UTILIZATION OF ADSORBENTS FOR REMOVAL OF DYES FROM ISOTHERMS

Pawananjaya R Malladi[1], Guruprashanth N[2], Lohitha S J[3], Shruthi N P[4]

[1,2]*Assistant Professor, Department of Civil Engineering, Jain Institute of Technology, Davangere, Karnataka, India,*
[3]*Lecturer, Department of Civil Engineering, D.R.R Government Polytechnic, Davangere, Karnataka, India,*
[4]*Lecturer, Department of Civil Engineering, Government Polytechnic, Harihara. Karnataka, India,*

Abstract – *The various pollutants contained in industrial wastewater, colour is considered to be very important from the stand point of aesthetics and is stated as a visible pollutant of various industries like dye making, pulp and paper, tanneries, coffee pulping, pharmaceuticals, food processing, electroplating, distilleries, etc., spew out coloured and toxic effluents to the water bodies rendering them murky, dirty and unsuitable for further use. Being one of the most important recalcitrant's, colour persists for long distances in flowing waters retards photosynthetic activity in streams, inhibits the growth of aquatic biota, decreases recreational value of the streams and has a tendency to sequester metal ions producing micro toxicity to fish and other organisms. Many researchers have focused their investigation on relatively cheaper and commercially available materials such as maize comb, fly ash, carbonized wool, bentonite clay and human hair, bone, meal wheat and rice barn and turkey feather for the treatment of wastewater and demonstrated that they have high adsorptive capacity for dyes. In the present study, attempts have been made to access the removal efficiency of adsorbents namely Maize Shell and Orange Peel in removing colours Rhodamine-B and Congo Red from synthetic wastewaters. Experiments were carried out by varying the parameters like initial dye concentration, contact time, pH, adsorbent dosage and grades of adsorbents.*

Key Words: *Activated Coconut Shell, Cross-Linked Polyvinyl Pyrrolidone, Electrical Conductivity, Refuse Derived Fuel, Remazol Sodium Carbonate.*

1. INTRODUCTION

The environmental pollution is becoming the most challenging threat to the human beings as a result of rapid industrialization and growth population throughout the world. Mostly the areas situated around industrial belts are under stress due to the continuous disposal of the untreated wastes from the various industries. The quality of water is continuously deteriorating due to addition of toxic as well as coloured effluents from various industries where different dyes are used. The industries, which generate coloured effluent, are the textile and dye manufacturing industries, pulp and paper mills, tanneries, electroplating factories, distilleries, food processing industries etc. Amongst these industries, the textile industry in India is one of the oldest and largest industries in the country. These mills require volumes of water of high purity and generate equally large volumes of coloured wastewater. The wastewater from the textile industry is known to be strongly coloured, presenting large amount of suspended solids, pH broadly fluctuating, high temperature, besides high chemical oxygen demand (COD). The textile effluents mainly comprise of carbonate, hydroxide, chloride, peroxide, sulphite, nitrite, silicate, oxychloride and sulphide of sodium, sulphuric acid, hydrogen peroxide, bleaching powder, starch gum etc, used in various wet processing units such as desizing, kiering, bleaching, mercerization, dyeing, printing and finishing in the textile industries. Colour is the first contaminant to be recognized in this wastewater (10-50 mg/1) is highly visible and reduces the light penetrations in water systems, thus causing a negative effect on photosynthesis. Among the various techniques used for decolourization namely adsoiption, membrane filtration, electrokinetic coagulation, ion-exchange method, ozonation and biological treatment. Adsorption has evolved into one of the most effective physical processes for decolourization of textile wastewater due to its low cost, simple design, sludge free operation and superior colour removal. It is generally recognized that conventional biological processes are not totally effective for the colour removal. Biological treatment, although very common, requires large land area and is constrained by sensitivity towards diurnal variation as well as toxicity of some chemicals and less flexibility in design and operation. On the other hand, physico-chemical treatment like adsorption is free from afore related problems. The objective of the study is to carry out batch adsorption studies, to assess the removal efficiency of Rhodamine-B and Congo red by adsorbents namely maize shell and orange peel under varied experimental conditions like initial dye concentration, contact time, pH, adsorbent dosage and grades of adsorbents.

