ADSORPTION ISOTHERM STUDIES OF CONGO RED USING ACTIVATED AND CARBONIZED PALM KERNEL SHELL

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CERTIFICATION

This is to certify that this research work was carried out by NNAEMEKA PATIENCE NDI with Matriculation Number AST/2372060579 in the Department of Physical Science Laboratory Technology, School of Applied Science.

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DEDICATION

This project is dedicated to Abba my father, the Lord Almighty who without His divine guidance and provision I wouldn't be here. I also want to appreciate my family and friends

ACKNOWLEDGEMENT

All praises and adoration goes to almighty God, who gave me the strength throughout my Higher National Diploma Program.

My utmost gratitude goes to my wonderful parents, who stood by me all through this program. And to my wonderful family, God bless you all for me.

My reserved gratitude goes to my wonderful and sweet project supervisor Dr Mrs M.O.E Ufuah and lastly, to all my friends and my fellow students of Auchi Polytechnic, Auchi. May God bless you all for your prayers and concern for making this program a successful one.

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ABSTRACT

The ability of palm kernel shell from both activated and carbonized was employed in analyzing the adsorption isotherm of congo Red in aqueous solution. The carbonised PKS was done by physical process while the activated PKS was impregnated with hydrochloric acid(HCL) and was later dried in the oven for 2hrs at 105 degrees. The equilibrium study was carried out using different concentration of 5ppm, 10ppm, 15ppm and 20ppm respectively and were fitted with Langmuir isotherm, Freundlich isotherm and Temkin isotherm. From the result gotten the Freundlich and Temkim isotherm described the adsorption process of this experiments. The correlation coefficient (R^2) value of adsorption isotherm was calculated to show suitable fit of the data. R^2 value of Freundlich isotherm for carbonized pks was calculated at 0.0185 while the activated pks was calculated at 0.9933 *and Temkin isotherm for categorized pks was calculated at 0.8097 while the activated pks was calculated at 0.9828. Pks was found to be very effective adsorbent for the treatment of heavy metal contaminated water and the short time of 2hrs is required for maximum adsorption. The use of PKS as activated and carbonized carbon is not only effective removal of Congo red but also for solving the problem of overabundance of PKS as a agricultural waste products*

Key words: carbonized, activated, adsorption, adsorbent, concentration, equilibrium

CHAPTER ONE

INTRODUCTION

1.2 BACKGROUND OF THE STUDY

Through the advancement of technology has given us, comforts but at the same industrialization have contributed greatly to the environmental pollution e.g. Water pollution, air pollution and soil pollution. The water and air pollution directly affect the human and soil pollution can contribute to the agricultural and food poisoning, which ultimately contribute to adverse effects to human and other living creatures. Water contamination is a major hazard for living things and human beings and there may be different kinds of contaminants such as bacteria, viruses, organic molecules, dyes and heavy metal ions e.g. Cr^{6+}, Pb^{2+}, Cd^{2+}, Zn^{2+}, Ni^{2+}, As^{3+} and Hg^{2+} etc. Among all of these water contaminants, heavy metal ions are non-biodegradable in nature and can accumulate in the human body continuously and may results severe adverse effects such as brain damage, skin diseases, liver damage, kidney failure, anemia, hepatitis, ulcers and are also carcinogenic (Sardans et al, 2011). Heavy metal ions enter the water and environment from different sources, namely industrial wastes, batteries, fertilizers, pesticides, petrochemicals, pharmaceutical, paper and pulp industries etc (Bobby et al, 2018). The water pollution is making the lives of millions of people at great risks of diseases, illness and even deaths. In addition, water pollution is continuously shortening the availability of drinking water. Designing the new valuable methods with easier implementation and cost effective for the purification of water remains a challenge (Bobby et al, 2018).

Different methods are widely applied for the removal of heavy metal ions from the aqueous solutions, namely reverse osmosis, evaporation, calorimetric, ion exchange, precipitation, membrane and coagulation (Bolisetty et al, 2019). Because of the high cost, energy consumption and low concentration of metal ions are problems in above techniques. Agricultural wastes have been exploited as adsorbent for the removal of heavy metal ions from water. They agricultural waste as adsorbents offer many advantages e.g. Low cost, easily available in large quantity and they contain different functional groups like phenolic groups, carbonyl groups, hydroxyl groups, amino, acetamido and sulfhydryl groups etc (Renu et al, 2017).. These functional groups play a pivotal role in the adsorption of heavy metal ions as they can form complexes and chelates with heavy metal ions. The absorption of heavy metal ions on agricultural adsorbent is termed as absorption, which involves complexations, chelation, chemisorption, diffusion through pores and adsorption on the surface. There is a need for the development of user friendly and cost-effective technique for the treatment of heavy metal contaminated water. Every year a lot of agricultural waste is produced from different crops and fields, among them is oil palm waste which is generated in millions of tons every year.

