain toxic compounds. For these reasons, the immediate and nuisance free removal of waste from its sources of generation followed by treatment and disposal is not only desirable but also necessary in an industrialized society. (Metcaff et.al., 1979).

I.4. TREATMENT OF WASTE WATER :

A number of industrial effluents, including those from the textiles, leather tanning, electroplating, pigment and dyes, sugar industries, metallurgical and metal finishing contain anions, cations and heavy metals like chromium, zinc, copper, nickel, cadmium and others. If they are discharged directly into the domestic sewers, rivers and other water bodies, it will cause water pollution. Some components of these effluents may be toxic to aquatic life. It may change the BOD which in turn affects the aquatic life. It may cause severe problems to human beings and animals. To avoid all these problems the effluents should be treated properly before they are discharged in to domestic sewers and other water bodies.

Different methods :

Mainly three methods are used in effluent treatment. They are as follows :

1. Physical method
2. Chemical method
3. Biological method

Several methods of physical, chemical processes such as reduction, precipitation, ion exchange reaction with silica, electro-chemical reduction, evaporation, reverse osmosis, direct precipitation, etc need high capital cost and recurring expenses such as chemicals which are not suitable for small scale industries. Studies on the treatment of effluents have revealed that adsorption could be highly effective, cheap and an easy method among the physico-chemical treatment processes. Owing to the high cost and difficulty in procurement of activated carbon, efforts are being directed towards sending efficient and lowcost bioadsorbent materials.

A variety of low cost materials of vegetable origin (Bio adsorbents) like bagasse, coconut jute, (Chand et . al., 1994), Mango shell (Ajmal et.al., 1998), Jamoon seeds, Sorghum straw (Kumawat and Dubey, 1991) **Acacia arabica** bark (Singh and coworkers, 1994), waste tea leaves carbon (Sing and Lal, 1992), rice husk (Srinivasan et.al., 1988), Saw dust, ground nut husk carbon (Periasamy, et. al., 1991). Irish pea nut, pea nut shell, walnut shell, bone and biomass such as **Aspergillus tereus**, and **Mucar remanianus** etc. can be used for the removal of dissolved suspended solids and heavy metals from the effluents.

I.5. OBJECTIVES :

In the present work, five bioadsorbents namely powdered mango shell, powdered jamoon seeds, carbonized bagasse (a waste material in sugar cane industries and sugar cane juice shops), **A. arabica** bark, carbonized rice husk and alum were used as the adsorbents for the treatment of dye industry effluent. The objectives of this work are

I) To separate solids from the liquid.
ii) To oxidise organic and oxygen demanding materials.
Iii) To neutralize the effluent.
Iv) To remove heavy metals.
V) To compare their performances in the treatment of effluent.

REVIEW OF LITERATURE

CHAPTER - II

REVIEW OF LITERATURE

The review of literature pertaining to the study bioadsorbents an ecofriendly and low cost technology for the treatment of industrial effluents. The treatment of dyeing industry effluent using physicochemical methods is given below :

Atkin and Lowe (1979) reported that the textile finishing industries use large quantities of water and produce large volumes of effluent. About 50 percent of the total volume of the effluent from the textile processing is generally only form dyeing. (Manivasakam,1995). The waste water from dyeing with amounts to 1400-400m^3/day (Agarwal, 1996).

Yarn dyeing is carried out with varied types of dyes. In this process fabrics and yarns are treated with different colour in Jiggers. The yarns and fabrics are passed through the dye bath in order to be impregnated with colour. About 30-60 units of water are consumed per every kg of cloth dyed, there by amounting to about 50 percent of the total wastes in the mill. Dyeing operations are performed under such a wide range of governing parameters like types of dyeing, concentration of chemicals, types of solvents, method of contact between the cloth and dyes.

Owing to these elaborate operations, the dyeing industry discharge large quantities of colourful untreated or little treated effluent containing noxious pollutants such as dyes, mordants, acids, alkalies, nitrates, chromium salts, chlorides, soaps, and metallic ions. These effluents are usually highly coloured and have contributed significantly to the load of pollutants on surface of water sources such as the river, stream, ponds and open lands.These pollutants may also penetrate deep in to the soil and pollute the underground water considerably.

II.1. DYEING INDUSTRY EFFLUENT AND ITS IMPACT ON ENVIRONMENT

Textile finishing industry uses large quantities of water and produces large volumes of effluent (Atkin and Lowe, 1979). Tobutt (1975) opined that many dyes used as colouring materials are toxic to some organisms and may cause direct destruction of aquatic conditions. The sludge and effluent from textile dyeing and finishing operations had been designated as a hazardous waste in accordance with the Resource Recovery and Conservation Act (Bixler, 1979) the ecological problem connected with the presence of heavy metals in dye wastes was discussed by Janak and Gruener (1979).

According to Shah (1979) 16 percent of the total effluent of the textile mills as surveyed by Ahmedabad Textile Industry's Research Association (ATIRA) is coming from dyeing department, whereas, Manivasakam (1987) reported that about 50 percent of the total volume of the effluent is generated only from dyeing, which are intensely coloured and contain excess suspended and dissolved solids with high BOD.

Colours from dyeing industry are not usually toxic, but they are aesthetically objectionable when they impart colour in drinking water supply. Certain chemicals used in dyeing such as chromium are toxic (Rao and Datta,1987). Several investigators reported the toxic effects of the textile effluents of seed germination and growth. (Dayana, 1987; Jain and Kumari, 1990; and Gupta and Nathawat, 1991).

Effluent from dyeing and paper industries delayed the commencement of germination and reduced both germination percent and germination value (Shanmugavel, 1993).

Agarwal (1996) reported that the wastewater from the dyeing section amounts to 400-420 m^3 per day. Saree printing and dyeing industry of Mathura are contributing significantly to water pollution by releasing enormous quantity of coloured effluent. Thambi and Paul (1997) reported that the untreated effluents from dye stuff production and dyeing mills may be highly coloured and this is particularly objectionable if discharged in to open water, the transparency of stream would be reduced. Because dyes absorbs sunlight, plant in drainage streams may perish, thus the ecosystem of stream can be seriously effected.

II.2. TREATMENT OF DYEING EFFLUENT BY ADSORPTION TECHNIQUE :

Adsorption is the exchange of material at the interface between two immiscible phases in contact with one another. This process is being mostly employed for the removal of gaseous and liquid pollutants is a well known phenomenon (Mattson and Mark, 1971).

Kumar and Dara (1980) had used modified barks such as **A. arabica** bark, **Pterocarpus marsupium** and **Terminalia tomentosa** for the removal of heavy metal ions from industrial waste waters.

Mittal and Mehrotra(1980) has worked out that 90 – 95 percent colour was removed at different pH and various initial coloiur concentrations from the pulp and paper mill waste water using alum and clay.

Desai (1982) had treated the textile effluent with settling chemicals such as gypsum and alum. Effect of bleaching powder was also studied as it was felt that it may help to decolorize the effluent. The effluent was treated by primary settling using burnt ash to reduce the pollution load to tolerance limit.

The rate of dye removal from effluent using suspended activated carbon had been studied. A rapid initial uptake of dye was attributed to surface mass transfer and then the rate of dye removal was greatly reduced, as intraparticle diffusion becomes the rate controlling step. The effect of three variables, namely agitation, initial dye concentration and adsorbent particle size had been investigated.(Mckay, 1982).

According to Kulkarni (1982) water hyacinth was shown to be effective in reducing the colour and colour of cotton processing effluent which had previously been subjected to partial biological treatment.

Adsorption of sandcryl orange and hanasyn black on peat moss and rice husk was found to be 98 and 78 percent effective. (Nawar and Doma, 1984). Asfour et.al., (1985) reported 55 percent decolourization of Astrazone blue at 80^0 C by hard sawdust.

Devi and Gopal (1986) has evaluated a biological toxic reduction (depollution) technique has shown that the heavy metal pollutants were absorbed by water weed hyacinth with varying efficiency depending upon the duration of exposure of the plant to the lethal environment.

Srinivasan et.al., (1988) reported that the activated carbon prepared by carbonization of rice husk with sulphuric acid followed by CO_2 activation, can be used to remove chromium.

Nagesh and Krishnaiah (1989) had studied removal of chromium by adsorption on activated charcoal from synthetic effluents.

Sheela and Dastidar (1989) had treated the black liquor wastes having organic fraction about 95% of the total dissolved solids from small paper mills through lignin precipitation with the application of gypsum in presence of CO_2. The experiment had been conducted with varying temperature concentration of black liquor and reaction time.

Bokade et.al., (1990) had found that spoiled alumina from aluminum hydroxide manufacturing industry, after activation can be used for removing common pollutants from waste waters. Black liquor for paper mill and dairy waste was taken for this study. 99% colour and 84% BOD has been removed by alumina.

Low and Lee (1990) opined that coconut husk can be effectively used for the removal of methylene blue. Powdered banana pith was used as an adsorbent and effective removal of dye mixture was observed by Kanchana (1990).

Saw dust of **Bassia latifolia** can be used as a adsorbent for removal of copper (II) in industrial effluents. The adsorbing capacity of sawdust is pH dependent. Maximum percent removal of copper (II) on saw dust is at pH 7.3 (Vaishya and Prasad, 1991).

Kumawat and Dubey (1991) had shown that, Jowar (**Sorghum vulgare**. L.) and its combination with calcium carbonate can be used for removal of heavy metals from waste waters. The efficacy of metal removal of Sorghum straw had been compared with that of activated charcoal and teak sawdust.

Bottom ash had been used to remove copper and lead from waste water by adsorption. The experiments had been conducted at different pH ranges (Kaur et .al., 1991).

Kannan and Vanangamudi (1991) had studied on removal of chromium (VI) by adsorption on lignite coal. A number of batch experiments had been conducted on adsorbent - adsorbate system at various pH values (1-6) with different amounts of adsorbent.

The results of Murthy et.al., (1991) indicated that, activated charcoal powder, fuller earth and bottom ash could remove colour from pulp and paper mill waste waters imparted by dye used in colour paper production. The variables like dose, pH, particle size and time had also been investigated.

Periasamy et. al., (1991) had conducted experiments on removal of hexavalent chromium by activated groundnut husk carbon.

Grau (1991) had treated the textile industry waste waters by a sequence of physical, chemical and biological processes.

Application of biogas residual slurry for the removal of Congored from aqueous solution to the extent of 95-98 percent in the pH range 2.3-7.0 (Namachivayam and Yamuna, 1992). Namachivayam and Yamuna (1993) studied the adsorption of acid brilliant blue on biogas residual slurry including concentration, agitation time, adsorption dosage and pH.

Waste tea leaves carbon had been used as a bio-adsorbents for the removal of chromium (VI) from aqueous solutions (Singh and Lal, 1992).

Mishra et.al., (1993) had reported various treatment methods such as membrane filtration, electrokinetic coagulation, ion-exchange method, adsorption techniques, and the application of surfactant for precipitating the dyes from the effluent for decolorizing the textile effluent.

Kadirvelu (1993) reported that carbonized coir pith remove completely the colour, BOD and COD in the dyeing waste water.

Leached **A. arabica** bark had been used for the removal of hexavalent chromium (Singh et.al., 1994). Chand et.al., (1994) had used activated coconut jute carbon and activated bagasse carbon to remove chromium (VI) from waste water.

Jemaitatis et.al., (1994) had decolorized the dyeing effluent by the precipitation of polymer complexes based on cationic polymers and anionic substances in disperse dye solutions in the concentration range 0.05-1gpl.

Himesh and Mahadevaswamy(1994) has found that the sorption potential of a bioadsorbent for the removal of Cu(II) from industrial effluent. Cowdung was used as the biosorbent for this study.

Singaram(1994) had investigated the removal of chromium from tannery effluents by using 3 water weeds, water hyacinth(**Eichornia crassipes**), Psuedo water hyacinth and **Lemna** sp.

Activated carbon prepared from rice husk had been used to remove colour from the effluent. Batch adsorption studies were carried out using reactive dye in aqueous solution with carbon. Effect of variables namely carbon loading, pH, dye concentration and shaking time had been studied. (Prabu et .al., 1995).

Adsorption using activated carbon one of the most efficient treatment methods available for removal of organic matters such as dyes, phenols, etc., and some inorganic materials from textile waste water. Two types of activated carbon, granular and powdered are available. Granular carbon are employed in great extents which are larger than 42 mesh, powdered carbons are comparatively smaller than 325 mesh. The carbonaceous materials such as coal, lignite peat, lignin, bagasse, nut shells, saw dust and petroleum residues are used as activated carbon (Manivasakam, 1995).

Nigam et.al., (1996) reported that, a microbial consortium PDW can be used for decolourization of commercially important textile dyes under anaerobic conditions. It removes 76% of colour from textile plant effluent after 3 days.

Joth et .al., (1996) removed anthroquinone disperse red-15 by a yeast strain, **Pichia anomala** by biodegradation method.

