International Journal of
Science and Engineering Investigations vol. 4, issue 46, November 2015
ISSN: 2251-8843

Biosorption of Heavy Metal in Leachate using Activated Carbon from Sawdust and Groundnut Shell

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Abstract- The removal of heavy metal in leachate using activated carbon from sawdust and groundnut shell was carried out. Activated carbon was prepared from groundnut shell and sawdust using HNO_3 acid as activating agent. Three experimental samples was set up and filled with 100ml of leachate water, 10g of the carbonized and the activated samples were discharged into two of the experimental set up, while the third bottle was let alone as control to check the heavy metal content of the leachate The experimental set up was discharged into a glass column and analyzed for heavy metal content using the atomic adsorption spectrophotometer.

The capacity of the removal of lead, zinc, chromium, copper and vanadium metal by this activated carbon was carried out, and their comparison was made

The result showed that the rate of adsorption of zn, cr, pb and cu metals using sawdust was 23%, 89%,0%,0%.139% respectively and using groundnut shell is -40%, 26%, 0% and -320.8% respectively. From the results, it can be concluded that the sawdust had high efficiency of metal adsorbance than the groundnut shell.

Keywords- *Activated carbon, Heavy metals, Leachate, Atomic Adsorbance Spectrophotometer*

I. INTRODUCTION

Due to modernization, the industrial use of metals especially heavy metals has risen alarmingly, thus becoming of prior concern because of their toxicity to flora and fauna. Recovery of heavy metals from industrial waste streams is becoming increasingly important as society realizes the necessity for recycling and conservation of essential metals.

The intensification of industrial activity and environmental stress greatly contributes to the significant rise of heavy metal pollution in water resources making threats on terrestrial and aquatic life.

However, rapid industrialization and urbanization have resulted in the production of huge amount of wastewater containing all types of pollutants. Increasing of environmental awareness has led to more stringent regulations on the quality of water and wastewater. This has led to search for appropriate techniques to cope with these limits. Various techniques have been developed by researchers for treatment of such wastewater. The real challenge is to select the efficient, economic technique that has the least adverse effect on the environment. The treatment method may be physical, chemical or biological in nature. Examples of the treatment methods include; foam filtration, filtration, ion exchange, sedimentation, solvent extraction, adsorption, chemical oxidation, membrane processes stepwise coagulation, GAC/O3 oxidation, Fenton process, lime softening , coagulation, electrochemical processes, electrocoagulation, chemical precipitation.

These methods have some drawbacks; including low efficiency for removal of trace concentration of pollutants in case of chemical/biological oxidation, electrolysis, ion exchange and solvent extraction. Coagulation and precipitation processes produce large amount of sludge and require pH control. Furthermore, ozonation will remove color from wastewater without decreasing the COD Membrane processes suffer from the problem of fouling of the membrane used. Many of these processes lack in cost effectiveness, energy intensive processing and the low removal efficiency for some pollutants.

On the other hand, adsorption has many advantages on the other processes. This process has the characteristics of convenience, easy operation and simplicity in design It has a wide application for removal of different pollutants. Other important advantages of this process include: low operation cost, high flexibility, simple design and operation, easy automation, lack of sensitivity to toxic pollutants and the capability of operation at very low concentration, environmentally friendly, less investment in terms of initial cost.

The most important criteria in adsorption processes is to find a low cost adsorbent that is widely available, having high adsorption capacity, possess rapid rate of removal and having low adverse effect on the treated water. Many adsorbents have been investigated.

Activated carbon is the most employed adsorbent for heavy metal removal from aqueous solution [1]. However, the extensive use of activated carbon for metal removal from industrial effluents is expensive [2], limiting its large application for wastewater treatment. Therefore, there is a growing interest in finding new alternative low-cost adsorbents for metal removal from aqueous solutions, such as; micro-organisms [3,4] and the residuals of agricultural products [5,6].

Activated carbon can be produced from various biomass materials. With the increasing ecological and economical significance of environmental protection, the use of waste biomass as feedstock material for the production of activated carbons is attracting increasing interest [7]. There has been much effort in recent years developing activated carbons with high methane adsorption capacity for use in natural gas storage [11]. Less attention has been given to the transport or dynamic aspects, probably due to the increased experimental and analytical complexity required. Although various precursors and preparation methods have been investigated, much work remains before activated carbon sorbents can be systematically tailored to optimize natural gas storage [11]. In gas storage, the high-energy micropores are of prime interest because of their role in determining affinity and capacity. On the other hand, species transportation to and from the micropores must also occur on a time scale short enough to make full use of the available capacity.

