REMOVAL OF ACID RED 1 DYE USING ORANGE AND BANANA PEELS

Soham Sudhir Shinde[1], Imran Salim Shaikh[2]

[1]*Undergraduate students, Dr. D.Y Patil Institute of Engineering, Management and Research, Akurdi, Pune, Maharashtra.*

Abstract - *Many Industries like Textile, Paper, Food, Cosmetics, Leather, Printing, Plastic as well as Pigment and Dye manufacturing industries eject tons of dyes as effluent in the water bodies. Dyes and their byproducts are harmful for the environment as well to the living organisms. Acid Red 1 is considered to be harmful due to its low biodegradability. Traditional technique for elimination of dyes from the effluent consist of Activated carbon, but due to its harmful effects on the environment and high cost another alternative method i.e., adsorption of dyes by natural adsorbent material has been studied in this project. Fruit peels of Orange and Banana are used as an adsorbent material in this project and a detailed comparison of their efficiency of adsorption is to be studied.*

Key Words: **Wastewater treatment, Adsorption, Acid Red 1 Dye, Fruit peels, Adsorption kinetics, low-cost bio adsorbent, eco-friendly.**

1. INTRODUCTION

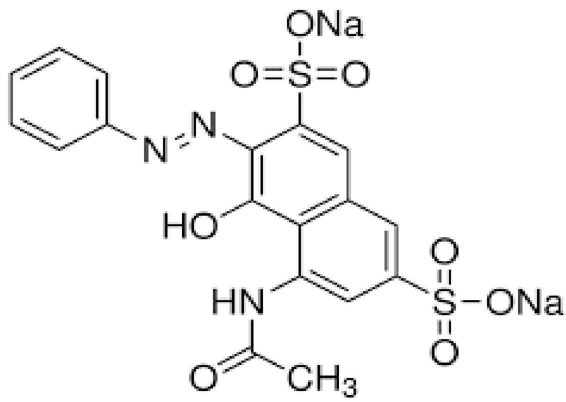
Water pollution has emerged as a pressing global environmental concern. In the contemporary era, a critical environmental issue revolves around industrial effluents contributing to water pollution, with a particular focus on synthetic dyes. Industries utilize various synthetic dyes, such as Acid Red 1, to colour fabrics and baby food. The presence of these dyes in industrial effluents gives rise to multiple challenges, including reduced light penetration, diminished oxygen solubility, and compromised respiration process for marine life. Azo dyes, known for their diverse chemical structures and ease of synthesis, are prevalent in the industry. However, their non-biodegradable nature and enhanced stability due to complex structures pose environmental concerns. Furthermore, the toxic and carcinogenic properties of these dyes have severe implications for the kidneys, liver, brain, fertility, and the central nervous system. Therefore, there is an urgent need to regulate and minimize the amount of coloured dyes in industrial effluent liquids before their elimination into water bodies. Adsorption stands out as the most widely employed technique among various removal methods due to its cost-effectiveness and efficiency in reducing hazardous organic and inorganic pollutants in industrial wastewaters.

1.1 Acid Red 1 Dye

Acid Red 1 (AR1) serves as the subject of investigation in this research, functioning as a potent acid dye with an anionic nature. Its chemical composition is represented by the formula C18H13N3Na2O8S2, and it possesses a molecular weight of 509.42 g/mole.

Acid Red 1 dye is a vivid, red-blue light, powdery substance. It dissolves readily in water, forming a vibrant red solution, and exhibits slight solubility in ethanol and soluble fiber elements. However, it remains insoluble in other organic solvents. Primarily utilized in wool dyeing within a strong acid medium, this dye is instrumental in piece-dyeing wool. It can be applied directly to wool fabrics, polyamide fibers, and silk for printing purposes. The molecular structure of Acid Red 1 is depicted in Figure 1.1.

Figure 1.1 Molecular structure of Acid Red 1 Dye



1.2 Adsorbent Preparation

Substantial amounts of orange and banana peels are discarded in the process, presenting an opportunity for their use in adsorbent preparation. The initial step involves cleaning the peels with water to eliminate dust particles and water-soluble impurities, followed by a two-day drying period in sunlight. Subsequently, the peels are crushed to achieve a fine powder, ultimately stored in an airtight container. Subsequently, the peels are crushed to achieve a fine powder(1mm), ultimately stored in an airtight container.

