OPTIMIZING CONDITIONS FOR PREPARING AVOCADO SEEDS ACTIVATED CARBON FOR BEST ADSORPTION OF LEAD IONS FROM WASTEWATER.

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A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF BIOLOGICAL AND PHYSICAL SCIENCES IN THE SCHOOL OF PURE AND APPLIED SCIENCES IN PARTIAL FULFILMENT OF REQUIREMENTS FOR THE AWARD OF THE DEGREE OF BACHELOR OF SCIENCE OF KARATINA UNIVERSITY

DECLARATION

DECLARATION BY THE STUDENT

I declare that this project is my original wok and has never been submitted in any other university or used in any other institution for award of any degree program.

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Signature…………………………. Date……………………………

DECLARATION BY THE SUPERVISOR

This project has been submitted with my approval as university supervisor.

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Signature………………………… Date …………………………….

DEDICATION

I dedicate this work to my lovely family members for their continued support and encouragement during my entire study period and up to date.

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ABBREVIATIONS AND ACRONYMS

FAAS Flame Atomic Absorption Spectrophometer

WHO World Health Organization

NEEMA New England Environment Marketing Association

AC Activated Carbon

ABSRACT.

With Kenya's industrialization comes an increase in the pollution of water bodies by heavy metals. Wastewater treatment techniques currently used are pricy. Membrane filtration, chemical precipitation, ion exchange, solvent extraction, and flotation are a few of them. There are emerging new and less expensive technologies that use activated carbon and locally accessible biomass. In order to remove lead ions from wastewater, this study set out to prepare activated carbon and to determine the optimal temperature, PH, adsorbent mass, and phosphoric acid concentrations for carbonization and activation using avocado (*Persea americana*) seed wastes. Activated carbon was prepared by made by soaking fifty grams of (*Persea americana*) seeds powder in 50 % phosphoric acid for 24 hours, which was then oven dried for 48 hours at 105°C. Dried sample was heated using a heating mantle at 300°C. After cooling, the sample was washed with 0.1 HCl to remove ash content, and then washed with 0.1M NaOH to neutralize pH. Optimizing parameters such as temperature, PH, adsorbent mass and phosphoric acid concentration were studied. Adsorption of lead ions increased with increase in concentration up to an optimum 50% concentration. Adsorption of lead ions increased with increase in PH up to an optimum PH of 4. Adsorption of lead ions increased with increase in adsorbent mass up to an optimum adsorbent mass of 1.2g. Adsorption of lead ions increased with increase in temperature up to an optimum temperature of 600°C. Thus, optimizing activation conditions would produce a better activated carbon from avocado seeds that would be used to remove heavy metal ions from water. It also eliminates the problem of agricultural wastes accumulating in our environment

CHAPTER ONE: INTRODUCTION.

1.1Background information.

Kenya is experiencing an increase in the scarcity of clean drinking water as a result of the country's growing industrialization. Some light industries, including those that manufacture plastics, paint, weld, and batteries, dispose of their toxic waste in the open; where it eventually makes its way into bodies of water (Müller et al.,2020). The principal contaminants are toxic metals like lead, which are known to result in death, brain damage, and kidney failure (Jabeen et al., 2021). The currently available conventional techniques could have high price and be unavailable. As a result, there is increased interest in new, low-cost materials and techniques that can be used to treat industrial waste streams. There are numerous inexpensive agricultural byproducts that are accessible for example cassava waste (Periyasam et al.,2020), rice husk (Isiuku et al.,2019) and avocado seeds (*Persea americana*) (Jiménez-Arias et al.,2021). Characterization of natural, activated, and carbonized forms of adsorbent materials made from avocado seeds. Journal of Analytical and Applied Pyrolysis that can effectively remove significant amounts of organic and metal ion pollutants from aqueous solutions. Activated carbon is a porous carbonaceous substance with a high capacity for adsorption used as an adsorbent material for the purification of gases and liquids. It has a huge surface area for adsorption of chemical reactions because of its extreme porosity. It also has high internal porosity due to its network of interconnecting pores. Coal, wood, coconut shells, avocado seed and other precursor materials can all be converted into activated carbon through various activation processes. Recently, there has been interest in producing activated carbon utilizing agricultural waste as a precursor material. (Baskaran et al.,2022). Potential economic and environmental effects could result from the manufacture of activated carbon from agricultural byproducts. Using agricultural waste product is advantageous due to: turning unwanted low-value agricultural waste into beneficial high-value adsorbents, Second, removing organic waste from the environment, Third, by lowering the amount of activated carbon imported, it will boost the domestic economy (Nnaemeka et al.,2022).

