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Comparative Studies on Application of Various Adsorbents in Textile Waste Water

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Abstract: This thesis aims to explore the potential of employing natural adsorbents, such as cashew nut shells, date seeds, orange peels, and coir pith, to mitigate COD levels in textile wastewater. The wastewater used for the study was sourced from a textile industry located in Salem. The investigation involved batch studies, wherein the effectiveness of each selected absorbent in reducing COD was assessed to determine the most efficient among the four sorbents. The initial concentration from the batch research served as a basis for identifying the optimal adsorbent, with the COD of the textile wastewater maintained consistently along with the initial dye concentration. To conduct the study, the adsorbent was incrementally introduced in 10 g portions into conical flasks. Over a10-minute period following a 20-minute contact time, the supernatant liquid from each conical flask was collected using syringes. The COD concentration in the obtained samples was determined using a standard methodology. Results revealed that date seeds exhibited the highest percentage of COD removal at 67%, followed by cashew nut shells at 45%, coir pith at 33%, and orange peels at 23%. The data obtained indicated that cashew nut shells and date seeds achieved the highest percentages of COD reduction, respectively. On the other hand, the Orange Peel Adsorbent displayed the least reduction in COD. Based on the collected findings, date seeds emerge as a promising adsorbent for effectively lowering COD in the treatment of textile wastewater.

Keywords: Adsorption, Adsorbent, COD reduction, Textile Waste Water

1. Introduction

Water is an essential natural resource required by all living organisms, including humans, animals, and plants. Covering 71% of the Earth's surface, water holds a volume of 1400 million cubic meters. However, 97% of this water, found in oceans and salty lakes, remains unsuitable for use. Only a mere 20% of the world's freshwater resources, constituting 3% of the total, are fit for human consumption, residential use, and agriculture. In Polar

Regions, over 80% of freshwater exists as snow. [1] Rivers, lakes, ponds, and other sources provide access to freshwater, maintaining its liquid state from 0 to 100 degrees Celsius.

Water contamination has emerged as a significant global concern. Various industries, including textiles, paper, paints, pharmaceuticals, food and beverages, leather, cosmetics, tanneries, printing, and plastics, utilize a diverse range of dyes for product coloring. Among these, the textile sector holds prominence in dye usage for fiber coloring. [2] Given the volumes and composition of effluents released, the textile industry has been identified as a key contributor to wastewater.

The textile production process involves intricate stages and a multitude of chemicals, as evident from a comprehensive industry analysis. Manufacturing textiles, whether from natural fibers, cotton, polyester blends, or synthetic fibers, initiates with fiber creation, followed by yarn spinning. [3] Yarns are reinforced with sizing agents like wax, polyvinyl alcohol, and starch to endure the stress of high-speed loom weaving. Pre-treatment of woven fabric precedes coloring, printing, and finishing. Throughout pre-treatment, various chemicals come into play. Enzymes or reactive chemicals are employed, followed by scouring with detergents and sodium hydroxide. Bleaching with hydrogen peroxide eliminates the fabric's natural hue, while a concentration of sodium hydroxide mercerizes and stabilizes it. [4] Dyeing and printing involve multiple dyes (reactive, dispersion, vat), dyeing auxiliaries, and chemicals. Subsequently, finishing agents like resins, softeners, silicones, fluorocarbons, and more, impart final qualities to the fabric. Textile factory effluents harbor a diverse range of contaminants arising from various processes and materials. The dynamic nature of dyeing and finishing operations leads to variations in dyestuffs, chemicals, and textile aids on a daily or even intra-day basis. This effluent contains an array of waste chemical contaminants, including sizing agents. Throughout these processes, multiple additives such as wetting agents, complexing agents, dyes, pigments, softening agents, stiffening agents, fluorocarbon, surfactants, oils, and wax are employed. [5] These additives influence factors like heat, color, acidity, basicity, soluble substances, as well as higher suspended solids (SS), chemical oxygen demand (COD), and biochemical oxygen demand (BOD).