Agricultural waste of oil palm produced millions of tons from Malaysia, Indonesia, Cameron, Africa, China and Nigeria. Malaysia is among the biggest producer and supplier of oil palm with about 4.5 million hectares cultivation and produce about 90 × 106 tons of agricultural waste of oil palm14. Palm Kernel shell (PKS) is the sustainable source and usually it is burned to dispose causing greenhouse effect and resulting in a negative impact to the environment. A lot of research efforts are being done to recycle and utilize the agricultural waste for the betterment instead of open burning which making a negative impact to the environment and causing ozone layer depletion (Nasir et al, 2018). Application of agricultural waste as an adsorbent for the removal of pollutants, especially heavy metal ions from water and that is a cost effective and eco-friendly technique for the treatment of heavy metal ions contaminated water. Different waste materials of plants have been applied for the treatment of heavy metal contaminated water, e.g. Algae, rice husk, corn cob, olive oil by products, livestock waste egg shell, activated carbon, rice husk, sawdust, forest by-products and waste etc (Karri et al, 2018).

Palm kernel shell (PKS) of oil palm is useful material to be applied as an adsorbent for the removal of heavy metal ions, as the good quality of organic compounds in it capable of adsorption of metal ions through biosorption mechanisms mentioned above. PKS is sustainable agricultural waste produced in millions of tons every year. The disposal of large quantity PKS causes adverse effects to the environment as it disposed-off by burning causing a lot smoke (Nicholas et al, 2018).

1.2. SIGNIFICANCE OF THE STUDY

With a positive result of this study, this result can be applied in:

1. Textile industries
2. Tannery industries for the decontamination of their effluents.

1.6 SCOPE OF THE STUDY

This study covers adsorption isotherm studies of palm kernel shell

1.7 LIMITATIONS OF THE STUDY

Limitations encountered in this study include

1. Difficulty in carbonization process of the palm kernel shell
2. Financial constraints
3. Irregular power supply

1.8 AIMS AND OBJECTIVES

The aim of this study is to determine the Adsorption isothermal on palm kernel

CHAPTER TWO

LITERATURE REVIEW

2.1. Description of Palm Kernel

In Indonesia, Malaysia and several West African countries, oil palm is commercially cultivated in plantationswheretreesaregrownona25to30year rotation followed by removal and replanting (Durst et al., 2004). In Nigeria, oil palm is an important tree because of the value of the crude palm oil, fronds, stems and leaves. Because of the magnitude of this industry, several residues are co-produced with palm oil. These include: the empty fruit bunch (EFB), palm fruit fiber (PFF), palm oil mill effluent (POME) and palm kernel shell (PKS). Whereas oil palm is chiefly cultivated for palm oil (PO) and palm kernel oil (PKO), the PKS (as residue) has been regarded as 'waste' from palm oil processing by Obengetal.(1997), Larteyetal.(2019). It has been shown that approximately 15 to 18 tonnes of fresh fruit bunches are produced per hectare per year and PKS comprises about 64% of the bunch mass (Obisesan, 2914; Adewumi, 2019). In the developing world, waste PKS is either burned to supply energy at palm oil mills or left in piles to compost.

Many of the residues of oil palm harvesting and processing are valued for various applications. PKS has been laid on roads to improve vehicular traction along plantation farms where there are no tarred roads. In a few communities, women have sold PKS as a source of heat for cooking; though much accumulates in piles when more is produced than utilized. PKS is commonly used in combustion processes, especially at oil mills as boiler fuel to generate heat and electricity (Yusoff, 2016) although PKS alone is not well regarded as a fuel due in part to smoke emissions (Yusoff, 2016). As a result, it is often combined with wood fuels, like sawdust or wood, to improve the calorific value of the biomass feed to the boiler (Kuti, 2007). Though its combustion value is substantial, the process of burning PKS releases significant volatiles and particulates which pose pre-ignition and pollution concerns. Instead of combusting PKS for energy, alternative products like concrete filler for infrastructure materials and bio-carbon for water treatment have been considered to establish new markets for this resource.

One of such options is production of activated carbon from PKS. Ogedengbe (2015) investigated the use of both charred and non-charred PKS for filtering effluent from sedimentation tanks of a water treatment plant. A dual media filtration unit composed of charred PKS and fine sand resulted in long filtration cycles and good water quality. The effluent from non-charred PKS beds also reduced the turbidity of the effluent except that the water had the odor and taste of palm nuts. As with other forms of activated carbon, the use of PKS for water treatment depends upon its surface composition and chemical functionality. Characterization of PKS is needed to assess its applicability for treating a wide range of wastewater.

