

COMPARATIVE STUDY ON THE REMOVAL OF ZINC (ZN) METAL USING ADSORBENT ORANGE PEEL AND COCONUT SHELL CARBON AND OPTIMIZATION BY RESPONSE SURFACE METHODOLOGY

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in
Civil Engineering

By

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**DEPARTMENT OF CIVIL ENGINEERING
SCHOOL OF BUILDING AND ENVIRONMENT**

SATHYABAMA

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

Accredited with Grade "A" by NAAC

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APRIAL - 2023



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of Sarath Kumar C (Register No: 39200036), Britto Francies A (Register No: 39200008) who carried out the project entitled **“Comparative study on the removal of Zinc (Zn) metal using adsorbent orange peel and coconut shell carbon and optimization by response surface methodology”** under our supervision from September 2022 to April 2023.

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DECLARATION

We Sarath Kumar C (Register No: 39200036), Britto Francies A (Register No: 39200008) here by declare that the Project Report entitled “Comparative study on the removal of Zinc (Zn) metal using adsorbent orange peel and coconut shell carbon and optimization by response surface methodology ” done by us under the guidance of Mrs. B. PRIYADHARSHINI is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Civil Engineering.

DATE: 13.04.2023

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1. 

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SIGNATURE OF THE CANDIDATES

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ABSTARCT

A large portion of the water environment is being contaminated and destroyed due to the direct liberation of industrial effluents, agricultural and municipal activities that are toxic to humans, animals, and plants. Among the several pollutants, heavy metals are considered to be a serious hazard throughout the world. In this study, easily available waste products were used for the adsorption of heavy metal. Characterization of orange peel and activated coconut shell carbon was carried out by SEM. An aqueous solution of zinc metal was prepared and adsorption of heavy metal was performed by varying pH, initial concentration, time, and dosage. The metal productivity was optimized using Response Surface Methodology (RSM) with central composite design (CCD) by varying the obtained data. The model prediction result is in agreement with experimented result (R^2 0.9706, 0.9799 adj R^2 0.9432, 0.9572 for orange peel and coconut shell carbon). ANOVA table shows that the adsorption of activated coconut shell carbon was higher comparison to orange peel. The optimization of orange peel and carbon made from coconut shell pH, initial concentration, time, and dosage found to be the maximum adsorption capacity of both adsorbent (pH(8,7), initial concentration(50,40), time(150,120), dosage(0.5,0.5) respectively for orange peel and carbon made from coconut shell was obtained.

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LIST OF SYMBOLS AND ABBREVIATIONS

ACRONYMS	EXPANSIONS
q	EQUILIBRIUM
Co	INITIAL METAL CONCENTRATION
%	PERCENTAGE
Ce	FINAL METAL CONCENTRATION
V	VOLUME OF THE SOLUTION
m	MASS OF THE ADSORBENT
CCD	CENTRAL COMPOSIT DESIGN
OPP	ORANGE PEEL POWDER
RSM	RESPONSE SURFACE METHODOLOGY

CHAPTER 1

INTRODUCTION

1.1 GENERALS

Water is an essential natural resource that is crucial for the survival of all living beings on Earth. It covers around 71% of the Earth's surface, with oceans containing the majority of the world's water resources. However, only a small fraction of this water is suitable for human consumption, and freshwater accounts for just 2.7% of the world's water resources. The uneven distribution of water resources across the globe presents a significant challenge for effectively managing and sustaining the use of water. Furthermore, access to safe drinking water and sanitation remains a critical issue in many parts of the world, with millions of people still lacking these basic necessities. Therefore, there is a growing recognition of water as a fundamental human right, and concerted efforts are being made worldwide to ensure equitable and efficient use and management of this precious resource.

Water contamination is a widespread problem that can occur due to various natural and human-made factors. Industrial pollution, agricultural practices, inadequate waste disposal, sewage and wastewater, and natural phenomena such as floods and earthquakes are the primary causes of water contamination. These factors can lead to the seepage of harmful chemicals, waste materials, pesticides, fertilizers, and hazardous substances into groundwater and surface water, resulting in contamination. Moreover, improperly treated sewage and wastewater can contain pathogens and chemicals that can further contribute to water body contamination. It is essential to identify and address these causes to ensure the provision of safe and clean drinking water for everyone.

The need for better living standards and industrialization has led to higher exposure to air pollution from sources such as traffic, energy production, and industrial activities. Scientific data has shown the link between certain air pollutants and health effects, resulting in the establishment of pollution limits in ambient air.

1.2 HEAVY METALS

Heavy metals are dangerous metallic elements that can cause harm to living organisms, including humans. Heavy metals including, cadmium, mercury, chromium, lead, arsenic, and nickel, can enter the environment through natural sources and human activities such as mining and industry, causing pollution. Even small amounts of these metals can be harmful to living beings and can accumulate in the body, causing damage over time to organs, the immune system, and the nervous system. Regulations and guidelines have been established to limit exposure to heavy metals in the environment, food, and consumer products, and monitoring and mitigation strategies are being developed to reduce their presence.

Heavy metals can have natural sources such as the Earth's crust, weathering of rocks, and wildfires. However, human activities such as mining, industrial processes, agriculture, burning of fossil fuels, and waste disposal are the primary sources of heavy metal pollution in the environment. These activities can release heavy metals into the air, soil, and water, leading to their accumulation in food chain and it posing a significant risk to the human health and the environment. Therefore, efforts are being made to limit the release of heavy metals and reduce their impact through regulations and mitigation strategies.

Numerous techniques are accessible to eliminate heavy metals from polluted water, soil, or air, which involve ion exchange, chemical precipitation, reverse osmosis, activated, phytoremediation, carbon adsorption, bioremediation, and electro kinetic remediation. The selection of a suitable method is based on the particular circumstances and the type and concentration of heavy metals present. It is imperative to consider the environmental implications of each method and ensure that it effectively mitigates the risks to public health and the environment. Evaluating the environmental impact of each approach and implementing appropriate measures to minimize any negative effects are crucial steps in ensuring the sustainability and safety of the process.

Table 1.1 Cause and sources of metal contamination

HEAVY METAL	CAUSES	MAJOR SOURCES
Lead (Pb)	Lung cancer, intestine cancer, carcinoma	lead batteries, Industrial activities, leaded gasoline.
Cadmium(Cd)	Alzheimer's, kidney damage, gastric cancer, lung cancer, breast cancer.	Phosphate fertilizers, waste incineration process.
Mercury (Hg)	Colorectal cancer, skin cancer, brain cancer	Coal combustion, mining, fish, paint industry, volcanic eruption etc
Zinc(zn)	Gastrointestinal disorders, kidney and liver abnormal functioning	Oil refining, plumbing, brass manufacturing
Copper(Co)	Abdominal disorders, metabolic activity abnormalities	Copper polishing, plating, printing
Cobalt (Co)	Haematological, cardiovascular, hepatic	Hip alloy replacement
Iron (Fe)	Vomiting, diarrhea, abdominal pain, dehydration and lethargy	High take of iron supplements and oral consumption
Arsenic (As)	Highly effects dermal region, brain and cardiac problems.	Atmospheric deposit, mining, pesticides
Chromium (Cr)	Lung disorders, renal and reproductive system	Steel fabrication, electroplating, textile

1.3 ADSORPTION METHOD

The heavy metal adsorption method is a technique utilized to eliminate heavy metals from polluted air or water by utilizing a substance that attracts and adheres to the metals known as an adsorbent. This adsorbent can either be a natural substance like activated carbon or a synthetic substance like a polymer resin or zeolite. The heavy metals stick to the surface of the adsorbent via adsorption when it comes into contact with contaminated water or air. The adsorbent is then separated from the water or air, and the heavy metals are removed. This method is commonly used because of its efficiency, simplicity, and affordability. Nonetheless, the proper disposal of the contaminated adsorbent should be taken into consideration to avoid further environmental pollution.

The adsorption method is a technique for testing the presence and concentration of heavy metals in water or air. An adsorbent material is exposed to the sample and analyzed to determine the amount and type of heavy metals present using techniques such as X-ray fluorescence spectroscopy or inductively coupled plasma mass spectroscopy. This method is reliable and widely used but requires consideration of factors such as the type and concentration of heavy metals and the accuracy of the analysis technique.

1.4 ADSORBENT

There are several adsorbents available that can be used to remove metals through adsorption. These include activated carbon, zeolites, chitosan, silica gel, alumina, and various types of clay. The selection of the appropriate adsorbent depends on various factors, such as the concentration and type of metals to be removed, pH of the solution, and the desired removal efficiency. Activated carbon is widely used because of its high surface area and ability to remove a wide range of metals. Zeolites are also effective in removing specific metals and can be regenerated for reuse. Chitosan is a biodegradable adsorbent made from crustacean shells and is effective in removing some heavy metals from water. The choice of adsorbent is crucial to ensure efficient and effective removal of heavy metals from contaminated water or air.

Carbon-based adsorbents are materials composed primarily of carbon that are used to remove pollutants from various fluids, such as water and air. Activated carbon is the most commonly used carbon-based adsorbent for heavy metal and organic pollutant removal due to its high surface area and strong adsorption capacity. Other carbon-based adsorbents, such as carbon nanotubes, graphene oxide, and biochar, have also shown potential for removing heavy metals from contaminated water or soil. The effectiveness of carbon-based adsorbents depends on factors such as surface chemistry, pore size, surface charge, and the type and concentration of pollutants present in the media. Hence, selecting an appropriate carbon-based adsorbent is crucial for efficient and cost-effective heavy metal removal.

The orange peel adsorbent is a natural and low-cost material derived from the waste generated in citrus fruit processing industry. It can be utilized for the removal of pollutants, including heavy metals, organic pollutants, and dyes, from contaminated water or other fluids. The adsorption properties of orange peel are attributed to its high content of pectin and cellulose. Several studies have demonstrated the effectiveness of orange peel adsorbent in removing heavy metals such as lead, copper, and cadmium from contaminated water. Orange peel adsorbent is considered an attractive alternative to conventional adsorbents due to its low cost, ready availability, and biodegradability. However, to optimize the efficiency of the adsorption process, it is necessary to consider various factors, including the initial concentration of pollutants, pH, and contact time.

CHAPTER 2

LITERATURE SURVEY

2.1 GENERAL

The following major research project has been taken from international journals as reference to analyze the concepts for the project.

2.2 REVIEW OF THE LITERATURES

Thais Fernandes Nesllas et al. 2023, this study's goal was to determine whether leftover pineapple crown and shrimp chitosan might be used to treat Laguna da Jansen effluent. In order to ascertain. the ideal circumstances for the adsorptive processes, the researchers adopted an experimental approach. The findings demonstrated that both forms of biomass were capable of adsorbing contaminants due to their active chemical groups and pore-rich shape. The variable that had the biggest impact on how effectively the two studied biomasses were treated was discovered to be the substrate content. However, it was discovered that the vegetable adsorbent was more effective when there was 15g of substrate and 30 days of processing.

Malyuba A.et.al.2022, This investigation looked at the removal of metal ions from aqueous solutions using both acid-modified and unmodified activated carbon, including Ni^{2+} , Mn^{2+} , Cr^{6+} , and Cd^{2+} . Nitric acid was used to prepare the activated carbon, and both granular and powder forms of the material were used to assess the metal ion adsorption. The findings demonstrated that activated carbon's surface oxidation reduced surface area and pore width while increasing the intensities of functional groups. Unmodified activated carbon has a higher capacity for adsorbing all four metal ions than oxidised AGC and APC carbons. Because of its smaller size and faster diffusion, Cr^{6+} is more selective than other ions after acid treatment, leading to higher adsorption to the acidic groups. For the competitive ions, DKR modelling performed better than Freundlich and Langmuir. While Cr^{6+} adsorption was physical on AC and through ion exchange on AGC and APC, Ni^{2+} and Cd^{2+} were attracted to the surface of the AC through ion exchange. In the presence of other ions, Mn^{2+} exhibited weak attraction to all activated carbons.

Swee Su Lim , et al .2021 This study investigated the potential of using microbial fuel cells (MFCs) to remove zinc from industrial effluents while also recovering metals. The results showed that the MFCs achieved over 96% removal of Zn^{2+} from synthetic and industrial samples with Zn^{2+} concentrations below 2.0 nM after 22 hours of operation. However, only 83% and 42% of the zinc recovered from synthetic and industrial samples, respectively, was attached to the cathode surface, indicating that electroprecipitation was the dominant process. Energy dispersive X-ray (EDX) analysis revealed that the recovered chemical contained both Zn and O, indicating the formation of $Zn(OH)_2$. The study developed Nernst equations and rate law expressions to understand the mechanism of Zn^{2+} removal, which were used to calculate the Zn^{2+} concentration and removal efficiency. The zero-, first-, and second-order rate equations were successfully fitted to the data, predicting the ultimate Zn^{2+} removal efficiency and potential mechanistic reactions in the MFC, electrolysis cell, and control modes. The half-lives of the Zn^{2+} removal process were calculated to be 7.0 and 2.7 hours using synthetic and industrial samples, respectively.