Numerous methods have been developed to treat textile effluents, but due to high salinity, coloration, and non-biodegradable organics, standalone techniques often fall short. Coagulation generates significant sludge quantities, adding to pollution and treatment costs. While oxidation processes, except for dispersion dyes, effectively decolorize dyes, they struggle with COD removal. [6] Electrochemical oxidation introduces pollutants and hikes treatment expenses. Given the intricate effluent composition, a single method seldom offers effective treatment.

Integrated approaches have emerged as a solution, starting with activated sludge treatment to remove organics and advancing to oxidation, UV radiation, membrane separation, or adsorption. [7] Adsorption, particularly through natural adsorbents, stands out for its ability to eliminate colors from wastewater efficiently, even in diluted solutions, without generating sludge.

Cost-effective, commercially available materials for COD adsorption are gaining traction. Agricultural byproducts, coir pith waste, sawdust from Indian rosewood and pine trees, banana pith, rice husks, and orange peel serve as economical alternatives to activated carbon. [8] This study evaluates whether natural adsorbents can effectively replace expensive yet inefficient conventional filter media for COD removal in textile wastewater treatment.

2. Materials and Methods

2.1 Collection of Industrial wastewater

The textile wastewater sample was procured from the Salem-based textile industry. To ensure accurate results, the prepared experimental sample was created through dilution of the stock solution obtained from the collected wastewater. The sample was diluted a hundredfold by combining 99 cc of pure water with 1 cc of the sample.

Table 1. Characterisation of Industrial Waste Water

S.No.	Parameter	Value (mg/l)
1	pH	8.8
2	Total solids	71680
3	Suspended solids	45900
4	Dissolved solids	45690
5	Chemical Oxygen Demand	48,000

Following standard protocols, the laboratory analysis of the industrial wastewater's properties was conducted. Table 1 presents a summary of the characteristics of industrial waste.

2.2. Preparation of Cashew NutShell

Cashew nut shells, sourced from Tamil Nadu's Pudukkottai District in India, were employed as an adsorbent. The natural waste was meticulously washed to eliminate dust and soluble matter, followed by air-drying at room temperature. Subsequently, the shells underwent further drying at 105°C in a hot air oven for an hour. Afterward, the dried shells were finely powdered and sieved through a mesh size of 100.

For the preparation of DateSeed, the date seeds were initially powdered. They were then cooked in distilled water to eliminate washable contaminants. The resulting solution was subjected to multiple filtration rounds to achieve clarity. The impurity-free, fully dried material was processed into date seed powder. Date seeds were dried at 105°C in a hot air oven for an hour, followed by grinding into a fine powder. The resulting date seed powder, having passed through a 100-size sieve, was utilized as an adsorbent.

2.3. Preparation of Orange Peel

Orange peels were collected from the nearby areas and subjected to the removal of moisture by air-drying at 105°C for 48 hours. Following the drying process, the peels were finely ground into powder and then sieved through a mesh with a size of 600.

2.4. Preparation of Coir Pith

Coconut fibers were procured from a local store and underwent meticulous cleansing using distilled water. Subsequently, they were air-dried at 55°C for a duration of four hours within an oven. A segment of the fibers was finely ground and sieved to achieve particles with a size of 150 mm. The remaining portion of the fibers was transformed into filamentous shape with a uniform length of 2.0 cm.

2.5. Batch Adsorption Studies

Ten 250 ml conical flasks were filled with a known concentration of COD sample from textile wastewater. To each flask, varying amounts of cashew nutshell adsorbent—ranging from 1 to 10 grams—were added.

After 20 minutes of agitation, the solution was allowed to undergo a reaction. Over a 10-minute span following a 20-minute contact time, the liquid supernatant from each conical flask was collected using syringes. The COD concentration in the collected sample was determined using a standard method. The same procedure was repeated with the remaining adsorbents.

