MAKERERE UNIVERSITY

COLLEGE OF NATURAL SCIENCES

SCHOOL OF PHYSICAL SCIENCES

DEPARTMENT OF CHEMISTRY

REMOVAL OF CHLORIDE IONS IN WASTE WATER USING ACTIVATED CARBON FROM MAIZE COBS AND COCONUT SHELLS

BY

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DECLARATION

I, MUNIIRAH SWABRAH, hereby declare to the best of my knowledge that this research project report is original and is a product of completion of my efforts and other references stated under the supervision of Dr. Job.S. Kasule. Therefore, it has not been submitted to any other academic institution for any other qualification.

Signature……………………
Date……04.10.24……

DEDICATION

This piece of work is dedicated to my beloved parents, my friends, my classmates, and the entire staff of the Chemistry department. All the above-mentioned played a great role in guiding me, and supporting me, they have been a great source of inspiration and motivation which enabled me to get knowledge and practical skills as well as my entire academic journey. May the Almighty bless you all abundantly.

ACKNOWLEDGEMENT

I extend my sincere gratitude to the lecturers; **Dr. Mubiru Edward, Dr. Kasule Job** among others of the College of Natural Sciences for enabling me to add value to my life skills as I am pursuing my course. I wish to humbly thank my supervisor, **Dr. Nsamba Hussein Kisiki** for his mentorship during my entire project period.

Furthermore, thank my beloved parents**; Hajj Sengooba Asuman, Hajat Hamidah Nassuna** and my siblings; **Atwia, Barila, Hanifa, Fatima, Uthman, Diina**, and my beloved aunt **Nassuna Sumayya Namayanja** for supporting me unconditionally in many different ways, socially I also extend my appreciation to my special thanks go to my classmates; **Shirat, Diana, Shamira, Justus, Shafiq**, **Shiphrah, Joy, Wardha** for the good teamwork that was portrayed during the study of this course, without you I would not have gained to my expectations. I also wish to extend my gratitude to Mr. Kusiima Brian for his guidance during the practical session of the project. Most importantly, I thank the **Almighty God** for enabling me to accomplish this program well.

APPROVAL

I, **Muniirah Swabrah,** certify that I carried out the research project. The report is now ready for submission as partial fulfilment for the award of Bachelor of Science in Industrial Chemistry, Makerere University with due approval.

Approved by:

Dr. Job.S. Kasule,

Lecturer Makerere University,

University Supervisor

Signed…………………………………

Date…………04/10/2024…………………

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ABSTRACT

In a study carried out to remove chloride ions from a waste water sample using activated carbon from maize cobs and coconut shells. A waste water sample from surface run off water was collected. The initial chloride content of ions in waste water was determined as (10196.07317mg/L Cl). This is a highly unacceptable level of chloride ions in water therefore there is need to remove the chloride ions in this waste water sample. Activated carbon was used as the adsorbent to remove the chloride ions in water. The activated carbon was made from coconut shells and maize cobs. It was then characterized. An orbital shaker was used to determine the time contact for 8 intervals from 0-70 minutes. The results were tabulated. The percentage removal from the beakers with activated carbon from coconut shells was the highest with (77.18906532%) and the one from maize cobs was (70.5539021%). This indicated that coconut shells are a better source of activated carbon than maize cobs.

CHAPTER ONE: INTRODUCTION

1.1 PROJECT TITLE

REMOVAL OF CHLORIDE IONS IN WASTE WATER USING ACTIVATED CARBON FROM MAIZE COBS AND COCONUT SHELLS

1.2 OBJECTIVES OF THE STUDY

1.2.1 General objective

To determine the chloride ions in the waste water after treatment with activated carbon.

1.2.2 Specific objectives

i. To determine the chloride content in the waste water
ii. To prepare activated carbon from maize cobs and coconut shells.
iii. Characterization of the activated carbon
iv. To determine the best source of activated carbon from either maize cobs and coconut shells.

1.3 PROBLEM STATEMENT

Chloride ions are negatively charged ions formed when chlorine atoms gain an electron. When the amount of chloride ions is higher in the wastewater, it has detrimental effects on the environment. Chloride ions are essential for environmental processes such as ocean acidification and water cycle, in water treatment plants among others. The increase in chloride ions can potentially affect water quality and infrastructure. Chloride ions increase in water due to natural and anthropogenic sources. These include geological formations; chloride rich rocks and sediments can leach into ground water, sea water intrusion; coastal aquifers can be contaminated with chloride rich sea water. Agricultural activities; the use of fertilizers and pesticides containing chlorine compounds. Industrial processes for example chemical manufacturing and processing and waste disposal. The other sources include urban runoff, natural sources and human activities like water softening processes, treatment processes, swimming pool and spa discharge. Excess chloride ions in waste water can lead to salinization of water bodies where the treated waste water is discharged this high salinity can negatively impact aquatic life especially sensitive species. High chloride levels can corrode infrastructure like pipes and machinery leading to damage and increasing maintenance costs. Monitoring and controlling chloride levels in waste water to prevent these negative impacts on the environment and infrastructure is crucial. High chloride levels can lead to an increase in disinfection byproducts. These disinfection byproducts like trihalomethanes, halo acetic acids among others cause cancer which causes genetic damage and cancer in laboratory animals, neurological problems such as asthma and bronchitis, skin problems such as rashes and irritation. Chloride ions can interfere with ion exchange processes used in water treatment by competing with other ions for binding sites. This interference can reduce the efficiency of ion exchange processes. High concentrations of chloride ions in waste water contribute to unpleasant tastes and odors in drinking water. This can affect the acceptability of treated water for consumption. Therefore, an increase in the concentration of chloride ions in waste water leads to UNBS standard operating procedures and NEMA regulations regarding wastewater handling and disposal at these facilities.

