

INTRODUCTION

“Let not the wastes of the industry hurt the lives of the living beings”

Natural resources are God’s gift to mankind. It is the greatest duty of humans to preserve and conserve the nature and earth. Industries play an important role in the progress of economic development in the country. The unsustainable use of natural resources by the industries has caused many irreparable losses to the earth. Environmental pollution is one of the greatest problems that the world is facing today. All kinds of industries contribute various forms of pollutants to the environment. These pollutants can kill animals and plants, affect human lives and health, imbalance ecosystems, degrade air quality and soil (**Kudesia, 2015**). Water is the key ingredient for sustaining life on earth. Despite its importance to human survival and prosperity water remains the most poorly managed resource on earth. The deterioration of the quality of surface as well as ground water due to improper disposal methods and insufficient control of toxic effluents released from various industries like textile, dyeing, printing, leather, paint, cosmetics, plastics, pharmaceutical, paper and pulp etc imposes major threat to human life (**Wu et al., 2014**). In order to provide a sustainable environment for aquatic life and humans, waste water treatment becomes highly significant.

Textile and Dyeing Industries

Chemistry is responsible for the real “world of colour” through the creation of dyes pigments and paints. Synthetic dyes are used to colour the fabrics in textile industry. Colour is applied by the process of dyeing which involves immersion of a fabric in a solution of a dyestuff in water. The amount of dyestuff required is very small but its production and application require a number of chemicals. In overall production, nearly 80% of the dyes are utilized by the textile industry and the remaining goes to paints, printing inks, rubber and leather industries. India is a major exporter of dyes, since the production of some of the dyes and intermediates are banned in the developed countries because of pollution (**Kudesia, 2015**).

The textile dyeing and finishing industry has created a huge pollution problem as it is one of the most chemically intensive industries on earth and major polluter of clean water. Large quantities of water are required for textile processing, dyeing and printing. The daily water consumption of an average sized textile mill having a production of about

8000 kg of fabric per day is about 1.6 million liters (**Kant, 2012**). It has been estimated that the total dye consumption in textile industry worldwide is more than 10,000 tons per year and about 10-15% of textile dyes are lost during the dyeing process and discharged as aqueous effluents in different environmental components (**Dawood and Sen, 2014**).

Impact of Industries, Agriculture and Domestic Pollution on River Ganga, Cauvery and Noyyal

River Ganga the largest river in India is a typical example for aquatic pollution. The holy river Ganga has historical importance and the water was considered as Amirtham. Running water has the ability for self purification. Ganga water has this ability. But due to overload of pollutants River Ganga has lost that ability of self purification. Now it is slowly becoming a national drainage for the states like Bihar, Uttar Pradesh, Uttaranchal and West Bengal. The river Ganga is polluted by Domestic sewage, Industrial effluents, Tannery effluents, Pesticide pollution and Cremation pollution. It contains heavy load of coliform bacteria. It contains 10^{12} coliform per 100 ml of water (normal limit is less than $10^3/100$ ml of water). This means that Ganga water is nearing the grade of sewage water. The oxygen content of the Ganga water is very low 3 mg/l (normal oxygen content should be more than 10 mg/l) and BOD of river Ganga is very high 9.7 mg/l (normal level should be less than 3 mg/l) (**Arumugam and Kumaresan, 2005**)

Cauvery is the largest river in South India. It starts in Karnataka and passes through Tamil Nadu through Salem, Erode, Trichy and Tanjur. Physical, chemical and biological parameters of Cauvery water showed that the Cauvery water is not suitable for drinking and bathing due to domestic sewage, industrial effluents, pesticides pollution, tannery effluents and cremation pollution (**Arumugam and Kumaresan, 2005**).

The river Noyyal starts from Vellingiri hills in the Western Ghats in Tamil Nadu and runs through Coimbatore and Tirupur towns and joining the river Cauvery. Tirupur has more than 750 bleaching and dyeing industries in and around the city. It is estimated that when these units function to full capacity, about 1,000,000 m³ of water is required per day. The effluents (approximately 75000 m³ per day) are let into river Noyyal. The amount of pollutants released vary from one industry to another depending on the techniques and chemicals employed (**Manivasagam, 1995**). In textile processing, large quantity of effluents generated during bleaching and dyeing processes. (**Senthilnathan and Azee 1999**). About 150 chemicals are used in these operations. The quantity of water used to process one kg of hosiery fabric is 175 to 200 l generating about 150 to 175 l of effluent. About 30 to 100 kg common salt, important ingredients in dyeing are used for 100 kg of

cloth. The effluent from bleaching and dyeing industry is highly coloured, highly alkaline (800 mg/l), high total hardness (6300 mg/L), BOD upto 120 mg/l and COD upto 9160 mg/l is also recorded. High BOD and COD are expected to reduce dissolved oxygen in water. Dyes even in low concentrations are extremely visible, posing aesthetic problems, and are toxic to human and aquatic life (Ashraf, 2016; Nurchi *et al* ,2014; Chang *et al* , 2014; Arica *et al* , 2017; Arica *et al* , 2019; Bayramoglu *et al* , 2018). Traces of heavy metals such as Cu, Zn, Cr, and Cd also seen (Azeez, 2001).