Jiang Huang , et al,2020, A new bacterial strain named XZN4, isolated from cattle and poultry dung, has been discovered to have resistance to zinc. Researchers conducted single-factor tests to determine the ideal conditions for eliminating zinc(II) from the strain. Results showed that a pH of 5, initial zinc concentration of 100 mg/L, bacteria concentration of 6 g/L, a temperature of 25-30 °C, and a 60-minute removal equilibrium period were the most effective conditions. The bacteria use a single-molecule layer adsorption mechanism along with degradation to remove zinc(II), as supported by SEM, energy dispersive spectrum analysis, infrared spectrum analysis, and sterilisation control experiment. The XZN4 strain was able to achieve a highest removal rate of 88.6% and a maximal removal amount of 10.30 mg/L, successfully reducing the concentration of zinc(II) in complicated livestock and poultry effluent to below the discharge standard. Furthermore, the strain exhibited high environmental tolerance. These findings offer promising prospects for the use of XZN4 in the removal of zinc(II) from contaminated water sources.

Lihong Han et al ,_2020, investigated the effects of orange peel powder (OPP) on the rheological and reho-fermentation properties of high-gluten wheat dough and bread ageing. The results showed that OPP's fibre, pectin, and polyphenol content had an impact

on the properties of wheat dough and bread quality. Low levels of OPP (up to 5%) increased water absorption and reduced retrogradation, but higher levels negatively impacted gluten-dilution and increased water sequestration. OPP also increased the elasticity of the dough and the overall amount of CO₂ produced during fermentation, while decreasing the gas retention coefficient. However, there was no significant impact on bread storage. These findings suggest that OPP can modify the composition of wheat dough and inform the use of OPP in the production of cereal products.

Gulnaziya Issabayeva , et al 2019, This study evaluated the potential of using granular palm shell activated carbon (PSAC) and raw wastewater from a rubber products manufacturing plant to remove zinc. Agriculture waste-based adsorbents have been shown to be effective in removing heavy metals from aqueous solutions. The study investigated various parameters, including temperature, PSAC dose, particle size, suspended solids content, and duration, to optimize the zinc adsorption process. The optimal conditions were found to be 0.25-0.5 mm PSAC, 200 rpm, 10 g PSAC/L, 150 min duration, 70°C, and pH 7-8, resulting in a maximum zinc removal of 96%. The addition of PSAC to the wastewater improved the pH and zinc adsorption, and increasing the temperature significantly enhanced zinc removal. These findings suggest that commercializing the zinc adsorption stage of the current wastewater treatment system for the rubber industry is feasible. This strategy could reduce solid waste disposal and improve wastewater treatment efficiency..

S Saputro et al , 2019 The objective of this work was to use solid-phase spectrophotometry (SPS) to analyse the best mass ratio of activated carbon from corn cobs and coconut shells for adsorbing Pb(II) ions. The experiment involved several steps, including the production of carbonated coconut shell and corn cob using a muffle boiler, activating the carbon from the corn cob and coconut shell with 1M HCl and 15% ZnCl₂, respectively, and contacting the adsorbent mixture with 20 mL of simulated waste containing Pb(II) ions in various ratios (1:0, 0:1, 1:1, 2:1, 1:2). SPS was used to assess the Pb(II) levels, and FTIR was used to describe the adsorbents.

Sushanta Kumar Behera , et al , July 2018 This study aimed to optimize the production of clean coal from low-grade coal, which is abundant but has a high ash and moisture content. Three factors - hydrofluoric acid concentration, temperature, and duration - were studied to determine their effects on ash reduction. A quadratic model was proposed using the central composite design method to identify the ideal process

conditions for maximum ash reduction. The results showed that HF concentration had the most significant impact on ash removal, indicating its importance over time and temperature.

Xiaotao Zhang , et al , 2017A new study has investigated the potential of a low-cost activated carbon (XSBLAC) made from *Xanthoceras Sorbifolia* Bunge hull to remove zinc(II) ions from aqueous solutions. The XSBLAC was characterized using N₂-adsorption/desorption isotherms, EDX, XRD, SEM, and FTIR studies. To optimize the process factors for zinc(II) removal, an adsorption study was conducted using XSBLAC. The experimental results were found to be in good agreement with the pseudo-second-order kinetic model, and the Langmuir equilibrium isotherm was found to be the most suitable. Thermodynamic parameters, including enthalpy (H^0), entropy (S^0), and Gibbs free energy (G^0), were determined to ascertain the nature of the adsorption process. The results indicated that the process was endothermic and spontaneous. The XSBLAC's desorption capabilities were evaluated, and HNO₃ was found to demonstrate the best performance. FTIR and SEM/EDX spectroscopic investigations were used to fully understand the adsorption mechanism. Overall, the findings suggest that XSBLAC has great potential as a low-cost and effective method for removing zinc(II) ions from contaminated water sources.

Ami Cobb Senior, 2012 This research discusses the issue of chemical pollutants in drinking water sources in the developing countries and the possibility of activated carbon to remove these impurities. The expansion of industrialization and high-input agriculture have introduced chemical impurities like pesticides, herbicides, and fertilisers into drinking water supplies, whereas water treatment technologies in the developing world typically focus on removing suspended solids and microbial pathogens. A simple, affordable, and efficient activated carbon generation method using regional agricultural waste byproducts was evaluated for the community of Bluefields, Nicaragua, as a viable solution to this issue. On-site production of coconut shell charcoal was done while looking into several chemical activation methods.

Shashi Prabha , et al ,2007 , The removal of hexavalent chromium from drinking water was examined using two inexpensive adsorbents, groundnut husk carbon and groundnut husk carbon coated with silver. The adsorbent amount, pH, contact time, and

agitation rate of the batch trials were varied. The Freundlich adsorption isotherm was used to examine the adsorption data. The outcomes demonstrated a relationship between the amount of adsorbent utilised, the pH of the solution, and the contact time and the adsorption capacity of the adsorbents. At pH 3, 97% of the hexavalent chromium was removed at the maximal rate within 5 hours of contact time. The study additionally discovered that chemically modified adsorbents, particularly those treated with oxidising agents like silver, have superior chromium removal capacities than the pure adsorbents in terms of the study looked at two low-cost methods for removing hexavalent chromium from drinking water. The study also discovered that, in terms of their adsorption rate, chemically modified adsorbents—in particular those treated with oxidising agents like silver—had superior chromium removal capacities to pure adsorbents. Overall, the study found that groundnut husk carbon treated with silver had a better capacity for chromium adsorption and would work well as a cheap adsorbent to remove hexavalent chromium from drinking water.

CHAPTER 3

AIM AND SCOPE OF THE INVESTIGATION

3.1 AIM OF THE STUDY

Comparative study was done for the removal of Zinc (Zn) ion from water using adsorbent orange peel and coconut shell carbon and optimization by Response Surface Methodology.

3.2 OBJECTIVE OF STUDY

1. Preparation of adsorbent orange peel powder and coconut shell carbon.
2. To carry out adsorption method for removal of zinc using the prepared adsorbent and to evaluate efficiency of adsorbent.
3. Comparing the removal of Zinc metal by optimization of parameter using response surface methodology.

3.3 SCOPE OF THE PROJECT

Zinc is a commonly found metal in our water bodies a specific amount is good for the health but more than it is harmful for the living organisms and the environment. To remove the zinc ion from water some cheap and low cost adsorbents are being used so that we can compare between them which can be used as a best adsorbent for the removal of zinc.

CHAPTER 4

AND INVESTIGATION

4.1 METHODOLOGY

The methodology of the experimental study is shown in the below figure 4.1.

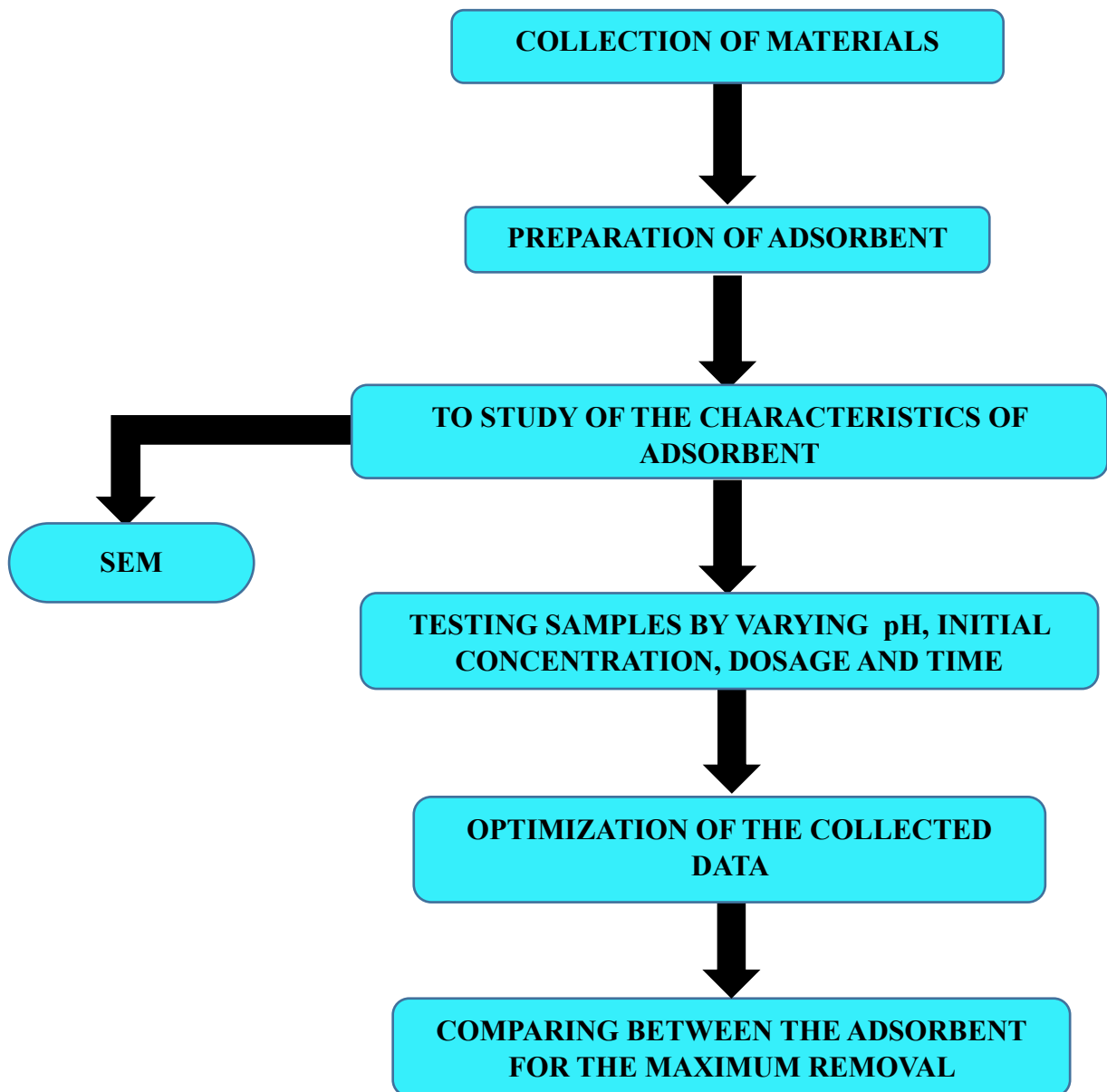


Figure 4.1: Methodology

4.2 MATERIALS COLLECTED

The orange peel was bought from a local market in Chennai, while the coconut shell was obtained from a nearby coconut oil plant. Furthermore, the zinc chloride and zinc sulphate were obtained from a nearby chemical shop.

4.3 PREPERATION OF ADSORBENTS

4.3.1 PREPARATION OF COCONUT SHELL CARBON

Activated carbons were prepared at 500°C-800°C by burning the coconut shell in the absence of oxygen. Soak charcoal in a chemical solution (CaCl_2 25%) for 12-18 hours to make the charcoal activated. Coconut shell charcoal washed the charcoal with distilled water. Spread on a tray to dry at room temperature. Then, dried it in a hot air oven at a temperature of 100°C for 3 hours. After it cools down it was crush it into a fine powder with a piece of wood and packed the activated charcoal in air glass containers.



Figure 4.1 Activated Coconut Shell Carbon

4.3.2 PREPARATION OF ORANGE PEEL POWDER

Orange peels were cut into small pieces and dried under sunlight for 3 weeks and crushed into fine powder. The dried orange peel powder was taken along with 2 litres of distilled water and washed properly to remove the impurities. After washing it was filtered using what-man's filter paper. The dried orange peels were oven-dried at 60°C – 80°C for 24 hours. After the cool down it was packed it in air-tight glass containers.



Figure 4.2 Dried orange peel powder

4.4 INSTRUMENTATION

The instruments used for the adsorption experiment are given in the table below

Table 4.1 Instruments used for the adsorption experiment

Instrument	Purpose of the Instrument
Analytical Balance	Weight Measurement
Furance	Preparation of carbon
Hot air oven	Drying the adsorbent
pH meter	Measurement of pH
Ultra-pure water system	Preparation of the stock solution
Rotary Shaker	Agitate the solution
Atomic Absorption spectrophotometer	Estimation of metal ion concentration

4.5 PERPETRATION OF STOCK SOLUTION

The procedure for preparing a solution of zinc sulfate involved taking a 1000 ml volumetric flask that was cleaned and dried. Initially, 100 ml of purified water was added to the flask, followed by the addition of 28.8 gm of zinc sulfate with continuous stirring. Then, 700 ml of purified water was poured into the flask and mixed thoroughly. After allowing the solution to cool down to room temperature, the volume was made up to 1000 ml with purified water. The resulting solution was then ready for use.