Raji et.al., (1997) had studied the removal of Pb (II) ions from aqueous solutions by polymerized sawdust. This has been found to be dependent on contact time, concentration, temperature, particle size and pH.

Manju and Anirudhan(1997) had removed chromium (VI) from aqueous solution by using coconut fibre pith carbon. Sharma et.al., (1997) reported on the use of activated carbon derived from coconut shell for adsorption of phenol.

A very effective adsorbent usually employed in activated carbon and this has been widely used to reduce the concentration of organic pollutants like chloro, cyano, nitro and amino compounds. Decolourization of disperse dyes are effected with activated carbon (Thambi, 1997).

Ajmal et.al., (1998) has conducted batch experiments on adsorption behaviour of cadmium, zinc, nickel and lead from industrial effluents by **Mangifera indica** seed shell.

Fly ash of low and high carbon contents had been used for the removal of two basic dyes, methylene blue and malachite green from waste water (Mall and Upadhyay, 1998).

Thakur et.al., (1998) had conducted experiments to remove colour from dye effluent. Adsorption with charcoal, ion-exchange resins, precipitation with salts, oxidation, reduction, electrolysis and floatation were the methods used for decolourization of effluent.

MATERIALS AND METHODS

CHAPTER – III

MATERIALS AND METHODS.

III.1. COLLECTION OF THE SAMPLE

In the present work treatment of dye industry effluent by adsorption technique has been studied. Powdered mango shell, powdered jamoon seeds, **A. arabica** bark, carbonized bagasse, carbanoized rice husk and Alum were used as an adsorbents. The pysico – chemical characteristics has also been analysed.

The dyeing effluent from an industry situated in Tirupur has been selected for the present study. The sample was collected in 5 liter sterilized polythene containers.

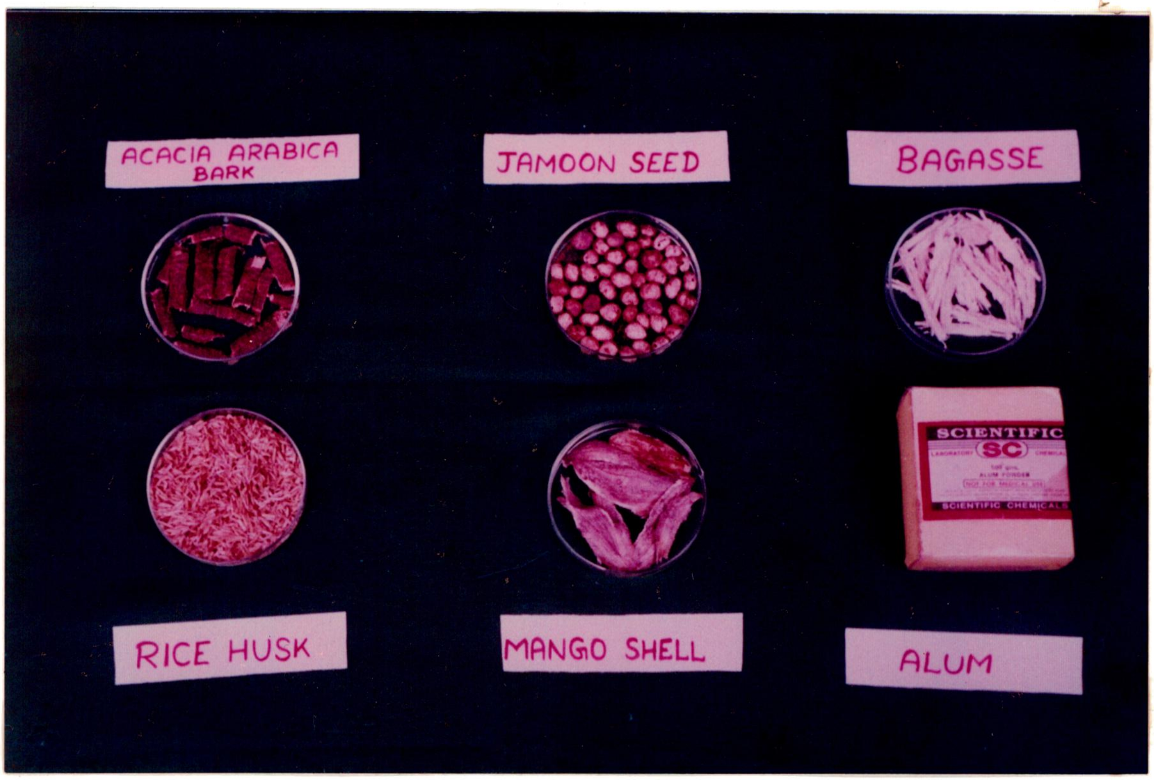
III.2. ADSORBENTS

For the present study mango shell, jamoon seeds, **A. arabica** bark, activated bagasse carbon(ABC) activated rice husk(ACH) were used. The mango seeds, raw bagasse were collected from juice shops. The jamoon seeds were collected from the fruit sellers and the raw rice husk was from the rice mill. The bark of **A. arabica** was also collected. The dried material was ground and sieved through a 200 – 250 mesh.

III.3. BATCH EXPERIMENT

To study the adsorbent capacities of the adsorbents batch experiments were carried out. A number of stoppered 250 ml conical flasks containing equal

PLATE .1



Materials used for effluent treatement

PLATE.2

Raw effluent before treatment.

T1 - Powdered magnoshell

T2 - Powdered jamoon seeds

T3 - Carbonized bagasse

T4 - *Acacia arabica* bark

T5 - Carbonized rice husk

T6 - Alum

PLATE.3

Experimental setup during batch study.

T1 - Powdered magnoshell

T2 - Powdered jamoon seeds

T3 - Carbonized bagasse

T4 - *Acacia arabica* bark

T5 - Carbonized rice husk

T6 - Alum

values of (100ml) effluents were maintained at room temperature. weighed amount of (1g) adsorbents were added in to each of the conical flasks and thoroughly shaken for 1 hour using a mechanical shaker. The contents of the flasks were filtered using Whatman's No.4 filter paper. The filtrate was then analysed for various parameters following standard procedure. (APHA Publications, 1985)

III.4. PHYSICAL PARAMETERS

(i). Colour :

Colour of the untreated and treated effluent was observed visually.

(ii) Odour :

Sample collected in 250 ml glass bottle at room temperature was sniffed. The sample was odorless.

(iii) Temperature :

The temperature of the effluent was noted at the collection spot using a centigrade thermometer.

(iv) pH :

The pH of the sample was analysed using a digital pH meter (Systronic model No : 112).

(v) Electrical Conductivity :

Electrical conductivity is a measure of water's capacity to convey electric current. It was measured using an electrical conductivity meter.

(vi) Solids :

Total dissolved solids (TDS)

- A well mixed and known volume of sample was filtered through a standard glass fibre filter .

-The filtrate was evaporated to dryness in a weighed dish and dried to constant weight at 180^0 C

- The increase in dish weight represented the total dissolved solids.

$$\text{mg of Total dissolved solids} = \frac{A - B \times 1000}{\text{volume of sample in ml}}$$

A = Weight of dried residue + dish weight (mg)

B = Weight of dish (mg)

Total suspended solids (TSS)

- A well mixed sample was passed through a weighed standard glass fibre filter or Whatman No 30 filter paper by applying suction.
- The residue retained was dried to a constant weight at 103 – 105^0C.
- The increase in the weight of the filter represents the total suspended solids.

$$\text{mg of Total suspended solids} = \frac{A - B \times 1000}{\text{volume of sample in ml}}$$

A = Weight of filter + Dried residue(mg)

B = Weight of filter(mg).

III . 5 . CHEMICAL PARAMETERS :

Chloride :

Chloride is a common anion seen in water, sewage and other effluents.

Principle :

Silver nitrate reacts with chloride ion forming silver chloride. The end point of the reaction is the production of red colour by the reaction of silver nitrate with potassium chromate.

Reagents :

i)Standard silver nitrate titrant, 0.0282 N – 4.791g Silver nitrate was dissolved in 1000ml distilled water and standardized it against 0.028 N Sodium chloride solution.

ii) Standard sodium Chloride titrant, 0.028 N – 1.648g sodium chloride was dissolved in 1000 ml distilled water.

iii) Potassium chromate indicator – 25g of pottasium chromate was dissolved in 100ml distilled water.

Procedure :

To 100ml of the sample 1.0 ml potassium chromate indicator was added and titrated against silver nitrate solution until a slightest reddish precipitate persisted.

$$\text{mg / l of chloride(as Cl)} = \frac{\text{A-B x N x 35450}}{\text{ml}}$$

A = ml titration of sample

B = ml titration of blank.

N = Normality of Silver nitrate.

Sulphate :

Sulphate ions were precipitated as barium sulphate, crystals of uniform size in acid medium and it was measured by spectrophotometer.

Regents :

i)Conditioning reagent – 75g sodium chloride was dissolved in 300 ml distilled water. 30ml concentrated hydrochloric acid and 100ml 95% ethylalcohol were added . To this 50ml glycerol was added and mixed well.

ii) Barium chloride crystals 20 – 30 mesh.

iii) Standard sulphate solution – 147.9mg of anhydrous sodium sulphate was dissolved in 1000 ml distilled water.

Procedure :

- In a series of 250 ml conical flasks 5,10,15,20,25 and 30 ml of standard sulphate solution was taken and diluted to 100 ml.

-5.0 ml conditioning regent was added and stirred well.

- 0.5g of barium chloride crystals were added to the above solution and stirred well.

- After one minute the solution was poured in to absorption cell of spectrophotometer and the readings were taken at the wavelength of 420 nm.

$$\text{mg / l of sulphate(as } SO_4) = \frac{\text{mg of sulphate x 1000}}{\text{volume of sample taken}}$$

Nitrogen :

Principle: Nitrate iron reacts with brucine in strong sulphuric acid solution to form an yellow colour which is measured photometrically.

Reagents :

i)Nitrate stock solution – 722 mg of Potassium nitrate(previously dried at 105^0C for 24 hours) was dissolved in distilled water and made upto 1000ml in volumetric flask.

ii) Nitrate standard solution – 100ml nitrate stock solution was pipetted out in to a 1000ml volumetric flask and made up to the mark with distilled water.

iii) Brucine – sulfanilic acid solution – 1g brucine sulfate and 100mg sulfanilic acid were dissolved in 70 ml hot distilled water. 3ml con.Hcl was added, cooled and diluted to 100ml with distilled water. The solution is stable for several months.

iv) Sulphuric acid solution – 500ml con. H_2SO_4 was added carefully to 75 ml distilled water. It was cooled to room temperature.

v) Sodium arsenite solution – 1.83g sodium- arsenite, was dissolved in 100ml distilled water.

Procedure :

-In to a series of 50ml beakers 0.5,1.0,2.0,2.5,3.0,3.5,4.0,4.5 and 5.0 nitrate standard solution was taken and diluted to 5ml with distilled water, include a beaker containing 5ml distilled water as the blank.

-2ml or suitable aliquot of the sample containing not more than 10mg / l nitrate, nitrogen was placed in a 50ml beaker. The volume was adjusted to 5 ml.

-1ml bruine-sulfanilic acid solution was added to the blank, standards and sample and mixed well.

-In to a second series of 50ml beakers, 10ml H_2SO_4 solution was placed.

-The contents of the first series of 50ml beakers containing blank, standard and sample were transferred to each of second series of 50ml beakers containing H_2SO_4 solution and mixed well. This was repeated for 4 – 6 times to ensure complete mixing.

-Kept the beakers in the dark for 10 ± 1minutes.

-While the colour was developing, 10ml distilled water was added to each of the empty beakers. After 10 minutes the water was added to respective beakers containing blank, standards and sample.

-Allowed to cool in the dark of 20-30 minutes.

-The absorbance of the standards and sample were measured after setting the blank at 100% transmittance at a wave length of 410nm.

-A calibration curve was prepared and the mg equivalent of nitrate nitrogen in the sample was find out.

$$\text{mg / l nitrate nitrogen} = \frac{\text{mg.nitrate nitrogen x 1000}}{\text{ml sample taken for estimation}}$$

mg / l Nitrogen(NO_3) = mg / l nitrate nitrogen x 4.43

Phosphate :

Phosphate is one of the major element found in the dye effluent.

Reagents:

i)Phenolphthalein indicator solution – 500mg phenolphthalein was dissolved in 50ml of ethanol or isopropyl alcohol. 50ml of distilled water was added. 0.02 N sodium hydroxide was added dropwise until a faint pink colour appeared.

ii)Sulphuric acid – nitric acid solution – 75ml of con H_2SO_4 was added to about 150 ml of distilled water and cooled. To this 1ml of con HNO_3 was added and diluted to 250 ml with distilled water .

iii)Ammonium molybdate solution – 25g of ammonium molybdate was dissolved in 200ml of distilled water. 280ml of con H_2SO_4 was added carefully to 400ml distilled water and cooled. The molybdate solution was added to the diluted acid and the mixture was diluted to 1000ml.

iv)Stannous chloride solution – 2.5g of stannous chloride was dissolved in 100ml of glycerol and heated gently in a water bath. The solution was stirred well to mix.

v)Phosphate stock solution – 439g of potassium dihydrogen phosphate was dissolved in distilled water and made up to 1000 ml.

vi)Phosphate standard solution – 10 ml of phosphate stock solution was pipetted in to a 100ml flask and made up to 100ml.