2. MATERIALS AND METHODOLOGY

Issues like adsorbents used and their preparation, colours tried and their concentrations, pH, contact time, adsorbent dosage details of experimental set up carried out are discussed in this paper.

2.1 Colours/dyes tried (c)

Textile industry wastewaters are highly polluted due to the strong concentration of toxic dyes. Various dyes are used in textile industry. Among them in this work, dyes namely, Rhodamine B and Congo red were used for experimentation.

2.2 Colour intensity tried

Synthetic colored solutions of intensity 200, 300 and 400 ppm were used for experimentation.

2.3 Preparation of dye solutions

An accurately weighed quantity of Rhodamine B and Congo red dyes were dissolved in double distilled water to prepare stock solutions of concentrations 200, 300 and 400 ppm for both the dyes.

2.4 Adsorbents used (Ad)

Adsorbents namely maize shell and orange peel were used for experimentation. Two grades of each adsorbent were used, grade-I being 90 µ and grade-II being 150 µ grain size to access the efficiency of removal of colors, and the adsorbent dosages used were 10, 25 and 40 mg/l.

2.4.1 Preparation of adsorbents

Adsorbents were prepared as per the procedure given by researchers and are documented in the further subsections

2.4.1.1 Preparation of Adsorbent: Maize Shell

Locally available Maize shell powder was screened and then washed with distilled water until the supernatant solution became clear. It was then soaked in 10 % HCl acid for 24 hours to remove any further impurities and then rinsed with distilled water until the supernatant solution reached pH 7. The washed powder was dried at 110^0 C in oven and was sieved for two-grain sizes of 90 µ and 150 µ and used for experimentation.

2.4.1.2 Preparation of Adsorbent: Orange Peel

It was prepared as per the procedure given by Kannan et al., (2005). Locally available waste peels of oranges were collected, dried and pulverized. Then it was acid digested(4N HNO_3), heated for about 90 min in hot water bath at with 80^0 C and washed several times with water to remove acid. Then the peels were dried in oven at 120^0 C for 5 hours. It was powdered and sieved to two constant particle sizes viz 90 and 150 µ and used for experimentation.

2.5 Contact times tried

To evaluate removal efficiency of color, experiments were conducted with the various contact times namely 10, 25 and 40 minutes.

2.6 pH value considered

To evaluate removal efficiency of dyes, experiments were conducted with the various pH values viz, 4, 8 and 12. The pH values were attained by addition of NaOH or HCl.

2.7 Analysis of samples

The samples were analyzed for their colour concentrations using UV-VIS SL-159(Indian model) spectrophotometer. The wavelengths of 543nm for Rhodamine-B and 497nm for Congo red were used to develop calibration curves. The calibration curves developed. Effluent colour intensities were red from calibration curves corresponding to absorbance records from UV-VIS spectrophotometer.

2.8 Experimental setup and experimentation

Batch adsorption studies were carried out under varied experimental conditions as discussed above. For a predetermined condition of experimentation, 1-liter sample was taken in 6 beakers. The beakers were placed in jar test apparatus for required period of contact time and then the sample was filtered through Whatman no.44 filter paper and it was analyzed for final concentration. By knowing colour intensity in influent and effluent, the efficiency was calculated. Also by knowing the efficiency, mg of colour adsorbed per gm of adsorbent was calculated. Results are tabulated and are represented by linear/ bar charts. Based on observations, inferences are drawn. Further any attempt has been made for development of Isotherms. The Table 3.1 summarizes materials and methodology adopted in the present work.

Table -1: Summary of Experimental Setup and Experimentation.