Even though the industrial units have established individual effluent treatment plants and common effluent treatment plant (CETP), they are facing so many technological, social and legal problems for running the plants efficiently. Hence the parameter from such units is still higher than the water quality parameters for irrigation purposes (Krishnaraj and Elangovan, 2001).

Evidence for Noyyal river pollution (Business Standard, Aug 08, 2018)

Pollution from textile plants leads to severe frothing in Coimbatore's Noyyal River



Roads in Tamil Nadu's Coimbatore have been covered in froth from **Noyyal River**.

Coimbatore's Noyyal River transforms into frothing disaster (India Today, July 12, 2018)

Cotton-like froth rising in the air from Tamil Nadu's Noyyal river in Coimbatore does not look any less of a snow to children. But, this lethal form of foam is nothing but a poisonous contamination of pollutants degrading not only the groundwater but also causing

skin allergies and respiratory ailments. **The river is surrounded by many fabric dyeing units. The effluents from these units are released into the river causing much pollution.**



Times of India, February 4th, 2019

Tirupur city corporation seized seven septic tank cleaning vehicles as they were found to have releasing the collected wastes including industrial effluents from textile units in Noyyal river and drainage on Wednesday.



The waste water released from these industries contains huge amount of dyes, number of chemicals and other materials which are unsuitable for further use and can cause environmental problems. The various pollutants generated from textile industry are shown in **Table 1**.

**Table 1 Pollutants generated by different processes of textile industry
(Kudesia, 2015)**

S.NO	Process	Generated Pollutants
1	Desizing	Starch, glucose, carboxymethyl cellulose, poly vinyl alcohol, resins, fats and waxes do not exert a high BOD
2	Kiering	Caustic soda, waxes and grease, soda ash, sodium silicate and fragments of cloth
3	Bleaching	Hypochlorite, chlorine, caustic soda, hydrogen peroxide, acids
4	Mercerization	Caustic soda
5	Dyeing	Dye stuff, mordant and reducing agents like sulphides, acetic acid and soap
6	Printing	Dyes, starch, gums oil, china clay, mordants, acids and metallic salts
7	Finishing	Traces of starch, tallow, salts, special finishes etc.,

Since dyes possess complex aromatic molecular structure and high stability to heat and light, they remain in the environment and resist biodegradation (**Ventura and Martin, 2013**).

Many dyes and their degradation products are carcinogenic and mutagenic. Textile dyes can also cause allergies such as contact dermatitis, respiratory diseases, skin irritation and irritation to mucous membrane (**Gupta and Suhas, 2009**).

The dyes not only deteriorate the aesthetic properties of water by imparting significant colour but also increase the chemical oxygen demand(COD), biological oxygen demand (BOD), dissolved and suspended solids of water leading to damage to the aquatic systems (**Aparna Roy et al., 2013**). They prevent the passage of sunlight entering the

water, diminish the photosynthetic activity of algae and influence the food chain **(Ghaly et al., 2014)**. Thus the problems of undesirable effects of a large number of chemicals and dyestuffs used in textile industry are truly critical.

Industries are spending billions on research to reduce pollution and on construction of effluent treatment plants. The public concern for industrial air and water pollution is leading to considerable restrictions on all industrial activities polluting the environment. Government has proposed laws limiting the amount and kind of waste that can be dumped as such. Considering the adverse effect on environment and health of people due to the effluent being thrown out of the textile dye industry we need to wake up to the serious problem and make every effort to reduce pollution **(Kant, 2012)**.

Installation of on-site treatment plants or Common Effluent Treatment Plants (CETPs) is considered as one of the viable solutions for small to medium enterprises for effective waste water treatment. However, many of the operating CETP's are not performing genuinely due to various technical and managerial reasons, lack of space and financial problems. But environmental problems endanger the health and safety of our people. There is a constant need to have an effective process that can efficiently remove dyes economically **(Central pollution control board, 2011)**.