4.6 ADSORPTION EXPERIMENT

In this study, the batch adsorption method was performed to remove zinc ions from a solution by varying pH, initial concentration, time, and adsorbent dosage. Then, a stock solution of the metal ion was prepared at the desired initial concentration. The pH level of the metal solution was adjusted to the targeted value using HCl or NaOH. A known amount of the adsorbent material was added to the metal solution, and the mixture was incubated for a desired amount of time. The solution was filtered to remove the adsorbent material, and the metal concentration of the filtrate was measured using appropriate methods. The amount of metal removed was calculated by subtracting the final concentration from the initial concentration. The experiment was repeated for varying dosages of the adsorbent material, initial concentrations of the metal ion, pH values, and incubation times to determine the optimum conditions for metal removal. The data obtained from the experiments were analyzed to identify the optimum conditions for maximum metal removal. All experiments were performed under controlled conditions and appropriate safety measures were taken.



Figure 4.3 Orange peel powder

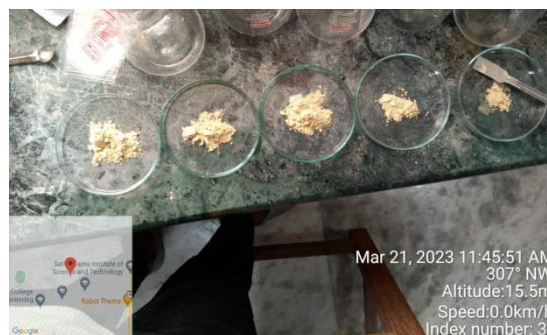


Figure 4.5 Activated Coconut shell carbon

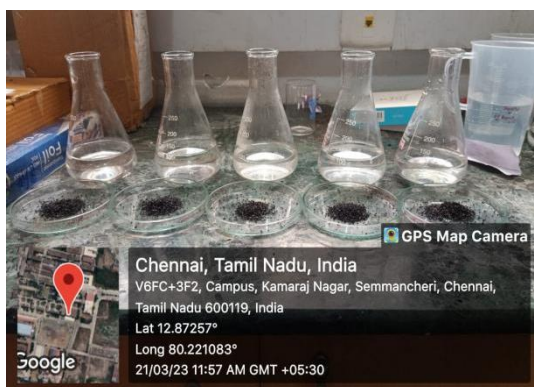


Figure 4.6 Adsorbent



Figure 4.7 Adsorbents were mixed with the zinc ion solutions and kept for the adsorption process .



Figure 4.8 After the adsorption process sample was filtered and stored in the containers



Figure 4.9 Stord samples were tested in atomic adsorption spectrometry

Batch zinc adsorption experiments were performed to determine the adsorption capacity of activated coconut shell carbon and orange peel powder at various metal concentrations ranging from 10 to 50 ppm, as well as a fixed amount (0.3mg) of activated coconut shell carbon and orange peel powder to calculate the adsorption constant using different methods. Isotherms. 100 ml of various zinc (II) solutions with concentrations

ranging from 10 to 50 ppm were utilized. For zinc, flasks were filled with activated coconut shell carbon and orange peel powder (0.3 g) and agitated at room temperature at 150 rpm for 90 minutes. AAS was used to determine the beginning and final concentrations of the solutions at the maximum adsorption wavelength, as well as the adsorption capacities of the adsorbent. After reaching equilibrium, the metal uptake capacity for each sample was determined using equation based on a mass balance on the metal ion. Equation (1)

$$q = \frac{(C_0 - C_e) \times V}{m} \quad (1)$$

Where m is the mass of adsorbent (g), V is the volume of the solution (L), C_0 is the initial concentration of metal (mg/L), C_e is the equilibrium metal concentration (mg/L) and q_e is the metal quantity adsorbed at equilibrium (mg/g). Experiments were carried out at different initial concentration, dosage of adsorbent, time and pH values. The initial pH of the solution was adjusted with either HCl or NaOH. The percent removal of metals from the solution was calculated by the following equation (2)

$$R\% = \frac{C_0 - C_e}{C_0} \times 100 \quad (2)$$

Where, C_0 is initial metal concentration (mg/L), and C_e is final metal concentration (mg/L).

4.7 STATISTICAL ANALYSIS

Design-Expert software version 13 was used for the optimization of reaction parameters. Response Surface Methodology (RSM) and a Central Composite Design (CCD) to optimize the parameters involved in removing zinc from contaminated water sources. The study focused on identifying the optimal conditions for the removal of zinc using this approach. The four parameters that were considered for optimization were: initial concentration, dosage, contact time, and pH. The CCD design matrix included 30 experiments, which were conducted in triplicate to minimize the experimental error. The experimental data obtained were analysed using the Design-Expert software to develop a second-order polynomial equation for predicting the yield of zinc removal.

4.7.1 RESPONSE SURFACE METHODOLOGY

Response surface methodology (RSM) is a statistical and mathematical strategy for optimising and improving system or process performance by modelling the link between

input variables and output variables. RSM entails a series of experiments that investigate the effects of input factors on the response variable, and statistical methods are used to construct a system model. The model is used to forecast the response for various input variable combinations, and the best settings are obtained by identifying the combination that maximises or minimises the response. RSM may be used in a variety of domains like as manufacturing, engineering, chemistry, biology, and economics. Factorial designs, central composite designs, and response surface designs are common RSM methodologies.

Response surface methodology (RSM) is used to optimise the adsorption process and discover the best adsorption conditions. RSM entails creating a series of trials to evaluate the impacts of input factors such as adsorbate concentration, pH, contact duration, and temperature on the response variable, which might be the adsorption capacity, rate, or percentage of adsorbate removed. The findings of these tests are used to build a mathematical model of the adsorption process that can predict the response variable for different combinations of input variables and identify optimisation restrictions. RSM has been used effectively to optimise the adsorption of various pollutants from diverse aqueous solutions, leading in considerable increases in adsorption efficiency.

4.7.2 CENTRAL COMPOSITE DESIGN(CCD)

Using Design Expert to optimize a CCD experiment includes multiple steps. First, the elements that influence CCD performance, such as pixel size and layout, substrate doping profile, and electrode design, must be recognised. The response factors, such as sensitivity, dynamic range, and noise level, are then determined. A CCD design is generated in Design Expert with an appropriate number of runs, and the experiment is executed, measuring the response variables for each run. The data is analysed using statistical methods such as ANOVA and regression to determine the important factors that influence the response variables and the best settings for each component.

The optimisation tools in Design Expert may be used to identify the combination of factor values that delivers the greatest overall performance for the CCD. Finally, the optimised CCD design is confirmed by carrying out further tests and comparing the outcomes to the projected performance based on the optimisation findings.

CHAPTER 5

RESULT AND DISCUSSION

5.1 EFFECT ON COCONUT SHELL CARBON

5.1.1 EFFECT OF pH

The impact of pH on the effectiveness of eliminating zinc ions from stock solutions. The study found that the removal efficiency of zinc ions was significantly influenced by pH variations. Under specific conditions of room temperature and agitation speed of 150 rpm, the removal of zinc ions increased to a maximum and then decreased with pH variation, particularly at pH 7, where the maximum percentage of zinc removal was approximately 75%. The study also explored the effect of pH on the adsorption rate of zinc ions from the stock solution. It was observed that the surface of the adsorbent became positively charged at pH below 7, resulting in an increased attraction between the adsorbent surface and negatively charged zinc ions, leading to a higher adsorption rate. Conversely, at pH above 7, the adsorbent surface became negatively charged, which decreased the attraction between the adsorbent and zinc ions, leading to a lower adsorption rate. These findings underscore the significance of pH in optimizing the conditions for efficient removal of zinc ions from aqueous solutions.

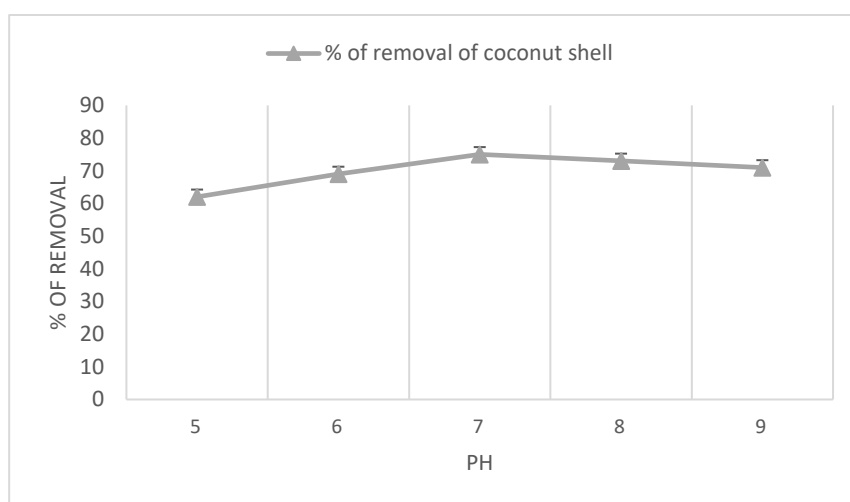


Figure 5.1 Effect Of pH On Coconut Shell Carbon

5.1.2 EFFECT OF INITIAL CONCENTRATION

The study looked at the effect of initial zinc concentration on the rate of zinc adsorption at pH 7 and room temperature during a 120-minute contact time range of 10-50mg/L. The results showed that when the original zinc concentration grew, the proportion of zinc removed reduced. This is due to the restricted number of accessible unoccupied adsorbent sites in comparison to the increasing number of moles of zinc, resulting in lower zinc adsorption at higher starting concentrations. The investigation also demonstrated that given a fixed adsorbent dosage, the adsorbent's adsorption capability was almost the same, resulting in a decrease in zinc removal as the starting concentration increased. These findings indicated that the initial concentration of the metal had a significant impact on zinc adsorption.

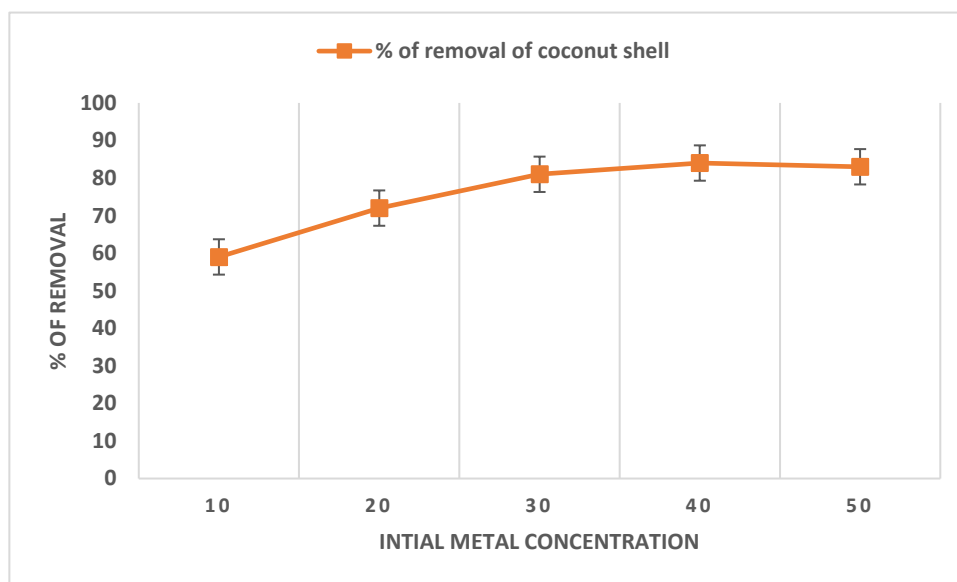


Figure 5.2 Effect Of metal concentration On Coconut Shell Carbon

5.1.3 EFFECT OF AMOUNT OF DOSAGE

The efficacy of Zn adsorption was examined by increasing the quantity of adsorbent from 0.1 to 0.5 mg while maintaining the pH and contact duration constant. The results revealed that as adsorbent dose was raised, zinc removal efficiency rose, most likely due to a larger availability of exchangeable sites for the ions. Nevertheless, after adding 0.5 mg of adsorbent, no further rise in adsorption occurred, indicating that

equilibrium conditions had been attained. At 0.5 mg, the maximal percentage of Zn elimination was 77%. Overall, the study emphasizes the need of adjusting adsorbent dose for optimal performance in Zn adsorption.

