COMPARATIVE STUDY OF THE ADSORPTION OF LEAD, Pb AND CADMIUM, Cd BY ACTIVATED CARBON FROM JATROPHA CACUS AND MORINGA HUSK

Abstract

Moringa husks and Jatropha cacus were evaluated using decoloration of methylene blue for the removal of lead (Pb) and cadmium (Cd) from water sample. The results showed that Moringa has better properties: physicochemical properties: pH, moisture content (%), ash content (%), carbon content (%), volatile matter (%), surface area (m^2/g), electrical conductivity (µs/cm), bulk and density (g/L), 6.4, 14, 4, 63.26, 10, 787, 867 and 400 respectively, decoloration of methylene blue at 10 to 90 minutes ranges from 11 to 87 % , Pb and Cd adsorption capacity 55.7 and 50.2, % degradation 85 and 82 than the Jatropha cacus. The Moringa husk was characterized using Fourier Transform Infrared (FTIR), Scanning Electron Microscope (SEM) and its adsorption properties were studied by Langmuir and Freundlich kinetic isotherms

Keywords: Activated carbon,Adsorption, Jatrpha cacus, Moringa husks, Methylene blue

Introduction

Water pollution by heavy metal has been recorded as a major problem in the global context. It occurs due to the direct and indirect discharge of diverse chemicals in to the water bodies without sufficient treatment to reduce and diminish the harmful compound (Alfarra *et al*., 2014). Pollution of surface and ground water caused by human and industrial activities has been recorded as a major problem in the global context (Satya *et al*., 2011). Water pollution considered as the leading universal cause of 80 % of diseases (OECD, 2006). According to the United Nation Organization reports that there 1.1 billion people still do not have access to safe supply of drinking water, the majority of them are among the world's poorest and developing countries (Abaliwano *et al*., 2008)

Every day thousands of chemicals are discharged directly and indirectly in to water bodies without further treatment for elimination of the included harmful compound (Salim *et al*., 2008). Heavy metals are without doubt as the most hazardeous and harmful metals even if they present as traces, since they accumulate in the tissue of living organisms (Rao *et al*., 2010)

Advantage of chemical activation process include washing of corrosion during the treatment processes (Teng *et al*., 1998)

Comment [U1]: Delete

Comment [U2]: Delete

Comment [U3]: Please recast the abstract

Comment [U4]: Provide a space after comma

Comment [U5]: The citation is not in the references column.

Comment [U6]: Citation not in the references column.

Comment [U7]: The problem statement is not properly explained.

Comment [U8]: This statement is odd. The citation does not correspond with the reference.

Moringa oleifera is a multipurpose tree with variety of applications including coagulant in water treatment. Research has shown that the husk can be converted in to activated carbon by carbonization and activating process. (Warhust *et al*., 1997)

Comment [U9]: Is Jatropha cacus a tree?

The aim of the research work is to produce activated carbon from Moringa husks and Jatropha cacus in comparison for the removal of lead and cadmium from water and waste water sample which has been an agricultural waste

Comment [U10]: Aim is not well stated. Please use the same font.

METHOD

Study area

The study area is Nationa Research Institute for Chemical Technology (NARICT) Zaria, Basawa Town in Sabongari Local Government Area of Kaduna State in Northern Nigeria where plantations of both the Jatropha and Moringa are situated in the institute and the water sample was collected from Hunkuyi Dam during dry and raining season, 2019.