Physically, PKS is relatively dense when compared to other biomass varieties, which has positive implications for transporting it for processing. Its high porosity supports its use in water treatment, but because of residual oleic acid, pyrolysis should first be employed to create a biocarbon sorbent. Compositionally, PKS is high in lignin, hemicellulose and silica-containing ash, resulting in a material with a large heating value that is unfortunately prone to forming particulate matter upon combustion. As such, alternative use as filler in infrastructure materials is recommended to fully take advantage of the natural strength properties that this composition provides. Though conversion to energy at power plants with sufficient pollution abatement equipment downstream of combustion remains an option, several characteristics of PKS support its use as material filler and sorbent for water treatment, both of which are greatly needed by the developing nations of the world.

In addition to energy production and water treatment, PKS can serve as a filler to reduce the costs of building and road-making materials. For instance, Okafor (2018), Okpala (2010) and Alengaram et al. (2008) have independently worked on determining the potential of PKS as a concrete reinforcement agent. According to Okafor (2018) PKS can produce concrete with compressive strength not exceeding 30 MPa, but compares well with conventional aggregates such as granite for concrete grades of 25 MPa and less. Similarly, Okpala (2012) has shown that PKS is suitable for light- weight structural applications, while PKS mixed with concrete shows good sound absorption capacity and low thermal conductivity. The mechanical properties, such as crack width, deflection, ultimate strength, concrete strain and steel strain of PKS concrete were compared with those of normal weight concrete by Alengaram et al. (2008). This work shows that even though the flexural strength of the PKS concrete was 15% lower than that of normal weight concrete, its compressive strength was 6 MPa more than the targeted 30 MPa. These results show that PKS can be used in light weight structures up to loads of 36 MPa.

Road-making is another application that can potentially benefit upon using PKS as material filler. It is recommended that for heavily trafficked roads, PKS can replace aggregates of stone dust and bitumen in 10% blends with asphalt (Ndoke, 2016). Complete replacement of traditional aggregates is possible for lightly trafficked roads in rural settings. Even the partial displacement of bitumen will reduce the human and ecosystem toxicity levels associated with roadways, as bitumen contains polyaromatic hydrocarbons, several of which are known carcinogens. Though PKS is typically either burned or abandoned, the present study suggests its use as a valuable co-product water treatment and as filler for building and construction materials. The efficacy of PKS for the above applications, water treatment and materials reinforcement depends upon its composition and surface chemistry. Hence, there is need for a comprehensive characterization of PKS to assist in deciding amongst its possible applications. In this investigation, both compositional and surface characteristics of PKS are measured using analytical devices and established methods with the objective of informing potential users and marketers of its intrinsic value for sustainable economic development (Ndoke, 2016).

2.2 Adsorption studies

Adsorption is a surface process that leads to transfer of a molecule from a fluid bulk to solid surface. This can occur because of physical forces or by chemical bonds. Usually it is reversible (the reverse process is called desorption); then it is responsible not only for a subtraction of substances but also for release. In most of the cases, this process is described at the equilibrium by means of some equations that quantify the amount of substance attached on the surface given the concentration in the fluid. These equations are called isotherms (the most famous are the Langmuir and the Freundlich equations) because of the dependence of their parameters on the temperature, which is one of the most important environmental factors affecting adsorption. Adsorption has a fundamental role in ecology: it regulates the exchanges between geosphere and hydrosphere and atmosphere, accounts for the transport of substances in the ecosystems, and triggers other important processes like ionic exchange and enzymatic processes.

Types of Adsorption

According to Freundlich (1906), On the basis of interaction forces between adsorbate and adsorbent, adsorption is of two types.

1. **Physical adsorption:**

This type of adsorption is also known as physisorption. It is due to weak Van der Waals forces between adsorbate and adsorbent.

For example, H_2 and N_2 gases adsorb on coconut charcoal.

2. Chemical adsorption:

This type of adsorption is also known as chemisorption. It is due to strong chemical forces of bonding type between adsorbate and adsorbent. We can take the example involving the formation of iron nitride on the surface when the iron is heated in N2 gas at 623 K.

Adsorption of gas on a solid is a spontaneous exothermic reaction. The amount of heat liberated when a unit mass of a gas is adsorbed on the surface is called heat of adsorption.

Physisorption and Chemisorption Adsorption Characteristics

Characteristics of physical adsorption:

1. This type of adsorption is caused by physical forces.
2. Physisorption is a weak phenomenon.
3. This adsorption is a multi-layered process.
4. Physical adsorption is not specific and takes place all over the adsorbant.
5. Surface area, temperature, pressure, nature of adsorbate effects physisorption.
6. Energy for activation is low (20 – 40 kg/mol).

