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OPTIMIZATION OF ADSORPTION PROCESS FOR REMOVAL OF SULPHONATED DI AZO TEXTILE DYE

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Abstract

Treatment of textile waste water has emerged as a great matter of concern amongst scientific community because of essentiality and scarcity of this valuable natural resource. Various techniques have been employed for waste water treatment, amongst which use of natural materials have made a significant contribution in the area of sustainable environment. This paper focuses on the use of the seeds of Argemone Mexicana, a weed for removal of a textile dye from its synthetic solution. Optimisation of several parameters has been carried out for elimination of dye from water resource at neutral conditions. Variation in different parameters affecting decolorization of the dye from aqueous solution, have been studied at length. Maximum decolorization (About 60%) has been observed after four hours with 0.1 g of the elected natural adsorbent obtained after passing through sieve size of 300 µm.

Keywords: Adsorption, Argemone Mexicana, Decolorization, Sulphonated di azo dye, Textile effluent.

INTRODUCTION

Water being one of the five basic elements of life is victimized the most by human population in every possible manner. Rapid industrialization and increase in living standards have been the key factor in detoriating the quality of water. Many industries and factories discard their waste into the water stream without any treatment, which ultimately affects the standards of water. Amongst various industries, textile industries are the prime contributors of water pollution. Textile industries discharge their effluents into water resource which comprises of large amount of unfixed dyes lost during the dyeing process. Approximately ten thousand different kinds of dyes are manufactured amongst which large amount is being consumed annually in the whole world 1. The dyes are purposely made recalcitrant so that they cannot easily remove from the textiles. Different synthetic dyes are used globally which generally contains azo linkages.

Azo dyes are the class of dyes which are extensively used without taking their toxicity into consideration. The -N=N- bond present in these dyes makes them toxic in nature. The by-products formed after reaction cannot be easily degraded with single technique 2. Various treatment methods have been employed for removal of these toxic elements from the aquatic resource, but still the research is going on to enhance the percentage removal and also to make water standard such that they can be used for other purposes rather than dumping into sea 3,4,5,6,7. The only solution of this grim problem is to think about solution keeping in mind the concept of sustainability.

Different techniques have been employed to treat the colored waste water from textiles which include both physico-chemical and biological processes. Amongst all the known techniques, adsorption has proved to be more efficient than others because of use of variety of materials available in plenty as a waste 8. Several adsorbents are currently used for treatment of colored effluent such as Mango seeds 9, Annona squmosa seeds 10, Castor seeds 11, Guava seeds 12, Moringa oleifera seed 13, Rosa canina sp. seeds 14 etc. Use of natural materials caters to the need of treatment of colored effluent keeping in view the sustainability and economy of process.

For the experimentation a diazo sulphonated toxic dye was selected for the preparation of synthetic solution. Due to the presence of double azo linkage along with sulphonic acid group, direct red 81 dye gets easily dissolved in water 15. It has been reported to be carcinogenic for living beings 16. Significant intake of the dye may produce gastro-intestinal irritation.

The present investigation aims at exploring the adsorption capacity of a natural adsorbent, Argemone Mexicana (Figure 1) to decolorize the textile dye during adsorption. In Maharastra, India, Argemone Mexicana is commonly known as Dhotara and is widely available in road sides and barren lands. According to the data available, several harmful allelopathic effects of Argemone Mexicana on germination and seedling vigour of some important crops have been reported in India 17, 18, 19. In several parts of India it has also been reported as a crop weed.

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Figure 1: Argemone Mexicana

MATERIALS AND METHODS

Direct red 81 is an anionic acidic sulphonated azo dye having IUPAC name as disodium, (3E)-7-benzamido*4*oxo-3-[[4- [(4-sulfonatophenl) diazenyl] phenyl] hydrazinylidene] naphthalene -2- sulfonate . The dye was obtained from Sigma- Aldrich and its stock solution was prepared in distilled water. The structure is shown in figure 2.

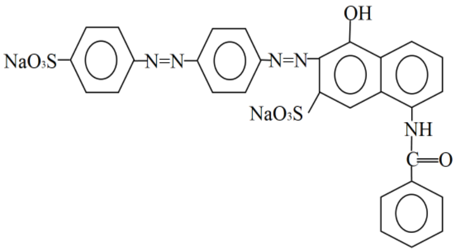

Figure 2: Structure of direct red 81 dye

For experimentation, seeds of Argemone Mexicana were collected from Lavale and Sus Pashan road, near the Symbiosis International University Campus Pune, were available in surplus.

Material development

The capsules were separated from the plant carefully with the help of cutter and tongs and placed in sunlight for drying. Seeds were removed from the capsules and further dried in oven at 110˚C for 4 hours. Seeds were grounded and sieved using IS Standard test sieves in different sizes i.e., in range of 600-425, 425-300, 300-125µm.

Instrumentation

The Adsorption studies of the test solutions were carried out using Systronic double beam spectrophotometer model no. 2203. Equiptronics digital pH meter EQ-610 was used for carrying out pH measurements. For shaking the flasks, an orbital shaker BTI-05 was used.

