

MODELLING OF FLUIDIZED BED FOR ADSORPTION OF CRYSTAL VIOLET DYE USING AGRO WASTE BIOMASS

Submitted in partial fulfillment of the requirements
for the award of Bachelor of Technology
degree in Chemical Engineering
by

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SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A++" by NAAC
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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **T. LOKESH KUMAR (40190010)** who carried out the project entitled **"MODELLING OF FLUIDIZED BED FOR ADSORPTION OF CRYSTAL VIOLET DYE USING AGRO WASTE BIOMASS"** under my supervision from November 2023 to April 2024.

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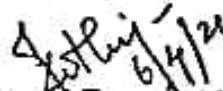
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DECLARATION

I, **T. LOKESH KUMAR** hereby declare that the Project Report entitled **"MODELLING OF FLUIDIZED BED FOR ADSORPTION OF CRYSTAL VIOLET DYE USING AGRO WASTE BIOMASS."** done by me under the guidance of **DR. MICHAEL RAHUL SOOSAI, M.Tech, Ph.D,** is submitted in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Chemical engineering.

DATE: 06.04.2024 .

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ABSTRACT

This abstract explores the synthesis of biomass from the *Chromolaena odorata* plant's stem and leaves was activated using sulfuric acid to adsorb crystal violet (CV) dye. The adsorption operation of CV dye was studied considering the effect of variables like pH, initial dye concentration, time, adsorbent dosage, and temperature. This study investigates the application of agro waste biomass as an eco-friendly adsorbent in a fluidized bed system for the removal of Crystal Violet (CV) dye from aqueous solutions. With the escalating concerns regarding environmental pollution caused by synthetic dyes, the utilization of sustainable and low-cost adsorbents has gained significant attention. In this research, agro waste biomass derived from agricultural residues was characterized and employed as a novel adsorbent for the efficient removal of CV dye. A comprehensive experimental investigation was conducted to analyze the adsorption behavior of CV dye onto the agro waste biomass within a fluidized bed reactor. Various operating parameters such as bed height, flow rate, initial dye concentration. They were further tested in FTIR spectroscopy, XRD (X-Ray diffraction) and SEM images. The utilization of agrowaste biomass in fluidized bed reactors for the removal of Crystal Violet dye from aqueous solutions is investigated in this project. A fluidized bed reactor with specific dimensions of 35 cm in length and 3.5 cm in diameter is employed for the adsorption process. The optimization parameters, including adsorption time (15 mins) dye removal % peaks at 68.31, adsorbent volume (60 ml) dye removal % peaks at 89.81, initial dye concentration (200 mg/l) dye removal % peaks at 91.57, adsorbent dosage (20 g/l) dye removal % peaks at 85.0, and liquid flow rate (0.20 LPH) dye removal % peaks at 85.0, are systematically studied to enhance the efficiency of dye removal. The project aims to develop a comprehensive model for the fluidized bed system, considering these parameters, to predict the performance and optimize the removal process. The utilization of agrowaste biomass as an adsorbent offers a sustainable and cost-effective approach for environmental remediation. The findings of this study contribute to advancing the understanding of fluidized bed adsorption systems for dye removal, with potential applications in wastewater treatment processes.

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LIST OF ABBREVIATIONS

Ppm	- Parts Per Million
UV-Vis	- Ultraviolet-Visible
FTIR	- Fourier Transformation Infrared Spectroscopy
SEM	- Scanning Electron Microscopy
EDAX	- Energy Dispersive X-ray Analysis
XRD	- X-ray Diffraction
FESEM	- Field Emission Scanning Electron Microscopy
EDS	- Ehlers- Danlos syndrome

CHAPTER - 1

INTRODUCTION

1.1 BACKGROUND

Water is an important component as all the living organisms on earth need water for their daily vital activities. With the growth of population and urbanization, the need for water gets intensified. However, the various man-made activities allow the pollutants like dye molecules to make their way into natural water bodies, rendering the water dangerous for consumption. The polluted water bodies deeply affect the health of humans and many other living organisms consuming it. Water is an important component as all the living organisms on earth need water for their daily vital activities. With the growth of population and urbanization, the need for water gets intensified. However, the various man-made activities allow the pollutants like dye molecules to make their way into natural water bodies, rendering the water dangerous for consumption. The polluted water deeply affects the health of humans and many other living organisms consuming it. Thus, it becomes essential to treat water in a large quantity, with the fast and straightforward process to make it safe for consumption of not only humans but also of the other living organism living among us.

Crystal Violet, a synthetic triarylmethane dye renowned for its remarkable versatility, owes its lineage to the groundbreaking invention of Mauveine in 1856, a milestone marking the advent of synthetic dye production. Since this pivotal moment, the textile industry has experienced a steady surge in the utilization and advancement of synthetic dyes, now satisfying a substantial portion—approximately 65 to 70%—of its dyeing requirements. Synthetic dyes offer an extensive palette of colors at a fraction of the cost compared to their natural counterparts, boasting enhanced stability and ease of application. Originating in the late 19th century, Crystal Violet's vibrant violet hue has solidified its status as a cornerstone in microbiology, leaving an indelible mark on scientific research and industrial applications alike. Its significance in microbiology is unparalleled, particularly in Gram staining techniques, where it serves as a vital tool for

differentiating bacterial cell walls a fundamental step in microbiological analysis. Beyond its pivotal role in microbiology, Crystal Violet proves invaluable in histology, aiding in the visualization of cellular structures under microscopic scrutiny with remarkable clarity and precision.

Crystal Violet's significance transcends its mere function as a laboratory reagent, profoundly impacting industrial sectors and scientific endeavors in multifaceted ways. Within textile dyeing processes, Crystal Violet emerges as more than just a coloring agent; it serves as a catalyst for creativity, imbuing fabrics with hues that are not only visually captivating but also durable and long-lasting. The vibrant shades it imparts to textiles enhance their aesthetic appeal, making them more desirable in the eyes of consumers and driving market competitiveness. Moreover, Crystal Violet's role extends beyond the realm of aesthetics; it embodies a fundamental aspect of chemical and material science, serving as a potent tool for indicating and monitoring reactions. In chemical laboratories, its distinct color change provides invaluable insights into reaction progress and endpoint determination, facilitating precise control over experimental conditions and ensuring the reproducibility of results.

In addition to its application in textile dyeing and chemical analysis, Crystal Violet finds utility in diverse scientific disciplines. In microbiology, for instance, it serves as a vital staining agent for visualizing and differentiating microbial structures, aiding researchers in the identification and classification of microorganisms. Its ability to selectively bind to certain cellular components makes it indispensable in microbial research, contributing to our understanding of microbial ecology, pathogenesis, and antimicrobial susceptibility. Furthermore, Crystal Violet's versatility extends to the pharmaceutical industry, where it plays a crucial role in drug formulation and analysis. Its use as a colorimetric indicator facilitates the detection and quantification of pharmaceutical compounds, ensuring the quality and efficacy of medications.

The enduring legacy of Crystal Violet as a versatile and indispensable tool underscores its profound impact on scientific research, industrial processes, and technological advancements. Its vibrant hue and unique properties continue to

shape various fields, fostering innovation and driving progress. From enhancing the visual appeal of textiles to enabling precise analysis in chemical reactions and microbial studies, Crystal Violet's multifaceted versatility makes it an invaluable resource in advancing knowledge and addressing real-world challenges. Its ubiquity across diverse disciplines reaffirms its status as a cornerstone of scientific inquiry and industrial innovation, embodying the intersection of art, science, and technology in contemporary society.

Yet, the multifaceted contributions of Crystal Violet transcend mere enumeration. Its versatility, reliability, and cost-effectiveness underscore its indispensability across numerous fields, propelling advancements in both academia and industry. From microbiology to industrial chemistry, Crystal Violet's enduring legacy continues to shape scientific inquiry and industrial innovation, enriching our understanding of the natural world and enhancing the fabric of modern society.

Crystal Violet, a compound with multifaceted applications, exerts diverse effects across several domains. In the realm of microbiology, its significance is profound. Crystal Violet is a cornerstone in Gram staining techniques, a fundamental procedure used to differentiate between different types of bacteria based on their cell wall characteristics. Through this staining process, Gram-positive bacteria acquire a violet or blue hue, while Gram-negative bacteria are counterstained with a contrasting color. This differentiation is pivotal for microbial analysis, aiding in the identification and classification of bacteria, which in turn facilitates the diagnosis of infectious diseases.

Moving to the field of histology, Crystal Violet finds extensive use in staining tissues for microscopic examination. Histological examination relies heavily on the ability to visualize cellular structures with clarity and contrast. Crystal Violet enhances this visualization, allowing researchers and pathologists to discern cellular morphology, tissue architecture, and pathological changes with greater precision. The staining properties of Crystal Violet are particularly valuable in identifying specific cell types within tissues, contributing significantly to our understanding of biological systems and disease processes.

Beyond the realms of science and medicine, Crystal Violet also plays a significant role in industrial applications, particularly in textile dyeing. Its ability to impart vibrant and long-lasting colors to fabrics has made it a popular choice in the textile industry. Textiles dyed with Crystal Violet exhibit enhanced aesthetic appeal, making them more attractive and marketable to consumers. The widespread use of Crystal Violet in textile dyeing underscores its importance in industrial processes and consumer goods.

However, the biological effects of Crystal Violet merit careful consideration, especially in research and experimental settings. While it is commonly employed in assays to assess cellular viability, proliferation, and cytotoxicity, high concentrations of Crystal Violet can induce cytotoxic effects, leading to cell death or impairment of cellular functions. Therefore, researchers must meticulously control the concentration and exposure duration of Crystal Violet in biological assays to ensure accurate and reliable results while minimizing unintended harm to cells.

Moreover, the environmental impact of Crystal Violet cannot be overlooked. The discharge of Crystal Violet dye into natural water bodies poses a significant threat to aquatic ecosystems. High concentrations of Crystal Violet can disrupt the delicate balance of aquatic environments, affecting the growth, reproduction, and survival of aquatic organisms. Consequently, the regulation of Crystal Violet release into the environment is imperative to safeguard the integrity of aquatic ecosystems and preserve biodiversity.

The adsorption of crystal violet dye plays a crucial role across a spectrum of applications, ranging from wastewater treatment to analytical chemistry, where the binding of crystal violet molecules onto surfaces, predominantly solid materials like activated carbon or other adsorbents, is pivotal. This process serves as the linchpin in removing crystal violet from solutions, making it imperative to comprehend thoroughly to optimize removal techniques and boost efficiency.

Understanding the intricacies of crystal violet adsorption entails delving into a myriad of factors, each exerting a significant influence on the process. Among these factors, pH stands out as a key determinant, as variations in pH levels can profoundly affect the surface charge of both the dye molecules and the adsorbent material, consequently altering their interaction and adsorption capacity. Similarly, temperature plays a critical role, influencing the kinetic energy of the system and thus impacting the rate and extent of adsorption.

Moreover, the properties of the adsorbent material itself, such as surface area, pore size distribution, and surface chemistry, significantly influence crystal violet adsorption. For instance, materials with higher surface areas and tailored surface chemistries often exhibit enhanced adsorption capacities due to increased active sites available for interaction with dye molecules. Beyond these factors, the presence of other ions or organic matter in the solution can also influence crystal violet adsorption by competing for adsorption sites or forming complexes with the dye molecules, thereby altering their availability for adsorption.

By unraveling the complex interplay of these factors, researchers can gain valuable insights into the mechanisms governing crystal violet adsorption, paving the way for the development of more efficient and sustainable removal techniques. This exploration not only enhances our understanding of dye removal processes but also holds promise for addressing pressing environmental challenges associated with dye pollution. Thus, this introduction serves as a springboard for a deeper dive into the nuanced dynamics of crystal violet adsorption, highlighting its significance and potential implications across various scientific and environmental domains.

The biomass employed for the adsorption operation in this study was sourced from *Chromolaena odorata*, a local invasive plant commonly known as Siam Weed. Originally indigenous to South America, *C. odorata* has successfully spread to various regions of India. This plant species possesses distinct growth characteristics that contribute to its invasive nature. Despite having a woody base, *C. odorata* exhibits a flexible and soft stem structure, allowing it to thrive as a creeper, often sprawling over other vegetation and reaching impressive heights of

up to 10 meters in favorable conditions. Notably, each plant produces a prolific number of seeds, estimated to range between 80,000 to 90,000 per individual, equipped with mechanisms for attachment to various surfaces like cloth, fur, and machinery, facilitating its widespread dispersal over long distances.

Another remarkable aspect of *C. odorata*'s biology is its rapid regenerative ability. Capable of sprouting from its roots and exhibiting vigorous growth rates of up to 3 centimeters per day under optimal environmental conditions, this plant demonstrates resilience and adaptability in diverse habitats. Moreover, the leaves of *C. odorata* are valued for their medicinal properties, particularly for their antimicrobial qualities, making them traditionally sought-after for healing wounds and other ailments. By harnessing the biomass derived from *C. odorata* for the adsorption process, this study not only addresses environmental concerns associated with invasive species but also capitalizes on the unique properties of this plant for sustainable applications in wastewater treatment and other environmental remediation efforts.

In the present study, we embarked on a novel endeavor by utilizing the stem of *Chromolaena odorata*, an invasive plant notorious for its disruptive effects on local vegetation, for the adsorption of CV dye. To the best of our knowledge, this represents the inaugural application of *C. odorata* biomass in such adsorption operations, marking a significant breakthrough in the field. Our approach commenced with a systematic exploration, initially employing a one-variable-at-a-time methodology to conduct adsorption studies. Subsequently, we adopted a more sophisticated statistical approach, namely response surface methodology (RSM), to systematically investigate the optimal conditions of various variables aimed at maximizing dye removal percentage.