This research aims at removal of chloride ions in waste water and the determination of the best source of activated carbon from either maize cobs and coconut shells. The two materials are environmentally friendly and can easily be accessed in the environment. The choice of the source of adsorbents is because of their reusability, eco-friendly, low cost and their sustainability.

1.4 JUSTIFICATION OF THE STUDY

The study was intended to determine the concentration of chloride ions after the treatment of waste water using activated carbon from maize cobs and coconut shells. This study utilizes the agricultural waste materials as adsorbents offers a fresh perspective on waste water treatment. This study justifies environmental significance because chloride ions can harm aquatic ecosystems and effective removal mitigates this risk. It enhances economic benefits using low cost, readily available materials like maize cobs and coconut shells reduces treatment expenses. The use of agricultural materials for treatment is a sustainable solution that aligns with circular economy principles converting waste into a valuable resource.

This study investigates the adsorption properties of maize cobs and coconut shells and advances understanding of adsorption mechanisms. The study contributes the development of sustainable, cost effective and environmentally friendly wastewater treatment solutions. This issue aligns with several Sustainable Development Goals (SDGs).

1.4.1 SDG 6: Clean water and sanitation

This targets the universal access to safe and affordable drinking water. The removal of chloride ions ensures water quality and safety for human consumption.

1.4.2 SDG 12: Responsible consumption and production

This targets environmental impacts of chemical use reduction. Efficient removal of chloride ions reduces the environmental impact of industrial processes.

1.4.3 SDG 14: Life below water

This targets the prevention of marine pollution. Reduction of chloride ions in effluents enables o protect aquatic life.

1.4.4 SDG 15: Life on land

This targets on the conservation and restoring of ecosystems. The removal of chloride ions enables to maintain water quality by removing chloride ions that support ecosystem health.

The removal of chloride ions essential for ensuring water quality, public health and environmental sustainability.

1.5 SCOPE OF THE WORK

The waste water was collected from outlet pipes of a distillery located in central Uganda, Wakiso District. Laboratory analysis of wastewater was carried out by the Makerere University Chemistry laboratory in Kampala. All activities of this research were carried out over 2 months, from April 2024 to June 2024.

1.6 INTRODUCTION

Industrial waters are effluents that are result from human activities which are associated with raw material processing and manufacturing. Industrial waters are from pharmaceutical electronic, petrochemical and food processing industries. Industrial waste waters are treated before discharged to the environment (Gilcreas, F.W, 1996).The preliminary treatment enhances the downstream by removing materials which interfere with mechanical, chemical or biological process. This uses the racks and coarse screens. The primary treatment is the removal of settleable suspended solids.60% of the suspended solids are removed by unaided gravity settling. BOD_5 are removed with suspended solids. The secondary treatment, in this phase begins with the treatment of the actual industrial waters. An aerator is used. Activated sludge is used to treat the waste water.

The tertiary treatment is when chlorine added to disinfect the water before discharge. Chlorination is the most common procedure for disinfection of waste water. Chlorination of treated wastewater has been shown to result in the formation of toxic disinfection by-products (DBPs) (Bayo et al., 2009; Wang et al., 2007). Previous studies have identified general toxicity arising from DBPs in wastewaters using bioluminescence assays, and have correlated this to chlorine dose, total nitrogen (TN), inorganic carbon, UV_{254} and pH (Bayo et al., 2009). However, while DBPs in chlorinated potable water have attracted a high scientific and public interest (Hrudey, 2009; Richardson et al., 2007), the effect of DBPs in wastewater on the receiving aquatic environment is not well understood. Wastewater is most frequently treated to secondary level prior to chlorination or dechlorination and subsequent discharge to the environment. Nevertheless, even tertiary-treated wastewater can have a higher total organic carbon (TOC) and total nitrogen (TN) content than most raw source waters. The higher nitrogen content of wastewater can lead to the formation of nitrogen-containing DBPs (Najm and Trussell, 2001), which are generally more toxic than carbon-based DBPs (Plewa et al., 2008) Wastewater discharges are released to freshwater, estuarine or marine environments, where recreational water quality is considered a very important environmental value requiring protection. While wastewater discharges to the marine environment are likely to become rapidly diluted due to the large size of the receiving water body, treated wastewater can be the dominant contributor to inland freshwater streams, particularly during the drier months of the year.