Comment [U11]: National

Preparation of the precursor material

Jatropha corcus and Moringa husk was collected from National Research Institute for Chemical Analaysis (NARICT) was washed thoroughly with water, sun drying for 1 hour, crushing and sieving in to workable particles size. The samples was kept in a clean container for carbonization and analysis

Comment [U12]: cacus

Chemicals and impregnating agent

All the chemicals used were of analytical grade. The impregnating agent for the chemical activation of Moringa husk and Jatropha cacus was phosphorous acid (H_3P0_4)

Comment [U13]: phosphorus acid

Chemical Activation and carbonization

The sample materials were carbonized in the absence of air in a muffle furnace at a temperature 500 – 100 ^{0}C for 60 minutes and the 200 g of carbonized sample was mixed with an aqueous solution of phosphoric acid (Activating agent). The mixture was then subjected to heat at a temperature of 120 ^{0}C for 3 hours to vaporize the water. The dried mixture was subjected to heat at a temperature of 650 ^{0}C in a muffle furnace to enable activation of the pores of the carbon sample

Comment [U14]: Please indicate the carbonization temperature.

Determination of moisture content

Thermal drying method was used in the determination of moisture content of the sample. 1.0 g of dried activated carbon was weighed in triplicate and placed in crucible, washed, dried and weighed crucible. The crucibles was then placed in an oven and dried at 105 ^{O}C to constant weight for 4 hours according to the method of (Rengaraj *et al*., 2002)

The percentage moisture content was calculated as:

$$\text{Moisture (\%)} = \frac{loss\ in\ weight\ on\ drying\ (g)}{initial\ sample\ weight\ (g)} \times 100$$

Comment [U15]: Where is the equation number?

Determination of ash content

Oven dry washed crucibles at 105 ^{O}C and allow to cool at room temperature in a desiccator. The crucible was weighed and 1.o g of the sample was weighed in to the crucible and placed in muffle furnace, allowing the temperature to rise to 500 ^{O}C the temperature was maintained for 3 hours, after which the sample was cooled to room temperature in a desiccator. The crucible and the was weighed

Comment [U16]: Please use reported speech.

Comment [U17]: 1.0

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Comment [U19]: Incomplete statement.

Ash content was calculated below:e

Comment [U20]: The ash content was calculated according to equation ?

$$\text{Ash (\%)} = \frac{Ash\ weight\ (g)}{Oven\ dry\ weigh\ (g)} \times 100$$

Comment [U21]: Please check for the correctness of this highlighted equation.

Determination of adsorption capacity

Comment [U22]: Please recast the description of the method.

20 g of the prepared activated carbon was added to 100 ml raw water shake thoroughly and allow to stand for the period of an hour to establish adsorption-desorption equilibrium, filtered and then analyze the presence of lead, pb and cadmium, cd both before and after the interaction with the activated carbon using adsorption spectroscopy.

The adsorption capacity was calculated using the equation below

$$Qt = \frac{(Ci - Ct)V}{W} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Comment [U23]: Some equations came before this one.

Where:

Qt = adsorption capacity at time, t (mg/g)

Ci = concentration of metal before interaction with the activated carbon (mg/L)

Ct = concentration of metal after interaction with the activated carbon (mg/L)

V = volume of the effluent (L)

W = weight of the activated carbon (g) (Hameed, 2009)

Surface area of the activated carbon

The specific surface area of the prepared activated carbon was determined using Sear's method by agitating 1.5 g of the activated carbon sample in 100 ml diluted hydrochloric acid at pH = 3, 30 g of sodium chloride was added while stirring the suspension, then the volume was made up to 150 ml using de-ionized water. The solution was titrated with 0.1N sodium hydroxide to rise the pH from 4 to 9 and the volume recorded

Comment [U24]: Please provide the citation for the method for the determination of surface area.

The surface area was calculated below

$S = 32V - 25$

Where:

S = Surface area of the activated carbon

V = volume of sodium

Scanning electron microscope (SEM) analysis

A scanning electron microscope (SEM) is a type of electron microscope that produces image of a sample by scanning it with a focused beam of electron. The electrons interact with atoms in the sample, producing various signals that contain information about the sample surface topography and composition. The electron beam is generally scanned and the beam's position is combined with detected signal to produce an image. (Daneshvar *et al.*, 2007)

Comment [U25]: This literature is not needed in the method and therefore should be deleted.