Furthermore, our investigation extended to assessing the reusability of the adsorbent, a critical aspect for evaluating its long-term efficacy and sustainability in practical applications. Through a series of experiments, we aimed to ascertain the feasibility of utilizing the *C. odorata* stem biomass as a reusable adsorbent for prolonged and efficient dye removal from aqueous solutions.

In addition to these fundamental studies, we designed and implemented a single-stage batch adsorber, envisioning its potential for large-scale dye removal operations. This innovative design not only demonstrates the scalability of our approach but also lays the groundwork for the practical implementation of our findings in real-world settings.

By repurposing biomass from an invasive plant species like *C. odorata* for dye adsorption, our research not only addresses environmental concerns associated with invasive flora but also presents a sustainable solution for wastewater treatment. Through this interdisciplinary endeavor, we contribute to both environmental conservation efforts and the advancement of efficient water treatment technologies, paving the way for a more sustainable future.

CHAPTER - 2

LITERATURE SURVEY

Chauhan P et al. (2021) High selectivity and adsorption proficiency of surfactant-coated selenium nanoparticles for dye removal application. The rate of environmental pollution augmenting at an alarming rate due to the continuous disposal of toxic dyes directly into the environment and water streams. The direct contact of dyes with water resources directly affects the living beings. The identification of superior methods for the treatment of water pollution caused due to effluent dyes needs higher consideration among researchers for the well-being of living flora and fauna. The available methods for controlling the decontamination of water through toxic dyes have various drawbacks. So, it is highly significant to develop such materials which can easily adsorb the dyes without causing any toxic effect on the environment and living beings. While keeping all the facts in mind, the current work highlights the comparative enhancement in adsorption capacity and selectivity of Brij-58-coated selenium nanoparticles (Brij-58@Se NPs) towards the removal of bromophenol blue (BB) dye from series of chosen dyes in aqueous media. The fabricated Se NPs were methodically characterized and the adsorption behaviour displayed fast adsorption efficiency (98% within 6 min) for BB dye out of series of chosen dyes. The efficacy of the adsorbent was further tested in six different water resources and displayed 95% adsorption efficiency for BB dye in different wastewater samples. Therefore, Brij-58@Se NP is expected as a potential adsorbent for the adsorption of organic dyes from wastewater samples.

Anyanwu S et al. (2017) Effect of ethanolic extract of *Chromolaena odorata* on the kidneys and intestines of healthy albino rats. The use of plants and plant products for medicinal purposes is an age-long practice in traditional communities and is becoming prominent globally. This study was performed to evaluate the effect of ethanolic extract of *Chromolaena odorata* on the kidney and intestine of albino rats.

Marques BS et al. (2019) Adsorption of a textile dye onto piacava fibers: kinetic, equilibrium, thermodynamics, and application in simulated effluent. This research was conducted to evaluate the methylene blue dye adsorption by piacava fibers. The effects of adsorbent amount, pH, kinetics, equilibrium, and thermodynamics were analyzed, as well as the adsorbent performance in the treatment of synthetic textile effluents. The adsorbent characterization was also performed. Experimental kinetic data were fitted with pseudo-first-order, pseudo-second-order, and Elovich models. The equilibrium tests were done at 298, 308, and 318 K, and the models of Freundlich, Langmuir, Redlich–Peterson, and Sips were used. The adsorption was favored using 0.025 g of adsorbent, pH 10, and 318 K. The Elovich model provided better fit to kinetic data. The equilibrium experimental points were well represented by the Sips model. The maximum experimental adsorption capacity of methylene blue dye was 427.3 mg g^{-1} . It was verified a spontaneous, favorable, and endothermic adsorption. Piacava fiber was a promising low-cost material to be used for color removal in effluents containing methylene blue.

Dahunsi SO et al. (2018) Anaerobic conversion of *Chromolaena odorata*. This study evaluated the anaerobic mono-digestion of two different samples of *Chromolaena odorata*. Combinations of mechanical and thermo-alkaline pretreatments were applied to one of the two samples and labeled as “X” while the second had no thermo-alkaline treatment and was labeled as “Y”. The Central Composite Design was used to design the pretreatments. The physicochemical characteristics of the substrates were carried out using standard methods after appropriate pretreatments. From the experimental set-ups, the most probable actual Combination of different pretreatment methods enhanced enormous biogas yield from the digested substrates. Optimization of the generated biogas data was carried out using the Response Surface Methodology (RSM) and the Artificial Neural Networks (ANNs). The coefficient of determination (R^2) for RSM was lower compared to that of ANN. This shows that ANNs model gives higher accuracy than RSM model. Further utilization of this weed for biogas production is encouraged by the results from this study.

Rahul et al. (2022) Use of activated *Chromolaena odorata* biomass for the removal of crystal violet from aqueous solution: Kinetic, Equilibrium and Thermodynamic study In the present study, biomass from the *Chromolaena odorata* plant's stem was activated using sulfuric acid to absorb crystal violet (CV) dye. The adsorption operation of CV dye was studied considering the effect of variables like pH, initial dye concentration, time, adsorbent dosage, and temperature. The pseudo-second-order equation best fitted the kinetic study, and thermodynamic parameters calculated were activation energy (9.56 kJ/mol), change in Gibbs energy (81.43 to 96.7 kJ/mol), enthalpy change (6.89 kJ/mol), and entropy change [-254.4 J/ (mol K)]. Response surface methodology (RSM) estimated at pH (4.902), adsorbent dosage (8.33 g/L), dye concentration (82.30 ppm), temperature (300.13 K) dye removal of 97.53% is possible. FTIR, SEM, XRD, BJH, and BET confirmed adsorption operation. The adsorbent can be reused for 5 cycles effectively. Langmuir isotherm best fitted the adsorption operation was used for designing a theoretical single-stage batch adsorber for large-scale operation.

Dhanush et al. (2016) Synergy of Siam weed (*Chromolaena odorata*) and poultry manure for energy generation: Effects of pretreatment methods, modeling and process optimization The co-digestion of *Chromolaena odorata* with poultry manure was evaluated in this study. Two samples of the weed: (A: which was pre-treated with mechanical, chemical and thermal methods) and (B: which was pretreated using mechanical and chemical methods only) were separately digested with poultry manure. Biogas generation started from the 2nd to 4th and 4th to 7th day for samples 'A' and 'B' respectively. The most desired actual biogas yield from samples 'A' and 'B' were 3884.20 and 2544.70 (10-4m³/kg VS) respectively and the gas composition was 68±2% Methane and 20±2% Carbon dioxide for sample A while it was 62±3% Methane and 22±2% Carbon dioxide for sample B. In all, there was a 38.06% increase in gas generation in 'A' over 'B'. The coefficient of determination (R²) for the Response Surface Methodology (RSM) model (0.9009) was high suggesting high accuracy in the modeling and prediction. The worldwide usage of *C. odorata* is encouraged.

Samuel & ahedi (2018) Anaerobic conversion of *Chromolaena odorata* (Siam weed) to biogas This study evaluated the anaerobic mono-digestion of two different samples of *Chromolaena odorata*. Combinations of mechanical and thermo-alkaline pretreatments were applied to one of the two samples and labelled as “X” while the second had no thermo-alkaline treatment and was labelled as “Y”. The Central Composite Design was used to design the pretreatments. The physicochemical characteristics of the substrates were carried out using standard methods after appropriate pretreatments. From the experimental set-ups, the most probable actual biogas yields in experiments “X” and” Y” were 0.3554 m³/kg Total Solid (TS)fed and 0.1803 m³/kg TSfed with the desirability of 99 and 100%, respectively. Further shown in the result is a 49.2% higher experimental (actual) biogas yield in experiment “X” over “Y”. Gas chromatographic analysis revealed the CH₄ and CO₂ content of both experiments to be 65 ± 1.5%; 21 ± 3% and 53.5 ± 2.5%; 26 ± 3%, respectively. Combination of different pretreatment methods enhanced enormous biogas yield from the digested substrates. Optimization of the generated biogas data was carried out using the Response Surface Methodology (RSM) and the Artificial Neural Networks (ANNs). The coefficient of determination (R²) for RSM was lower compared to that of ANN. This shows that ANNs model gives higher accuracy than RSM model. Further utilization of this weed for biogas production is encouraged by the results from this study.

CHAPTER – 3

AIM AND SCOPE

3.1 AIM

The aim is to utilize Siam weed leaves and stems to develop an adsorbent, followed by thorough characterization to assess its potential applications. Subsequently, a fluidized bed adsorber will be designed and modeled for efficient operation. The focus will be on its use in wastewater treatment processes, with optimization studies conducted to enhance performance and efficiency. Through this approach, the goal is to create an effective and sustainable solution for wastewater treatment, contributing to environmental preservation.

3.2 SCOPE

1. Siam weed is a waste biomass.
2. The adsorption of crystal violet dye is widely studied in fields like environmental science and material science.
3. Its scope includes wastewater treatment, where adsorption onto various materials like activated carbon or nanomaterials helps remove the dye from water.
4. Additionally, research explores adsorption for sensing applications and drug delivery systems, showcasing the versatile scope of crystal violet adsorption in different scientific domains.

3.3 OBJECTIVE

1. Develop a comprehensive model for a fluidized bed system.
2. Utilize agrowaste biomass as an adsorbent for the removal of Crystal Violet dye from aqueous solutions.
3. Investigate the influence of key parameters such as adsorption time, adsorbent volume, initial dye concentration, adsorbent dosage, and liquid flow rate on the efficiency of dye removal.

4. Optimize the aforementioned parameters to enhance the performance of the fluidized bed reactor.
5. Evaluate the sustainability and cost-effectiveness of using agrowaste biomass as an adsorbent compared to conventional methods.
6. Contribute insights into the applicability of fluidized bed technology for environmental remediation.
7. Conduct experimentation and modeling to advance understanding of fluidized bed systems for dye removal applications.
8. Emphasize environmental sustainability and resource efficiency in the development and implementation of the proposed technology.

CHAPTER 4

MATERIALS AND METHODS

4.1 MATERIALS

The following materials were used for the synthesis Chromolaena :

1. Chromolaena(siam weed)
2. Hot air oven
3. Crystal violet dye
4. sulfuric acid (H_2SO_4)
5. Magnetic pellet.
6. Water
7. Sodium Bicarbonate (NaHCO_3)
8. 1-liter beakers
9. Filter papers
10. Stirrer
11. Air Pump
12. Rotameter
13. Fluidized glass column

4.2 PREPARATION OF STOCK SOLUTION

To prepare a 1000 mL solution of 1000 ppm crystal violet dye, the procedure had begun by accurately weighing 1 gram of crystal violet dye using a digital balance. The dye had been dissolved in a small volume of appropriate solvent in a clean 1000 mL volumetric flask, ensuring complete dissolution. Then, the flask had been filled to the mark with the solvent, and careful mixing had been done to achieve uniformity. The concentration had been verified and adjusted if necessary. Finally, the flask had been labeled with the solution details and stored appropriately. This procedure had ensured the creation of a precise solution suitable for various applications.

4.3 PREPARATION OF ADSORBENT

The preparation process of *Chromolaena odorata* involves a series of meticulously orchestrated steps aimed at optimizing its properties for various applications. Initially, the harvested stems and leaves are carefully spread out in a thin layer and exposed to sunlight. This crucial drying phase serves to reduce the moisture content of the plant material, a pivotal factor that can significantly impact subsequent processing steps and the overall quality of the final product. Excessive moisture content not only poses challenges during grinding and sieving but also increases the risk of microbial growth and degradation, ultimately compromising the efficacy of the material in its intended applications.

Following thorough drying, the plant material undergoes grinding into a fine powder using specialized equipment such as a grinder or mill. This mechanical breakdown enhances the material's surface area and facilitates uniformity in particle size distribution. Subsequently, the powdered material is meticulously sieved to achieve the desired particle size range, typically between 75 to 100 μm . This precise control over particle size ensures consistency in the material's characteristics and performance, especially in applications where surface area plays a critical role, such as adsorption processes.

The next stage involves the activation of the powdered *Chromolaena odorata* material through acid treatment. A portion of the powder is mixed with a specific volume of 0.1 N H_2SO_4 (sulfuric acid) solution and stirred for a predetermined duration, typically 18 hours. During this period, the acid interacts with the plant material, facilitating the breakdown of organic components and creating surface functional groups. These modifications enhance the material's adsorption properties by increasing surface reactivity and pore volume. Acid activation is a widely utilized technique in materials science to modify the surface chemistry of adsorbents, thereby enhancing their capability to adsorb target substances from solution.

After acid activation, the material undergoes neutralization to eliminate any residual acid present. This neutralization step involves soaking or rinsing the material in a solution of 0.1 N NaHCO_3 (sodium bicarbonate), a mild base. The

sodium bicarbonate effectively neutralizes the remaining acid, mitigating the risk of interference with subsequent processes or applications. Additionally, neutralization helps stabilize the pH of the material, making it more suitable for specific adsorption applications and ensuring its safety for handling.

Finally, the prepared *Chromolaena odorata* material undergoes a final drying phase to remove any excess moisture and prepare it for storage or further processing. This drying process is typically conducted in an oven set to a specific temperature (353 K or approximately 80°C) for a defined duration (6 hours). Proper drying is essential to maintain the stability of the material, prevent microbial growth, and ensure consistent performance in subsequent applications.

In essence, each step in the preparation process of *Chromolaena odorata* plays a crucial role in enhancing its properties and suitability for diverse applications, ranging from environmental remediation to industrial processes. Through meticulous attention to detail and precise execution, the prepared material exhibits optimized characteristics, making it a valuable resource in various fields.

4.4 Methodology for Preparation of Adsorbent

➤ Drying



Fig 4.1 Drying of Siam weed

- Harvested stems and leaves are spread thinly and exposed to sunlight.
- Reduce moisture content to prevent microbial growth and facilitate subsequent processing.