Procedure :

Sulphuric acid – Nitric acid digestion:

-A well mixed sample was kept in a microkjeldahl flask and 1ml of con H_2SO_4 and 5ml of con HNO_3 were added. The sample was digested to a volume of 2ml. The sample was cooled and about 20ml distilled water was neutralized with in 1N sodium hydroxide solution using phenolphthalein indicator.

-In to a series of 100ml Nessler's tubes appropriate volume of phosphate working solution was pipeted covering the range up to 20μ g phosphate and diluted to 100ml. 100ml distilled water was included as blank.

-To the blank, standard and sample, 4.0ml of ammonium molybdate and stannous chloride were added and mixed well.

-After 10 minutes, the colour was read using spectrophotometer at 690nm.

Carbonate :

Reagents:

i)0.1N Hydrochloric acid

ii)Phenolphthalein indicator.

Procedure :

-1.5ml of sample was taken in a conical flask. 4 drops of phenolphthalein indicator was added to this.

-The colour was disappeared. It was titrated against 0.1 Hydrochloric acid until pink colour appeared. The number of ml of acid used was recorded.

Calcium:

The pH of the sample was made sufficiently high(12 – 13) to precipitate magnesium as hydroxide and calcium was allowed to react with EDTA in the presence of murexide indicator.

Reagents:

i)Sodium hydroxide(1N) – 40g of Sodium hydroxide was dissolved in 100ml of distilled water and made up to 1000ml.

ii)Murexide(Ammonium purpurate) – 150mg of the dye was dissolved in 100g of absolute ethylene glycol.

iii)Standard EDTA titrant (2.02N) – 3.723g AR Grade disodium ethylene diamine tetra acetate dehydrate was dissolved in distilled water and made up to 1000ml.

Procedure:

-50ml of the sample was taken.

-2.0ml NaoH solution was added to produce pH 12 – 13.

-1-2 drops of indicator was added.

-Titrate immediately with EDTA to get proper end point.

$$\text{mg / l Calcium(as Ca)} = \frac{\text{Volume of EDTA titrate} \times 1 \times 1000}{\text{Volume of sample taken for titration.}}$$

Magnesium :

When magnesium is precipitated in the presence of the dye brilliant yellow, the dye is absorbed on the colloidal precipitate and its colour changes from orange to red.

Reagents :

i)H_2SO_4 N/50 – 0.6 ml con H_2So_4 was diluted to 1000ml with distilled water.

ii)Calcium sulphate solution – Large quantity of calcium sulphate was disssolved in 1000ml of distilled water.

iii)Aluminium sulphate – 310mg of aluminium sulphate was dissolved in 0.3ml con H_2SO_4 and made up to 1000ml with distilled water.

iv)Stabilizing solution – 1g of cellulose was dissolved in 100ml of distilled water.

v)Brilliant yellow solution - 2.5 g of solid dye was dissolved in 500ml distilled water.

vi)Sodium hydroxide(6N) – 120g sodium hydroxide was dissolved in 500ml distilled water.

vii)Magnesium stock solution-1g pure magnesium metal turning was taken in a conical flask and dissolved in 150ml distilled water. 5ml of 1:1 H_2SO_4 was added in 1ml portion of the above solution.

vii)Magnesium working solution – 100ml of magnesium stock solution was made up to 1000ml with distilled water.

Dechlorinating solution - 1g of anhydrous sodium sulphate was dissolved in 100ml distilled water.

Procedure :

-100ml volumetric flasks were placed with appropriate volume of magnesium working solution, covering up to the range of 600 μg and diluted to 50ml with distilled water . A 100ml of volumetric flask with 50ml distilled water was kept as blank.

-The sample was placed in a volumetric flask and diluted to 50ml with distilled water.

-To the blank, standard and sample solution, 1ml 0.02 N H_2SO_4 , and 20ml calcium sulphate solutions were added.

-The volume was brought to 80ml with distilled water and added 5.0ml stabilizing solution, 2.0ml brilliant yellow solution and 3.5 ml NaOH solution.

-The optical densities of the blank, standard and sample were measured using a spectrophotometer at a wave length of 525 nm.

Sodium:

Sodium is of importance when salinity of total dissolved solids is considered. Sodium content of sample was measured by flamephotometric method.

Reagents:

i)Deionized distilled water .

ii)Sodium stock solution – 2.524g of sodium chloride dissolved in little deionized distilled water and made up to 1000ml.

Procedure:

Dilutions were made as required and valid in flame photometer.

Iron:

Reagents:

i)0.01 N potassium permanganate

ii)10% pottassium thiocyanate.

iii)5N hydrochloric acid.

Procedure:

-To 25ml of the sample, 1ml of 5 N hydrochloric acid was added and heated for 10 minutes,

-Cooled and oxidized by adding 0.01N Potassium permanganate until permanent pale pink colour appeared.

-The solution was transferred to 50ml standard flask and to this, 1ml of 10% potassium thiocyanate was added and shaken well. The solution was made up to 50ml with distilled water and mixed well.

-The cololur was read at 532nm.

Chromium:

Hexavalent chromium reacts with diphenyl carbazide. This reaction forms an inner metallic complex of hexavalent chromium and diphenyl carbazone. This complex can be extracted and concentrated in isoamyl alcohol. To accelerate the extraction, salt solution was added to form a 50 % saturated aqueous solution.

Acidity of 1ml to 25ml made up sample was adjusted to neutrality with 1:1 ammonium hydroxide and 1:1 H_2SO_4. 1 ml of 0.25 percent solution of diphenyl semicarbazine in acetone was added. 2.5 ml of 55 percent sodium dihydrogen phosphate monohydrate was added as a buffer solution and diluted to 10ml. This solution was read at 540nm against reagent blank.

Copper:

In neutral or weakly acidic solution (pH 3 – 9),copper reacts with 2,9, -dimethyl –1, 10-Phenanthroline(neocuproine) to form a complex which is extractable in to a $CHCl_3$ – CH_3 OH mixture to produce a yellow solution. The latter can be measured spectrophotometrically at 457nm.

Reagents:

i)Concentrated sulphuric acid
ii)Concentrated nitric acid.
iii)1 % NH_2 OH . HCl
iv)40% sodium citrate solution.

Procedure :

-100ml of sample was taken in a 250ml beaker. 1ml con H_2SO_4 and 5ml con HNO_3 were added. It was heated to sulphur trioxide fumes.

-5ml con H_2SO_4 was added repeatedly and heated to fumes or till the solution became colourless.

-It was cooled, 80ml redistilled water was added and boiled. Cooled and filtered in to 100ml volumetric flask. It was made up to 100ml.

-50ml aliquot was pipetted in to a 125ml separatory funnel and diluted to 50ml with redistilled water.

-5ml 1% $NH_2OH.HCL$, 10ml 40% sodium citrate solutions were added and mixed thoroughly . The pH was adjusted to 4-6 by adding 10ml neocuproine reagent (100mg / 100ml CH_3OH) and shaken for 30 seconds.

-25ml of $CHCl_3$ extract was withdrawn in to volumetric flask. This was repeated and $CHCl_3$ extract was transferred in to the volumetric flask. These extracts were diluted up to 25ml with CH_3OH and shaken well.

-It was measured at 450 – 460 nm against a reagent blank.

Zinc:

Reagents:

i)5 percent Potassium permanganate.

ii)40 percent NH_2OH HCl.

iii)40 percent Sodium citrate solution.

iv)0.01 percent dithizone – CCl_4 solution.

Procedure :

-20ml of sample was taken in a flask. 10 ml of 5 % $KMnO_4$ solution and 2- 3 ml con H_2SO_4 were added to this.

-It was refluxed for 4 hours.

-It was cooled, 40% $NH_2OH.HCl$ was added to reduce $KMnO_4$, filtered and made up to 100ml.

-20ml of aliquot was taken in a separatory funnel. 5 – 10ml of 40% sodium citrate solution was added and the pH was adjusted to 8.0 – 8.5 with dil NH_4OH .

-It was extracted with 0.01% dithizone - CCl_4 solution .

-Back – extracted with 1% HNO_3 and transferred to a 25 ml volumetric flask. 2.5 ml of 1M KCl was added and the pH was adjusted to 6.0 by HNO_3. The volume was made up to 25ml in the volumetric flask.

-The amount of Zinc was measured polarographically at $E_{½}$ = -1.0 Volts.

Dissolved oxygen:

Oxygen is dissolved in most waters in varying concentrations. In industrial water dissolved oxygen is a nuisance as it induced corrosion reactions.

Reagents:

i)0.1N Sodium thiosulphate(Stock solution) – 24.83g of Sodium thiosulphate was dissolved in 1 liter of distilled water.

ii)Standard solution – 250 ml of the stock solution was made up to 1 liter with distilled water.

iii)Manganous sulphate – 480g of manganous sulphate was dissolved in 1 liter of distilled water.

iv)Alkaline iodide – 780g of potassium hydroxide and 150g of potassium iodide were dissolved in one liter of distilled water.

v)Concentrated Sulphuric acid.

vi)1% Starch solution.

Procedure(Winkler's method)

-250ml reagent bottle was immersed in to the sample and filled without any air bubble.

-To the sample , 1ml of manganous sulphate and 1ml of alkaline iodide were added.

-The bottle was stoppered and shaken for 1minute and the precipitate was allowed to settle.

-1ml of concentrated sulphuric acid was added and the bottle was shaken again to dissolve the precipitate.

-50ml of the sample was measured in to a conical flask and 1ml of starch was added. The sample turned blue.

-The sample was titrated against the sodium thiosulphate until the solution decolourized.

$$\text{Amount of oxygen / l} = \frac{\text{K x 200 x 0.698 x volume of sodium thiosulphate}}{\text{Volume of the sample}}$$

$$\text{K} = \frac{\text{Volume of reagent bottle}}{(\text{Volume of reagent bottle}) - (\text{Volume of reagent})}$$

200 = The constant value obtained by multiplying the equivalent weight of oxygen and normality of sodium thiosulphate for 1 liter(8 x 0.025 x 1000 = 200)

0.698 = Conversion factor to convert ppm to ml/l.

Bio – Chemical oxygen demand(BOD)

BOD was estimated following the dilution method. BOD refers to the quantity of oxygen required by bacteria and other microorganisms in the biochemical degradation and transformation of organic matter under aerobic conditions.

BOD determination involves the measurement of dissolved oxygen content in the sample before and after five days incubation at 20^0C. The reduction in oxygen content is due to the demand exerted by the microbial population and it is the measure of oxidisable organic matter.

Reagents :

A good quality distilled water containing less than 10 μg/l copper and free from chloride was used in the preparation of the reagent.

i)Calcium chloride solution – 1.375g of calcium chloride was dissolved in 50ml of distilled water.

ii)Magnesium sulphate solution – 1.25 g of magnesium sulphate was dissolved in 50 ml distilled water.

iii)Ferric chloride solution – 1.0128g of ferric chloride was dissolved in 50ml of distilled water.

iv)Phosphate buffer solution – 0.544g Potassium dihydrogen phosphate, 0.835g disodium hydrogen and 0.048g ammonium chloride were dissolved in distilled water and made up to 25ml. This solution was stored in a refrigerator to prevent mould growth.

i)Preparation of dilution water:

1ml of each of calcium chloride, magnesium sulphate, ferric chloride and phosphate buffer solution were added in to 1 liter of aerated distilled water and mixed well. The standard dilution water was prepared freshly before use.

ii)Seedling of the dilution water:

It is essential to seed dilution water when BOD determined is made on samples of industrial effluent. The seedling material generally used is supernatant of the domestic sewage.

2ml of the sewage was added as seed to 1 liter of dilution water.

iii)Dilution of sample:

Effluent was diluted with seeded dilution water (1 percent dilution). Each diluted sample was taken in a set of 2 BOD bottles.

iv)Determination of dissolved oxygen(DO) before and after 5 days incubation:

In one flask DO was determined immediately, while the other was kept for incubation at 20^{0}C for 5 days. After 5 days DO of the incubated sample was determined.

$$\text{BOD mg/l} = \frac{(DO_0 - DO_5 - BC) \times 100}{\text{Percent sample}}$$

DO_0 = Initial dissolved oxygen content in mg/l

DO_5 = Dissolved oxygen content after incubation for 5 days.