Scanning electron microscopy (SEM) analysis: A Hitachi X-650 scanning electron micro-analyzer was used to take the micrographs of the samples, at an accelerating voltage of 10.0 KV and a working distance of 10.0 mm, the activated carbon was mounted on aluminum stubs using conductive glue and then coated with a thin layer of carbon paste tape on copper pegs and coated with a film of evaporated gold, prior to the observation.

UV-Visible spectroscopic analysis

A computer based UV-Vis spectrophotometer was used for the determination of concentration of samples. The system was switched on and warm up to 30 minutes, thoroughly clean quartz cuvettes was use. One of the cuvettes was fill with the reference compound and the other one with compound whose absorbance were measure at maximum wavelength. To get the relationship between concentration and absorbance of the compound, a calibration curve was plotted. Calibration solutions were made from standard solutions of known concentration. The absorbance was plotted against concentration of the calibrated samples. These calibration curves was stored in the system itself and the concentration of the unknown sample was calculated directly from the absorbance.

Particle size distribution

20 g of the prepared activated carbon was sieved using sieves of different mesh sizes (2 mm, 1 mm, 800 µm, 700 µm, 500 µm, 400 µm, 300 µm, 200 µm, 100 µm, 50 µm and pan) placed on electrical vibrator in descending order for 5 minutes and the fractions collected, weighed

RESULTS

Characterization of Moringa husk and Jatropha cacus activated carbon produced

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The activated carbon produced from Moringa husk and Jatropha cacus was characterized using proximate analysis (Table 1)

Table 1: Physicochemical Properties of Jatropha Cacus and Moringa Husk Activated Carbon

Comment [U27]: The table can be prepared better. Please remove serial number.

S/N	Parameter	Results	
		Moringa	Jatropha
1	pH	6.4	6.8
2	Moisture content (%)	14	15
3	Ash content (%)	4	4
4	Carbon content (%)	63.26	40.260
5	Volatile matter (%)	10	8
6	Surface area (m^2/g)	787	896
7	Electrical conductivity (µs/cm)	867	824
8	Bulk density (g/L)	400	397
9	Adsorption capacity of pb and cd (mg/g)	55.7 and 50.2	
10	% adsorption of pb and cd	85 and 82	

Table 2: Particle Size Distribution of Jatropha Cacus and Moringa Husks Activated Carbon

S/N	Mesh sizes (mm or µm)	Particle size distribution Moringa(mm)	Jatropha (mm)
1	2mm	0.71	0.52
2	1mm	0.54	0.35
3	800	2.35	2.22
4	700	2.31	2.11
5	500	2.20	2.06
6	400	2.07	1.90
7	300	2.00	1.80
8	200	0.81	0.61
9	100	0.17	0.42
10	50	0.00	0.00
11	Pan	0.00	0.00