The Guidelines for Managing Risks in Recreational Water (National Health and Medical Research Council, 2008) stipulate the acceptable levels of pathogen indicators such as enterococci that would be considered low risk for activities such as swimming and boating. It is generally accepted that effluent disinfection is required to manage this potential risk. Chlorination is the traditional means of disinfection, and the cost of retro-fitting the disinfection system from chlorination to an alternative is often regarded as cost-prohibitive.

However, chlorine and DBPs in wastewater effluents may present an environmental issue. Although the toxicity of chlorine itself can be mitigated by dechlorinating the effluent prior to discharging into the environment, this process does not remove DBPs. It is important to understand the impact of DBPs on aquatic ecosystems, since DBPs will inevitably be formed by wastewater chlorination. The potential for incomplete disinfection (Camarillo et al., 2011) resulting from these processes is another risk that must be considered in planning toward improved chemical and microbial water quality outcomes for receiving waters. Chloride ions can be removed by various processes and the most common are sulfur compound or activated carbon (AC) (White 1999). Activated carbon has successfully been used to remove of chloride ions in waste water. (Magee 1956; Suidan et al. 1977; Suidan et al. 1980). Chloride removal by activated carbon is quite effective.

The study aimed to remove chloride ions from waste water using activated carbon derived from coconut shells and maize cobs regarded as agricultural waste. Alternative disinfection strategies such as use of a carbon filter warrant further consideration for greater use.

CHAPTER TWO: LITERATURE REVIEW

2.1 THEORETICAL REVIEW

2.1.1Waste water

Waste water refers to any water that has been contaminated by human use and is no longer suitable for its original purpose. It includes water from households, industries and agriculture that contains pollutants. Waste water may include water about 95%, non-pathogenic bacteria, pathogens like virus, bacteria, animals and gases. The contaminants in waste water can harm aquatic life, contaminate drinking water sources and damage ecosystems. Organic chemicals in industrial waste water can be toxic and disrupt the balance of ecosystems. Waste water treatment is essential to remove contaminants before the releasing the water back to the environment to prevent pollution and protect public health. The treatment process involves physical, chemical and biological methods to clean the water and make it safe for disposal and re use.

2.1.2Chloride ions

Chloride ions are negatively charged ions formed when chlorine atoms gain an electron. They crucial in biological and chemical processes. Chloride ions are essential for environmental processes such as ocean acidification and water cycle, in water treatment plants among others. The increase in chloride ions can potentially affect water quality and infrastructure. Chloride ions increase in water due to natural and anthropogenic sources. These include geological formations; chloride rich rocks and sediments can leach into ground water, sea water intrusion; coastal aquifers can be contaminated with chloride rich sea water. Agricultural activities; the use of fertilizers and pesticides containing chlorine compounds. Industrial processes for example chemical manufacturing and processing and waste disposal. The other sources include urban runoff, natural sources and human activities like water softening processes, treatment processes, swimming pool and spa discharge. Chlorination is the most common procedure for disinfection of water and waste water. The main issue of chlorination is the oxidation reaction between chlorine and natural organic matter that results into the production of harmful byproducts (Allard et al. 2013; Reguero et al. 2013). Natural organic matter is a heterogeneous mixture of complex organic materials derived from allochthonous and autochthonous sources, associated with many biotic ana abiotic processes (Zhao et al. 2016). In many cases, the protection of the distribution system is compulsory. A minimum concentration of 0.5mg Cl_2/L is recommended with a minimum contact time of 30 minutes and a water turbidity of ideally less than 1 NTU (WHO 2011). The recommended chlorine residual which is centrally treated at the point of delivery is 0.2 to 0.5 mg/L for the water protection in the distribution network. The target of low chlorine residual dose (0.3 to 0.5 mg/L) leads to increase of taste acceptability of chlorinated water and reduction in risk of waterborne diseases. After chlorination, chloride ions are formed as a result of the reaction between chlorine and water

Chloride ions are a common pollutant in waste water and their removal is essential to reduce, prevent environmental and health impacts. Activated carbon from agricultural waste materials like maize cobs and coconut shells has gained attention as sustainable and cost-effective adsorbent for waste water treatment.

2.1.3 Adsorption Technology

This is a surface phenomenon-based separation process where a substance is attracted and retained onto the surface of a solid material(adsorbent). This technology is used to remove contaminants and pollutants from water and air, separate gases and liquids and recovery of valuable substances. Adsorption technology offers various benefits; high efficiency in removing impurities, low energy requirements, cost effectiveness and eco-friendly. Adsorption can either be physical or chemical depending on the interaction between the material in usage and the adsorbate. Physical adsorption involves weak attractive forces such as Van der Waal interactions between the ions being adsorbed and the adsorbent. Chemical adsorption involves the formation of stronger chemical bonds between the adsorbent and the adsorbate. These strong chemical bonds are formed as a result of a chemical reaction between the adsorbate and the material on which they are held.

The common type of adsorbents

Activated carbon is a highly porous material that offers a large surface area for pollutant adsorption. It is effective for removing organic contaminants.

Zeolites are naturally occurring or synthetic materials that have a well-defined pore structure that can be used to target specific pollutants. They are often used for the removal of heavy metals and ammonia.

Clays are naturally occurring minerals that have a potential for removal of organic and inorganic pollutants from waste water. Their effectiveness is limited in comparison to other adsorbents.

