

REMOVAL OF ACID BLUE 9 DYE USING MNP IMPREGNATED WITH POMEGRANATE PEEL CHARACTERIZATION AND APPLICATION STUDIES

Submitted in partial fulfilment 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

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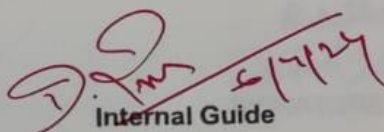
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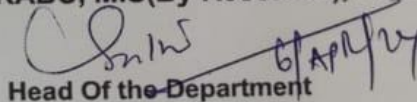
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BONAFIDE CERTIFICATE

This is to certify that this project report is a bonafide work of **SATHISH B (40190024)** and **SYED MOHAMMED SUHAIL (40190027)** who carried out the project entitled "**REMOVAL OF ACID BLUE 9 DYE USING MNP IMPREGNATED WITH POMEGRANATE PEEL CHARACTERIZATION AND APPLICATION STUDIES**" under my supervision from **NOVEMBER 2023 to APRIL 2024**.


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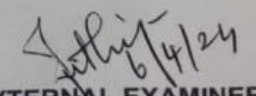

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EXTERNAL EXAMINER

DECLARATION

We, **SATHISH B (40190024)** and **SYED MOHAMMED SUHAIL (40190027)** hereby declare that the Project Report is the bonafide work of entitled "**REMOVAL OF ACID BLUE 9 DYE USING MNP IMPREGNATED WITH POMEGRANATE PEEL CHARACTERIZATION AND APPLICATION STUDIES**" done by us under the guidance of **Dr D. Prabu, M.S (By Research), Ph.D.**, is submitted in partial fulfilment of the requirements for the award of Bachelor of Technology degree in **CHEMICAL ENGINEERING**.

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ABSTRACT

In recent years, the environmental impact of synthetic dyes has garnered significant attention due to their persistence in water bodies and potential harm to ecosystems and human health. This study explores the potential of utilizing pomegranate peel-derived magnetic nanoparticles (MNPs) impregnated with pomegranate peel (PP) for the removal of acid blue dye from aqueous solutions. The characterization of the synthesized PP-MNPs was conducted using various techniques including scanning electron microscopy (SEM), X-ray diffraction (XRD), and Fourier-transform infrared spectroscopy (FTIR). The results indicated the successful formation of spherical MNPs with a crystalline structure, and the presence of functional groups from the pomegranate peel extract on the nanoparticle surface. Batch adsorption experiments were performed to evaluate the adsorption efficiency of PP-MNPs towards acid blue dye under different experimental conditions such as initial dye concentration, pH, contact time, and temperature. The results revealed that PP-MNPs exhibited high adsorption capacity and rapid kinetics for the removal of acid blue dye, with equilibrium reached within a short period. The acid blue 9 (dye) removal percentage was 88.42% at optimum conditions studied were pH 4, 30 minutes contact time, 5 mg/L, 125 μm size and 0.2 g/L dosage which was considered high for untreated material. The adsorption process was found to follow pseudo-second-order kinetics and Langmuir isotherm model, suggesting monolayer adsorption onto a homogeneous surface. Overall, the findings of this study demonstrate the promising potential of pomegranate peel-derived MNPs impregnated with pomegranate peel as an effective and eco-friendly adsorbent for the removal of acid blue dye from aqueous solutions. This approach not only offers a sustainable solution for dye wastewater treatment but also adds value to agricultural waste by repurposing pomegranate peel into a valuable resource for environmental remediation.

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LIST OF ABBREVIATIONS USED

- PP-NM – Pomegranate Peel Nano Material
- PP-AC – Pomegranate Peel Activated Carbon
- AB9 – Acid Blue 9
- MNP – Magnetic Nano Particles
- FTIR – Fourier Transform Infrared Spectroscopy
- SEM – Scanning Electron Microscopy
- EDX – Energy Dispersive X-ray
- XRD – X-ray Diffraction
- VSM – Vibrating Sample Magnetometer
- BET – Brunauer-Emmett-Teller

CHAPTER 1

1 INTRODUCTION

In recent years, the pollution caused by synthetic dyes discharged from various industries has become a significant environmental concern. Acid dyes, commonly used in textile, leather, and paper industries, are particularly problematic due to their persistence in water bodies and harmful effects on aquatic life. Efforts to mitigate this pollution have led to the exploration of natural and cost-effective methods for dye removal.

One promising approach involves the utilization of biomaterials such as pomegranate peel, which contains bioactive compounds capable of adsorbing dye molecules from aqueous solutions. Pomegranate (*Punica granatum* L.) is widely recognized for its antioxidant properties and rich content of polyphenols, making it an attractive candidate for environmental remediation applications.

Furthermore, the modification of pomegranate peel with magnetic nanoparticles (MNP) enhances its adsorption capacity and facilitates the separation of the adsorbent from the treated solution through magnetic field manipulation. This synergistic combination of natural adsorbent and magnetic nanoparticles offers an efficient and eco-friendly solution for the removal of acid dyes from wastewater.

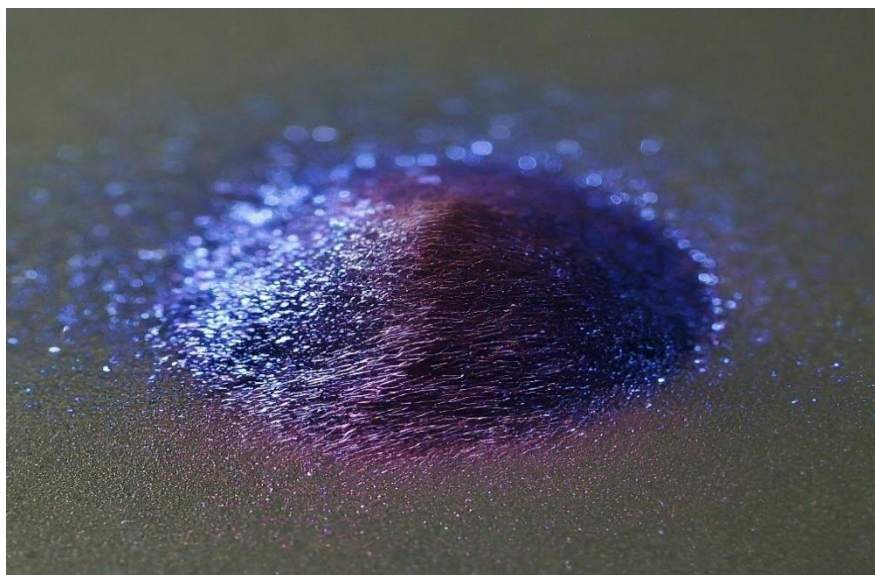


Figure 1.1: Acid Blue 9 dye

This study aims to investigate the adsorption efficiency of pomegranate MNP impregnated with pomegranate peel for the removal of acid blue dye from aqueous solutions. By examining the adsorption kinetics, isotherms, and influencing factors such as pH and initial dye concentration, valuable insights can be gained into the effectiveness of this novel adsorbent for dye removal.

The findings of this research could contribute to the development of sustainable and cost-effective strategies for wastewater treatment, addressing both environmental concerns and the growing demand for cleaner water resources. Furthermore, the utilization of agricultural by-products like pomegranate peel highlights the potential for transforming waste into valuable resources, promoting a circular economy and sustainable development.

1.1. Environmental Impact of Synthetic Dyes

The widespread use of synthetic dyes in various industries, including textiles, leather, and paper, has resulted in their significant presence in the environment. These dyes are often discharged into waterways through industrial effluents. Their presence poses several environmental concerns:

- **Aesthetic Deterioration:** Dyes significantly alter the aesthetic qualities of water bodies, turning them an unpleasant colour that discourages recreational activities.
- **Reduced Light Penetration:** Light penetration is crucial for photosynthesis by aquatic plants and algae, forming the base of the aquatic food chain. Dyes significantly hinder this process, disrupting the entire ecosystem.
- **Aquatic Toxicity:** Certain dyes, including Acid Blue 9 (AB9), exhibit some level of toxicity to aquatic life, especially at high concentrations. Studies have shown disrupted feeding behaviour, reduced growth, and even mortality in exposed organisms.
- **Persistence and Bioaccumulation:** The complex structure of dyes like AB9 makes them resistant to natural biodegradation, leading to their accumulation in the environment over time. This persistence allows for potential magnification of their effects within the food chain.

- **Inefficient Wastewater Treatment:** Conventional wastewater treatment methods often struggle to remove dyes from industrial effluents. This leads to their release into waterways, further exacerbating environmental contamination.
- **Acid Blue 9 dye** serves as a valuable colorant in various industries, particularly the textile sector. Its vibrant blue color and good dyeing properties make it a popular choice. However, considerations regarding material compatibility, desired color shade, and safety regulations are crucial when determining its suitability for specific applications.

1.1.1. APPLICATION OF ACID BLUE 9 DYE:

Acid Blue 9 dye is a versatile colorant with a variety of applications across different industries. This report explores the key uses of this synthetic dye.

- **Textile Industry:**
 - **Primary Application:** Acid Blue 9 finds its most prominent use in dyeing textiles made from protein fibers like wool and silk. It can also be used for dyeing nylon and fabrics containing nylon blends.
 - **Dyeing and Printing:** The dye can be employed for both dyeing and printing processes on these fabrics. It imparts a vibrant blue color with a greenish tinge.
- **Food Industry (Limited Use):**
 - **Specific Applications:** In some regulated cases, Acid Blue 9 is approved for use as a food colorant under the designation FD&C Blue No. 1. However, its application in food is limited due to potential safety concerns.
- **Other Applications:**
 - **Paper Colouring:** Acid Blue 9 can be used as a colouring agent in the paper industry to create blue-toned paper products.
 - **Leather Colouring:** The dye finds application in colouring leather products, providing a blue hue.
 - **Plastics Colouring:** In specific instances, Acid Blue 9 dye can be used to colour certain types of plastics.

▪ **Factors Influencing Applications:**

- **Material Compatibility:** The suitability of Acid Blue 9 for an application depends on the material's ability to absorb and retain the dye effectively.
- **Desired Colour:** The blue colour with a greenish cast provided by Acid Blue 9 may not be suitable for all applications where a pure blue colour is desired.
- **Safety Regulations:** The use of Acid Blue 9 in food items is subject to strict regulations due to potential health concerns.

1.2. Need for Sustainable Solutions:

The environmental hazards associated with synthetic dyes necessitate the development of sustainable and efficient dye removal technologies. Traditional methods often rely on expensive chemicals or generate hazardous byproducts. This research explores a biomaterial-based approach utilizing an innovative adsorbent: magnetic nanoparticles impregnated with pomegranate peel activated carbon (M-PPAC).

1.2.1 Advantages of M-PPAC:

M-PPAC offers several advantages for dye removal:

- **Biomaterial Utilization:** Pomegranate peel, a readily available agricultural byproduct, serves as the base material. This not only reduces waste but also leverages its natural properties for dye adsorption.
- **High Polyphenol Content:** Pomegranate peels are rich in polyphenols, known for their ability to bind with dye molecules. This inherent property makes them well-suited for dye removal applications.
- **Magnetic Nanoparticle Integration:** Modifying the pomegranate peel with magnetic nanoparticles (MNPs) offers additional benefits.
- **Enhanced Adsorption Capacity:** MNPs provide additional surface area for dye molecule adsorption, increasing the overall removal efficiency.

- **Magnetic Separation:** After treatment, the magnetic properties of the MNPs allow for easy separation of the adsorbent from the treated solution using an external magnetic field. This simplifies the recovery and reuse of the adsorbent, making the process more cost-effective.

In recent years, researchers have embarked on a quest for innovative and responsible adsorbents and techniques to tackle AB9 removal. This journey has led them to explore two promising avenues:

- **Harnessing the Power of Activated Carbon-** Activated carbon has established itself as a cornerstone in the realm of adsorption due to its remarkable properties. Its highly porous structure, characterized by a network of microscopic pores and cavities, provides an extensive surface area. This vast expanse serves as a battleground for dye molecules, creating numerous "active sites" where they can be captured and immobilized. The high surface area of activated carbon allows for the adsorption of large quantities of dye molecules, making it a potent weapon in the fight against dye pollution.
- **Unlocking Potential in Agricultural Byproducts:** The quest for sustainable solutions has led researchers to explore the potential of agricultural waste materials for activated carbon production. One such material gaining significant attention is pomegranate peel, a byproduct generated in abundance by the pomegranate juice industry. Pomegranate peels offer a compelling advantage: their transformation from waste into a valuable resource contributes to a circular economy. This approach not only reduces waste generation but also provides a cost-effective and eco-friendly source material for activated carbon production.

The activation process itself is a fascinating dance between removing unwanted impurities and creating the desired porous structure. This process can be achieved through two primary methods: physical and chemical activation. Physical activation typically involves exposing the material to high temperatures under an inert atmosphere, causing the decomposition of internal structures and the formation of

pores. Chemical activation, on the other hand, utilizes chemical reagents like potassium hydroxide (KOH) to achieve the same goal. The specific activation method chosen depends on the desired properties of the final activated carbon product.

Adding another layer of innovation to the mix are magnetic nanoparticles. These tiny warriors, often composed of iron oxide, possess a unique superpower: their ability to be manipulated by an external magnetic field. This characteristic has revolutionized the field of wastewater treatment. When magnetic nanoparticles are incorporated with activated carbon, a powerful synergy emerges. The activated carbon still provides its vast surface area for dye adsorption, while the magnetic nanoparticles act as microscopic magnets, attracting and binding additional dye molecules. This combined approach can significantly enhance the overall adsorption capacity of the material.

Perhaps the most significant benefit of incorporating magnetic nanoparticles lies in their ease of separation from the treated wastewater. Following the adsorption process, an external magnetic field can be applied to the solution. The magnetic nanoparticles, along with the adsorbed dye molecules, readily respond to the field and are drawn towards the magnet. This simple yet powerful separation technique eliminates the need for complex filtration processes and allows for the easy recovery and potential reuse of the adsorbent, further promoting sustainability and cost-effectiveness.

In conclusion, the search for effective and sustainable methods to remove Acid Blue 9 dye from wastewater has led researchers down a path of continuous innovation. The combination of activated carbon derived from agricultural waste like pomegranate peel, and the strategic integration of magnetic nanoparticles, offers a promising solution. This approach leverages the remarkable properties of both materials, resulting in an efficient, cost-effective, and environmentally friendly weapon in the fight for cleaner water. It is a testament to scientific ingenuity and its potential to address environmental challenges through sustainable practices.

Activated carbon is a widely used adsorbent due to its high surface area and porosity, which provide ample active sites for the adsorption of contaminants. Pomegranate peel, a byproduct of pomegranate juice processing, has been identified as a promising precursor for activated carbon production due to its abundance and potential to reduce waste. The activation process involves the removal of impurities and the development of a porous structure through physical or chemical methods.

Magnetic nanoparticles, such as iron oxide nanoparticles, have gained attention in recent years for their ability to be easily separated from a solution using an external magnetic field. When combined with activated carbon, magnetic nanoparticles can enhance the adsorption capacity and facilitate the recovery of the adsorbent from the treated wastewater, thus improving the overall efficiency of the process.

1.3 POMEGRANATE PEEL

Pomegranate peel is the outer layer of the pomegranate fruit, which is often discarded before eating the juicy arils. The peel is a rich source of nutrients and antioxidants, including polyphenols and flavonoids. Studies have found that pomegranate peel contains compounds such as tannins and flavonoids, which can bind with heavy metals and remove them. The use of pomegranate peel as an adsorbent for heavy metals removal has several advantages, including its low cost, availability, and eco-friendly. However, more research is needed to optimize the process and to investigate the feasibility of using pomegranate peel in large scale.

Pomegranate, a fruit cherished for its vibrant red arils, possesses a hidden treasure – its peel. Often discarded as waste, pomegranate peel holds remarkable potential in environmental cleanup, particularly for removing heavy metals from water. This readily available and cost-effective resource offers a sustainable solution to a growing environmental concern.

Pomegranate peels are not just a fibrous casing; they are brimming with valuable compounds. Studies have revealed a rich tapestry of minerals and antioxidants, including:

- **Polyphenols:** These powerful antioxidants are known for their ability to bind with and neutralize harmful free radicals. In the context of heavy metal removal, polyphenols act as chelating agents, forming complexes with metal ions, effectively rendering them less mobile and toxic.
- **Flavonoids:** Another class of antioxidants present in pomegranate peels, flavonoids contribute to their metal-binding capacity. They possess functional groups that readily interact with metal ions, facilitating their removal from the aqueous environment.
- **Tannins:** These naturally occurring astringent compounds play a crucial role in heavy metal adsorption. Tannins have multiple binding sites that can effectively capture and immobilize metal ions within their complex structures. The MNP impregnated with PP have shown great promise in removing heavy metal from contaminated water and soil. This method offers eco-friendliness, selectivity, and cost-effectiveness, while the magnetic properties simplify material recovery. It holds promise for addressing heavy metal contamination and promoting environmentally conscious water treatment practices.

1.3.1 The Allure of Sustainability:

The traditional methods for heavy metal removal often rely on expensive and energy-intensive processes that can generate harmful byproducts. Pomegranate peel offers a compelling alternative due to its inherent advantages:

- **Cost-Effectiveness:** Being an agricultural byproduct readily available in large quantities, pomegranate peel eliminates the need for expensive synthetic adsorbents.

- **Environmental Friendliness:** Utilizing a natural material minimizes the environmental footprint associated with wastewater treatment compared to conventional methods.
- **Abundant Resource:** The widespread cultivation of pomegranates ensures a readily available source of raw material for large-scale treatment applications.

Pomegranate peel, often relegated to the waste bin, emerges as a powerful ally in the fight against heavy metal pollution. Its natural bounty of chelating agents and its readily available nature make it a sustainable and cost-effective solution for environmental remediation. By harnessing the potential of this natural resource, we can move towards cleaner water and a healthier planet.

CHAPTER 2

2. LITERATURE SURVEY:

- Mohd Azmier Ahmad, Nur Azreen Ahmad (2014) - KOH activation and microwave-induced methods were used to turn pomegranate peel into activated carbon. The nitrogen-adsorption surface area (BET), TGA, SEM, and FTIR were used to describe the produced activated carbon (PPAC). Both the total pore volume ($0.470 \text{ cm}^3/\text{g}$) and surface area ($941.02 \text{ m}^2/\text{g}$) increased significantly according to BET measurements. PPAC was used to adsorb Remazol Brilliant Blue Reactive (RBBR) dye, and various operating parameters were studied, including pH, initial dye concentration, contact time, and solution temperature in batch systems. The best dye removal was 94.36% at pH 2. Adsorption kinetics was found to follow pseudo-second-order kinetic model. It was studied that the Freundlich isotherm model fitted the adsorption data most with the highest correlation ($R^2 \geq 0.99$) and lowest normalized standard deviation, Δq_e . The adsorption of RBBR dye onto PPAC was found to be spontaneous and exothermic in nature.
- Gasser M Khairy, Ahmed M Hesham, Hossam Elden S Jahin, Sabry A El-Korashy, Yasser Mahmoud Awad - This study synthesized iron nanoparticles loaded atop hydro char, resulting in a novel eco-friendly and economical bio-adsorbent. Pomegranate peels were utilized as a feedstock to produce hydro char (HC). Using the black solution of iron nanoparticles as a hydrothermal carbonization media, the hydrothermal carbonization technique was used to produce hydro char. The hydro char bio-adsorbent was characterized using FTIR, Transmission electron microscope (TEM), Zeta potential techniques, X-ray diffraction (XRD), Brunauer-Emmett-Teller (BET) surface area, SEM with EDX analysis, and Thermal analysis. The batch experiments like initial concentration, contact time, solution temperature, adsorbent dosage, and pH on the adsorption capacity of the bio-adsorbent for Cu (II) and Methylene Blue were examined and determined. Maximum sorption capacity of Cu (II) and Methylene Blue was 95.24 and 278 mg g^{-1} . This study shows good efficiency in removal of Methylene Blue dye using Pomegranate Peel.