2. MATERIALS AND METHOD

The Acid Red 1 dye obtained from the market was utilized to prepare an experimental solution in the laboratory at the desired concentration. Batch experiments were conducted in 100 mL conical flasks, where a magnetic stirrer ensured continuous agitation to facilitate better contact among the dye particles and the adsorbent material. Distilled water was used for all dye adsorption experiments.

A standard solution of synthetic industrial waste containing Acid Red 1 dye at a concentration of 1 gm/L was prepared and subsequently diluted according to the experimental requirements.

The prepared solution underwent characterization using an FTIR spectrometer (Model- Paragon 1000PC) operating in the wavelength range of 4000 to 400 cm-1. The FTIR investigation aimed to assess the surface functional groups that play a role in the adsorption process.

3. Adsorbent Characterization

The adsorbents prepared are also subjected to characterization through FTIR analysis. The subsequent sections will delve into the assessment of their performance and characterization.

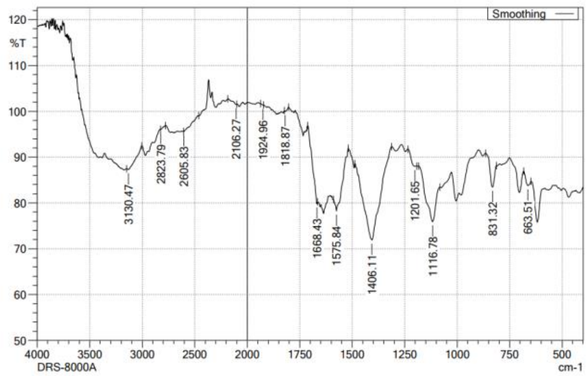


Figure 3.1 FTIR Analysis of orange peels

The prominent point in the high-intensity region indicates the existence of a substantial amount of hydroxyl (OH) groups found in carbohydrates and lignin. A distinct absorption at 1045 cm^{-1} suggests the presence of C-O-H or C-O-R (alcohols or esters). Furthermore, the presence of C-H stretching vibrations, coupled with aliphatic chain bending vibrations ($-CH_2-$ and $-CH_3-$) around 1428 cm^{-1}, contributes to the fundamental configuration of these lignocellulosic materials. Carbonyl clusters, like as esters, are indicated by the signal at 1736 cm^{-1}, while the band around 1617 cm^{-1} suggests the presence of aliphatic and/or unsaturated aromatic compounds.

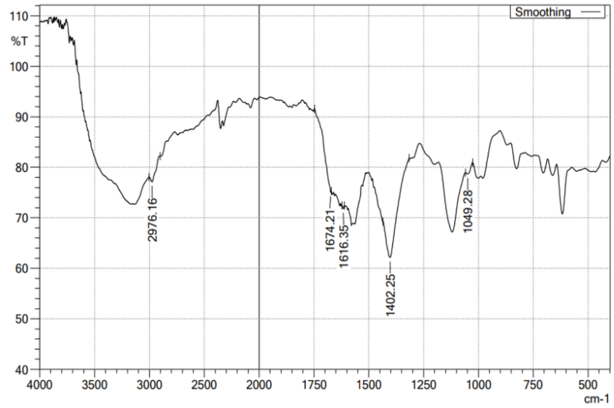


Figure 3.2 FTIR Analysis of Banana peels

In the spectrum, a wide frequency range extending from 3600 to 2800 cm^{-1} specifies the presence of polymeric particles containing free hydroxyl groups. A point at 1609 cm^{-1} suggests N-H bending vibrations of aliphatic amines. The presence of carboxylic acids or related compounds is implied by the C=O stretching vibrations of the carboxyl group ($-COOH$, $-COOCH_3$) at 1734 cm^{-1}, indicating their involvement in the binding method. Additionally, the point at 1457 cm^{-1} may correspond to the aromatic ring vibration of lignin. Points at 1288 and 1364 cm^{-1} are associated with C-H bending of cellulose nanocrystals and C-H bending of cellulose, hemicelluloses, or lignin polymers, respectively. Furthermore, the point at 1107 cm^{-1} is referred to stretching of the C-N bond of aliphatic amines.