The adsorption process

Contact: The adsorbent material comes into contact with the fluid (gas or liquid) containing the adsorbate.

Attraction: The adsorbent surface attracts the adsorbate molecules through weak intermolecular forces (van der Waal, electrostatic or chemical bonds).

Accumulation: The adsorbate molecules accumulate on the adsorbent surface forming a thin layer.

Equilibrium: The adsorption process reaches equilibrium where the rate of adsorption equals the rate of desorption (release of adsorbate back into the fluid).

Saturation: The adsorbent surface becomes saturated with adsorbate molecules reaching its maximum capacity.

Desorption: The adsorbent material can be regenerated by desorbing the adsorbate allowing the adsorbent to be re used.

The factors influencing adsorption

Surface area and porosity: The larger the surface area and porosity of the adsorbent material, the more sites are available for adsorption.

Chemical properties: The chemical properties of both the adsorbent and adsorbate such as polarity and functional groups and how they affect the adsorption process.

Temperature: Temperature can influence the adsorption capacity and rate with optimal temperature varying on the system.

Pressure: Higher pressures enhance adsorption but excessive pressure can lead to decreased adsorption capacity.

Concentration: The concentration of the adsorbate in the fluid affects the adsorption rate and capacity.

Contact time: The longer the contact time, the more adsorption takes place.

Particle size: The size and shape of adsorbent influence the adsorption process.

Surface modification: Chemical modifications to the adsorbent surface can enhance or diminish adsorption.

Understanding of these factors enables the optimization of adsorption systems for various applications that include water treatment, gas separation and biomedical applications.

2.1.4. Activated carbon

Activated carbon is a highly porous material that offers a large surface area for pollutant adsorption. It is effective for removing organic contaminants. Activated carbon from agricultural waste materials like maize cobs and coconut shells has gained attention as a sustainable and cost-effective adsorbent for waste water treatment. Chloride ions in particular are a concern in waste water due to their potential and health impacts. Maize cobs and coconut shells are converted into activated carbon through various activation methods including chemical activation, physical activation thermal activation. The prepared activated carbon is characterized by its surface area, pore size and functional groups which affect its adsorption capacity.

Studies have shown that activated carbon from maize cobs and coconut shells exhibits high adsorption capacity for chloride ions. A study by Otunola et al. (2020) found that activated carbon from maize cobs removed up to 90% of chloride ions from waste water. Another study by Vishal et al.(2019) reported that activated carbon from coconut shells achieved a maximum adsorption capacity of 350mg/g for chloride ions.

Batch adsorption experiments are commonly used to evaluate the adsorption performance of activated carbon from maize cobs and coconut shells. The effect of initial chloride ion concentration, contact time, adsorbent dosage, pH and temperature on adsorption are investigated. The results show that activated carbon from maize cobs and coconut shells exhibits high adsorption capacity for chloride ions with maximum capacities ranging from 200 to 500mg/g. the adsorption process is influenced by factors such as pH 6-8, temperature 30-40^0C and contact time 2-4 hours (Kumar et al., 2020; Singh et al; 2019).

The adsorption kinetics and thermodynamics are studied to understand the adsorption mechanism and the factors affecting the adsorption process. The results show that the adsorption of chloride ions onto activated carbon from maize cobs and coconut shells follows a pseudo second order kinetic model and is spontaneous and exothermic in nature. The adsorption performance of activated carbon from maize cobs and coconut shells is compared with other adsorbents for example zeolites, commercial activated carbon and biomass-based adsorbents. The results show that activated carbon from maize cobs and coconut shells have comparable or even better adsorption capacity than other adsorbents.

The scalability and cost effectiveness of activated carbon from maize cobs and coconut shells are evaluated. The use of activated carbon from maize cobs and coconut shells offers several advantages that include low cost, high availability and eco-friendly. These materials can easily be regenerated and reused, making them a sustainable option for waste water treatment. The results show that the production of activated carbon from maize cobs and coconut shells is scalable and cost effective, making it a promising adsorbent for large-scale waste water treatment.

CHAPTER THREE: MATERIALS AND METHODS

3.1. MATERIALS

Silver nitrate solution, Sodium chloride crystals, distilled water, burette, Pipette, Magnetic stirrer, Timer, Volumetric flasks, pH meter, analytical balance, magnetic stirrer, orbital shaker, potassium hydroxide and concentrated sulphuric acid

3.1.1Sample collection and storage

Samples were collected in wide-mouth glass bottles transferred to the laboratory and poured into separating funnels and prepared as detailed below:

- Sampling bottles were used to collect waste water.
- A laboratory pen was used to label the sampling bottle with a sample id.
- The waste water was stored in the refrigerator for preservation.

Samples are to be preserved until analysis time. The sample temperature was left to increase to room temperature before analysis.

