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Adsorption Techniques for Removal of Colour from Textile Effluent

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Abstract: Textile waste water includes a large variety of dyes and chemical additions that make the environment challenge for textile industry not only as liquid waste but also in the chemical composition. Main pollution in textile waste water comes from dyeing and finishing process. The chemical reagents used are diverse in chemical composition, ranging from inorganic compounds to polymers and organic products.

I. INTRODUCTION

A. Need for textile effluent treatment

The effluents are mutagenic, carcinogenic and toxic. Dyes in waste water leads to calamities I,e the incidence of bladder tumors has been reported higher in dye industry workers than general population. The presence of very low concentration of dyes in effluent is highly visible and undesirable. Cause high electrolyte and conductivity concentrations in dye waste water leading to acute and chronic toxicity problems. Contain heavy metals that are complex compounds.[1-3]

B. Physical treatment for colour removal

Physical techniques such as precipitation , coagulation, ion exchange, adsorption and membrane separation are used to remove or separate the colour physically and result in need for solid waste disposal. some of the physical techniques are mentioned below,[1]

C. Adsorption

Adsorption is the phenomenon by which the molecules of a gas, vapors or liquid spontaneously concentrate at contacting surface without undergoing any reaction. It is an effective method for lowering the concentration of dissolved organics in an effluent. The use of any adsorbent, whether ion exchanger, activated carbon or high surface area inorganic material, for removing species from liquid stream depends on the equilibrium between the adsorbed and free species.[1]

D. Activated carbon

Activated carbon has been evaluated extensively for the treatment of different classes of dyes i,e acid, direct, basic, disperse, reactive dyes etc..The molecular structure of a dye has a significant effect on the extent to which it will be absorbed with decreasing solubility and polarity of the dye favoring absorbability on carbon. Water soluble dyes such as acid, basic, direct, mordant and reactive dyes are not readily absorbed by carbon. Therefore, the carbon adsorption is neither efficient nor economical. Factors such as choice of activated carbon, temperature, ph, contact time and dosage must be taken into consideration for optimal removal of dyes from waste water. The other limitations are the high cost and 10-15% loss of adsorbent on reactivation[4].

E. Peat

The cellular structure of peat makes it an ideal choice as an adsorbent. It has the ability to adsorb transition metals and polar organic compounds from dye containing effluents. Peat requires no activation, unlike activated carbon, and also costs much less. It has a much larger surface area, and hence has a better capacity[5-7].

F. Wood chips

They show a good adsorption capacity for acid dyes although due to their hardness it is not as good as other available adsorbents. Longer contact times are required .Adsorbed wood is conventionally burnt to generate power although there is potential for SSF of the dye adsorbed wood chips.[1]

G. Flyash and coal

A fly ash concentration increases the adsorption rate of the mixture due to increasing the surface area available for adsorption. This combination can be substituted for activated carbon, with the ratio of flyash:coal 1:1.

H. Silica Gel

An effective material for removing basic dyes, although side reactions, such as air binding and airfouling with particulate matter, prevents it being used commercially.

I. Other Materials

Natural clay, corn cobs, rice hulls etc for dye removal is advantageous mainly due to their widespread availability and cheapness. They are economically attractive for dye removal, compared to activated charcoal, with many comparing well in certain situations. These materials are so cheap regeneration is not necessary and the potential exists for dye adsorbes materials to be used as substrates in solid state fermentation for protein enrichment.

II. MEMBRANE FILTRATION

This method has the ability to clarify, concentrate and, most importantly, to separate dye continuously from effluent. [1]
Four processes based on membrane pores,
Micro filteration, Ultrafilteration, Nano filteration, Reverse osmosis, microfilteration

A. Microfilteration

Size-0.1-10microns.Removes sand, slit, clays, giardia, lambia, cryptosporidium, cysts, algae, some bacterial species and oil emulsions. Used in separation of oil and water emulsions.

B. Ultra Filteration

The process is similar to reverse osmosis.Size-0.003-0.1 microns. Removes soluble organic materials, protozoa, bacteria and viruses. Used as an pre treatment of nano filteration and reverse osmosis.

C. Nano Filtration

Size-0.001microns. Pressure driven filtration process.600 to 1000 kilopascal pressure is required. It removes micro molecular organic compounds. Micro-organism, hardness of water, demineralization, colour removal. Used in desalination.

D. Reverse Osmosis

Size-0.00 microns. It removes natural organic substances, pesticides, cysts, bacteria, viruses. Used in desalination

III. ON EXCHANGE

Ion exchange process is normally used for the removal of inorganic salts and some specific organic anionic components such as phenol. All salts are composed of a positive ion of a base and a negative ion of an acid. Ion exchange materials are capable of exchanging soluble ions and cations with electrolytic solutions. Waste water is passed over the ion exchange resin until the available exchange sites are saturated. Both cation and anion dyes can be removed from dye containing effluent this way. The major disadvantage is cost. Organic solvents are expensive, and the ion exchange method is not very effective for disperse dyes [6-7].

IV. CHEMICAL METHOD FOR TREATMENT OF WASTEWATER

Chemical techniques such as ozonolysis chemical oxidation, chemical reduction, used to remove the colour from the effluent by breaking down the dye into simpler fragments and destroy chromopore responsible for colour.