BC = The difference between the DO content of blank on the initial day and after five day's incubation (blank correction)

Chemical Oxygen Demand(COD):

Chemical oxygen demand is the amount of oxygen(expressed in mg/l) consumed under specified conditions in the oxidation of organic and oxidisable inorganic matter corrected for the influence of chlorides.

The organic matter of the sample was completely oxidized by refluxing with a known excess of potassium dichromate solution under acidic conditions.The unreacted dichromate was back titrated with a standard solution ferrous ammonium sulphate solution.

$$\text{COD mg/l} = \frac{\text{Blank titre value} - (\text{sample titre value}) \times (\text{normality of FAS}) \times 8 \times 1000}{\text{Volume of sample taken for estimation}}$$

RESULTS AND DISCUSSION

CHAPTER – IV

RESULTS

The results pertaining to the study "Bioadsorbents an eco-friendly and low cost technology for the treatment of industrial effluents " are presented below :

IV.1. PHYSICO – CHEMICAL CHARACTERISTICS OF DYEING EFFLUENT

The physico –chemical parameters of dyeing industry effluent from Tirupur as compared with ISI standard of industrial water in to public sewers. (IS : 3306 – 1974) is presented in Table.I. The effluent had different colours like blue, green, red, pink etc., but did not produce any offensive odour. The effluent was alkaline with a pH9.0 which was equal to the tolerance limit (5.5-9.0) prescribed by Indian Standard Institution. The effluent had total suspended solids with in the prescribed level(467 mg/l), where as , the total dissolved solids was found to be very high(4040 mg/l) compared to the ISI permissible limit(2100 mg/l). The electrical conductivity was 5.9 d. Sm^{-1}. Effluent contained very high amount of chlorides(1649 mg/l), sodium(219 mg/l) and low amount of sulphate (479 mg/l) when compared to the ISI limits(600 and 1000mg/l respectively). It was found to contain high quantity of calcium(806mg/l), magnesium(392 mg/l), phosphate (154 mg/l) and nitrogen(196 mg / l). Among the heavy metals, copper was found in traces(0.81 mg/l), while iron content was very high(19.1 mg/l). BOD of the effluent sample was high (789 mg/l). when compared to the ISI standard (500 mg/l) and very high COD(1694 mg /l) was observed as compared to the prescribed standard(250 mg/l).

IV. 2. EFFICACY OF SELECTED BIOADSORBENTS IN THE TREATMENT OF DYEING EFFLUENT.

A batch study was undertaken using powdered mango shell, powdered jamoon seeds, carbonized bagasse, **A.arabica** bark carbonized rice husk and

TABLE - I

PHYSICO - CHEMICAL CHARACTERISTICS OF DYEING EFFLUENT

S.No.	Parameters	ISI Standards of industrial waste water in to public sewers. IS:3306-1974	Raw effluent
1	pH	5.5 - 9.0	9.0
2	Electrical conductivity(d.Sm^{-1})	-	6.3
3	Total dissolved solids	2,100	4,040
4	Total suspended solids	750	467
5	BOD	500	789
6	COD	250	1,694
7	Nitrogen	50	196
8	Sulphate	1,000	479
9	Chloride	600	1,649
10	Carbonate	-	142
11	Phosphate	-	154
12	Calcium	-	806
13	Magnesium	-	392
14	Sodium	60	219
15	Iron	-	19.1
16	Chromium	0.05	6.7
17	Copper	-	0.81
18	Zinc	-	4.8

(All the Parameters are in mg/l except electrical conductivity)

TABLE - II

INFLUENCE OF BIO ADSORBENTS ON THE PHYSICO CHEMICAL PARAMETERS OF DYEING EFFLUENT

S.No.	Parameters	Raw effluent	Powdered mango shell T_1	Powdered jamoon seeds T_2	Carbonized bagasse T_3	*A.arabica* bark T_4	Carbonzed rice husk T_5	Alum T_6
1	pH	9.00	7.80	5.90	7.20	6.80	6.90	2.30
2	Electrical conductivity ($d.Sm^{-1}$)	6.30	2.20	3.00	1.80	3.60	1.90	2.30
3	Total dissolved solids	4040.00	1436.50	1942.00	1194.55	2335.00	1258.50	1513.00
4	Total suspended solids	467.00	164.92	279.00	100.46	381.00	99.06	176.00
5	BOD	789.00	286.01	649.00	242.81	692.00	169.71	272.00
6	COD	1694.00	562.94	896.00	462.12	1175.00	372.08	642.00

(All the Parameters are in mg/l except electrical conductivity)

TABLE - III

INFLUENCE OF BIO ADSORBENTS ON THE ELEMENTAL COMPOSITION OF DYE ING EFFLUENT

.No.	Elements	Raw effluent mango shell	Powdered jamoon seeds T_1	Powdered bagasse T_2	Carbonized bark T_3	*A.arabica* rice husk T_4	Carbonzed T_5	Alum T_6
1	Nitrogen	196.00	51.67	165.00	64.50	171.00	36.71	68.00
2	Sulphate	479.00	197.04	368.00	198.80	322.00	440.01	162.00
3	Chloride	1649.00	689.90	496.00	561.81	732.00	438.60	698.00
4	Carbonate	142.00	62.71	139.00	51.86	141.00	60.71	128.00
5	Phosphate	154.00	61.61	123.00	78.70	85.00	38.46	52.00
6	Calcium	806.00	202.60	392.00	138.70	479.00	122.06	195.00
7	Magnesium	392.00	98.75	113.00	42.81	230.00	58.71	98.00
8	Sodium	219.00	70.02	148.00	55.37	172.00	61.22	109.00

(All the Elements are in mg/l)

TABLE - IV

INFLUENCE OF BIO ADSORBENTS ON THE HEAVY METALS PRESENT IN DYE ING EFFLUENT

.No.	Heavy metals	Raw effluent	Powdered mango shell T_1	Powdered jamoon seeds T_2	Carbonized bagasse T_3	*A.arabica* bark T_4	Carbonzed rice husk T_5	Alum T_6
1	Iron	19.10	7.06	8.90	2.81	16.20	2.71	6.60
2	Chromium	6.70	2.10	4.20	1.36	4.80	Traces	3.10
3	Copper	0.81	0.27	0.31	0.12	0.68	0.21	0.18
4	Zinc	4.80	0.79	1.92	0.84	2.14	Traces	0.96

(All the heavy metals are in mg/l)

TABLE - V

PERCENTAGE OF REDUCTION OF THE PHYSICO - CHEMICAL PARAMETERS OF THE TREATED EFFLUENT

S.No.	**Parameters**	**Powdered mango shell T_1**	**Powdered jamoon seeds T_2**	**Carbonized bagasse T_3**	***A.arabica* bark T_4**	**Carbonzed rice husk T_5**	**Alum T_6**
1	pH	13.0	34.4	20.0	24.4	23.3	74.4
2	Electrical conductivity	65.0	52.3	71.4	42.8	69.8	63.4
3	Total dissolved solids	64.4	51.8	70.4	42.2	68.8	62.5
4	Total suspended solids	64.6	40.2	78.4	18.4	78.7	62.3
5	BOD	63.7	17.7	69.2	12.2	78.4	65.5
6	COD	66.7	47.1	72.7	30.6	78.0	62.1
7	Nitrogen	73.6	15.8	67.0	12.7	81.2	65.3
8	Sulphate	58.8	23.1	58.4	32.7	8.1	66.1
9	Chloride	58.1	69.9	65.9	55.6	73.4	57.6
10	Carbonate	55.8	2.1	63.4	0.007	57.2	9.8

TABLE - V

PERCENTAGE OF REDUCTION OF THE PHYSICO - CHEMICAL PARAMETERS OF THE TREATED EFFLUENT

S.No.	Parameters	Powdered mango shell T_1	Powdered jamoon seeds T_2	Carbonized bagasse T_3	*A.arabica* bark T_4	Carbonzed rice husk T_5	Alum T_6
11	Phosphate	59.9	20.1	48.8	44.8	75.0	66.2
12	Calcium	74.8	51.3	82.7	40.5	84.8	75.8
13	Magnesium	74.8	71.1	89.0	41.3	85.0	75.0
14	Sodium	68.0	32.4	74.7	21.4	72.0	50.0
15	Iron	63.0	53.4	85.2	15.1	85.8	65.4
16	Chromium	68.6	37.3	79.7	28.3	99.0	53.7
17	Copper	66.6	61.7	85.1	16.0	74.0	77.7
18	Zinc	83.5	60.0	82.5	55.4	99.0	80.0

alum. After one hour treatment, the physico-chemical parameters of the effluent was analysed and the results are presented in Table II, III, IV.

IV. 2.1 INFLUENCE OF BIOADSORBENTS ON THE PHYSICO- CHEMICAL PARAMETERS OF DYEING EFFLUENT

pH: (Figure .1)

The raw effluent collected had the pH 9.0. After treatment, maximum reduction (74.4 percent) was observed in treatment with alum(2.3pH). This was followed by powdered jamoon seeds, where the pH was 5.9, the reduction percentage being 34.4 , while in treatment with **A.arabica** bark, the pH was reduced to 6.8 showing 24.4 percent reduction. Next to this carbonized rice husk showed 23 percent reduction, this was followed by carbonized bagasse where the reduction was twenty percent with the pH 7.2. Treatment with powdered mango shell showed minimum reduction 13 percent and the pH was 7.8.

The order of reduction percent was as follows:

pH $T_6 > T_2 > T_4 > T_5 > T_3 > T_1$.

$74.4 > 34.4 > 24.4 > 23.0 > 20.0 > 13.0$

Electrical conductivity :

The electrical conductivity recorded in raw effluent was 6.3 d.Sm-1 . A 71 percent reduction was noticed in carbonized bagasse treatment, and 69 percent reduction was noticed in carbonized rice husk treatment. This was followed by 65 percent reduction in powdered mango shell and 63 percent reduction in alum treatment. Powdered jamoon seeds treatment has shown 52 percent of reduction. This was followed by **A.arabica** bark treatment with 42 percent reduction.

The order of reduction percent was as follows :

ED $T_3 > T_5 > T_1 > T_6 > T_2 > T_4$

$71.0 > 69.0 > 65.0 > 63.0 > 52.0 > 42.0$

Total dissolved solids (TDS) (Figure.2)

In the untreated dyeing effluent the total dissolved solid content was (4040 mg/l) which was reduced to maximum extent(70.4 percent) in treatment with carbonized bagasse (1194.55 mg /l) and this was followed by the carbonized rice husk treatment (1258.5 mg / l) showing 68.8 percent reduction. Next to this, powdered mango shell showed 64.4 percent reduction(1436.5 mg/l). 62.5 percent reduction was showed by alum treatment(1513.0 mg/l). This was followed by powdered jamoon seeds treatment(1942.0mg/l) showing 51.8percent reduction. The minimum reduction 42.2 percent was in treatment with **A.arabica** bark(2335 .0 mg/l).

The order of reduction percent was as follows :

TDS $T_3 > T_5 > T_1 > T_6 > T_2 > T_4$

70.4 > 68.8 > 64.4 > 62.5 > 51.8 > 42.2

Total suspended solids (TSS)

With respect to this parameter the maximum reduction(78.7 percent) was observed in treatment with carbonized rice husk(99.06 mg / l). When compared to the raw effluent(467 mg / l). Next to this maximum reduction(78.4 percent) was showed by carbonized bagasse (100.46 mg/l). This was followed by powdered mango shell treatment(164.92 mg / l) showing 64.6 percent reduction. Alum treatment (176.0mg /l) showed 62.3 percent reduction. This was followed by powdered jamoon seeds treatment(279 mg / l) showing 40.2 percent reduction. Minimum reduction (18.4 percent) was observed in **A.arabica** bark treatment (381 mg/l).

The order of reduction percent was as follows

TSS $T_5 > T_3 > T_1 > T_6 > T_2 > T_4$

78.7 > 78.4 > 64.6 > 62.3 > 40.4 > 18.4

Bio – Chemical Oxygen Demand(BOD) (Figure.3)

The BOD of the raw effluent was 789 mg / l which was highly reduced to 169.71 mg / l(78.4 percent reduction) in treatment with carbonized rice husk. Treatment with carbonized bagasse showed 69.2 percent reduction (242.81 mg/l). This was followed by alum treatment(272 mg/l) showed 65.5 percent reduction. Next to this, 63.7 percent reduction was observed in powdered mango shell treatment(286.01 mg / l). Minimum reduction(17.7 percent) was observed in powdered jamoon seeds treatment (649 mg /l) and this was followed by **A.arabica** treatment (692 mg / l) showing 12.2 percent reduction.