3.2. METHODS

3.2.1Standardization of silver nitrate

A solution of silver nitrate of 1.0M. 170.5g of silver nitrate were added to a 1.0L of water. The solution was standardized using sodium chloride. 0.1g of NaCl were added to 50.0mls of water. The solution was topped up to 100mls.The potassium indicator was prepared by dissolving 5.0g in 5.0mls of water.Titrate the silver nitrate solution with sodium chloride solution until the endpoint is reached. Record the volume of sodium chloride solution added to reach the end point. Calculate the concentration of the silver nitrate solution using the formula.

$$concentration\ of\ AgN03 = (weight\ of\ NaCl(g) * \frac{1000}{Volume\ of\ AgN03(L) * 169.87})$$

3.2.2Preliminary tests done on waste water sample

pH testing; determines the acidity or basicity of a sample, temperature measurements, total suspended solids, turbidity measurement

3.2.3 Determination of chloride ions before treatment with activated carbon

The laboratory glassware was cleaned thoroughly.50.0mls of the sample of waste water were added to a conical flask. The flask was topped up to 100.0mls with distilled water. The sample solution was titrated silver nitrate solution using potassium chromate indicator.

$$concentration\ of\ chloride = \frac{average\ titre\ value * normality\ of\ AgN03 * molecular\ waeight\ of\ Cl}{50}$$

3.2.4 Preparation of activated carbon

Coconut shells

Before analysis, it was necessary to carefully clean and dry all of the glassware. The coconut shells were cleaned with deionized water and dried at 110^0C for 48h to reduce the moisture content. The dried samples were then crushed and ground using a grinder the crushed coconut shells were mixed with potassium hydroxide in a ratio of 1: 1.The mixture was put in a crucible and placed in a furnace at 500^0C for 4h. The product was cooled to room temperature and washed with HCl and deionized water until the pH of the washing solution reached 6-7. The activated carbon was characterized using X-ray diffraction (XRD).

Maize cobs

Before analysis, it was necessary to carefully clean and dry all of the glassware. The coconut shells were cleaned with deionized water and dried at 110^0C for 48h to reduce the moisture content. The dried samples were then crushed and ground using a grinder the crushed coconut shells were mixed with potassium hydroxide in a ratio of 1: 1. The mixture was put in a crucible and placed in a furnace at 500^0C for 4h. The product was cooled to room temperature and washed with HCl and deionized water until the pH of the washing solution reached 6-7. The activated carbon was characterized using X-ray diffraction (XRD). The activated carbon was stored in aluminum foil

3.2.5 Characterization of the activated carbon

Coconut shells

The pore size and structure of the activated carbon were determined using nitrogen adsorption Brunauer Emmett- Teller (BET) and scanning electron microscope (SEM). Samples were prepared by cutting the dried samples to fit the specimen stub. The sample surface was sputter coated with a thin film of platinum before being viewed using SEM (Chandra et al. 2009). Adsorption was performed at -196.2^{0}C using an automatic volumetric sorption analyzer and immersion calorimetry at 19.9^{0}C(Marin et al. 2009). The surface area and a pore size of CSAC produced were determined using the BET analysis software. The BET surface area was measured using standard BET equation applied with relative pressure (P/P_0) ranging from 0.06 to 0.30. The cyclic voltammetry test was used to estimate specific capacitance value. The unit was expressed in Farads per mass (Fg^{-1}) of carbon material. The CSAC electrodes were soaked in 10M KOH of electrolyte for 2 hours and these symmetric electrodes were sandwiched with separators using Teflon cell before undergoing cyclic voltammetry test. The symmetric electrodes of CSAC were tested at 0-1V with scan rate of 2mVs^{-1} in aqueous electrolyte (10M KOH).

Maize cobs

The surface functional groups of activated carbon were analyzed by Fourier Transformation Infrared (FTIR) spectroscopy and were scanned through a range of 600-4000cm^{-1}. The nitrogen adsorption isotherms were determined based on the automated adsorption instruments. The activated carbon was pre heated at 90^{0}C and degassed at 300^{0}C in a vacuum with a holing time of 10h. the nitrogen adsorption was measured over relative pressure (P/P_o) and the BET surface area was calculated by BET (Brunauer-Emmett-Teller).

3.2.6 Analysis of the chloride ions after treatment

The glassware was cleaned thoroughly and dried.2g of activated carbon of each sample were placed in each 250ml beaker. The waste water was added to the beakers. The beakers were placed on an orbital shaker. The samples were analyzed after 0, 10,20,30,40,50,60 and 70 minutes. The volume of silver nitrate was tabulated.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1. RESULTS

4.1.1 Standardization of silver nitrate 1M

The silver nitrate was standardized with sodium chloride and the results were tabulated.

samples	Weight of Na$_{Cl}$ (grams)	Vol of AgNO3(**mls**)		Normality of AgNO3 (NAgNO3)		
	(WNacl)	(VAgNO3)				
				W_{NaCl} x 1000		
					35.55 x VAgNO3	
1	0.9633	[redacted]	16.50		1.642245	
2	0.9780	[redacted]	17.20		1.599450	
		Average:			1.620848	

Table 1 : A table showing calculation of normality of silver nitrate

4.1.2 Results before treatment with activated carbon

Sample identification		2024.03.004		
		1	2	3
	Volume of the Vsample	50	50	50
	Titre Value of AgNO3(VAgNO3)	8.9	9	9
Total Chloride of water as Cl		10138.46824	10253.678 1	10253.678 1
mg/L Cl	Average	10196.07317		

Table 2: A table showing the value of chloride mg/L before treatment.