Contact time (min)	pH	Adsorbent details			Colours	
		Name	Grade	Quantity Used (mg/l)	Used	Intensity Tried (mg/l)
10	4	Maize shell	I (90µ)	15	Rhodamine B	200
25	8	Maize shell	I (90µ)	45		300
40	12	Orange Peel	II (150µ)	70	Congo red	400

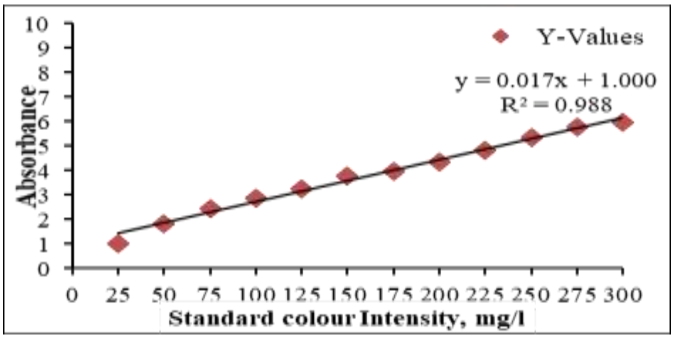

Chart -1: Calibration Curve for Rhodamine-B

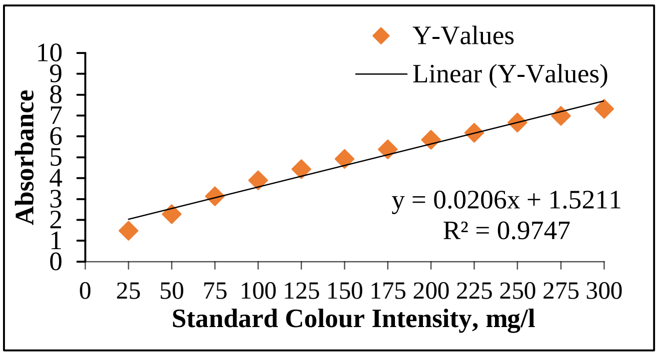

Chart -2: Calibration Curve for Congo red

Fig- 1: Dry Orange Peels for Adsorbent

Initial Concentration Co mg/l	Equilibrium Concentration Ce mg/l	Removal Efficiency %	Log Qe	Log Ce	Ce/ Qe
200	3	98.5	3.4	0.4 7	2.4
300	20.4	93.2	3.6	1.3	15. 9
400	49.7	87.56	3.6	1.6 9	38. 2

3. RESULT AND DISCUSSIONS

1. From the result it is clear that the extent of removal of Congo - Red increases with increase in contact time and decreases after attaining a maximum value. The increase in percentage removal of Congo - Red after 25 min is found to be substantially low and hence these time values are fixed as the optimum contact time.

2. For pH 8 other variables of experimentation remains same. The same trends have been observed but the colour removal efficiencies were lower than that of pH 4. Maximum removal efficiency of 59.23 % (Co = 200 mg/l, T = 25 min, Dosage = 70 mg/l) and minimum removal efficiency of 31.53 % (Co = 400 mg/l, T = 10 min, Dosage = 15 mg/l) were recorded.

3. With pH 12 maximum and minimum removal efficiencies of 52.85 % and 26.27 % were recorded. These values confirmed the observation made viz.., inverse relationship Co and pH and removal efficiency and direct relationship with adsorbent dosages on removal efficiency.

The maximum removal efficiency of Congo red with maize shell adsorbent is 89.31 % (Co = 200 mg/l, T = 40 min, pH = 4, Dosage = 70 mg/l, size = 90 micron) and with orange peel adsorbent is 74.85 % (Co = 200 mg/l, T = 25 min, pH = 4, Dosage = 70 mg/l, size = 90 micron). Comparison of results of Congo red removal by maize shell and orange peel adsorbents under all the experimental conditions studied revel that maize shell adsorbent has higher removal efficiency when compared to orange peel. Lastly, by comparing all the results it was found that maize shell adsorbent having greater removal efficiency when compared to orange peel.

3.1: Development of Isotherms

Isotherms development for optimized condition of removal efficiency based on data given in below table-4.25. The data obtained from the batch type adsorption experiment were fitted with the Langmuir and Freundlich adsorption isotherms, respectively by plotting the values of (i) (Ce/Qe) against Ce and (ii) Log Qe against Log Ce.