A. Oxidative Process

This is the most commonly used method of declourisation by chemical means. This is due to its simplicity of its application. The main oxidizing agent is usually hydrogen peroxide. This agents need to be activated by some means, for example ultra violet light. Many methods of chemical decolourisation vary depending on the way in which hydrogen peroxide is activated. Chemical oxidation removes the dye from dye containing effluent by oxidation resulting in aromatic ring cleavage of the dye molecule.[5]Oxidants are used in waste water treatment as a first step in the removal of heavy metals to oxidize organicsor as a last step in a treatment process, to oxidize odoriferous compounds such as hydrogen peroxide or to oxidize in organics such as cyanide and for disinfection.Common oxidizing agents are oxygen, chlorine, sodium hypochloride, calcium hypochlorite, potassium permanganate, hydrogen peroxide [6,7].

B. Ozonation

It is very good oxidizing agent due to its high instability compared to chlorine. Oxidation by ozone is capable of degrading chlorinated hydrocarbons, phenols, pesticides and aromatic hydrocarbons. Ozonation leaves the effluent with no color and low COD suitable for discharge into environmental waterways. One major advantage is that ozone can be applied in gaseous state and therefore does not increase the volume of waste water and sludge.

C. Fentons Reagent

Fentons reagent is a suitable chemical means of treating waste waters which are resistant to biological treatment are poisonous to live biomass. Chemical separation uses the action of sorption or bonding to remove dissolved dyes from waste water and has been shown to be effective in decolorizing both soluble and insoluble dyes. One major disadvantage of this method is sludge generation through the flocculation of the reagent and the dye molecules.

D. Photo Chemical Method

This method degrades the dye molecule into carbon dioxide and water by Uv treatment in presence of hydrogen peroxide. Degradation is caused by the production of high concentration of hydroxyl radicals. Uv light may be used to activate chemicals such as hydrogen peroxide and the rate of dye removal is influenced by the intensity of the uv radiation, PH, dye structure and the dye bath composition.[5]

Some chemicals used in ozonolysis and oxidation are mentioned below

D. Sodium hypochloride

This method attacks at the amino group of the dye molecule by Cl+. It initiates and accelerate azo- bond cleavage. This method is unsuitable for disperse dyes. An increase in discoloration is seen with increase in chlorine concentration. The use of chlorine for dye removal is becoming less frequent due to negative effects it has when released into water ways.

E. Cucurbituril

It is a cyclic polymer of glycoluril and formaldehyde. Cucurbituril, sonamed because its structure is shaped like a pumpkin. Buschmann showed extraordinary good sorption capacity of curcurbituril for various types of textile dyes. Cucurbituril is known to form host guescomplexes with aromatic compounds and this may be the mechanism for reactive dye adsorption. The formation of insoluble cucurbituril cation aggregates since adsorption occurs fast[8].

F. Electro Chemical Decolourization

Electro chemical ion generation is an proven technology for removing colour, OD, COD, TOC, solid and heavy metals such as chromium, copper, zinc from textile mill waste water. This system most commonly uses an electro chemical cell to generate ferrous hydroxide directly by steel electrodes. The electrochemical cell consists of fibre glass body containing a number of electrodes separated from each other by small gaps. Waste water flows through the gaps and remains in contact with electrodes[5]. A direct current power supply is connected between the two electrodes of the cell. As current flows from one electrode to another through the process water, the positively charged sides of the electrode give off ferous ions. At negative side water decompose into hydrogen gas and hydroxyl ions. The processed water enters degassing tank, PH is adjusted to 7 to 11.

V. BIOLOGICAL TREATMENT OF WASTE WATER

A. Decolourisation By White Rot Fungi

White rot fungi are those organisms that are able to degrade lignin, the structural polymer found in woody plants. The common white rot fungi is phanerochaete chryosporium. This fungus is capable of degrading dioxins, polychlorinated biphenyls, and other chloro organics.Kirby in 1999 has shown that p. chysosporium had the ability to decolourize artificial textile effluent by upto 99% within 7 days.White rot fungi are able to degrade dyes using enzymes such as lignin peroxidases, manganese dependent peroxidase. Other enzyme used for this purpose are glucose-1-oxidase and glucose-2-oxidase, along with laccase and phenoloxidase.[6] Azo dyes are not readily degraded by micro-organisms but these can be degraded by p.chrysosporium [9-10].

B. Decolourization By Algae

Few species of algae are capable of degrading azo dyes to their aromatic amines through an induced form of azo reductase and further metabolize the aromatic amines to simple organic compounds or carbondioxide. Chlorella and oscillatoria are few species of algae. These algae species utilize azo dyes as their sole source of carbon and nitrogen. Such algae can be used for stabilization of ponds as they play a role in aromatic amine removal.[6]

C. Decolourisation By Bacteria

Numerous bacteria are capable of dye decolourisation .Bacterial cultures are capable of degrading azo dyes uch bacteria include bacillus subtilis, bacillus cereus. It is an difficult task and extended period is required for adaptation .Bacterial cultures took place in 1990.Bacteria has a capacity to mineralizing sulphonated azo-mordant yellow. An alteration from anaerobic to aerobic is required in dye degradation

D. Decolourisation By Yeast

Yeasts, such as klyveromyces marxianus, are capable of decolourizing ramazol black by 78-98%.[6]

VI. CONCLUSION

Physical and chemical method are suitable for dye removal are effective only if the effluent volume is small. Biological activity, in liquid state fermentations, is incapable of removing dyes from effluent on a continuous basis. This is due to the time period of a few days required for decolourisation- fermentation process. The use of adsorption techniques offers much potential in the treatment of dye containing effluents and suggested alternative incorporates the adsorption method with decolourisation.

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