- Fatma Mohamed, Mostafa R. Abukhadra, Aftab Aslam Parwaz Khan, Khalid A. Alamry, Abdullah M. Asiri & Mohamed Shaban – This study uses pomegranate peel extract at varying dosage (2 g, 4 g, and 6 g) and with the peel residues present, green hematite nanoparticles were created. The nanoparticles were used as environmentally friendly adsorbents to remove methylene blue dye pollutants from water. The equilibration times were attained after 480 min. The adsorption systems for the synthetic materials are of the chemisorption type, according to the isotherm and kinetic investigations. Pseudo-second order adsorption behaviors of these systems can be proven. Additionally, compared to other models studied, the adsorption data showed a mono-layer uptake form that was more appropriate for the Langmuir model. Additionally, the items performed exceptionally well in terms of eliminating the dyes that were examined, including methyl orange, crystal violet, safranin, methylene blue, and Congo red.
- Riham Atef, N. M. Aboeleneen & Nabil M. Abdel Monem - Waste pomegranate peels were effectively used to create a low-cost nanoparticle material. The effects of various operating conditions on the removal of brilliant green (BG) dye from an aqueous solution were investigated by batch adsorption tests. Pomegranate peel nanoparticles (PPNP) in SEM pictures revealed the surfaces' roughness. The PPNP's mean particle size was 613.4 nm, and its specific surface area was 354.46 m²/g. The average crystallite size of PPNP was shown in the XRD pattern to be 13.50 nm, and the EDS investigation indicates that 83% of the material is carbon. According to the experimental results, the best conditions for BG removal effectiveness were 20 minutes, 0.3 g of adsorbent mass, 25 °C, and pH 8. The kinetic data can be described well with the pseudo-second-order model and the isotherm data was found to fit the Dubinin model. In this work, thermal activation of pomegranate peels—an agricultural waste—was utilized to create an inexpensive, environmentally benign adsorbent at the nanoscale. With their large surface area and well-developed porosity, the produced nanoparticles were found to be a potential adsorbent. Large-scale applications and wastewater treatment technology will be significantly impacted by the produced adsorbent.

- Imane Akkari, Zahra Graba, Nacer Bezzi, Farid Ait Merzeg, Nadia Bait & Azedine Ferhati - This study describes the removal of Basic Red 46 (BR46) dye from aqueous solution using raw pomegranate peel (RPP), a low-cost biosorbent. The amorphous form of RPP is indicated by the XRD pattern. The primary functional groups of the biosorbent are amine (NH₂), carboxyl (COOH), and hydroxyl (OH). Using scanning electron microscopy (SEM), the uneven and rough surface of RPP is visible. The Brunauer–Emmett–Teller (BET) surface of 1.046 m².g⁻¹ and the average pore diameter of 60.121 Å indicate that the molecule could easily access into the pores. Reduced particle size of RPP gives up an increase of the adsorption capacity of 70 mg.g⁻¹ in 2 min, to attain 86.13 mg.g⁻¹ with a removal rate of 86% in 60 min of contact for initial dye concentration of 200 mg.L⁻¹ and biosorbent dosage of 2 g.L⁻¹. Biosorption experimental isotherms data fit well with the Temkin model. The adsorption process of BR46 onto RPP was spontaneous, exothermic, and the pseudo-second order described was found to fit the kinetic data.
- Badr M. Thamer, Faiz A. Al-aizari, and Hany S. Abdo - The dye and textile industries' explosive growth has sparked widespread public concern about the pollution that dye wastewater produces, which may be harmful to people's health. In this study, we used a single-step surface modification technique with 5-sulfonate-salicylaldehyde sodium salt to successfully increase the adsorption efficiency of activated carbon generated from pomegranate peel waste (PPAC). The prepared PPAC and S-PPAC were characterized via FESEM, EDS, FTIR and BET surface area. Characterization studies confirmed the highly porous structure of the PPAC and its successful surface modification, with surface areas reaching 1180.63 m²/g and 740.75 m²/g for the PPAC and S-PPAC, respectively. The maximum adsorption capacity was achieved at 785.53 mg/g with the S-PPAC, an increase of 22.76% compared to the PPAC at 45 °C. The isothermic adsorption and kinetic studies demonstrated that the adsorption process aligned well with the Freundlich isotherm model and followed the Elovich kinetic model, respectively. The thermodynamic study confirmed that the adsorption of CV dye was endothermic, spontaneous and thermodynamically favorable onto PPAC and S-PPAC.

CHAPTER 3

AIM AND SCOPE

3.1 AIM

- To synthesize of Pomegranate Peel impregnated Magnetic Nanoparticle.
- To characterize of Pomegranate Peel impregnated Magnetic Nanoparticle.
- To Remove of Acid blue 9 dye from wastewater using pomegranate peel impregnated nanoparticles.

3.2 SCOPE

- To make an approach that offers an effective and eco-friendly method for the removal of Acid blue 9 dye from water sources, addressing environmental pollution concerns associated with synthetic dye contamination.
- To utilize agricultural waste (pomegranate peel) as a valuable resource, contributing to waste reduction and sustainable practices in agriculture and water treatment.
- To check MNP impregnated PP natural adsorption properties can be tailored to selectively target Acid Blue 9 dye, making it suitable for treating specific sources of contamination.
- To make the use of magnetic nanoparticles that simplifies the separation process and allows for the recovery and potential reuse of the impregnated material, making it cost-effective and efficient.

CHAPTER 4

4 MATERIALS AND METHOD

The following materials are used to synthesize magnetic nanoparticles of pomegranate peel.

4.1 MATERIALS

Pomegranate peel was collected from fresh juice shop at local market in Puducherry.

4.1.1 Chemicals Required

- Hydrochloric Acid (HCl)
- Ferric Chloride (FeCl_3)
- Ferric Sulphate ($\text{Fe}_2(\text{SO}_4)_3$)
- Ammonium Hydroxide (NH_4OH)
- Ethanol ($\text{C}_2\text{H}_5\text{OH}$)
- Distilled Water

4.2.2 Equipment Required

- Muffle Furnace
- Hot Air Oven
- Burette
- Hot Plate Magnetic Stirrer
- Rotary Shaker

4.2 METHOD

4.2.1 DRYING OF POMEGRANATE PEEL

- Pomegranate peel was collected, and rinsed twice with tap water, then with deionized water, to remove dust.
- The wet pomegranate peel was then sun-dried for 10 to 14 days.

4.2.2 PREPARATION OF POMEGRANATE PEEL ACTIVATED CARBON

- Collecting pomegranate peels: Collect fresh pomegranate peel and wash neatly to remove contaminants for it.
- Allow to dry for completely it should be wet inside.
- The pomegranate peel cut into little pieces (approximately 3 cm) and placed in a small mud pot, sealed with clay and placed in a Muffle furnace for an hour at 400-500°C.



FIG 4.1 POMEGRANATE PEEL KEPT IN CLAY POT

- The Pomegranate peel powder from the clay pot was grounded into powder, sieved at 85 μm and kept into powder jars for experimental usage.
- The pomegranate peel powder is activated by soaking it in distilled water and hydrochloric acid (HCl) for about 24 hours.



FIG 4.2 SOAKED ACTIVATED CARBON

- After filtering the solution, the solid powder is thoroughly washed with distilled water. It is then dried in a muffle oven for one hour at 150°C to produce pomegranate peel activated carb

4.2.3 Impregnation Process

- The Activated Carbon is then impregnated with 2g of Ferric Chloride (Fe_3Cl), 1g of Ferric Sulphate ($\text{Fe}_2(\text{SO}_4)_3$) and 1g of the Pomegranate peel activated carbon.
- The conical flask is filled with all the solid components and placed inside a hot plate magnetic stirrer and 50 ml of distilled water were added to it.
- The mixture is then allowed to stir constantly for 15 minutes at a temperature of 40°C.

1. **Selection of MNPs:** High-quality MNPs with suitable magnetic properties are chosen for the process. These nanoparticles are typically composed of materials like iron oxide (Fe_3O_4) or magnetite.

2. **Combining MNPs and Pomegranate Peel Extract:** The extracted pomegranate peel solution is mixed with the MNPs. This can be done through techniques like co-precipitation, co-adsorption, or simply by immersing the MNPs in the extract.

3. **Stirring and Mixing:** The mixture is often stirred or sonicated to ensure uniform distribution of the pomegranate peel extract on the surface of the MNPs. This step facilitates the impregnation process.

4. **Drying and Solidification:** The impregnated MNPs are typically dried to remove excess solvent, leaving behind the impregnated pomegranate peel on the surface of the nanoparticles. This creates a solid composite material



FIG 4.3 IMPREGNATION PROCESS

4.2.4 Filtration and Drying

- After the co-precipitation, give it 15 minutes to cool. filter the sample now and then wash it with distilled water and Ethanol to prevent rusting.
- The Filtrate is then dried in Muffle Oven at 150°C for 30mins. The powdered particle is the Magnetic Nanoparticle impregnated with pomegranate peel



FIG 4.4 MAGNETIC NANOPARTICLE OF POMEGRANATE PEEL

4.3 Adsorption experiment

In a 250 ml Erlenmeyer flask, 100 mL of the wastewater was mixed with biosorbent at a pH of 3 and a dye concentration of 15 mg/L. The experiment was conducted at ambient temperature and 150 rpm on a multi-channel shaker. The sample was taken out and filtered using filter paper at predetermined contact times (10, 15, 30, 45, and 60 minutes). The 15th minute was chosen as the optimal contact period for the remainder of the adsorption studies.

Using a UV/VIS spectrophotometer, the absorbance of the supernatant was calculated at maximum wavelength 560 nm. The outcome was presented as a percentage of heavy metal elimination.

4.4 Characterization

Obtain small finely particles of pomegranate peel the sample should be in a uniform and representative. Fourier Transform Infrared (FTIR) analysis was applied to the magnetic nanoparticle of pomegranate peel to determine the surface functional groups and the spectra were recorded from 4000 to 400cm⁻¹.

Scanning electron microscopy (SEM) characterization is a method for examining the topography and morphology of the surface material of biosorbents. It is also used to analyse the biosorbent's porosity structure and particle shape. Compare the obtained spectra with reference spectra or data to identify compounds present in it. It can provide valuable insight into the chemical composition of pomegranate peel and particle shape. Compare the obtained spectra with reference spectra or data to identify compounds present in it. It can provide valuable insight into the chemical composition of pomegranate peel.

CHAPTER 5

Results

5.1. Fourier Transform Infrared (FTIR)

The FTIR spectra of the native and loaded Magnetic nanoparticle of Pomegranate peel are presented in Figure 5.1. The native PMPP sample exhibited a broad adsorption peak at 3421.10 cm^{-1} indicating the presence of bonded and free hydroxylic group due to O-H group vibration. The peak is observed at 2917 cm^{-1} corresponds to C-H stretching. The FTIR discussions has confirmed the existence of five major peaks at 3421.10 cm^{-1} , 2917 cm^{-1} , 1699.22 cm^{-1} , 1400.37 cm^{-1} and 1056.60 cm^{-1}

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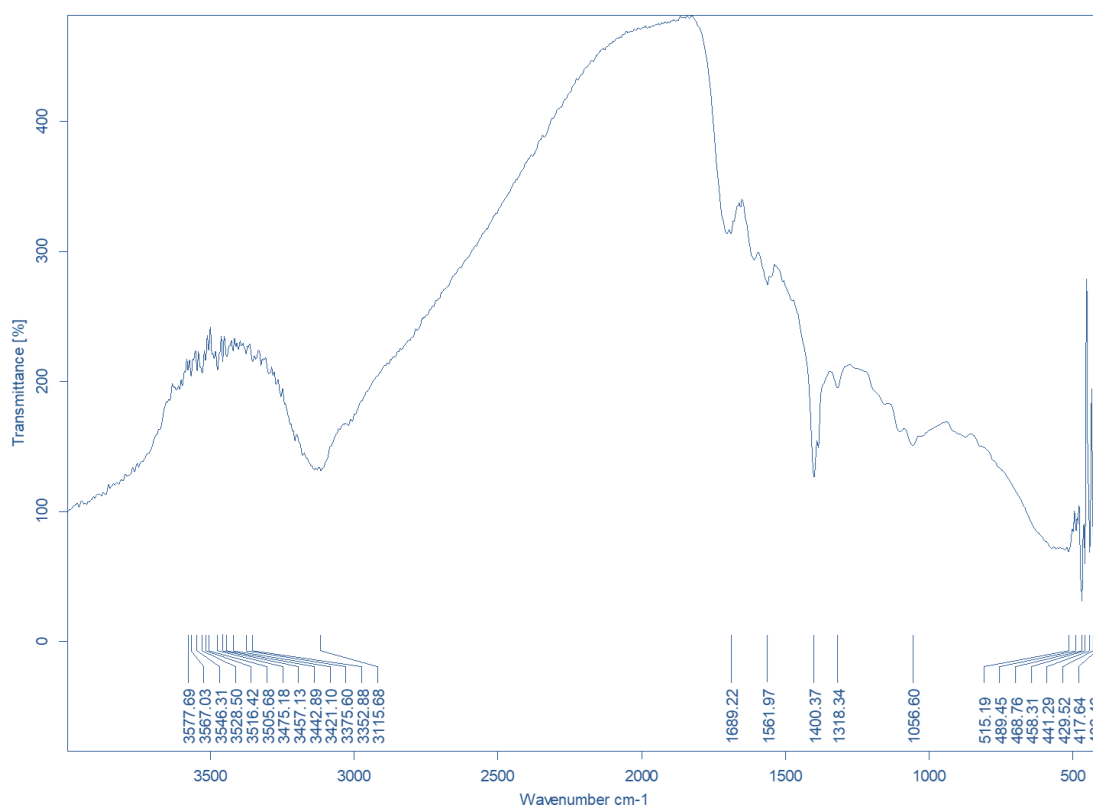


FIG 5.1 FTIR SPECTRUM OF POMEGRANATE PEEL

5.1.1 After Adsorption FTIR Result

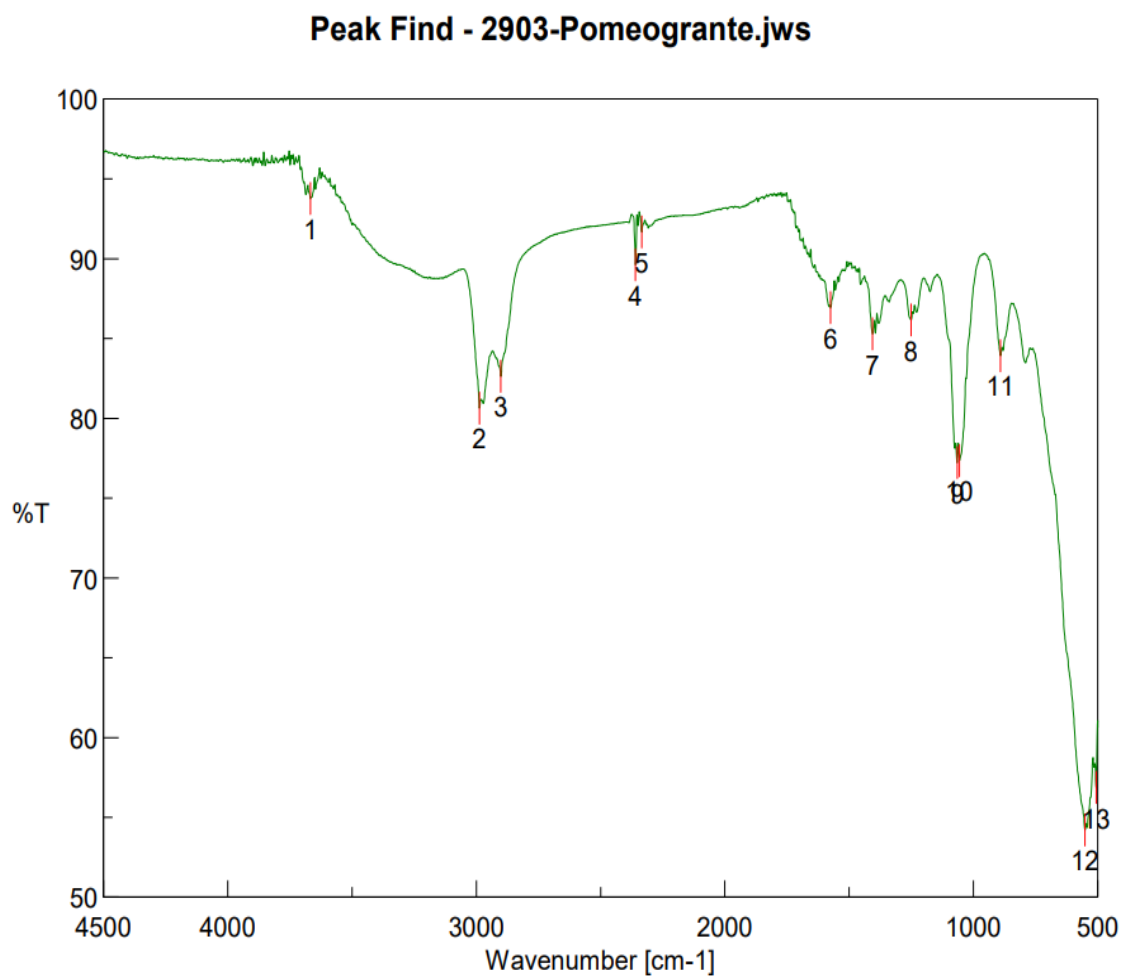


FIG. 5.2 FTIR SPECTRUM AFTER ADSORPTION

The peak obtained from magnetic nano particles after adsorption are shown in Fig. 5.2. The presence of sulphate bonds confirms the presence of dye particles in the given sample of magnetic nano particles thus confirming adsorption process.

5.2. Scanning electron microscopy (SEM)

FIG 5.2 shows the morphology of the surface of native and loaded PMPP. The SEM micrograph shows a soft amorphous and heterogeneous structure of typical non-cellulosic content. Also, the absence of orientation and fibrous structure of cellulose and porosity was observed.

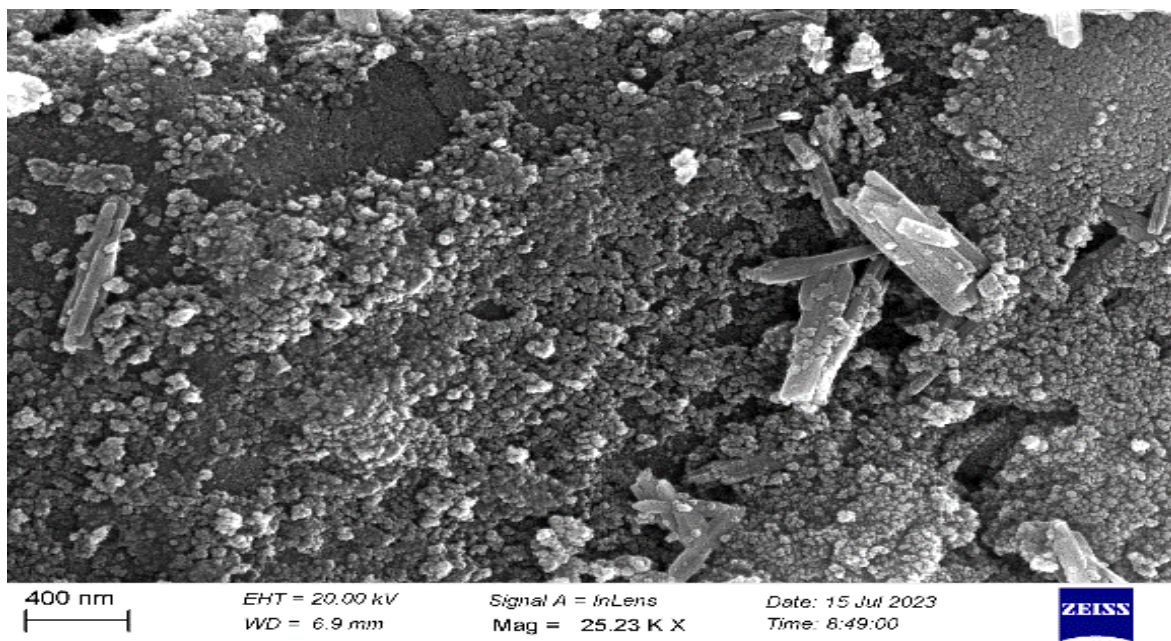


FIG 5.2 SEM IMAGE (A) OF PP-NM.