➤ **Grinding**



Fig 4.2 Grinding of Siam weed

- Dried material is ground into a fine powder.
- Increase surface area and ensure uniformity.

➤ **Sieving**



Fig 4.3 Seiving of siam weed

- Powdered material is sieved to achieve desired particle size range (typically 75 to 100 μm).
- Ensures consistency in particle size distribution.

➤ **Acid Activation**



Fig 4.4 Acid activation for siam weed

- Portion of powder mixed with 0.1 N sulfuric acid solution.
- Stirred for 18 hours to enhance adsorption properties by creating surface functional groups.

➤ **Neutralization**



Fig 4.5 Neutralization of Acid Activation Weed

- Acid-treated material neutralized using 0.1 N sodium bicarbonate solution.
- Stabilize pH, mitigate acid interference, and ensure safety for handling.

➤ **Final Drying**

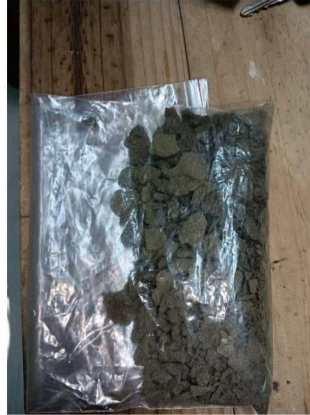


Fig 4.6 Final Drying of Siam Weed After Acid Activations

- Excess moisture is removed by drying the material in an oven at 80°C for 6 hours, ensuring stability and consistency.

4.5 Method for Modelling of fluidized bed:

This setup involves several components interconnected to facilitate a specific process:

- **Electric Air Pump:** This device generates compressed air to initiate the flow within the system. It serves as the primary source of air pressure.
- **Inlet Pipe:** A conduit that connects the electric air pump to the inlet port of the rotameter. This pipe directs the compressed air from the pump into the rotameter.
- **Rotameter:** A device used to measure the flow rate of a fluid, in this case, air. It typically consists of a tapered tube with a float that rises or falls according to the flow rate. The inlet pipe introduces the air from the pump into the rotameter.

- **Outlet Pipe:** Another pipe attached to the outlet port of the rotameter. This pipe carries the air out of the rotameter and serves as a continuation of the airflow-pathway.
- **Glass Column:** This is where the air eventually reaches after passing through the rotameter and outlet pipe. The glass column could serve various purposes depending on the specific application, such as mixing, separation, or observation of the air flow.



Fig 4.7 Modelled Fluidized Bed

4.6 Characterization of Adsorbents

Fourier Transform Infrared (FTIR) Spectroscopy was employed to analyze surface functional groups of *Chromolaena odorata*. The spectrum was obtained by recording wavelengths ranging from 4500 to 500 cm⁻¹ in transmission mode. X-Ray Diffraction (XRD) was utilized to examine structural variations in the prepared adsorbents. Field-emission scanning electron microscopy (FESEM) with energy dispersive X-ray spectroscopy (EDX) was done to study the morphological structure of the adsorbents.

4.7 Adsorption Experiment

The experimental investigation delved deeply into exploring the adsorption potential of *Chromolaena odorata*'s acid-activated stem (AASCO) towards Crystal Violet (CV) dye, employing a meticulously designed modelled fluidized bed setup as the experimental platform. Within this setup, meticulous attention was paid to maintaining experimental integrity and accuracy. The setup's total volume of 1000 mL provided ample space for conducting the experiments, ensuring sufficient interaction between the AASCO adsorbent and the CV dye solution. Moreover, the inclusion of 50 mL of the prepared dye solution within this setup facilitated precise control over the experimental conditions, allowing for accurate measurement and analysis.

To establish the desired concentrations for experimentation, the CV dye solution was meticulously derived from a stock solution of 1000 ppm. This process involved careful dilution to achieve the specific concentrations required for testing. Such meticulous preparation ensured that the experimental conditions accurately reflected real-world scenarios, enhancing the reliability and applicability of the study's findings.

In initiating the adsorption process, great care was taken to introduce a precise quantity of the AASCO adsorbent into the CV dye solution. This step was critical in ensuring consistent and reproducible results across experiments. The subsequent exposure of this mixture to a fluidized bed environment, with a controlled flow rate of 0.2 LPH maintained for a duration of 15 minutes, provided optimal conditions for adsorption to occur. This carefully controlled environment promoted efficient

interaction between the adsorbent and the dye molecules, facilitating the adsorption process.

Throughout the experimentation, a systematic approach was adopted to investigate key variables such as the dosage of AASCO adsorbent, initial CV dye concentrations, and the duration of exposure. By systematically varying these parameters, the study aimed to elucidate their influence on the adsorption process comprehensively. This meticulous exploration allowed for a nuanced understanding of the factors affecting adsorption efficiency, enabling the identification of optimal conditions for maximum adsorption capacity.

Upon completion of the adsorption operation, stringent filtration procedures were employed using Whatman number 1 filter paper to separate the adsorbent-dye complex from the solution. This step was crucial in isolating the adsorbed dye molecules for subsequent analysis. The subsequent analysis of the filtrate using a UV-vis spectrophotometer, with a focus on determining the residual CV dye concentration at its maximum absorption wavelength ($\lambda_{\text{max}}=590 \text{ nm}$), provided quantitative insights into the extent of adsorption achieved.

In conclusion, the experimental investigation represented a meticulous and thorough exploration of the adsorption potential of AASCO towards CV dye, conducted with a high degree of precision and attention to detail. By employing a systematic approach and stringent experimental protocols, valuable insights were gained into the factors influencing adsorption efficiency, paving the way for further advancements in the field of adsorption science and environmental remediation strategies.

$$\text{Dye Removal\%} = \frac{(C_o - C_t)}{C_o} \times 100 \quad (1)$$

$$\text{Biosorption Capacity (mg/g)} = \frac{(C_o - C_t)}{m} V \quad (2)$$

where C_o is the concentration of CV dye initially present in aqueous solution (mg/L), C_t is the CV dye concentration at time t (mg/L), m is the mass of the biomass (g), and V is the volume of the solution

CHAPTER – 5

RESULTS AND DISCUSSION

5.1 FTIR(Fourier Transform Infrared)

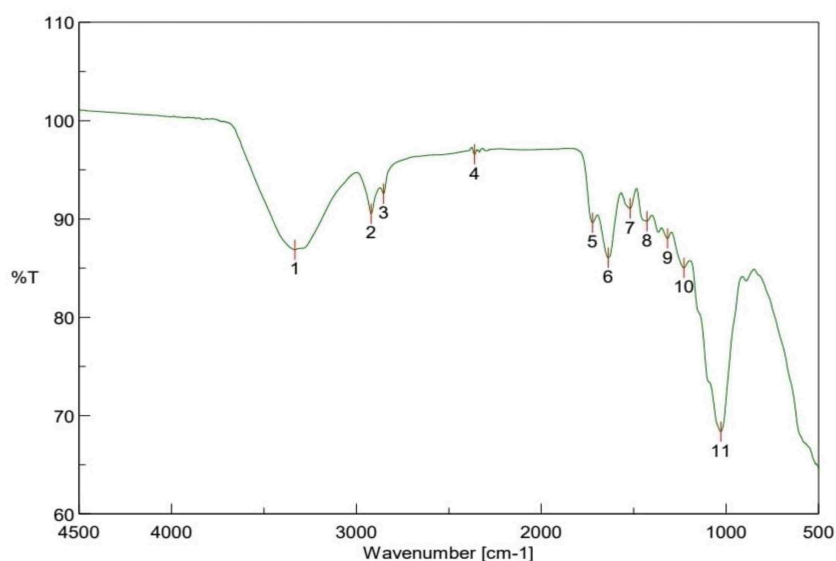


Fig 5.1 FTIR Spectroscopy Results for Synthesis of Chromolaena

The spectrum of *C. odorata* biomass obtained from FTIR analysis reveals several key features:

1. Broadband at 3500 to 3000 cm⁻¹: This indicates -OH bond stretching, suggesting the presence of hydroxyl groups in the biomass.
2. Small peak at 1750 cm⁻¹: This peak is attributed to -CH₂ and -COOH bond stretching, indicating the presence of carboxylic acid and alkane groups.
3. Distinctive peak near 1150 cm⁻¹: This peak suggests the presence of -COOH functional groups associated with aldehydes, ketones, carboxylic acids, and amides.

The presence of carbonyl and hydroxyl functional groups in *C. odorata* biomass indicates its hydrophilic nature, allowing it to bind pollutants in water.

Furthermore, when the biomass of *C. odorata* is activated with sulfuric acid, the FTIR spectra show additional features:

1. New peak at 1109 cm^{-1} : This peak indicates C = S bond stretching, suggesting the formation of new sulfur-containing bonds near the originally present -COOH bonds.
2. New peaks at 2837 cm^{-1} and 2974 cm^{-1} : These peaks indicate the formation of carboxylic acid groups near the alkane and alcohol groups present in *C. odorata* biomass.

These findings confirm the successful activation of *C. odorata* biomass with sulfuric acid, which enhances its ability to adsorb pollutants from water.

5.2 XRD (X-Ray diffraction).

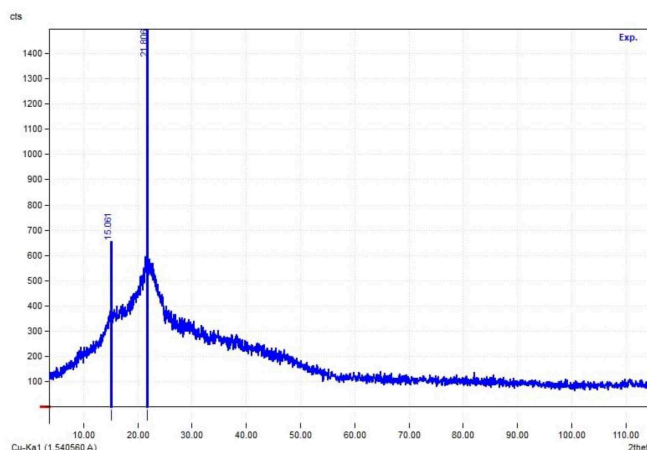


Fig 5.2 X-Ray Diffraction Spectroscopy

- XRD spectrum is indicated in Fig. 5.2, which shows a well-defined and intense peak at 2 (degree of 21.956), indicating the presence of crystalline and well-defined structures present in *C. odorata* biomass.
- Furthermore, the intensity of the well-defined peak does not reduce after the biomass is activated with acid Fig. 5.2 or after the adsorption operation.
- Therefore, Fig. 5.2 indicates that the adsorption of CV dye on *C. odorata* will probably take place on the upper part of the crystalline surface.

5.3 FESEM Images of Sample before adsorption

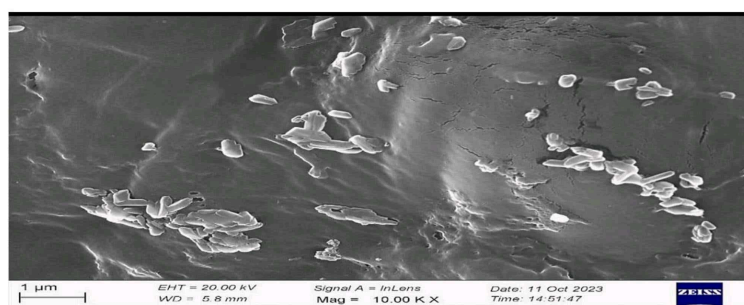


Fig 5.3 SEM Image Under 10.00 KX Magnification

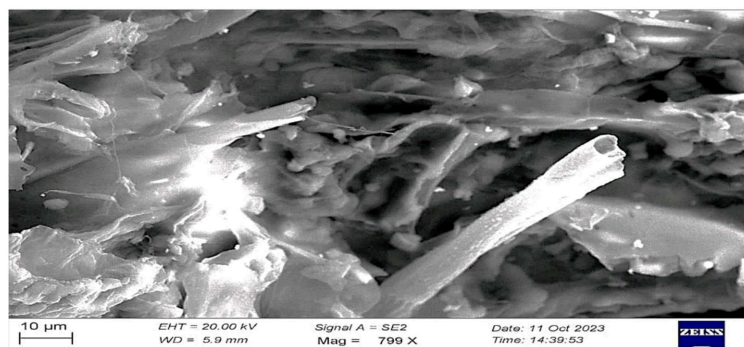


Fig 5.4 SEM Image Under 799X Magnification

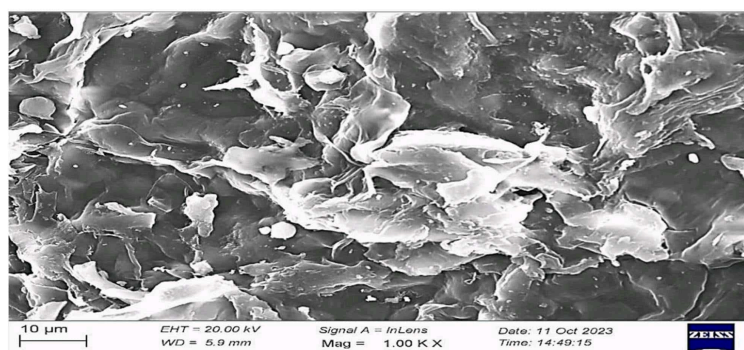


Fig 5.5 SEM Image Under 1.00 KX Magnification

SEM analysis was employed to study the physical morphology of the surface of the biomass. The SEM images of *C. odorata* biomass, acid-activated *C. odorata* biomass, and CV dye absorbed on *C. odorata* were obtained. From the SEM image, it is evident that acid activation of *C. odorata* biomass has led to an

increase in the cavities present on the biomass surface. Consequently, after the adsorption study, it was observed that the dye molecules were attached to the activated surface of the biomass, indicating the effectiveness of the activation process in enhancing the adsorption capacity of *C. odorata* biomass.

