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Artificial Intelligence Based Adsorptive Removal of Textile dye from Wastewater

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Abstract: *The textile knit industry extensively utilizes a wide array of both organic and inorganic chemicals as dyes, which ultimately contribute to the generation of substantial wastewater. Unfortunately, the rate at which this wastewater is being discharged from textile facilities has escalated to concerning levels. The indiscriminate disposal of colored effluents into water bodies poses severe threats to the environment, rendering them toxic to both human and aquatic life. This wastewater typically exhibits elevated concentrations of chemical oxygen demand (COD) and biochemical oxygen demand (BOD), along with significant quantities of suspended solids and various other contaminants. Addressing the treatment of wastewater in textile industries demands highly sophisticated methods due to its complex composition. While techniques such as chemical treatments, coagulation, flocculation, reverse osmosis, Nano-filtration, and ultra-filtration have been proposed, their implementation is often hindered by their complexity and costliness. This is particularly challenging for textile industries in developing nations like Bangladesh, where financial resources may be limited. In response to these challenges, there has been a growing recognition of the paramount importance of adsorption in environmental protection efforts, particularly concerning the removal of textile dyes from wastewater. While some adsorbents have proven effective in eliminating dyes and other pollutants, there remains a notable disparity in their performance. Hence, there is an urgent need for the development of novel adsorbents that meet several key criteria: they must be cost-effective, energy-efficient, adaptable in design, biodegradable, and readily accessible. The quest for such innovative adsorbents opens up avenues for research and development. Natural materials, for instance, hold promise as potential adsorbents due to their abundance and eco-friendly nature. Additionally, advancements in nanotechnology offer opportunities to engineer highly efficient adsorbent materials with enhanced properties. Furthermore, exploring hybrid systems that integrate adsorption with complementary treatment processes could further enhance overall efficiency and sustainability. Collaboration between stakeholders across academia, industry, and governmental bodies is essential to drive forward the development and adoption of these novel adsorbents. Furthermore, supportive policies and incentives can incentivize investment in cleaner production practices and foster the widespread implementation of sustainable wastewater treatment technologies. Ultimately, by addressing these challenges and embracing innovative solutions, the textile industry can mitigate its environmental footprint while ensuring the continued well-being of ecosystems and communities worldwide.*

Key Words: *Textile Dye Activated Carbon, Wastewater.*

1. INTRODUCTION

1.1 What is Dye?

Dye is a substance that alters the colour of an object, and dyeing, an ancient textile colouring method, involves soaking textiles in a liquid that interacts with the material to create a new colour. The term "dye" originates from the Middle English word "dy(e)e," derived from the Old French "deice." Dyeing encompasses the application of dye to various materials like fabric, hair, paper, or skin. Dyes are often crafted from plant sources like flowers and plants, either collected from nature or cultivated for dye production. Additionally, aniline coal tar dyes, derived from coal tar pitch sourced from petroleum, are among the most prevalent types of dyes. [1]

1.2 What is Ai?

Artificial Intelligence (AI) stands as a fundamental and widely recognized discipline within computer science, focused on constructing intelligent systems capable of addressing problems akin to human intelligence. The primary goal of integrating AI into systems is to augment computer capabilities relevant to human cognition, including learning, problem-solving, reasoning, and perception. AI has witnessed rapid expansion and finds applications across various domains such as healthcare, urban development, transportation, e-commerce, finance, and education. Within AI, there are distinct subfields like machine learning, deep learning, and data analytics, which play pivotal roles in facilitating intelligent decision-making and driving advancements in areas such as block chain, cloud computing, the Internet of Things (IOT), and the Fourth Industrial Revolution. [2]

1.3 Applications

1. Process Optimization: Aspen Plus allows you to simulate and optimize the process of biodiesel production from soybeans. By adjusting various parameters and configurations, you can identify the optimal conditions for maximizing biodiesel yield, reducing energy consumption, or improving the overall process efficiency.

2. Techno-economic Analysis: Aspen Plus enables you to perform techno-economic analyses of the integrated bio refinery system. By considering factors such as feedstock costs, utility requirements, equipment sizing, and product values, you can evaluate the economic viability of the biodiesel production process. This analysis can help in making informed decisions regarding plant design, investment, and profitability.