Metals, a major category of globally-distributed pollutants, are natural elements that have been extracted from the earth and harnessed for human industry and products. Metals are notable for their wide environmental dispersion from such activity; their tendency to accumulate in select tissues of the human body; and their overall potential to be toxic even at relatively minor levels of exposure. Today heavy metals are abundant in our drinking water, air and soil due to our increased use of these compounds. They are present in virtually every area of modern consumerism from construction materials to cosmetics, medicines to processed foods; fuel sources to agents of destruction; appliances to personal care products. It is very difficult for anyone to avoid exposure to any of the many harmful heavy metals that are so prevalent in our environment. Some metals, such as copper and iron, are essential to life and play irreplaceable roles in, for example, the functioning of critical enzyme systems. Other metals are xenobiotics, i.e., they have no useful role in human physiology (and most other living organisms) and, even worse, as in the case of lead and mercury, may be toxic even at trace levels of exposure. Even those metals that are essential, however, have the potential to turn harmful at very high levels of exposure, a reflection of a very basic tenet of toxicology--“the dose makes the poison.”

The abundance of sawdust and groundnut shell in this part of the world, their low prices and non-aggressive nature towards the environment are advantages for its utilization in the point of view of wastewater and waste cleanup.

The hazardous ill effects of heavy metals on the environment and public health is a matter of serious concern. Biosorption is emerging as a sustainable effective technology. Heavy metal in water resources are one of the most important environmental problems of countries.

The toxicity of metal pollution is slow and interminable, as these metal ions are non-bio – degradable. In view of this research work is for the purpose of evaluating the biosorption of heavy metals in leachate obtained from OPM dumpsite, and the adsorbents that will be used are sawdust and groundnut shell.

Waste waters containing heavy metals are produced each year by textile industries and other wastes from various industrial processes, most of the chemical methods used in cleaning up of these heavy metals are not effective. This necessitated the use of groundnut shell and sawdust for adsorption of heavy metals. Groundnut shell is a carbonaceous fibrous solid waste which encounters disposal problem and is generally used for its fuel value, and the use of activated carbons however has been widely considered because of their high adsorption on dyes and is a highly porous, amorphous solid consisting of micro crystallites with a graphite lattice, usually prepared in small pellets or a powder. It is non-polar and cheap.

II. MATERIALS AND METHODS

A. *Collection of Samples*

The sawdust from mahogany was collected from Rumuosi timber line in Port Harcourt – Rivers State, south-south of Nigeria.

The groundnut shell was obtained from swali ultra-modern market, Yenagoa Local government are of Bayelsa state, south-south of Nigeria.

1) *Carbonization Procedure*

1000kg of the mahogany sawdust was collected from Rumuosi timber line; it was weighed with the triple beam balance and further dried in a tray drier oven at temperature of 60^0c for 3 hours. The sample was brought out and reweighed, and the moisture content was noted, 970g of the sample was weighed and wrapped in a foil paper then discharged into a muffle furnace for carbonization. The sample was carbonized at a temperature of 700^0c. After which it was brought out of the furnace and immediately cooled in a desiccator at a temperature of 280^0c. The sample was reweighed and the final weight after carbonization was 540g.

2) *Size Reduction*

Further size reduction was done by crushing the sample to a particular size of 2mm mechanically. The ample was sieved with a sieve of 2mm mesh size. This was done to increase to surface area.

The same procedure was repeated for groundnut shell.

3) *Activation Procedure of Samples*

500g of the sample was weighed out for activation. The activation was done using nitric acid (HNO3) in a concentration of 0.5m. The preparation of the nitric acid was done by diluting 3.15ml HNO3 concentration solution in 1000ml of distilled water using a standard volumetric flask. 500g of the sample weighed into a 1000ml beaker and 500ml of the 0.5m, HNO3 was added to it. It was stirred and the beaker was heated to dryness using an electric hot plates for about 2 hours after which it was allowed to cool. Then the activated sample was discharged into a water bath with distilled after, it was washed repeatedly to neutralize the sample till the ph was adjusted to ph6 then the water was drained off and the sample was dried in a tray drier for about 3hours at a temperature of 110^0c.