The average amount of chloride ions is 10196.07317mg/L Cl. According to the World Health Organisation (WHO), it recommends the following guidelines; desirable level is less than 200mg/L, the acceptable level is between 200-400mg/L and unacceptable level is above 600mg/L. The average value of chloride ions in waste water sample is very high. High levels of chloride in water can give it a bitter or salty taste and may be harmful to people with certain medical conditions.

4.1.3. Characterisation of activated carbon

Coconut shells

Morphology of the prepared activated carbon and coconut shells

A scanning electron microscope (SEM) was used to examine the surface of the prepared coconut shells activated carbon adsorbent. During carbonisation, most volatile matter was released. However, no pores developed due to absence of an activating agent. In the CSAC, however, hollow pits were observed and these were due to the loss of volatile matter and the effect of KOH activating agent on the carbon material.

When the irradiation time is above 20 minutes, the activation reaction is over because the activating agent is used up. This means that the ratio of KOH used also has an influence on pore development during the activation process. This phenomenon of the activation process is found to be similar to a previous study (Yongbin et al, 2007).

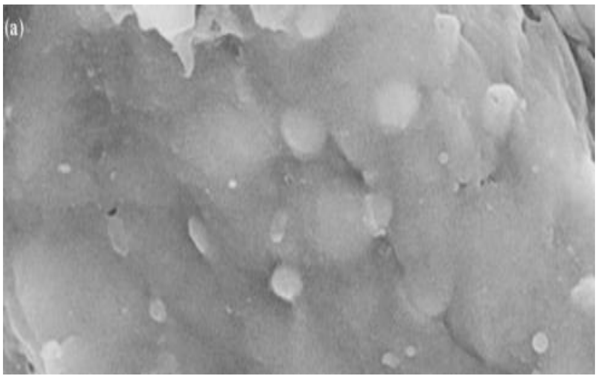

Figure 1: SEM micrographs of (a) coconut shell carbon

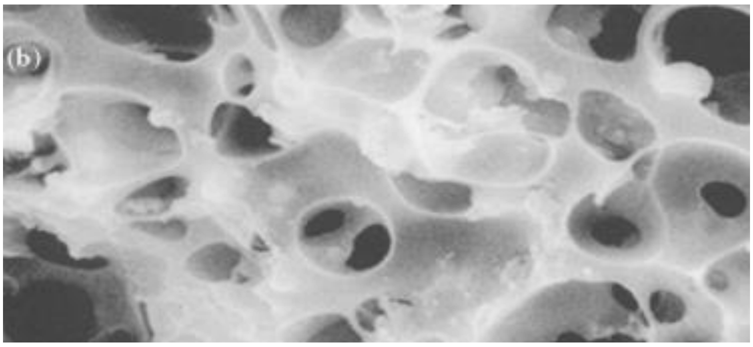

Figure 2: SEM micrograph of (b) coconut shell activated carbon

Maize cobs

The Fourier transform infrared (FTIR) spectra of activated carbon presented functionality/ groups. The finger print region from 1000-1500cm^{-1} revealed the concentration of C-C, C-OH, C-O,C-N stretching and aromatic compounds with strong and medium transmittance. The peaks at 1080 and 1220cm^{-1} corresponds to the stretching modes of C-C and C-O bonds.

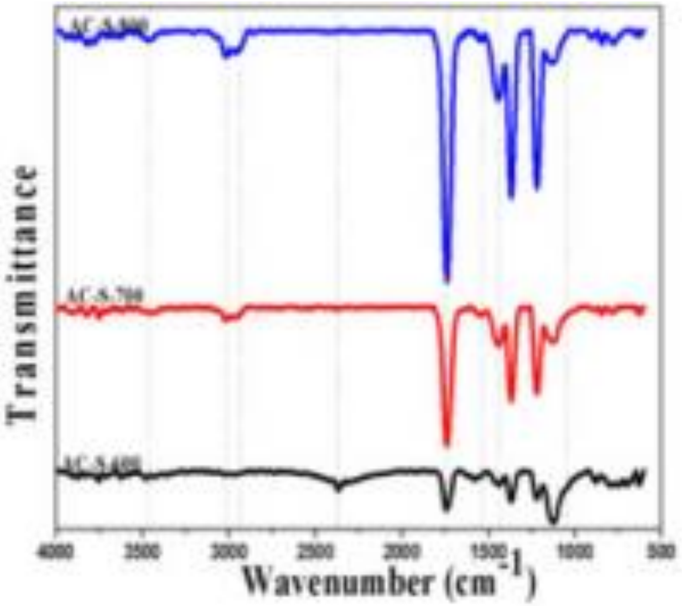

Figure 3: Fourier transform Infrared (FTIR) spectra

4.1.4 Results after the treatment with activated carbon

The beakers with activated carbon from coco nut shells were labelled A and the ones of B were from maize cobs

time of contact(minutes)	Vol used in sample A	Vol used in sample B
0	35.0	32.0
10.0	34.5	31.8
20.0	23.8	20.2
30.0	13.4	13.0
40.0	10.8	10.8
50.0	20.4	12.5
60.0	15.6	12.0
70.0	14.6	14.1