5.4 Electron Dispersive X-Ray (EDX)

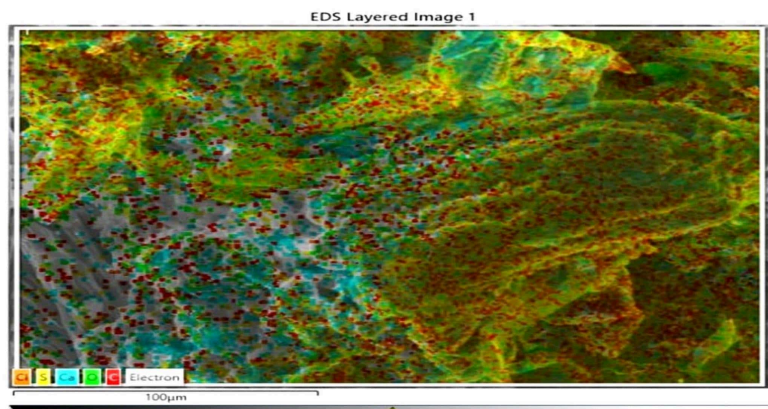


Fig 5.6 EDS Layered Image of Siam Weed Before Adsorption

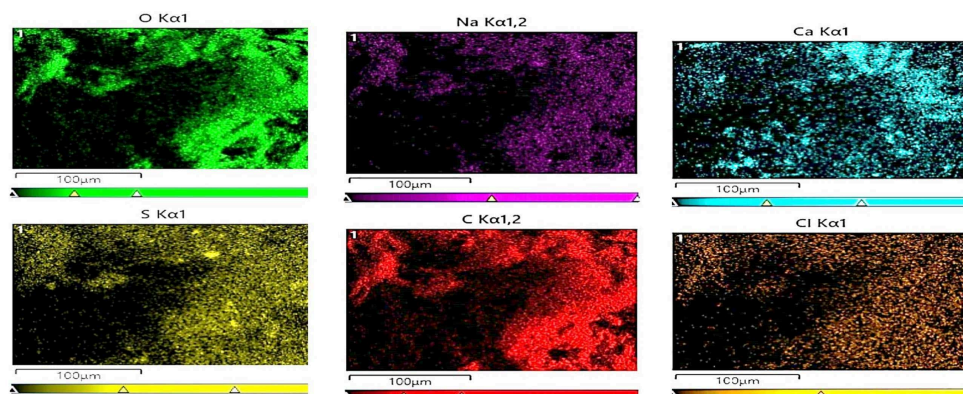


Fig 5.7 EDS Layered Image of o,s,na,c,ca,cl before Adsorption

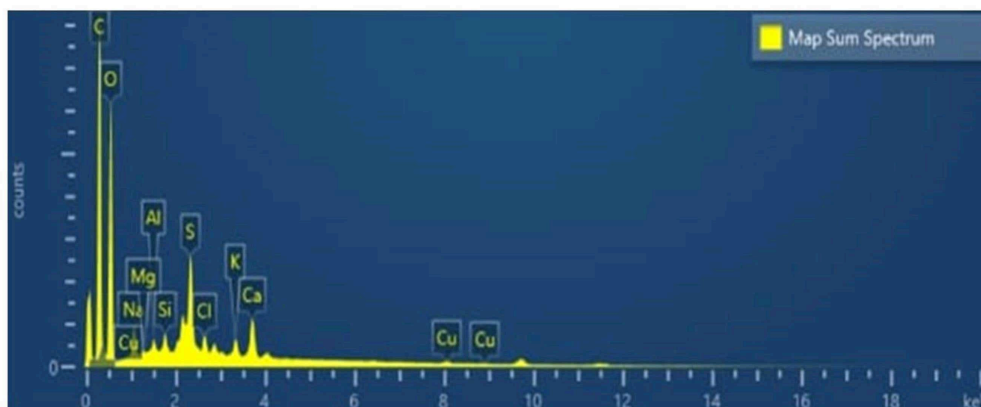


Fig 5.8 EDX Spectra of Siam Weed

Table 5.1 EDAX Spectra of Siam Weed Before Adsorption

Element	LineType	Weight %	Weight % Sigma	atomic%
C	κ series	56.58	0.38	65.31
O	κseries	36.73	0.34	31.83
Na	κ series	1.14	0.04	0.69
Mg	κ series	0.08	0.02	0.04
Al	κ Series	0.25	0.02	0.13
Si	κ series	0.36	0.02	0.18
S	κ series	1.89	0.04	0.82
Cl	κ series	0.55	0.02	0.22
κ	κ series	0.55	0.02	0.2
ca	κ series	1.44	0.03	0.5
cu	κ series	0.43	0.06	0.09
Total		100		100

The EDAX mapping shows the composition of the adsorbent sample. The carbon and oxygen peaks obtained are due to the large amounts of C-H, C-O and O-H bonds present in Siam weed. The presence of sodium and sulfur is due to the addition of sodium bicarbonate and sulfuric acid during the activation process.

5.5 FESEM image after adsorption

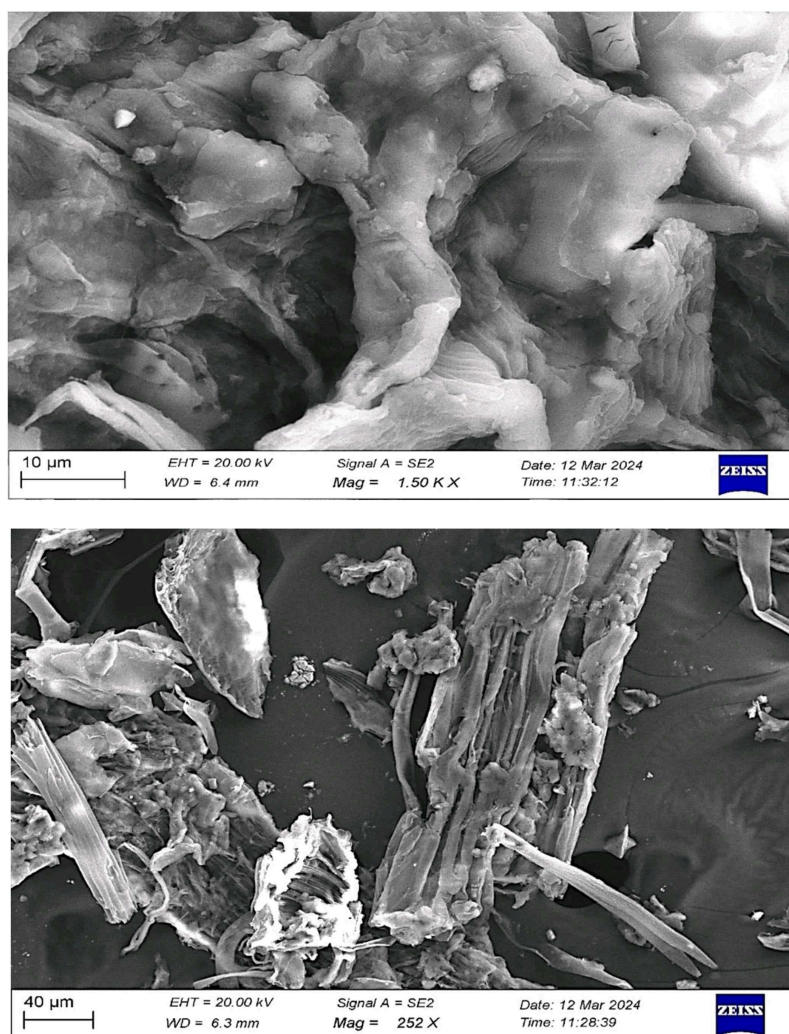


Fig 5.9 FESEM Images of Siam Weed After Adsorption

After adsorption: These images show a similar structure to that of siam weed before adsorption, but the pore size has reduced since it is already occupied by dye molecules.

5.6 FACTOR IMPACTING ADSORPTION

5.6.1 Optimization of time

The collected samples are tested with UV spectrophotometer, and the removal percentage of the adsorbent can be found by calculating the absorbance value obtained

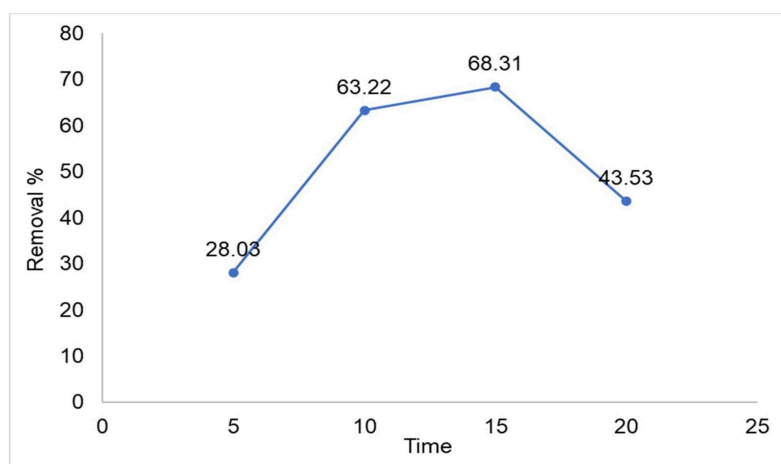


Fig 5.10 Effect of Optimisation of Time

From the data present, it can be concluded that the optimum contact time for the maximum removal of dye particles is approximately 15 minutes. One possible explanation for this observation is that after 15 minutes, most of the active sites of the adsorbent are likely occupied by dye molecules, leading to saturation of the adsorption capacity.

Additionally, it is plausible that after 15 minutes, the rate of desorption becomes slightly higher than the rate of adsorption. This means that while some dye molecules continue to be absorbed onto the active sites of the adsorbent, there is also a concurrent process of dye molecules being released from the adsorbent surface back into the solution. This equilibrium between adsorption and desorption processes could result in a plateau in the removal efficiency observed around 15 minutes. Therefore, the observed optimal contact time of 15 minutes likely

represents a balance between adsorption and desorption kinetics, where the adsorption capacity of the adsorbent is maximized before desorption processes start to dominate.

5.6.2 Optimization of volume

The collected samples are tested with UV spectrophotometer, and the removal percentage of the adsorbent can be found by calculating the absorbance value obtained

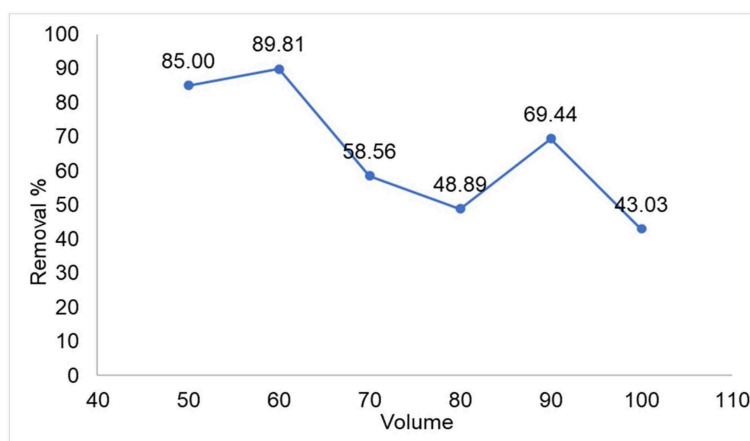


Fig 5.11 Effect of Optimisation of Volume

Based on the study where the removal of crystal violet dye was investigated by varying the initial concentration (60, 70, 80, 90, 100 ml) while keeping the adsorbent dosage constant at 0.2 g and a contact time of 15 minutes, it can be concluded that the adsorption of 60 ml is the most efficient for the maximum removal of dye particles. This conclusion aligns with the principle that at lower concentrations of the dye solution, there are numerous accessible adsorption sites available on the surface of the adsorbent. Consequently, more dye molecules have the opportunity to interact with and be absorbed onto these accessible sites, leading to a higher adsorption rate. However, as the concentration of the dye solution increases, more dye molecules compete for the limited number of accessible sites on the adsorbent surface. Eventually, as the concentration

continues to rise, these sites become saturated with dye molecules, meaning that additional increases in concentration do not result in proportionate increases in adsorption. Consequently, the adsorption rate may start to decline once these sites are fully occupied. Therefore, the observed optimum efficiency at 60 ml suggests that this concentration strikes a balance where there are enough accessible adsorption sites for efficient removal of dye.

5.6.3 Optimization of concentration

A UV spectrophotometer is used to evaluate the collected samples, and the absorbance value obtained can be used to calculate the removal percentage of the adsorbent.

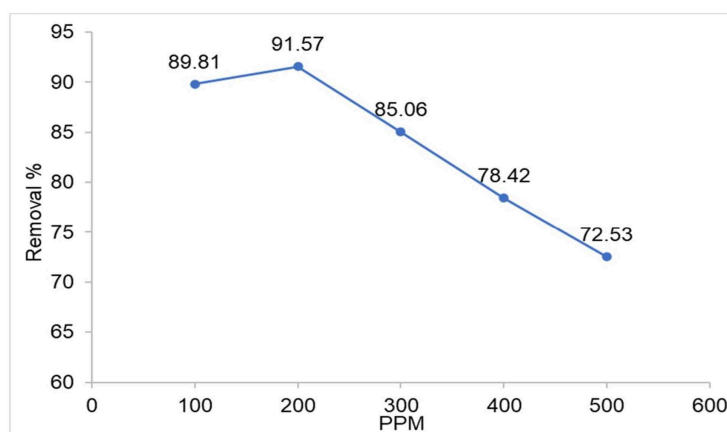


Fig 5.12 Effect of Optimization of PPM

Based on the study where the removal of crystal violet dye was investigated by varying the initial concentration (100, 200, 300, 400, 500 ppm) while keeping the adsorbent dosage constant at 0.2 g and a contact time of 15 minutes, it can be concluded that the adsorption of 20 ppm is the most efficient for the maximum removal of dye particles. This observation aligns with the principle that at lower concentrations of the dye solution, there are numerous accessible adsorption sites available on the surface of the adsorbent. As a result, more dye molecules have

the opportunity to interact with and be adsorbed onto these accessible sites, leading to a higher adsorption rate. However, as the concentration of the dye solution increases, more dye molecules compete for the limited number of accessible sites on the adsorbent surface. Eventually, as the concentration continues to rise, these sites become saturated with dye molecules, meaning that additional increases in concentration do not result in proportionate increases in adsorption. Consequently, the adsorption rate may start to decline once these sites are fully occupied.