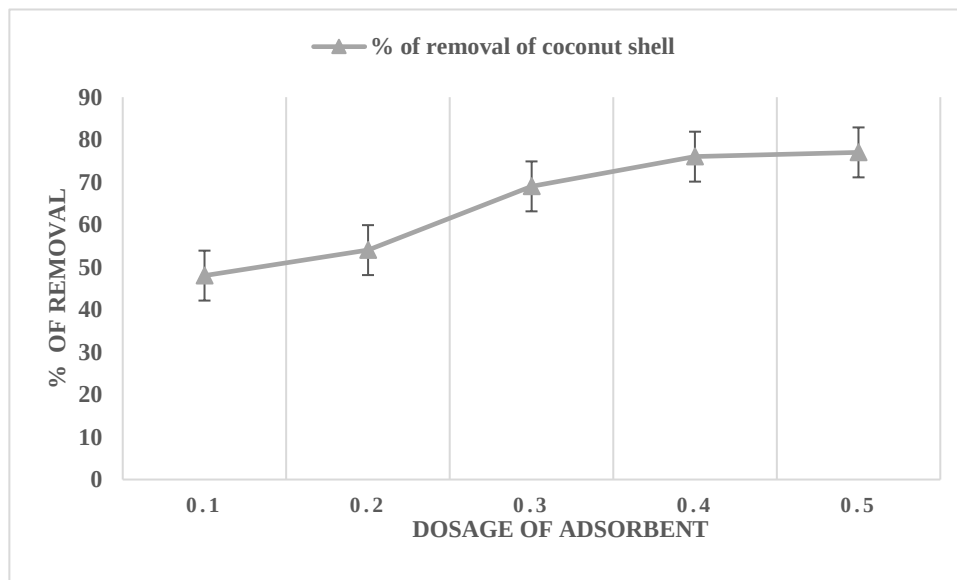


Figure 5.3 Effect Of adsorbent dosage On Coconut Shell Carbon

5.1.4 EFFECT OF TIME

The study investigated the impact of contact time on the removal of metal ions, specifically Zinc, from wastewater. The amount of adsorbent and pH of the solution were

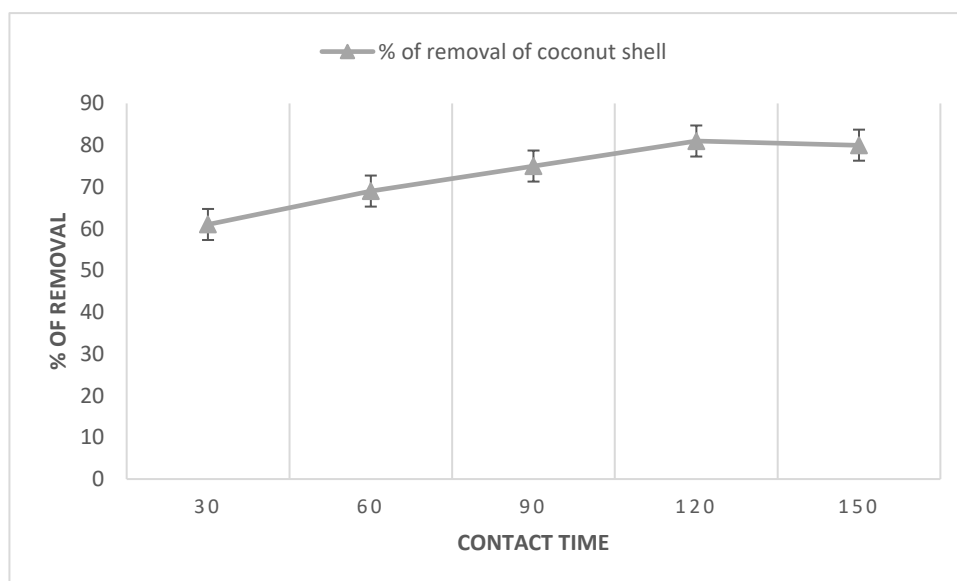


Figure 5.4 Effect of contact time on Coconut Shell Carbon

kept constant, and it was found that an increase in contact time led to an increase in the removal of Zinc until equilibrium was reached at 120 minutes. The percentage removal of Zinc increased from 69% to 81% as the contact time varied from 30 to 150 minutes, after which it remained constant at 80%. Based on these findings, it can be concluded that the most effective duration for achieving the maximum removal of Zinc is 120 minutes. Additionally, it is important to take into consideration the equilibrium time as a crucial parameter for developing an economical wastewater treatment system.

5.2 EFFECT ON ORANGE PEEL POWDER

5.2.1 EFFECT OF pH

The impact of pH on the efficacy of eliminating zinc ions from aqueous solutions was investigated and it was observed that the removal efficiency of zinc ions was significantly affected by the pH. The experimental results showed that under the given conditions of room temperature and agitation speed of 150 rpm, the removal of zinc ions increased to a maximum and then decreased with the variation of pH, particularly at pH 8. At a pH of 8, the maximum percentage of zinc removal was found to be approximately 71%. The implications of these findings are significant for the efficient elimination of zinc ions from aqueous solutions. The study emphasizes the critical role of pH in optimizing the conditions for achieving efficient removal of zinc ions from aqueous solutions. These results provide valuable insights that can inform the development of effective strategies for wastewater treatment and other industrial applications.

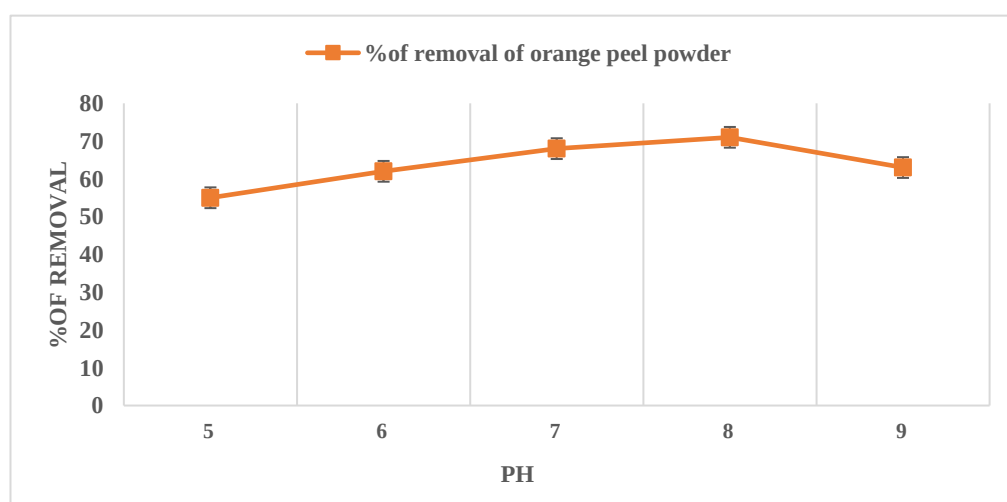


Figure 5.5 Effect of pH on Orange peel powder

5.2.2 EFFECT OF INITIAL CONCENTRATION

The study looked at the effect of initial zinc concentration on the rate of zinc adsorption at pH 7 and room temperature during a 120-minute contact time range of 10-50mg/L. The results showed that when the original zinc concentration grew, the proportion of copper removed was reduced. This is due to the restricted number of accessible unoccupied adsorbent sites in comparison to the increasing number of moles of copper, resulting in lower zinc adsorption at higher starting concentrations. The investigation also demonstrated that given a fixed adsorbent dosage, the adsorbent's adsorption capability was almost the same, resulting in a decrease in zinc removal as the starting concentration increased. These findings indicated that the initial concentration of the metal had a significant impact on zinc adsorption.

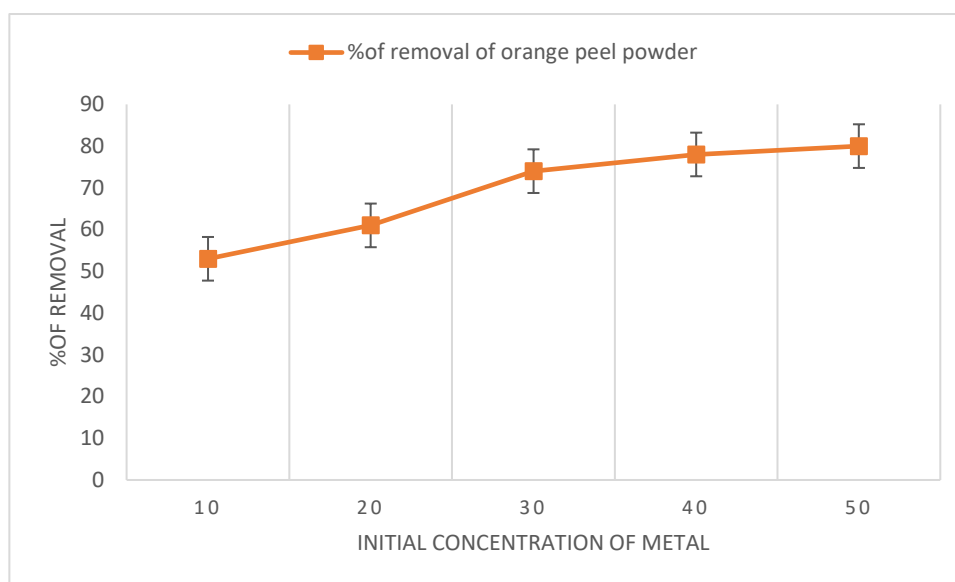


Figure 5.6 Effect Of initial metal concentration on Orange peel powder

5.2.3 EFFECT OF AMOUNT OF DOSAGE

The efficacy of Zn adsorption was examined by increasing the quantity of adsorbent from 0.1 to 0.5 mg while maintaining the pH and contact duration constant. The results revealed that as adsorbent dose was raised, zinc removal efficiency rose, most likely due to a larger availability of exchangeable sites for the ions. Nevertheless, after adding 0.5 mg of adsorbent, no further rise in adsorption occurred, indicating that equilibrium conditions had been attained. At 0.5 mg, the maximal percentage of Zn elimination was 78%. Overall, the study emphasizes the need of adjusting adsorbent dose for optimal performance in Zn adsorption.

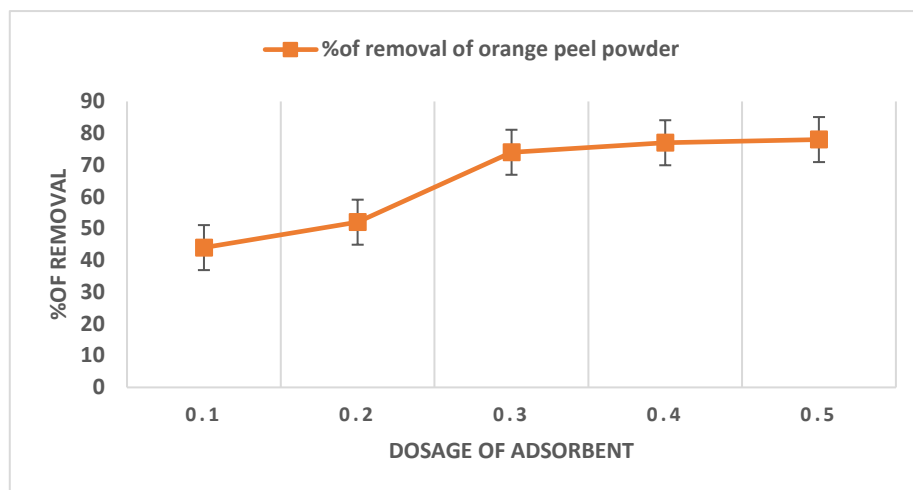


Figure 5.7 Effect Of adsorbent dosage on Orange peel powder

5.2.4 EFFECT OF TIME

The study investigated the impact of time on the removal of metal ions, specifically Zinc. The dosage of adsorbent and pH of the solution was kept constant, and it was found that an increase in contact time led to an increase in the removal of Zinc until

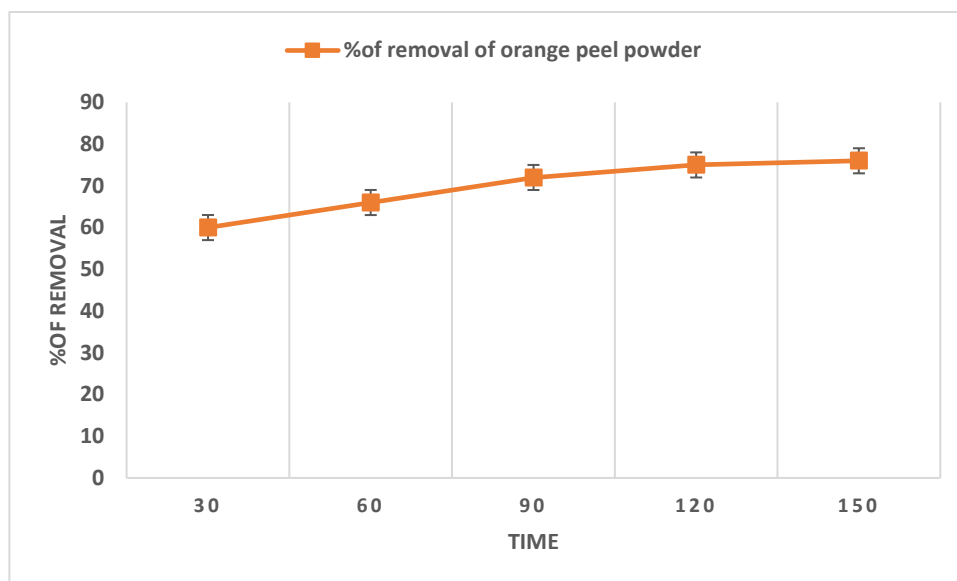


Figure 5.8 Effect of Contact time on Orange peel powder

equilibrium was reached at 210 minutes. The percentage removal of Zinc increased from 60% to 76% as the contact time varied from 30 to 270 minutes, after which it remained constant at 76%. Based on the findings of this study, it can be inferred that the ideal contact time for achieving maximum removal of Zinc is 210 minutes. Moreover, the study highlights the importance of considering the equilibrium time as a critical parameter for designing an economically viable wastewater treatment system. These results provide

valuable information that can guide the development of effective strategies for wastewater treatment and other industrial processes.

