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Removal of Dyes from Industrial Wastewater by Adsorbent

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***Abstract*— In recent years, the industrial dye waste water causes major pollutions in environment. As the waste water discharges into the water bodies, it produces maximum issues to the society and responsible for water-borne diseases. Therefore, it is necessary to reduces the pollutant contain before discharging the textile dye effluent. The water used in textile industry to dye, finish, and washed clothes. In India alone textile industry uses 425000000 gallons (1 gallon = 3.784lit) of water daily. Approximately 500 gallons of water is used in production of one pair of jeans. For the removal of dyes from textile waste water using adsorption by activated carbon of bagasse being used. The used of novel adsorbent such as bagasse fly ash combined with zeolite. Then novel adsorbent is used for the treatment of dyes which arises from textile mill industrial waste water. The goal of research is to developed new and efficient adsorbent technique. The bagasse is soaked in 1M of HCL solution and dry it. Followed by drying, it is heated at such temperature at which ash will formed. Then zeolite is crushed in ball mill and sieved. The sieved material and fly ash from bagasse are mixed in KOH solution. After which it become hard at normal temperature. This hard cake is then break in small pieces and forms a bed for adsorption of dyes. This result showed that adsorption of activated carbon (charcoal) of bagasse is good economical method of removal of dyes.**

***Index Terms*—Textile waste water, bagasse ash, zeolite, adsorption method**

I. Introduction

INTRODUTION

Saving water to save the planet and to make the future of mankind safe is what we need now. With the growth of mankind, society, science, technology our world is reaching to new high horizons but the cost which we are paying or will pay in near future is surely going to be too high. Among the consequences of this rapid growth is environmental disorder with a big pollution problem. Anthropogenic activities have caused a great harm to the quality of our lifeline, i.e. water. Because of fast depletion of the freshwater resources, there seems to be a crisis of the same. Water pollution is a global concern and, it is the high time that we realize the gravity of the situation. Removing pollutants from water is the crying need of the hour and developing a cost effective and environmentally safe method to achieve the same is a challenging task for chemical engineers. After all, it is the future of mankind, which is at stake. A dye is a coloured substance that has an affinity to the substrate to which it is being applied. Dyes appear to be coloured because they absorb some wavelengths of light more than others. Humans are estimated to use dyes for thousands of years and the earliest use of the colorant is believed to be by Neanderthal man about 1,80,000 years ago . The year 1856 witnessed a historic discovery of first synthetic dye, Mauvine, by Perkin. In due course of time, these synthetic dyes gained huge popularity and began to be synthesized on a large scale. In fact, it has reached to a level of annually, over 7.0x105 and nearly 1000 different types of dyes are produced worldwide.

A. *Background of Present Research*

Now-a-days, a large amount of waste water having colour is generated by many industries like textile, leather, paper, printing, plastic and so on. The presence of dye materials greatly influence the quality of water and the removal of this kind of pollutant is of prime importance .Owing to their complicated chemical structures, dyes are difficult to treat with municipal waste treatment operations. Even a small quantity of dye does cause high visibility and undesirability. Moreover, the colour produced by dyes in water makes it aesthetically unpleasant.

B. *Research Objectives*

Several physical, chemical and biological de-colorization methods such as coagulation/flocculation treatment, biodegradation processes, oxidation methods, membrane filtration and adsorption have been reported to be investigated for the removal of dyes from industrial effluents [11]-[14]. Among the studied methods, removal of dyes from adsorption is found to be the most competitive one because it does not need a high operating temperature and several colouring materials can be removed simultaneously [6]. The versatility of adsorption is due to its high efficiency, economic feasibility and simplicity of design [8]. As there are various parameters to effect adsorption process such as, charge density and structural stability of the adsorbent so, in the thrust of a comprehensive study.

II. Reviews on Some Recent Works on Dyes

Several studies have been conducted on the adsorption of different dyes from various adsorbents. In 2012, the adsorption of acid blue 25, Cd^{2+} and Zn^{2+} on a physically activated bituminous carbon and a phosphoric activated carbon from wood was studied using single and binary (dye/metal) solutions