The general process of preparing activated carbon involves two major steps carbonizing and activating. Carbonation involves thermal decomposition of precursor materials in an inert environment at a temperature of 600℃.In activation the carbonized material must now be activated to develop a pore structure through oxidizing at a temperature of 800℃ (Chemerys et al.,2018). Chemical activation is preferred because it produces activated carbon at a lower temperature and has a higher yield, larger surface area, and better development of micropore structure than physical activation. The function of (AC) is purification of solutions and gases, removal of taste and odor from water and removal of heavy metal ions from ground water. (Özdemir et al.,2018).

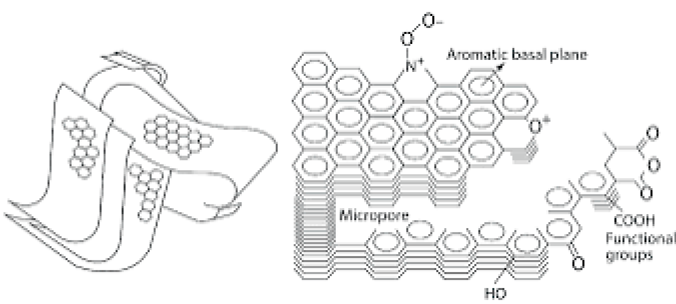


Figure 1.1 ***Structure of activated carbon. (Atila et al.,2020)***

Originally from central Mexico, the avocado tree (*Persea americana*), which belongs to the lauraceous genus, was first discovered. Most often, it is grown for its nutritional, therapeutic, and aesthetic properties. This study intends to show how powdered activated carbons made from avocado seeds may be produced and how well they can remove lead ions from water.

1.2 Statement of the problem.

There is scarcity of clean drinking water. (Ogolla et al 2017). The contamination of the water supply with heavy metals is one of the major global health issues. Therefore, it is crucial to get rid of these and other chemical pollutants from water. Available wastewater treatment methods are expensive to buy and maintain, they include: membrane filtration, chemical precipitation, ion exchange, and phytoremediation. Thus, there is a requirement for low-cost methods to remove heavy metal ions from water by use of agricultural waste (Renu,et al., 2017).

1.3 Justification of the problem.

Heavy metal ion removal from water using conventional techniques is not only expensive to purchase and maintain, but also harmful to the environment. Alternatively, we can use agricultural waste which are: non-toxic, readily available, and biodegradable alternative to cheap adsorbents. Avocado seed-derived activated carbon has the capacity to remove heavy metal ions such as lead from water. Using inexpensive activated carbon made from avocado seeds for the removal of Pb (II) ions could therefore be a solution to the problem of managing water and wastewater in underdeveloped countries.

1.4 Objectives.

1.4.1 General Objectives.

To determine optimum conditions for preparing activated carbon derived from avocado seeds for best adsorption of lead ions from waste water.

1.4.2 Specific objectives.

I) To prepare activated carbon from avocado (*Persea americana*) seed.

ii) To determine the best concentration of the activating phosphoric acid.

iii)To determine optimum conditions of PH, adsorbent mass, and activation temperature for removal of lead ions from waste water.

1.5 Hypothesis.

Activated carbon derived from avocado (*Persea americana*) seed provide an effective way of removing heavy metal ions from wastewater.

1.6 Significance of the study.

Using agricultural waste to create activated carbons that can be produced locally at a low cost as purifiers or adsorbents for contaminated water. It tries to clean up the environment by eliminating organic waste pollution. Additionally, it promotes the use of regional technologies to boost the economy, foster growth, advance development, and generate employment.