Adsorption studies

Preliminary batch experiments were performed to study the effects of important parameters such as effect of concentration, amount of adsorbent, particle size and contact time at neutral conditions. The pH of the test solutions was maintained as 7 so as to get the idea of sorption capacity at neutral conditions. For experimentation, 25 ml of dye solution in 100 ml of volumetric flask with a weighed amount of adsorbent were taken. For proper contct between adsorbent and adsorbate, the flasks were shaken periodically at 100 rpm. The solutions thereafter were kept for 24 hours for saturation. Final concentration of the supernant liquid from the flask was spectrophotometrically analysed after 24 hours at a wavelength of 508nm.

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Amount of dye adsorbed is calculated by the following formula

$$q_e = \frac{C_o - C_e}{m} \quad (1)$$

where, q_e is the amount dye adsorbed, C_o and C_e are the initial and equilibrium dye concentration (mol/L), respectively and m is the amount of adsorbent in g/L.

RESULTS AND DISCUSSION

Effect of concentration

Adsorption is greatly influenced by the concentration of the solution, as the adsorptive reactions are directly proportional to the concentration of the solute.

A desired concentration range of 1×10-5 to 10×10-5 M was selected and fixed amount of adsorbent (0.1g) was added to these solutions. It was found that as the concentration of dye increased, adsorption also increased at room temperature (28 ± 2^0 C), suggesting better performance of Argemone Mexicana seeds at higher concentrations at neutral pH (figure 3). An increase in the removal efficiency was attributed to the availability of a number of active sites on the adsorbents with increase in concentration 20, 21. Although, further increase in concentration did not allowed adsorption signifying saturation of the active sites of adsorbent.

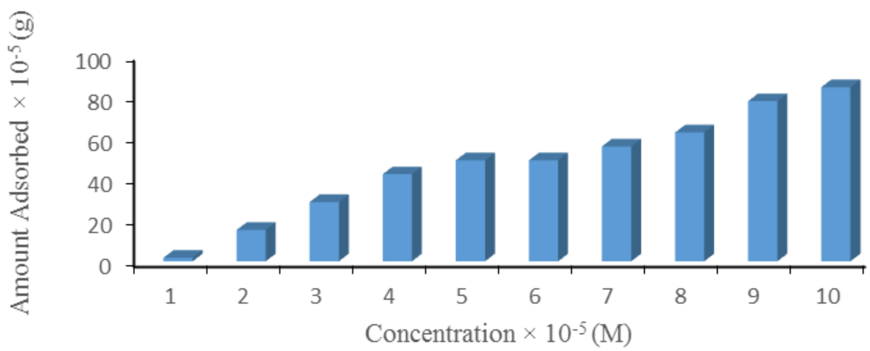

Figure 3: Effect of concentration on the adsorption of direct red 81 by Argemone Mexicana seeds (adsorbent dose =0.1g and sieve size =300µm , pH=7).

Effect of amount of adsorbent

To ascertain the effect of variation in amount of adsorbent, 0.02 g to 0.1 g of Argemone Mexicana seeds were taken in separate 100ml volumetric flasks having a dye solution of 4×10^{-5} M concentration at pH 7. After 24 hours it was found that there was considerable increase in adsorption with increase of amount of adsorbent upto 0.1g (Table 1), which may be due to an increase in number of active sites of adsorbent material with increasing amount of adsorbent [22]. Further increase in amount of adsorbent did not bring any considerable change in adsorption (Figure 4).

Table 1: Effect of amount of adsorbent on the adsorption of direct red 81
(Dye concentration = 4×10^{-5} M, sieve size =300 µm, pH=7)

Amount of adsorbent (g)	0.02	0.04	0.06	0.08	0.1
Amount adsorbed × 10^{-5} (g)	23.64	32.09	35.46	43.91	52.35

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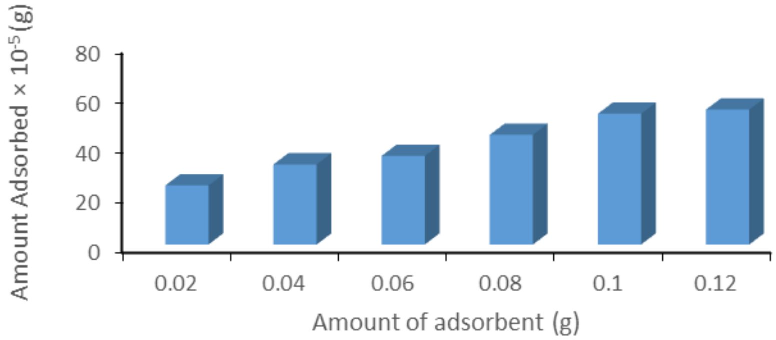

Figure 4: Effect of amount of adsorbents on the adsorption of direct red 81 by Argemone Mexicana seeds (Dye concentration =4×10^{-5}M , adsorbent dose =0.1g, sieve size =300µm and pH 7.0).

