Removal of Colour from Textile Effluent using Natural Adsorbent (Calotropis Gingantea)

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Abstract: Increased in industrialization and human activities have serious impact on the environment through disposal of dye effluent into natural streams and colour is one of the parameter by which one can identify whether the water is normal water or it is a textile effluent. The presence of colour in the environment can be harmful to a variety of living species, ground and ground water table. The presence of colour and other parameters contaminants in aqueous streams, arising from the discharge of untreated water containing effluents into water bodies, is one of the most important environmental issues. Symptoms of coloured effluent affect the soil and ground water table, etc. Adsorption technique is one of the most important technologies for the treatment of polluted water from colour, but seeking for the low-cost adsorbent is the target of this study. Removal of colour studied using adsorbent prepared from activated carbon of Calotropis gigantea latex. Batch adsorption experiments performed by varying adsorbent dosage, pH of effluent and contact time. Adsorption of colour is highly pH dependent and the results indicate that the maximum removal (92.59%) took place at dose 100mg/l in the pH range of 8. Kinetic experiments reveal that the transparency of colour reached equilibrium within 50 min. Comprehensive characterization of parameters indicates that activated carbon of Calotropis latex is an excellent material for adsorption of colour to treat wastewater containing lower concentration of the colour.

Keywords: Dye Effluent, Low-cost adsorbent, Activated carbon, Adsorption.

I. INTRODUCTION

The environmental issues associated with residual colour in textile effluents have posed a major challenge to environmental scientists as well as the textile coloration processors. The requirements to remove colour from textile effluent on site prior to discharge to sewer have been progressively tightened due to increased public complaints about colour watercourses. Dye are highly are dispersible aesthetic pollutants and are difficult to treat, as most dyes are highly stable molecules made to resist degradation by light ,chemical ,biological and other treatment or exposure. There has been a lot of research going in the past few decades to develop efficient and cost effective technologies to remove colour from textile effluent.

TEXTILE EFFLUENTS:

Wet processing operations during textile chemical processing, i.e.desizing, scouring, bleaching, dyeing, printing and finishing, are the major causes of water pollution. A major contribution to colour in the wastewater is usually the dyeing and the washing operation after, dyeing during which as much as50% of the dye might be released into the effluent. During dyeing, most of the dye is exhausted on the fibre; but the unfixed dye goes into wastewater causing deep colour. The wastewater is extremely variable in composition due to large number of dyes and other chemicals used in processing.

DYESTUFF AND COLOUR REMOVAL FROM TEXTILE EFFLUENT:

Colour removal is a pertinent problem for all categories of textile effluents due to the variety of chemicals used in dyeing and printing of fibre, yarn or fabric.

Colour pollution can be most efficiently controlled by good source reduction practices, administrative and engineering controls, process and product design and work practices. The search for dynamic response and improved productivity has served to focus the attention of the coloration industry on right first time (RFT) production techniques. A high level of RFT minimizes waste and makes a significant contribution to reduce colour loads in the effluent. Improving the exhaustion levels of the various dyes in the dye bath is another area which has received lot of attention from researchers as it will not only improve shade reproducibility and problems of repeat shades but also solve the colour effluent problem which will then reduce to a matter of controlling and handing spills and clean-up. Dye showing a high level of exhaustion and fixation on the fibre have been and will continue to be the prime targets of research and development activity.

Most current practices for wastewater decolourization fall into following four main classes:

Physical or physic-chemical techniques, i.e. Precipitation, coagulation or flocculation, ion exchange, adsorption, and membrane separation. These remove or separate the colour physically and result in need for solid waste disposal.

Chemical techniques, i.e ozonolysis, chemical oxidation / reduction, etc. These technologies remove the colour from the effluent by breaking down into simpler fragments and destroy the chromo pore responsible for colour.

Biological techniques, i.e. aerobic and anaerobic digestion, where by decolourization takes place either by adsorption of dyes on activated sludge or by biological degradation of dye molecules, and

Electrochemical techniques, i.e. electro dialysis / ion oxidation. It combines the oxidation of the dye and the other pollution contaminants by means of the electrolytic process with the physic-chemical precipitation of the sludge.

II. PLANT DESCRIPTION

CALOTROPIS GINGANTEA:

From pre-historic times to the modern era in many parts of the world and India, plants, animals and other natural objects have profound influence on culture and civilization of man. Since the beginning of civilization, human beings have worshiped plants and such plants are conserved as a genetic resource and used as food, fodder, fiber, fertilizer, fuel, febrifuge and in every other way Calotropisgingantea is one such plant and we are using this plant for the colour removal process because the activated carbon of this plant acts as the adsorbent.

Calotropis gigantea Calotropis latex

SYSTEMATIC POSITION 0F THE SELECTED PLANT:

Kingdom	Plantae
Order	Gentianales
Family	Asclepiadaceae
Sub family	Asclepiadoideae
Genus	Calotropis
Species	Gigantea

Ecology and Distribution:

Natural habitat:

Calotropis is drought resistant; salt tolerant to a relatively high degree, grows wild up to 900 meters (msl) throughout the country and prefers disturbed sandy soils with mean annual rainfall: 300-400 mm. Through its wind and animal dispersed seeds, it quickly becomes established as a weed along degraded roadsides, lagoon edges and in overgrazed native pastures. It has a preference for and is often dominant in areas of abandoned cultivation especially disturbed sandy soils and low rainfall. It is assumed to be an indicator of over cultivation.

