Review Paper (T-1)

USE OF VARIOUS TECHNOLOGIES, METHODS AND ADSORBENTS FOR THE REMOVAL OF DYE

Monika Kharub
Department of Biotechnology and Environmental Sciences,
Thapar University, Patiala, Punjab (INDIA)
E-mail : monika.kharub@thapar.edu

Received November 25, 2011 *Accepted March 5, 2012*

ABSTRACT

A number of the adsorption techniques are used to remove different classes of pollutants from waters, especially those that are not easily biodegradable. Among different pollutants present in the nature dyes represent one of the most problematic groups of the pollutant in the environment. Currently, a number of different technologies and methods such as biological, physical and chemical are widely used for the removal of dyes from wastewater. Different adsorbents and commercial activated carbon is a preferred sorbent for color removal, but it is not widely used because of high cost. In this review paper, a panoptic list of sorbent literature has been compiled. It is evident from the literature survey of recent papers that low-cost sorbents have demonstrated outstanding removal capabilities for certain dyes.

Key Words : Adsorbent, Dye, Removal, Coir pith carbon, Fungal Biomass

INTRODUCTION

Mostly industrial sector, such as plastics and paper, dyestuffs, textile use dyes to color their products and also consume a large amount of the water. As a result, they generate a huge amount of coloured wastewater in to the environment. It is recognized that public perception of water quality is greatly influenced by the colour. It is reported that colour in the water is the initial and first contaminant to be recognized in the wastewater[1]. Over 100,000 commercially available dyes exist and more than 7×10^5 tonnes per year are generated in the world annually[2]. Due to better solubility in water, these dyes are considered as the common water pollutants and such types of dyes are frequently available in the small quantities in the industrial wastewater system. Due to increasingly stringent restrictions on the organic content of industrial effluents, it is necessary to eliminate dyes from wastewater before they are discharged in to the environment. Most of the dyes are carcinogenic and toxic in nature and when discharged in to the water they pose serious hazards to the aquatic biota[3]. Among a number of different techniques of dye removal from the aqueous medium it was reported that the adsorption technique has proved one of the best technology and showed good results in the removal of different colouring materials from the water system[4]. A number of different adsorbents and sorbents are also prepared from the materials for the removal of dyes from the environment such as the choice of hazelnut shells is justified by the combustibles avoiding any regeneration or disposal treatment. The use of hazelnut shells as sorbent was not proposed until now, whereas this material was considered as a source of activated carbon useful material for the removal of certain heavy metals from the wastewater[5].

Not only this activated carbon has a number of applications, one of which is that it is widely used as an efficient adsorbent for purification of water, air and many chemical and natural products[6]. This is possible due to the presence of large surface area to volume ratio and because of the large porous nature of the solid which contains a large number of micropores and mesopores. Currently, it has been reviewed by a number of scientists that activated carbon has been an effec-

tive adsorbent for dye removal[7]. The paper reviews about the different methods for the removal of dyes from the wastewater such as Physical, chemical and biological methods. A number of other adsorbents such as fly ash and different adsorbents prepared from the hazelnut shell, coir pith carbon, Durian peel, waste tyre rubber, mesoporous activated carbon and fungal biomass have been widely used for the removal of dyes from the aqueous solution.

Some of the recent studies on methylene blue adsorption onto activated carbon are also reported[8]. It has been reported that at natural pH of 8.6 (94%) colour removal of dye by coir pith carbon was achieved in comparison to commercial carbon which is less that is (90%). It was also found that coir pith carbon was also found to be effective for the removal of metals and chlorophenols [9,10].

MATERIAL AND METHODS

2.Technologies for color removal

Several different methods are reported in the literature for the removal of pollutants from effluents shown in **Table 1**.

Table 1: Showing different technologies for colour removal[11]

Process	Technology	Advantages	Disadvantages
Conventional treatment processes	Coagulation Flocculation Biodegradation	Simple, economically feasible	High sludge production, handling and disposal problems
		Economically attractive publicly acceptable treatment	Slow process, necessary to create an optimal favourable environment, maintenance and nutrition requirements
	Adsorption on activated carbons	The most effective adsorbent, great, capacity, produce a high-quality treated effluent	Ineffective against disperse and vat dyes, the regeneration is expensive and results in loss of the adsorbent, non-destructive process
Established recovery processes	Membrane separations	Removes all dye types, produce a high-quality treated effluent	High pressures, expensive, incapable of treating large volumes
	Ion-exchange	No loss of sorbent on regeneration, effective	Economic constraints, not effective for disperse dyes
	Oxidation	Rapid and efficient process	High energy cost, chemicals required
Emerging removal processes	Advanced oxidation process	No sludge production, little or no consumption of chemicals, efficiency for recalcitrant dyes	Economically unfeasible, formation of by-products, technical constraints
	Selective	Economically attractive, regeneration is not necessary, high selectivity	Requires chemical modification, non-destructive process
	bioadsorbents Biomass	Low operating cost, good efficiency and selectivity, no toxic effect on micro-organisms	Slow process, performance depends on some external factors (pH and salts)

The technologies can be divided into three categories: biological, chemical and physical[11].

2.1 Biological treatments

As compared to physical and chemical treatment processes biological treatment process is proved often the most economical. It has been reported

that the biological treatment has flexibility in design and operation whereas it is constrained towards the toxicity and diurnal variation and also requires a large land area[12]. It has been observed that the biological treatment along with the current conventional biological treatment processes is not proven satisfactory for color elimination[11].