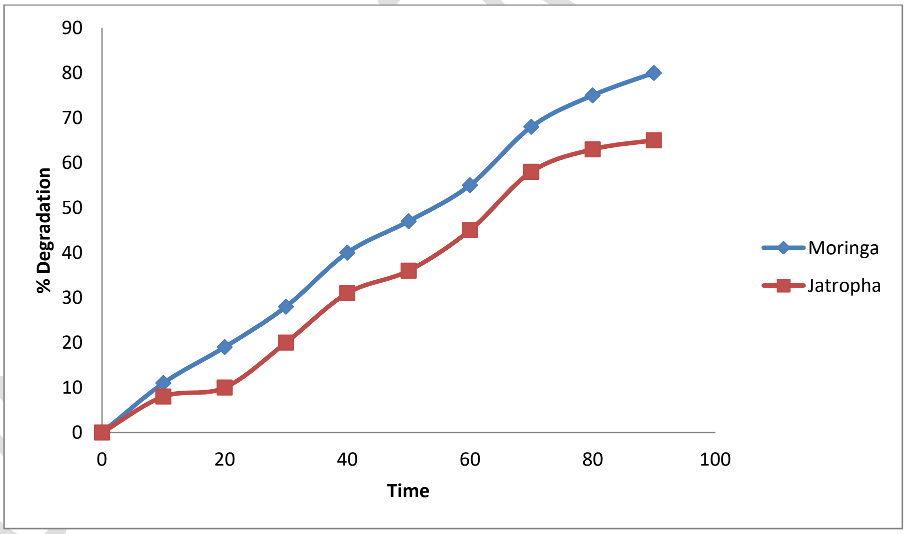

Figure 1: Percentage Degradation of Methylene Blue Using Moringa Husk and Jatropha Cacus Activated Carbon

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Comment [U29]: Please provide the unit for time.

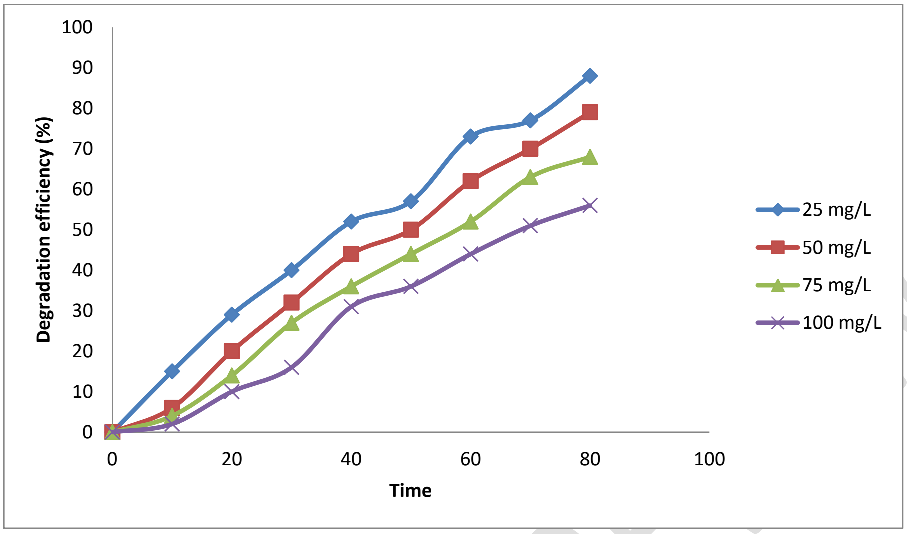

Figure 2: Effect of Methylene Blue Concentration on its Degradation using Moringa Husk Activated Carbon

Comment [U30]: The time has no unit.

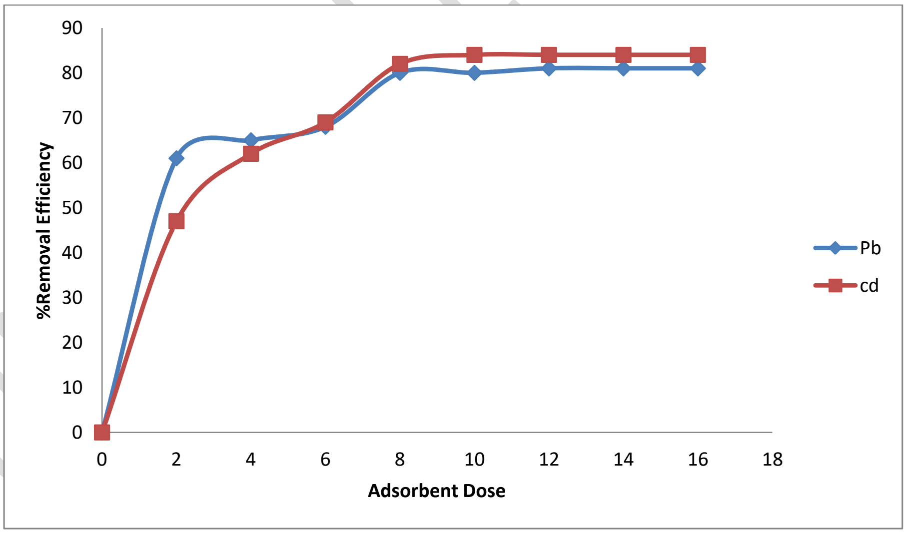

Figure 3: Efficiency of Lead (pb) and Cadmium (cd) Removal in Relation to Adsorbent Dose using Moringa Husk Activated Carbon

Comment [U31]: Please recast. The adsorbent dose does not have a unit.