Table 3: A table showing volume of silver nitrate after treatment

time of contact(minutes)	Cl adsorbed in sample A	Cl adsorbed in sample B
0	113	45
10.0	2,526	2,661
20.0	4,871	4,285
30.0	5,457	4,781
40.0	3,292	4,397
50.0	4,375	4,510
60.0	4,600	4,037
70.0	7,870	7,194

Table 4: A table showing Chloride adsorbed by the activated carbon

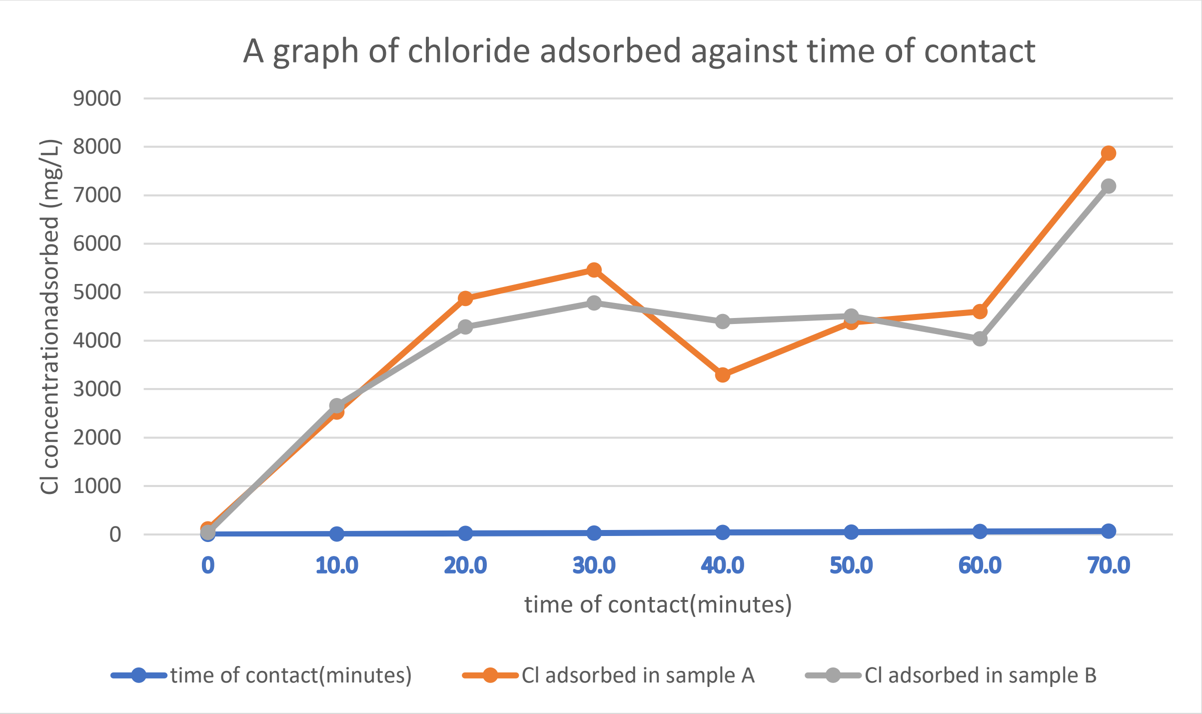

Figure 4: A graph of chloride ions adsorbed against time of contact

time of contact	% removal in A	% removal in B
0	1.105860535	0.442344214
10.0	24.77127598	26.09830862
20.0	47.7731751	42.02270032
30.0	53.52364988	46.88848667
40.0	32.29112761	43.12856085
50.0	42.90738875	44.23442139
60.0	45.11910982	39.58980714
70.0	77.18906532	70.55390211

Table 5: A table showing percentage removal of chloride from the waste water sample

4.2 DISCUSSION

In this study, 8-time variations were used, namely 0, 10, 20, 30, 40, 50, 60 and 70 minutes. At 0 minutes or initially, the percentage removal is less indicating minimal adsorption. As contact time increases to 10 minutes, the percentage removal increases. At 20 and 30 minutes, the percentage removal also increases. At 40 minutes, the percentage removal decreases. Equilibrium had been attained meaning the rate of adsorption was equal to the rate of desorption. This is due to the occurrence of desorption. It occurred due to the adsorbed ions release into the water sample. It led to the decrease in the adsorption percentage removal. Further as the time of contact increases, the percentage removal increases due to the availability of surface area on the activated carbon to adsorb more.

A graph of adsorbent time and percent removal was plotted.