1.7 Scope and limitations of the study.

i) The study was restricted to activated carbon by activation with phosphoric acid and not from other activating agents.

ii) The study focused on the activation temperature of below 800°C only.

iii) The research focused only on one heavy metal ion, that is Pb (II) ions. Other heavy metal ions and pollutants were not considered**.**

CHAPTER TWO: LITERATURE RIVIEW.

2.1 Heavy metals.

The earth's crust contains very small amounts of lead naturally. It has an atomic number 82, mass 207, and bluish-gray metal (JT Ingraffia., 2020). Lead is used in the production of x-ray shield d even in very small doses, exposure to non-essential heavy metals is harmful to human health (F Yang et al.,2019). Human activities such as the use of heavy metal-containing compounds for agricultural and domestic uses, such as using heavy metal fertilizer, eating tainted food, and smoking cigars, as well as industrial activities such as burning coal and petroleum products in power plants, mining, and smelting operations are sources of heavy metal contamination (JS Oehlers et al., 2021). Numerous other natural occurrences, such as volcanic eruptions and the weathering of rocks and minerals, contribute to the pollution of streams, rivers, and lakes (Z Wang, et al., 2020). The required standards by NEEMA and WHO are shown in the table below.

Table2.1: WHO and NEMA standards for domestic water

Parameter	NEMA Guide Value (Max allowable)	WHO Guide Value (Max allowable)
pH	6.5-8.5	6.5-8.5
Pb	0.05 mg/L	0.01 mg/L

The usage of lead-based compounds in household and agricultural products, as well as the release of lead fumes from industrial sources, are the causes that lead-to-lead exposure in the environment. Human exposure to lead can occur through ingesting tainted food or drink, inhaling lead-containing dust particles and consumption of traditional medicine. (PM Campbell et al., 2018). Age and physiological state have a major impact on human lead absorption. Compared to adults, who can only absorb 35–50% of lead through drinking water, young children can consume more than 50% of it. (R Akhbarizadeh and colleagues, 2018) Older buildings' plumbing systems, which frequently use lead-containing pipes, solders, and faucets, can contaminate drinking water. When mining and using industrial effluent for activities like melting lead and printing books, there is a high percentage of lead in the water (M Schindler et al., 2022). Food that has been grown in lead-contaminated soil can cause Pb (II) ions to adsorb, which then leads to accumulation in edible plant parts and, ultimately, to negative effects on the human body (Kinuthia et al.2020) Humans accidentally consume polluted food and water, which contain high concentrations of Pb (II) ions (H Abeidi et al. 2021). According to earlier research, the central nervous system accumulates Pb (II) ions after humans are exposed to them. Early signs of lead exposure in humans include dullness, memory loss, headaches, and irritability. Anemia, elevated blood pressure in older people, severe brain and kidney damage, miscarriage in pregnant women, and death are all consequences of prolonged exposure to lead ions (M Qiu et al. 2021).

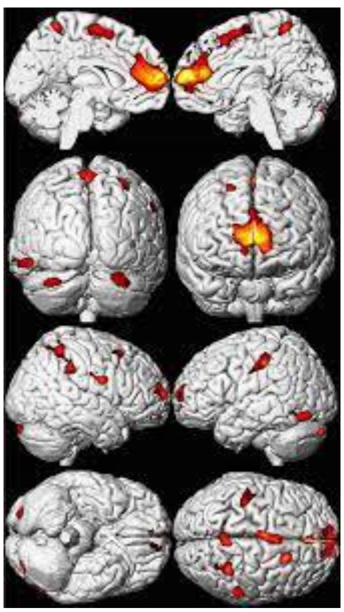


Figure 2.1 **Effects of lead exposure to the brain. (Cecil et al.,2008)**

2.1.1 Heavy metal removal from wastewater.

2.1.1.1 Membrane filtration.

In nanofiltration, filter membranes with 0–10 nm-sized particle diameters are employed. By preventing particles larger than the pores of nanoscale membranes, the filter membrane enhances the removal of heavy metals (N Abdullah et al., 2019). Applying pressure to overcome the osmotic pressure is required for reverse osmosis. It requires the use of a semi-permeable membrane. Heavy metal ions can be removed because particles with pores larger than those of a semipermeable membrane cannot pass through them (C Muankaew et al., 2020). Membrane filtration has drawbacks such as the production of chemical sludge and expensive purchase and maintenance costs (S Rajoria et al., 2022).