The order of reduction percent was as follows :

BOD $T_5 > T_3 > T_6 > T_1 > T_2 > T_4$
78.4 > 69.2 > 65.5 > 63.7 > 17.7 > 12.2

Chemical oxygen Demand(COD) (Figure.3)

The COD of the raw effluent was 1694 mg/l. With respect to this parameter also maximum reduction(78.0 percent) was found in treatment with carbonized rice husk and this was followed by carbonized bagasse treatment(462.12mg/l) showing 72.7 percent reduction. In treatment with powdered mango shell(562.94 mg /l) 66.7 percent reduction was showed. The reduction of 62.1 percent was observed in treatment with alum(642 mg/l). This was followed by powdered jamoon seeds treatment(896 mg/l) showing 47.1 percent reduction. The minimum reduction was showed by **A.arabica** bark treatment(1175 mg / l) with 30.6 percent reduction.

The order of reduction percent was as follows.

COD $T_5 > T_3 > T_1 > T_6 > T_2 > T_4$
78.0 > 72.7 > 66.7 > 62.1 > 47.1 > 30.6

IV.2.2. INFLUENCE OF BIOADSORBENTS ON THE ELEMENTAL COMPOSITION OF DYEING EFFLUENT:

Nitrogen(Figure.4)

Analysis of untreated dye effluent showed nitrogen content of 196mg/l. Of the six treatments, maximum reduction(81.2 percent) was observed in carbonized rice husk(36.71 mg/l) followed by powdered mango shell treatment(51.67 mg / l) showing 73.6 percent reduction. Next to this 67 percent reduction was found in carbonized bagasse treatment and this was followed by alum treatment(68 mg / l) showing 65.3 percent reduction. 15.8 percent reduction was found in powdered jamoon seeds treatment(165.0 mg/l) and minimum reduction (12.7 percent) was recorded in treatment with **A.arabica** bark.

The order of reduction percent was as follows :

N_2 $T_5 > T_1 > T_3 > T_6 > T_2 > T_4$

81.2 > 73.6 > 67.0 > 65.3 > 15.8 > 12.7

Sulphate(figure.6)

The sulphate content of raw effluent was 479 mg / l. It was highly reduced to 162.0 mg/l in alum(66.1 percent reduction), 197.04mg /l in powdered mango shell treatment (58.8 percent reduction). In carbonized bagasse treatment it was 198.80 mg /l with 58.4 percent reduction, in **A.arabica** bark treatment(322.0 mg/l) showing 32.7 percent reduction. In powdered jamoon seeds treatment it was reduced to 368.0 mg/l (23.1 percent). The lowest percentage of reduction(8.1 percent) was found in carbonized rice husk treatment(440.01 mg/l) .

The order of reduction percent was as follows:

SO_4 $T_6 > T_1 > T_3 > T_4 > T_2 > T_5$

66.1 > 58.8 > 58.4 > 32.7 > 23.1 > 8.1

Chloride (Figure.4)

Chloride content of untreated effluent was 1649 mg / l. Considerable reduction in chloride content was observed in all the treatments, maximum being 73.4 percent in carbonized rice husk(438.6 mg /l), followed by powdered jamoon seeds treatment(496 mg / l) showing 69.9 percent reduction, and this was followed by carbonized bagasse treatment(561.81 mg / l) showing 69.9 percent reduction. And this was followed by carbonized bagasse treatment(561.81 mg/l) showing 65.9 percent reduction. In powdered mango shell treatment (689.9 mg / l), 58.1 percent reduction was observed. In powdered mango shell treatment(689.9 mg/l), 58.1 percent reduction was observed. The treatment with alum (698 mg / l) showed 57.6 percent reduction. The lowest percentage of reduction(55.6 percent)was found in **A.arabica** bark treatment (732 mg/ l). The order of reduction percent was as follows:

Cl $T_5 > T_2 > T_3 > T_1 > T_6 > T_4$
73.7 > 69.9 > 65.9 > 58.1 > 57.6 > 55.6

Carbonate(Figure.6)

The carbonate content of 142 mg/l in raw effluent was reduced to 51.86 mg/l in carbonized bagasse(63.4% reduction), 62.71 mg / l in powdered mango shell (55.8% reduction), 60.71 mg / l in carbonized rice husk(57.2percent reduction), 128.0 mg/l in alum treatment(9.8 percent reduction) 62.71 mg/l in powdered jamoon seeds treatment(2.1 percent reduction) and least percentage of reduction was found in **A. arabica** bark treatment (85.00).
The order of reduction percent was as follows :

CO_3 $T_3 > T_5 > T_1 > T_6 > T_2 > T_1$
63.4 > 57.2 > 55.8 > 9.8 > 2.1 > 0.007

Phosphate(Figure.6)

The phosphate content of raw effluent was 154 mg / l. This was highly reduced by carbonized rice husk treatment (38.46 mg/l) showing 66.2 percent reduction. In powdered mango shell treatment(61.61mg / l), 59.9 percent reduction was observed . The content of phosphate reduced to 78.70 mg/l in carbonized bagasse(48.8% reduction) and 85.00 mg/l in **A.arabica** treatment. The minimum reduction (20.1 percent) was found in powdered jamoon seeds treatment(123.00mg/l).

The order of reduction percent was as follows :

PO_4 $T_5 > T_6 > T_1 > T_3 > T_4 > T_2$

75 > 66.2 > 59.9 > 48.8 > 44.8 > 20.1

Calcium (Figure.5)

Calcium content of untreated effluent was 806 mg / l. Considerable reduction in calcium content was observed in all the treatments. It was highly reduced by carbonized rice husk treatment(122.06 mg / l) showing 84.8 percent reduction and this was followed by carbonized bagasse treatment(138.7 mg/ l) showing 82.7 percent reduction and this was followed by carbonized bagasse treatment (138.7 mg / l) showing 82.7 percent reduction. In alum treatment(195 mg / l) 75.8 percent of calcium was removed and in powdered mango shell treatment(202.6mg/l) 74.8 percent of calcium was removed. This was followed by powdered jamoon seeds treatment(392 mg / l) showing 51.3 percent reduction and minimum reduction(40.5 percent) was found in **A.arabica** bark treatment.

The order of reduction percent was as follows :

Ca $T_5 > T_3 > T_6 > T_1 > T_2 > T_4$

34.8 > 82.7 > 75.8 >74.8 > 51.3 > 40.5

Magnesium (Figure .5)

The content of magnesium in the raw effluent was 392 mg / l. The maximum reduction (89.0) was observed in carbonized bagasse treatment (42.81 mg/l), this was followed by carbonized rice husk treatment (58.71 mg/l) showing 85 percent reduction. The content of magnesium was reduced to 98 mg/l in alum treatment(75% reduction) and 98.75 mg /l in powdered mango shell treatment(74.8%reduction). In powdered jamoon seeds treatment it was reduced to 98.75 mg/l(71.1 % reduction). Minimum reduction(41.3 percent) was observed in **A.arabica** bark treatment(230 mg / l).

The order of reduction percent was as follows :

Mg $T_3 > T_5 > T_6 > T_1 > T_2 > T_4$

89.0 > 85.0 > 75.0 > 74.8 > 71.1 > 41.3

Sodium (Figure . 5)

The sodium content of untreated effluent was 219 mg / l. The maximum reduction (74.7 percent) was found in carbonized bagasse treatment (55.37 mg / l) this was followed by carbonized rice husk(61.22 mg/l) showing 72 percent reduction. In powered mango shell treatment (70.02 mg / l) and the percentage of reduction was 68.0. This was followed by alum treatment(109 mg / l) showing 50 percent reduction. The percentage of 32.4 reduction was observed in jamoon seeds treatment(148 mg /l). The lowest percentage 21.4 reduction was found in **A.arabica** bark treatment(172 mg / l)

The order of reduction percent was as follows :

Na $T_3 > T_5 > T_1 > T_6 > T_2 > T_4$

$74.7 > 72.0 > 68.0 > 50.0 > 32.4 > 21.4$

IV.2.3. INFLUENCE OF BIOADSORBENTS ON THE HEAVY METALS PRESENT IN DYEING EFFLUENT

Iron.(Figure.7)

Iron , one of the heavy metal seen in dyeing effluent was 19.1mg/l in raw effluent. The maximum reduction(85.8 percent) was found in carbonized rice husk treatment(2.71 mg/l), this was followed by carbonized bagasse(2.81 mg/l) showing 85.2 percent reduction. In alum treatment(6.6mg/l) iron content was reduced to 65.4 percent, in powdered mango shell treatment(7.06 mg/l), it was reduced to 63 percent, and in powdered jamoon seeds treatment(8.9 mg/l) it was reduced t 53.4 percent. The minimum reduction(15.1%) was obsesrved in **A.arabica** bark treatment(16.2 mg/l).

The order of reduction percent was as follows :

Fe $T_5 > T_3 > T_6 > T_1 > T_2 > T_4$

$85.8 > 85.2 > 65.4 > 63.0 > 53.4 > 15.1$

Chromium(Figure.7)

The raw effluent when analysed was found to contain 6.7mg/l of chromium. This was reduced to a maximum extent(99.0 percent) in treatment with carbonized rice husk, followed by carbonized bagasse(79.7 percent) with chromium content of 1.36 mg/l and powdered mango shell treatment(68.6 percent reduction) with the content of 2.10 mg/l. In alum treatment(3.1 mg/l) the percentage of reduction was 53.7 and in powdered jamoon seeds treatment(4.2 mg/l), the percentage of reduction was 37.3. the minimum extent (28.3) was observed in treatment with **A.arabica** bark(4.8mg/l).

The order of reduction percent was as follows :

Cr $T_5 > T_3 > T_1 > T_6 > T_2 > T_4$
$99 > 79.7 > 68.6 > 53.7 > 37.3 > 28.3$

Copper(Figure.8)

The raw effluent contains lesser content of copper 0.81mg /l than other metals. . This also highly reduced by carbonized bagasse treatment 85.1 percent and this was followed by alum treatment(74.7 percent).

The order of reduction percent was as follows

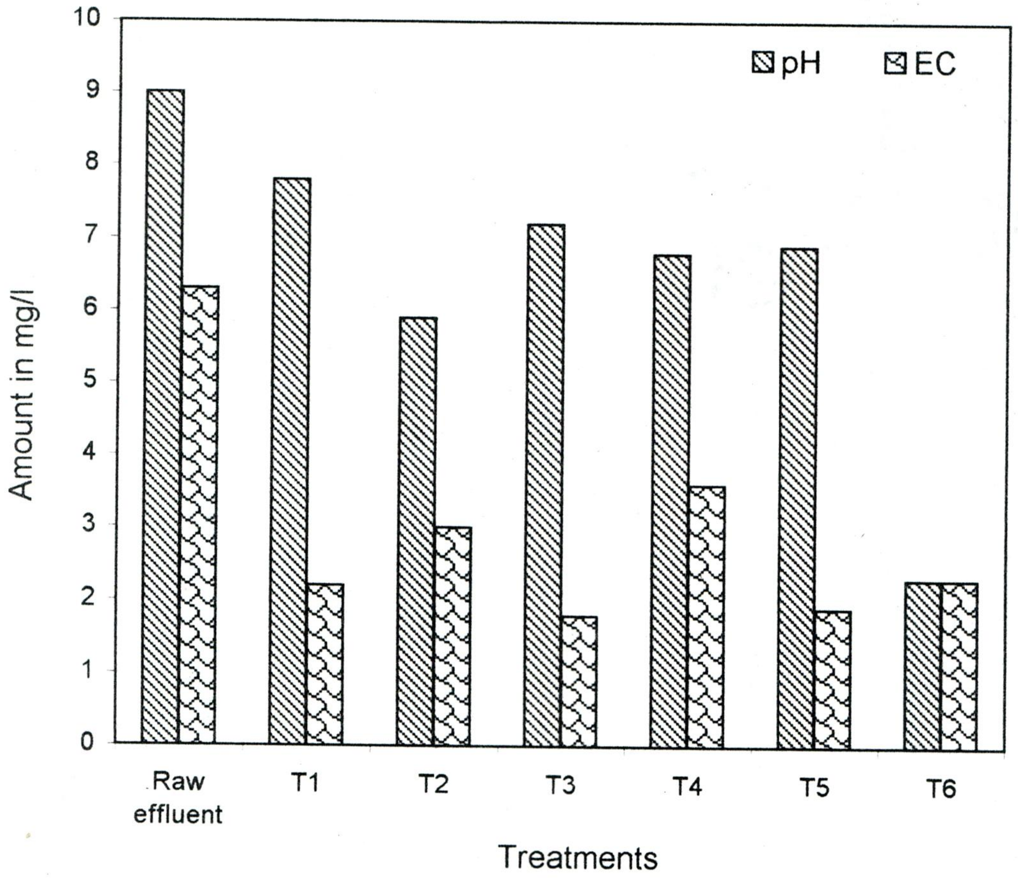
Cu $T_3 > T_6 > T_5 > T_1 > T_2 > T_4$
$85.1 > 77.7 > 74 > 66.6 > 61.7 > 16.0$

Zinc(Figure.8)

The Zinc content of raw effluent was 4.8 mg/l. This was highly reduced by carbonized rice husk treatment(99%) and followed by powdered mango shell treatment(83.5 percent) with 0.79mg/l of zinc. 82.5 percent reduction was showed by carbonized bagasse (0.84 mg/l) and 80 percent reduction was showed by alum treatment(0.96 mg/l). In powdered jamoon seeds(1.92 mg/l) 60 percent reduction was observed and minimum reduction(55.4 percent) was showed by **A.arabica** bark.