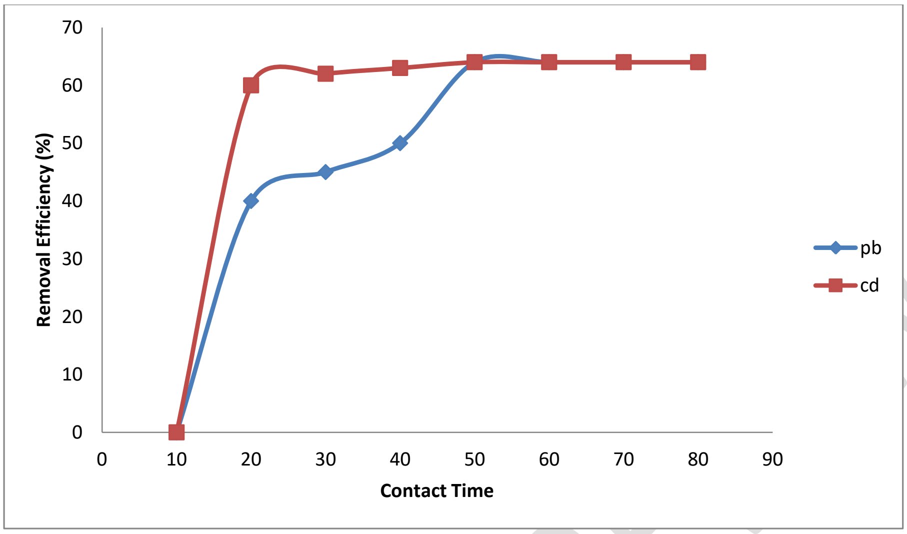

Figure 4: Percentage Removal of Lead (pb) and Cadmium (cd) Based on Contact Time Using Moringa Husk Activated Carbon

Comment [U32]: Figures 3 and 4 are confusing.