3. Results and Discussions

3.1. Performance Evaluation of Cashew nutshell

Ten conical flasks, each with a volume of 250 ml, were utilized to contain a known concentration of COD in the sample of textile wastewater. In each flask, varying amounts of the generated adsorbent, specifically 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 grams, were added. Following 20 minutes of agitation, the solution was allowed to undergo the reaction process. Over a 10-minute period subsequent to a 20-minute contact time, the supernatant liquid from each conical flask was meticulously collected using syringes. The COD concentration in the obtained samples was determined using a standardized approach. The data was then presented in a graph, illustrated in figure 1, depicting the relationship between different dosages of the cashew nut shell adsorbent and the corresponding percentage decrease in COD.

It is obvious from the graph shown above that the permanent reduction in COD increases with a rise in adsorbent dosage. For a dosage of 10 g of adsorbent cashew nut shell, a 69% reduction in COD was achieved.

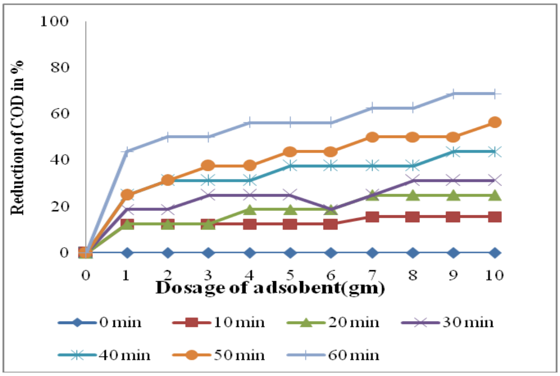

Figure1. Percentage Reduction of COD using Cashew nut shell as adsorbent.

3.2. Performance Evaluation of Cashew nut shell

Ten 250 ml conical flasks were filled with textile effluent samples of known COD levels. Subsequently, quantities of 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 grams of the synthesized adsorbent were introduced to each respective flask. Following a 20-minute agitation period, the solutions were set aside to react. After the 20-minute contact time, the supernatant liquid from each flask was extracted using syringes over a 10-minute span. A standard analysis was performed on the collected samples to ascertain their COD concentrations.

3.3 The relationship between various doses of Date seed adsorbent and the resulting percentage COD reduction is visualized in Figure 2.

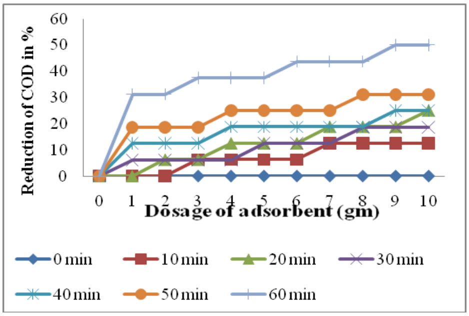

Figure 2. Percentage Reduction of COD using Date seed as adsorbent

The graph depicted above clearly demonstrates that the percentage reduction of COD rises as the Adsorbent dosage increases. A substantial COD reduction of 69% was achieved with a dosage of 10 grams of Date seed adsorbent.

3.4. Performance Evaluation of Coir Pith

Ten conical flasks, each with a volume of 250 milliliters, were utilized to hold specific quantities of the textile wastewater sample. In each flask, varying amounts of the synthesized adsorbent—1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 grams—were introduced. Following 20 minutes of agitation, the solution was subjected to reaction in a shaker. Using syringes, the liquid supernatant from each flask was collected over a 10-minute interval after the 20-minute contact period. The collected samples underwent analysis to determine their COD concentration through standard procedures. Figure 3 illustrates the graph depicting the correlation between different dosages of Coir Pith adsorbent and the resulting percentage reduction in COD.

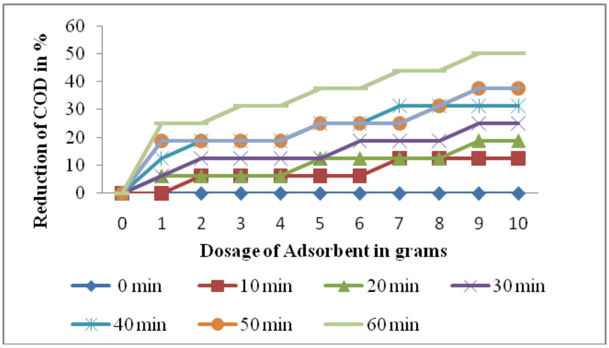

Figure 3. Percentage Reduction of COD using Coir Pith as adsorbent

The graph depicted above illustrates a distinct trend: an elevated Adsorbent dosage corresponds to an augmented percentage reduction of COD. Notably, a substantial 50% reduction in COD is achieved with a 10 g adsorbent dosage of Coir Pith.