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TABLE I
MATERIALS FOR DYES REMOVAL FROM AQUEOUS SOLUTION

S. No.	Adsorbent(s)	Dye(s)
1.	Bamboo dust, coconut shell, groundnut shell, rice husk, Bagasse	Methylene blue
2.	Silk cotton hull, coconut tree, sawdust, sago waste, maize cob	Rhodamine-B, Congo red, Methylene blue, methyl violet, malachite Green
3.	Partheniumhysterophorus	Methylene blue, malachite Green
4.	Rice husk	Malachite green
5.	Orange peel	Acid violet 17
6.	Indian rosewood	Malachite green
7.	Hardwood	Astrozone blue
8.	Mahogany sawdust, rice husk	Acid yellow 36
9.	Orange peel	Congo red, Rhodamine-B, procion orange

TABLE II
TEXTILE INDUSTRIAL WASTE WATER CHARACTERISTIC

Parameters	Standard effluents	Cotton	Synthetics	Wool
PH	5.5-9.0	8-12	7-9	3-10
BOD	30-350	150-750	150-200	5000-8000
COD	100-250	200-2400	400-650	10,000-20,000
TDS	1500-2100	2100-7700	1060-1120	10,000-15,000

[15]. It was found that the presence of Acid blue 25 (AB25) on dye–metal binary solutions enhanced the adsorption of Zn2+ and Cd2+ on bituminous and wood commercial ACs in a very similar way, in spite of the differences of the textural and surface chemistry properties of both carbons In 2012, adsorption of acid dyes on SBA-3 ordered mesoporous silica, ethylene- di- amine functionalized SBA-3 (SBA-3/EDA), aminopropyl functionalized SBA-3 (SBA-3/APTES) and pentaethylene hexamine functionalized SBA-3 (SBA-3/PEHA) materials was studied[16]. The SBA-3/PEHA was found to have the highest adsorption capacity for all acid dyes. Batch studies were performed to study the effect of various experimental parameters such as chemical modification, contact time, initial concentration, adsorbent dose, agitation speed, and solution pH and reaction temperature on the adsorption process. In 2010, chemically modified sugarcane bagasse as a potentially low-cost bio sorbent for the removal of methyl red was studied [8]. The kinetics of methyl red adsorption followed the pseudo first order kinetic expression and Langmuir isotherms model fit well. From the study, it was inferred that sugarcane bagasse has a good potential to be used for small scale industries, which produces dyes as their effluent, after it was being pre-treated with phosphoric acid. In 2010, the removal of reactive red 23, reactive blue 171, acid black 1 and acid blue 193 from aqueous solution using fly ash was studied [5]. The results showed that adsorption was pH dependent, adsorption increased with the initial dye concentration; the reaction was spontaneous and exothermic in nature. In 2010, the porous magnetic microspheres prepared with sulfonated macro porous Polyvinyl-benzene as a template and their ability to remove cationic dyes was studied [3]. The results show that methyl violet and basic fuchsin can be successfully removed from the adsorbent used and even the adsorbent is easily regenerated.

A. Factors Affecting Adsorption of Dye

There are many factors will affect the adsorption of dye molecules such as solution pH, initial dye concentration, adsorbent dosage and temperature. In-depth study and optimization of these parameters will greatly help in the development of industrial-scale treatment process for the dye removal. Thus, these factors will be discussed in the next section.

B. Effect of Solution pH

The pH of the solution is a very important parameter in the adsorption process, particularly for dye adsorption. The magnitude of electrostatic charges which are imparted by the ionized dye molecules is controlled by the solution pH. As a result the rate of adsorption will vary with the pH of the medium used. In general, at low solution pH, the percentage of dye removal will decrease for cationic dye adsorption, while for ionic dyes the percentage of removal will increase. In contrast, high solution pH is preferable for cationic dye adsorption but shows a lower efficiency for anionic dye adsorption. At high solution pH, the positive charge at the solution interface will decrease while the adsorbent surface appears negatively charged As a result, the cationic dye adsorption will show an increase and the anionic dye adsorption will decrease. At low pH solution, the positive charge on the solution interface will increase and the adsorbent surface will appear positively charged, which results in decrease in cationic dye adsorption and an increase in anionic dye adsorption.

C. Effect of Initial Dye Concentration

The dye removal efficiency is highly dependent on the initial dye concentration. The effect of initial dye concentration relies on the immediate relation between the dye concentration and the available binding sites on the adsorbent surface. The removal efficiency will decrease with an increase in the initial dye concentration due to the saturation of adsorption sites on the adsorbent surface. There will be unoccupied binding sites on the adsorbent surface at a low dye concentration, and when the initial dye concentration increases, there will be insufficient sites for the adsorption of dye molecules, thus decreasing the dye removal efficiency.