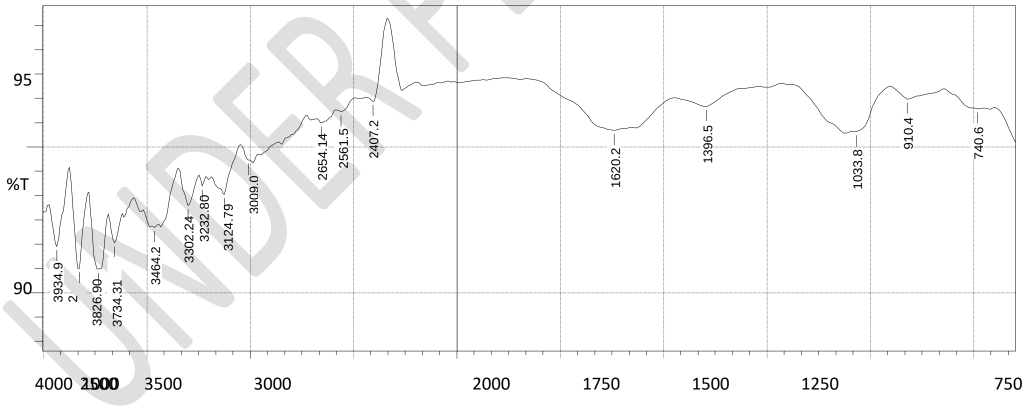

Figure 5: Fourier Transform Infrared (FTIR) Spectra of the Pure Moringa Husks

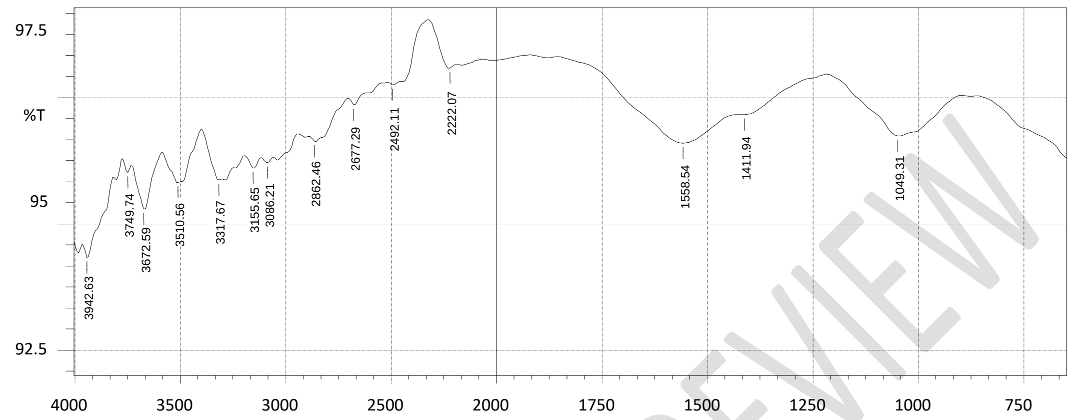

Figure 6: Fourier Transform Infrared (FTIR) Spectra of the Activated Moringa Husks

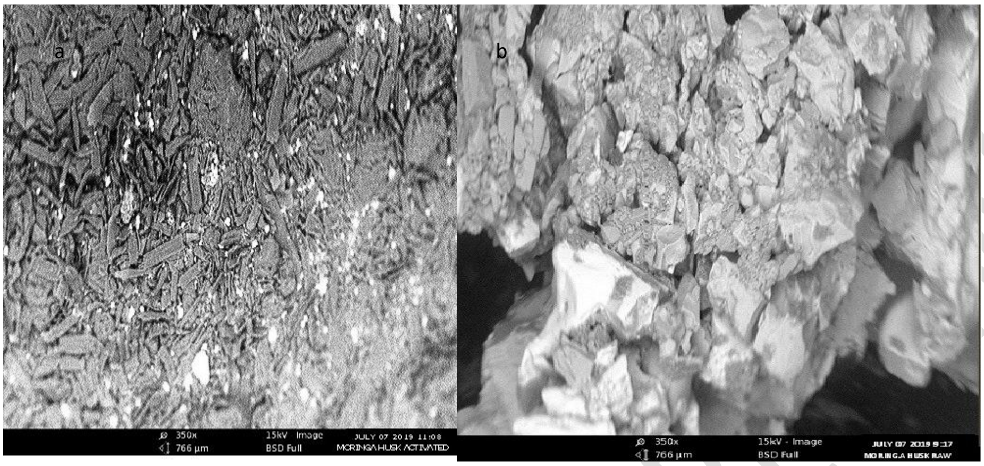

Figure 7: Image of Scaning Electron Microscope of (a) Pure Moringa husk (b) Activated Moringa husks

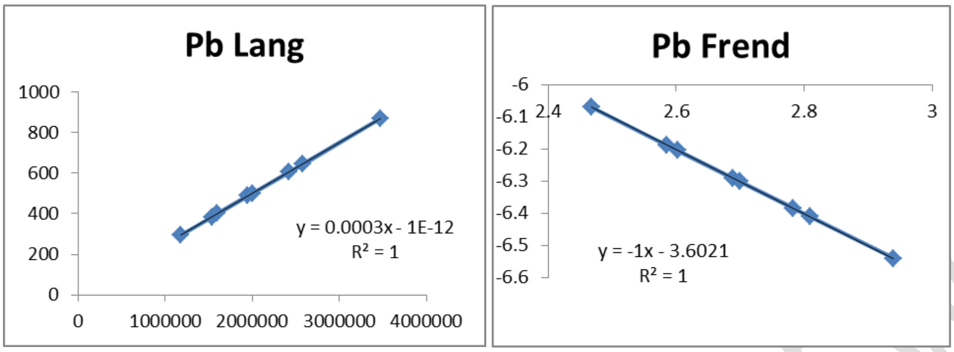

Figure 8: Application of Langmuir and Freundlich Equation for the Removal of Pb Using Moringa Activated Carbon