The order of reduction percent was as follows:

Zn $T_5 > T_1 > T_3 > T_6 > T_2 > T_4$
$99.0 > 83.5 > 82.5 > 80.0 > 60.00 > 55.4$



VARIATION OF pH AND EC IN THE TREATED EFFLUENT

FIGURE 1

T1 - Powdered magnoshell

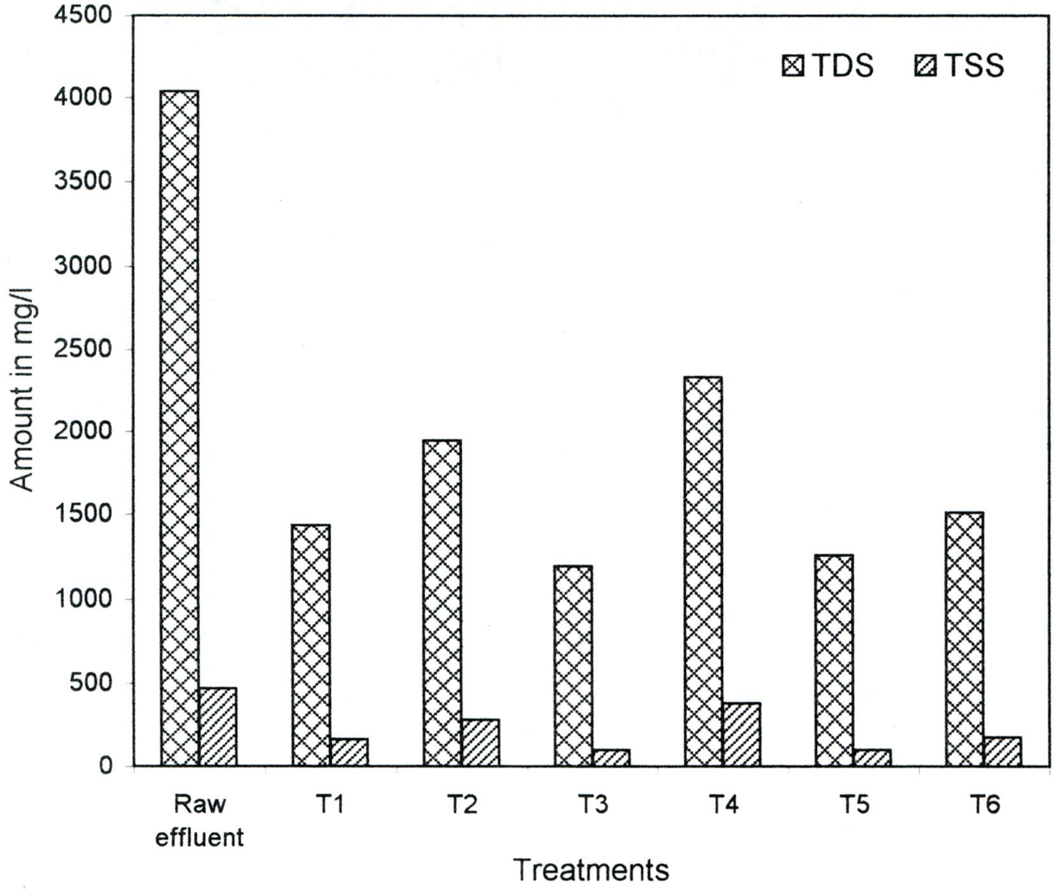
T2 - Powdered jamoon seeds

T3 - Carbonized bagasse

T4 - *Acacia arabica* bark

T5 - Carbonized rice husk

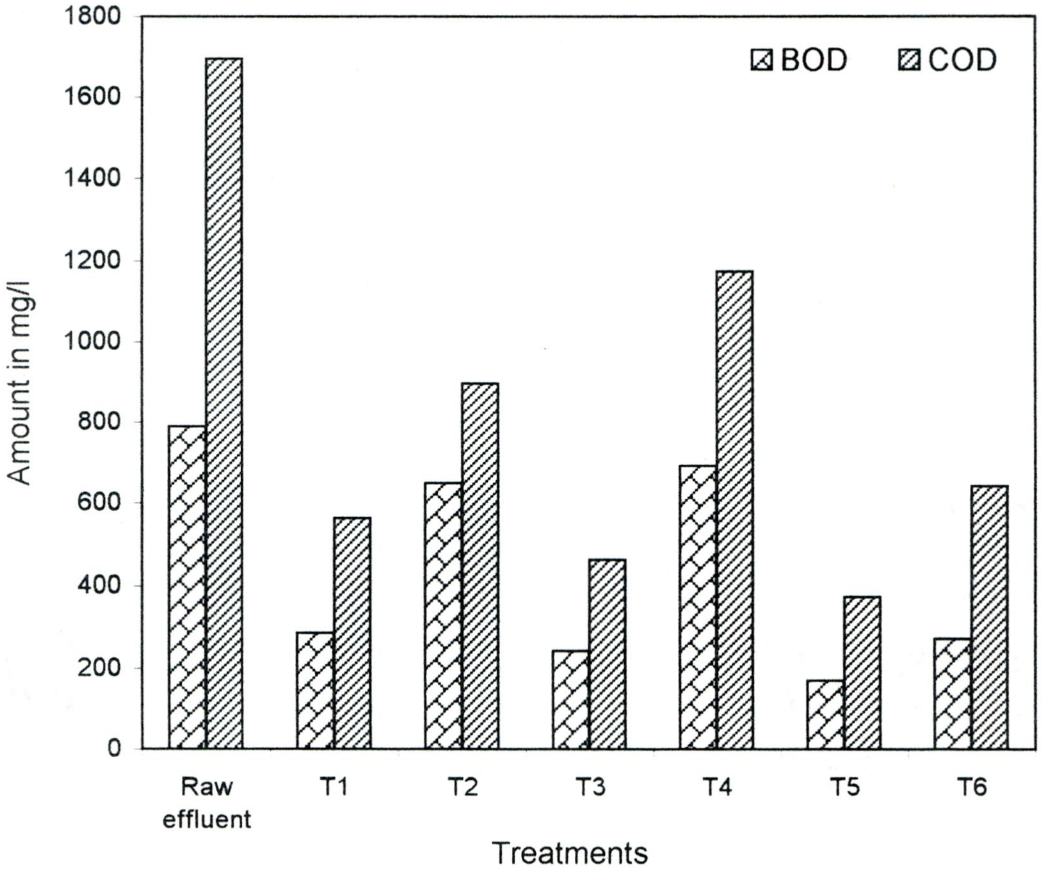
T6 - Alum



TDS AND TSS VALUES IN THE TREATED EFFLUENT

FIGURE 2

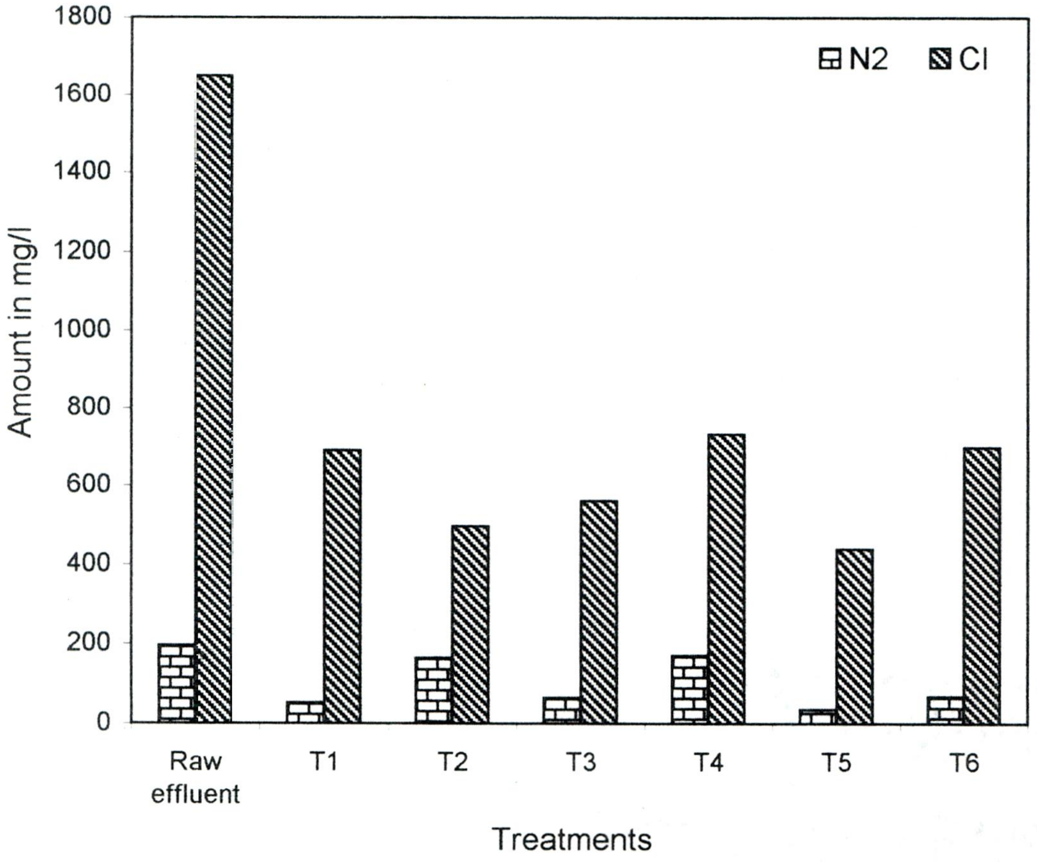
T1	-	Powdered magnoshell	T2	-	Powdered jamoon seeds
T3	-	Carbonized bagasse	T4	-	*Acacia arabica* bark
T5	-	Carbonized rice husk	T6	-	Alum



VARIATION OF BOD AND COD IN THE TREATED EFFLUENT

FIGURE 3

T1	-	Powdered magnoshell	T2	-	Powdered jamoon seeds
T3	-	Carbonized bagasse	T4	-	*Acacia arabica* bark
T5	-	Carbonized rice husk	T6	-	Alum