2.2 Chemical methods

Chemical methods includes a number of processes such as coagulation or flocculation combined with flotation and filtration, precipitation- flocculation with Fe(II)/$Ca(OH)_2$, electrokinetic coagulation, conventional oxidation methods by oxidizing agents (ozone), irradiation, electro-flotation or electrochemical processes. These chemical techniques are helpful in the removal of dyes from the wastewater but are expensive and hence not much used and having one disadvantage of disposal problem because of the accumulation of the concentrated sludge. These methods are efficient for waste water treatment purposes contaminated with different pollutants in them, but are not that much used due to some reasons of high electrical energy demand, large consumption of the chemical reagents and high cost.

2.3 Physical methods

A number of different physical methods are used such as membrane-filtration processes (Reverse osmosis, electrodialysis, nano-filtration) and various adsorption techniques. The major disadvantage associated with the membrane filtration processes is that they have a limited lifetime, the problem of membrane fouling and the cost of periodic replacement must thus be included in any analysis of their economic viability. It was reported that adsorption is an effective and best equilibrium process for the removal of decontaminants from the wastewater.

3. Use of activated carbons for colour removal

Adsorption techniques employing solid sorbents are widely used to remove certain classes of chemical pollutants from waters, especially those that are practically unaffected by conventional biological wastewater treatments. However, amongst all the sorbent materials proposed, activated carbon is the most popular for the removal of pollutants from wastewater. Because of their great capacity to adsorb dyes, activated carbon are the most effective adsorbents. This capacity is mainly due to their structural characteristics and their porous texture which gives them a large surface area, and their chemical nature which can be easily modified by chemical treatment in order to increase their properties.

4. Low cost adsorbents for removal of dye

4.1 Removal of dye by hazelnut

It has been investigated that batch adsorption onto ground hazelnut shells of Methylene blue, was up to 1000 mg L^{-1}, and Acid Blue 25, up to 500 mg L^{-1} in comparison with sawdust of various species of wood, it was studied in order to explore the potential use of hazelnut shells for the removal of dye as low cost adsorbent13. The equilibrium data were processed according to Langmuir's model and higher adsorption capacity values towards both dyes were shown by hazelnut shells than wood sawdust.

4.2 Removal of dye by adsorption on coirpith carbon

It was reported that by varying the different parameters such as agitation time, adsorbent dose, dye concentration, pH and temperature carried out the potential feasibility for removal of methylene blue dye from the effluent with the help of adsorbent of thermally activated coir pith carbon prepared from coconut husk14. It has been observed that as the initial concentration of dye decrease, more the removal of dye was observed with increase in the amount of adsorbent.

4.3 Durian (Durio zibethinus Murray) peel as adsorbent for dye removal

It has been reviewed that durian peel (DP), an agricultural waste, is proved to be best for the removal of acid dye from the aqueous solutions. Also the sorption equilibrium and kinetics studies of acid green 25 (AG25) from aqueous solutions at different initial dye concentrations (50-500 mg/L), pH conditions (2-10), and temperature (30-50 ^{0}C) on DP were studied in a batch mode operation[15]. The results indicated that Durian peel showed good potential for the removal of acid dye from aqueous solution.

4.4 Fly ash as an adsorbent for removal of methylene blue from wastewater

It was reported that adsorption on to fly ash

which is a low-cost adsorbent is proved one of the most effective techniques for color removal from wastewater[16]. Also it has been reported that fly ash is now a days in widely used as an adsorbent. Experiments of continuous mode sorption were carried out to remove methylene blue from its aqueous solutions in hydro cyclone equipment. At an adsorbent dosage of 900 ppm and the pH condition of 6.75 maximum removals of 58.24% was observed for an initial methylene blue concentration of 65 ppm.

4.5 Dye removal from tyre char prepared by waste tyre rubber

It was found that temperatures over 773K did not show any improvement in the total surface area but lower char yields with increased aromatisation were reported. The best-fit in between the predicted and experimental data were observed from the modelling of dye adsorption isotherms. Furthermore, it has been reported that the amount adsorbed by the tyre char is inversely proportional to the total surface area when compared with a commercial carbon, having size like for the Acid Yellow 117 dye (MW= 848 g/mol), which reveals that factors other than total surface area are involved in the adsorption potential of the tyre chars[17].

4.6 Removal of dye by Mesoporous activated carbon

The experimental data obtained by varying the different activation conditions (e.g. temperature, holding time and acid treatment) that activated carbons produced from tyre rubber is able to remove certain mineral contents such as Ca, K and Na, which affect the reactivity of gas-solid reactions in the subsequent physical activation process (CO_2 as activating agent) whereas those which posses high mesopore volume up to 0.855 cc/g which has been proved more favourable to the adsorption process for the removal of large absorption of dye from the aqueous solution[18].

CONCLUSION

This review literature covers a group of different adsorbents for the removal of various dyes from the effluents. Less work seems to have done to make a comparison between various activated carbons prepared from different sources, methods and technologies in order to get an idea to find out the maximum removal efficiency of dyes of different adsorbents from the aqueous medium. If low cost adsorbents perform well in removing dye colour at low cost, they can be adopted they can be used widely in the industrial sector to improve profit and to minimize the cost inefficiency in the industrial sector. Not only this, low cost adsorbents also offer a lot of promising benefits for commercial purposes in the future. Literature also reveals that in some cases low costs adsorbent prepared from different wastes increased the removal efficiency. However, very less work has been carried out in this direction especially to understand the mechanism of adsorption. All future researches might be accompanied by adsorption/ sorption process so that the problem of sludge generation can be overcomed.

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