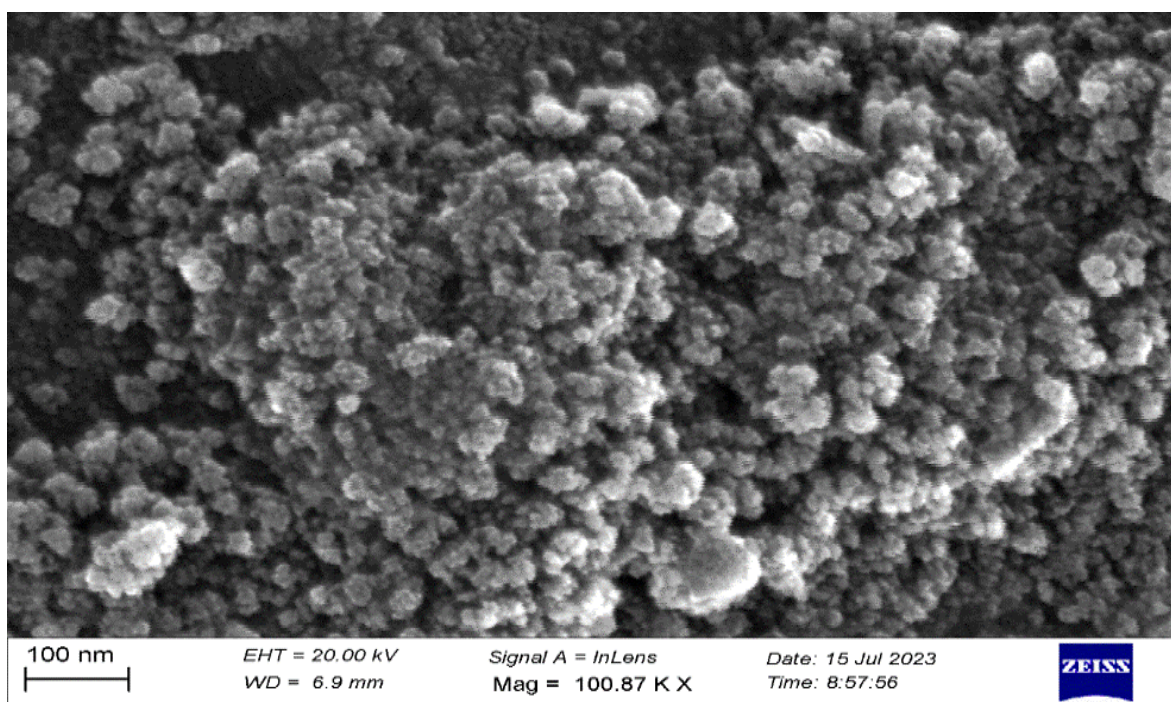


FIG 5.2 SEM IMAGE (B) OF PP-NM

5.2.1 SEM Result after Adsorption

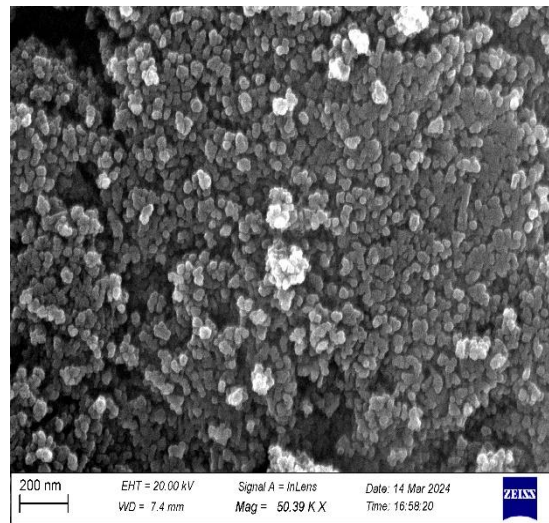
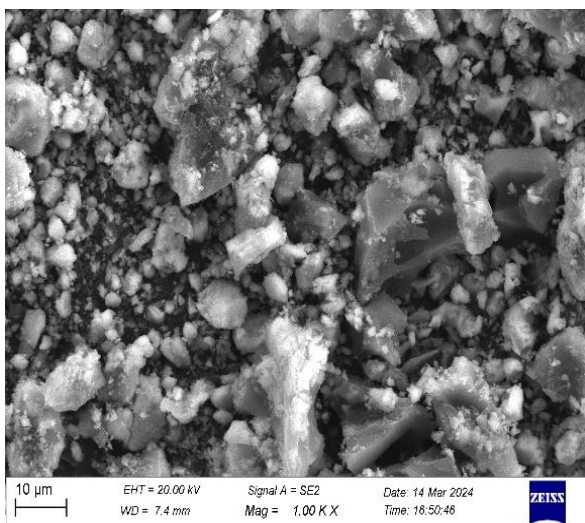


FIG 5.3 SEM IMAGE (A) OF PP-NM AFTER ADSORPTION

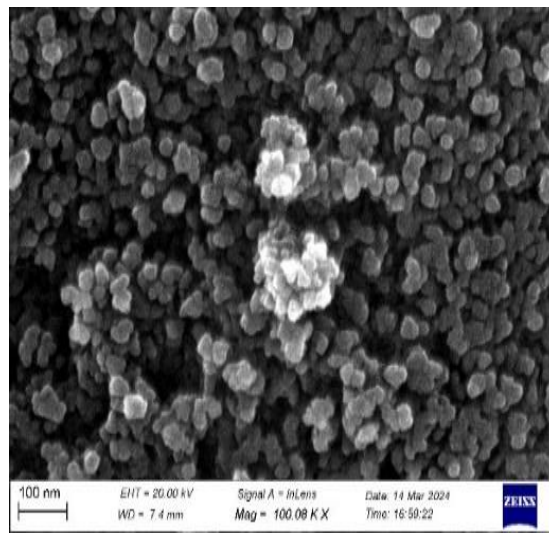
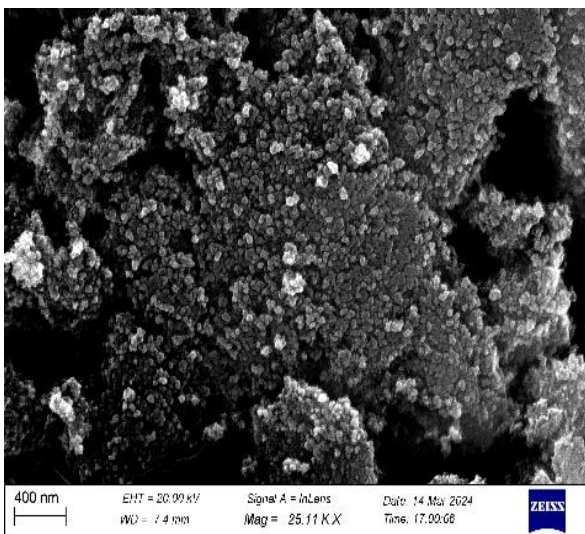


FIG 5.3 SEM IMAGE (B) OF PP-NM AFTER ADSORPTION

Following Dye adsorption, the Pomegranate peel nano particles were sent to Scanning electron microscopy testing, to look for any changes in morphology before and after adsorption. These images are shown in Fig. 5.3 (A) and Fig. 5.3 (B). These images when compared to before adsorption has decreased number of pores indicating there could be dye molecules adsorbed by it.

5.3 Electron Dispersive X-Ray (EDX)

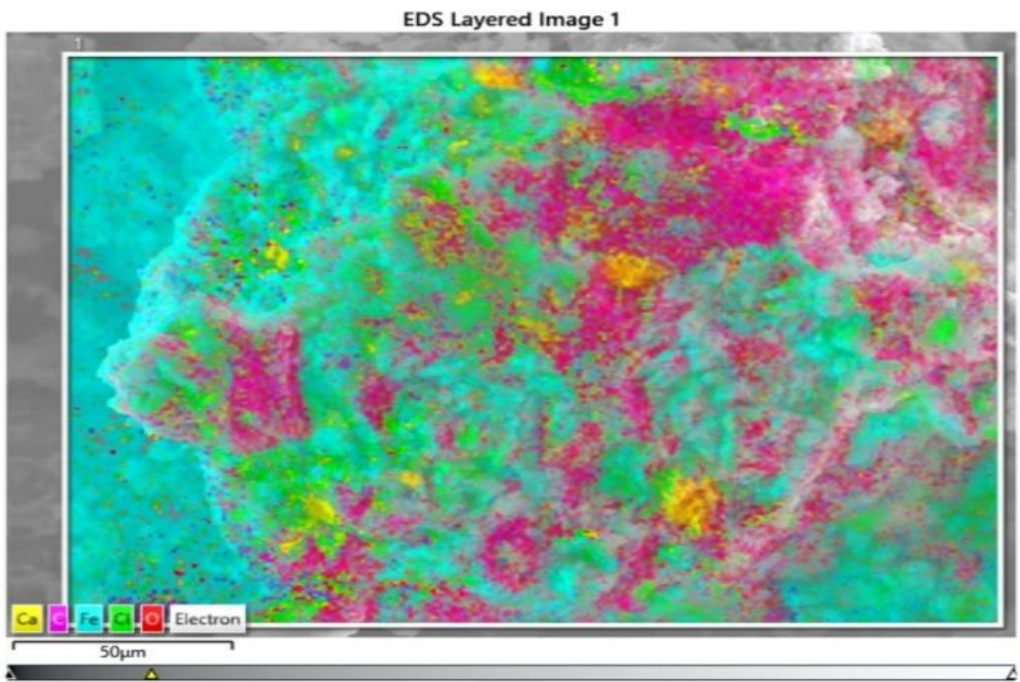


FIG 5.4 EDX IMAGE (A) OF PP-NM

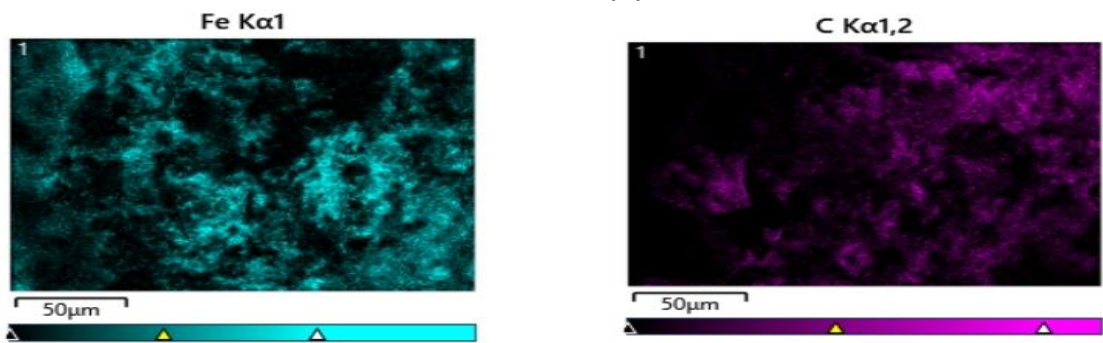


FIG 5.4 EDX IMAGE (B) OF P-NM

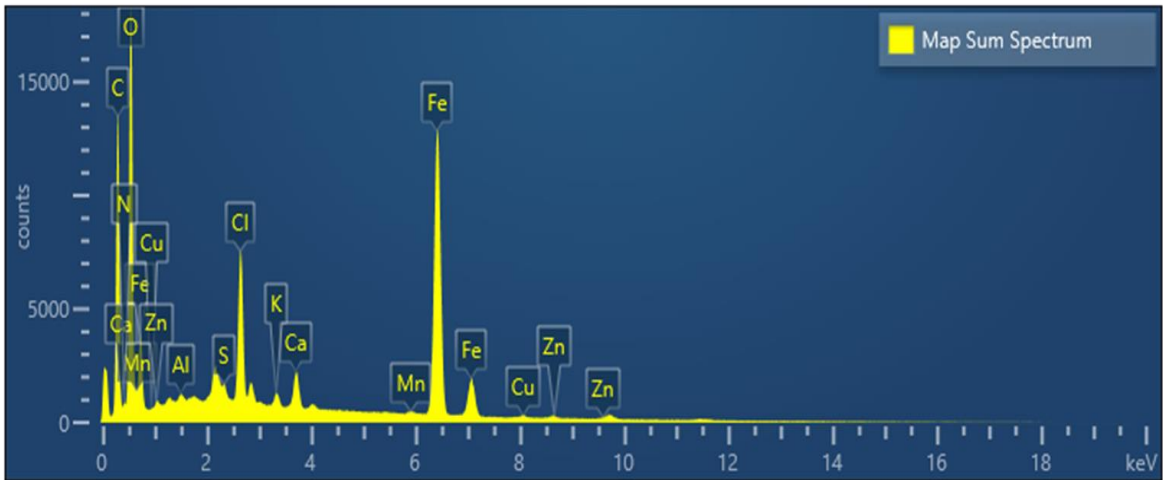


FIG 5.5 EDX IMAGE (C) OF PP-NM

TABLE 5.1 EDX MAP SPECTRUM OF PP-NM

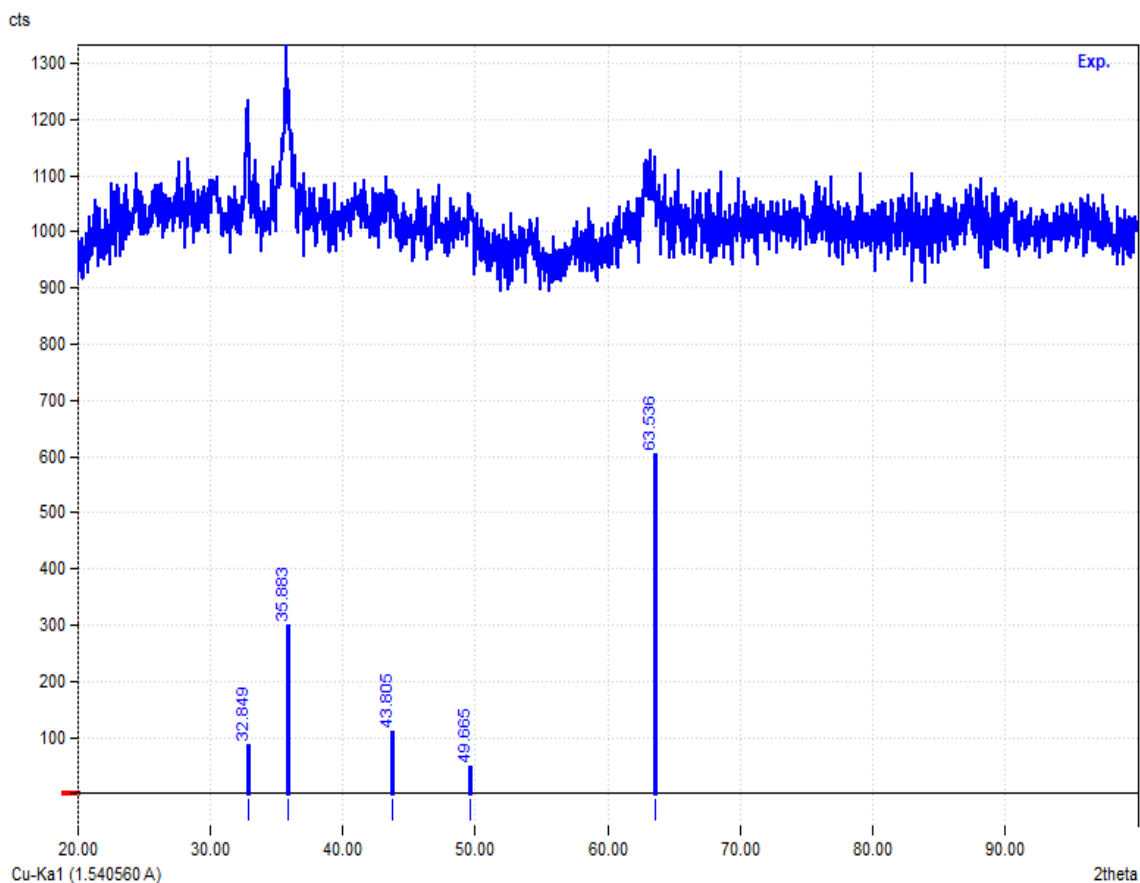
Map Sum Spectrum				
Element	Line Type	Weight %	Weight % Sigma	Atomic %
C	K Series	43.29	0.31	58.61
N	K Series	3.18	0.4	3.69
O	K Series	29.69	0.21	30.17
Al	K Series	0.13	0.01	0.08
S	K Series	0.06	0.01	0.03
Cl	K Series	2.58	0.02	1.18
K	K Series	0.28	0.01	0.12
Ca	K Series	0.84	0.02	0.34
Mn	K Series	0.13	0.02	0.04
Fe	K Series	19.23	0.13	5.6
Cu	K Series	0.24	0.03	0.06
Zn	K Series	0.35	0.04	0.09
Total		100		100

5.4 X-RAY DIFFRACTION

XRD can also be used to analyse thin films, powders, and nanoparticles. The technique can be combined with other spectroscopic techniques such as XPS and FTIR to provide a more comprehensive understanding of the properties of a sample. Overall, XRD spectroscopy is a valuable tool for understanding the crystal structure and properties of materials, and it has numerous applications in research and industry.

TABLE 5.2 XRD PEAK LIST

Sl.NO	Theta	d[Å]	1/10(Peak height)	Counts (Peak area)	FWHM
1.	32.85	2.7242	853.82	83.02	0.3310
2.	35.88	2.5006	1000.00	295.91	1.0074
3.	43.80	2.0650	171.89	106.73	2.1139
4.	49.67	1.8341	314.52	45.04	0.4875
5.	63.54	1.4631	421.47	603.21	4.8722



A prominent peak observed at $2\theta = 35.7^\circ$ corresponds to the crystallographic planes of iron oxide (Fe_2O_3), indicating the presence of magnetic nanoparticles in the impregnated material. This peak confirms the crystalline nature of the magnetic component. A broad peak at $2\theta = 63.0^\circ$ is indicative of the amorphous carbon content derived from the pomegranate peel. The amorphous nature of this peak suggests the presence of organic matter. By analysing the width of the iron oxide peak at $2\theta = 32.85^\circ$ using Scherrer's equation, the crystallite size of the magnetic nanoparticles can be calculated, providing insights into the material's properties. Overall Structure Confirmation: XRD results affirm the presence of both magnetic nanoparticles and amorphous carbon from pomegranate peel, validating the composition of the impregnated material designed for efficient dye removal.

5.5 VSM: Vibrating sample magnetometer

A strong and uniform magnetic field is applied to the sample. This magnetic field can be adjusted to various strengths and orientations. A strong and uniform magnetic field is applied to the sample. This magnetic field can be adjusted to various strengths and orientations. As the sample vibrates in the magnetic field, the magnetization of the sample is measured. The VSM records changes in the sample's magnetic moment as a function of the applied magnetic field. The collected data can be used to determine various magnetic properties of the sample, including its magnetic susceptibility, hysteresis loop, coercivity, remanence, and other parameters. studying the magnetic properties of materials such as ferromagnetic, antiferromagnetic, and paramagnetic substances. They are crucial tools in understanding the magnetic behaviour of materials for applications in electronics, magnetism, and magnetic materials research.