2.1.1.2 Chemical precipitation.

Chemical precipitation refers to the reaction that occurs when chemical precipitates and heavy metal ions interact to generate a precipitate. After that, water used to separate the precipitate using filtration or sedimentation. After filtration is finished, the water is decanted and made usable (TE Cintra et al., 2019). Iron is used to precipitate copper, lead, and cadmium, while calcium hydroxide, sodium hydroxide, and (L Habte, 2019).

2.1.1.3 Ion exchange.

The reversible exchange of ions is involved in this. It is necessary to apply ion exchange resin, whether it is natural or synthetic. Ion exchange resin has cationic exchangers that can exchange ions in aqueous solutions with positively charged metal ions.SO3H and COOH are the two cationic exchangers that are most frequently used (M Chen., 2020). The disadvantage of ion exchange resin is the high cost of purchase.

2.1.1.4 Solvent extraction.

This involves three processes of solvent extraction for the removal of heavy metal ions are extraction, scrubbing, and stripping. The organic phase, which contains the extractant, is combined with the aqueous solution, which contains the metal, in the extraction process. The extractant reacts with the metal ions in the aqueous solution, which are subsequently transported to the organic phase. The aqueous phase is then removed and recycled to remove other metals from solutions then, the organic phase moves on to the scrubbing stage, where additional metal ions and contaminants are taken out of the organic phase that contains metal ions using the right aqueous solution. The loaded organic phase is then purified of any additional metal ions and impurities after the loading procedure. The metal ions are taken out of the organic phase as salts in this step. They are then changed into the appropriate oxides or free metals through processes like evaporation or electrolysis (Fenglian and Qui., 2017).

2.1.1.5 Floatation.

By adding collectors or surfactants—which are negatively charged compared to the positively charged metal ions being removed—to aqueous solutions, heavy metal ions are removed via flotation. By using a collector, the surface becomes more hydrophobic, improving the separation of hydrophobic and hydrophilic particles. The ion surfactants float as a result of higher concentrations of hydrophilic and hydrophobic particles, which promotes the formation of precipitate and enhances the removal of heavy metal ions. The main disadvantage of flotation is that it functions best at very low concentrations (G Pooja et al., 2022)

2.1.2 Knowledge gaps.

According to a review of the literature, lead ions have been removed from aqueous solutions using agricultural products (Pakade et al., 2017). Although it hasn't been proven, activated carbon made from avocado (*Persea americana*) seeds can remove Pb (II) ions from wastewater. The performance of Pb (II) ion adsorption onto activated carbon made from avocado (Persea americana) seed seeds was also not examined in prior studies.

2.2 Factors affecting the adsorption of heavy metals from their solutions.

2.2.1 PH

The decrease in competition between proton and metal cations for the same functional groups and the decrease in positive charge of the adsorbent, which results in a lower electrostatic repulsion between the metal cations and the surface, are the causes of the increase in metal removal with increasing pH values. At higher pH levels, metal hydroxides may precipitate, lowering the concentration of free metal ions in the solution. (P Zhao et al., 2022)

2.2.2The concentration of metal ion.

Even though the amount of metal ions adsorbed increases as the initial metal ion concen tration increases, the removal capacity of metal ions decreases as the metal ion concentr ation rises because there are only a limited number of active sites that become saturated at a certain concentration. (NC Joshi et al.,2018).

2.2.3 Adsorbent dose.

More surface area becomes available as the dose is raised, exposing more active sites for the bin ding of metal ions and speeding up the adsorption rate. For a given initial concentration of most metals, the rate of lead adsorption is essentially unaffected by an increase in adsorbent mass. (M Sulyman *et al*., 2021).

CHAPTER THREE: MATERIALS AND METHODS

3.1 Study design.

There werestages to the research, with sample collectionandpreparation taking place in t he first stage. Prepare stock solutions and working standards as part of the second phase. In the third phase, adsorption was performed.