5.6.4 OPTIMIZATION OF DOSAGE

The collected samples are tested with UV spectrophotometer, and the removal percentage of the adsorbent can be found by calculating the absorbance value obtained

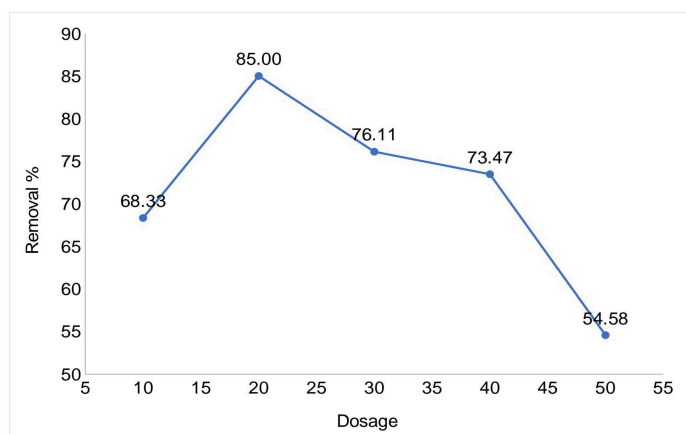


Fig 5.13 Effect of Optimization of Dosage

The data suggests that the optimum dosage for the maximum removal of dye particles is at 20 g/L of adsorbent dosage. One possible explanation for this finding is related to the availability of adsorption sites on the surface of the adsorbent material.

At low dosages of the adsorbent, there are plenty of available adsorption sites on the surface. As more adsorbate (dye particles) are introduced into the system,

these sites become progressively filled. This leads to an increase in the adsorption rate as more dye particles are captured by the available sites.

However, as the dosage of the adsorbent continues to increase, the available sites become gradually saturated. Once the maximum capacity of the adsorbent is reached, further increases in dosage lead to fewer additional adsorption sites being available for dye molecules. Consequently, the adsorption rate starts to decrease because there are fewer sites available for additional adsorption, despite the higher dosage of the adsorbent.

5.6.5 Optimization of LPH

The collected samples are tested with UV spectrophotometer, and the removal percentage of the adsorbent can be found by calculating the absorbance value obtained

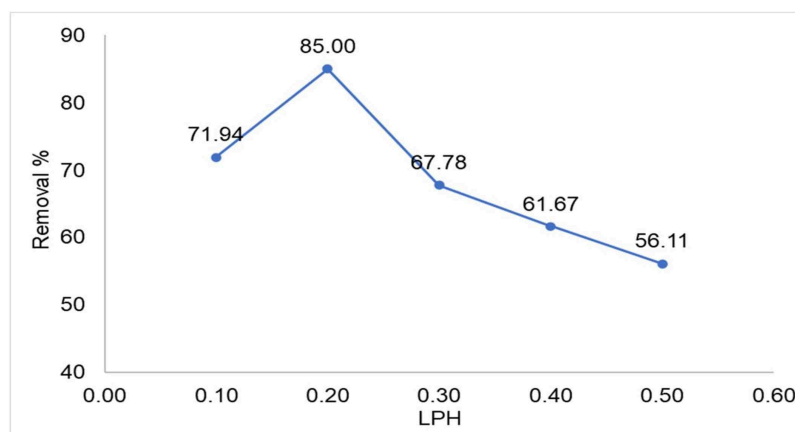


Fig 5.14 Effect of Optimization of LPH

Based on the study where the removal of crystal violet dye was investigated by varying the initial concentration (0.10, 0.20, 0.30, 0.40, 0.50, 0.60 LPH) while keeping the adsorbent dosage constant at 0.2 g and a contact time of 15 minutes, it can be concluded that the adsorption of 0.20 LPH is the most efficient for the maximum removal of dye particles. This conclusion aligns with the principle that at lower concentrations of the dye solution, there are numerous accessible adsorption sites available on the surface of the adsorbent. Consequently, more

dye molecules have the opportunity to interact with and be absorbed onto these accessible sites, leading to a higher adsorption rate. However, as the concentration of the dye solution increases, more dye molecules compete for the limited number of accessible sites on the adsorbent surface. Eventually, as the concentration continues to rise, these sites become saturated with dye molecules, meaning that additional increases in concentration do not result in proportionate increases in adsorption. Consequently, the adsorption rate may start to decline once these sites are fully occupied.

CHAPTER – 6

CONCLUSION AND SUMMARY

The present adsorption study has shown the feasibility of CV dye adsorption on the AASCO adsorbent. The batch adsorption experiment data was used in the study of adsorption kinetics and isotherm. In conclusion, the adsorption of Crystal Violet dye demonstrates a promising method for wastewater treatment or dye removal processes. The efficient adsorption capacity observed in this study suggests the potential application of the adsorbent material in real-world scenarios, contributing to environmental remediation efforts. Further research and optimization are recommended to enhance the efficacy and scalability of this adsorption process.

The adsorption-desorption reusability study indicated that the AASCO adsorbent could be reused for 3 cycles with higher CV dye removal efficiency. This study primarily suggests that the adsorption operation of CV dye molecules by AASCO adsorbent is a thermodynamically feasible process. A scale-up of the adsorption operation was theoretically investigated by designing a single-stage adsorber.

Adsorption of crystal violet dye involves the binding of the dye molecules to a solid surface, typically through physical or chemical interactions. This process is often used in water treatment to remove dye pollutants. The efficiency of adsorption depends on factors like surface area, material characteristics, and dye concentration. Studies focus on optimizing conditions for maximum adsorption capacity and understanding the mechanisms involved, which can include electrostatic interactions, Van der Waals forces, or chemical bonding. Overall, the goal is to develop effective and sustainable methods for removing crystal violet dye from aqueous solutions.

REFERENCES

- Adnan Özcan*, Elif Mine Öncü, A. Safa Özcan - Adsorption of Acid Blue 193 from aqueous solutions onto DEDMA-sepiolite - Journal of Hazardous Materials, Volume 8, (2006) Pg No. 37-62.
- Carla-Cezarina Pădurețu et Al - Influence of the parameters of chitin deacetylation process on the chitosan obtained from crab shell waste, Korean J. Chem. Eng., Volume 10, (2019) Pg No. 102-165.
- Dong-Wan Cho, Byong-Hun Jeon, Chul-Min Chon, Franklin W. Schwartz, Yoojin Jeong, Hocheol Song - Magnetic chitosan composite for adsorption of cationic and anionic dyes in aqueous solution, Journal of Industrial and Engineering Chemistry, Volume 6, (2015) Pg No. 875-987.
- Dotto G.L., Pinto L.A.A. - Adsorption of food dyes onto chitosan: Optimization process and kinetic, Carbohydrate Polymers, Volume 5, (2010) Pg No. 232-276,
- Dotto G.L., Pinto L.A.A.* - Adsorption of food dyes acid blue 9 and food yellow 3 onto chitosan: Stirring rate effect in kinetics and mechanism, Journal of Hazardous Materials, Volume 7, (2011) Pg No. 98-106.
- Fatemeh Hosseini, Somayeh Sadighian, Hassan Hosseini-Monfared & Niyaz Mohammad Mahmoodi - Dye removal and kinetics of adsorption by magnetic chitosan nanoparticles, Desalination and Water Treatment, Volume 12, (2016) Pg No. 234-267.
- Galan, J.; Trilleras, J.; Zapata, P.A.; Arana, V.A.; Grande-Tovar, C.D. - Optimization of Chitosan Glutaraldehyde-Crosslinked Beads for Reactive Blue 4 Anionic Dye Removal Using a Surface Response Methodology, Life, Volume 15, (2021) Pg No. 562-762.
- Harikishore Kumar Reddy D., Seung-Mok Lee - Application of magnetic chitosan composites for the removal of toxic metal and dyes from aqueous solutions Advances in Colloid and Interface Science, Vol 7, (2013) Pg No.8-16.

- Jank M. , Köser H. , Lücking F. , Martienssen M. & Wittchen S. - Decolorization and Degradation of Erioglaucine (Acid Blue 9) Dye in Wastewater, *Environmental Technology*, Volume 16, (1998) Pg No. 102-165.
- Jesús Sánchez-Martín, Jesús Beltrán-Heredia and M Teresa Rodríguez Sánchez - Removal of Erioglaucine (Acid Blue 9) with a new coagulant agent from *Acacia mearnsii* tannin extract - *Coloration Technology*, Society of Dyers and Colourists, Volume 7, (2011) Pg No. 98-106.
- Jyh-Ping Chena*, Pei-Chin Yanga, Yunn-Hwa Mab, Tony Wuc - Characterization of chitosan magnetic nanoparticles for in situ delivery of tissue plasminogen activator - *Carbohydrate Polymers*, Volume 2, (2010) Pg No. 98-106.
- Karla M. Gregorio-Jauregui - One-Step Method for Preparation of Magnetic Nanoparticles Coated with Chitosan, *Journal of Nanomaterials*, Volume 7, (2012) Pg No. 167-198.
- Leonardo Gomes Braga Ferreira¹, Robson Xavier Faria², Natiele Carla da Silva Ferreira³, and Rômulo José Soares-Bezerra³ - Brilliant Blue Dyes in Daily Food: How Could Purinergic System Be Affected? - *International Journal of Food Science*, Volume 7, (2016) Pg No. 98-106.
- Reyes F. G. R., Valim M. F. C. F. A. & Vercesi A. E. - Effect of organic synthetic food colours on mitochondrial respiration, *Food Additives & Contaminants*, Volume 2, (1996) Pg No. 98-106.
- Tariq J. Al-Musawi¹, Nezamaddin Mengelizadeh², Orabi Al Rawi¹, Davoud Balarak³ - Capacity and Modeling of Acid Blue 113 Dye Adsorption onto Chitosan Magnetized by Fe₂O₃ Nanoparticles - *Journal of Polymers and the Environment*, Volume 4, (2021) Pg No. 56-186. 2021

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ABSTRACT

This abstract investigates the synthesis of biomass from the stem and leaves of the *Chromolaena odorata* plant, which was activated by the adsorption of crystal violet (CV) dye using sulfuric acid. from aqueous solutions. The usage of inexpensive and sustainable adsorbents has drawn a lot of interest due to growing worries about the environmental harm that synthetic dyes cause. The utilization of agrowaste biomass in fluidized bed reactors for the removal of Crystal Violet dye from aqueous solutions is investigated in this project. A fluidized bed reactor with specific dimensions of 35 cm in length and 3.5 cm in diameter is employed for the adsorption process. The optimization parameters, including adsorption time (15 mins), adsorbent volume (60 ml), initial dye concentration (200 mg/l), adsorbent dosage (20 g/l), and liquid flow rate (0.20 LPH), are systematically studied to enhance the efficiency of dye removal. For the adsorption process, a fluidized bed reactor with precise measurements of 35 cm in length and 3.5 cm in diameter is used. To improve the effectiveness of dye removal, the optimization parameters—adsorption duration (15 mins), adsorbent volume (60 ml), beginning dye concentration (200 mg/l), adsorbent dosage (20 g/l), and liquid flow rate (0.20 LPH)—are methodically investigated. With these factors taken into account, the project seeks to create a thorough model for the fluidized bed system that would optimize the removal process and forecast performance. Using biomass from agricultural waste as an adsorbent provides an economical and environmentally friendly method of environmental cleanup. With potential applications in wastewater treatment procedures, the study's findings advance our understanding of fluidized bed adsorption systems for dye removal.

CHAPTER - 1 INTRODUCTION

1.1 BACKGROUND

Crystal Violet, a synthetic triarylmethane dye renowned for its remarkable versatility, owes its lineage to the groundbreaking invention of Mauveine in 1856, a milestone marking the advent of synthetic dye production. Since this pivotal moment, the textile industry has experienced a steady surge in the utilization and advancement of synthetic dyes, now satisfying a substantial portion—approximately 65 to 70%—of its dyeing requirements. Synthetic dyes offer an extensive palette of colors at a fraction of the cost compared to their natural counterparts, boasting enhanced stability and ease of application. Originating in the late 19th century, Crystal Violet's vibrant violet hue has solidified its status as a cornerstone in microbiology, leaving an indelible mark on scientific research and industrial applications alike. Its significance in microbiology is unparalleled, particularly in Gram staining techniques, where it serves as a vital tool for differentiating bacterial cell walls—a fundamental step in microbiological analysis. Beyond its pivotal role in microbiology, Crystal Violet proves invaluable in histology, aiding in the visualization of cellular structures under microscopic scrutiny with remarkable clarity and precision.

Crystal Violet's significance transcends its mere function as a laboratory reagent, profoundly impacting industrial sectors and scientific endeavors in multifaceted ways. Within textile dyeing processes, Crystal Violet emerges as more than just a coloring agent; it serves as a catalyst for creativity, imbuing fabrics with hues that are not only visually captivating but also durable and long-lasting. The vibrant shades it imparts to textiles enhance their aesthetic appeal, making them more desirable in the eyes of consumers and driving market competitiveness. Moreover, Crystal Violet's role extends beyond the realm of aesthetics; it embodies a fundamental aspect of chemical and material science, serving as a potent tool for

indicating and monitoring reactions. In chemical laboratories, its distinct color change provides invaluable insights into reaction progress and endpoint determination, facilitating precise control over experimental conditions and ensuring the reproducibility of results.