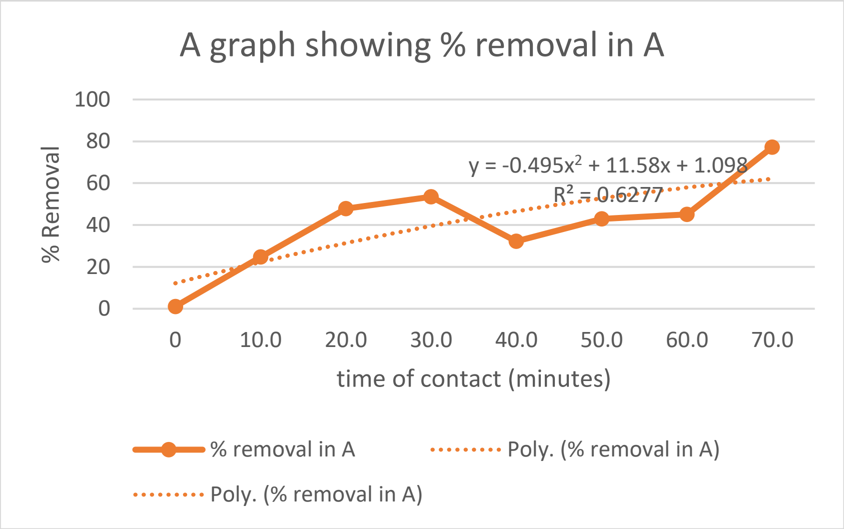

Figure 5: A graph of % removal in A against time of contact

Initially, the chloride ions were adsorbed by the activated carbon. A sharp increase in the percentage removal indicated that there was a higher number of binding sites on the activated carbon. The line has an initial positive slope that reflects increasing absorption. As time progressed, the percentage removal slowed down. This was due to the saturation of binding sites on the activated carbon. This occurrence led to the release of the absorbed chloride ions hence decreasing the percentage removal. The curve became less steep as desorption becomes significant. The coefficient of regression (R) is 0.6277. this indicates that 62.77% of the variability in data is explained by the linear relationship between percentage removal and the time of contact.

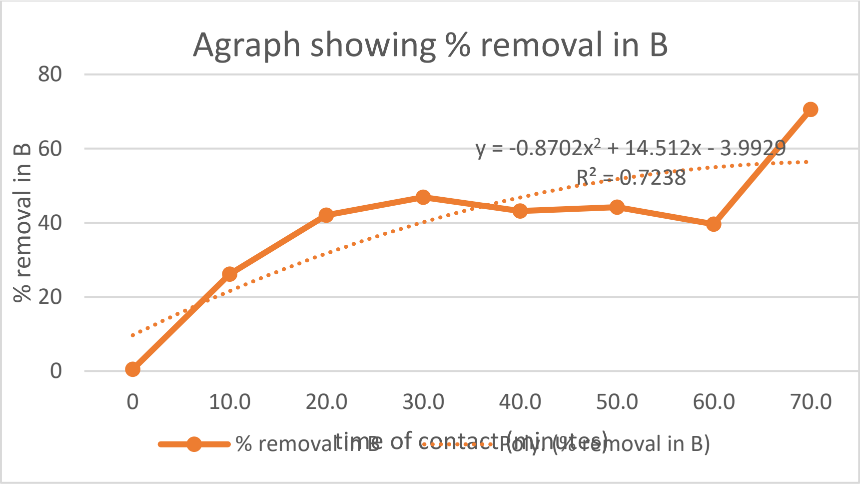

Figure 6: A graph of % removal in B against contact time

Initially, the chloride ions were adsorbed by the activated carbon. A sharp increase in the percentage removal indicated that there was a higher number of binding sites on the activated carbon. The line has an initial positive slope that reflects increasing absorption. As time progressed, the percentage removal slowed down. This was due to the saturation of binding sites on the activated carbon. This occurrence led to the release of the absorbed chloride ions hence decreasing the percentage removal. The curve became less steep as desorption becomes significant. The coefficient of regression (R) is 0.7238. this indicates that 72.38% of the variability in data is explained by the linear relationship between percentage removal and the time of contact.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.0. CONCLUSION

Both figure 2 and 3 involve adsorption and desorption. Figure 2 showed a constant rate of change in removal percentage. Figure 3 suggested an initial increase in removal followed by a decrease. The percentage removal in A was higher than the one in B. There is a percentage removal of 77.19% while a removal of 70.55% at 70 minutes. The percentage removal in A increases rapidly showing adsorption is dominant initially. It was observed that the activated carbon in A was a better source than the one in B. According to literature, a comparison published in the Journal of Chemical and Engineering Data found that activated carbon from coconut shells had a higher adsorption capacity for chloride ions than activated carbon from maize cobs with a percentage of 88.5% and 79.2%. Coconut shells have a naturally high surface and a well-developed network of micropores. This enables its activated carbon to adsorb more chloride ions thus a higher percentage removal than the one from maize cobs.

5.1 RECOMMENDATION

Coconut shells were observed to have a better source of activated carbon than maize cobs. Coconut shells have higher percentage of carbon than maize cobs. This results into higher yield of activated carbon. Coconut shells have a well-developed network of micropores. These tiny pores are highly effective at a trapping and adsorbing various molecules due to their increased surface area. Coconut shells are harder and more durable. The activated carbon from coconut shells is more resistant to abrasion and during usage. It leads to a longer lifespan thus enhancing sustainability.

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APPENDIX

Figure 7: Crusher

Figure 8: Furnace

Figure 9: Maize cobs

Figure 10: Coconut shells

Figure 11: Palintest photometer

Figure 12: pH meter

Figure 13: activated carbon