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# WATER POLLUTION BY DYES WITH SPECIAL REFERENCE TO ADSORPTION AND ADSORBENTS

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## ABSTRACT

Chemicals evaporate into the air we breathe or are absorbed via our skin, causing allergic reactions in children before they are born. Because a very little number of synthetic dyes in water (less than 1 ppm) is highly apparent, it affects the aesthetic merit, transparency, and gas solubility of water bodies, color is frequently the first pollutant to be identified in a wastewater. They absorb and reflect sunlight entering water, inhibiting photosynthesis and interfering with aquatic animals' growth. This article highlights about the water pollution by dyes with special reference to adsorption and adsorbents.

***Keywords:* Water, Pollution, Dyes, Adsorption, Adsorbents**

## INTRODUCTION

Paints, fabrics, printing inks, papers, and plastics are just a few of the consumer products that use dyes. They enhance the appearance of materials by adding colour and patterns. Natural dyes derived from plants, fruits, and flowers have been used to colour cloth and other materials since 3500 BC. Chemical dyes were used to replace these dyes, which link with the fabric and provide a richer color that lasts through washing and exposure. W. H. Perkins' invention of synthetic dyes in 1856 resulted in a wide spectrum of colorfast dyes with a wider color range and brighter colors [1].

Depending on the type of textile or product being dyed, a variety of dyes containing various chemical compounds are utilised in manufacture. Textile dyes alone come in over 3600 different varieties. Acid dyes for coloring animal fibres, basic dyes for paper, direct dyes for cotton-wool or cotton-silk, and pigment dyes for paint and inks are among the other dye types [2]. These dyes are made from a variety of chemicals, but the most common include sulfuric acid, chromium, copper, and other metallic elements. Dyes are blended after being combined, manufactured in a reactor, filtered for impurities, and dried. Many different additives, solvents, and chemical substances are employed to initiate reactions along the way. The great desire for diverse patterns and unique hues in clothing and other fabrics is intimately linked to the variance in chemical use. The continually changing demands result in a waste stream that is exceedingly variable and diverse. The textile business is one of the world's major industries, producing 60 billion kg of fabric every year and consuming up to 9 trillion gallons of water. This huge water consumption is a major source of pollution. Water is used for rinsing and processing dyes and goods, as well as cooling and cleaning equipment.

As a result, "dye application" has grown into a multibillion-dollar industry. During the dyeing process, approximately 10-15% dyes are discharged into the environment, making the effluent brightly colorful and aesthetically unappealing [3]. Textile wastewater contributes to severe environmental deterioration as well as human sickness. Around 40% of the world's colourants contain organically linked chlorine, which is a recognized carcinogen. Organic compounds contained in textile industry effluent are a major source of concern in water treatment because they react with many disinfectants, particularly chlorine. Additionally, depending on the concentration and period of exposure, they can have acute and/or chronic impacts on organisms. The removal of colour from dye-containing wastewater is the first and most pressing problem, although the goal of dye degradation is to eliminate or significantly reduce toxicity (i.e. detoxification).

Synthetic dyes have been removed from water and wastewater using a variety of approaches to reduce their environmental impact [4].

Coagulation or flocculation combined with flotation and filtration, precipitation, Fe(II)/Ca(OH)2 flocculation, electroflotation, electrokinetic coagulation, conventional oxidation methods (e.g. with ozone), irradiation or electrochemical processes; and biological methods such as aerobic and anaerobic microbial degradation and the use of pure enzymes are among the chemical methods used. These chemical methods are sometimes costly, and while the colors are removed, the resulting concentrated sludge poses a disposal issue. Because of the extensive chemical use, there is also the danger of secondary pollution. Other new strategies for pollutant degradation, known as advanced oxidation processes, which are based on the creation of very powerful oxidizing agents such as hydroxyl radicals, have recently been deployed with success. Although these approaches are effective in the treatment of polluted waters, they are inefficient in the treatment of non-polluted waters [5].

Membrane filtration technologies (Nano filtration, Reverse osmosis, Electro dialysis) and adsorption techniques are two popular physical methods.