Characteristics of chemical adsorption:

1. This type of adsorption is caused by chemical forces.
2. It is a very strong process.
3. This type of adsorption is almost a single-layered phenomenon.
4. Chemisorption is highly specific and takes place at reaction centres on the adsorbant.
5. Surface area, temperature, nature of adsorbate effects chemisorption.

6. Energy of activation is very high 40 – 400 kJ/mol.

Adsorption Isotherm

Adsorption is usually described by isotherms. It is due to the fact that temperature plays an important role or that it has a great effect on the whole process. Moreover, there are several isotherm models that are used to describe the adsorption technique.

Applications of Adsorption

1) Air pollution masks:

These consist of silica gel or activated charcoal powder, when dust or smoke are paused through them, those particles get adsorbed on the surface of these materials.

2) Separation of noble gases by Dewar's flask process:

A mixture of noble gases of Ne, Ar, Kr is passed through Dewar's flask in presence of heated coconut charcoal. Argon and Krypton gels adsorbed leaving Neon.

3) Purification of water:

By the addition of alum stone to the water, impurities get adsorbed on the alum and water gets purified.

4) Removal of moisture and humidity:

Moisture in the air is removed by placing silica gel on which water molecular gets adsorbed.

5) Adsorption chromatography:

It is used to separate pigments and hormones.

6) Ion exchange method:

In this method of removing the hardness of water, calcium and magnesium ions get adsorbed on the surface of ion exchange resin

7) In metallurgy:

In the froth floatation process of concentration of ore, the particle gets adsorbed on the froth.

Langmuir Isotherm Formulation

The release of adsorbed gas is commonly described by a pressure relationship called the Langmuir Isotherm. The Langmuir adsorption isotherm assumes that the gas attaches to the surface of the coal or shale, and covers the surface as a single layer of gas (a monolayer). At low pressures, this dense state allows greater volumes to be stored by sorption than is possible by compression.

For application to CBM reservoirs in the field, the equation is modified to account for ash and moisture content of the coal.

The Freundlich equation

The Freundlich equation or Freundlich adsorption isotherm, an adsorption isotherm, is an empirical relationship between the quantity of a gas adsorbed into a solid surface and the gas pressure. The same relationship is also applicable for the concentration of a solute adsorbed onto the surface of a solid and the concentration of the solute in the liquid phase. In 1909, Herbert Freundlich gave an expression representing the isothermal variation of adsorption of a quantity of gas adsorbed by unit mass of solid adsorbent with gas pressure. This equation is known as Freundlich adsorption isotherm or Freundlich adsorption equation. As this relationship is entirely empirical, in the case where adsorption behavior can be properly fit by isotherms with a theoretical basis, it is usually appropriate to use such isotherms instead (see for example the Langmuir and BET adsorption theories). The Freundlich equation is also derived (non-empirically) by attributing the change in the equilibrium constant of the binding process to the heterogeneity of the surface and the variation in the heat of adsorption.

2.4 Congo Red

Congo red stain is used for the visual detection of amyloid in muscle and nerve fresh frozen sections in patients who have amyloidosis. The dyeing of amyloid is by a mechanism similar to the direct textile dyeing of cotton. The linearity of the dye configuration permits hydrogen bonding of the azo and amine groups of the dye to similarly spaced carbohydrate hydroxyl radicals of the amyloid substance. The use of a staining solution containing high content of alcohol and free alkali releases native internal hydrogen bonding between adjacent polysaccharide chains and creates more potential sites for the binding of the dye.

Congo red is an organic compound, the sodium salt of 3,3′-([1,1′-biphenyl]-4,4′-diyl)bis(4-aminonaphthalene-1-sulfonic acid). It is an azo dye. Congo red is water-soluble, yielding a red colloidal solution; its solubility is greater in organic solvents. However, the use of Congo red has long been abandoned, primarily because of its carcinogenic properties.

Behavior in solution

Congo red (pH indicator)

Due to a color change from blue to red at pH 3.0–5.2, Congo red can be used as a pH indicator. Since this color change is an approximate inverse of that of litmus, it can be used with litmus paper in a simple parlor trick: add a drop or two of Congo red to both an acid solution and a base solution. Dipping red litmus paper in the red solution will turn it blue, while dipping blue litmus paper in the blue solution will turn it red. This property gives

Congo red a metachromatic property as a dye, both in strongly acidic solutions and with strongly acidophilic tissue.

Congo red has a propensity to aggregate in aqueous and organic solutions. The proposed mechanisms suggest hydrophobic interactions between the aromatic rings of the dye molecules, leading to a π–π stacking phenomenon. Although these aggregates are present under various sizes and shapes, the "ribbon-like micelles" of a few molecules seem to be the predominant form (even if the "micelle" term is not an entirely appropriate name for it). This aggregation phenomenon is more prevalent in high Congo red concentrations, at high salinity and/or low pH.