3.2 Chemicals and reagents.

1.60 grams of analar grade lead (II) nitrate was dissolved in 800 mL of distilled water, and the mixture was topped off with 1000 mL distilled water to create a stock solution of Pb2+ ions. After that, the solution was diluted to provide the desired standard solutions. Every time the solution pH will change, 0.1 M sodium hydroxide and nitric (V) acid solutions was utilized. By separately diluting 10, 20, 30, 40, 50, 60, 70, 80, and 90 mL of the concentrated acid with 1000 mL distilled water to the necessary percentages, H3PO4 acid was prepared.

3.3 Raw material.

The avocado seeds, which was purchased from Karatina Market, was used in an unspeci fied kind of trial. Before being dried for a week in the sun, the seeds were cleaned. After being divided into small pieces with a knife, they were combined into powder using an electric blender with a highpower setting. The finished powder was 105 °C oven dried f or 24 hours.

3.4 Preparation of AC.

50 grams of raw avocado seed powder was soaked for 24 hours in 50% phosphoric acid before being dried for 48 hours at 105 °C in an oven. The dried sample was heated to 55 0 °C for 30 minutes in an electric muffle furnace after being burned at 300 °C for 24 ho urs in anovenThe sample was washed with 0.1M HCl to remove ash and 0.1M NaOH to raise the pH of the activated carbon to 7. The sample was allowed to cool. Following th at, it was kept in a stoppered bottle and oven dried for 24 hours at 105 C. (AK Kamau et al.,2022)

3.5Optimization of activating acid concentration.

Ten samples of the powder, each weighing 50 grams, was dissolved for 24 hours in a mi xture of 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100% H3PO4 acid in a volume of 100 m L. This was done in order to mix the powder and acid uniformly and to give all of the pa rticles a chance to interact with the acid. The samples were heated to 300°C in the muffl e furnace for an hour. The activating acid was removed after carbonization and cooling, rinsed with warm distilled water to a pH of 7, and dried at 105°C.Adsorption tests were carried out using 0.2 g of each AC in a 30 mL solution containing 80 mg/L of Pb2+ ions at pH 6 for 20 minutes at 25°C and 120 rpm in a water bath shaker. (Onyancha et al., 2008).

3.6 Optimizing conditions.

3.6.1 Optimization of PH variation.

0.5 grams of activated carbon was combined with 50 mL of 4 mg/L of Pb (II) ions, the metal pH was maintained in a vessel, to assess the influence of pH on Pb (II) ion adsorption onto activated carbon. The pH of the solutions was changed to 2, 4, 6, and 8 The mixes was maintained in a mechanical shaker for 120 minutes at a temperature of 25°C and 130 rotations per second. 0.5 M HNO3 and NaOH was used to alter the ph. After the predetermined period of time will have passed, the sample mixes were taken out of the mechanical shaker and allowed to stand for 30 minutes before the number of metal ions still in equilibrium were counted using a flame atomic absorption spectrophotometer. Conditions for the experiment was based on research by (Kowanga et al., 2016).

3.6.2 Optimization of adsorbent mass.

To test the impact of sorbent mass on the removal of Pb (II) ions from aqueous solution at the op timal pH of 4, 4 mg/L of Pb (II) ions solution was combined with various dosages of activated ca rbon (0.1, 0.3, 0.6, 0.9, 1.2,1.4,and1.6 grams). The solutions were kept at a temperature of 25°C and 130 revolutions per minute in a mechanical shaker for 120 minutes. After the predetermined period of time, the sample mixtures were removed from the mechanical shaker and left to settle for 30 minutes. The quantity of residual metal ions was calculated using a flame atomic absorption spectrophotometer after the sample mixtures have been filtered using Whatman number 42 filter paper. Pb (II) was analyzed in triplicate for varied adsorbent dosage levels. (HT Kara, et al., 2021)

3.6.3 Optimization of activation temperature.

10 samples of the powder, weighing 50 g each, was placed in 100 mL of the optimal activating acid concentration and left to soak for 24 hours. This was done to ensure a uniform combination

of the powder and acid and to enable contact between the acid and all of the particles. To find the ideal temperature, the samples was heated for 1 hour at various temperatures, including 150, 200, 300, 400, 500, 600, 700,800, and 900 ℃. They were removed from the furnace after carbonization and cooling. Adsorption assays was performed on 0.2 g of each AC in a water bath shaker at 120 rpm for 20 minutes at 25 ℃ and an 80 mg/L Pb2+ ions solution at pH 6. AAS was used to calculate the amount of Pb2+ that will still be present in the filtrate. The sample chosen to represent the ideal temperature was the one where adsorption was greatest. (AK Kamau et al.,2022.)