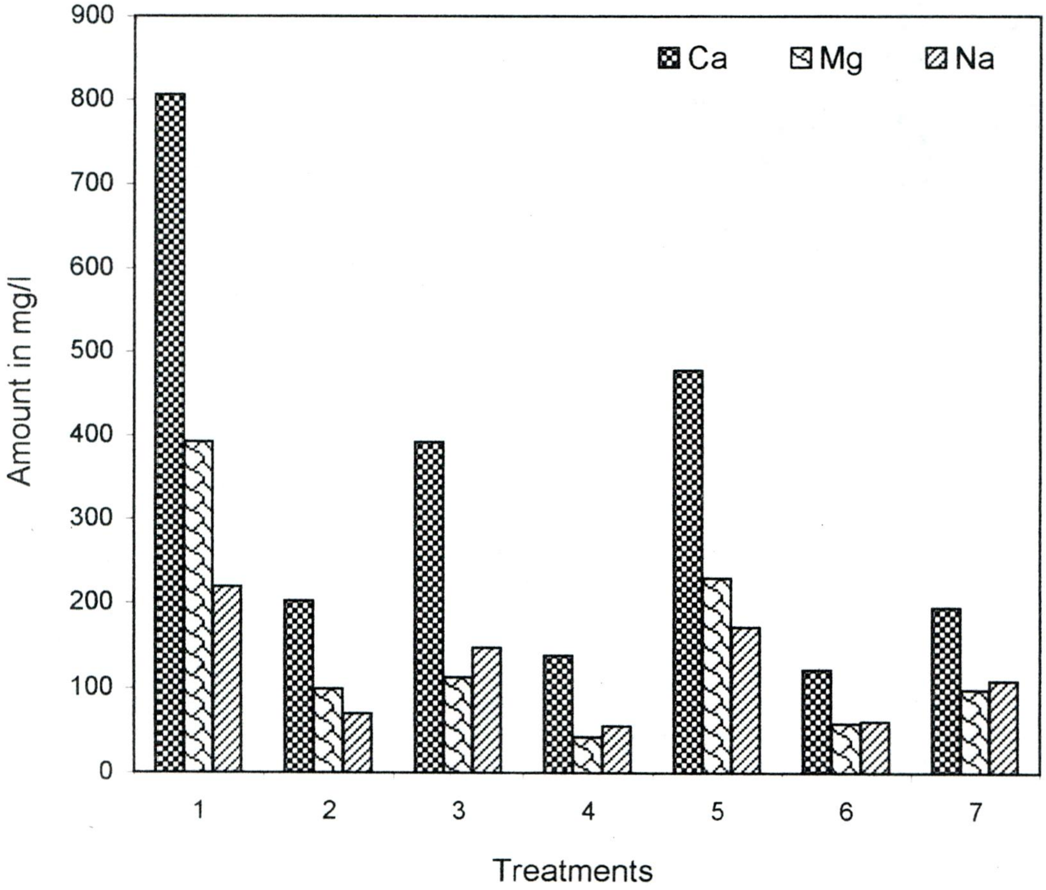


CHANGE IN NITROGEN AND CHLORIDE CONTENT

FIGURE 4

T1 - Powdered magnoshell
T3 - Carbonized bagasse
T5 - Carbonized rice husk

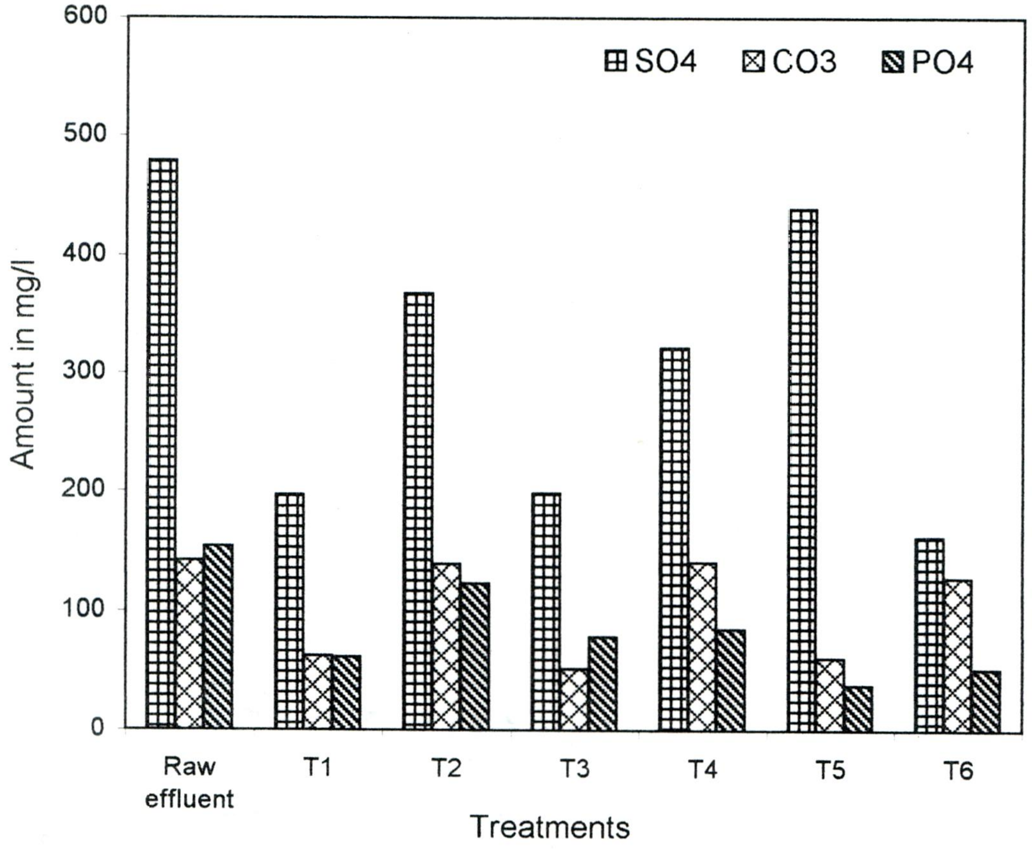
T2 - Powdered jamoon seeds
T4 - *Acacia arabica* bark
T6 - Alum



CALCIUM, MAGNESIUM AND SODIUM LEVEL IN THE TREATED EFFLUENT

FIGURE 5

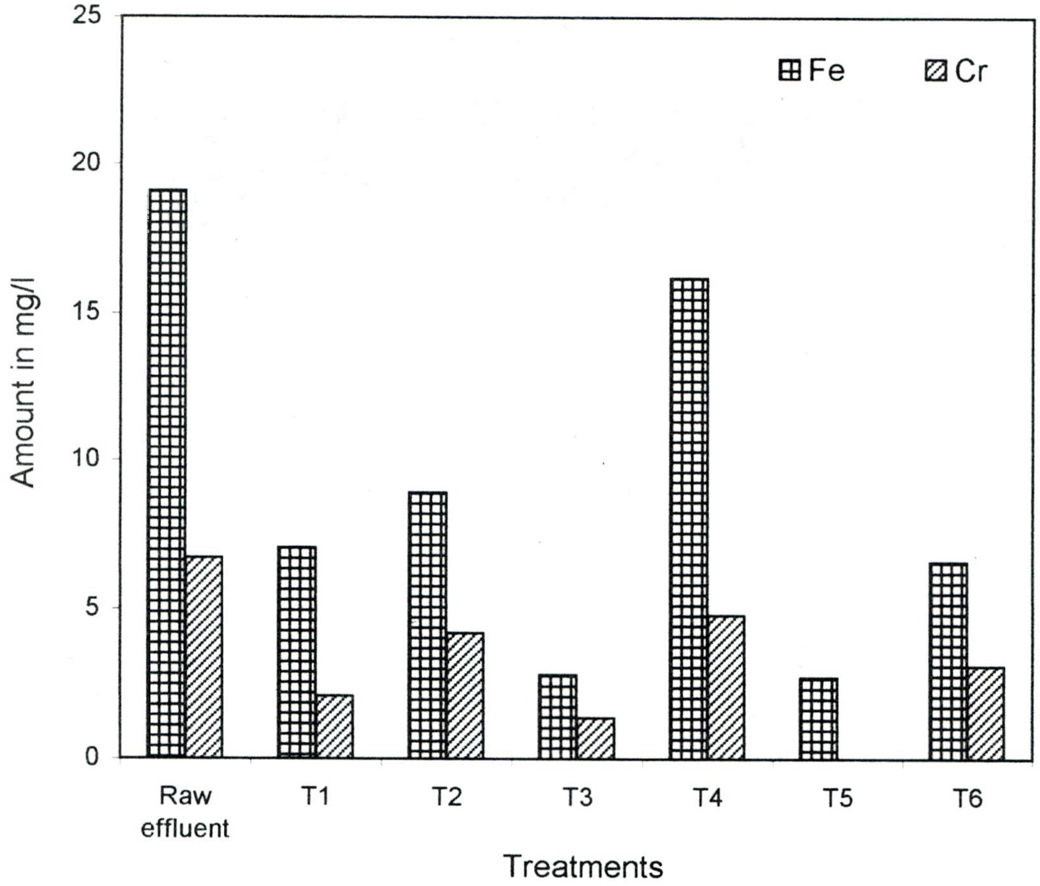
T1	-	Powdered magnoshell	T2	-	Powdered jamoon seeds
T3	-	Carbonized bagasse	T4	-	*Acacia arabica* bark
T5	-	Carbonized rice husk	T6	-	Alum



SULPHATE, CARBONATE AND PHOSPHATE CONTENT IN THE TREATED EFFLUENT

FIGURE 6

T1 - Powdered magnoshell
T2 - Powdered jamoon seeds
T3 - Carbonized bagasse
T4 - *Acacia arabica* bark
T5 - Carbonized rice husk
T6 - Alum

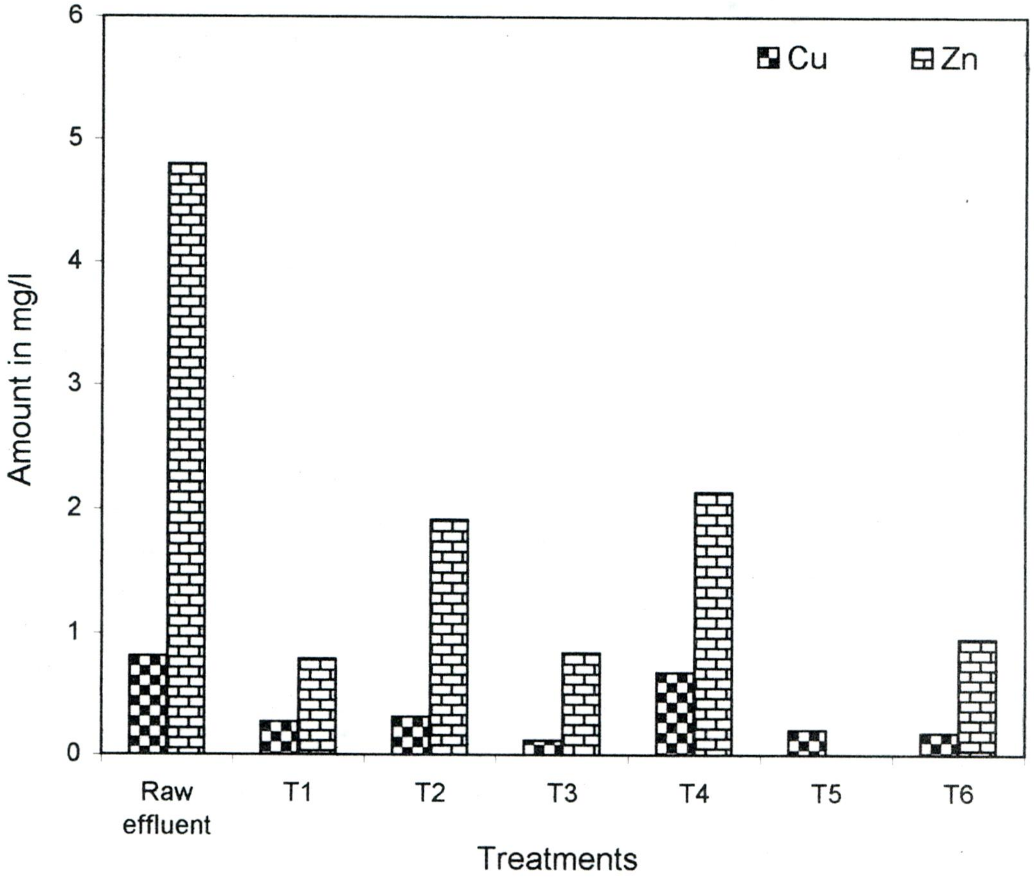


IRON AND CHROMIUM LEVEL IN THE TREATED EFFLUENT

FIGURE 7

T1 - Powdered magnoshell
T3 - Carbonized bagasse
T5 - Carbonized rice husk

T2 - Powdered jamoon seeds
T4 - *Acacia arabica* bark
T6 - Alum



CHANGE IN COPPER AND ZINC LEVEL IN THE TREATED EFFLUENT

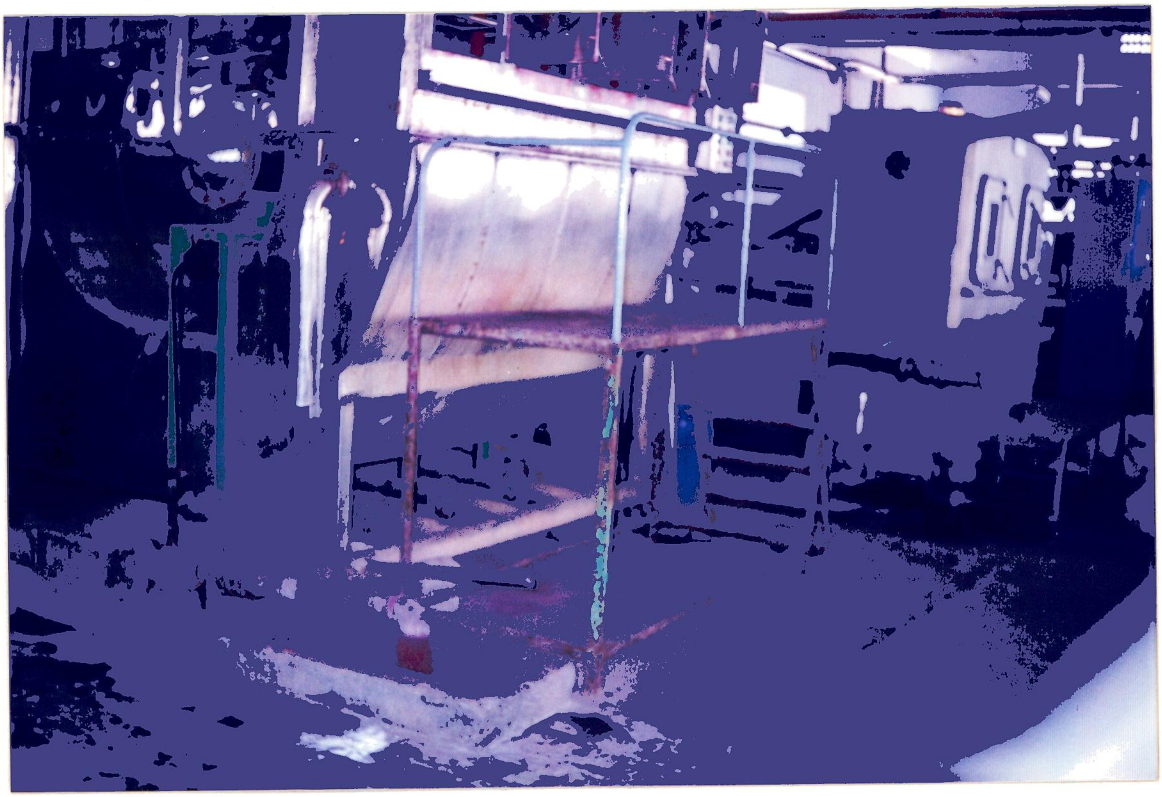
FIGURE 8

T1 - Powdered magnoshell
T3 - Carbonized bagasse
T5 - Carbonized rice husk
T2 - Powdered jamoon seeds
T4 - *Acacia arabica* bark
T6 - Alum