3. Environmental Impact Assessment: The simulation in Aspen Plus can provide insights into the environmental impact of the soybean bio refinery system. By modelling the energy and material flows, you can estimate greenhouse gas emissions, water consumption, and waste generation associated with biodiesel production. This information can contribute to sustainability assessments and help in developing greener production strategies.

2. Experimental analysis

2.1 Raw Materials used for project:

- Industrial Waste Water
- Textile Dye
- Activated carbon adsorbents. Activated carbon (AC) is one of the most widely used adsorbents due to its high efficiency, porosity and high surface area
- Add microorganism

2.2 Equipments used for project:

1. pH sensor
2. Adsorbent material (Wheat bran, biochar ,activated carbon)
3. Ultrasonic Sensor(measure the water level)
4. Heavy metal detector
5. Algorithm (Python Programing)
6. Screening
7. Grit removal
8. Clarifier
9. Aeration
10. Secondary clarifier
11. Disinfection

2.3 Specifications

2.3.1 Software requirements

1. Operating system: Windows XP/7 Higher
2. Programming Language: Python
3. Tools: Jupiter notebook
4. Database: MySQL 5.1

2.3.2 Hardware Requirements

1. System: i5 2.7 GHz.
2. Hard Disk: 300 GB
3. Monitor: 15 VGA Color.
4. Ram: 4 GB
5. Arduino
6. Sensors: Ultrasonic Sensors, color detector Sensor, Water level Sensor, ph Sensor

4. Experimental Process

1. Industrial waste water is the contaminated water; it contains various pollutants, including chemicals, Textile Dye, oils and solids which can be harmful to the environment and human health if it not properly treated. This water comes from industries and stored in storage tank.

2. Waste water first goes into the screening for removing the large size material like garbage.

3. After the screening greets removal process is used for separating and removing small dense particles like sand and gravel.

4. Then this water comes in clarifier for the removal of solids, in clarifier heavier particles allow to settle down to the bottom and lighter particles float to the surface.

5. Water sent into the aeration tank, in this process in which air or oxygen is introduced into the water, it promotes the growth of beneficial microorganisms that help breakdown organic pollutants and improve water quality.

6. Secondary clarifier is a unit operation it is used after the aeration process for separate biological sludge from treated water, this sludge contain microorganisms that help in the treatment process. It is used for settle the sludge.

7. pH sensor is a device used to measure the acidity or alkalinity of a liquid. It is fitted after the secondary clarifier, it measure the concentration of hydrogen ion in the liquid and provides a ph value which indicate the level of acidity.

8. After the pH measuring we used the Adsorption column, it is a device used for separating the substances from fluid stream. It contains an adsorbent material that selectively adsorbs heavy metal and specific components from the fluid.

9. We need to check the pH after the adsorption process due to that pH sensor is used here for measuring the pH value, it gives pH value below the 7 or above the 7.

10. After measuring pH this water drain into the river.

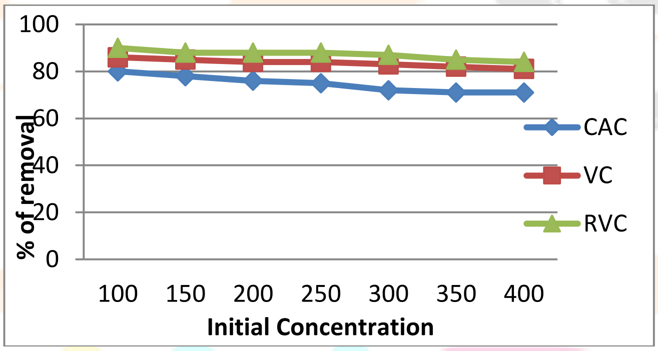
Table 1: Researchers' data of dye and adsorption capacity

Researchers	**Dye**	**Adsorption capacity**
Namasivayam and Arasi [3]	Congo red	4.05 mg/g
Wang et al. [29]	Methylene Blue	7.8 × 10-6 mol/g
Gupta et al.[5]	Rhodamine B	1.16 × 10-5 mol/g
Shivkumar S. Prajapati et al. [7]	Phosphate	205.13 mg/g
G. M. Ratnamala et al. [8]	Remazol Brilliant Blue	27.8 mg/ g
Manoj Kumar Sahu et al.[38]	Safranin-O	89.4 mg/g
Shirzad-Siboni, Mehdi, et al [39]	Acid Blue 113	83.33 mg/g
Shirzad-Siboni, Mehdi, et al [39]	Reactive Black 5	35.58 mg/g
Kong, Chun-yan [9]	Lead (Pb)	38.2 mg/g