4. RESULT AND DISCUSSION

Parameters such as effect of Adsorbent loading, Initial concentration of Dye, temperature, pH, Agitation speed and contact time were studied in the experimentation.

4.1 Effect of Adsorbent loading

The experiment involved changing the adsorbent quantity from 0.2 to 1 g/L. Initially, there remained a gradual growth in the elimination of Acid Red 1 dye with increasing amounts of banana peel concentrate and orange peel concentrate. This rise can be referred to the augmented surface area, providing more adsorption sites for dye molecules. However, after a certain point, the removal rate stabilizes. The removal percentages were determined to be 67% using orange peel and 59% using banana peel as the adsorbent. Increasing the dosage of the adsorbent led to enhanced adsorption efficiency for both banana peels and orange peels. The effect of adsorbent quantity on the elimination of Acid Red 1 was analyzed and is depicted in Fig. 4.1.1 and 4.1.2 for orange and banana peel, respectively.

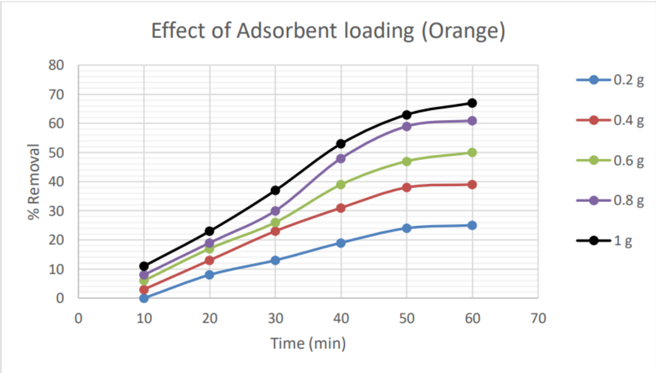


Figure 4.1.2 Effect of Adsorbent Loading for Orange (Parameters- Temp=30 ℃, pH=3, Concentration=100 mg/l, Agitation speed= 400rpm)

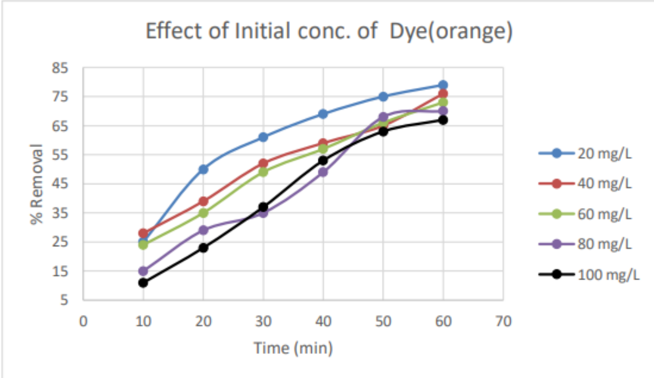


Figure 4.2.3 Effect of Initial concentration of dye for Orange (Parameters- Temp=30 ℃, pH=3, Loading=1gm, Agitation speed= 400rpm)

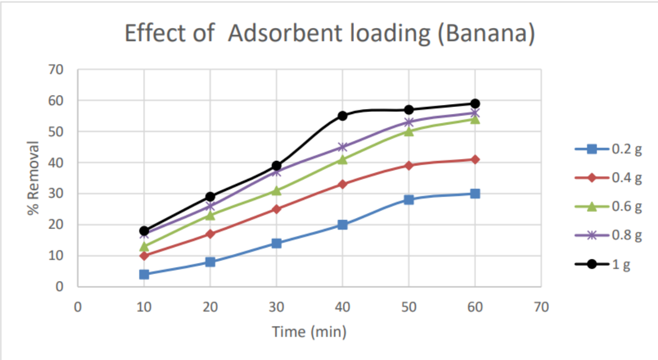


Figure 4.1.2 Effect of Adsorbent Loading for Banana (Parameters- Temp=30 ℃, pH=3, Concentration=100 mg/l, Agitation speed= 400rpm)