Comment [U33]: Poorly plotted graphs. The graphs do not have axes labels.

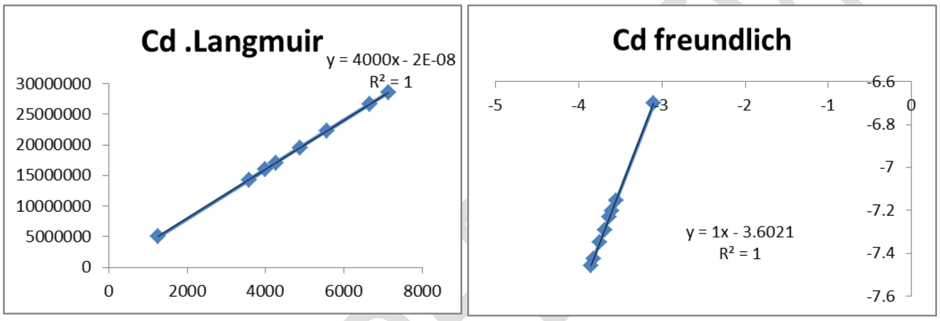

Figure 9: Application of Langmuir and Freundlich Equation for the Removal of Cd Using Moringa Activated Carbon

Comment [U34]: Poorly plotted graghs. Please replot.

DISCUSSION

activity of the moringa husk and jatropha cacus activated carbon was first evaluated using decoloration of methylene blue.Methylene blue is used as a text model in evaluating the activity of serries of photocatalyst (Disanto *et al.*,1972). The figure (1) shows that Moringa activated carbon has high percentage of degradation than Jatropha cacus activated carbon for an instance, at 90 minutes moringa has 80 % degradation while Jatropha cacus has 65 % degradation of methylene blue respectively. therefore, Moringa husk activated carbon has an adge over the Jatropha cacus activated carbon in the removal of lead (pb) and cadmium (cd) from the hunkuyi dam

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The effect of concentration of methylene blue on its degradation using Moringa husk activated carbon was investigated by varying the concentration of the methylene blue from 25 to 100 mg/L (Figure 2) which shows that the percentage removal of methylene blue decreased with increasing methylene blue concentration, when the conccentation varried from from 25 to 100 mg/L, the percentage degradation of methylene blue decreased from 88 % to 45 %. At higher concentation, the methylene blue molecules absorbed some of the incident radiation which will decrease the amount of available light photons that will drive the photocalytic process (Jaafar *et.al.*,2012)

The effect of the different amount of Moringa activated carbon on its percentage removal of lead, Pb and cadmium, cd was investigated by varying the concentration of the activated carbon from 2, 4, 6, 8, 10, 12, 14 and 16 grams. Figure 3 shows that the percentage removal of the lead, pb and cadmium, cd increase with increase in the adsorbent dose from 2 g to 10 g at 47 and 60 % to 82 and 84 % removal of lead, pb and cadmium, cd respectively however, the increases was sharply from 0 to 79 % in the case pb and 0 to 81 % in the case of cd at dose of 8 g but slower with further increment of dose until it remained contend, the significant slower of a sample containing increment of dose from 10 g to 16 g can be attributed to decreased in amount of dose absorbed per unit mass, similar trend was reported in the work of Aji M. M *et al*., (2017)