Diagnostic Use

In histology and microscopy, Congo red is used for staining in amyloidosis, and for the cell walls of plants and fungi, and for the outer membrane of Gram-negative bacteria. Apple-green birefringence of Congo red stained preparations under polarized light is indicative of the presence of amyloid fibrils. Additionally, Congo red is used for the diagnostics of the Shigella flexneri serotype 2a, where the dye binds the bacterium's unique lipopolysaccharide structure. Furthermore, Congo red may also be used to induce expression of the type III secretion system of Shigella flexneri, bringing about the secretion of IpaB and IpaC, which form translocation pores within host cell membrane, allowing effector proteins to pass through and alter the host cell's biochemistry. The dye can also be used in flow cytometry experiments for the detection of Acanthamoeba, Naegleria and other amoebal cysts. In confocal microscopy, Congo red can be used as a stable fluorescent stain.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

Apparatus/Reagents

- Distilled water
- HCl (Hydrochloric acid) 1M
- Ammonium chloride (NH_4CL)
- Beakers
- Kiln furnace
- Measuring cylinder
- Syringes
- Specimen bottles
- Heating Apparatus
- Analytical sieves
- Weighing balance
- Mechanical shaker
- Visible spectrophotometer
- Masking tape
- Mortar and pestle
- Naoh - 2M
- Tap water

3.2. Collection of Sample

The palm kernel shells were obtained from a local source, palm kernel mill at Jattu Ozairue, Etsako West Local Government Area, Edo state, Nigeria.

The dye Congo Red was purchased from Medi Plus.

3.3. Preparation of Carbonized Adsorbent

The palm kernel shell was washed severally with water to remove particles and dirt and then rinsed again with distilled water. The washed palm kernel was sun dried for 24hrs.

A portion of the sample was taken for carbonization, carbonization is a process of heating palm kernel in the absence of oxygen. The palm kernel shell was then in a kiln (muttle furnace) in the absence of oxygen at varied temperature ranging from 300oC to 800oC for one hour. The carbonized palm kernel shell was crushed with mortal and pestle to powdered form. The crushed palm kernel shell was taken for sieve analysis by making it pass through a set of sieve with the particle size (53um, 125um, 212um, 300um, 425um and 600um, the sieve were arranged in a descending order and was shaken manually to allow the particles pass through each size of the sieve for separation. The particle size 212um was selected for analysis.

3.4. Preparation of Activated Adsorbent

To activate the crushed palm kernel shell of size 212um was weighed and 100g was collected for activation. 500ml of distilled water was boiled and turned into a beaker, 32.2g of NH_4CL was turned into the boiled water and mixed until dissolved, then the 100g of palm kernel was poured into the NH_4CL solution and left to soak for 30mins. When the time elapsed, the soaked palm kernel shell was sieved using sieve size of 125um. The wet palm kernel shell was dried in the oven for 10hrs at 120^oc. In order to wash out the NH_4CL, the palm kernel shell was soaked in 1M HCl (Hydrochloric acid) solution which was previously heated in a water bath. The soaked palm Kernel shell was rinsed with hot water severally and was dried in the oven for 2 hrs

3.5. Preparation of Dye Solution

1g of Congo red was dissolved in 1000cm3 of distilled water to give 1000ppm solution using cylinder and was stored in the container was stock solution and was labelled appropriately.

A serial dilution (5ppm, 10ppm, 15ppm, 20ppm) was made stock solution and was labelled. It was stock solution by using the formula below.

In order to know the absorbance of each concentration of the dye solution, the serial solution was taken from Visible Spectrophotometer. Visible Spectrophotometer was single beam. The solution was placed in a 5ml cuvette by means of syringe at wavelength 480nm and zeroed for calibration.

$$C_1V_1 = C_2V_2$$

$C_1 =$ Concentration of stock solution

C2 = Concentration of the Standard Solution

V1 = Volume of the stock solution

V2 = Volume of the Standard solution

Isotherm Studies

100ml of the Congo red solution of concentration 5ppm, 10ppm, 15ppm and 20ppm was prepared, by adding 1g of the absorbent (for both activated and carbonized PKS) was added to the containers holding the solution. The sample containers was manually shaken for 1hr, at the end of 1hr, samples were collected from each container and it was determined using Visible Spectrophotometer at 480nm.