- The plant grows very well in a variety of soils and different environmental conditions.
- It does not require cultivation practices. It is one of the few plants not consumed by grazing animal.
- It thrives on poor soils particularly where overgrazing has removed competition from native grasses.
- Sometimes this plant is the only survivor in some areas, where nothing else grows.
- It is drought tolerant and the pioneer vegetation in desert soil.
- Presence of latex, extensively branched root system and thick leaves with waxy coverage are the xerophytes adaptations. Hence, it is distributed in tropical and subtropical area of the world and throughout India.

Chemical constituents:

Phytochemical studies on Calotropis procera have afforded several types of compounds such as Cardenolide, triterpinoids, alkaloids, resins, anthocyanins and proteolytic enzymes in latex, flavonoids,tannins, sterol,saponins, and cardiac glycosides. Flowers contain - terpenes, multiflorenol, and cyclisadol.

Leaves:

Theleaves contain mainly the amyrin, amyrin acetate, ß-sitosterol,urosolicacid, cardenolide,calotropin,calotropagenin.

Latex:

The latex contains caoutchouc, calotropin,calotoxin0.15%, calactin 0.15%, uscharin 0.45%, trypsin, voruscharin, uzarigenin, syriogenin andproceroside

PRESENT SCENARIO OF DYEING INDUSTRIES IN TIRUPUR:

Tirupur is located on the bank of Noyyal River. Noyyal is a tributary of river Cauvery. Geographically the town is at 11.7^0 north latitude and 77.5^0 east longitudes. The town spreads over an area approximately 27 sq.km and a population of 3.5 lakhs. It is located on the bank of Noyyal River. It is one of the well-known places in hosiery and knitwear manufacture in international market. Tirupur accounts for 90% of India's hosiery and knitwear export. The main activities in industrial sector here are ginning, weaving, knitting, bleaching, and dyeing, printing and allied works. Tirupur has become an important textile cluster in India both for overseas market and domestic market. It has 2500 knitting and stitching units, 729 dyeing and bleaching units, 300 printing units, 100 embroidery units.

The dyes units discharge untreated effluent into the river. In year 1997, after the Tamil Nadu Pollution Control Board (TNPCB) directions they installed 8 Common Effluent Treatment Plants (CETP) and individual effluent treatment plants (IETP) consisting of physical, chemical and biological treatment process. Even then, the treated effluent from the $CETP_S$ and IETPS did not meet the Total Dissolved Solid (TDS), chloride, heavy metal and colour standards. The discharge of high TDS, chloride effluent, dye water and heavy metals into Noyyal River had significantly affected the river water quality, ground water quality as well as the Orathupalayam dam which is constructed across Noyyal River at 32 km downstream of Tirupur. In year 2006, the honorable High Court of Madras and TNPCB directed the bleaching dyeing units to install Zero Liquid Discharge (ZLD) plant consisting of RO plant. At present there are 17 CETPs with ZLD plant are in operation. Yet the small scale industries do not follow proper treatment process as it expenses lot for them.

In Tamil Nadu dyeing industries are operated in Erode, Karur, Salem, Tirupur districts. Among these districts the majority of the industries are located in the Tirupur locality. Industries around this district pollute the ground and surface water to great extent. Therefore it would be right to select this area as the recommendations provided for the highly pollution area would suit the less polluted areas. The present statistics of the dyeing industries located in the Tirupur district is depicted below.

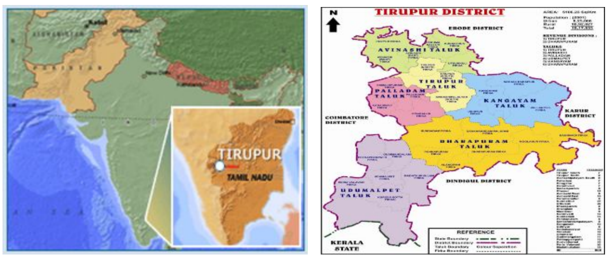


Fig: Location of Tirupur District

III. COLLECTION OF ADSORBATE

Location: Virapandi Pirivu – Tirupur (11.063200''N, 77.344878''W)

Amount of sample collected: 50litres.
Dye industry: K.R.P dyes.

- The samples are collected in sterilized bottle to avoid contamination of effluent.
- The samples are collected in the center part, discharge point, left and right part of the effluent tank.
- Samples are collected at a depth of 2m from the effluent tank.
- The samples are stored in refrigerator after 2 hours from collection.

Fig : Collection of Adsorbate

COLLECTION OF ADSORBENT:

- The adsorbent (Calotropis latex) was collected from the aerial parts of the healthy plants by using razor blades.
- The latex mixture was gently handled to maintain its uniformity for testing.