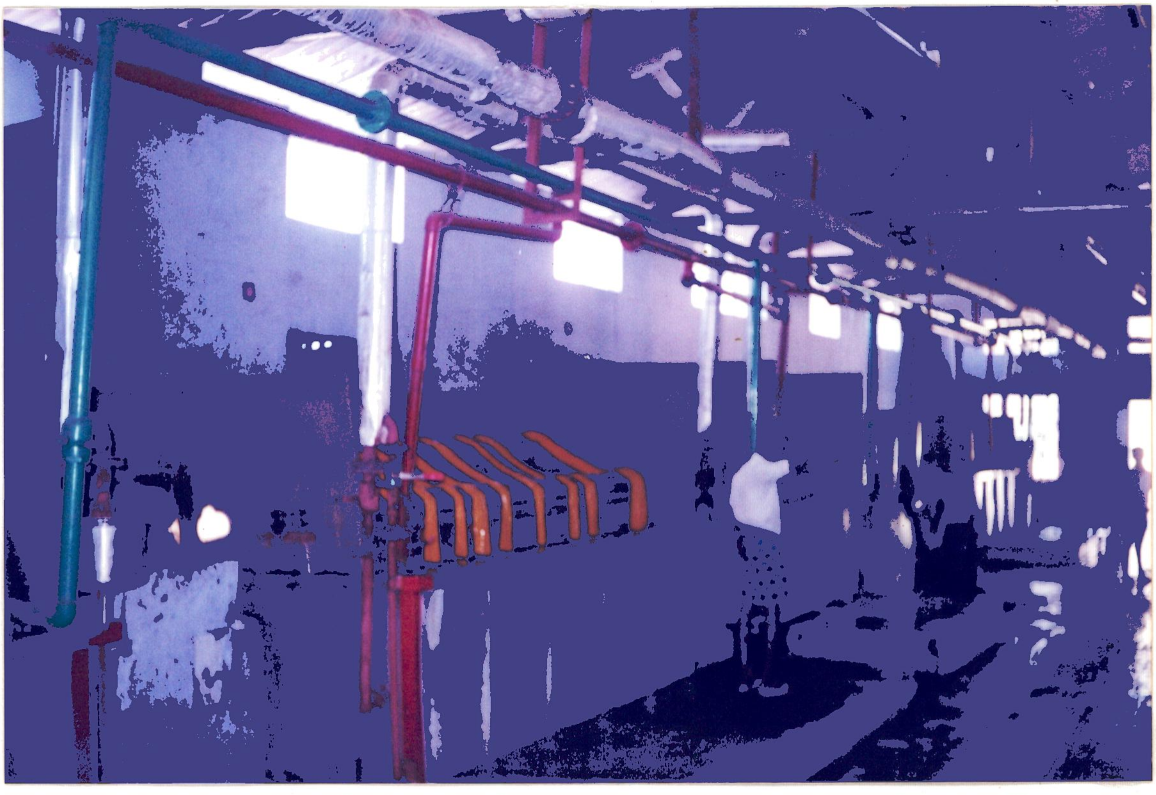
PLATE.4

Effluent drainage.

PLATE.5



a) Soft flow jet dyeing machine.



b) Winch dyeing machine.

PLATE.6.

a,

b. Effluent treatment plant.

DISCUSSION

Textile industry in India is facing several problem in recent years. With the stringent measures taken by the pollution control board to check the flow of untreated effluents in to natural water bodies such as rivers, ponds and lakes and soils, many industries were closed temporarily till establishing proper effluent treatment systems. Several small scale units like dyeing units cannot afford to expend huge amounts in establishing such treatment system. Simple eco-friendly and low cost technologies are essential to enable these units to treat their effluents. In the present investigation, an attempt was made to study the physico chemical characteristics of the effluent.

The colour and dye bearing waste waters discharged in to water streams not only contribute negatively to the aesthetic value but also offers considerable resistance to biodegradation and may upset aquatic life. Such coloured waste waters are unfit for recycling without proper treatment(Mall and Upadhayay, 1988).

Analysis of the physico, chemical characters of the dyeing effluent showed that its was similar the effluent from Selvapuram area of Coimbatore described by Agarwal in having high sulphate content and trace amounts of heavy metals such as chromium, zinc, copper, and iron. However other inorganic and organic materials such as chloride, sodium, magnesium, phosphate, and nitrogen level far exceed the value of Selvapuram effluent. Chloride, sodium and sulphate, BOD, COD values and chromium, iron content also were found to be very high exceed from ISI limits.

A batch study using waste materials such as bagasse, mango shell, jamoon seeds, rice husk, **A.arabica** bark had indicated notable reduction in BOD, COD, TDS and TSS of dyeing effluent. Heavy metals like iron, chromium, copper and Zinc had also been reduced by these bioadsorbents significantly.

Several investigators had used these bioadsorbents for the removal of dye, BOD, COD , TDS, TSS and heavy metals from the dyeing effluent. Carbonized rice husk treatment showed better result. The amount of TDS, TSS, BOD and COD and other heavy metals were highly reduced by carbonized rice husk. The colour was slightly removed in this treatment. The same result was showed by (Prabu and Thangavelu, 1988).

Powdered mango shell treatment showed 64.4 percent removal of TDS, 64.6 percent removal of TSS. Considerable reduction in BOD and COD was also found in this treatment . It removed 83.5 percent of Zinc from the dyeing effluent, and other heavy metals like chromium, copper and iron has also been removed in this treatment. This result coincides with the result of Ajmal et .al(1998).

Carbonized bagasse has given better result. The content of TDS, TSS, BOD, COD, and heavy metals were highly reduced in this treatment. 79.7 percent of Chromium, and 85.2 percent of iron has been removed by carbonized bagase. The activated bagasse carbon was used to remove hexavalent chromium from waste water by Chand et . al.,(1994). It showed almost same efficiency in the removal of chromium.

Leached **A. arabica** bark treated with formaldehyde used to remove chromium(VI) from aqueous solution. This sorbent possesses 85 percent sorption capacity (Singh et. al.,1994). So this was used as a bio adsorbent for treating dyeing effluent. It has low efficacy for treating dyeing effluent. It showed minimum reduction of TDS, TSS, BID, CID and heavy metals.

In carbonized rice husk treatment 99 percent of Chormium and Zinc has been removed. 85.8 percent of iron, 74 percent of copper has also been removed in this treatment.

A minimum carbon dosage(166mg/l) showed maximum removal of total chromium(88 percent) and the optimum pH range was 2.0 – 3.0 (Srinivasan et .al.,1988). Next to carbonized bagasse, carbonized rice husk was efficient in the treatment of dyeing effluent.

Treatment with Alum showed significant reduction in TDS, TSS, BOD, COD and heavy metals present in the dyeing efficient. The colour was completely removed by alum. The similar result was obtained by Mittal and Mehrotra(1980). In their experiment 90 – 95 percent of colour was removed at different pH and various initial colour concentration. Desai,(1982) had also used alum along with activated carbon to decolourize the effluent and quickened the process.

The over all study indicate that among the used bioadsorbents carbonized bagasse, and carbonized rice husk has the great efficacy in treatment of dyeing effluent. They gave the better result. Powdered mango shell was found to posses almost the equal efficiency of that of carbonized rice husk and carbon bagasse. The colour has been slightly removed by the bioadsorbents but completely removed by alum.

SUMMARY AND CONCLUSION

CHAPTER - V

SUMMARY AND CONCLUSION

1.In the present study the effluent obtained was from Tirupur, which has many number of dyeing units discharged large quantities of colourful waste water.

2.The Physico chemical analysis of the effluent was carried out and compared with ISI standards.

3.Physical parameters such as pH and total dissolved solids were found to exceed the permissible limits.

4.Of the chemical parameters biochemical oxygen demand, chemical oxygen demand, chlorides, Sodium and sulphate content and heavy metals, content were found to exceed the permissible limit.

5.Calcium(806 mg/l) and iron(19.1 mg/l) content were very high compared to the permissible limits(150 mg/l and 0.01 mg/l respectively).

6.A batch study was carried out using powdered mango shell, powdered jamoon seeds, carbonized bagasse, **A.arabica** bark, carbonized rice husk and one chemical alum.

7.Bioadsorbent are very cheap and easily available compared to the cost of alum. The bioadsorbent treatment produced considerable reduction in physical and chemical parameters which was almost equal to alum treatment. So bio adsorbents are more preferable than alum.

8.Of the six treatments, carbonized bagasse was found to be effective in reducing level of physical parameters such as TDS(1194.55 mg/l with 78.4 percent reduction) and TSS (100.46 mg/l with 78.4 percent reduction) and it was followed by carbonized rice husk with the reduction of 68.8 percent and 78.7 percent receptively.

9.Chemical parameters such as chlorides(561 mg/l with 65.9 percent reduction), Sodium(55.37 mg/l with 74.7 percent reduction), sulphate(198 mg/l) with 58.7 percent reduction), phosphate(78.mg/l with 48.8 percent reduction), nitrogen (64 mg/l with 72.7 percent reduction), BOD(242 mg/l with 78.7 percent reduction), and COD (462.12 mg/l with 69.2 percent reduction) showed in carbonized bagasse treatment.

10.The heavy metal chromium content decreased in carbonized rice husk treatment. When compared with the untreated effluent (6.7 mg/l), the reduction percentage being 99.0.

11.Carbonized bagasse and carbonized rice husk was found to be effective in purifying the effluent.

12.Powdered mango shell was also found to be effective in reducing the physical parameters such as TDS(1436.5 mg/l with 64.4percent reduction), TSS(164.92mg/l with 64.6 percent of reduction), BOD, COD and reducing the amount of heavy metals.

13.From the present study it is evident that carbonized bagasse, carbonized rice husk and powdered mango shell can be used as an effective material for treating dyeing effluent.

CONCLUSION :

From the present study it was inferred that using the bioadsorbents and the chemical alum treatments the physical and chemical parameters can be very well brought under the permissible limits. Alum treatment method was found to be effective next only to the bioadsorbents. A combination of these methods can very well decrease the water pollution to a major extent. The preparation of activated carbon, used by several investigators was found to be expensive. The efficiency of powdered mango shell almost matched with that of carbonized materials. It is a waste material, obtained very cheaply and also an easily available one. By using mango shell we can reduce the soil pollution also. So powdered mango shell was preferable than the carbonized materials. Construction of a treatment plant in the industries is highly expensive. Small scale industries can not spend huge amount for this. Bioadsorbent treatment is an ecofriendly and low cost technology for reducing the pollution level.

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APPENDIX

Preparation of powdered Mango shell :

The powder of mango shell was treated with 100ml of 1.0 N solution of disodium hydrogen phosphate . After a given soaking time(90 minutes) the solution was filtered and the sample was washed several times with distilled water. The adsorbent was then finally dried at 100^0C and kept in polyethylene bottles.

Preparation of carbonized bagasse.

Four parts of bagasse was treated with three parts of concentrated sulphuric acid by weight and was kept in an oven maintained at 150 – 160^0 C for a period of 24 hours. The carbonized material was washed well with water to remove the free acid and dried at 105 – 110^0C for 24 hours. The carbon was ground and sieved through a 200 – 250 mesh.

Preparation of A.arabica bark:

The bark was dried at 50^0C for 24 hours and powdered in a grinder and passed through a sieve of 200 – 250 mesh. A mixture of aqueous formaldehyde solution 39 percent and 20 parts by volume of 0.2 N Sulphuric acid was heated at 50^0C and 2 parts by weight of ground bark was added. The mixture was stirred for two hours at 50^0C and filtered through sintered glass funnel. This sample was washed with cool water until the pH of the filtrate was 4 – 5. Sample was then air-dried for 24hours at 50^0C.

Preparation of Carbonized rice husk :

Rice husk carbon(RHC) was prepared by treating 4 parts of rice husk with 3 parts by weight of concentrated sulphuric acid and keeping in an air oven maintained in the temperature range of 140 – 160^0C for a period of 24 hours. The carbonized material was washed well with water to remove free acid and dried at 105 – 110^0C for 24 hours. The carbon was ground and sieved through a 200 – 250 mesh.