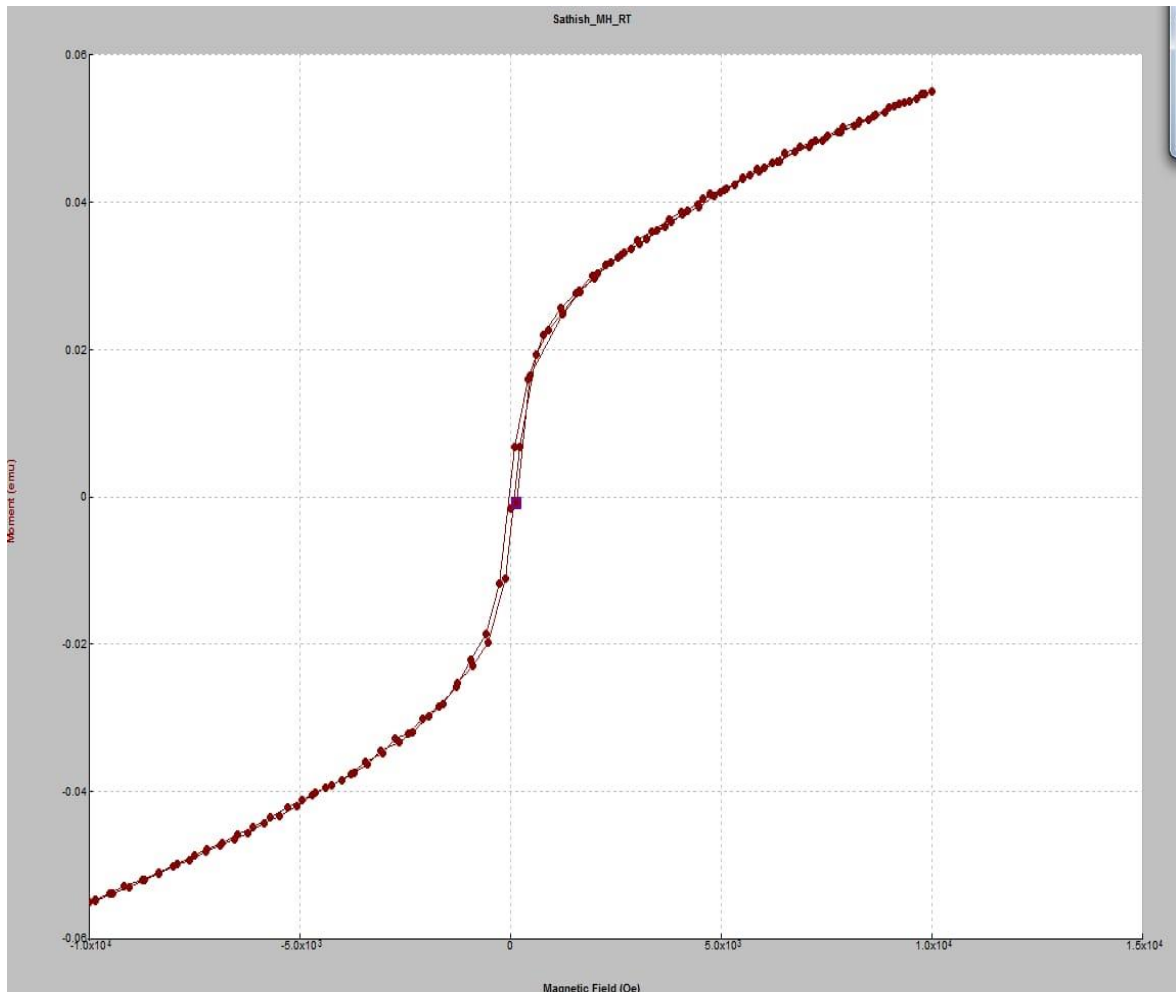


FIG 5.7 VSM IMAGE OF PP-NM

5.6 BET ISOTHERM

- The BET isotherm is a mathematical model that describes the adsorption of gas molecules onto a solid surface.
- It is commonly used to analyze and characterize the surface area of porous materials, such as catalysts or adsorbents.
- The BET isotherm is particularly relevant when studying monolayer adsorption onto a surface with multilayer formation.
- Temperature : 77.350K
- Molecular Wt. : 28.013
- Cross Section: 16.200Å²
- Slope = 1.960
- Intercept = 0.629
- Correlation coefficient, $r = 0.999304$
- Micropore volume = 0.001 cc/g
- Micropore area = 1.929 m²/g
- External surface area = 30.316 m²/g

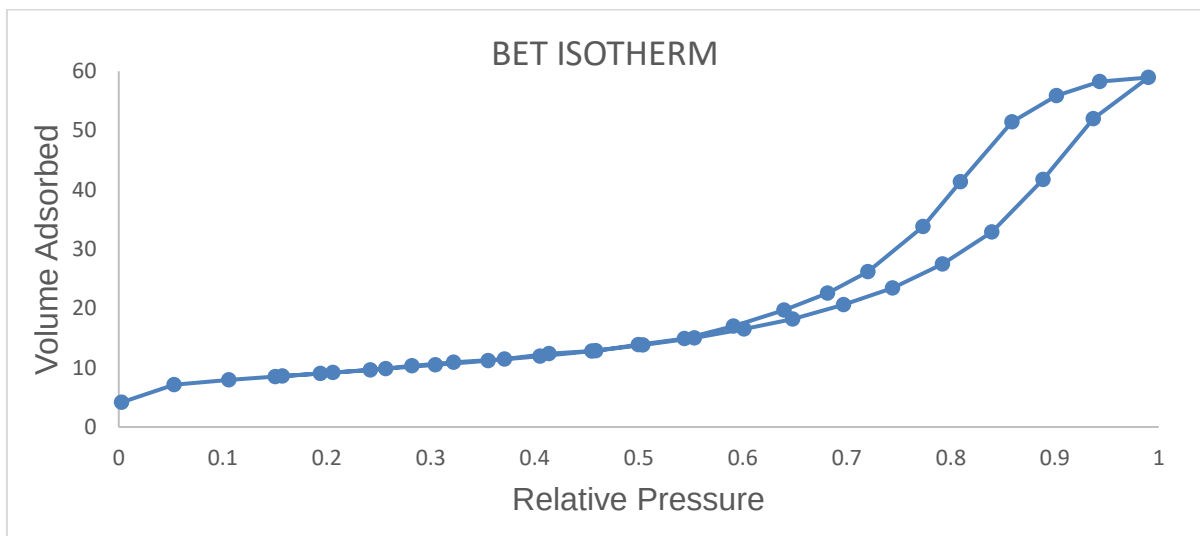


FIG 5.8 BET ISOTHERM GRAPH

The hysteresis loop in the figure 5.8 suggests the presence of mesopores. In a BET isotherm, an H2 hysteresis loop indicates the presence of bottle-shaped pores, also known as ink bottle pores, within the material. These pores have wider bodies and narrower necks. The adsorption isotherm shows a higher amount of gas adsorbed during the adsorption phase compared to the desorption phase at the same relative pressure. This difference is due to the energy required to desorb the gas molecules from the narrow necks of the pores.

5.7 ADSORPTION STUDIES:

To perform Adsorption studies, prepare Stock solution of 1000 ppm of Acid blue 9 dye. Now take 2ml of stock solution and add 98 ml of water to make 20 ppm of solution. Now we need to check pH for 20 ppm of solution contain in 6 conical flask we got 5.88 pH for 20 ppm solution. Now we need to change pH for 20 ppm solution (2,3,4,5,6,7). For changing pH we add 0.1M of HCL and 0.1 M of NaOH drop by drop to change pH of 20 ppm solution (In form Acidic and Base).



FIG 5.9 BATCH STUDIES

5.8 OPTIMIZATION PARAMETERS

Add 0.2g of adsorbent in each of prepared pH adjusted stock solution of 20 ppm. Cover it with Aluminum foil and keep it in rotary shaker for 6 hours. Take sample solution of 5 ml after every 15 minutes for first 2 hours and every 30 minutes for next two hours and one reading for upcoming every hour. The collected samples are the given to UVS (ultra-violet Spectroscopy) test to find optimum pH.

5.9 CALIBRATION CURVE:

The concentration should span the expected range. Analyze each standard solution using the instrument or method you are calibrating. As absorbance, signal intensity, or any relevant parameter. Common method includes curve or other regression models depending on the data distribution. Curve to determine the concentration of an unknown sample by measuring its response and in interpolating from the curve. Calibration curve is crucial for accurate quantitative analysis in various fields

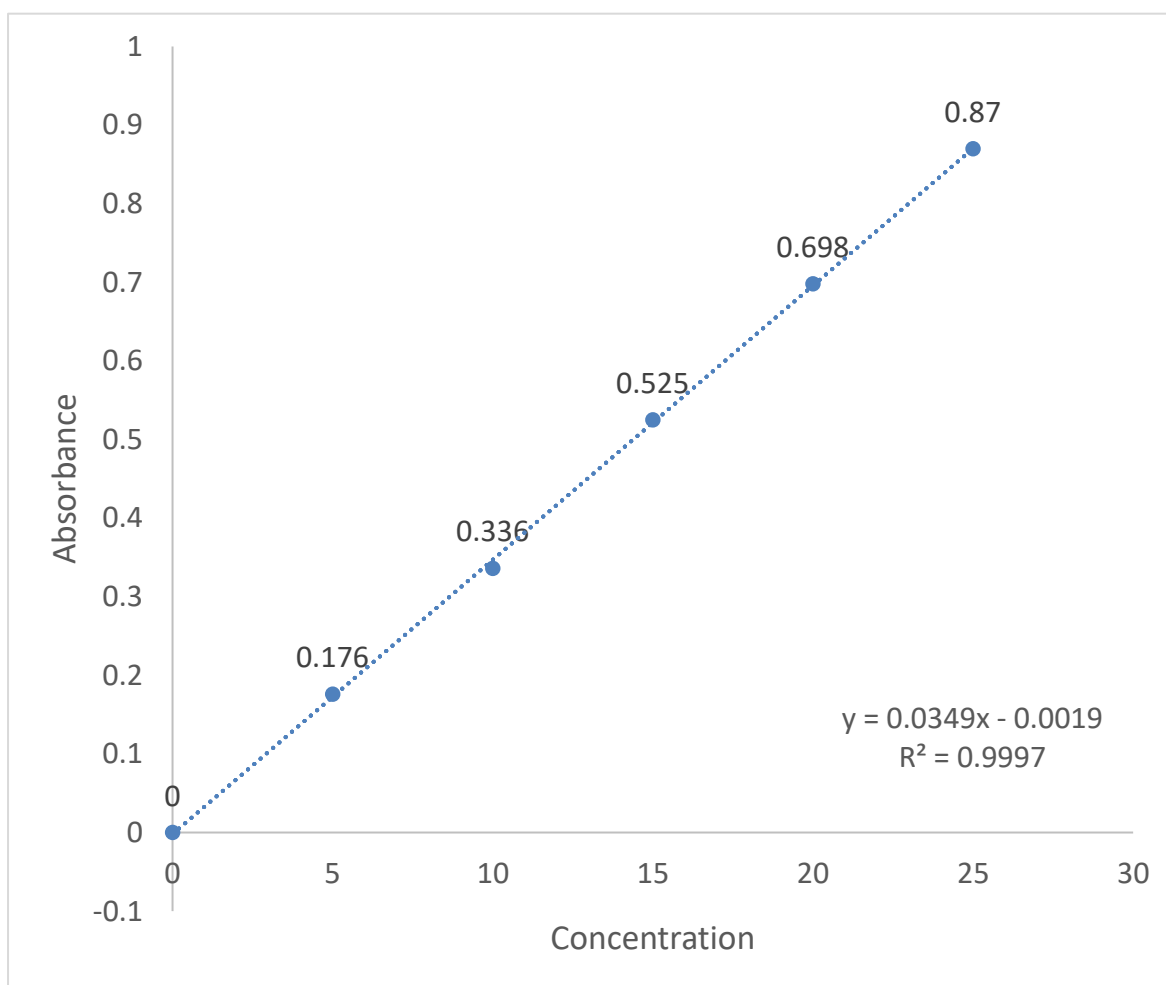


FIG 5.10 CALIBRATION CURVE

5.10 Optimization of pH

The Efficiency of dye removal using pomegranate peel due to presence of different functional groups present on the surface of peel. Pomegranate peel may exhibit improve the quality dye adsorption at specific pH range. Pomegranate peel contain (COOH)and (OH) Groups can influence the electrostatic interaction with charged dye molecules. Dyes can exist in different forms based on their pH such as ionized and non-ionized. Ionization state of dye effect its interaction with the charged functional groups on the pomegranate peel. Adsorption involves in mechanism like electrostatic attraction, hydrogen-bonding.

The removal of acid blue dye was studied by varying the initial pH(2,3,4,5,6mg/L) initial concentration 20mg/l and 30 minutes as contact time. It is inferred that the removal of Acid Blue Dye increased from 42.3% at 2 pH and reached maximum of 88.10% at 4 pH and started to decline with increase in pH.

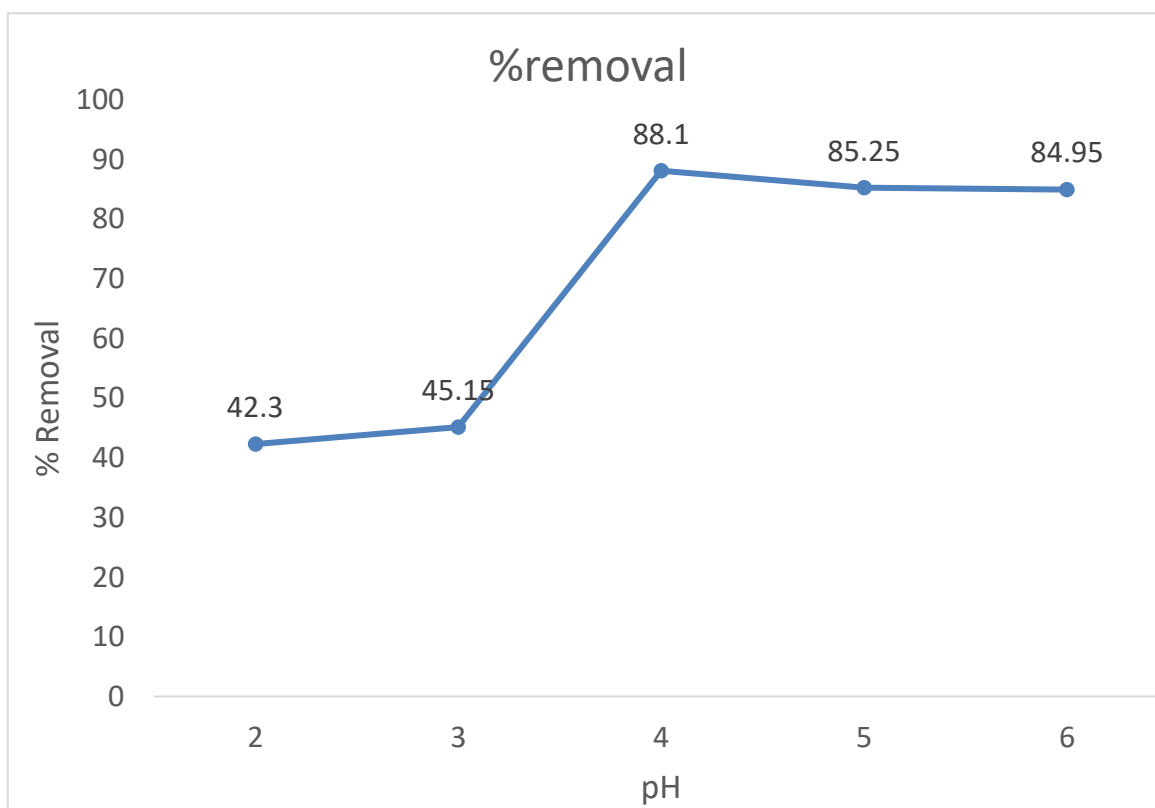


FIG 5.11 EFFECT OF pH ON ACID BLUE 9 DYE REMOVAL BY PP-NM (VOLUME = 100 ml, TIME = 30 mins, CONC = 20mg/l, TEMP = 305.15 K and OPTIMUM pH IS 4 FOR 88.18% REMOVAL)

5.11 OPTIMIZATION OF CONTACT TIME:

The pH can influence domain of the mechanism impact the overall adsorption process. Measure the efficiency of dye removal at different pH values to establish at a comprehensive rate. The pH of the solution plays a crucial role in the adsorption of dyes on the pomegranate peel conducting across range of pH values will help to determine the effective situation for dye removal.

The removal of Acid blue 9 dye solution was studied by varying contact time (0,15,30,45,60,75,90 minutes). The single, uneven adsorption curves suggests that the molecules have covered the adsorbent surface in monolayer. The highest percentage of removal is inferred at 30 minutes with a percentage removal of 88.1%.

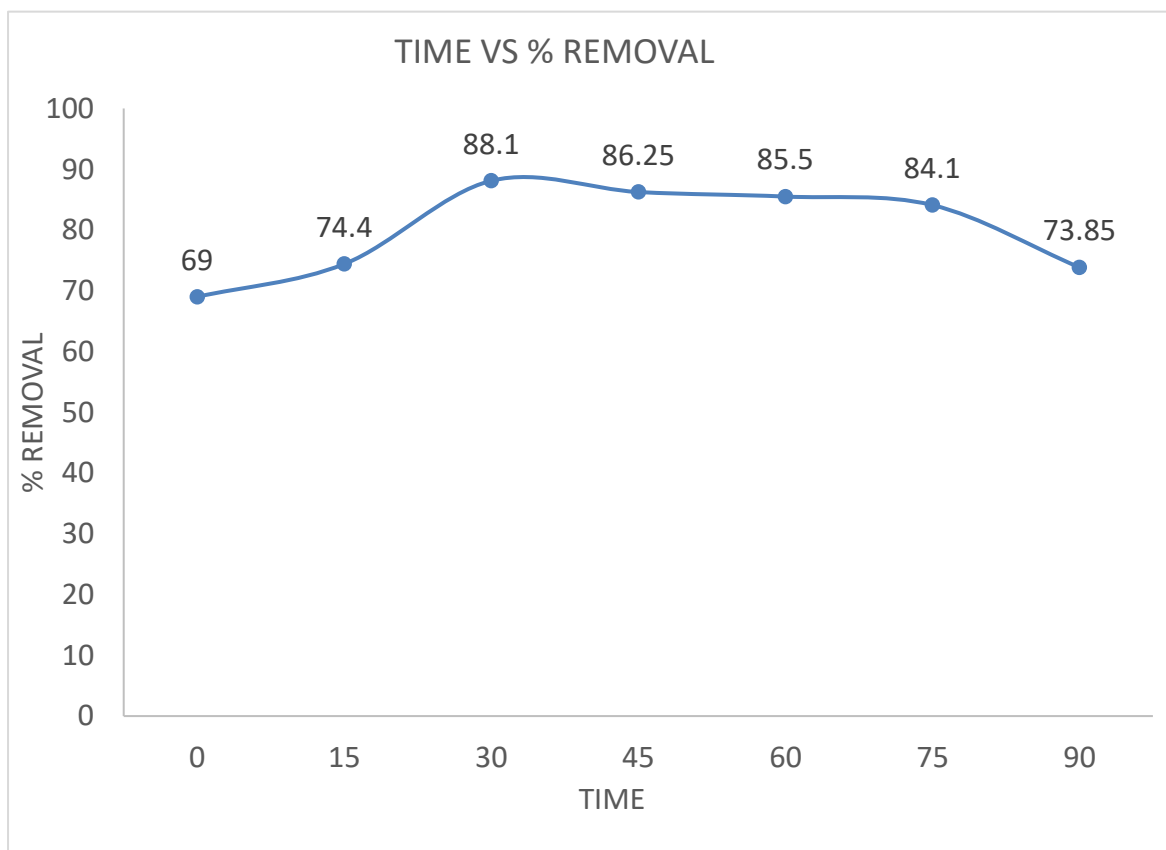


FIG 5.12 EFFECT OF CONTACT TIME ON ACID BLUE 9 DYE BY PP-NM (VOLUME = 100ml, DOSAGE = 0.2 g/l, TEMP = 305.15 K, pH= 4, OPTIMUM TIME = 30 mins FOR 88.1% REMOVAL)

5.12 OPTIMIZATION OF DOSAGE:

The key factor in determining the adsorption potential of a given concentration of Acid Blue 9 dye is the dosage of PP-NM. The plot of the adsorbent dosage against percentage removal is shown in Fig. 6.6. The elimination percentage increases from 82.25% to 87.75 % and the gradually declines with an increase in dosage of between 0.1 g/l to 0.5 g/l. This shows that the ideal dosage is 0.2 g/l.