A number of conventional **physical, chemical and biological treatment** methods are used for waste water treatment and they vary in their environmental impact, effectiveness and cost. **(Mahajan, 2004 ; Kant, 2012)**. Conventional methods of waste water treatment are

Physical Methods: Sedimentation, Filtration, Coagulation, Reverse Osmosis, Adsorption, Membrane Treatment

Chemical Methods: Neutralization, Reduction, Oxidation, Ion Exchange and Electrolysis

Biological Methods: Stabilization, Aerated Lagoons, Trickling filters, Activated Sludge, Fungal Treatment and Anaerobic Digestion

Easiness of design, minimum operation and lesser cost makes adsorption process as very useful technique for water decontamination applications.

Carbonaceous materials that exhibit a high degree of porosity, large surface area and good mechanical properties are used as adsorbents to remove toxic non-biodegradable substances from waste waters.

Adsorption is a process of adhesion of atoms, ions or gas molecules on the surface of another solid or liquid. The substance over which adsorption occurs is known as adsorbent and the substance which is adsorbed is called adsorbate.

Activated carbon (commercial) is the most widely used adsorbent used in gas purification, oil purification, sugar refining, medicine, sewage treatment, air filters in gas masks and many other applications. **Lowitz (1786)** was the first to observe the decolourizing effect of charcoal on coloured solution.

Adsorption using Commercial activated carbon as adsorbent is a powerful technology for dye removal from aqueous effluent due to its huge surface area and outstanding adsorption capacity. But its high regeneration cost has led to search for more suitable, efficient and cheaper natural adsorbents particularly from the waste material **(Bharthi and Ramesh, 2013)**.

Natural materials and biomass adsorbents have fascinated more attention because of its outstanding properties such as biodegradability, biocompatibility and renewability. Agricultural waste materials have little or no economic value and often pose a disposal problem. Thus the consumption of natural and agricultural wastes as adsorbents after carbonization and activation is of great importance (Crini *et al.*, 2006). Carbonization was carried out using chloride and sulphate salts and sulphuric acid. Carbonization or pyrolysis involves slow heating of the material in the absence of air at below 600^oC. During carbonization dehydration takes place followed by pyrolytic decomposition of the processor with concurrent elimination of many non-carbon elemental species. The release of low molecular weight volatile products followed by lighter aromatics result in a product called char rich in fixed carbon and the pores formed during carbonization exhibit very good adsorption property **(Bhaskaran, 2011)**. Commercial activated carbon has a typical surface area in the range of 400-1500 m²/g.

The adsorption capacity of activated carbon depends on the following factors.

- ❖ Physical properties of the activated carbon such as pore size and surface area.
- ❖ The chemical nature of the carbon source or the amount of oxygen and hydrogen associated with it.
- ❖ Chemical composition and concentration of the contaminant (adsorbate)
- ❖ The temperature and pH of the water.
- ❖ The flow rate or time exposure of water to activated carbon.

Many studies have been undertaken to investigate the use of carbon prepared from readily available and cheap biomass feed stocks and agricultural residues such as straw, coir pith, peanut shell/hull, rice husk, saw dust, cotton stalks, spent grains, fruit stones, olive waste cakes and coffee husk (**Nair and Vinu, 2016 and Bharathi and Ramesh, 2013**)

In view of the above facts the present work is aimed to study the removal of Crystal Violet (CV), Acid Blue110 (AB110), Remazol Black-5 (RB5) and Congo Red (CR) dyes from aqueous solution and also from dyeing industrial effluent by adsorption technique using a low cost, eco- friendly carbon adsorbent prepared from the fruit pods of naturally occurring biomass *Bauhinia racemosa* using Conc.H₂SO₄ and H₃PO₄ was carried out.

OBJECTIVES

The objectives of the present work are

- ❖ To prepare the carbon adsorbent from the fruit pods of *Bauhinia racemosa* by sulphuric acid activation and phosphoric acid activation processes.
- ❖ To characterize the prepared eco friendly carbon adsorbent.
- ❖ To determine the feasibility of the removal of CV, AB110, RB5 and CR dyes by batch mode adsorption studies using the adsorbent prepared by changing the factors that significantly influence the performance of adsorption like Initial dye concentration, Dosage of adsorbent, pH and Temperature.
- ❖ To examine the Lagergren, Intraparticle diffusion and Elovich rate equations for the adsorption of dyes used in this study.
- ❖ To calculate the thermodynamic parameters for the adsorption of CV, AB110, RB5 and CR dyes.
- ❖ To interpret the results in terms of Langmuir and Freunlich adsorption isotherms.
- ❖ To compare the adsorption capacities of sulphuric acid and phosphoric acid activated carbons with commercial activated carbon.
- ❖ To evaluate the adsorption efficiency of *Bauhinia racemosa* – sulphuric acid activated and *Bauhinia racemosa* – phosphoric acid activated carbons on the application of treatment of industrial waste water containing the dyes used in this study.