The adsorption desorption equilibrium of the Moringa activated carbon was investigated on the Percent Removal Efficiency of pb and cd Based on Contact Time. Figure 4 shows that about 65 % removal of pb and cd was achieved in an hour. It also shows that the percentage removal remained constant at 60 – 80 minutes; this signified that equilibrium is reached at 60 minute in which is the maximum required time for the removal the lead, pb and the cadmium, cd. Similar trend was reported in the work of Aji M. M *et al*., (2017). In batch adsorption, monolayer of adsorbate is normally formed on the surface of adsorbent and the rate of removal of adsorbate species from aqueous solution is controlled by the rate of transport of the species to the empty sites (Elaigwu *et al*., 2010).

Fourier Transform Infrared Spectroscopy (FTIR) was used to identify the functional groups present in the pure and prepared activated Moringa husks used for the absorption of lead (Pb) and cadmium (Cd) (Figure 4 and 5). Each peak in the FTIR spectrum were assigned to respective functional group observed at 3934.9 – 3009.0 cm-1, 2654.14 – 2407.2 cm-1, 1620.2 cm-1, and 1396.5 cm-1 (Figure 4), while, 3942.63 – 222.07 cm-1, 1558.54 – 1411.94 cm-1 and 1049.31 cm-1 (Figure 5) which can be assigned to alcohol, aldehyde, alkene and phenol respectively for the pure Moringa husks, while Alcohol, aldehyde, phenol and nitro-compound respectively for the activated Moringa husks. According to (Zheng, 2014) functional groups present in a compound play a vital role on the absorption feature of the particular compound. Also according to (Fan, 2011) the chemical nature of the compound also an important factor in understanding the absorption process of a particular compound

Comment [U37]: Zheng et al., 2014

Comment [U38]: (Fan and Wang, 2011)

The morphological characteristic of the pure and activated Moringa husks were investigated using Scanning Electron Microscope (SEM) analysis (Figure 7a and b). Non compact arrangement of the non-particles with shape rice of which the particles are not aggregated being like shapes of small particles of wood with little or no pores making it difficult to determine it exact shape and sizes (Figure 7a) this is also observed in the work of (Kim *et al*., 2010), while Figure 7b shows the microgram of the activated Moringa husks that most of the particles are aggregated and exhibited a compact arrangement in the form of rocks

The removal isotherms of the heavy metals: lead (Pb) and cadmium (Cd) were represented using Langmuir and Freundlich equations. The analysis of the data for the removal of Pb and Cd were graphically shown in Figure 8 and 9 which shows that the kinetic isotherms of the Langmuir and Freundlich perfectly fitted and described the absorption processes of the lead (Pb) and cadmium (Cd) using activated carbon from Moringa husks. Both the Langmuir and Freundlich equations has the same correlation coefficient greater than 0.5, that is 1 which were well fitted in to isotherms equations equilibrium and also fitted better for sample of each adsorbate, this is also observed in the work of (Kehinde *et al*., 2008), also in the work of (Mohammed *et al*., 2015) which showed that the Langmuir isotherms has better adsorption equilibrium than the Freundlich isotherm equation in the removal of iron (Fe) and manganese (Mn). Under adsorption process the plot of Langmuir equation usualy predicts the favorability of a system in batch processes which is normally described by separation factor (Anirudhan *et al*., 2008)

Conclusion

Moringa husks and Jatropha cacus were activated for removal of lead and cadmium in water sample but was evaluated using decoloration of methylene blue. The results obtained shows that Moringa has better properties: physicochemical properties, particle size distribution, adsorption of lead and cadmium than the activated Jatropha cacus. The Moringa husks was then characterized using Fourier Transform Infrared (FTIR), Scanning Electron Microscope (SEM) and its adsorption properties were then studied by Langmuir and Freundlich kinetic isotherms

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Comment [U39]: Reference is incomplete

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Comment [U40]: Please use the same style in your references.

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Comment [U41]: I suppose there is a comma before this highlighted name.