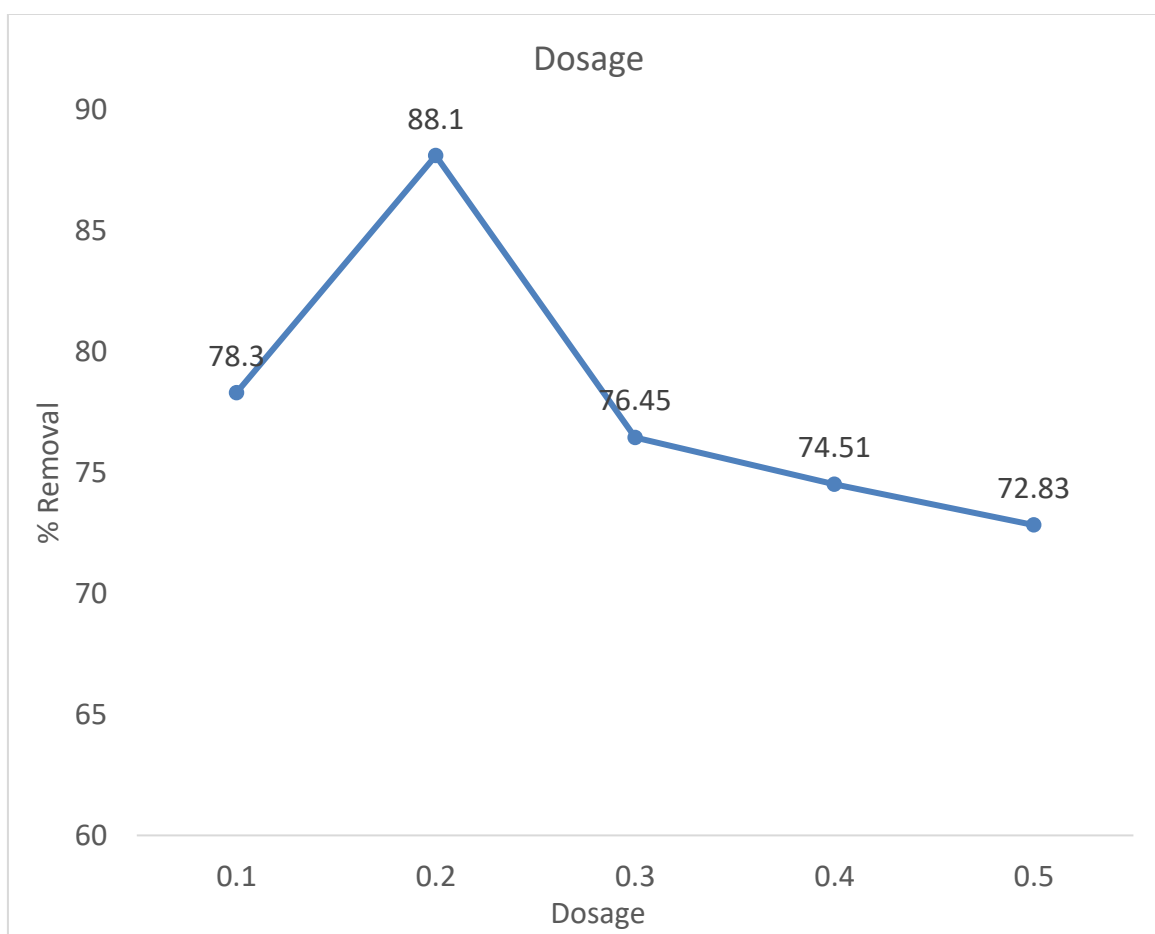


FIG 5.13 EFFECT OF DOSAGE ON ACID BLUE 9 DYE REMOVAL BY PP-NM (VOLUME = 100 ml, TIME = 30 mins, CONCENTRATION = 20mg/l, TEMP = 305.15 K, Ph = 4, OPTIMUM DOSAGE = 0.2g/l FOR 87.75% REMOVAL)

5.13 Langmuir Isotherm model

The Langmuir isotherm is a fundamental tool for characterizing adsorption processes on adsorbents. The Langmuir isotherm is a mathematical model used to describe the relationship between the concentration of a gas or solute (adsorbate) and the amount adsorbed onto a solid surface (adsorbent) at equilibrium.

The Langmuir Isotherm equation is

$$q_e = \frac{q_m K_L C_e}{1 + K_L C_e} \quad (1)$$

and the equilibrium parameter is given by Equation

$$R_L = \frac{1}{1 + K_L C_0} \quad (2)$$

Where, K_L is the Langmuir constant associated with the affinity of the dye to the adsorbent (L/mg),

q_e is the equilibrium adsorption amount of dye adsorbed on adsorbent (mg/g),

$q_{\max}$ is the maximum monolayer adsorption amount of dye adsorbed onto adsorbent (mg/g), and

C_0 (mg/L) and C_e (mg/L) are the initial and equilibrium concentration of dye solution, respectively.

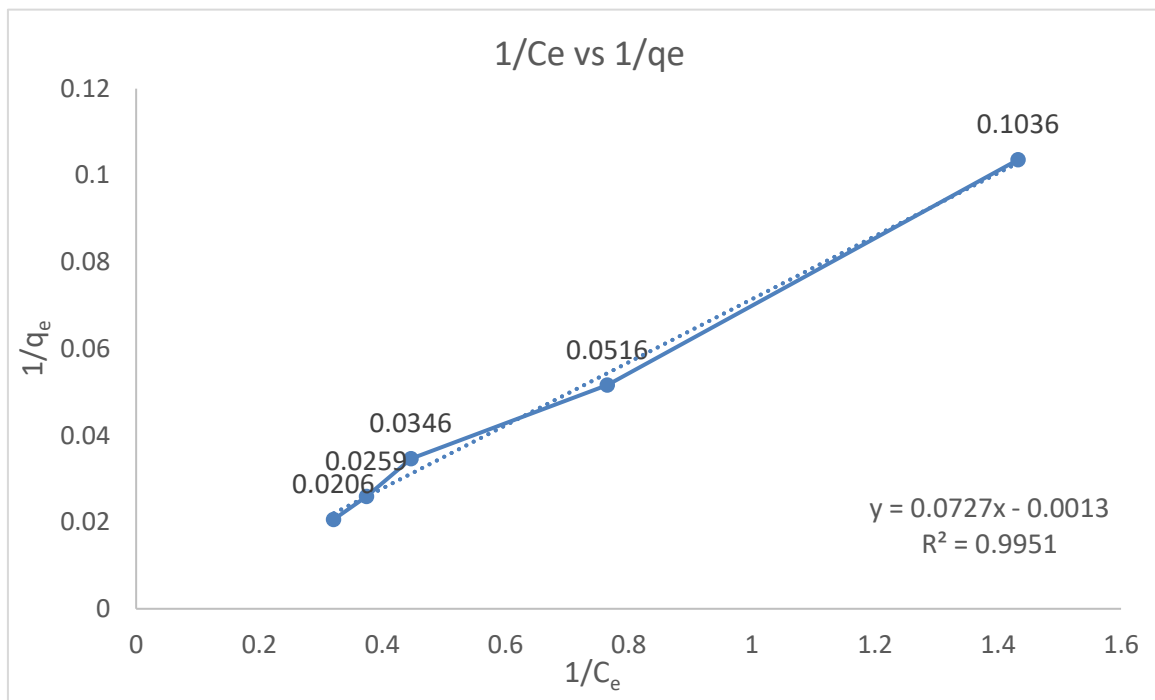


FIG 5.14 Langmuir isotherm for removal of Acid Blue 9 dye by PP-NM

5.14 FREUNDLICH ISOTHERM MODEL:

The Freundlich isotherm is a mathematical model used to describe the relationship between the concentration of a gas or solute (adsorbate) and the amount adsorbed onto a solid surface (adsorbent) at equilibrium. The Freundlich isotherm is typically represented by the following equation:

$$y = K_f * x^{(1/n)} \quad (3)$$

Where:

- **y (mg/g):** Represents the amount of adsorbate adsorbed per gram of adsorbent at equilibrium, measured in milligrams per gram (mg/g).
- **K_f ((mg/g) (Lⁿ)/mg):** Represents the Freundlich constant, which reflects a combination of the adsorption capacity and the intensity of the adsorption process. A higher K_f value indicates a higher overall adsorption capacity.
- **x (mg/L):** Represents the equilibrium concentration of the adsorbate remaining in the solution after interacting with the adsorbent, measured in milligrams per litre (mg/L).
- **n (dimensionless):** Represents the Freundlich exponent, which indicates the favorability of the adsorption process.

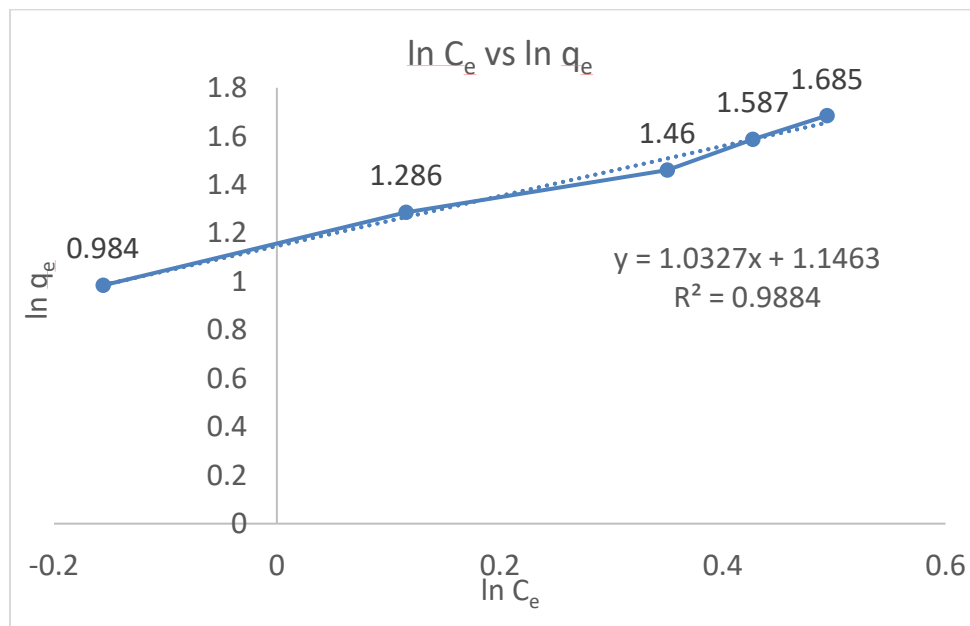


FIG 5.15 Freundlich Adsorption isotherm for removal of Acid Blue 9 dye by PP-NM

5.15 TEMKIN isotherm model:

The Temkin isotherm offers another perspective on describing the relationship between the concentration of a gas or solute (adsorbate) and the amount adsorbed onto a solid surface (adsorbent) at equilibrium

The Temkin isotherm is typically represented by the following equation:

$$q = KT * e (b * \epsilon) \quad (4)$$

Where:

- **q (mg/g):** Represents the amount of adsorbate adsorbed per gram of adsorbent at equilibrium, measured in milligrams per gram (mg/g). This is often used instead of y to distinguish it from the Langmuir and Freundlich notations.
- **KT (L/mol):** Represents the Temkin equilibrium binding constant, which is related to the maximum binding energy between the adsorbate and the adsorbent. A higher KT value indicates a stronger overall attractive force between the adsorbate and the surface.
- **b (RT/b):** Represents the Temkin isotherm constant, which is related to the heat of adsorption. It's a complex term involving the universal gas constant (R), temperature (T), and another constant (b). A positive b value suggests that the heat of adsorption decreases with increasing surface coverage (repulsive interactions dominate), while a negative b value indicates an increase in heat of adsorption with coverage (attractive interactions prevail).
- **$\epsilon (\ln(C_e))$:** Represents the logarithm of the equilibrium concentration of the adsorbate in the solution (C_e) in units of $\ln(\text{mg/L})$.

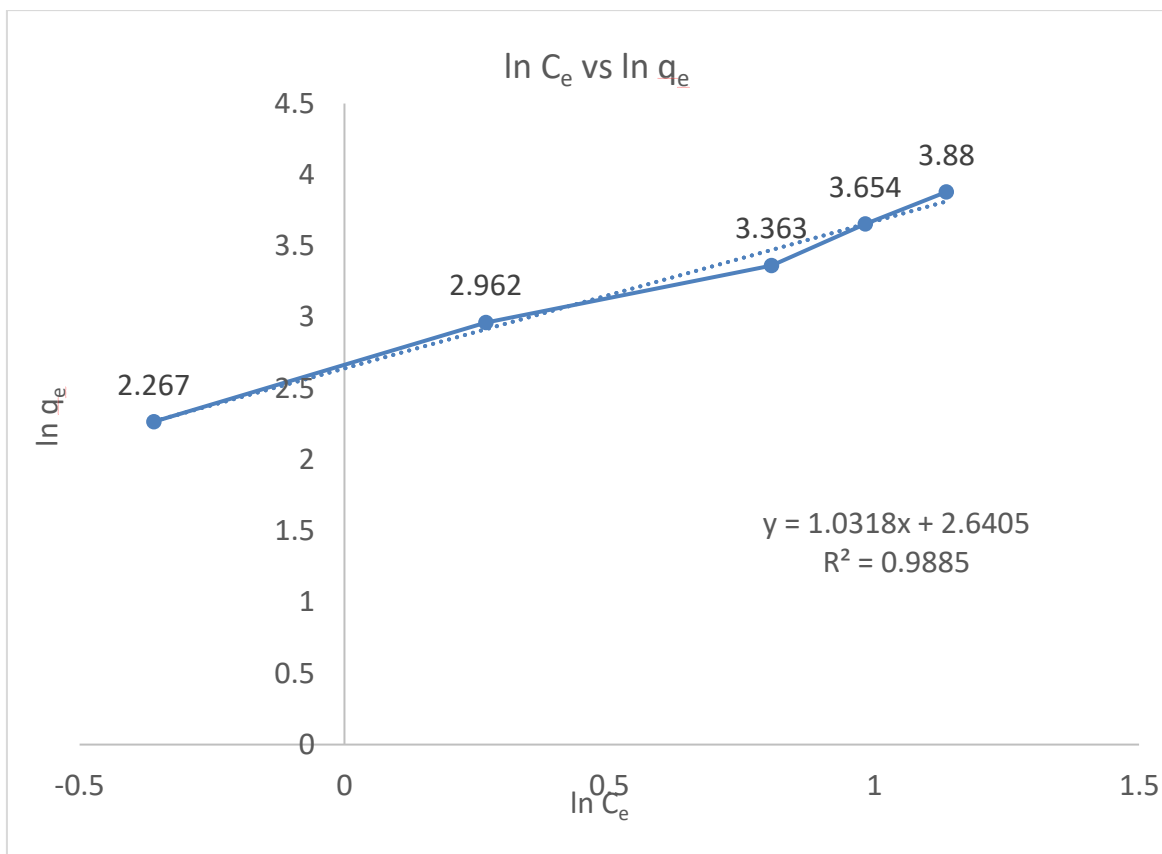


FIG 5.16 Temkin Adsorption Isotherm for removal of Acid Blue 9 dye by PP-NM

TABLE 5.3 Isotherm Model Comparison

Isotherm model	Intercept	Slope	R ²
Langmuir	0.0013	0.0727	0.9951
Freundlich	1.1463	1.0327	0.9884
Temkin	2.6405	1.0318	0.9885

On Comparing various isotherm models such as Langmuir, Freundlich and Temkin, it is evident that Langmuir isotherm model best fits the adsorption model. Also, the R² value of Langmuir isotherm model was found to be 0.9951 which is almost close to 1 stating Langmuir isotherm. This indicates that the adsorption of Acid Blue 9 dye using PP-NM follows monolayer adsorption. This can be backed by data obtained from BET which indicates even pore distribution that expand during adsorption and contract during desorption.

5.16 PSEUDO FIRST ORDER REACTION

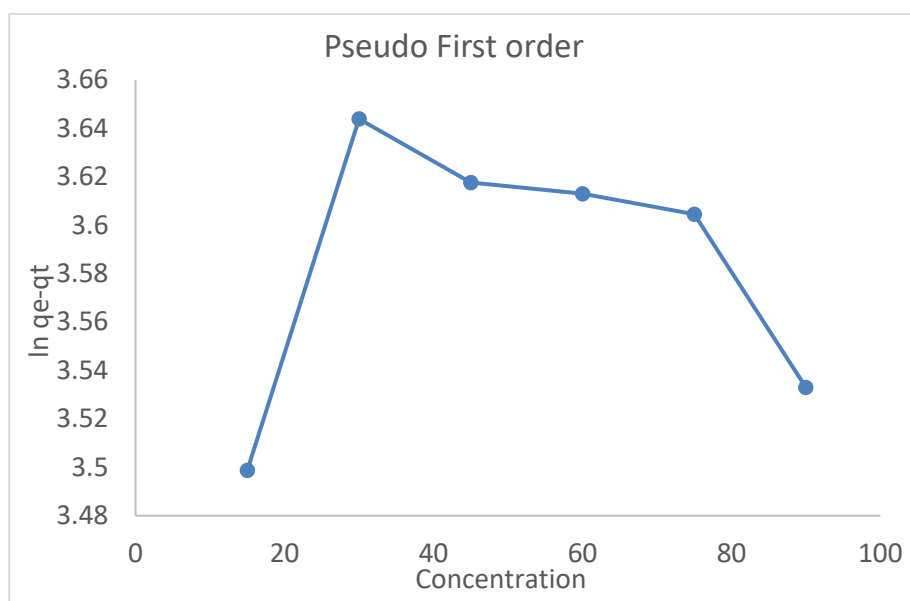


FIG 5.17 PSEUDO FIRST ORDER KINETICS

5.17 PSEUDO SECOND ORDER

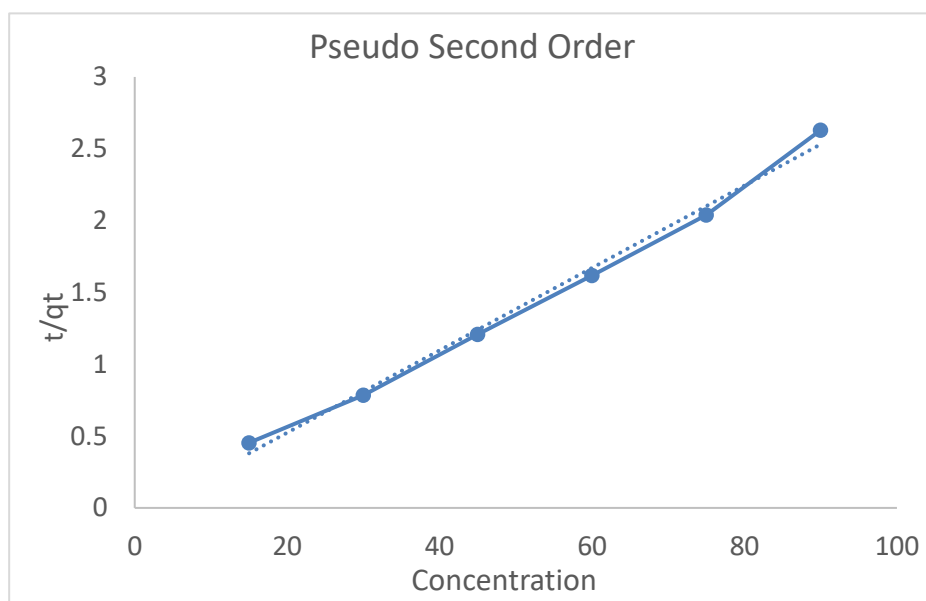


FIG 5.18 PSEUDO SECOND ORDER KINETICS

The adsorption of dye from the solution can be treated as reversible process where equilibrium can be achieved between the solution and adsorbent. By calculating the values for different parameters, Pseudo first and second orders can be studied. From the graph we can conclude that the adsorption process likely to follow Pseudo second order.

CHAPTER 7

CONCLUSION

Magnetic nano particles are materials that can remove contaminants from water. The results of this study found an alternative magnetic sorbent MNP- PP as an efficient absorber for the removal of acid blue 9 dye from wastewater. Using SEM, the surface morphology was investigated. FTIR was used to characterize the MNP-PP. Pomegranate peel powder was used as an alternative biosorbent to synthetic dyes. The acid blue 9 (dye) removal percentage was 88.42% at optimum conditions studied were pH 4, 30 minutes contact time, 20 mg/L, 125 μm size and 0.2 g/L dosage which was considered high for untreated material. The characterization done after adsorption with FTIR indicates the broadening of peaks due to molecular interaction, SEM indicates the decrease in pore size due dye uptake by nano particles and EDX detected the changes in Elemental composition. Producing biosorbent using green technology is necessary for the market in order contain procedure expenses. The removal of synthetic dyes (acid blue 9) from aqueous solutions using pomegranate peel powder has been demonstrated to be an effective alternative and reasonably priced biosorbent. Overall, the research using magnetic nano particles as adsorbents for removal of dye from aqueous solutions show compelling advantages over conventional adsorbents like activated carbon, including affordability, reusability and improved selectivity.

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**REMOVAL OF Eriglaucine-Disodium-salt USING MNP IMPREGNATED
WITH MEGRANATE PEEL CHARACTERIZATION AND APPLICATION
STUDIES**

¹ Submitted in partial fulfilment 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)

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BONAFIDE CERTIFICATE

This is to certify that this project report is a bonafide work of **SATHISH B (40190024)** and **SYED MOHAMMED SUHAIL (40190027)** who carried out the project entitled "REMOVAL OF Eriglucine-Disodium-salt USING MNP IMPREGNATED WITH POMEGRANATE PEEL CHARACTERIZATION AND APPLICATION STUDIES" under my supervision from MARCH 2023 to APRIL 2023.