The fundamental disadvantage of membrane processes is that they have a finite lifespan before fouling begins, therefore the expense of periodic replacement must be factored into any economic consideration.

Textile, tannery, pulp, and paper industries rarely use the above-mentioned techniques to treat their effluents due to their comparatively high operating costs and low removal efficiency. Adsorption, on the other hand, is a frequently utilised technology for treating dye-containing wastewaters due to its efficiency in removing contaminants that are too stable for other conventional procedures.

## ADSORPTION

Adsorption is the gathering of a material at the interface between two phases (liquid-solid interface or gas-solid interface). Adsorbent is the solid on which adsorption occurs, and adsorbate is the substance that collects at the interface. The two types of adsorption are chemical and physical adsorption. Chemical adsorption, also known as chemisorption, is characterized by the formation of strong chemical bonds between adsorbate molecules or ions and the adsorbent surface, which is mainly generated by electron exchange, and is thus commonly irreversible. Physical adsorption, sometimes called physisorption, is characterized by weak Van der Waals intraparticle interactions between the adsorbate and the adsorbent and is hence reversible in most cases. Most adsorbents, including agricultural by-products, are regulated by physical forces, with the exception of chemisorption. Adsorption is influenced by Van der Waals forces, hydrogen bonds, polarity, dipole-dipole n-n interaction, and other physical forces. Adsorption is an appealing option for dirty water rehabilitation, particularly if the sorbent is inexpensive and does not require a separate pretreatment step before use [6]. Adsorption techniques are frequently used in environmental remediation to remove certain chemical contaminants from rivers, especially those that are essentially unaffected by ordinary biological wastewater treatment. Adsorption has been shown to be superior to competing approaches in terms of design flexibility and simplicity, starting cost, sensitivity to dangerous pollutants, and ease of operation. Adsorption, on the other hand, does not produce any harmful chemicals [7]. Liquid-phase adsorption is one of the most commonly utilized dye colour removal processes, according to a significant body of research. Because a properly designed adsorption process produces high-quality treated effluent. This approach for treating contaminated water is appealing, especially if the sorbent is inexpensive and does not require a separate pre-treatment step.

The process of adsorption consists of three steps. At first, the adsorbate diffuses from the fluid stream to the adsorbent's exterior surface. Second, the adsorbate migrates to the adsorbent particles' pores. Because of their vast surface area, these holes account for the majority of adsorption. Finally, the molecules cling to the pore's surface area. Adsorption is a surface phenomenon caused by binding interactions between adsorbate atoms, molecules, and ions and the adsorbent's surface [8].

**The physical and chemical adsorption processes differ in the following ways:**

i) Chemisorption adsorbed molecules are extremely difficult to remove from the adsorbent. Physically adsorbed molecules can be removed by lowering the pressure or raising the operating temperature.

ii) Physical adsorption happens in most gas-solid or liquid-solid systems when the conditions are right. Chemisorption is a method that is very selective. For chemisorption to occur, a molecule must be capable of creating a chemical bond with the adsorbent surface.

iii) Chemisorption generates a monolayer of adsorbate molecules on the surface and ceases when all of the reactive sites on the adsorbent surface have been reacted. Due to van der Waals forces, physical adsorption can produce a multilayer of adsorbate molecules that stop one another.

iv) As the temperature rises, the chemisorption rate rises while the physical adsorption rate falls.

v) Adsorption basics help distinguish between physical adsorption, which includes only weak intermolecular interactions, and chemisorption, which involves the creation of a chemical connection between the adsorbate molecule and the adsorbent's surface.

## ADSORBENTS

Although this distinction is conceptually useful, there are many intermediate instances, and categorising a system unequivocally is not always achievable.

The following are some of the adsorbents that are used for removing colour from textile effluents:

### a. Activated Carbon (A.C.) is a Type of Carbon That Has Been Activated

Activated carbon has been extensively studied for the treatment of many dye classes, including acid, direct, basic, dispersion, reactive, and so on, and is presently the most generally used adsorbent for dyes. The US Environmental Protection Agency has named activated carbon adsorption as one of the finest possible control strategies.