Effect of particle size

The dye uptake was also observed under different particle sizes viz, 300, 425 and 600µm IS: 460 standard sieves. Figure 5 indicated that with decrement in size of particle, adsorption increased. Smaller size facilitated the accessibility of the adsorbent pores for diffusion of dye resulting in an increased adsorption [23]. The rate constant of each adsorption process was also calculated during adsorption of direct red 81 onto different sizes of Argemone Mexicana seeds. It is obtained that rate constant increased with decrease in size (Table 2).

Table 2. Effect of mesh size on the rate of adsorption of direct red 81 over Argemone Mexicana seeds at 30^{0}C temperature (Dye concentration =4×10^{-5}M, adsorbent dose =0.1g, and pH 7.0).

Sieve Size (µm)	Amount adsorbed × 10^{-5} (g)	k (h^{-1})
600	50.67	0.057
425	52.359	0.062
300	55.737	0.072

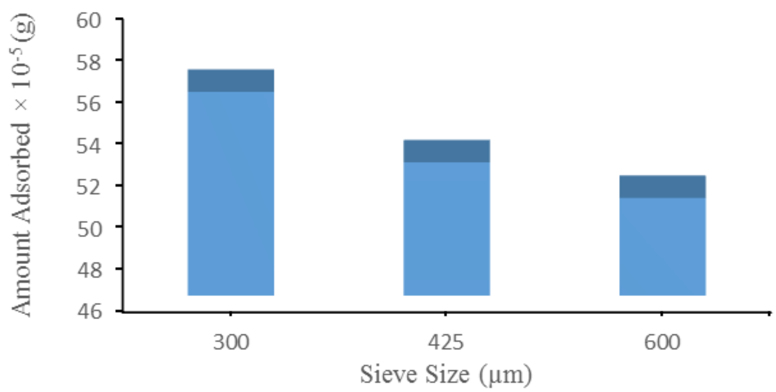

Figure 5. Effect of sieve size on the adsorption of direct red 81 by Argemone Mexicana seeds at room temperature (concentration =4×10^{-5}M , adsorbent dose =0.1g and pH 7.0)

Effect of contact time

Contact time study aids in understanding the optimum time duration required for adsorption during the experiment. Fixed amount of adsorbent was taken in 4×10^{-5} M dye solution for a duration of about 360 minutes and shaken at a speed of 100 rpm. The supernant solution was observed after every 30 minutes. Figure 6 clearly indicated rapid increase in uptake of the dye. Although at higher contact time, the rate of adsorption decreased and a saturation stage was reached due to accumulation of adsorption sites by the dye ions [24, 25]. At room temperature 240 minutes was sufficient to attain saturation in the adsorption process.

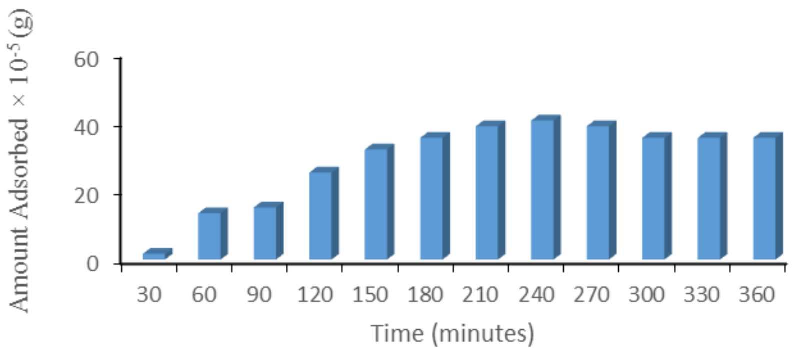

Figure 6: Effect of contact time on the adsorption of direct red 81 by Argemone Mexicana seeds (concentration =4×10^{-5}M , adsorbent dose =0.1g,particle size =300µm and pH 7.0)

CONCLUSION

Preliminary study explored the applicability of Argemone Mexicana seeds for removal of Direct red 81 dye from its aqueous solution. The ability of the natural adsorbent for removing color from textile effluent with different dosage, different contact time and different particle size were monitored. From the batch adsorption studies, it was revealed that at normal conditions i.e, at neutral pH and room temperature the chosen adsorbent considerably adsorbed the dye from its aqueous solution. Contact time studies revealed that after 240 minutes there was no appreciable adsorption, hence an optimum time of 240 minutes was sufficient for maximum color removal at neutral conditions. Study of particle size indicated that smaller the particle size greator is the rate of adsorption. Also the optimum adsorbent dosage at which maximum adsorption took place was found to be 0.1 g for Argemone Mexicana –direct red 81 dye system. According to the result analysis it can be concluded that Argemone Mexicana can be used for successful elimination of Direct red 81 textile dye.

FUTURE SCOPE OF WORK

The issue of water contamination is of concern with respect to the use of textile dyes. The mentioned research would open a new gateway to the use of waste materials for the removal of textile dyes (Azo dyes) from waste water, which would be a novel, cost effective and efficient approach towards water purification.

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