In addition to its application in textile dyeing and chemical analysis, Crystal Violet finds utility in diverse scientific disciplines. In microbiology, for instance, it serves as a vital staining agent for visualizing and differentiating microbial structures, aiding researchers in the identification and classification of microorganisms. Its ability to selectively bind to certain cellular components makes it indispensable in microbial research, contributing to our understanding of microbial ecology, pathogenesis, and antimicrobial susceptibility. Furthermore, Crystal Violet's versatility extends to the pharmaceutical industry, where it plays a crucial role in drug formulation and analysis. Its use as a colorimetric indicator facilitates the detection and quantification of pharmaceutical compounds, ensuring the quality and efficacy of medications.

The enduring legacy of Crystal Violet as a versatile and indispensable tool underscores its profound impact on scientific research, industrial processes, and technological advancements. Its vibrant hue and unique properties continue to shape various fields, fostering innovation and driving progress. From enhancing the visual appeal of textiles to enabling precise analysis in chemical reactions and microbial studies, Crystal Violet's multifaceted versatility makes it an invaluable resource in advancing knowledge and addressing real-world challenges. Its ubiquity across diverse disciplines reaffirms its status as a cornerstone of scientific inquiry and industrial innovation, embodying the intersection of art, science, and technology in contemporary society.

Yet, the multifaceted contributions of Crystal Violet transcend mere enumeration. Its versatility, reliability, and cost-effectiveness underscore its indispensability across numerous fields, propelling advancements in both academia and industry. From microbiology to industrial chemistry, Crystal Violet's enduring legacy continues to

shape scientific inquiry and industrial innovation, enriching our understanding of the natural world and enhancing the fabric of modern society.

Crystal Violet, a compound with multifaceted applications, exerts diverse effects across several domains. In the realm of microbiology, its significance is profound. Crystal Violet is a cornerstone in Gram staining techniques, a fundamental procedure used to differentiate between different types of bacteria based on their cell wall characteristics. Through this staining process, Gram-positive bacteria acquire a violet or blue hue, while Gram-negative bacteria are counterstained with a contrasting color. This differentiation is pivotal for microbial analysis, aiding in the identification and classification of bacteria, which in turn facilitates the diagnosis of infectious diseases.

Moving to the field of histology, Crystal Violet finds extensive use in staining tissues for microscopic examination. Histological examination relies heavily on the ability to visualize cellular structures with clarity and contrast. Crystal Violet enhances this visualization, allowing researchers and pathologists to discern cellular morphology, tissue architecture, and pathological changes with greater precision. The staining properties of Crystal Violet are particularly valuable in identifying specific cell types within tissues, contributing significantly to our understanding of biological systems and disease processes.

Beyond the realms of science and medicine, Crystal Violet also plays a significant role in industrial applications, particularly in textile dyeing. Its ability to impart vibrant and long-lasting colors to fabrics has made it a popular choice in the textile industry. Textiles dyed with Crystal Violet exhibit enhanced aesthetic appeal, making them more attractive and marketable to consumers. The widespread use of Crystal Violet in textile dyeing underscores its importance in industrial processes and consumer goods.

However, the biological effects of Crystal Violet merit careful consideration, especially in research and experimental settings. While it is commonly employed in assays to assess cellular viability, proliferation, and cytotoxicity, high concentrations of Crystal Violet can induce cytotoxic effects, leading to cell death or impairment of cellular functions. Therefore, researchers must meticulously control the concentration and exposure duration of Crystal Violet in biological assays to ensure accurate and reliable results while minimizing unintended harm to cells.

Moreover, the environmental impact of Crystal Violet cannot be overlooked. The discharge of Crystal Violet dye into natural water bodies poses a significant threat to aquatic ecosystems. High concentrations of Crystal Violet can disrupt the delicate balance of aquatic environments, affecting the growth, reproduction, and survival of aquatic organisms. Consequently, the regulation of Crystal Violet release into the environment is imperative to safeguard the integrity of aquatic ecosystems and preserve biodiversity.

The adsorption of crystal violet dye plays a crucial role across a spectrum of applications, ranging from wastewater treatment to analytical chemistry, where the binding of crystal violet molecules onto surfaces, predominantly solid materials like activated carbon or other adsorbents, is pivotal. This process serves as the linchpin in removing crystal violet from solutions, making it imperative to comprehend thoroughly to optimize removal techniques and boost efficiency.

Understanding the intricacies of crystal violet adsorption entails delving into a myriad of factors, each exerting a significant influence on the process. Among these factors, pH stands out as a key determinant, as variations in pH levels can profoundly affect the surface charge of both the dye molecules and the adsorbent material, consequently altering their interaction and adsorption capacity. Similarly, temperature plays a critical role, influencing the kinetic energy of the system and thus impacting the rate and extent of adsorption.

Moreover, the properties of the adsorbent material itself, such as surface area, pore size distribution, and surface chemistry, significantly influence crystal violet adsorption. For instance, materials with higher surface areas and tailored surface chemistries often exhibit enhanced adsorption capacities due to increased active sites available for interaction with dye molecules. Beyond these factors, the presence of other ions or organic matter in the solution can also influence crystal violet adsorption by competing for adsorption sites or forming complexes with the dye molecules, thereby altering their availability for adsorption.

By unraveling the complex interplay of these factors, researchers can gain valuable insights into the mechanisms governing crystal violet adsorption, paving the way for the development of more efficient and sustainable removal techniques. This exploration not only enhances our understanding of dye removal processes but also holds promise for addressing pressing environmental challenges associated with dye pollution. Thus, this introduction serves as a springboard for a deeper dive into the nuanced dynamics of crystal violet adsorption, highlighting its significance and potential implications across various scientific and environmental domains.

Another remarkable aspect of *C. odorata*'s biology is its rapid regenerative ability. Capable of sprouting from its roots and exhibiting vigorous growth rates of up to 3 centimeters per day under optimal environmental conditions, this plant demonstrates resilience and adaptability in diverse habitats. Moreover, the leaves of *C. odorata* are valued for their medicinal properties, particularly for their antimicrobial qualities, making them traditionally sought-after for healing wounds and other ailments. By harnessing the biomass derived from *C. odorata* for the adsorption process, this study not only addresses environmental concerns associated with invasive species but also capitalizes on the unique properties of this plant for sustainable applications in wastewater treatment and other environmental remediation efforts.

In the present study, we embarked on a novel endeavor by utilizing the stem of *Chromolaena odorata*, an invasive plant notorious for its disruptive effects on local vegetation, for the adsorption of CV dye. To the best of our knowledge, this represents the inaugural application of *C. odorata* biomass in such adsorption operations, marking a significant breakthrough in the field. Our approach commenced with a systematic exploration, initially employing a one-variable-at-a-time methodology to conduct adsorption studies. Subsequently, we adopted a more sophisticated statistical approach, namely response surface methodology (RSM), to systematically investigate the optimal conditions of various variables aimed at maximizing dye removal percentage.

Furthermore, our investigation extended to assessing the reusability of the adsorbent, a critical aspect for evaluating its long-term efficacy and sustainability in practical applications. Through a series of experiments, we aimed to ascertain the feasibility of utilizing the *C. odorata* stem biomass as a reusable adsorbent for prolonged and efficient dye removal from aqueous solutions.

In addition to these fundamental studies, we designed and implemented a single-stage batch adsorber, envisioning its potential for large-scale dye removal operations. This innovative design not only demonstrates the scalability of our approach but also lays the groundwork for the practical implementation of our findings in real-world settings.

By repurposing biomass from an invasive plant species like *C. odorata* for dye adsorption, our research not only addresses environmental concerns associated with invasive flora but also presents a sustainable solution for wastewater treatment. Through this interdisciplinary endeavor, we contribute to both environmental conservation efforts and the advancement of efficient water treatment technologies, paving the way for a more sustainable future.

CHAPTER – 3

AIM AND SCOPE

3.1 AIM

The aim is to utilize Siam weed leaves and stems to develop an adsorbent, followed by thorough characterization to assess its potential applications. Subsequently, a fluidized bed adsorber will be designed and modeled for efficient operation. The focus will be on its use in wastewater treatment processes, with optimization studies conducted to enhance performance and efficiency. Through this approach, the goal is to create an effective and sustainable solution for wastewater treatment, contributing to environmental preservation.

3.2 SCOPE

- Siam weed is a waste biomass.
- The adsorption of crystal violet dye is widely studied in fields like environmental science and material science.
- Its scope includes wastewater treatment, where adsorption onto various materials like activated carbon or nanomaterials helps remove the dye from water.
- Additionally, research explores adsorption for sensing applications and drug delivery systems, showcasing the versatile scope of crystal violet adsorption in different scientific domains.

CHAPTER 4

MATERIALS AND METHODS

4.1 MATERIALS

The following materials were used for the synthesis Chromolaena :

- Chromolaena(siam weed)
- Hot air oven
- Crystal violet dye
- sulfuric acid (H_2SO_4)
- Magnetic pellet.
- Water
- Sodium Bicarbonate (NaHCO_3)
- 1-liter beakers
- Filter papers
- Stirrer

- Air Pump
- Rotameter
- Fluidized glass column

4.2 PREPARATION OF STOCK SOLUTION

To prepare a 1000 mL solution of 1000 ppm crystal violet dye, the procedure had begun by accurately weighing 1 gram of crystal violet dye using a digital balance. The dye had been dissolved in a small volume of appropriate solvent in a clean 1000 mL volumetric flask, ensuring complete dissolution. Then, the flask had been filled to the mark with the solvent, and careful mixing had been done to achieve uniformity. The concentration had been verified and adjusted if necessary. Finally, the flask had been labeled with the solution details and stored appropriately. This procedure had ensured the creation of a precise solution suitable for various applications.

4.3 PREPARATION OF ADSORBENT

The preparation process of *Chromolaena odorata* involves a series of meticulously orchestrated steps aimed at optimizing its properties for various applications. Initially, the harvested stems and leaves are carefully spread out in a thin layer and exposed to sunlight. This crucial drying phase serves to reduce the moisture content of the plant material, a pivotal factor that can significantly impact subsequent processing steps and the overall quality of the final product. Excessive moisture content not only poses challenges during grinding and sieving but also increases the risk of microbial growth and degradation, ultimately compromising the efficacy of the material in its intended applications.

Following thorough drying, the plant material undergoes grinding into a fine powder using specialized equipment such as a grinder or mill. This mechanical breakdown

enhances the material's surface area and facilitates uniformity in particle size distribution. Subsequently, the powdered material is meticulously sieved to achieve the desired particle size range, typically between 75 to 100 μm . This precise control over particle size ensures consistency in the material's characteristics and performance, especially in applications where surface area plays a critical role, such as adsorption processes.

The next stage involves the activation of the powdered *Chromolaena odorata* material through acid treatment. A portion of the powder is mixed with a specific volume of 0.1 N H_2SO_4 (sulfuric acid) solution and stirred for a predetermined duration, typically 18 hours. During this period, the acid interacts with the plant material, facilitating the breakdown of organic components and creating surface functional groups. These modifications enhance the material's adsorption properties by increasing surface reactivity and pore volume. Acid activation is a widely utilized technique in materials science to modify the surface chemistry of adsorbents, thereby enhancing their capability to adsorb target substances from solution.

After acid activation, the material undergoes neutralization to eliminate any residual acid present. This neutralization step involves soaking or rinsing the material in a solution of 0.1 N NaHCO_3 (sodium bicarbonate), a mild base. The sodium bicarbonate effectively neutralizes the remaining acid, mitigating the risk of interference with subsequent processes or applications. Additionally, neutralization helps stabilize the pH of the material, making it more suitable for specific adsorption applications and ensuring its safety for handling.

Finally, the prepared *Chromolaena odorata* material undergoes a final drying phase to remove any excess moisture and prepare it for storage or further processing. This drying process is typically conducted in an oven set to a specific temperature (353 K or approximately 80°C) for a defined duration (6 hours). Proper drying is essential to maintain the stability of the material, prevent microbial growth, and ensure consistent performance in subsequent applications.

In essence, each step in the preparation process of *Chromolaena odorata* plays a crucial role in enhancing its properties and suitability for diverse applications, ranging from environmental remediation to industrial processes. Through meticulous attention to detail and precise execution, the prepared material exhibits optimized characteristics, making it a valuable resource in various fields.

4.4 Methodology for Preparation of Adsorbent

➤ Drying



FIG: 4.1 Drying of Siam weed

- Harvested stems and leaves are spread thinly and exposed to sunlight.
- Reduce moisture content to prevent microbial growth and facilitate subsequent processing.

➤ **Grinding**



FIG: 4.2 Grinding of Siam weed

- Dried material is ground into a fine powder.
- Increase surface area and ensure uniformity.

➤ **Sieving**



FIG:4.3 sieving of siam weed

- Powdered material is sieved to achieve desired particle size range (typically 75 to 100 μm).
- Ensures consistency in particle size distribution.

➤ **Acid Activation**



FIG:4.4 Acid activation for siam weed

- Portion of powder mixed with 0.1 N sulfuric acid solution.
 - Stirred for 18 hours to enhance adsorption properties by creating surface functional groups.
- **Neutralization**



FIG: 4.5 neutralization of acid activation weed

- Acid-treated material neutralized using 0.1 N sodium bicarbonate solution.
- Stabilize pH, mitigate acid interference, and ensure safety for handling.

➤ **Final Drying**



FIG: 4.6 Final Drying of siam weed after acid activations

To ensure stability and consistency, excess moisture is eliminated by drying the material for six hours at 80°C in an oven.