Activated carbon is a favoured sorbent, but its widespread use is hampered by its high cost. Activated carbon has a number of drawbacks. It's quite pricey; the better the quality, the more expensive it is; it's also nonselective and useless against disperse and vat dyes. Saturated carbon regeneration is also costly, time-consuming, and results in a loss of adsorbent. For most pollution control applications, the reliance of carbons on rather expensive starting materials is therefore unwarranted. As a result, many workers are looking for more cost-effective adsorbents.

**b. Low-Cost Adsorbents That Aren't Traditional**

Because of the aforementioned issues, research into the development of alternate sorbents to replace expensive activated carbon has increased in recent years. Various natural solid supports that can remove pollutants from contaminated water at a reasonable cost have gotten a lot of attention. For the removal of organic dyes, bio materials, agricultural wastes, and industrial wastes are used as low-cost adsorbents. They are as follows: cellulose (plant) biomass that has not been modified, such as corn/maize cobs, maize stalks, wheat straw, linseed straw, rice husks, wood chips, saw dust, bark, coirpith, banana pith, bagasse pith, palm fruit bunch particles, peat moss.

Bagasse, corn cob, rice hulls, coir pith, maize cob, silk cotton hull, sago waste, banana pith, coconut tree sawdust, date pits, straw, rice husk, fruit stones, nutshells, pinewood, sawdust, bamboo, and cassava peel have all been used to make carbons.

**c. Other Materials As Adsorbents**

In literature, various synthetic materials were also used as adsorbents for the removal of organic dyes. They are, alumina, Core-shell magnetic adsorbent nanoparticles, neutral polymeric adsorbent Macronet MN 200 (MN 200), Polyaminoimide homopolymer, Hydroxyl-functionalized ionic liquid-based cross-linked polymer, modified xanthan gum/silica hybrid nanocomposite, Uniform polyaniline microspheres, inorganic adsorbents (activated bauxite, fullers earth and a synthetic clay), rutile and Degussa P25 titanium dioxide, Poly (amidoamine-co-acrylic acid) copolymer, $Fe_2O_3$/MgO nanomaterials, synthetic calcium phosphates, Cobalt-nickel mixed oxide, $La(OH)_3$-modified exfoliated vermiculites, Silica grafted with a silsesquioxane containing the positively charged 1,4-diazoniabicyclo octane group, Sorel's cement $MnCl_2$ and $MgCl_2$, Amberlite IRA-958, Dodecylsulfate and dodecybenzenesulfonate intercalated hydrotalcites, hydroxyapatite/chitosan composite etc.

## FACTORS INFLUENCING ADSORPTION PROCESS:

**The following things influence or alter the adsorption process.**

a. contact time

b. dye concentration at the start

c. pH

d. adsorbent dose

e. temperature

The adsorption is carried out under the given experimental conditions in order to determine the maximum capacity of organic dye adsorption on the adsorbent.

### a. The influence of contact time

The adsorption investigation is carried out at various times when the adsorbate comes into contact with the adsorbent. It is assumed that as time passes, the potential of adsorbate adsorption on the adsorbent will rise.

### b. The impact of the dye concentration at the start

The concentrations of the dye solution are also crucial in determining the adsorbent's adsorption capability. As a result, it's best to run the experiment with different dye concentrations. This condition's data is used to investigate adsorption isotherms (Langmuir and Frendlich isotherms).

### c. The pH Effect

The effect of pH research is used to find the best pH for carrying out the experiment for maximal adsorbate adsorption on the adsorbent.

### d. Adsorbent dose effect

The amount of adsorbent is also predicted to influence the adsorption rate and percentage. As a result, adsorption is carried out by altering the amount of adsorbent.

### e. The Influence of Temperature

Temperature is an important factor in adsorption. As a result, it is also necessary to do the experiment at varied temperatures. The thermodynamic parameters such as free energy change, enthalpy change, and entropy change may be estimated using this temperature effect.

## CONCLUSION

The adsorption kinetics (psuedo first order and pseudo second order kinetics), adsorption isotherms (Langmuir and Frendlich isotherms), and adsorption thermodynamics can be derived using the data from the above experimental conditions of adsorption to better understand the mechanism of adsorption of adsorbate on adsorption surfaces.

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