DR. D. PRABHU, M.S(By Research), Ph.D.,
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Submitted for viva voce Examination held on

INTERNAL EXAMINER

EXTERNAL EXAMINER

DECLARATION

I, SATHISH B (40190024) and SYED MOHAMMED SUHAIL(40190027) hereby declare that the Project Report is the bonafide work of entitled **“REMOVAL OF Eriglaucine-Disodium-salt USING MNP IMPREGNATED WITH POMEGRANATE PEEL CHARACTERIZATION AND APPLICATION STUDIES”** done by us under the guidance of **Dr.D.Prabu, M.S (By Research), Ph.D.**, is submitted in partial fulfilment of the requirements for the award of Bachelor of Technology degree in **CHEMICAL ENGINEERING.**

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ABSTRACT

In recent years, the environmental impact of synthetic dyes has garnered significant attention due to their persistence in water bodies and potential harm to ecosystems and human health. This study explores the potential of utilizing pomegranate peel-derived magnetic nanoparticles (MNPs) impregnated with pomegranate peel (PP) for the removal of acid blue dye from aqueous solutions. The synthesis of PP-MNPs involved a facile and eco-friendly approach, making use of pomegranate peel extract as both a reducing and stabilizing agent, thereby eliminating the need for toxic chemicals.

The characterization of the synthesized PP-MNPs was conducted using various techniques including scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD), and Fourier-transform infrared spectroscopy (FTIR). The results indicated the successful formation of spherical MNPs with a crystalline structure, and the presence of functional groups from the pomegranate peel extract on the nanoparticle surface.

Batch adsorption experiments were performed to evaluate the adsorption efficiency of PP-MNPs towards acid blue dye under different experimental conditions such as initial dye concentration, pH, contact time, and temperature. The results revealed that PP-MNPs exhibited high adsorption capacity and rapid kinetics for the removal of acid blue dye, with equilibrium reached within a short period.

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The adsorption process was found to follow pseudo-second-order kinetics and Langmuir isotherm model, suggesting monolayer adsorption onto a homogeneous surface. Furthermore, thermodynamic studies indicated that the adsorption of acid blue dye onto PP-MNPs was spontaneous and endothermic in nature.

Overall, the findings of this study demonstrate the promising potential of pomegranate peel-derived MNPs impregnated with pomegranate peel as an effective and eco-friendly adsorbent for the removal of acid blue dye from aqueous solutions. This approach not only offers a sustainable solution for dye wastewater treatment but also adds value to agricultural waste by repurposing pomegranate peel into a valuable resource for environmental remediation.

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35 CHAPTER 1

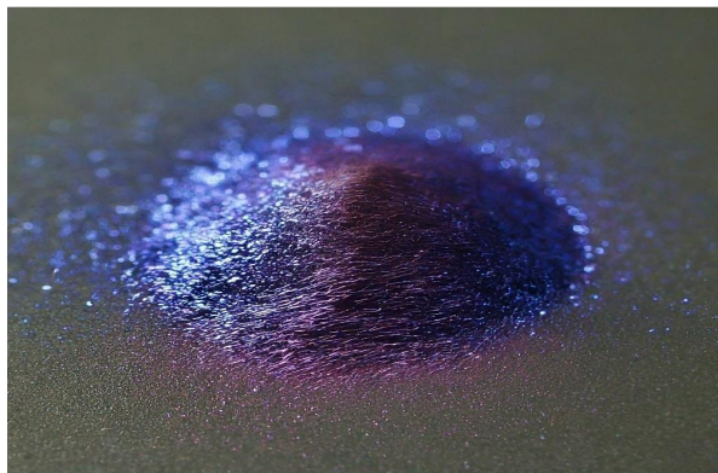
1 INTRODUCTION

1.1 BASIC INTRO

In recent years, the pollution caused by synthetic dyes discharged from various industries has become a significant environmental concern. Acid dyes, commonly used in textile, leather, and paper industries, are particularly problematic due to their persistence in water bodies and harmful effects on aquatic life. Efforts to mitigate this pollution have led to the exploration of natural and cost-effective methods for dye removal.

One promising approach involves the utilization of biomaterials such as pomegranate peel, which contains bioactive compounds capable of adsorbing dye molecules from aqueous solutions. Pomegranate (*Punica granatum* L.) is widely recognized for its antioxidant properties and rich content of polyphenols, making it an attractive candidate for environmental remediation applications.

Furthermore, the modification of pomegranate peel with magnetic nanoparticles (MNP) enhances its adsorption capacity and facilitates the separation of the adsorbent from the treated solution through magnetic field manipulation. This synergistic combination of natural adsorbent and magnetic nanoparticles offers an efficient and eco-friendly solution for the removal of acid dyes from wastewater.



This study aims to investigate the adsorption efficiency of pomegranate MNP impregnated with pomegranate peel for the removal of acid blue dye from aqueous solutions. By examining the adsorption kinetics, isotherms, and influencing factors such as pH and initial dye concentration, valuable insights can be gained into the effectiveness of this novel adsorbent for dye removal. Introduction

The findings of this research could contribute to the development of sustainable and cost-effective strategies for wastewater treatment, addressing both environmental concerns and the growing demand for cleaner water resources. Furthermore, the utilization of agricultural by-products like pomegranate peel highlights the potential for transforming waste into valuable resources, promoting a circular economy and sustainable development.

1.1. Environmental Impact of Synthetic Dyes*

The widespread use of synthetic dyes in various industries, including textiles, leather, and paper, has resulted in their significant presence in the environment. These dyes are often discharged into waterways through industrial effluents. Their presence poses several environmental concerns:

- * **Aesthetic Deterioration:** Dyes significantly alter the aesthetic qualities of water bodies, turning them an unpleasant color that discourages recreational activities.
- * **Reduced Light Penetration:** Light penetration is crucial for photosynthesis by aquatic plants and algae, forming the base of the aquatic food chain. Dyes significantly hinder this process, disrupting the entire ecosystem.
- * **Aquatic Toxicity:** Certain dyes, including Acid Blue 9 (AB9), exhibit some level of toxicity to aquatic life, especially at high concentrations. Studies have shown disrupted feeding behavior, reduced growth, and even mortality in exposed organisms.
- * **Persistence and Bioaccumulation:** The complex structure of dyes like AB9 makes them resistant to natural biodegradation, leading to their accumulation in the environment over time. This persistence allows for potential magnification of their effects within the food chain.
- * **Inefficient Wastewater Treatment:** Conventional wastewater treatment methods often struggle to remove dyes from industrial effluents. This leads to their release into waterways, further exacerbating environmental contamination.

Need for Sustainable Solutions*

The environmental hazards associated with synthetic dyes necessitate the development of sustainable and efficient dye removal technologies. Traditional methods often rely on expensive chemicals or generate hazardous byproducts. This research explores a biomaterial-based approach utilizing an innovative adsorbent: magnetic nanoparticles impregnated with pomegranate peel activated carbon (M-PPAC).

Advantages of M-PPAC*

M-PPAC offers several advantages for dye removal:

- * **Biomaterial Utilization:** Pomegranate peel, a readily available agricultural byproduct, serves as the base material. This not only reduces waste but also leverages its natural properties for dye adsorption.

- * **High Polyphenol Content:** Pomegranate peels are rich in polyphenols, known for their ability to bind with dye molecules. This inherent property makes them well-suited for dye removal applications.

- * **Magnetic Nanoparticle Integration:** Modifying the pomegranate peel with magnetic nanoparticles (MNPs) offers additional benefits:

- * **Enhanced Adsorption Capacity:** MNPs provide additional surface area for dye molecule adsorption, potentially increasing the overall removal efficiency.

- * **Magnetic Separation:** After treatment, the magnetic properties of the MNPs allow for easy separation of the adsorbent from the treated solution using an external magnetic field. This simplifies the recovery and reuse of the adsorbent, making the process more cost-effective.

In recent years, researchers have embarked on a quest for innovative and responsible adsorbents and techniques to tackle AB9 removal. This journey has led them to explore two promising avenues:

- * **Harnessing the Power of Activated Carbon:** Activated carbon has established itself as a cornerstone in the realm of adsorption due to its remarkable properties. Its highly porous structure, characterized by a network of microscopic pores and cavities, provides an extensive surface area. This vast expanse serves as a battleground for dye molecules, creating numerous "active sites" where they can be captured and

immobilized. The high ¹³ surface area of activated carbon allows for the adsorption of large quantities of dye molecules, making it a potent weapon in the fight against dye pollution.

* *Unlocking Potential in Agricultural Byproducts:* The quest for sustainable solutions has led researchers to explore the potential of agricultural waste materials for activated carbon production. One such material gaining significant attention is pomegranate peel, a byproduct generated in abundance by the pomegranate juice industry. Pomegranate peels offer a compelling advantage: their transformation from waste into a valuable resource contributes to a circular economy. This approach not only reduces waste generation but also provides a cost-effective and eco-friendly source material for activated carbon production.

The activation process itself is a fascinating dance between removing unwanted impurities and creating the desired porous structure. This process can be achieved through two primary methods: ¹³ physical and ¹⁸ chemical activation. Physical activation typically involves exposing the material to high temperatures under an inert atmosphere, causing the decomposition of internal structures and the formation of pores. ¹⁴ Chemical activation, on the other hand, utilizes chemical reagents like ¹⁵ potassium hydroxide (KOH) to achieve the same goal. The specific activation method chosen depends on the desired properties of the final activated carbon product.

Adding another layer of innovation to the mix are magnetic nanoparticles. These tiny warriors, often composed of iron oxide, possess a unique superpower: their ability to be manipulated by an external magnetic field. This characteristic has revolutionized the field of wastewater treatment. When magnetic nanoparticles are incorporated with activated carbon, a powerful synergy emerges. The activated carbon still provides its vast surface area for dye adsorption, while the magnetic nanoparticles act as microscopic magnets, attracting and binding additional dye molecules. This combined approach can significantly enhance the overall adsorption capacity of the material.

Perhaps the most significant benefit of incorporating magnetic nanoparticles lies in their ease ⁷ of separation from the treated wastewater. Following the adsorption process, an external magnetic field can be applied to the solution. The magnetic nanoparticles, along with the adsorbed dye molecules, readily respond to the field and are drawn towards the magnet. This simple yet powerful separation technique eliminates the need for complex filtration processes and allows for the easy recovery

and potential reuse of the adsorbent, further promoting sustainability and cost-effectiveness.

In conclusion, the search for effective and sustainable methods to remove AB9 dye from wastewater has led researchers down a path of continuous innovation. The combination of activated carbon derived from agricultural waste like pomegranate peel, and the strategic integration of magnetic nanoparticles, offers a promising solution. This approach leverages the remarkable properties of both materials, resulting in an efficient, cost-effective, and environmentally friendly weapon in the fight for cleaner water. It is a testament to scientific ingenuity and its potential to address environmental challenges through sustainable practices.

¹³ Activated carbon is a widely used adsorbent due to its high surface area and porosity, which provide ample active sites for the adsorption of contaminants. Pomegranate peel, a byproduct of pomegranate juice processing, has been identified as a promising precursor for activated carbon production due to its abundance and potential to reduce waste. The activation process involves the removal of impurities and the development of a porous structure through physical or chemical methods.

Magnetic nanoparticles, such as iron oxide nanoparticles, ²⁰ have gained attention in recent years for their ability to be easily separated from a solution using an external magnetic field. When combined with activated carbon, magnetic nanoparticles can enhance ⁴¹ the adsorption capacity and facilitate the recovery of the adsorbent from the treated wastewater, thus improving the overall efficiency of the process.

Acid Blue 9 dye is a versatile colorant with a variety of applications across different industries. This report explores the key uses of this synthetic dye.

Textile Industry:

- **Primary Application:** Acid Blue 9 finds its most prominent use in dyeing textiles made from protein fibers like wool and silk. It can also be used for dyeing nylon and fabrics containing nylon blends.
- **Dyeing and Printing:** The dye can be employed for both dyeing and printing processes on these fabrics. It imparts a vibrant blue color with a greenish tinge.

Food Industry (Limited Use):

- **Specific Applications:** In some regulated cases, Acid Blue 9 is approved for use as a food colorant under the designation FD&C Blue No. 1. However, its application in food is limited due to potential safety concerns.

Other Applications:

- **Paper Coloring:** Acid Blue 9 can be used as a coloring agent in the paper industry to create blue-toned paper products.
- **Leather Coloring:** The dye finds application in coloring leather products, providing a blue hue.
- **Plastics Coloring:** In specific instances, Acid Blue 9 can be used to color certain types of plastics.

Factors Influencing Applications:

- **Material Compatibility:** The suitability of Acid Blue 9 for an application depends on the material's ability to absorb and retain the dye effectively.
- **Desired Color:** The blue color with a greenish cast provided by Acid Blue 9 may not be suitable for all applications where a pure blue color is desired.
- **Safety Regulations:** The use of Acid Blue 9 in food items is subject to strict regulations due to potential health concerns.

Conclusion:

Acid Blue 9 dye serves as a valuable colorant in various industries, particularly the textile sector. Its vibrant blue color and good dyeing properties make it a popular choice. However, considerations regarding material compatibility, desired color shade, and safety regulations are crucial when determining its suitability for specific applications.

1.2 POMEGRANATE PEEL

Pomegranate peel is the outer layer of the pomegranate fruit, which is often discarded before eating the juicy arils. The peel is a rich source of nutrients and antioxidants, including polyphenols and flavonoids. Studies have found that pomegranate peel contains compounds such as tannins and flavonoids, which can bind with heavy metals and remove them. The use of pomegranate peel as an adsorbent for heavy metals removal has several advantages, including its low cost, availability, and eco-friendly. However, more research is needed to optimize the process and to investigate the feasibility of using pomegranate peel in large scale.

Pomegranate, a fruit cherished for its vibrant red arils, possesses a hidden treasure – its peel. Often discarded as waste, pomegranate peel holds remarkable potential in environmental cleanup, particularly for removing heavy metals from water. This readily available and cost-effective resource offers a sustainable solution to a growing environmental concern.

Pomegranate peels are not just a fibrous casing; they are brimming with valuable compounds. Studies have revealed a rich tapestry of minerals and antioxidants, including:

- **Polyphenols:** These powerful antioxidants are known for their ability to bind with and neutralize harmful free radicals. In the context of heavy metal removal, polyphenols act as chelating agents, forming complexes with metal ions, effectively rendering them less mobile and toxic.
- **Flavonoids:** Another class of antioxidants present in pomegranate peels, flavonoids contribute to their metal-binding capacity. They possess functional groups that readily interact with metal ions, facilitating their removal from the aqueous environment.
- **Tannins:** These naturally occurring astringent compounds play a crucial role in heavy metal adsorption. Tannins have multiple binding sites that can effectively capture and immobilize metal ions within their complex structures.

- The MNP impregnated with PP have shown great promise in removing heavy metal from contaminated water and soil.
- This method offers eco-friendliness, selectivity, and cost-effectiveness, while the magnetic properties simplify material recovery. It holds promise for addressing heavy metal contamination and promoting environmentally conscious water treatment practices.

The Allure of Sustainability:

The traditional methods for heavy metal removal often rely on expensive and energy-intensive processes that can generate harmful byproducts. Pomegranate peel offers a compelling alternative due to its inherent advantages:

- **Cost-Effectiveness:** Being an agricultural byproduct readily available in large quantities, pomegranate peel eliminates the need for expensive synthetic adsorbents.
- **Environmental Friendliness:** Utilizing a natural material minimizes the environmental footprint associated with wastewater treatment compared to conventional methods.
- **Abundant Resource:** The widespread cultivation of pomegranates ensures a readily available source of raw material for large-scale treatment applications.

Pomegranate peel, often relegated to the waste bin, emerges as a powerful ally in the fight against heavy metal pollution. Its natural bounty of chelating agents and its readily available nature make it a sustainable and cost-effective solution for environmental remediation. By harnessing the potential of this natural resource, we can move towards cleaner water and a healthier planet.

CHAPTER 2

2 LITERATURE SURVEY

1. ⁵ Musaab K. Rashed and Wissam Tayh (2020) - ⁵ Removal of Heavy metal from wastewater using Pomegranate peel
 - ⁵ Research was undertaken to evaluate the ability of pomegranate peel in removing heavy metals from wastewater.
 - ⁵ The effect of contact duration, initial concentration of metal ion and weight of adsorbent on the percentage of heavy metal removal were investigated.
 - It was found that nearly 80% of heavy metal were removed from wastewater.
2. A. Hashem, Chukwunonso O. Aniagor , Sayed M. Badawy (2022) – ²⁴ Characterization and Adsorption of raw Pomegranate peel powder for lead (II) removal
 - The adsorption potential of raw pomegranate peel was investigated via batch mode.
 - ² This study shows that lead ions could be efficiently removed using raw pomegranate peel powder.

1. **Adsorption Mechanism:** Magnetic nanoparticles can be functionalized with pomegranate peel components (e.g., tannins) that have shown potential for metal ion adsorption. The mechanism may involve chemical interactions and surface binding of Cu²⁺ ions to active sites on the pomegranate peel.

2. **Magnetic Separation:** The advantage of using magnetic nanoparticles is their easy recovery using a magnetic field after adsorption. This facilitates the separation of the adsorbent from the treated water, making it a practical and reusable method.

3. **Optimization:** The effectiveness of this method would depend on factors like the size and surface area of the nanoparticles, the concentration of pomegranate peel impregnated, and the pH of the solution. Optimization experiments would be

necessary to determine the ideal conditions.

4. **Environmental Benefits:** Pomegranate peel is a natural waste product, so utilizing it for water treatment could be environmentally friendly. However, it's important to ensure that the final disposal of the used adsorbent is also environmentally responsible.

5. **Competing Technologies:** Compare this method with other established techniques for removing Cu^{2+} ions, such as ion exchange, chemical precipitation, or activated carbon adsorption, to determine its competitiveness.

6. **Cost Analysis:** Consider the cost of producing and regenerating the impregnated nanoparticles compared to the benefits in terms of Cu^{2+} ion removal.

1. **Industrial Wastewater Treatment:** This method can be applied in industries with copper-contaminated wastewater, such as mining, electronics manufacturing, and metal plating. It provides an eco-friendly and cost-effective way to reduce copper levels before discharge.

2. **Municipal Water Treatment:** It can be incorporated into municipal water treatment facilities to remove trace amounts of copper from drinking water sources, ensuring compliance with water quality standards.

3. **Agricultural Runoff Remediation:** In agricultural areas where copper-based pesticides or fertilizers are used, this technology can help mitigate copper contamination in runoff water, preventing damage to aquatic ecosystems.

4. **Groundwater Remediation:** Contaminated groundwater sources, often polluted with heavy metals like copper, can benefit from this approach to restore water quality for consumption and ecological health.

6 CHAPTER 3

3. AIM AND SCOPE

3.1 AIM

- Synthesis of POMEGRANATE PEEL impregnated Magnetic Nanoparticle
- Characterization of POMEGRANATE PEEL impregnated Magnetic Nanoparticle
- Removal of heavy metals from wastewater using pomegranate peel impregnated nanoparticles.

3.2 SCOPE

- To make an approach that offers an effective and eco-friendly method for the removal of Cu^{2+} ions from water sources, addressing environmental pollution concerns associated with heavy metal contamination.
- To utilize agricultural waste (pomegranate peel) as a valuable resource, contributing to waste reduction and sustainable practices in agriculture and water treatment.
- To check MNP impregnated PP natural adsorption properties can be tailored to selectively target Cu^{2+} ions, making it suitable for treating specific sources of contamination.
- To make the use of magnetic nanoparticles simplifies the separation process and allows for the recovery and potential reuse of the impregnated material, making it cost-effective and efficient.

CHAPTER 4

4. MATERIALS AND METHOD

The following materials are used to synthesize magnetic nanoparticles of pomegranate peel.

4.1 MATERIALS

- Pomegranate peel was collected from fresh juice shop at local market in Puducherry.

4.1.1 Chemicals Required

- Hydrochloric Acid (HCl)
- Ferric Chloride (FeCl_3)
- Ferric Sulphate ($\text{Fe}_2(\text{SO}_4)_3$)
- Ammonium Hydroxide (NH_4OH)
- Ethanol ($\text{C}_2\text{H}_5\text{OH}$)
- Distilled Water

4.2.2 EQUIPMENT REQUIRED

- Muffle Furnace
- Hot Air Oven
- Burette
- Hot Plate Magnetic Stirrer
- Rotary Shaker

4.2.1 DRYING OF POMEGRANATE PEEL

- Pomegranate peel was collected, and rinsed twice with tap water, then with deionized water, to remove dust.
- The wet sugarcane bagasse was then sun-dried for 10 to 14 days.