5.3 OPTIMIZATION OF THE GIVEN DATA

The aim of the study is to develop an empirical model for modelling zinc adsorption, using response surface methodology (RSM). The study found that some adsorbents have difficulty in adsorbing certain metals due to the high cost and time required. The central composite designs were used in the study, with four independent parameters tested individually. The maximum removal of metal ion was used to determine the higher value +1 and lower values -1 for the central composite design. Thirty experiments were conducted, with six replications at the centre points, to determine the pure error. The results of this study can be used to better understand the factors that affect zinc adsorption and to develop more effective adsorbents.

Orange peel powder					Activated Coconut Shell Carbon				
Factors	Symbols	Coded levels			Factors	Symbols	Coded levels		
		-1	0	1			-1	0	1
pH	A	7	8	9	pH	A	6	7	8
Initial concentration	B	40	50	60	Initial concentration	B	30	40	50
Dosage	C	0.4	0.5	0.6	Dosage	C	0.4	0.5	0.6
Time	D	120	150	180	Time	D	90	120	150

5.1 Factors Selected For Central Composite Design

5.4 MODEL DEVELOPMENT

In order to determine the effect of various parameters on the performance of coconut shell and orange peel, a design of experiments (DOE) approach was employed. Four criteria, specifically pH, beginning concentration, dose, and duration, were identified as possible contributors influencing the response variable. Using specialised software, thirty experiment models were built based on these parameters. In order to precisely calculate the pure error, each model comprised six replications at the centre locations. Using software-generated parameters, all trials were conducted and resulting data was analysed to assess the impact of each parameter on the performance of coconut shell and orange peel.

COCONUT SHELL CARBON						
Run	A:pH	B:Initial concentration	C:Dosage	D:Time	Actual Value	Predicted Value
1	8	30	0.4	150	69.48	69.63
2	7	40	0.5	120	81.71	80.3
3	8	40	0.5	120	76.4	76.18
4	7	40	0.5	120	80.19	80.3
5	6	30	0.6	90	70.21	70.26
6	6	50	0.6	150	69.39	69.21
7	8	30	0.6	150	67.57	67.11
8	7	20	0.5	120	70.84	70.2
9	7	40	0.5	120	79.88	80.3
10	6	50	0.4	90	71.08	71.71
11	6	30	0.4	90	70.84	72.01
12	8	50	0.6	150	70.58	70.46
13	6	50	0.4	150	70.67	71.05
14	8	50	0.6	90	70.64	70.48
15	6	30	0.4	150	71.17	71.51
16	7	40	0.5	180	71.08	71.46
17	6	50	0.6	90	70.24	71.13
18	7	40	0.7	120	68.64	68.79
19	8	50	0.4	150	71.69	71.81
20	7	40	0.5	120	79.46	80.3
21	6	30	0.6	150	68.27	68.49
22	6	40	0.5	120	68.79	67.62
23	7	40	0.5	90	73.58	71.98
24	8	30	0.6	90	66.29	66.96
25	7	40	0.5	120	80.73	80.3
26	7	40	0.4	120	73.27	71.89
27	8	50	0.4	90	69.74	70.56
28	8	30	0.4	90	67.86	68.22
29	7	50	0.5	120	73.84	73.26
30	7	40	0.5	120	79.67	80.3

Table 5.2 Model Development For Coconut Shell Carbon

ORANGE PEEL POWDER						
Run	A:pH	B:Initial concentration	C:Dosage	D:Time	Actual Value	Predicted Value
1	8	50	0.7	150	72.27	72.26
2	10	50	0.5	150	68.16	68.83
3	9	60	0.6	120	69.24	69.34
4	8	50	0.5	150	77.08	76.35
5	8	50	0.5	150	75.64	76.35
6	7	40	0.6	120	67.17	67.23
7	6	50	0.5	150	70.57	69.02
8	8	50	0.5	90	66.01	65.77
9	9	40	0.6	180	69.87	69.31
10	7	60	0.4	180	70.05	70.39
11	7	60	0.4	120	67.32	68.65
12	7	40	0.4	180	68.74	69.41
13	9	60	0.4	120	69.64	69.3
14	8	30	0.5	150	67.75	68.04
15	8	50	0.5	150	77.24	76.35
16	9	60	0.4	180	68.47	69.19
17	8	50	0.5	150	76.14	76.35
18	7	60	0.6	180	71.21	71.95
19	7	40	0.4	120	68.65	68.73
20	9	60	0.6	180	71.45	71.48
21	8	70	0.5	150	71.3	70.12
22	9	40	0.4	180	68.04	67.83
23	8	50	0.3	150	72.34	71.47
24	8	50	0.5	210	69.24	68.59
25	9	40	0.6	120	68.47	68.24
26	7	40	0.6	180	69.7	70.15
27	8	50	0.5	150	75.87	76.35
28	8	50	0.5	150	76.14	76.35
29	9	40	0.4	120	68.97	69.01
30	7	60	0.6	120	67.64	67.96

Table 5.3 Model Development For Orange Peel Powder

5.5 RESPONSE SURFACE METHODOLOGY

5.5.1 ANOVA FOR COCONUT SHELL CARBON

In a recent study, a 2^4 factorial Central Composite Design (CCD) was hired using Design-Expert software to investigate the maximum removal of zinc. The design consisted of 30 runs, including six replicates and eight axial points. The resulting second-order polynomial equation, derived from the model, were used to predict the maximum removal of zinc.

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	560.2	14	40.01	40.82	< 0.0001	significant
A-pH	7.53	1	7.53	7.68	0.0143	
B-Initial concentration	14.01	1	14.01	14.3	0.0018	
C-Dosage	14.42	1	14.42	14.71	0.0016	
D-Time	0.3953	1	0.3953	0.4033	0.535	
AB	6.97	1	6.97	7.11	0.0176	
AC	0.2401	1	0.2401	0.245	0.6278	
AD	3.67	1	3.67	3.74	0.0722	
BC	1.37	1	1.37	1.4	0.2557	
BD	0.0272	1	0.0272	0.0278	0.8699	
CD	1.6	1	1.6	1.63	0.2208	
A ²	198.86	1	198.86	202.88	< 0.0001	
B ²	128.2	1	128.2	130.8	< 0.0001	
C ²	172.98	1	172.98	176.48	< 0.0001	
D ²	128.5	1	128.5	131.1	< 0.0001	
Residual	14.7	15	0.9802			
Lack of Fit	11.24	10	1.12	1.62	0.3086	not significant
Pure Error	3.46	5	0.6919			
Cor Total	574.91	29				

Table 5.4 ANOVA Table for Coconut Shell carbon

$$\begin{aligned} \text{\% Removal Of Zinc Using Coconut Shell Carbon} = & 80.3007 - 0.633361 A + 0.764167 B - \\ & 0.775 C - 0.128333 D + 0.66 AB + 0.1225 AC + 0.47875 AD + 0.2925 BC - 0.04125 BD - \\ & 0.31625 CD - 3.48589 A^2 - 2.14277 B^2 - 2.48902 C^2 - 2.14527 D^2 \end{aligned}$$

The independent variables, pH, initial concentration, time, and dosage, were coded as A, B, C, and D, respectively. The CCD matrix used in the study is presented in Table 2, while Table 3 displays the ANOVA results. The model's predicted values were observed to have a strong correspondence with the experimental values, as indicated by the high determination coefficient value of 0.9744 and adjusted R² values of 0.9505. This high degree of predictability is supported by the good agreement between the predicted value and the adjusted R² value, highlighting the model's significance. The results indicate that only a small percentage of the sample variance (2.56%) could not be accounted for by the model, yielding a 97.44% confidence interval for predictability. Furthermore, the lack of significant lack of fit adds to the model's overall goodness of fit.

To determine the significance of each coefficient, both the p-value and F-value were computed. A lower p-value and a higher F-value indicate that the associated parameter is more significant. According to the ANOVA results for the response surface quadratic model in this study, the F-value was 40.82, with a p-value of less than 0.0001, indicating the model's significance. These findings suggest that the model can effectively predict the response surface, and the variables that influence the response can be identified through their respective coefficients.

5.5.2 ANOVA FOR ORANGEL PEEL POWDER

In a recent study, a 2⁴ factorial Central Composite Design (CCD) was employed using Design-Expert software to investigate the maximum removal of zinc. The design consisted of 30 runs, including six replicates and eight axial points. The resulting second-order polynomial equation, derived from the model, was used to predict the maximum removal of zinc

The independent variables, pH, initial concentration, time, and dosage, were coded as A, B, C, and D, respectively. The CCD matrix used in the study is presented in Table 2, while Table 3 displays the ANOVA results. The results indicate that the predicted values from the model had a strong agreement with the experimental values, demonstrated by the high determination coefficient value of 0.9609 and adjusted R² values of 0.9245. The good agreement between the predicted value and adjusted R² value confirms the

significance of the model. In addition, the model can explain 96.09% of the sample variance, as only 3.91% of the variance could not be accounted for. The lack of significant lack of fit further supports the model's goodness of fit. Overall, these findings suggest that the model is effective and can accurately predict the outcome.

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	294.13	14	21.01	26.35	< 0.0001	significant
A-pH	0.0551	1	0.0551	0.0691	0.7962	
B-Initial concentration	6.52	1	6.52	8.18	0.0119	
C-Dosage	0.9322	1	0.9322	1.17	0.2966	
D-Time	11.89	1	11.89	14.91	0.0015	
AB	0.1388	1	0.1388	0.174	0.6825	
AC	0.5439	1	0.5439	0.6822	0.4218	
AD	3.43	1	3.43	4.3	0.0556	
BC	0.6602	1	0.6602	0.828	0.3772	
BD	1.13	1	1.13	1.42	0.2526	
CD	5.05	1	5.05	6.34	0.0237	
A ²	94.65	1	94.65	118.71	< 0.0001	
B ²	90.62	1	90.62	113.65	< 0.0001	
C ²	34.57	1	34.57	43.36	< 0.0001	
D ²	144.17	1	144.17	180.82	< 0.0001	
Residual	11.96	15	0.7973			
Lack of Fit	9.81	10	0.9812	2.28	0.1873	not significant
Pure Error	2.15	5	0.4295			
Cor Total	306.09	29				

Table 5.5 Anova Table For orange peel powder

% Removal Of Zinc Using Orange Peel Powder = 76.3517 -0.0479167 A + 0.52125 B + 0.197083 C + 0.70375 D + 0.093125 AB + 0.184375 AC - 0.463125 AD + 0.203125 BC + 0.265625 BD + 0.561875 CD - 1.8576 A² - 1.8176 B² - 1.1226 C² -2.2926 D²

smaller p-value and a larger F-value indicate greater significance of the associated parameter. In this study, ANOVA for the response surface quadratic model revealed an F-value of 26.35 and a p-value of less than 0.0001, indicating the model's significance.

These findings suggest that the model can effectively predict the response surface, and the variables that influence the response can be identified through their respective coefficients.

5.6 RESPONSE SURFACE PLOT FOR COCONUT SHELL CARBON

The link between two or more independent variables and a dependent variable is graphically represented using response surface plots, in conclusion. In your study, the initial concentration and pH are the independent variables, and the response variable is the substance's concentration. The figures demonstrate how alterations in the initial concentration and pH affect the substance's concentration. The experimental setup and conditions must be thoroughly explained, and the axes and units used in the plots must be explained in unambiguous terms. Along with any noteworthy discoveries or inferences made from the data, it is also important to highlight any trends or patterns seen in the plots.