Fig: Collection of Adsorbent

TESTS FOR ADSORBENT:

The physical characteristics of adsorbent are analysed such as:

Table: Physical characteristics of adsorbent

Parameters	**Observations**
Colour	White
Odour	Pungent
Particle Size	125µm

EXTRACTION PROCESS OF ADSORBENT: (CALOTROPIS GIGANTEA)

After the collection of adsorbent (Calotropis latex) from the local area it is kept cool for further extraction to be done. The extraction is the process of converting the raw materials into powdered form of activated carbon. This is done by using the muffle furnace of 550 for the period of 15 minutes and the fine powdered of activated carbon is obtained by cooling it in a desiccators and crushed to obtain the powdered form .To get the same particle size distribution of adsorbent 125 micron sieve is used .

Fig : Activated Carbon of Latex

IV: BIOSORPTION EXPERIMENTS

Effects of Contact Time:

One litre of textile effluent was taken and tested in the jar test apparatus at 120 rpm at 30^{o}C. The adsorption progress was monitored by measuring the absorbance of the solution at various time intervals, 5, 10, 15, 20, 30, 40, 50 and 60 min. Each time a sample was taken out of the being treated solution, it was filtered using a Whiteman's filter paper No.44 and the absorbance of the filtrate was measured by photo colorimeter at 420 nm. The extent of adsorption or removal of the dye was calculated from the decrease in absorbance of the solution by using the following equation:

$$\text{Removal (\%)} = \frac{A_0 - A_t}{A_0} \times 100\%$$

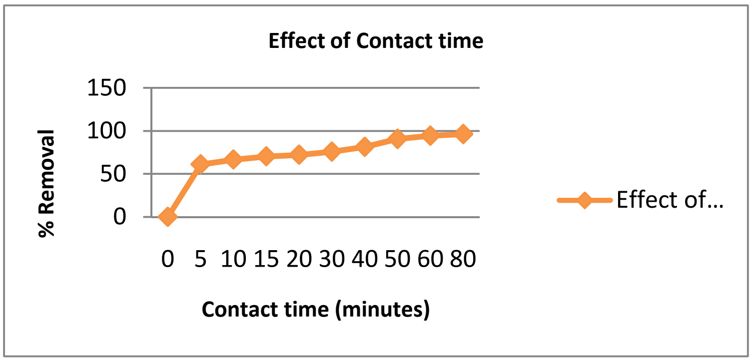
A_0- initial absorbance of the solution

A_t- Absorbance of the solution at time (t)

EFFECT OF ADSORBENT DOSE:

For investigating the effect of the adsorbent dose, the effluent was treated with different amounts of the adsorbent (5, 10, 15, 20, 25, 50, 75 and 100 mg) for 30 min of equilibrium time and the above mentioned procedure was used.

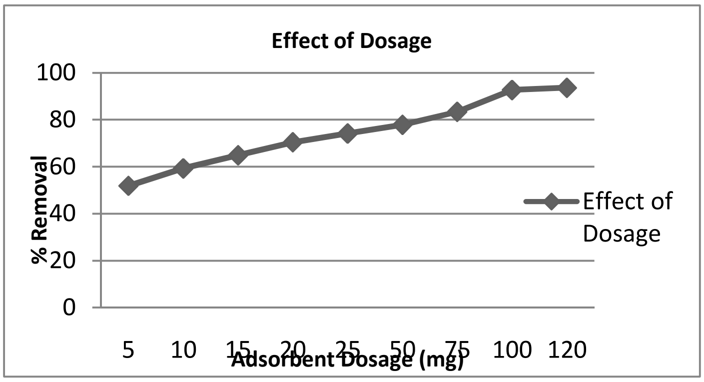
EFFECT OF CONTACT TIME:



Description:

For the first 5 min, the adsorption due to a large number of vacant sites on the adsorbent surface available at the initial stage. As time passes, the adsorption rate is decreased due to the accumulation of the dye molecules in the vacant sites. So 50 minutes, is chosen as the effective contact time.

EFFECT OF DOSAGE:



Description:

The optimum dosage level suggested is 100mg, because 92.6% colour is adsorbed and after further increase in dosage leads to small amount increase in the removal.

Characteristics	**Unit**	**Result**	**Standard**
pH	-	8.23	5.5-9
Colour	-	Colourless	Colourless
Odour	-	Unobjectionable	Unobjectionable
Temperature	-	$32.3^{0}C$	$40^{o}C$
Sulphate	Mg/l	920	400
Chloride	Mg/l	550	1000
Nitrite	Mg/l	0.012	-
COD	Mg/l	780	250
Total hardness	Mg/l	140	300
Alkanity	Mg/l	860	-

Fig. Removal of Colour from dye effluent at different amount of dosage of adsorbent

PARAMETERS FOR TREATED WATER:

RECOMMENDATIONS:

- For the industrial effluent tank of **80,000 litres** of dye effluent requires only**8 kg** of adsorbent.
- Since the natural adsorbent is easily available, we can use this adsorbent for the color removal of the dye effluent.
- It is a simple and more economic than compared to other mechanical Colour removal methods.

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