Concentration	Absorbance
5ppm	0.08
10ppm	0.097
15ppm	0.174
20ppm	0.280

CHAPTER FOUR

RESULTS AND DISCUSSION

Equilibrium relationship between adsorbent and adsorbate are described by adsorption isotherm. The table shows the relationship between percentage removal and final concentration

Removal Efficiency

Conc	Initial conc (ce)	Amt removed Carbonized	% removal Carbonized	Amount removed activated	% removal activated
5ppm	0.008	-0.446	-5575	-0.376	-4700
10ppm	0.097	-0.766	-789.6	-0.443	-456.7
15ppm	0.174	-0.543	-312.1	-0.394	-226.4
20ppm	0.280	-0.62	-221.9	-0.352	-125.7

LONGMUIR ISOTHERM FOR CARBONIZED PKS

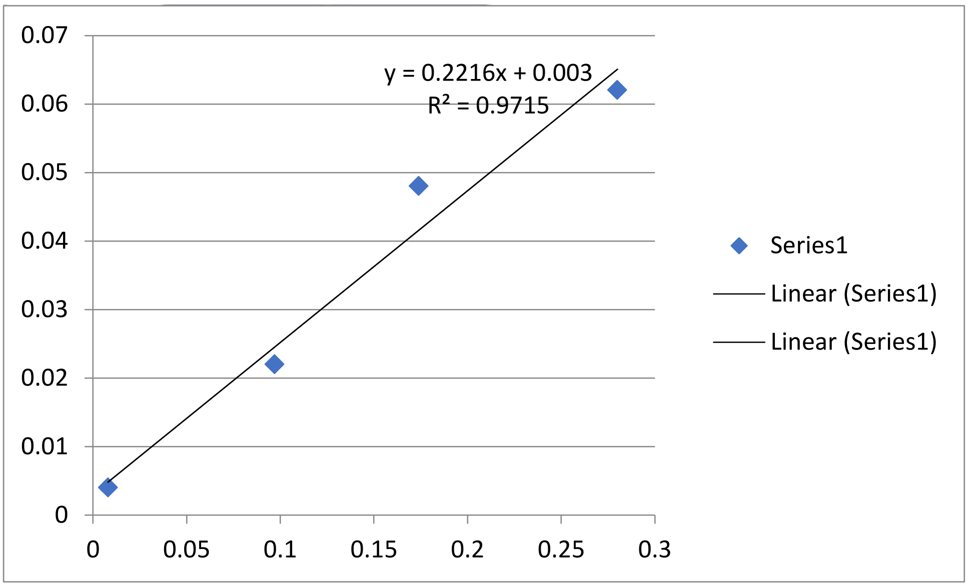
Table 1 Langmuir Isotherm

Table for ce/qe vs ce

Ce	**Ce/qe**

0.008	0.004
0.097	0.022
0.174	0.048
0.280	0.062

Graph 1 Langmuir Isotherm Carbonized PKS

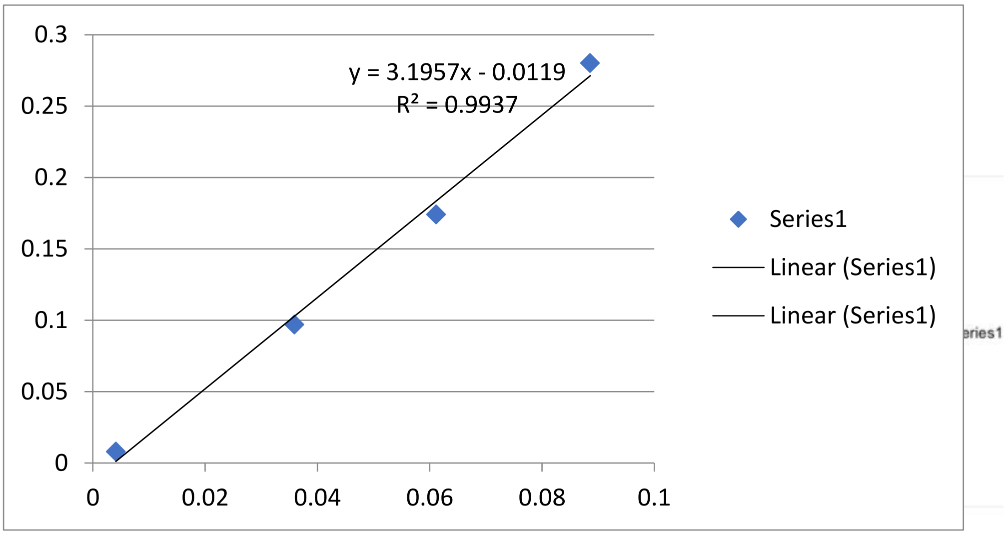


LONGMUIR ISOTHERM FOR ACTIVATED PKS

Tables 2 Langmuir Isotherm

Table for ce/qe for 2/2

Ce	**Ce/qe**
0.008	0.0041
0.097	0.0359
0.174	0.0612
0.280	0.0886



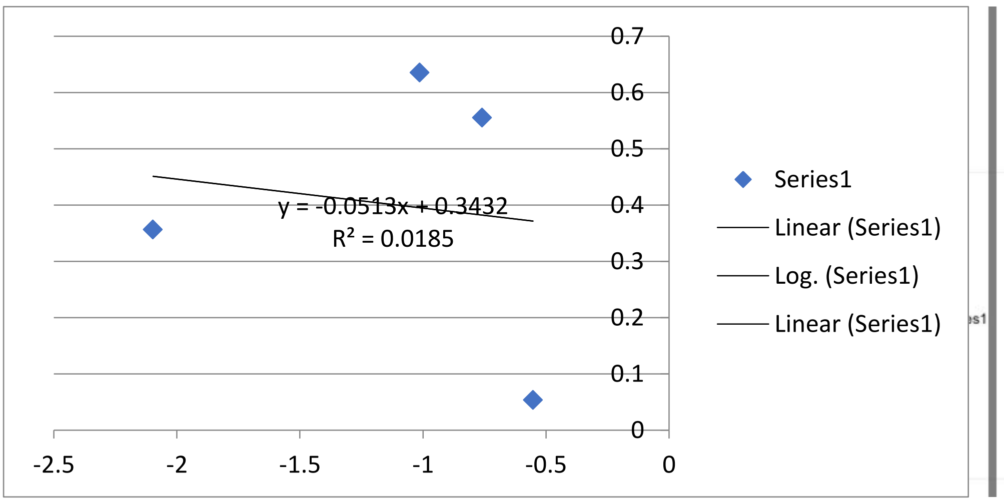
Graph 2 Langmuir Isotherm Activated PKS

Tables for Freundlich Isotherm Carbonised

Table 3 Log qe vs Log ce

Log Ce	Log qe
-2.0969	0.3560
-1.0132	0.6354
-0.7594	0.555
-0.5528	0.6532

Graph 3 Freundlich Isotherm Carbonized PKS

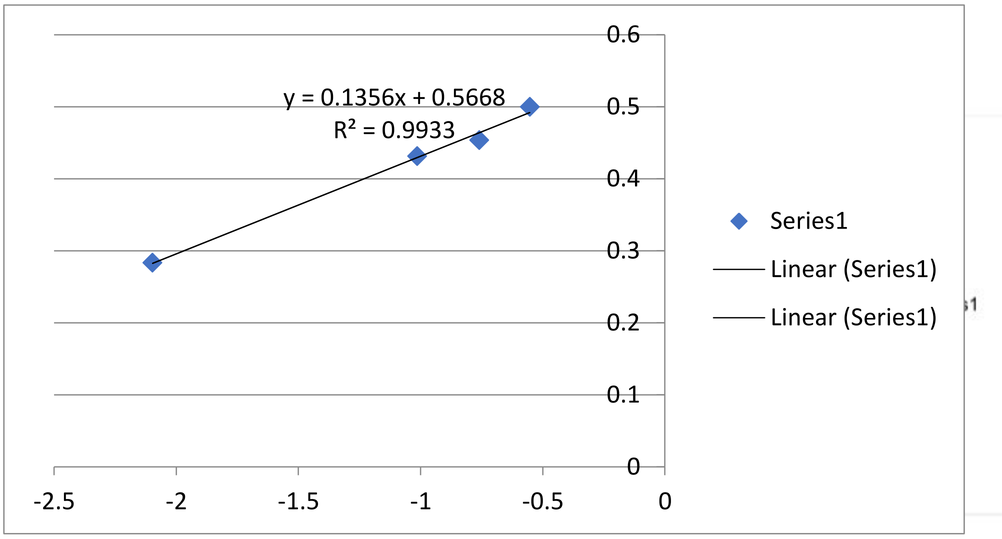


Tables 4 Freundlich Isotherm Activated

Table 4 Log qe vs Log ce

