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Determination of Adsorption Capacity of Copper II Sulphate on Kaolin

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Authors' contributions

This work was carried out in collaboration among all authors. Author HAA designed the study, performed the statistical analysis, wrote the protocol, carried out the laboratory analysis and wrote the first draft of the manuscript. Authors AMD KA and RSU managed the analyses of the study, literature searches and introduction. All authors read and approved the final manuscript.

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ABSTRACT

Copper II sulphate is one of those contaminants that undermine the economic, environment and deleterious health effects on people. Kaolin sample from Illela local government of Sokoto state, Nigeria was used as adsorbent for removal of Copper II sulphate and to check for the effect of concentration. The collected kaolin sample was pretreated to remove debris, grinded and dried. The adsorption methods of the parameters onto the kaolin were investigated by maintaining constant amount of adsorbent, temperature and other factors except for concentration. The results from different concentrations shows that with increase in concentration of the copper solution, the more the kaolin adsorbed. From the findings, it was established that kaolin form Illela local government of Sokoto state, Nigeria can serve as an economic, safe and effective natural adsorbent for removal of copper II sulphate from wastewater.

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1. INTRODUCTION

Environmental pollutants and their toxicity are a global concern due to their adverse effects and the severe health challenge they pose. Copper II sulphate happens to be one of those contaminants that undermine the economic, environment and deleterious health effects on people [1].

Copper II sulphate originate from chemicals used in various industrial sectors (textiles, mining, tanning etc.), agricultural sectors (e.g. pesticides, herbicides etc.) and medical sector such as pharmaceutical, hormonal and personal care products [2]. Most developing countries do not have the technology to remove this pollutant before they are being discharged into the environment.

Several methods have been developed in order to treat waste water. Some of which include centrifugation [3], filtration [4], oxidation and evaporation [5], ion exchange [6], electrodialysis [7], crystallization [8], ultra-filtration [9], precipitation [10], adsorption [11] among others.

Specifically, tannery industries release waste water containing copper during conversion of raw hides into leather products [12]. According to Nigeria Tanner council (NTC), tannery industries in Nigeria are among the oldest industries [13]. Due to large scale production of livestock, Nigeria is rated as one of Africa's leading leather producing countries [14]. Due to the ban of wet blue and crust export by the federal government of Nigeria, the number of skins produced by traditional tanners has fallen due to the use of low-grade skin and wet blue causing them to engage in improper disposal of tannery waste [1]. This waste contain copper II sulphate which has negative effect on the environment.

Adsorption depend on the utilization of either modified or unmodified adsorbent controlled by parameters such as concentration, dosage of adsorbent etc [15].

According to [16], the most promising adsorbent material used is clay minerals. The utilization of clay and its derivatives would solve the disposal problem, and also provide access to less expensive material for liquid waste treatment. Due to their low production cost, clays do not need to be regenerated after use which provide more advantage in using them as adsorbent. Kaolinite are commonly used in developing countries for removal of toxic pollutants due to their high specific area, availability, stability and structural characteristics.

Kaolinite is a clay mineral, part of the group of industrial minerals, with the chemical composition $Al_2Si_2O_5(OH)_4$. It is a layered silicate mineral, with one tetrahedral sheet linked through oxygenatoms to one octahedral sheet of aluminaoctahedral [17]. Rocks that are rich in kaolinite are known as kaolin or china clay [18].

These clay minerals are abundant in nature, they are non-toxic and they have significant roles in scavenging pollutants from waste water either via ion-exchange or adsorption process or both. The adsorption processes, which occur on the solid surface in contact with ionic solution involves the adsorption of potential counter ions which gives the surface either positive or negative charge with respect to charge originating from the crystal lattice [16].

Kaolinite group is classified as 1:1 type layer silicate with a tetrahedral sheet of silica (SiO_2) joined together with an oxygen atom and octahedral sheet of alumina (Al_2O_3). Kaolinite possess high chemical stability, low expansion and cation exchange capacity. The kaolinite group is structurally divided into dioctahedral and trioctahedral minerals [16].

Copper is a chemical element with the symbol Cu and atomic number 29. It is a ductile metal with very high thermal and electrical conductivity. Gram quantities of various copper salts can produce acute copper toxicity in humans, possibly due to redox cycling and the generation of reactive oxygen species that damage DNA. Corresponding amounts of copper salts (30 mg/kg) are toxic in animals [19].

The adsorption capacity of copper II sulphate on kaolin was investigated by controlling contact time, temperature and adsorbent dosage. From the result of the study, it was established that kaolin can serve as an economic, safe and effective natural adsorbent for removal of Copper II sulphate.

2. MATERIALS AND METHODS

2.1 Preparation of Kaolin Clay

About 200 g of kaolin was obtained from Illela local government of Sokoto state, Nigeria. The collected kaolin sample was pretreated to remove debris. The kaolin was grinded using ceramic mortar and pestle and then sieved to obtain fine particles. The powdered particle of the kaolin was dried for three (3) days at ambient temperature. Removal of impurities from the kaolin was done using physical separation of the dirt from the sieved clay.

2.2 Wavelength of Copper II Sulphate

A $CuSO_4$ solution was scanned on the UV/visible spectrophotometer to obtain the absorption spectrum (400-900nm) of the solution. The solution was observed to absorb maximally at about 810nm.