4.2.2 PREPARATION OF POMEGRANATE PEEL ACTIVATED CARBON

- Collecting pomegranate peels : collect fresh pomegranate peel and wash neatly to remove contaminants for it
- Allow to dry for completely it should be wet inside
- The pomegranate peel cut into little pieces (approximately 3 cm) and placed in a small mud pot, sealed with clay and placed in a Muffle furnace for an hour at 400-500°C.



FIG 4.1 POMEGRANATE PEEL KEPT IN CLAY POT
After

- The Pomegranate peel powder from the clay pot was grounded into powder, sieved at $85\ \mu\text{m}$ and kept into powder jars for experimental usage.
- The pomegranate peel powder is activated by soaking it in distilled water and hydrochloric acid (HCl) for about 24 hours.



FIG 4.2 SOAKED POMEGRANATE PEEL

- After filtering the solution, the solid powder is thoroughly washed with distilled water. It is then dried in a muffle oven for one hour at 150°C to produce pomegranate peel activated carbon.

4.2.3 Impregnation Process

- The Activated Carbon is then impregnated with 2g of Ferric Chloride (FeCl_3), 1g of Ferric Sulphate ($\text{Fe}_2(\text{SO}_4)_3$) and 1g of the Pomegranate peel activated carbon.
- The conical flask is filled with all the solid components and placed inside a hot plate magnetic stirrer and 50 ml of distilled water were added to it.
- The mixture is then allowed to stir constantly for 15 minutes at a temperature of 40°C .

1. **Selection of MNPs:** High-quality MNPs with suitable magnetic properties are chosen for the process. These nanoparticles are typically composed of materials like iron oxide (Fe_3O_4) or magnetite.

2. **Combining MNPs and Pomegranate Peel Extract:** The extracted pomegranate peel solution is mixed with the MNPs. This can be done through techniques like co-precipitation, co-adsorption, or simply by immersing the MNPs in the extract.

3. **Stirring and Mixing:** The mixture is often stirred or sonicated to ensure uniform distribution of the pomegranate peel extract on the surface of the MNPs. This step facilitates the impregnation process.

4. **Drying and Solidification:** The impregnated MNPs are typically dried to remove excess solvent, leaving behind the impregnated pomegranate peel on the surface of the nanoparticles. This creates a solid composite material.



FIG 4.3 IMPREGNATION PROCESS

4.2.4 filtration and Drying

- After the co-precipitation, give it 15 minutes to cool. filter the sample now and then wash it with distilled water and Ethanol to prevent rusting.
- The Filtrate is then dried in Muffle Oven at 150°C for 30mins. The powdered particle is the Magnetic Nanoparticle impregnated with Pomegranate peel.



FIG 4.4 MAGNETIC NANOPARTICLE OF POMEGRANATE PEEL

4.2.5 Magnetic Separation

- Magnetic Attraction was checked using a Magnet.

4.3 Adsorption experiment

In a 250 mL Erlenmeyer flask, 100 mL of the wastewater was mixed with biosorbent at a pH of 3 and a dye concentration of 15 mg/L. The experiment was conducted at ambient temperature and 150 rpm on a multi-channel shaker. The sample was taken out and filtered using filter paper at predetermined contact times (10, 15, 30, 45, and 60 minutes). The 15th minute was chosen as the optimal contact period for the remainder of the adsorption studies.

Using a UV/VIS spectrophotometer, the absorbance of the supernatant was calculated at maximum wavelength 514 nm. The outcome was presented as a percentage of heavy metal elimination.

4.4 Characterization

Obtain small finely particles of pomegranate peel the sample should be in a uniform and representative

Fourier Transform Infrared (FTIR) analysis was applied to the magnetic nanoparticle of pomegranate peel to determine the surface functional groups and the spectra were recorded from 4000 to 400cm⁻¹.

Scanning electron microscopy (SEM) characterization is a method for examining the topography and morphology of the surface material of biosorbents. It is also used to analyze the biosorbent's porosity structure and particle shape.

Compare the obtained spectra with reference spectra or data to identify compounds present in it

It can provide valuable insight into the chemical composition of pomegranate peel

CHAPTER 5

5. Results

Characterization of prepared biosorbent

5.1. Fourier Transform Infrared (FTIR).

- The FTIR spectra of the native and loaded Magnetic nanoparticle of Pomegranate peel are presented in Figure 5.1
- The native PMPP sample exhibited a broad adsorption peak at 3421.10 cm^{-1} indicating the presence of bonded and free hydroxylic group due to O-H group vibration.
- The peak is observed at 2917 cm^{-1} corresponds to C-H stretching.
- So far, The FTIR discussions has established the existence of five major adsorption peak at 3421.10 cm^{-1} , 2917 cm^{-1} , 1699.22 cm^{-1} , 1400.37 cm^{-1} and 1056.60 cm^{-1} .

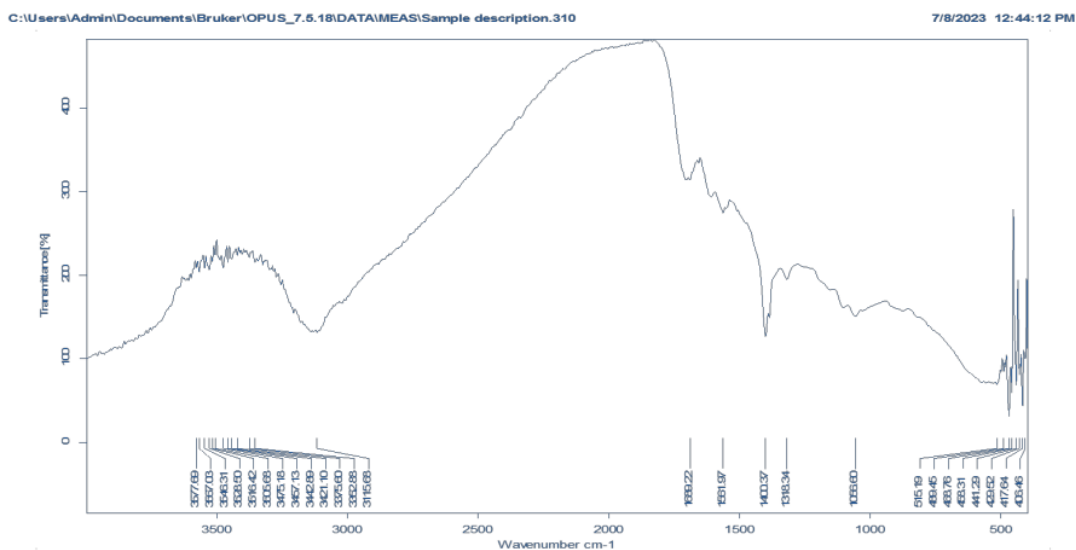


FIG 5.1 FTIR OF POMEGRANATE PEEL

5.2. Scanning electron microscopy (SEM).

- FIG 5.2 shows the morphology of the surface of native and loaded PMPP.
- The SEM micrograph shows a soft amorphous and heterogeneous structure of typical non-cellulosic content.
- Also, the absence of orientation and fibrous structure of cellulose and porosity was observed.

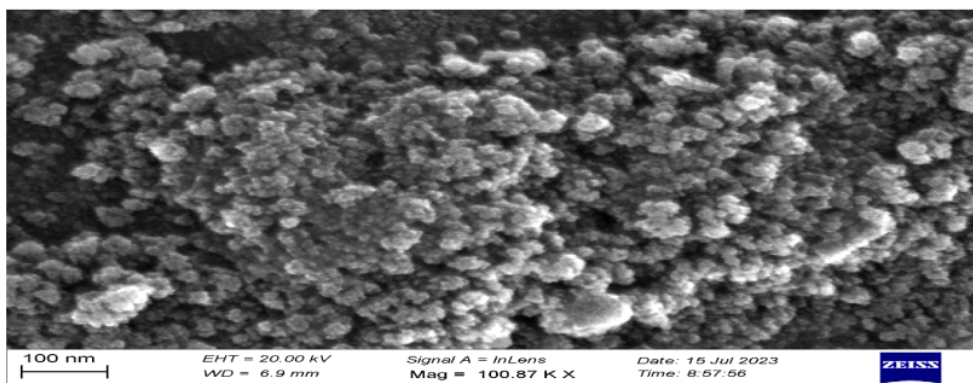
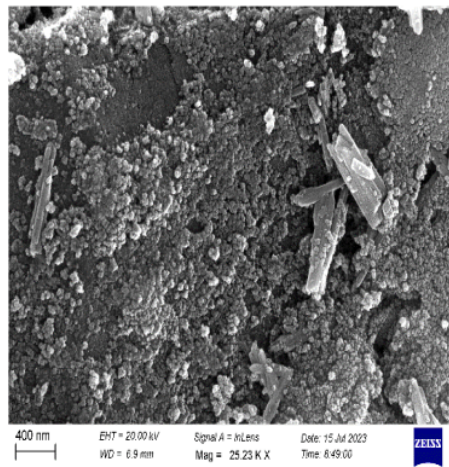
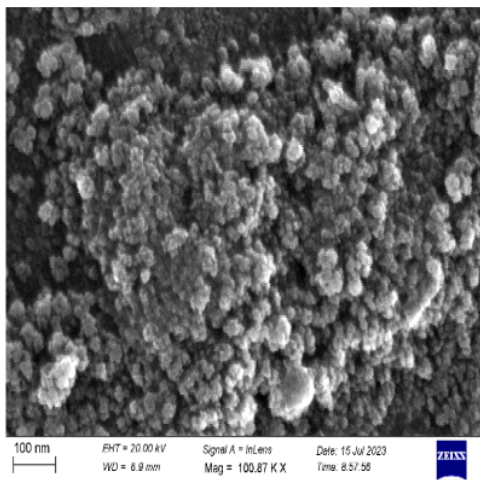
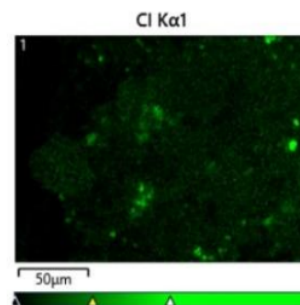
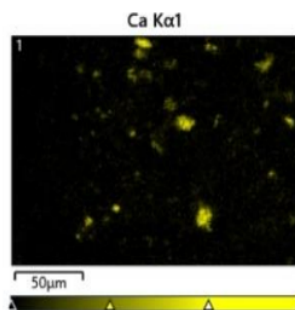
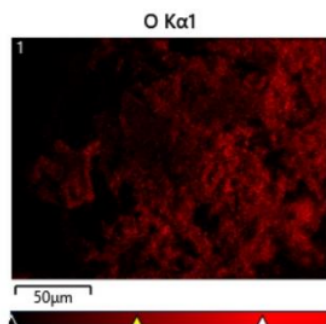
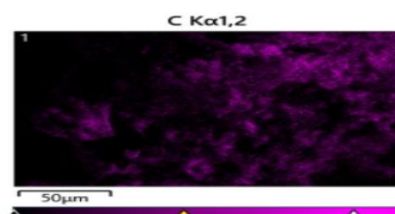
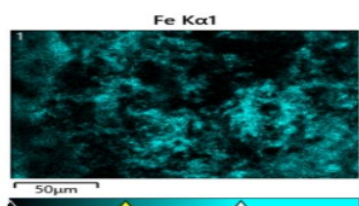
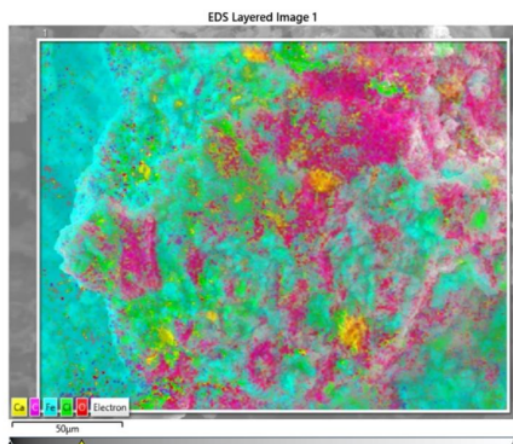
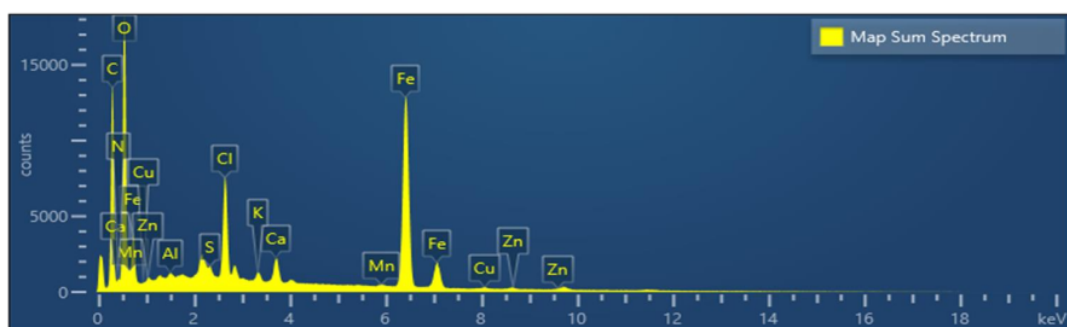


FIG 5.2 SEM MICROGRAPHS

5.3 Electron Dispersive X-Ray (EDX)





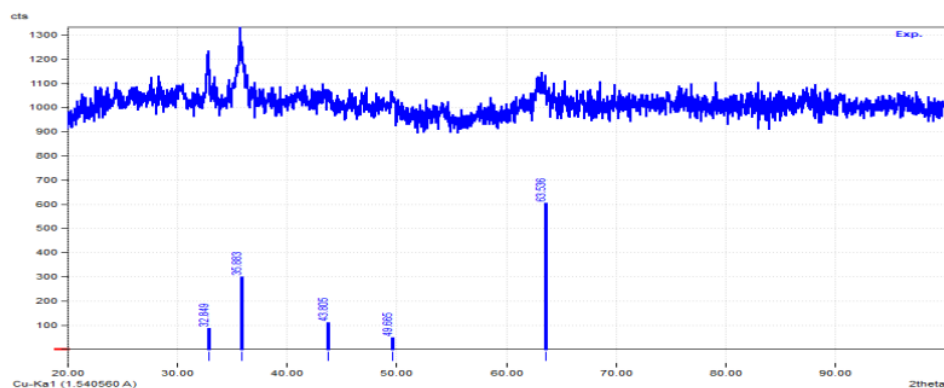
Map Sum Spectrum				
Element	Line Type	Weight %	Weight % Sigma	Atomic %
C	K series	43.29	0.31	58.61
N	K series	3.18	0.40	3.69
O	K series	29.69	0.21	30.17
Al	K series	0.13	0.01	0.08
S	K series	0.06	0.01	0.03
Cl	K series	2.58	0.02	1.18
K	K series	0.28	0.01	0.12
Ca	K series	0.84	0.02	0.34
Mn	K series	0.13	0.02	0.04
Fe	K series	19.23	0.13	5.60
Cu	K series	0.24	0.03	0.06
Zn	K series	0.35	0.04	0.09
Total		100.00		100.00

5.4 X-RAY DIFFRACTION

- XRD can also be used to analyze thin films, powders, and nanoparticles. The technique can be combined with other spectroscopic techniques such as XPS and FTIR to provide a more comprehensive understanding of the properties of a sample. Overall, XRD spectroscopy is a valuable tool for understanding the crystal structure and properties of materials, and it has numerous applications in research and industry.

SL.NO	Theta	d[A]	1/10(Peak height)	Counts (Peak area)	FWHM
1.	32.85	2.7242	853.82	83.02	0.3310
2.	35.88	2.5006	1000.00	295.91	1.0074
3.	43.80	2.0650	171.89	106.73	2.1139
4.	49.67	1.8341	314.52	45.04	0.4875
5.	63.54	1.4631	421.47	603.21	4.8722

- Peak at $2\theta = 35.7^\circ$: A prominent peak observed at $2\theta = 35.7^\circ$ corresponds to the crystallographic planes of iron oxide (Fe_2O_3), indicating the presence of magnetic nanoparticles in the impregnated material. This peak confirms the crystalline nature of the magnetic component.
- Amorphous Carbon Peak at $2\theta = 23.0^\circ$: A broad peak at $2\theta = 23.0^\circ$ is indicative of the amorphous carbon content derived from the pomegranate peel. The amorphous nature of this peak suggests the presence of organic matter.
- Absence of Copper Peaks: Notably, there are no discernible peaks

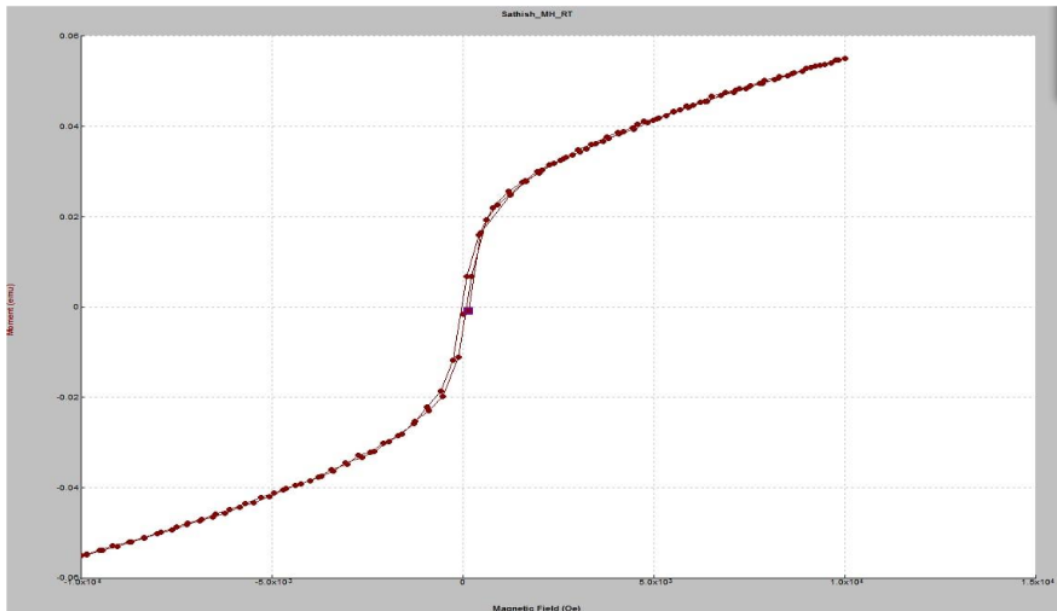


- corresponding to copper (Cu) phases, indicating successful adsorption of Cu^{2+} ions onto the impregnated material rather than their crystalline deposition.
 - Crystal Size Determination: By analyzing the width of the iron oxide peak at $2\theta = 32.85^\circ$ using Scherrer's equation, the crystallite size of the magnetic nanoparticles can be calculated, providing insights into the material's properties.
 - Overall Structure Confirmation: XRD results affirm the presence of both magnetic nanoparticles and amorphous carbon from pomegranate peel, validating the composition of the impregnated material designed for efficient Cu^{2+} ion removal.
-
- FIG 5.3 XRD GRAPH
 - This instrument is used to measure the magnetic properties of materials
 - Analyzing data from graph involves study of magnetic properties including their magnetization curves, hysteresis loop and other magnetic characteristics.

VSM: Vibrating sample magnetometer

- A strong and uniform magnetic field is applied to the sample. This magnetic field can be adjusted to various strengths and orientations.
- A strong and uniform magnetic field is applied to the sample. This magnetic field can be adjusted to various strengths and orientations.
- As the sample vibrates in the magnetic field, the magnetization of the sample is measured. The VSM records changes in the sample's magnetic moment as a function of the applied magnetic field.
- The collected data can be used to determine various magnetic properties of the sample, including its magnetic susceptibility, hysteresis loop, coercivity, remanence, and other parameters.