In summary, response surface plots A and B in Figure 5.9 show the relationship between the initial concentration of a substance, dosage, pH, and time of the resulting concentration of the substance. Dosage of the adsorbent is fixed at 0.5g and contact time is 120mins. Plot C shows how the concentration changes as the dosage and pH vary, while plot A shows how the concentration changes as the initial concentration and pH vary. These plots provide important information on the relationship between the independent variables and the concentration of the substance

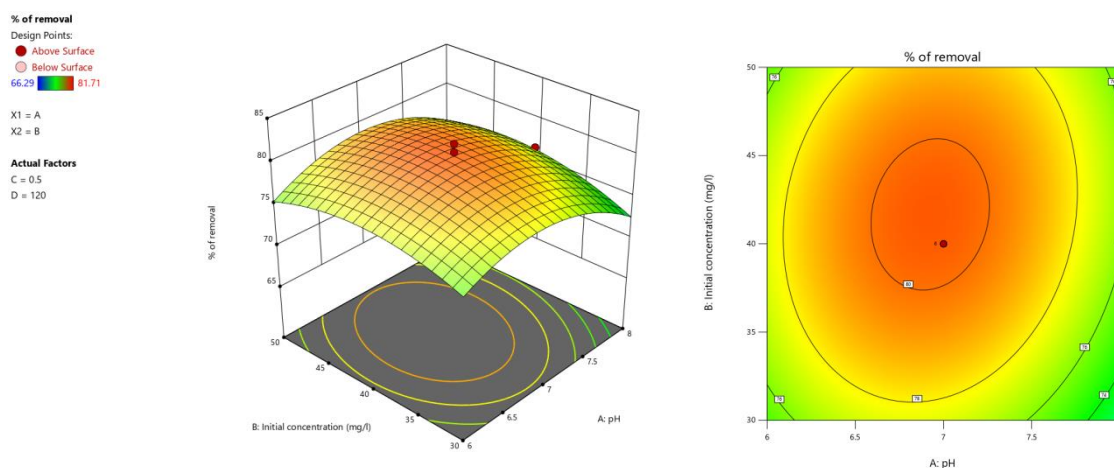


Figure 5.9 : Response surface plots A,B initial concentration and pH (dosage =0.5 g ; contact time = 120 min)

In summary, response surface plots C and A in Figure 5.10 show the relationship between the initial concentration of a substance, dosage, pH, and the resulting concentration of the substance. The initial concentration is fixed at 40mg/l, and the contact time is 120 minutes. Plot C shows how the concentration changes as the dosage and pH vary, while plot A shows how the concentration changes as the initial concentration and pH vary. These plots provide important information on the relationship between the independent variables and the concentration of the substance

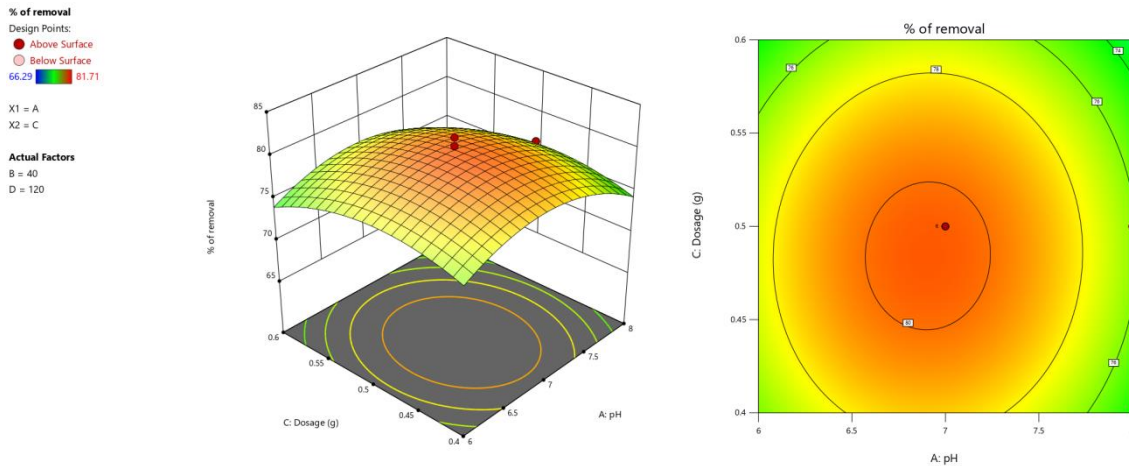


Figure 5.10 Response surface plots C, A dosage and pH (initial concentration =40mg/l ; contact time = 120 min)

The relationship between contact time, pH, initial concentration, dosage, and the final concentration of a chemical is shown by the response surface plots D and A in Figure 5.11. These diagrams offer important insights into how changes in the independent variables impact the substance's concentration.

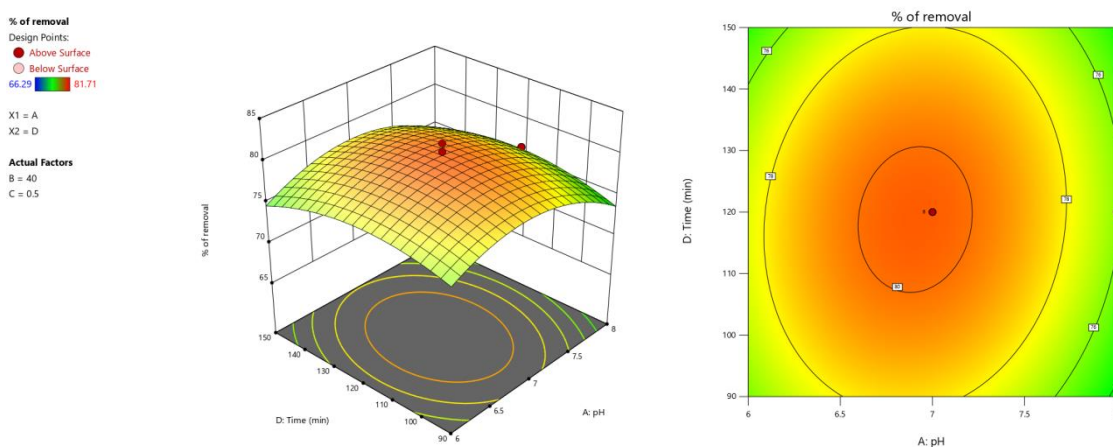


Figure 5.11 Response surface plots D, A time and pH (initial concentration =40mg/l ; contact dosage= 0.5g)

The relationship between the independent variables (starting concentration, dosage, pH, and contact duration) and the final concentration of a chemical is depicted in Figure 5.12 by the response surface plots C and B. These plots can be used to spot patterns and interactions between the variables and offer useful information on how the substance behaves under various circumstances. It's crucial to clearly describe the experimental setup and settings, as well as any noteworthy discoveries or inferences made from the data, when addressing these graphs in a report.

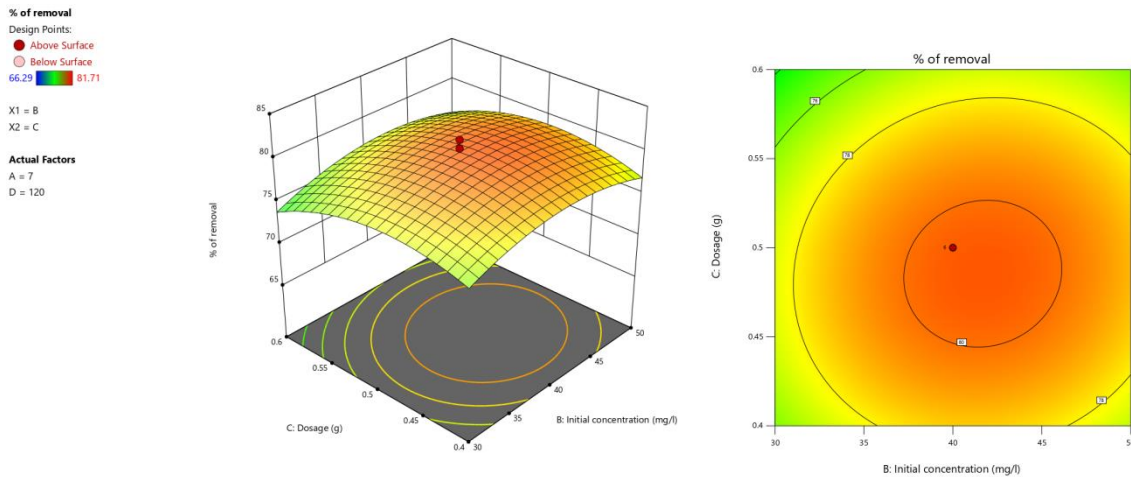


Figure 5.12 Response surface plots C, B dosage and initial concentration (pH =7 ; contact time = 120 min)

The relationship between the independent variables (starting concentration, dosage, pH, and contact duration) and the final concentration of a chemical is depicted in Figure 5.12 by the response surface plots C and B.

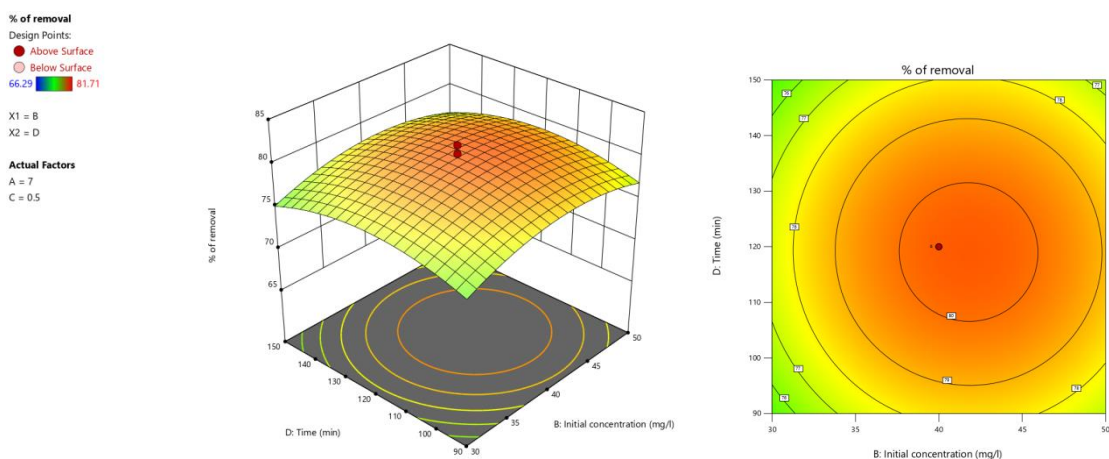


Figure 5.13 Response surface plots D,B time and initial concentration (pH=7 ; dosage = 0.5g)

In conclusion, Figure 5.14 shows the relationship between time, dosage, pH, initial concentration, and the final concentration of a chemical through the response surface plots D and C. These diagrams include crucial details on the effects of each independent variable on the substance concentration as well as any interdependencies between the variables..

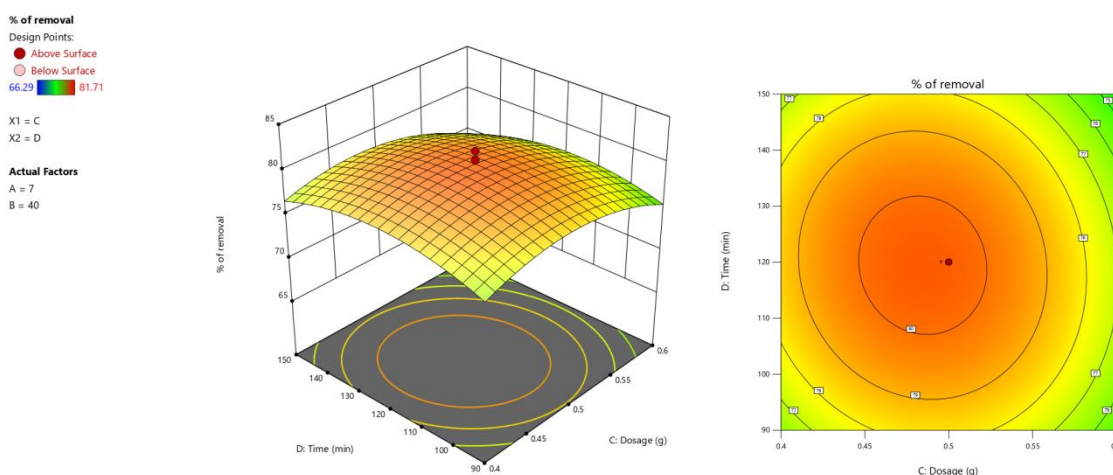


Figure 5.14 Response surface plots D,C time and dosage (pH =7 ; contact , initial concentration = 40ml/L)

5.7 RESPONSE SURFACE PLOT FOR ORANGE PEEL POWDER

Response surface plots B and A, shown in Figure 5.15, show the correlation between a substance's initial concentration, pH, dosage, contact time, and the final concentration. These diagrams can be used to determine how the independent factors affect the substance's concentration and to examine how these variables interact. The plots can also offer crucial insights into how the chemical behaves in various experimental setups. It is crucial to clearly describe the experimental setup, axes, and units utilised, as well as any noteworthy discoveries or inferences made from the data, when addressing these plots in a report.