D. Effect of Adsorbent Dosage

Adsorbent dosage is an important parameter in order to determine the adsorbent's capacity for a given amount of the adsorbate at the operating conditions. In order to study the effect of adsorbent dosage on the adsorption process, it can be carried out by prepare adsorbent-adsorbate solution with different amount of adsorbents added to fixed initial dye concentration then shaken together until equilibrium time. Generally the dye removal increases with increasing adsorbent dosage, where the amount of sorption sites at the surface of adsorbent will increase by increasing the dose of adsorbent, and as a result increase the percentage of dye removal from the solution. By analysing the effect of adsorbent dosage, it gives an idea for the ability of a dye adsorption to be adsorbed with the minimum amount of adsorbent, so as to identify the ability of a dye from an economic point of view. Hassani et al. Studied the adsorption of two cationic dyes, Basic Green 4 (BG4) and Basic Yellow 28 (BY28) by chemically modified nanoclay. They reported that a relatively strong increase in adsorbent dosage resulted in the increase of the removal efficiencies of both dyes at initial dye concentration of 30 mg/L, pH 6 and contact time of 35 min. They suggested that increasing adsorbent dosage will provides more surface area, thereby leading to more binding sites for the adsorption of target pollutants onto the modified nanoclay. Another research carried out by Sonawane and Shrivastava analyzed the effect of adsorbent dose on the removal of Malachite green by maize cob and they concluded that at 20 mg/L of dye, pH of 8 and a contact time of 25 min, the increase of percentage of dye removal from 90.0% to 98.5% when the adsorbent dose increased from 0.5 to 12 g/L.

E. Effect of Temperature

Temperature is an important factor that serves as an indicator as to whether the adsorption is an exothermic or endothermic process. If the adsorption is an endothermic process, the adsorption capacity will increases with increasing temperature. This may possibly due to the increase in the number of active sites and the mobility of the dye molecules at higher temperature [39]. In contrast, if the adsorption is an exothermic process, the adsorption capacity will decrease with increasing temperature. In this case, higher temperature may decrease the adsorptive forces between the dye molecules and the active sites on the adsorbent surface.

F. Chemically Modified Sugarcane Bagasse Adsorbent

For enhancing the adsorption sites on adsorbent's surface for the removal of basic dye the ground bagasse was treated with formaldehyde with w/v ratio of 1:5 at 54±2 degree C for 24 h. Then the content was filtered out and bagasse was separated and washed with distilled water and kept in an electric oven for 12 to 5 h at 80 degree C for drying. After drying it was mixed with sulphuric acid (98%) in a 1:1 ratio of acid and bagasse then placed in an electric oven at 100 degree C for 24 h. After the acid treatment the bagasse was washed with an excessive amount of distilled water and soaked in 1%NaHCO3 solution for overnight. Then the contents were filtered and washed with an excessive amount of distilled water till neutral pH was obtained (Ashoka and Inamdar, 2010). After air drying the contents were kept in an electric oven for 24 h at 100 degree C and the particle size was found to be 150 lm.

III. Result and Conclusion

It is found that percent adsorption of dyes increases by decreasing flow rate from 2 lit/hr to 1 lit/hr, by increasing bed height from 15cm to 45cm, by decreasing initial conc.150mg/lit to 100mg/lit, by increasing column diameter from 2.54cm to 3.5cm, by maintaining neutral pH & at temperature 45ºc than 25ºc & 35ºc.The result shows that, bagasse ash is a good adsorbent for dye effluent treatment. Sugar cane bagasse ash, an agricultural by-product, acts as an effective adsorbent for the removal of dyes from aqueous solution. Batch adsorption study was investigated for the removal of Acid Orange-II from aqueous solution. Adsorbents are very efficient in decolorized diluted solution. The effects of bed depth on breakthrough curve, effects of flow rate on breakthrough curve were investigated. The removal of dyes at different flow rate (contact time), bed height, initial dye concentration, column diameter, pH & temperature by Sugarcane Bagasse Ash as an adsorbent has been studied. It is found that percent adsorption of dyes increases by decreasing flow rate from 2 lit/hr to 1 lit/hr, by increasing bed height from 15cm to 45cm, by decreasing initial conc.150mg/lit to 100mg/lit, by increasing column diameter from 2.54cm to 3.5cm, by maintaining neutral PH & at temperature between 25ºC & 35ºC.The result shows that, bagasse ash is a good adsorbent for dye effluent treatment.

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