4.5 Method for Modelling of fluidized bed:

This setup involves several components interconnected to facilitate a specific process or measurement:

- **Electric Air Pump:** This device generates compressed air to initiate the flow within the system. It serves as the primary source of air pressure.
- **Inlet Pipe:** A conduit that connects the electric air pump to the inlet port of the rotameter. This pipe directs the compressed air from the pump into the rotameter.
- **Outlet Pipe:** Another pipe attached to the outlet port of the rotameter. This pipe carries the air out of the rotameter and serves as a continuation of the airflow-pathway.
- **Glass Column:** This is where the air eventually reaches after passing through the rotameter and outlet pipe. The glass column could serve various purposes depending on the specific application, such as mixing, separation, or observation of the air flow.

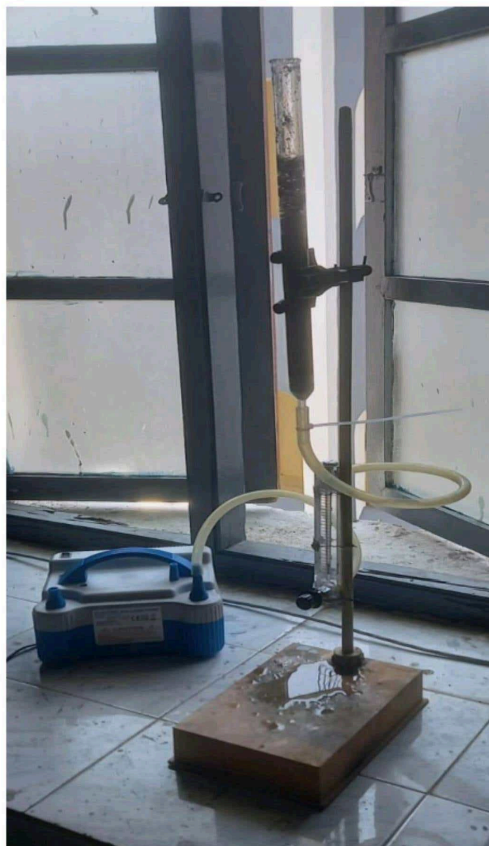


FIG: 4.7 Modelled Fluidized Bed

4.6 Characterization of Adsorbents:

Utilizing Fourier Transform Infrared (FTIR) Spectroscopy, the surface functional groups of *Chromolaena odorata* were examined. By capturing wavelengths between 4500 and 500 cm^{-1} in transmission mode, the spectrum was obtained. To investigate structural differences in the produced adsorbents, X-Ray Diffraction (XRD) was used. The morphological structure of the adsorbents was investigated

5 using energy dispersive X-ray spectroscopy (EDX) and field-emission scanning electron microscopy (FESEM).

4.7 Adsorption Experiment

The experimental investigation delved deeply into exploring the adsorption potential of *Chromolaena odorata*'s acid-activated stem (AASCO) towards Crystal Violet (CV) dye, employing a meticulously designed modelled fluidized bed setup as the experimental platform. Within this setup, meticulous attention was paid to maintaining experimental integrity and accuracy. The setup's total volume of 1000 mL provided ample space for conducting the experiments, ensuring sufficient interaction between the AASCO adsorbent and the CV dye solution. Moreover, the inclusion of 50 mL of the prepared dye solution within this setup facilitated precise control over the experimental conditions, allowing for accurate measurement and analysis.

To establish the desired concentrations for experimentation, the CV dye solution was meticulously derived from a stock solution of 1000 ppm. This process involved careful dilution to achieve the specific concentrations required for testing. Such meticulous preparation ensured that the experimental conditions accurately reflected real-world scenarios, enhancing the reliability and applicability of the study's findings.

11 In initiating the adsorption process, great care was taken to introduce a precise quantity of the AASCO adsorbent into the CV dye solution. This step was critical in ensuring consistent and reproducible results across experiments. The subsequent exposure of this mixture to a fluidized bed environment, with a controlled flow rate of 0.2 LPH maintained for a duration of 15 minutes, provided optimal conditions for adsorption to occur. This carefully controlled environment promoted efficient

interaction between the adsorbent and the dye molecules, facilitating the adsorption process.

Throughout the experimentation, a systematic approach was adopted to investigate key variables such as the dosage of AASCO adsorbent, initial CV dye concentrations, and the duration of exposure. By systematically varying these parameters, the study aimed to elucidate their influence on the adsorption process comprehensively. This meticulous exploration allowed for a nuanced understanding of the factors affecting adsorption efficiency, enabling the identification of optimal conditions for maximum adsorption capacity.

Upon completion of the adsorption operation, stringent filtration procedures were employed using Whatman number 1 filter paper to separate the adsorbent-dye complex from the solution. This step was crucial in isolating the adsorbed dye molecules for subsequent analysis. The subsequent analysis of the filtrate using a UV-vis spectrophotometer, with a focus on determining the residual CV dye concentration at its maximum absorption wavelength ($\lambda_{\text{max}}=590 \text{ nm}$), provided quantitative insights into the extent of adsorption achieved.

To ensure the reliability and robustness of the results, all experiments were conducted in triplicate. This approach not only minimized the impact of experimental variability but also allowed for the calculation of average values, which were utilized for further analysis and interpretation. Such meticulous attention to experimental rigor and precision enhanced the credibility of the study's findings, enabling a comprehensive understanding of the adsorption behavior and efficiency of AASCO in removing CV dye from aqueous solutions under varying experimental conditions.

In conclusion, the experimental investigation represented a meticulous and thorough exploration of the adsorption potential of AASCO towards CV dye, conducted with a high degree of precision and attention to detail. By employing a systematic approach and stringent experimental protocols, valuable insights were

gained into the factors influencing adsorption efficiency, paving the way for further advancements in the field of adsorption science and environmental remediation strategies.

CHAPTER – 5

RESULTS AND CHARACTERISATION

5.1 FTIR(Fourier Transform Infrared)

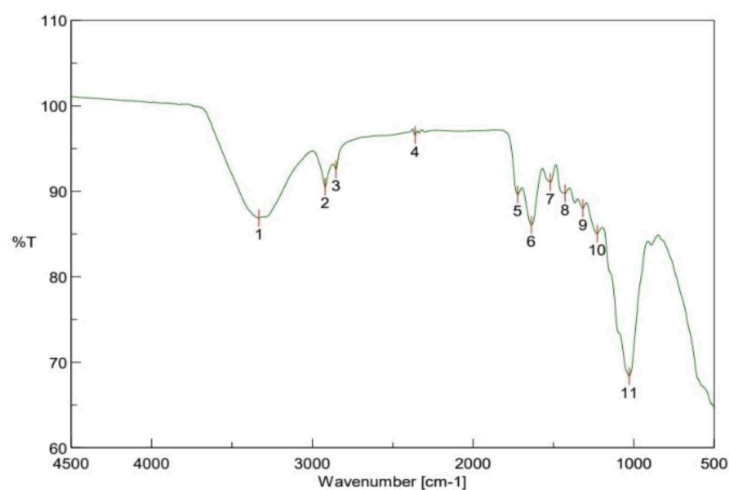


Fig:5.1 FTIR Spectroscopy results for synthesis of Chromolaena

FTIR examination of the biomass of *C. odorata* yielded the following important elements in the spectrum:

1. Broadband at $3500\text{--}3000\text{ cm}^{-1}$: This suggests the presence of hydroxyl groups in the biomass by showing -OH bond stretching.

2. A small peak at 1750 cm^{-1} is thought to be caused by the stretching of the -CH_2 and -COOH bonds, which indicates the existence of alkane and carboxylic acid groups.

3. A distinct peak at about 1150 cm^{-1} indicates the possibility of -COOH functional groups, which are connected to amides, carboxylic acids, ketones, and aldehydes.

The hydrophilic character of *C. odorata* biomass is indicated by the presence of carbonyl and hydroxyl functional groups, which enable it to bind.

These results validate the effective activation of sulfuric acid on *C. odorata* biomass, increasing its capacity to adsorb contaminants from water.

5.2 XRD (X-Ray diffraction).

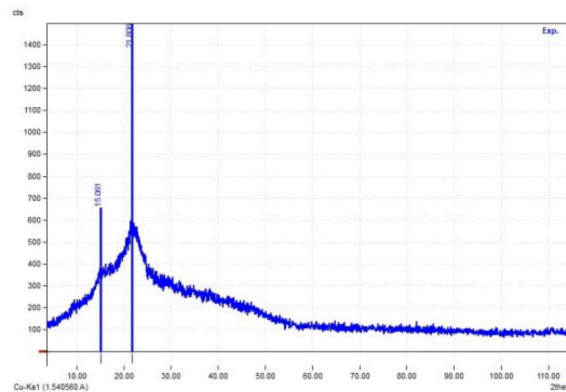


Fig:5.2 X-Ray diffraction spectroscopy

Figure 4.1.2 displays the XRD spectrum, which reveals a prominent peak at 2 (degree of 21.956) that is well-defined and indicates the presence of crystalline structures in the biomass of *C. odorata*.

Additionally, following the adsorption process or after the biomass is reacted with acid (Fig. 3e), the intensity of the well-defined peak does not decrease.

As a result, Fig. 4.1.2 suggests that the upper portion of the crystalline surface is most likely where CV dye will adsorb on *C. odorata*.

5.3 FESEM Images of Sample before adsorption

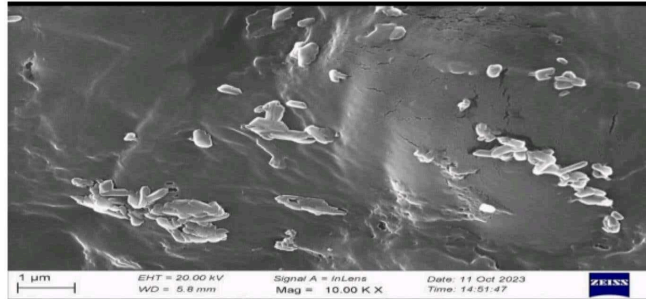


Fig:5.3 SEM Image under 10.00 KX magnification

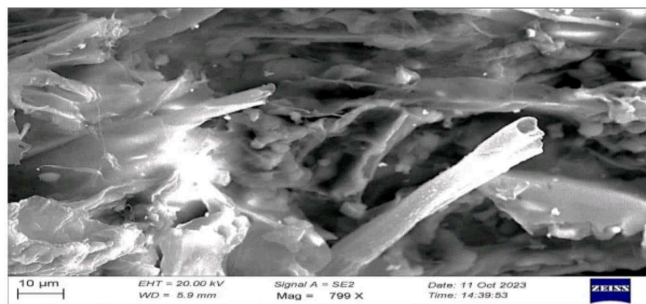


Fig:5.4 SEM Image under 799X magnification

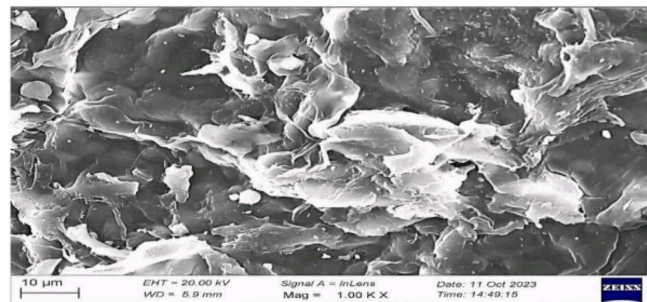


Fig:5.5 SEM Image under 1.0 KX magnification

To examine the physical shape of the biomass's surface, SEM analysis was used. The biomass of *C. odorata*, biomass of *C. odorata* activated with acid, and the CV dye absorbed by *C. odorata* were all captured in SEM pictures. It is clear from the SEM image that the acid activation of the *C. odorata* biomass increased the number of holes on the biomass surface. The activation method was successful in increasing the adsorption capacity of *C. odorata* biomass, as evidenced by the observation that the dye molecules were bound to the activated surface of the biomass following the adsorption investigation.