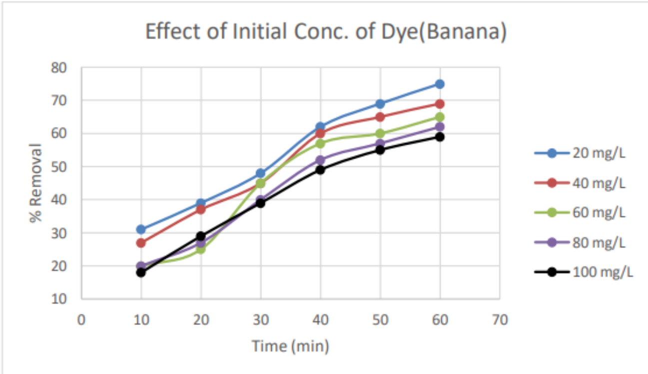


Figure 4.2.2 Effect of Initial concentration of dye for Banana (Parameters- Temp=30 ℃, pH=3, Loading=1gm, Agitation speed= 400rpm)

4.2 Effect of Initial Concentration

The effluent's original concentration was varied from 20 to 100 ppm, and the prepared adsorbent was employed for pollutant removal at different time intervals ranging from 10 to 60 minutes. It was detected that the removal efficiency was more for lower original concentrations and lower for higher initial concentrations. This discrepancy could be credited to the greater availability of adsorption spots at lower initial concentrations compared to higher ones, where fewer active sites are available for adsorption. The effect of original concentration and interaction period on the elimination of Acid Red 1 dye is described in Fig. 4.2.1 and Fig. 4.2.2 for orange peel and banana peel, respectively.

4.3 Effect of Temperature

The Effect of Temperature on adsorption process was studied by preparing a dye solution of 100 mg/l. 1gm of Orange and Banana adsorbent were added to dye solution and the experimentation was conducted at 20, 30, 40, 50 and 60 ^{o}C. As the temperature increases the percentage removal of dye also increases. It was found that at 60 ^{o}C, 71% and 65% of the dye was removed by orange peels and Banana peels.

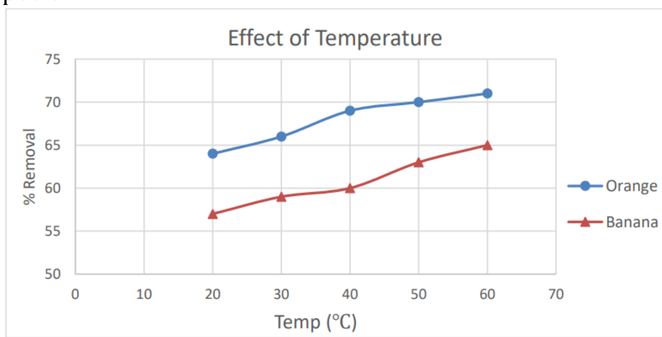


Figure 4.3 Effect of Temperature (Parameters- Time= 60min, pH=3, Concentration=100 mg/l, Loading=1gm, Agitation speed= 400rpm)

4.4 Effect of pH

The influence of pH on the adsorption process was investigated by preparing a dye solution with a concentration of 100 mg/L. 1 gram of orange and banana adsorbents were introduced into the dye solution, and the experiment was conducted at pH levels of 2, 4, 6, 8, and 10. As the solution's pH enlarged, the percentage removal of dye reduced. Specifically, at a solution pH of 2, 70% and 63% of the dye was removed by orange peels and banana peels, respectively. The pH of the dye mixture influences the adsorption capacity by affecting the surface charge of the adsorbent, the degree of material ionization in the solution, and the exposure of functional groups on the adsorbent's active sites. Furthermore, the chemical behavior of the dye solution itself is altered by variations in the solution's pH.