CHAPTER FOUR: RESULTS AND DISCUSSION.

4.1 Optimizing conditions for preparation of the activated carbon.

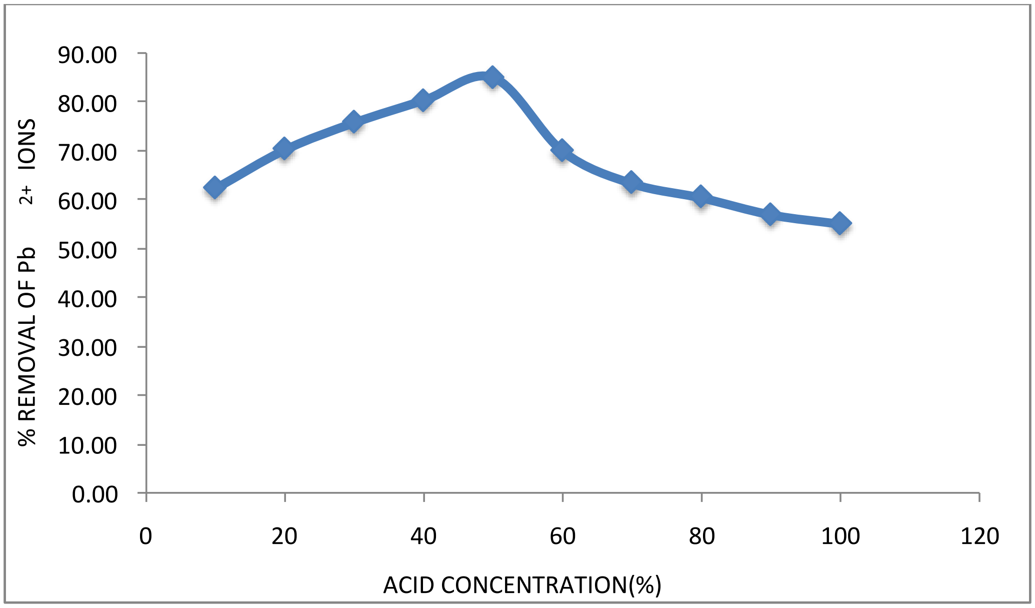
The goal of the optimization process was to determine the ideal carbonization temperature, PH, and activating phosphoric acid concentration needed to prepare activated carbon with the best lead ion adsorption from wastewater.

4.1.1 Optimum Concentration of activating phosphoric acid.

Variations in the percentage removals of lead ions by the adsorbents as the activating acid concentrations were varied from 10 to 100% v/v are as shown in table 4.1 and figure 4.1.

Table 4.1. Effect of acid concentration on activation of avocado seed carbon

H_3PO_4 Concentration (v/v)	10	20	30	40	50	60	70	80	90	100
%Removal (mg/L)	62.0	70.1	76.2	80.0	85.0	70.3	62.5	60.1	58.2	54.3