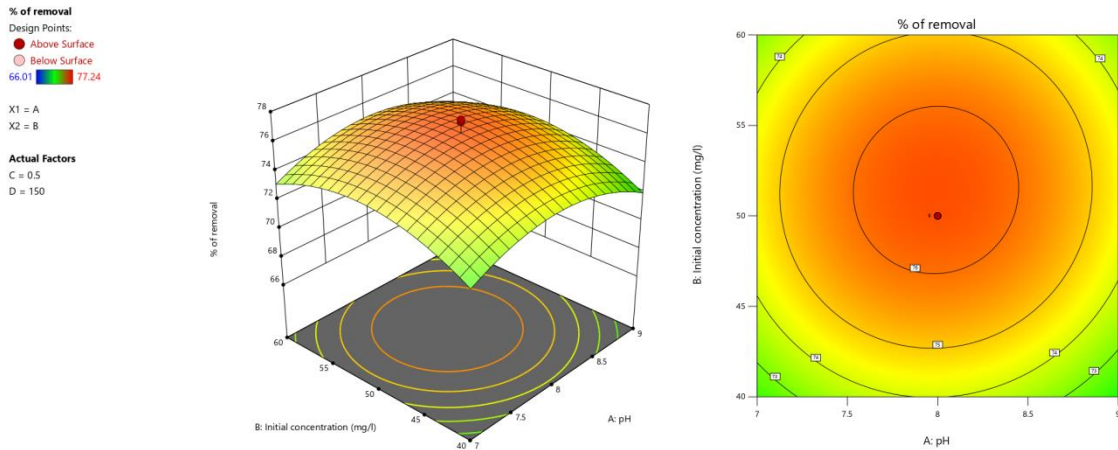


Figure 5.15 Response surface plots B,A initial concentration and pH (dosage = 0.5 ; time =150min)

Figure 5.16 is a response surface plot that illustrates the impact of different levels of chemical C and A dosage, and pH on a particular process, conducted for 150 minutes with an initial concentration of 50ml/L. The plot consists of three dimensions, and the response of the process is represented by the color of the surface. The plot reveals that higher dosages of chemical C, lower dosages of chemical A, and slightly acidic pH levels resulted in the most effective outcome for the process. Additionally, the impact of pH was not as significant as the dosage of chemical C and A.

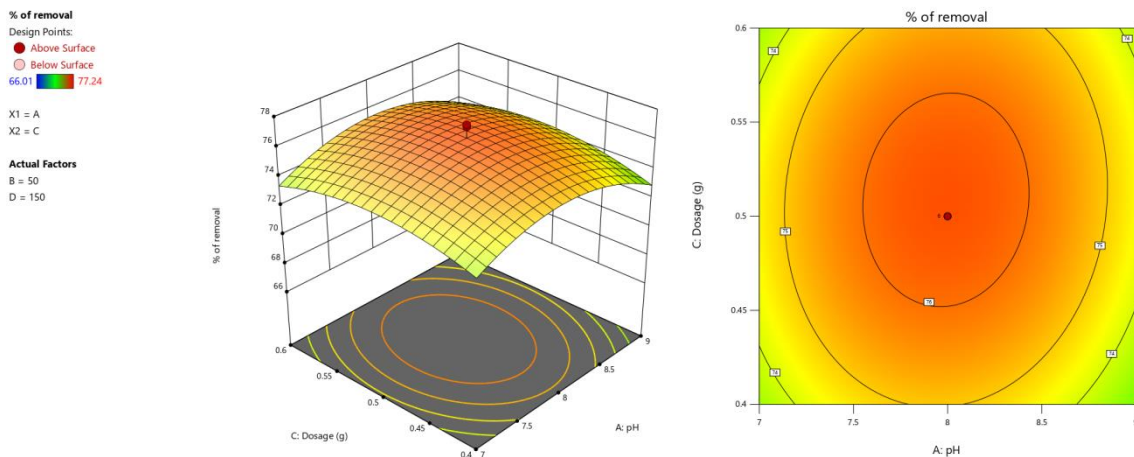


Figure 5.16 Response surface plots C, A dosage and pH(initial concentration =50ml/L ; time = 150mins)

Figure 5.17 is a response surface plot that illustrates the impact of varying levels of time and pH on a particular process, with a fixed initial concentration of 50ml/L and a dosage of 0.5g of chemical D and A. The plot consists of three dimensions, and the response of the process is indicated by the color of the surface. The plot reveals that the process is most effective when the

time is around 120-150 minutes and the pH is slightly acidic. Additionally, the effect of pH on the process is more significant than the effect of time.

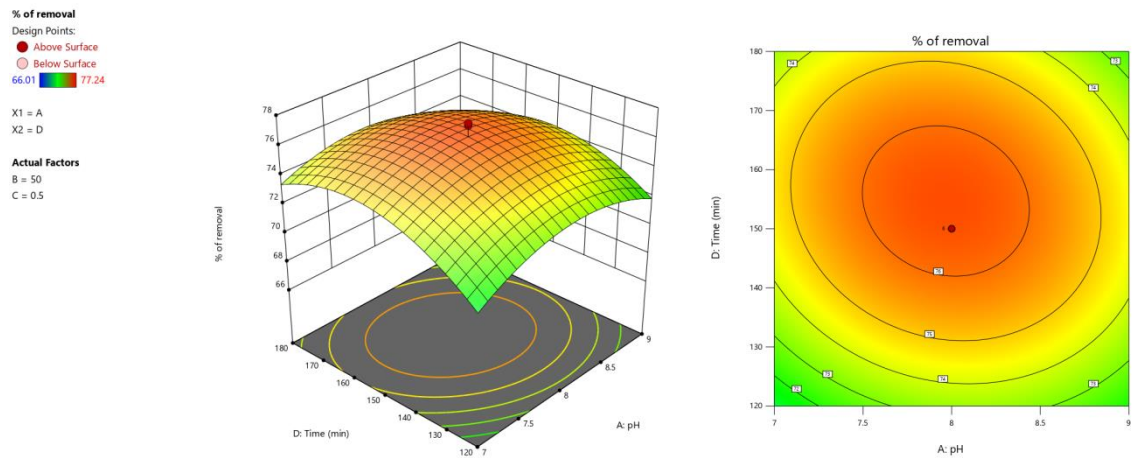


Figure 5.17 Response surface plots D,A time and pH (initial concentration =50mg/L ;dosage = 0.5g)

Figure 5.18 is a response surface plot that illustrates the impact of varying levels of dosage and initial concentration of chemical C and B on a particular process, with a fixed pH of 8 and time of 150 minutes. The plot consists of three dimensions, and the response of the process is indicated by the color of the surface. The plot reveals that the process is most effective when the dosage of chemical C is high and the initial concentration of chemical B is low. Additionally, the effect of initial concentration on the process is more significant than the effect of dosage.

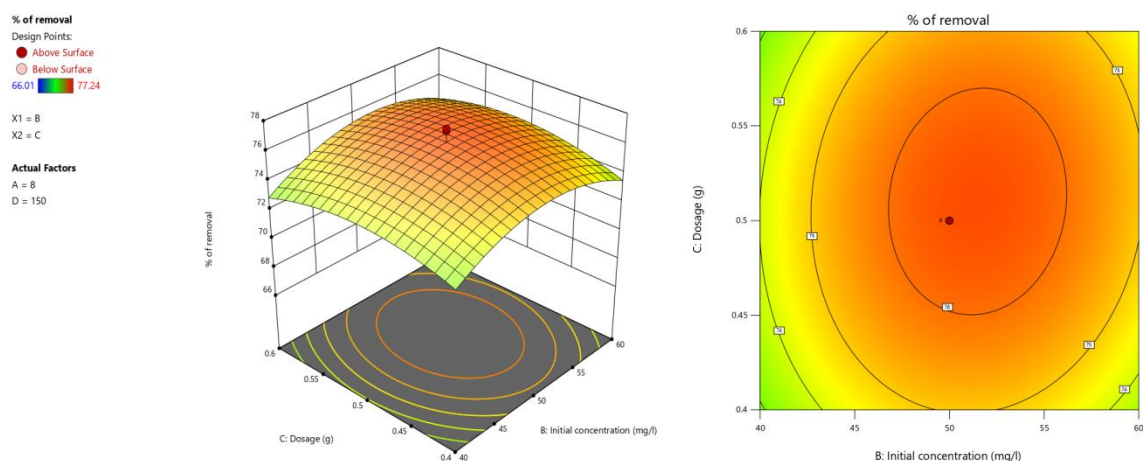


Figure 5.18 Response surface plots C,B dosage and initial concentration (pH =8 ; time= 150min)

Figure 5.19 is a response surface plot that illustrates the impact of varying levels of time and initial concentration of chemical D and B on a particular process, with a fixed pH of 8 and dosage of 0.5g. The plot consists of three dimensions, and the response of the process is indicated by the color of the surface. The plot reveals that the process is most effective when the time is around 150-180 minutes and the initial concentration of chemical B is low. Additionally, the effect of initial concentration on the process is more significant than the effect of time.

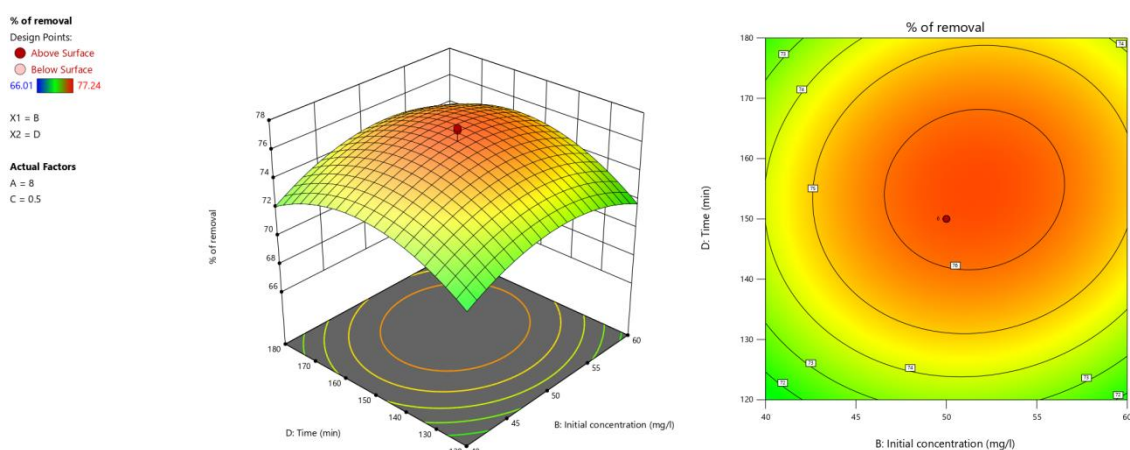


Figure 5.19 Response surface plots D,B time and initial concentration (pH =8 ; dosage = 0.5g)

Figure 5.20 is a response surface plot that illustrates the impact of varying levels of time and dosage of chemical D and C on a particular process, with a fixed pH of 8 and an initial concentration of 50 ml/L. The plot consists of three dimensions, and the response of the process is indicated by the color of the surface. The plot reveals that the process is most effective when the time is around 120-150 minutes and the dosage of chemical D is high, while the dosage of chemical C is low. Additionally, the effect of time on the process is more significant than the effect of dosage.

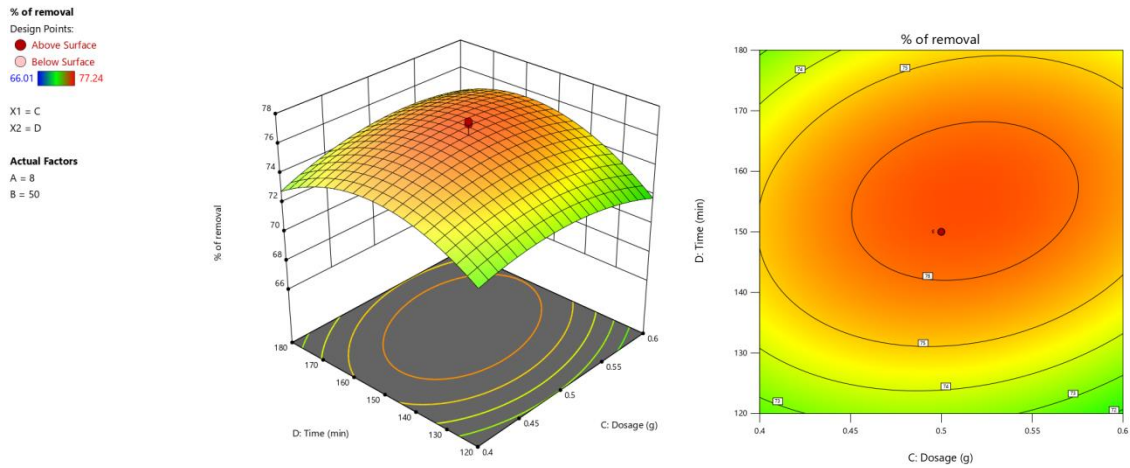


Figure 5.20 Response surface plots D,C time and dosage (pH =8 ; initial concentration = 50 ml/L)

Response surface plots provide a graphical representation of the relationship between input factors and the response of a process. By analyzing these plots, researchers can gain insights into the optimal conditions for the process, which can guide further experimentation and optimization.

5.8 CHARACTERIZATION OF THE ADSORBENT

5.8.1 SEM ANALYSIS

Scanning electron microscopy (SEM) was used to analyse the surface morphology of the activated carbon samples made from coconut shells at a magnification of 500nm. The resulting scans revealed a variety of grain particle sizes and pore distributions, with larger grains and hole diameters observed.

In order to characterise the samples, energy dispersive X-ray spectroscopy (EDX) was also used. The analysis indicated that the samples were comprised of 91.88% carbon particles, 7.26% oxygen, 0.12% sulphur (which was likely produced during the oven drying of the adsorbents), 0.51% calcium, and 0.23% chloride (which was used in the activation process of the coconut shell carbon).

These findings suggest that the activated coconut shell carbon samples possess a diverse surface morphology and chemical composition, which may have implications for their potential applications as adsorbents. These results could be useful for further research and development in this area.