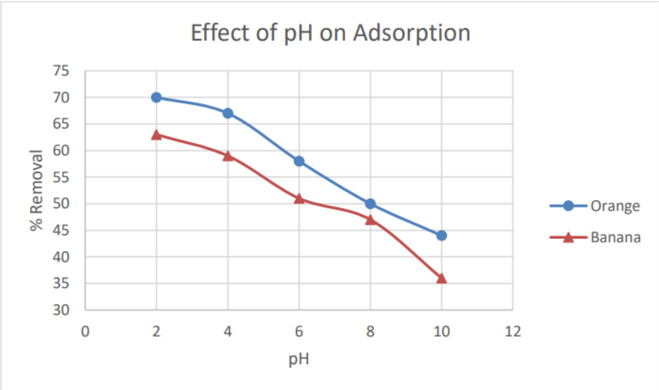


Figure 4.4 Effect of pH on Adsorption
(Parameters- Temp=30oC, Time= 60 min, Concentration=100 mg/l, Loading=1gm, Agitation speed= 400rpm)

4.5 Effect of Agitation speed

The Effect of Agitation speed on adsorption process was studied by preparing a dye solution of 100 mg/l. 1gm of Orange and Banana adsorbent were added to dye solution and the experimentation was conducted at 200, 400, 600, 800 and 1000 rpm. As the Agitation speed increases the percentage removal of dye also increases. It was found that at 1000 rpm, 71% and 61% of the dye was removed by orange peels and Banana peels respectively.

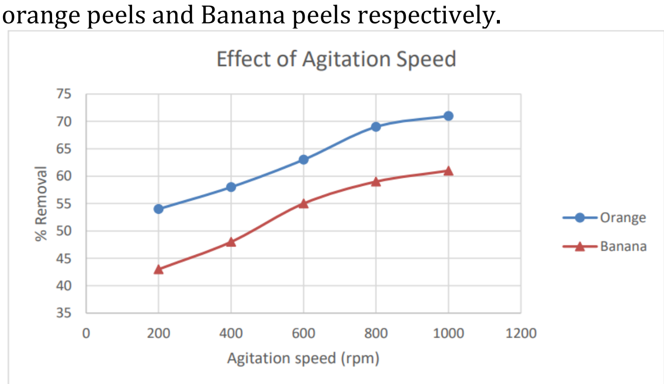


Figure 4.5 Effect of Agitation Speed
(Parameters- Temp=30oC, pH=3, Concentration=100 mg/l, Loading=1gm, Time= 60 min)

4.6 Effect of Contact time

The Effect of contact time on adsorption process was analyzed by preparing a dye solution of 100 mg/l. 1gm of Orange and Banana adsorbent were added to dye solution and the experimentation was conducted from 1 to 6 hours. As the time increases the percentage removal of dye also increases. It was found that after 6 hours, 75% and 69% of the dye was removed by orange peels and Banana peels respective.

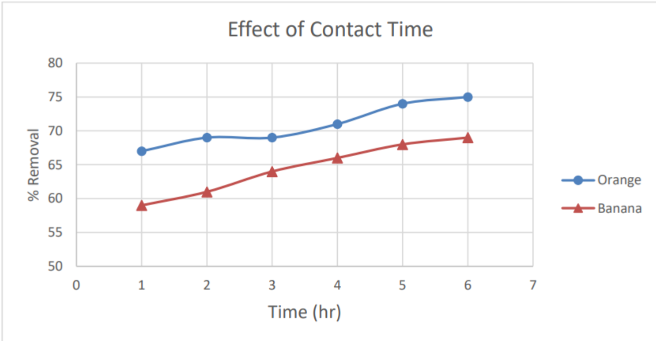


Figure 4.6 Effect of Contact Time
(Parameters- Temp=30oC, pH=3, Concentration=100 mg/l, Loading=1gm, Agitation speed= 400rpm)

5. CONCLUSIONS

Our theoretical analysis, encompassing the examination of various properties and characteristics, strongly suggests that fruit peel-derived adsorbents hold great promise for efficiently removing dyes from aqueous solutions. The specific attributes of these materials, such as more surface area, porous structure, and natural abundance, make them attractive candidates for further exploration and development. In the Experimentation we have studied six parameters (Initial concentration, Dye Loading, Contact Time, Temperature, Agitation speed and pH) which affect the adsorption process and hence the results of this experimental methods reveals that at optimum conditions maximum removal efficiency can be attended. Acid Red 1 dye is successfully removed from the effluent solution in this project.

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