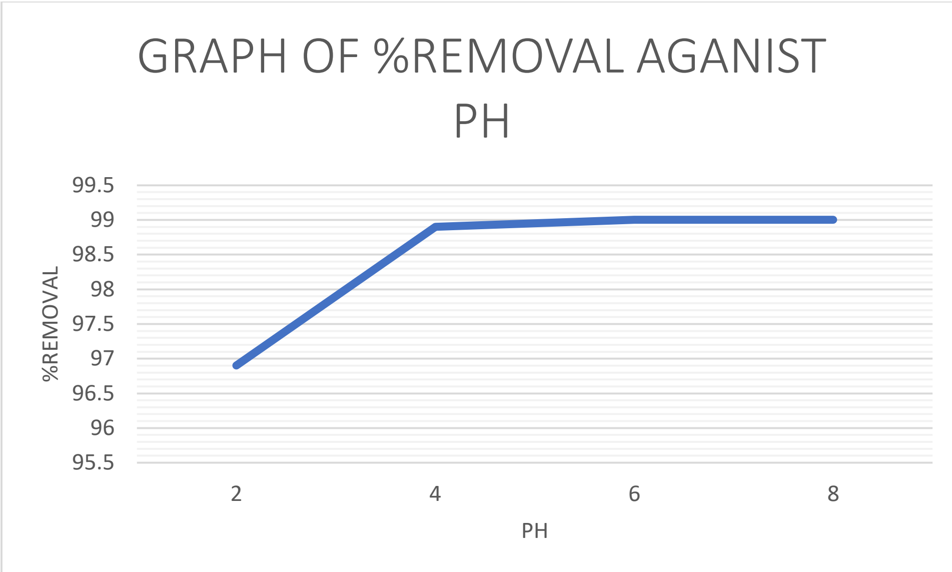


The percentage removal gradually increased for carbon activated using acid concentrations of 10 and 50%, respectively, from 62.0 to 85.0%. When carbon was activated with an acid concentration of 100%, the percentage of removals by adsorbents activated with acid concentrations above 50% gradually decreased to 55.3%. This is because the dehydration process, which involves the removal of volatile matter made of hydrogen, oxygen, Sulphur, or nitrogen, also intensifies as the acid concentration rises.

4.1.2 Effects of pH

Table 4.2. Effect of pH on adsorption rate

pH	2	4	6	8
% Removal of lead ion (mg/L)	96.9	98.9	99.0	99.0

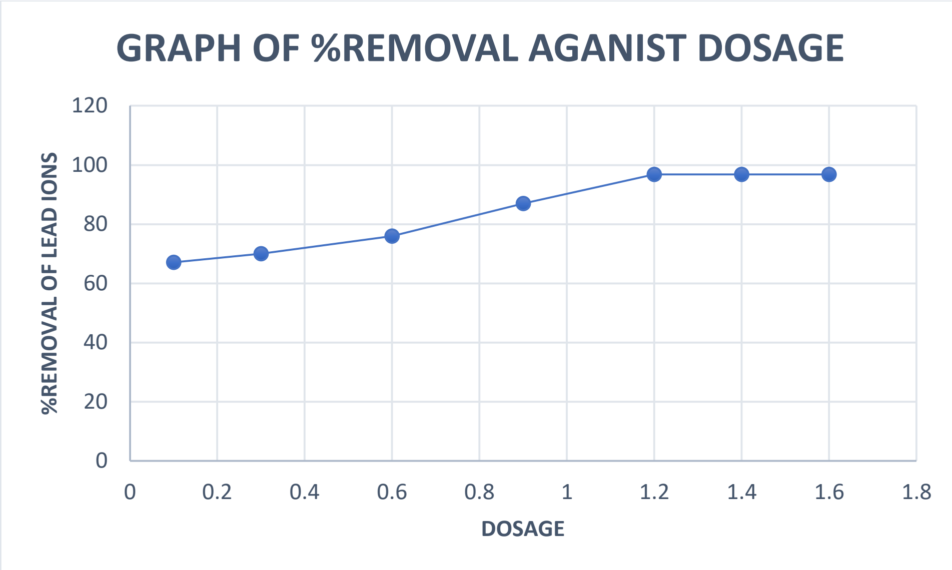


It was found that as the pH rose from 2 to an ideal pH of 4, the efficiency of adsorption also rose. At pH 4, the activated carbon removed 99.0%. Low electrostatic repulsion between the metal ions and the adsorbent surface is the result of decreased competition between protons and Pb2+ ions for the same functional groups and decreased positive charge of the carbon surface. The Pb2+ ions also precipitate out at high pH levels above 8, which results in lead hydroxides that later dissolve and reduce the amount of these ions, giving rise to the constant percentage removal values. Therefore, the speciation of metals and the dissociation of active functional sites on the adsorbent are controlled by the pH of a solution.