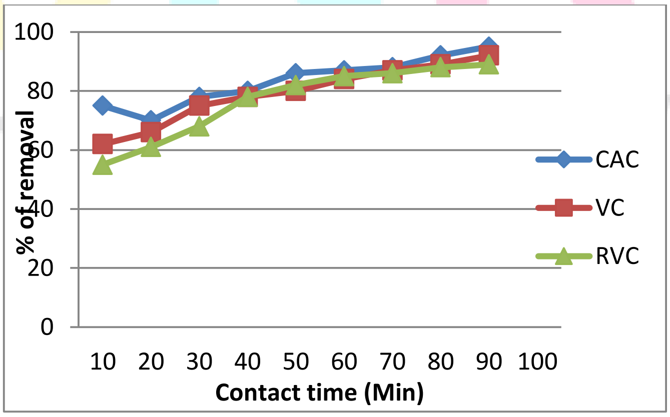
4. Result and Discussion

Table 2: Table 2: Presents findings by different scholars on variations in adsorption ability for Metal chloride sludge at varying pH

Researchers	Dye	Adsorption capacity	pH
Santos et al. [24]	Remazol Brilliant Blue	91.0 mg/g	7
Netpradit et al.[22]	Reactive Red 120	45.87 mg/g	8
Netpradit et al. [22]	Reactive Red 2	61.73 mg/g	9
Golder et al.[23]	Congo red	513 mg/g	3
BurcuUçar et al. [10]	Reactive Red 2	7.99 mg/g	7
BurcuUçar et al. [10]	Reactive Blue 4	4.48 mg/g	7
A. AZIZI et al.[42]	Reactive Dyes	85.81 mg/g	7
Selvam PP et al.[12]	Rhodamine B	42.19 mg/g	7
Santos et al.[13]	Direct Blue 85 dye	600 mg/g	4



Graph 1: Effect of Initial concentration



Graph 2: Effect of contact time on the extent of removal of crystal violet dye by various adsorbents

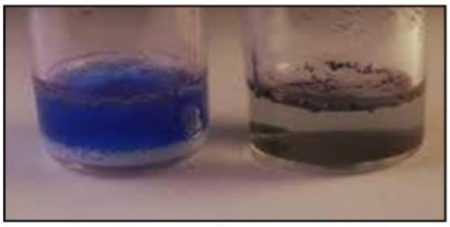


Figure1: Absorption of CV using low cost absorbent

5. Conclusion

Various strategies have been used to extract hazardous organic substances from drainage, such as filtration, coagulation, ion exchange, adsorption, Fenton reagent process, coordination, photo catalytic processes, aerobic degradation and anaerobic processes of degradation. Chemical and biological methods find to be constrained, as they often require high cost of the investment and work. At the other side physical approaches such as ion exchange and reverse osmosis are important because of their successful mechanism of extracting toxins from wastewater treatment. But due to its higher capital and running costs, these ion exchange and reverse osmosis approaches limit usage in large-scale industries. Among all available methods for separating pollutants from waste water, the adsorption shows possible methods for treating and removing organic pollutants in the treatment of wastes. Adsorption follows a surface trend which is more favorable than the other approaches available due to its low resources, running costs which easy architecture. According to the study, the most effective way of extracting organic and inorganic contaminants from industrial wastes is adsorption. Adsorption content accessible from a number of sources, including human, food, and industrial waste. Dye removal from wastewater using activated carbon is an efficient approach but was limited due to its high operational and maintenance costs in industrial processes. Numerous natural sources for the expulsion of colors from wastewater treatment are accessible in the adsorption process.

6. Future Scope and Benefits

Acting with various kinds of color dyes and implementing removal method with setup of heterogeneous adsorbents which will be the system's future work. Low cost adsorbents may be used for water treatment and waste control as well as limited, affordable and environmentally safe low cost adsorbents for water treatment need to be produced

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