3.5. Performance Evaluation of Orange Peel

Ten conical flasks, each with a volume of 250 ml, were employed to contain distinct samples of textile effluent, all possessing a predetermined COD concentration. In a systematic manner, 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 grams of the synthesized adsorbent were introduced to each respective conical flask. Post a 20-minute period of agitation, the solutions were subjected to a reaction phase within a shaker. Subsequently, the supernatant liquid from each conical flask was meticulously collected using syringes over the course of a 10-minute timeframe subsequent to the 20-minute contact period. Employing established protocols, the collected samples were subjected to routine analysis to ascertain their respective COD concentrations.

The resulting data is visually represented in figure 4, demonstrating the correlation between different dosages of orange peel adsorbent and the resultant percentage decrease in COD.

The graph displayed above unmistakably illustrates that the percentage reduction of COD escalates proportionally with the augmentation of adsorbent dosage. Notably, an adsorbent dosage of 10 grams for orange peel yields a substantial 50% reduction in COD.

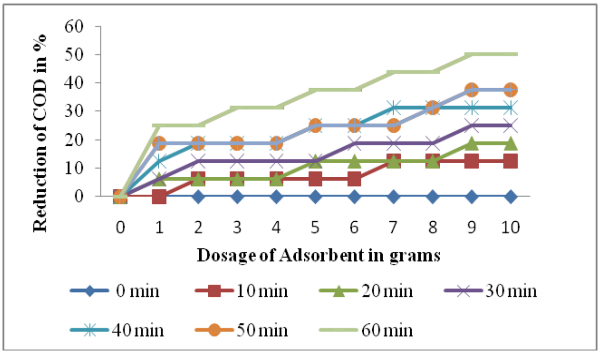

Figure 4. Percentage Reduction of COD using orange peel as adsorbent

3.6. Determination of effective adsorbent

Four 250-milliliter conical flasks were utilized to collect samples of wastewater. The initial COD level in the textile industry's wastewater remains consistent with the original dye concentration. In the first conical flask, 10 grams of cashew nut shell adsorbent were introduced. The second flask received a tenth of a gram of Date Seed adsorbent, the third flask received ten grams of coir pith absorbent, and the fourth flask received 10 grams of orange peel adsorbent. Following the adsorbent dosing, a 60-minute contact time was allowed. Using syringes, the supernatant liquid from each flask was extracted every 10 minutes over the course of the 60-minute contact period.

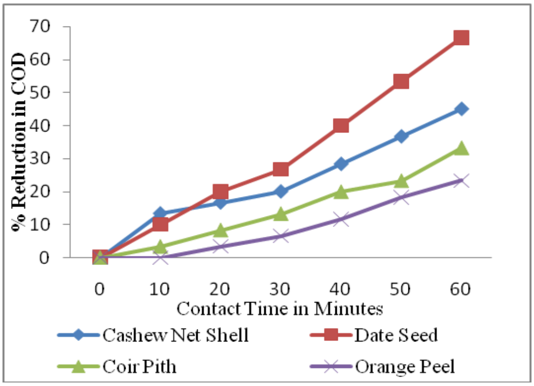

Figure 5. Percentage Reduction of for various adsorbent at a adsorbent dosent of 10 g at Different contact time

Date seed exhibited the highest removal percentage at 67%, followed by cashew nut shell at 45%, coir pith at 33%, and orange peel at 23%.

4. Conclusion

Date seeds and cashew nut shells have the capacity to effectively reduce COD in wastewater. In the upcoming years, there will likely be a noticeable surge in the utilization of agro-based bioadsorbents for dye removal. Both date seeds and cashew nut shells possess the potential to serve as economical and efficient adsorbents, contributing to the enhancement of wastewater treatment processes.

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