4.1.3 Effect of adsorbent mass.

Table 4.3. Effect of adsorbent mass on adsorption rate

Dosage (g)	0.1	0.3	0.6	0.9	1.2	1.4	1.6
% Removal of activated carbon. (mg/L)	67.1	70.0	76.0	87.0	96.8	96.8	96.8

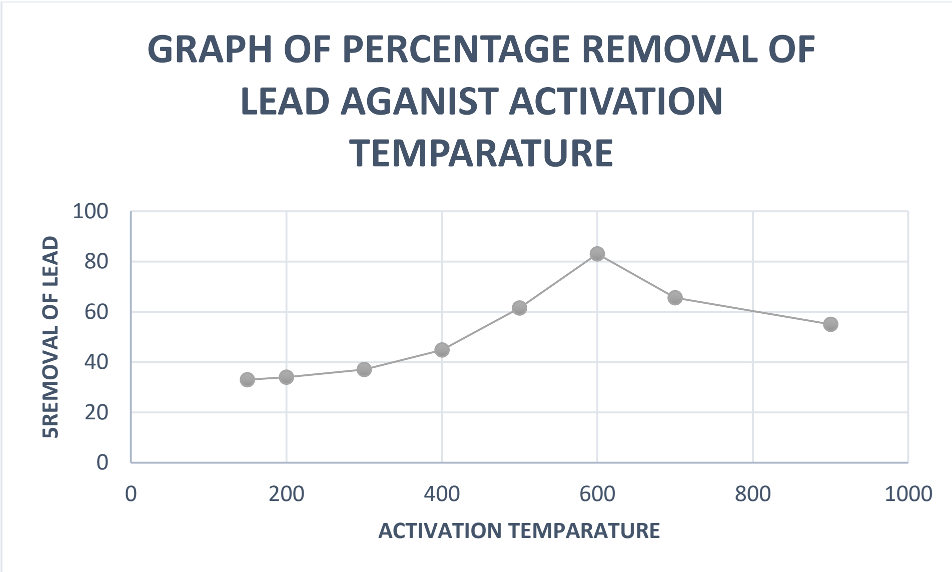


It was observed that the adsorption rate of Pb^{2+} increased with increase in adsorbent dose up to 1.2 g, beyond which it was constant as shown above and the activated carbon removed 96.8% with adsorbent mass of 1.2 g. As the dosage was increased, more binding sites became available, and the surface area grew. Since all of the Pb2+ ions have been maximally adsorbed on the available sites, further increases in adsorbent mass have no impact.

4.1.4 Optimum activation temperature

Table 4.4. Effect of activation temperature on avocado seed carbon

Temperature(°C)	150	200	300	400	500	600	700	900
% Removal (mg/L)	33.0	34.0	37.1	44.9	61.5	83.0	65.6	55.0



As the carbon is activated at 150 and 600℃, respectively, the percentage removal rises from 33.0 to 83.0%. At 600 most of the volatile substances have been vaporized as gaseous products and most of the materials burn off at temperatures above 600℃ and turn into ash, which weakens the carbon's ability to adsorb substances and its mechanical strength. At 900℃ activation temperature, it then drops to 55.0%. The quality of the activated carbon is most affected by the activation temperature. It makes sure that organic compounds in cellulosic material completely transform into graphene structures.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Activated carbon derived from avocado (*Persia americana*) seeds are an effective adsorbent for the removal of Pb (II) ions from water. Adsorption efficiency is affected by pH, adsorbent mass, temperature and acid concentration. The optimum pH for Pb (II)ions was found to be 4, the optimum temperature was found to be 600℃, whereas the optimum adsorbent mass for Pb (II) ions was 1.2g and the optimum acid concentration was found to be 50%.

5.2 Recommendations

1. Recommendation for further Studies should be conducted on the effect of temperature, adsorbent mass, PH and acid concentration, for the removal of Pb (II) ions from waste water.
2. Recommendation to conduct optimization experiments with various activation methods and compare the outcomes.
3. Recommendation for further Studies on the removal of such metal ions using agricultural product activated carbon should therefore be done.

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