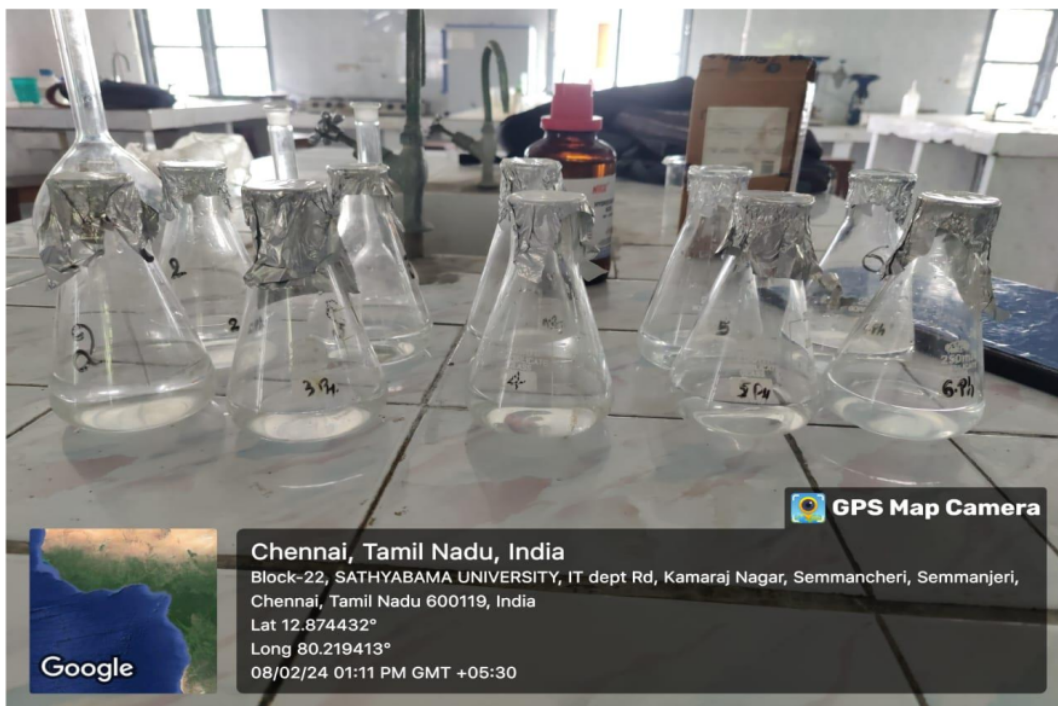
VSM RESULT:



studying the magnetic properties of materials such as ferromagnetic, antiferromagnetic, and paramagnetic substances. They are crucial tools in understanding the magnetic behavior of materials for applications in electronics, magnetism, and magnetic materials research.

ADSORPTION STUDIES:

- We are going to perform Adsorption studies
- Prepare Stock solution of 1000 ppm of cupric sulphate pentahydrate
- Now take 2ml of stock solution and add 98 ml of water to make 20 ppm of solution
- Now we need to check pH for 20 ppm of solution contain in 6 conical flask
- we got 5.88 PH for 20 ppm solution
- Now we need to change PH for 20 ppm solution (2,3,4,5,6,7)
- For changing PH we add 0.1M of HCL and 0.1 M of NaoH drop by drop to change PH of 20 ppm solution (In form Acidic and Base)

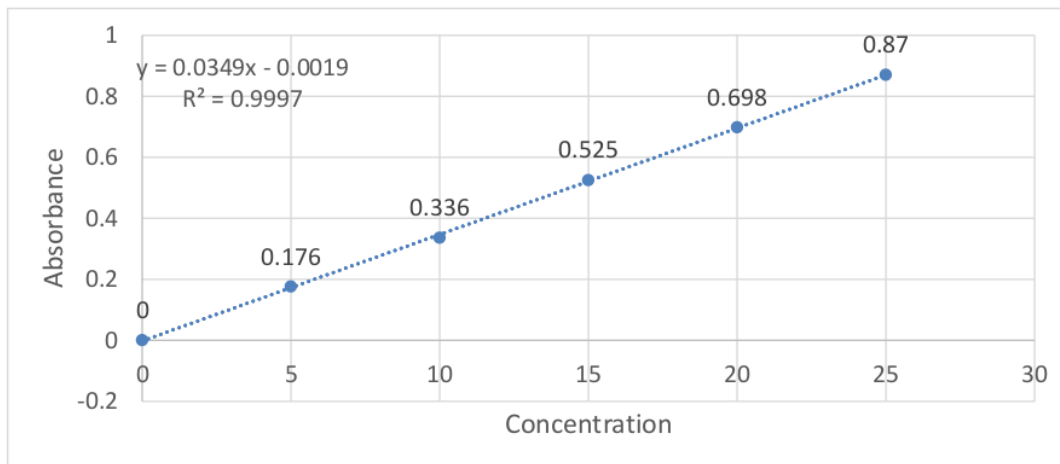


AFTER PREPARING 20 PPM OF SOLUTION WITH DIFFERENT PH (2,3,4,5,6,7)

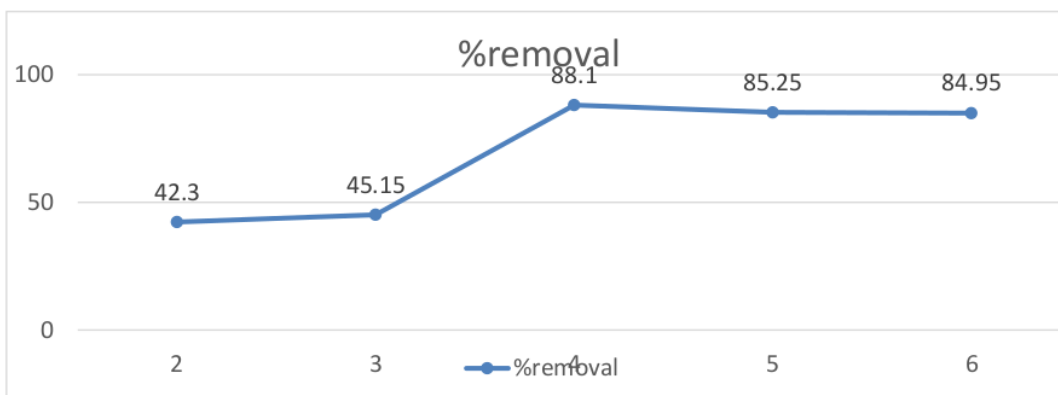
- Add 0.2g of adsorbent in each of prepared pH adjusted stock solution of 20 ppm.
- Cover it with Aluminum foil and keep it in rotary shaker for 6 hours.
- Take sample solution of 5 ml after every 15 minutes for first 2 hours and every 30 minutes for next two hours and one reading for upcoming every hour.
- The collected samples are the given to uvs (ultra-violet Spectroscopy) test to find optimum pH.



- **Calibration curve:** If you are referring to a calibration curve its commonly used in analytical chemistry
- The concentration should span the expected range
- Analyze each standard solution using the instrument or method you are calibrating
- As absorbance, signal intensity, or any relevant parameter
- Common method include curve or other regression models depending on the data distribution
- Curve to determine the concentration of an unknown sample by measuring its response and in interpolating from the curve
- Calibration curve are crucial for accurate quantitative analysis in various fields



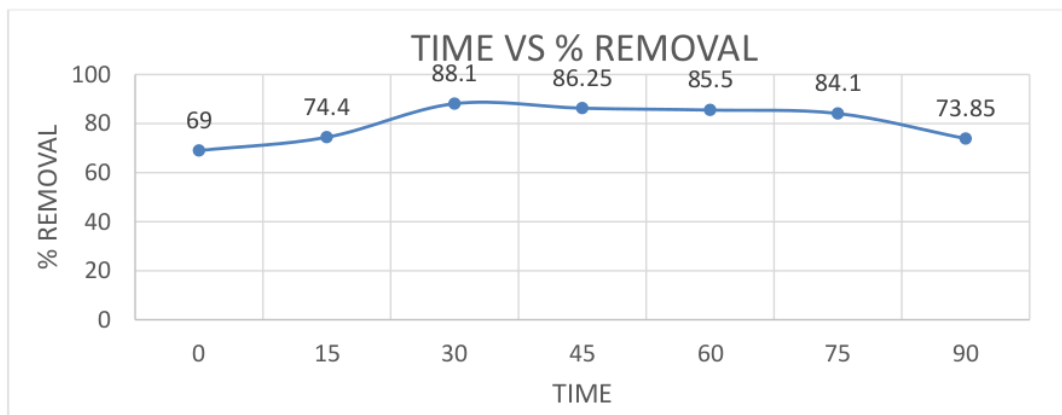
- **Effect of pH:** The Efficiency of dye removal using pomegranate peel due to presence of different functional groups present on the surface of peel
- Pomegranate peel may exhibit improve the quality dye adsorption at specific ph range
- Pomegranate peel contain (COOH)and (OH) Groups can influence the electrostatic interaction with charged dye molecules
- Dyes can exist in different forms based on their ph such as ionized and non-ionized. Ionization state of dye effect its interaction with the charged functional groups on the pomegranate peel
- Adsorption involves in mechanism like electrostatic attraction, hydrogen-bonding
- Ph can influence domain of the mechanism impact the overall adsorption process
- Ph dependent equilibria of both functional group and dye on the surface of pomegranate peel
- Adjust Ph can in an optimize condition for maximum dye adsorption
- Measure the efficiency of dye removal at different ph values to establish at a comprehensive
- The ph of the solution plays a crucial role in the adsorption of dyes on the pomegranate peel conducting across range of ph values will help to determine the effective situation for dye removal
- The removal of acid blue dye was studied by varying the initial pH(2,3,4,5,6mg/L) initial concentration 20mg/l and 30 minutes as contact time



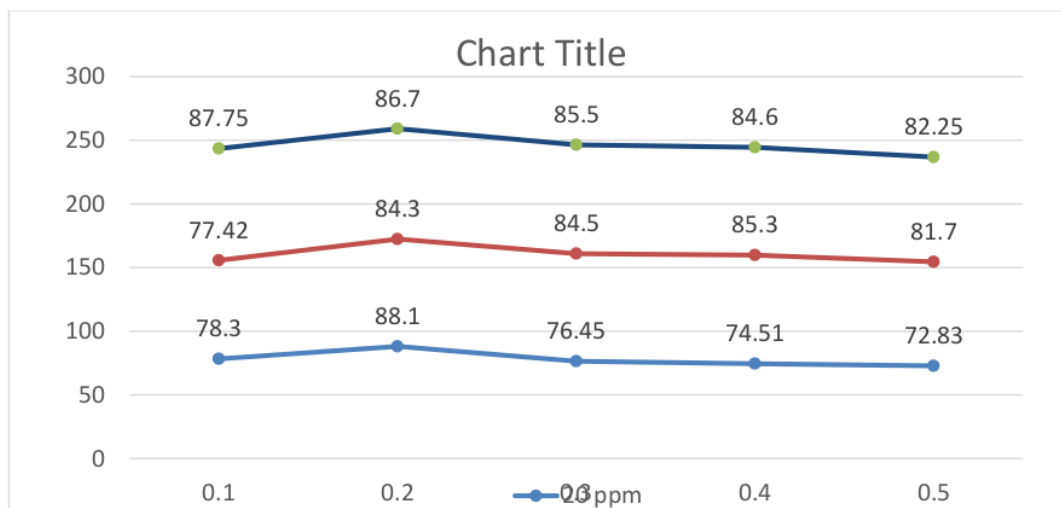
It is inferred that the removal of Acid Blue Dye increased from 42.3% at 2 PH and reached maximum of 88.10% at 4 PH and started to decline with increase in PH

Contact time :

The removal of Eriglaucine-Disodium-salt solution was studied by varying contact time (0,15,30,45,60,75,90 minutes) in this I am getting more removal at 30 minutes

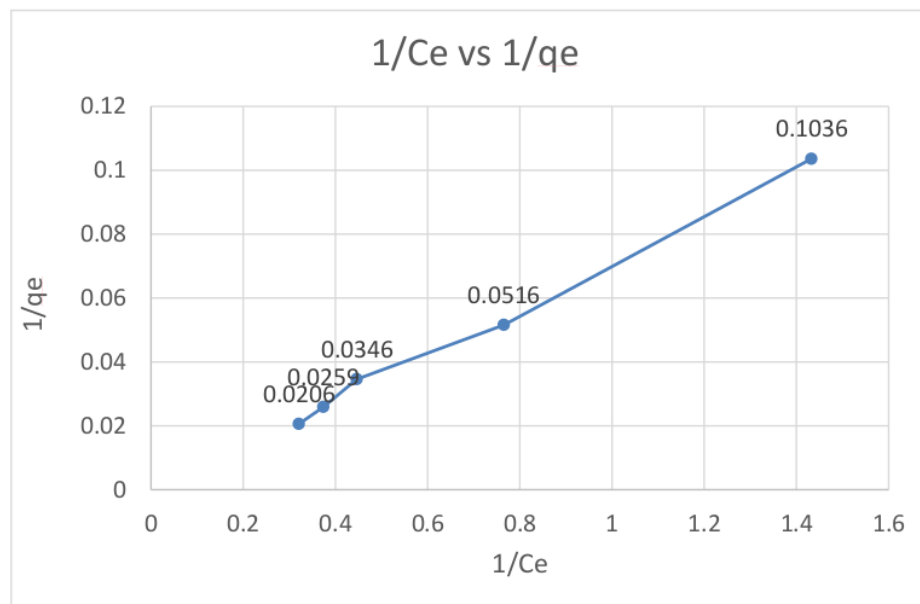


DOSAGE:



Langmuir Isotherm model

The Langmuir isotherm is a fundamental tool for characterizing adsorption processes on adsorbents. The Langmuir isotherm is a mathematical model used to describe the relationship between the concentration of a gas or solute (adsorbate) and the amount adsorbed onto a solid surface (adsorbent) at equilibrium.



1/ce	1/qe
1.432665	0.1036
0.765697	0.0561
0.446429	0.0346
0.374111	0.0259
0.320924	0.0206

FREUNDLICH ISOTHERM MODEL:

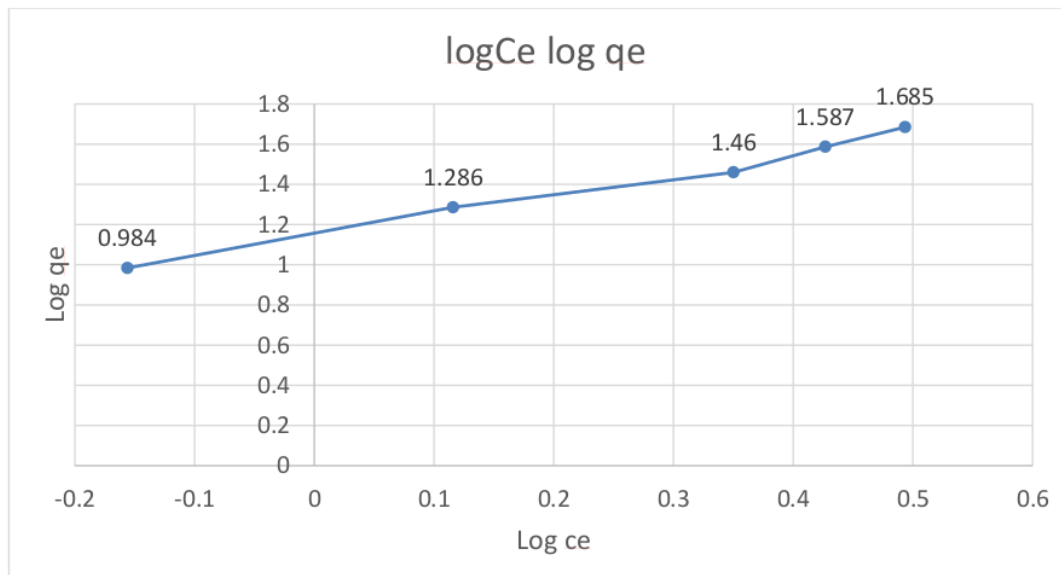
The Freundlich isotherm is a mathematical model used to describe the relationship between the concentration of a gas or solute (adsorbate) and the amount adsorbed onto a solid surface (adsorbent) at equilibrium

The Freundlich isotherm is typically represented by the following equation:

$$y = K_f \cdot x^{(1/n)}$$

Where:

- **y (mg/g):** Represents the amount of adsorbate adsorbed per gram of adsorbent at equilibrium, measured in milligrams per gram (mg/g).
- **K_f ((mg/g)(Lⁿ/mg):** Represents the Freundlich constant, which reflects a combination of the adsorption capacity and the intensity of the adsorption process. A higher K_f value indicates a higher overall adsorption capacity.
- **x (mg/L):** Represents the equilibrium concentration of the adsorbate remaining in the solution after interacting with the adsorbent, measured in milligrams per liter (mg/L).
- **n (dimensionless):** Represents the Freundlich exponent, which indicates the favorability of the adsorption process.



Log Ce	Log qe
-0.1561	0.984
0.11594	1.2866
0.35024	1.4605
0.42699	1.5872
0.49359	1.6852

TEMKIN isotherm model:

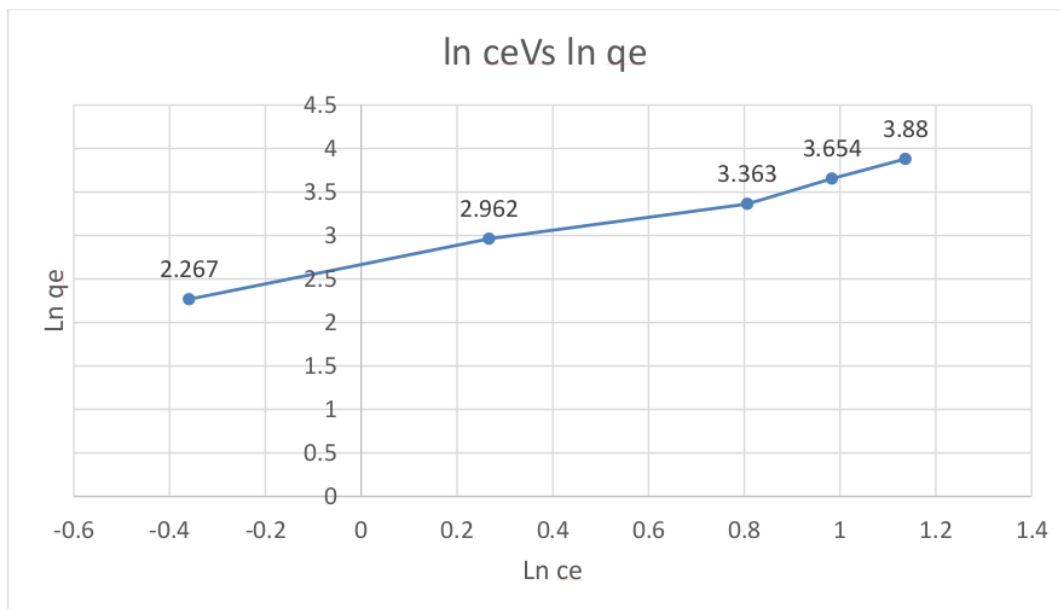
The Temkin isotherm offers another perspective on describing the relationship between the concentration of a gas or solute (adsorbate) and the amount adsorbed onto a solid surface (adsorbent) at equilibrium

The Temkin isotherm is typically represented by the following equation:

$$q = KT * \exp(b * \epsilon)$$

Where:

- **q (mg/g):** Represents the amount of adsorbate adsorbed per gram of adsorbent at equilibrium, measured in milligrams per gram (mg/g). This is often used instead of q_e to distinguish it from the Langmuir and Freundlich notations.
- **KT (L/mol):** Represents the Temkin equilibrium binding constant, which is related to the maximum binding energy between the adsorbate and the adsorbent. A higher KT value indicates a stronger overall attractive force between the adsorbate and the surface.
- **b (RT/b):** Represents the Temkin isotherm constant, which is related to the heat of adsorption. It's a complex term involving the universal gas constant (R), temperature (T), and another constant (b). A positive b value suggests that the heat of adsorption decreases with increasing surface coverage (repulsive interactions dominate), while a negative b value indicates an increase in heat of adsorption with coverage (attractive interactions prevail).
- **$\epsilon (\ln(C_e))$:** Represents the logarithm of the equilibrium concentration of the adsorbate in the solution (C_e) in units of $\ln(\text{mg/L})$.



Ince	Lnqe
-0.3595	2.267
0.2669	2.962
0.8064	3.363
0.9832	3.654
1.1365	3.880

6. CONCLUSION

- Magnetic nano particles are materials that can remove contaminants from water. The results of this study found an alternative magnetic sorbent MNP-PP as an efficient absorber for the removal of acid blue 9 dye from wastewater. Using SEM, the surface morphology was investigated. FTIR was used to characterize the MNP-PP.
- Pomegranate peel powder was used as an alternative biosorbent to synthetic dyes. The acid blue 9 (dye) removal percentage was 88.42% at optimum conditions studied were pH 1, 15th minutes contact time, 5 mg/L, 125 μm size and 0.1 g/L dosage which was considered high for untreated material.
- Producing biosorbent using green technology is necessary for the market in order to contain procedure expenses.
- The removal of synthetic dyes (acid blue 9) from aqueous solutions using pomegranate peel powder has been demonstrated to be an effective alternative and reasonably priced biosorbent.

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