Map Sum Spectrum				
Element	Line Type	Weight %	Weight % Sigma	Atomic %
C	K series	91.88	0.41	94.13
O	K series	7.26	0.40	5.58
S	K series	0.12	0.05	0.05
Cl	K series	0.23	0.05	0.08
Ca	K series	0.51	0.06	0.16
Total		100.00		100.00

Table 5.8 Elements found in Coconut shell carbon

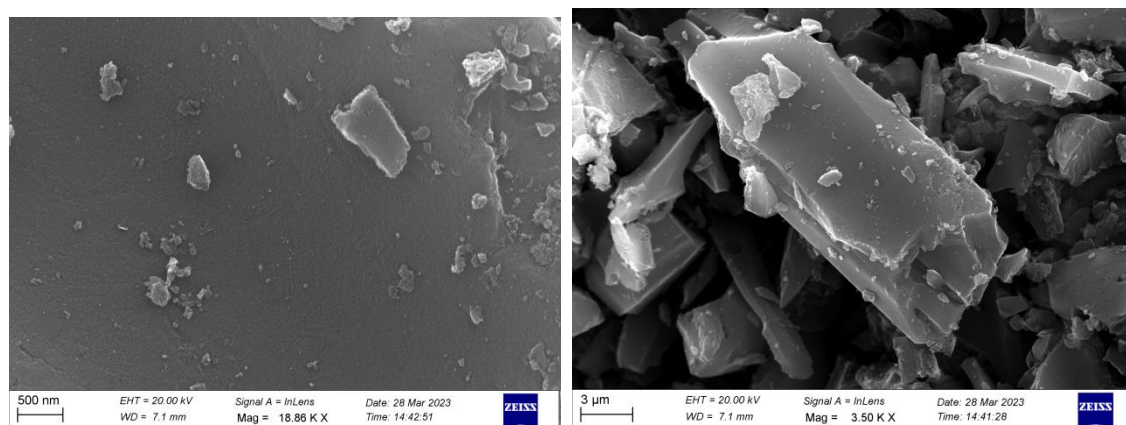


Figure 5.21 Surface morphology for Coconut shell carbon

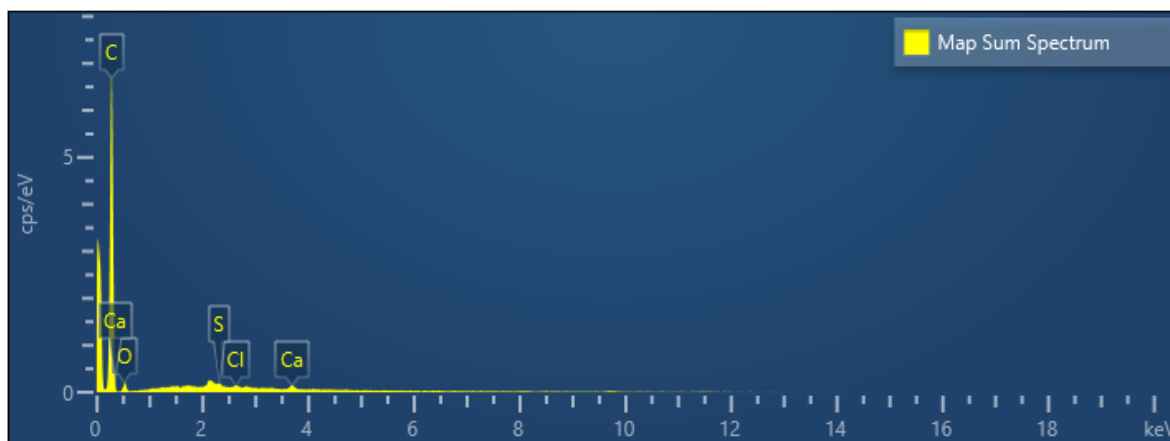


Figure 5.22 Elements present in Coconut Shell Carbon In Graph

5.8.2 ORANGE PEEL POWDER

SEM analysis was conducted on orange peel powder (OPP) using a magnification of 200nm, which revealed a variety of particle sizes and pore distributions. Moderate grains and hole diameters were observed. The morphology of OPP was further investigated using SEM after microwave treatment. The outcomes demonstrated that the surface of OPP was initially smooth and compact, but following microwave treatment it became broken and porous. The porous structure may facilitate mycelia development, although the surface structure of OPP was damaged by the microwave treatment.

The presence of elements in orange peel powder (OPP) is due to its natural composition and environmental factors. The Map Sum Spectrum of OPP revealed the following elemental composition (in weight %): C (60.91%) Carbon (C) is a primary component of organic compounds, such as cellulose and other carbohydrates found in the plant cell walls of oranges, which make up a significant portion of OPP., O (20.72%) Oxygen (O) is also found in organic compounds, such as water and other plant molecules., Na (1.71%), Mg (0.30%), S (0.42%), Cl (2.78%), K (10.88%), and Ca (0.61%) Sodium (Na), magnesium (Mg), potassium (K), and calcium (Ca) are all essential plant nutrients that can be absorbed by orange trees from the soil. Si (1.66%) Silicon (Si) is also present in small amounts in the soil and can be taken up by the plant. SEM analysis indicated that OPP has a porous structure that may be favorable for adsorption

Map Sum Spectrum				
Element	Line Type	Weight %	Weight % Sigma	Atomic %
C	K series	60.91	0.49	73.52
O	K series	20.72	0.38	18.78
Na	K series	1.71	0.06	1.08
Mg	K series	0.30	0.03	0.18
Si	K series	1.66	0.04	0.86
S	K series	0.42	0.03	0.19
Cl	K series	2.78	0.06	1.14
K	K series	10.88	0.15	4.03
Ca	K series	0.61	0.04	0.22
Total		100.00		100.00

Table 5.8 Elements found in Orange peel powder

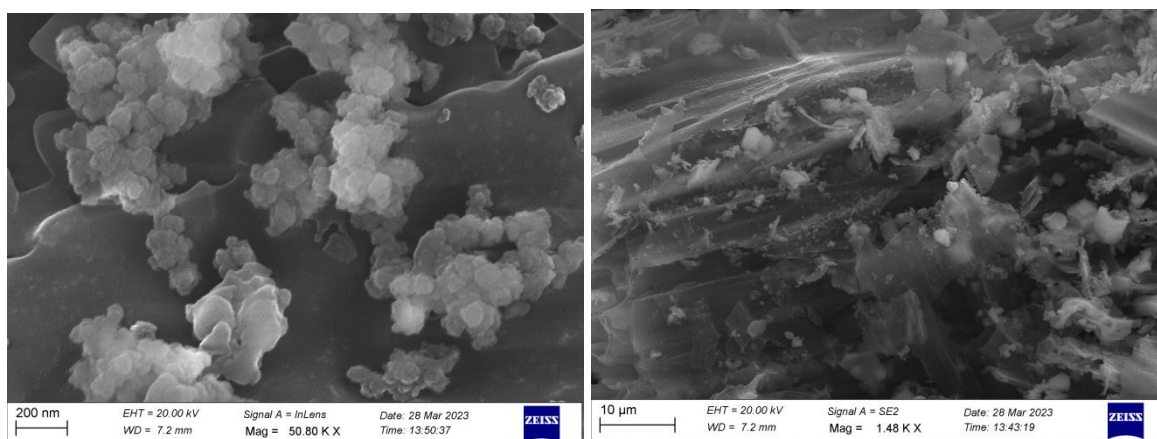


Figure 5.23 Surface morphology for Orange peel powder

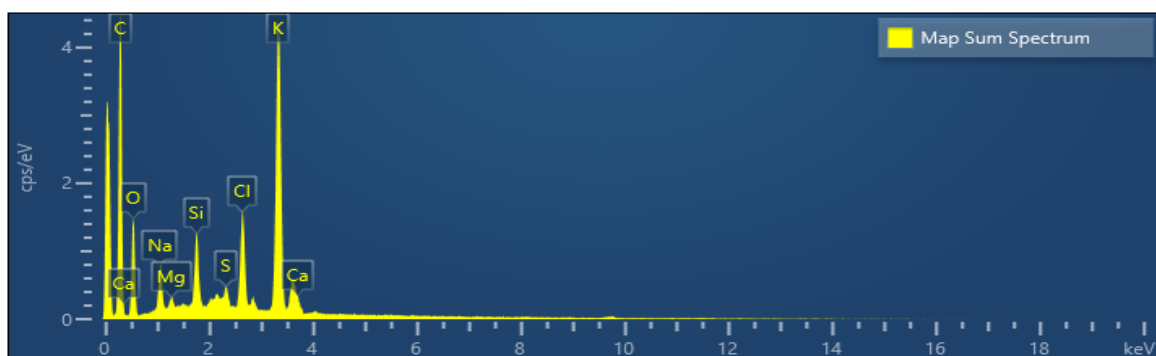


Figure 5.24 Elements present in Coconut Shell Carbon In Graph

5.9 COMPAIRING BETWEEN THE ADSORBENT

In the study, the efficiency of two types of adsorbents, carbon made from coconut shell and orange peel powder, was evaluated for the removal of zinc from the water. The maximum removal efficiency for coconut shell carbon and orange peel powder was found to be 80.73% and 77.24%, respectively, indicating that both adsorbents are capable of effectively removing zinc from contaminated water.

To optimize the adsorption process, several factors such as pH, initial concentration of zinc, time, and adsorbent dosage were studied. The results shows that the optimum pH level for both adsorbents was (7, 8) and the optimum initial zinc concentration were 40 mg/L for coconut shell carbon and 50 mg/L for orange peel powder. The optimum contact time was 120 minutes for coconut shell carbon and 150 minutes for orange peel powder. The optimum adsorbent dosage was 0.3 g/L for both adsorbents.

Based on the comparison of the two adsorbents, it was observed that coconut shell carbon was more effective in removing zinc from contaminated water than orange peel powder. This could be attributed to the high surface area and porosity of the coconut shell carbon, which provided more adsorption sites for the zinc ions. Moreover, coconut shell carbon is a commonly used and easily available adsorbent, making it a more feasible option for practical applications.

In conclusion, the study demonstrated that both coconut shell carbon and orange peel powder can be used as effective adsorbents for removal of zinc from water.

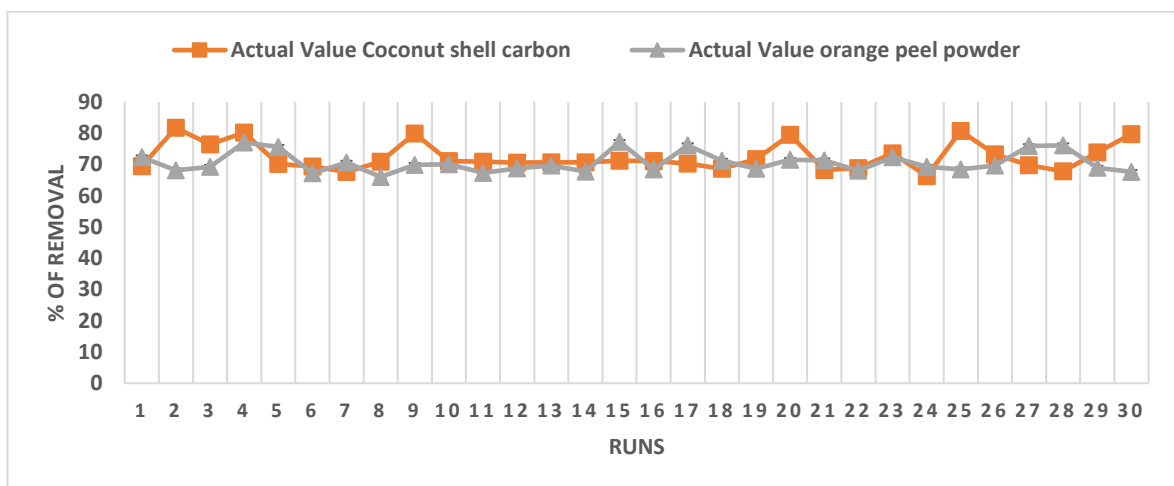


Figure 5.21 Comparison Between Coconut Shell Carbon And Orange Peel Powder

CHAPTER 6

CONCLUSION

6.1 CONCLUSION :

The Coconut shell and Orange peel were used as an adsorbent to remove the zinc metal ion where the percentage of removal is 80.73% and 77.24 % respectively. The efficiency of Coconut shell is high when compare to the other adsorbent. The predicted values from the RSM model were found to fit well with the experimental values, as evidenced by the high determination coefficient R^2 value of 0.9706, 0.9799 and adjusted R^2 values of 0.9432, 0.9572. The parameter were optimized using RSM, pH (8,7), initial concentration (50,40 mg/L), time (150,120mins), dosage (0.5,0.5 g) for respectively for orange peel and carbon made from coconut shell were obtained. Both the adsorbent are cost efficient but preparation of coconut shell carbon takes time comparing to orange peel powder. Orange peel powder and coconut shell carbon both are environmental friendly for the removal of zinc and other heavy metals. But the preparation of coconut shell carbon produce more greenhouse gases which is harmful to the environment and disposal of the carbon should be handled properly.

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