2.3 Preparation of Copper II Sulphate

Following the procedure described by [20] with slight modification, 6 grams of solid copper II sulphate was dissolved in 250 ml of distilled water in a volumetric flask. Using measuring cylinder, the solution was further diluted to form concentration of 1000ppm, 1400ppm, 1800ppm, 2200ppm, and 2600ppm which were used as the standards. Another five concentrations of 1100, 1400, 1700, 2000, and 2300ppm were made and they were used as the sample. All the samples were kept in different plastic centrifuge tubes and labeled.

2.4 Determination of Effect of Centration on Adsorption Capacity of Copper II Sulphate on Kaolin

The procedure was described by [21] with slight modification. Eight (8) ml of $CuSO_4$ sample solution was taken in a beaker and 1 g of kaolin was added and stirred. The mixture consisting of kaolin and copper was subjected to water bath at the temperature of 25^{o}C where both stirring and heating were done for 5 mins. After the period of 5 mins, the water bath was switched off. The mixture was transferred into a plastic centrifuge tube and centrifuged at 2000r/min for 10 mins causing the adsorbent to settled at the bottom of the centrifuge tube, the mixture was removed and transferred into another centrifuge tube. The sample was analyzed using UV spectrophotometer at 810nm of wavelength. The same procedure was repeated for all the samples. In each case, the concentration of the $CuSO_4$ was obtained from a standard curve. The amount of $CuSO_4$ adsorbed by the kaolin was calculated from equation 1. The equation was gotten from the UV spectrophotometer.

$$\text{Cui} = \frac{xi}{1000} \times 8\text{Cut} = \frac{xii}{1000} \times 8$$

Absorbed= Cui-Cut

$$= \frac{xi}{1000} \times 8 - \frac{xii}{1000} \times 8$$

$$\text{Absorbed=} \quad 8/1000\,(\,xi - xii\,) \qquad (1)$$

Xi= initial concentration of $CuSO_4$ before treatment with kaolin
Xii= final concentration $CuSO_4$ after treatment with Kaolin.

3. RESULTS AND DISCUSSION

The standards were examined to determine the adsorption rate of copper. Percentage of various standards, there concentration, adsorption, wavelength and weighing factor are shown in Table 1 and also shown on the standard curve.

Table 1. Standard table report

Sample ID	Concentration (mg/L)	Absorbance Mg
A	8000	0.389
B	10000	0.486
C	12000	0.589
D	14000	0.700
E	16000	0.769

In Table 2, the samples were examined to determine the adsorption rate of kaolin on copper. Result of various samples, there concentration and absorbance are shown below.

Table 1 shows the value of standard concentration that was made for all the samples, while Table 2 shows value of the samples after

Table 2. Result showing increase adsorption of $CuSO_4$ on kaolin with increase in concentration

Sample ID	Initial concentration (mg/L)	Concentration (mg/L)	Amount Adsorbed(mg/g)
A	8000	141	63.8
B	10000	350	77.2
C	12000	559	91.5
D	140000	817	105.5
E	160000	1318	117.5

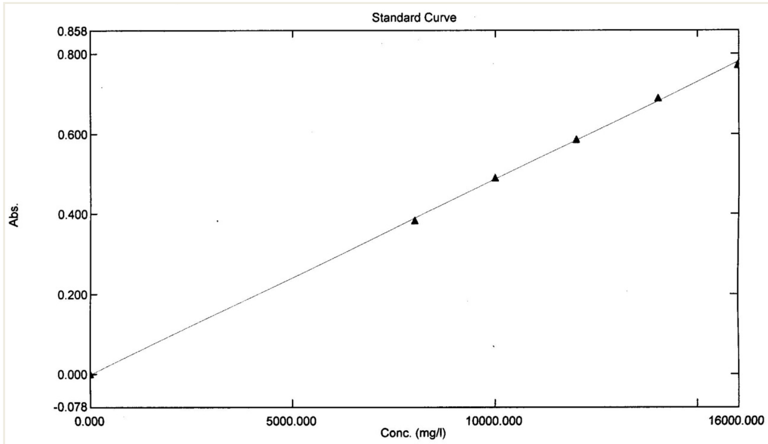

Fig. 1. Standard Curve

each sample has been subjected to the above procedure as described by [21] with slight modifications. Sample A with standard concentration of 8000ppm, shows concentration of 141 mg/L. The decrease in concentration shows that kaolin has adsorbed 63.8 mg/g of the copper. While sample B with concentration 10000ppm, shows concentration of 350 mg/L which means the kaolin has adsorbed 77.2 mg/g of the copper.

The standard concentration for the samples C, D and E was 12000ppm, 14000ppm and 16000ppm respectively. After the above procedure, they showed the concentration of 559 mg/L, 817 mg/L and 1318 mg/L respectively, showing that the kaolin has adsorbed 91.5 mg/g, 105.5 mg/g and 117.5 mg/g of the copper respectively.

Batch adsorption technique used in this study shows that at constant temperature and constant amount of adsorbent, kaolin adsorb copper II sulphate which is similar to the findings of [22] and when the concentration of copper (II) sulphate is increased, the adsorption capacity of the kaolin increases.

4. CONCLUSION

In this research, the kaolin clay gotten from Illela local government area of Sokoto State, Nigeria was used as adsorbent to check the effect of concentration of copper II sulphate, while maintaining constant temperature, quantity of adsorbent and other physical factors. Analysis of copper using UV/Spectrophotometer shows that when adsorption of the copper solution was done with kaolin, the higher the concentration, the more the adsorption by the kaolin. This means that kaolin can be used in treating copper II sulphate from wastewater or effluent before they are being discharged into the environment or river. These results provide additional information on uses of kaolin found in illela local government area of Nigeria which is quite cheap and non-hazardous to the environment in water treatment.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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