Table3.1. Effect of Initial Concentration on Removal of Rhodamine-B by Maize Shell

(C- Rhodamine-B, AD-Maize shell, pH-4, size-90μ, Contact time-40 min, Dosage-70 mg/l)

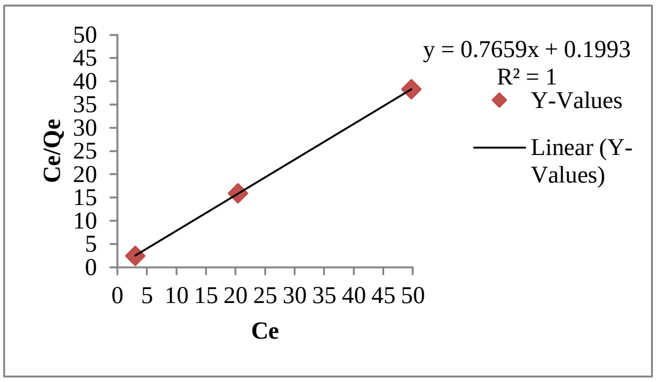

Chart -3: Langmuir Isotherm for Adsorption Rate of Rhodamine-B Dye on Maize Shell.

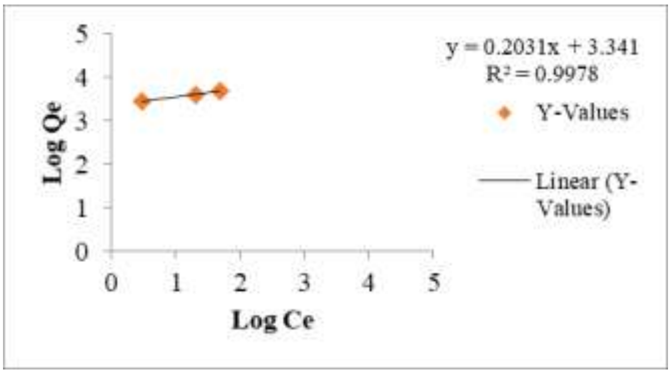

Chart -4: Freundlich Isotherm for Adsorption Rate of Rhodamine-B Dye on Maize Shell.

The Langmuir and Frundlich adsorption isotherms are found to be well fitted. When compared with R^2 values of both isotherms, the value of R^2 for Langmuir isotherm is greater when compared to Frundlich isotherm. Hence Langmuir isotherm is best fitted.

4. CONCLUSIONS

Based on the results of experimentation carried out under varied experimental conditions and the analysis of the same thereby the following conclusions have been drawn.

1. It is concluded that the size of adsorbent have greater influence on removal efficiency. The smaller size of adsorbent particles.
2. Contact time and adsorbent dosage found to have direct influence on removal efficiency. On other hand inverse relationship between removal efficiency and pH and initial concentration of dye where observed.
3. The highest removal efficiency of 98.5 % (Co = 200 mg/l, T = 40 min, pH = 4, Dosage = 70 mg/l) for Rhodamine-B and 89.31 % (Co = 200 mg/l, T = 40 min, pH = 4, Dosage = 70 mg/l) for Congo red with maize shell adsorbent have been recorded.
4. Minimum removal efficiency of 36.23 % (Co = 400 mg/l, T = 10 min, pH = 12, Dosage = 15 mg/l, size = 150 micron) for Rhodamine-B and 26.27 % (Co = 400 mg/l, T = 10 min, pH = 12, Dosage = 15 mg/l, size = 150 micron) for Congo red with orange peel adsorbent have been recorded.

5. LIMITATIONS OF PRESENT STUDY

The following are the limitations of present study and these limitations are attributed to non-availability of data, lack of infrastructure facility, time shortage, not within the preview of objectives of present study etc.

The experiments have been carried out only for set of variables. Confined conclusions can be drawn based only on the results of wide ranges of variables. Refined optimization of variables of experimentation could not be carried out.

6. SCOPE FOR FURTHER STUDY

The optimization of variables can be taken up for further study. Comparative studies to compare coagulation and columnar studies in removing various colours by various adsorbents can be taken up.

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