5.4 Electron Dispersive X-Ray (EDX)

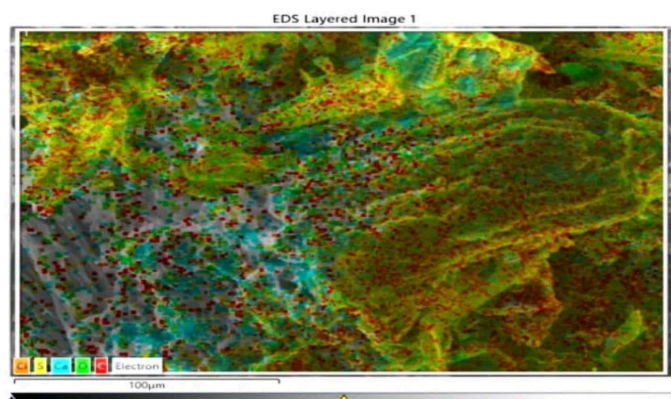


Fig: 5.6 EDS layered image of siam weed before adsorption

Fig: 5.7 EDS layered image of o,s,na,c,ca,cl before adsorption

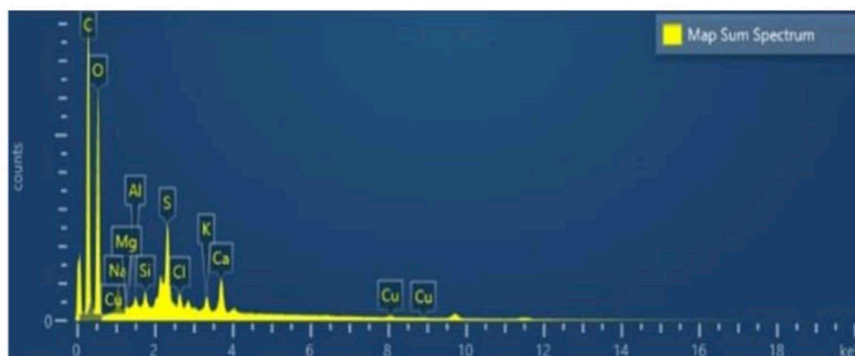
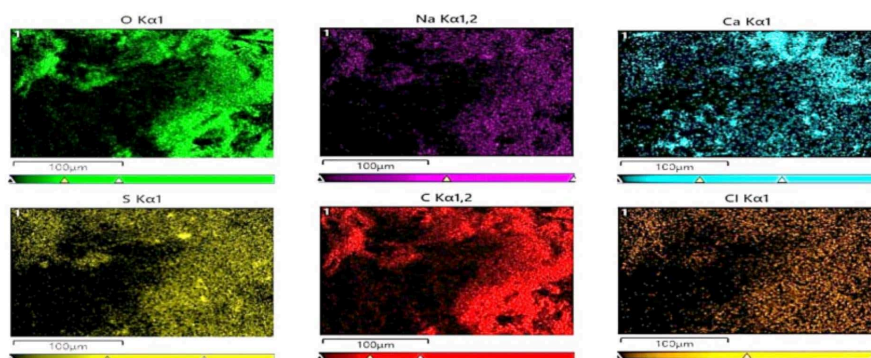
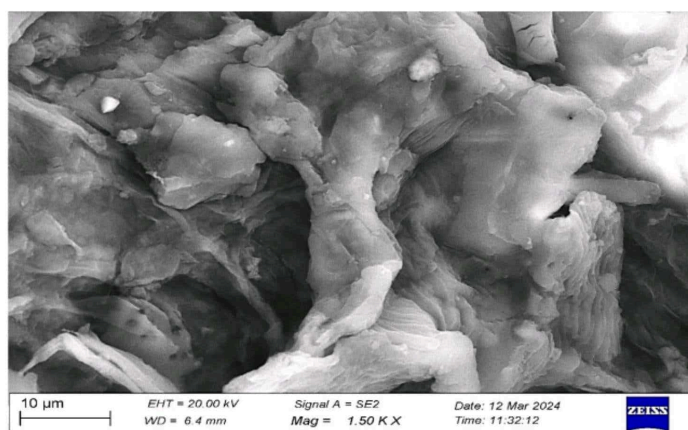


Fig: 5.8 EDX spectra of Siam weed

The EDAX mapping shows the composition of the adsorbent sample. The carbon and oxygen peaks obtained are due to the large amounts of C-H, C-O and O-H bonds present in Siam weed. The presence of sodium and sulfur is due to the addition of sodium bicarbonate and sulfuric acid during the activation process.



5.5 FESEM image after adsorption



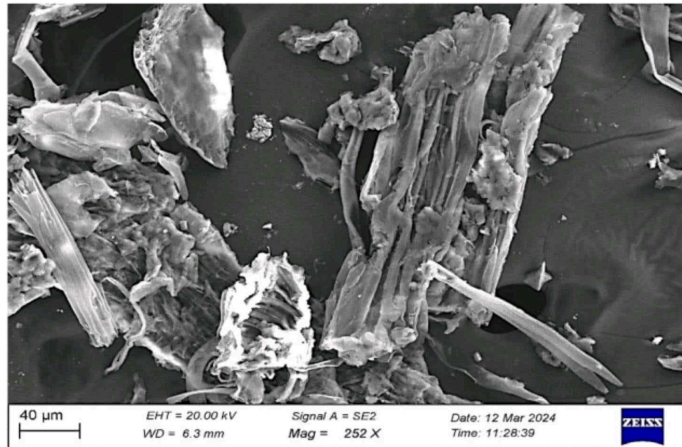


Fig 5.9 FESEM images of siam weed after adsorption

After adsorption: These images show a similar structure to that of siam weed before adsorption, but the pore size has reduced since it is already occupied by dye molecules.

5.6 FACTOR IMPACTING ADSORPTION

5.6.1 Optimization of time

The collected samples are tested with UV spectrophotometer, and the removal percentage of the adsorbent can be found by calculating the absorbance value obtained

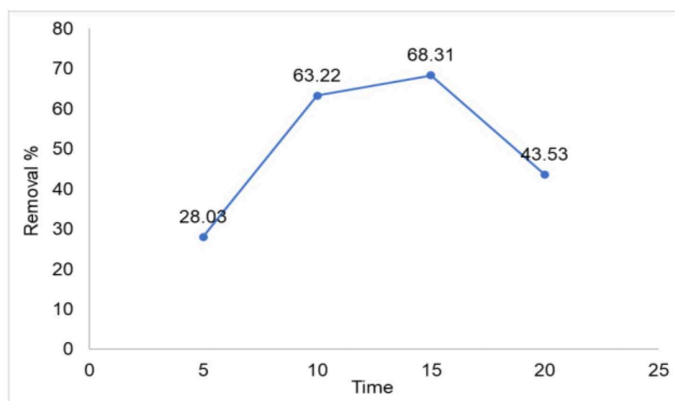


Fig 5.10 Effect of optimisation of time vs removal%

Based on the available data, it can be inferred that a maximum of fifteen minutes is the ideal contact time to remove dye particles. This discovery could be explained by the fact that, after 15 minutes, the majority of the adsorbent's active sites are probably filled by dye molecules, which causes the adsorption capacity to be saturated. Additionally, a simultaneous mechanism that releases dye molecules back into the solution from the adsorbent surface. It's possible that the equilibrium between the adsorption and desorption processes will cause the removal efficiency to plateau after around 15 minutes. As a result, the observed best contact time of 15 minutes probably reflects a balance between the kinetics of adsorption and desorption, where the adsorbent's adsorption capacity is maximized before the dominance of desorption processes begins.

5.6.2 Optimization of volume

The collected samples are tested with UV spectrophotometer, and the removal percentage of the adsorbent can be found by calculating the absorbance value obtained

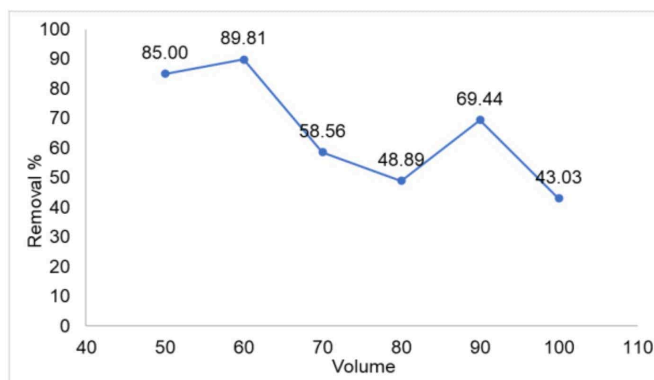


Fig 5.11 Effect of optimisation of volume vs removal%

It can be concluded that the adsorption of 60 ml is the most efficient for the maximum removal of dye particles based on the study where the removal of crystal violet dye was investigated by varying the initial concentration (60, 70, 80, 90, and 100 ml) while keeping the adsorbent dosage constant at 0.2 g and a contact time of 15 minutes. This result is consistent with the idea that there are lots of accessible adsorption sites on the surface of the adsorbent at lower dye solution concentrations. As a result, more dye molecules are able to interact and soak onto. However, more dye molecules vie for the few available sites on the adsorbent surface as the dye solution concentration rises. These sites eventually fill up with dye molecules as the concentration rises, which means that further concentration increases do not cause a corresponding increase in adsorption. Consequently, once these sites are fully occupied, the adsorption rate may begin to decrease. As a result, the concentration that yielded the highest effectiveness at 60 ml indicates that there are sufficient readily available adsorption sites to allow for effective dye removal.

5.6.3 Optimization of concentration

A UV spectrophotometer is used to evaluate the collected samples, and the absorbance value obtained can be used to calculate the removal percentage of the adsorbent.

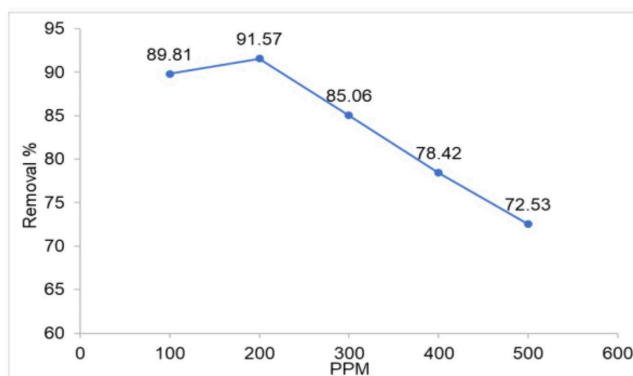


Fig 5.12 Effect of optimization of ppm vs removal%

Based on the study where the removal of crystal violet dye was investigated by varying the initial concentration (100, 200, 300, 400, 500 ppm) while keeping the adsorbent dosage constant at 0.2 g and a contact time of 15 minutes, it can be concluded that the adsorption of 20 ppm is the most efficient for the maximum removal of dye particles as the concentration of the dye solution increases, more dye molecules compete for the limited number of accessible sites on the adsorbent surface. Eventually, as the concentration continues to rise, these sites become saturated with dye molecules, meaning that additional increases in concentration do not result in proportionate increases in adsorption. Consequently, the adsorption rate may start to decline once these sites are fully occupied.

5.6.4 OPTIMIZATION OF DOSAGE

The collected samples are tested with UV spectrophotometer, and the removal percentage of the adsorbent can be found by calculating the absorbance value obtained

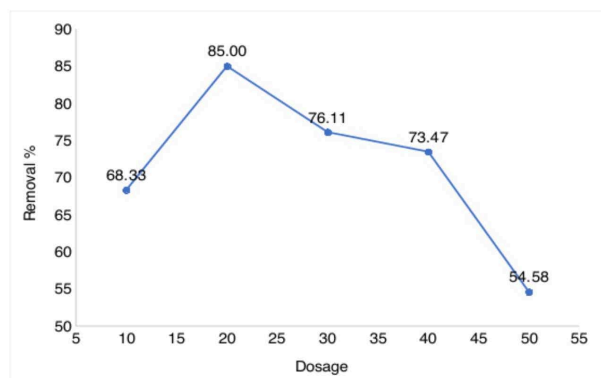


Fig 5.13 Effect of optimization of dosage vs removal%

The data suggests that f dye particles is at 20 g/L of adsorbent dosage. One possible explanation for this finding is related.

At low dosages of the adsorbent, there are plenty of available adsorption sites on the surface. As more adsorbate (dye particles) are introduced into the system, these sites become progressively filled. This leads to an increase in the adsorption rate as more dye particles are captured by the available sites.

However, as the dosage of the adsorbent continues to increase, the available sites become gradually saturated. Once the maximum capacity of the adsorbent is reached, additional adsorption sites being available for dye molecules. Consequently, the adsorption rate starts to decrease because there are fewer sites available for additional adsorption, despite the higher dosage of the adsorbent.

5.6.5 Optimization of LPH

The collected samples are tested with UV spectrophotometer, and the removal percentage of the adsorbent can be found by calculating the absorbance value obtained

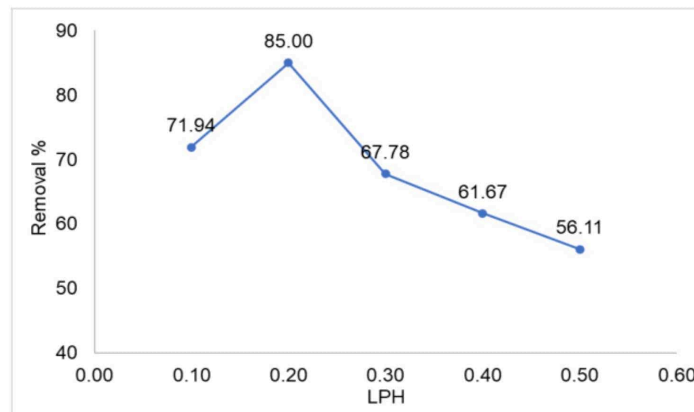


Fig 5.14 Effect of optimization of LPH vs removal%

It can be concluded that the adsorption of 0.20 LPH is the most effective for the maximum removal of dye particles based on the study where the removal of crystal violet dye was investigated by varying the initial concentration (0.10, 0.20, 0.30, 0.40, 0.50, and 0.60 LPH) while keeping the adsorbent dosage constant at 0.2 g and a contact time of 15 minutes. This result is consistent with the idea that there are lots of accessible adsorption sites on the surface of the adsorbent at lower dye solution concentrations. A higher adsorption rate results from giving more dye molecules the chance to interact with and absorb onto these accessible locations.

CHAPTER – 6

CONCLUSION AND SUMMARY

The viability of CV dye adsorption on the AASCO adsorbent has been demonstrated by the current adsorption investigation. The adsorption kinetics and isotherm were examined using the data from the batch adsorption experiment. To sum up, the adsorption of Crystal Violet dye presents a viable technique for operations involving the removal of dyes or the treatment of wastewater. The effective adsorption capability found in this study points to the adsorbent material's possible use in practical settings, supporting environmental rehabilitation initiatives. To improve this adsorption process's scalability and efficacy, more investigation and optimization are advised.

According to the adsorption-desorption reusability investigation, the AASCO adsorbent had a better CV dye removal efficiency and could be reused for three cycles. The main conclusion of this work is that it is thermodynamically possible for AASCO adsorbent to adsorb molecules of CV dye. By creating a single-stage adsorber, a theoretical scale-up of the adsorption process was examined. The process of adhering crystal violet dye molecules to a solid surface—usually by physical or chemical interactions—is known as adsorption. The removal of color contaminants from water is a common use for this procedure. Adsorption efficiency is influenced by surface area, material properties, and dye concentration, among other things. Research focuses on maximizing adsorption capacity by conditional optimization and comprehending the underlying mechanisms, which may entail chemical bonding, Van der Waals forces, or electrostatic interactions. Ultimately, the objective is to create sustainable and efficient processes for extracting crystal violet dye from aqueous solutions.

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