Log Ce	**Log qe**
-2.0969	0.2833
-1.0132	0.4313
-0.7594	0.4533
-0.5528	0.4996

Graph 4 Freundlich Isotherm Activated PKS

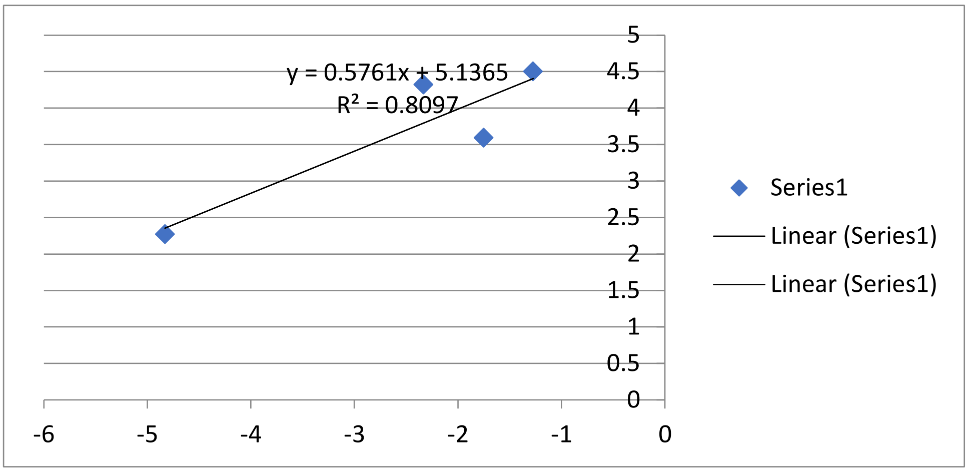


Tables 5 Temkin Isotherm

Table for qe vs Ince 2/2

Ince	**Qe**
-4.828	2.27
-2.333	-4.32
-1.7486	3.59
-1.2729	4.50

Graph 5 Temkin Isotherm Carbonized

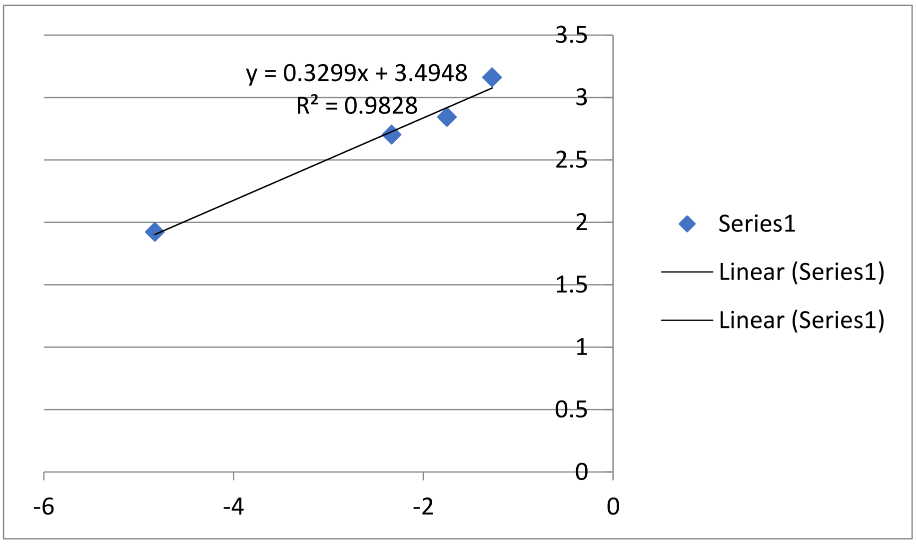


Tables 6 Temkin Isotherm Activated

Table 6 qe vs Ince 2/2

Ince	**Qe**
-4.828	1.92
-2.333	2.7
-1.7486	2.84
-1.2729	3.16

Graph 6 Temkin Isotherm Activated



Equilibrium/Isotherm Studies

The equilibrium studies carried out were Langmuir, Freundlich and Temkin Isotherm and the correlation value gotten from Langmuir do not correspond with the unity range. It shows that the Langmuir equation is jot fit for the description or interpretation of this adsorption process. Bit the rest of the isotherm study i.e (Freundlich and Temkun) the correlation values are in a close range. The fig 6 of 212um of Temkin study shows the highest correlation value i.e 0.9828 for activated PKS while Fig 5 of 212um of Freudlich study shows the highest correlation value of 0.9944 i.e for activated PKS

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The study indicates that both activated and carbonised PKS has a suitable adsorption capacity to remove Congo red a typical dye from aqueous solution. The equilibrium/ isothermal studies was gotten from the Langmuir isotherm, Freundlich isotherm and Temkim isotherm model with correlation values in a close range. The fig 7 and 8 of 212 sieve size shows the highest correlation value of 0.8097 and 0.9828 for carbonised and activated PKS respectively, while Fig 5 and 6 of sieve size 212 shows the highest correlation value of 0.0185 and 0.9933 for carbonised and activated PKS respectively.

This studies can be best used to describe and interpret the adsorption of condo red.

It is therefore sufficed to conclude that PKS can serve as cheap readily available effective adsorbent for the removal of Congo red from waste water which is a way of treatment before discharged into the environment.

5.2. Recommendation

From the study carried out, it shows

1. PKS is a good adsorbent; it is therefore recommended that much research should be carried out on their agricultural waste products such as coconut shell, melon shell, docanut seed shell e.t.c, in order to reduce the cost of imported adsorbent.
2. The government should try to provide the necessary machines and equipments needed for the investigation and also to the various institutions especially Polytechnics for easy research.
3. Nigeria government should provide more workshops to educate and train personnel on how to manage our agricultural waste to avoid environmental pollution.

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