III. Adsorption Process

100ml of leachate water collected was poured into three different 120ml sample bottle 10g of the sample of the activated carbon from mahogany sawdust was discharged into the second sample bottle.

The third sample bottle was not trated with the samples but let alone as control to check the heavy metal content of the leachate.

The sample bottle containing the activated carbon was agitated at regular interval for 1 hour, it was allowed for a contact time of 6 hours, after the completion of the contact time, it was discharged into a glass column. The clear fifteen was collected and analyzed for heavy metal content using the atomic adsorption spectrophotometer

A. AAS Procedure

The AAS was switched on and allowed to cool and run steadily for 18mm, the cathode camp of the metal concentration to be determined was inserted into the equipment and the specific wave length of the metal was selected on the machine. The equipment was standardized was two standard solution of metals by spraying the standard solution into the flame. It was cross checked with zero blank deionized water. The presence of the metals in the sample was determined by spraying the sample solution into the flame.

B. Moisture Content Determination

The hydroscopic moisture content of the sample was determined by using the tray driven oven. 1kg of the sample was placed in the tray drier oven at a temperature of 110^0c for 2 hours after which it was brought out and cooled in a desiccator when re-weighed and the final percentage moisture content was calculated using this formula

$$\% \text{ Moisture} = \frac{w1-W2}{W1} \times \frac{100}{1}$$

Where w_1 =initial weight of sample

W_2 = final weight of sample

$$\frac{1000-970g}{1000g} \times \frac{100}{1} = 3\%$$

C. Heavy Metal Removal

The heavy metals analyzed in the effluent water with the AAS machine are Manganese (Mn), Zinc (Zn), Copper (Cu), Cadmium (Cd), Lead (Pb) and Vanadium (V).

IV. RESULT AND DISCUSSION

TABLE I. Rate of Adsorption of Zn, Ch, Pb and Cu metals using sawdust and groundnut shell as adsorbent

Metals	Adsorbent	Initial (I) conc of metal in leachate (ppm)	Final (F) conc. Of metal in leachate (ppm)	Mean of adsorbance 1-F	% of ads $\frac{1-F}{1} \times 100$
Zinc	Sawdust	0.976	0.749	0.227	23.3
	Groundnut shell	0.976	1.366	-0.390	-40.0
Chromium	Sawdust	-0.454	-0.049	-0.405	89.2
	Groundnut	-0.454	-0.336	-0.118	26.0
Lead	Sawdust	0	0	-0.0028	0
	Groundnut	0	0	-0.0034	0
Copper	Sawdust	0.053	-162.3	-0.086	0.139
	Groundnut	0.053	1.223	-0.170	-320.8

From the results, the adsorbents/biosorbents exhibited a varying efficiency in removing hazardous ions from leachate which was function of the type of the material used and the ion in concern (Klimmek et al, 2001). The sawdust proved the more efficient from other material tested in the experimental process of the metal adsorbance.

The result showed that the rate of adsorption of zn, cr, pb and cu metals using sawdust was 23%, 89%, 0% ,0%, 0.139% respectively and using groundnut shell is -40%, 26%, 0% and -320.8% respectively. From the results, it can be concluded that the sawdust had high efficiency of metal adsorbance than the groundnut shell.

The metal adsorbancy of sawdust is due to a combination of physical adsorption of ions through surface binding forces, with chemical precipitations caused by its high calcium carbonate content. The potential of sawdust for large scale applications increases by considering the large availability of this material in much area. (13) However, groundnut shell exhibited lower metal removal efficiencies compared to sawdust. The low metal removal efficiency was expected though, since the material is not considered as typical adsorbent, although it may display some surface-retention properties.

Therefore, based on parameters such as efficiency, availability and purchase cost, only activated sawdust and groundnut shell were used in this experiment.

TABLE II. VARIATION OF ZINC CONCENTRATION

zinc conc	groundnut shell dosages	sawdust dosages
0	2.7	2.7
4	2.1	1.5
8	2.1	1.4
12	2.2	1.3
16	1.7	1.2
20	1.1	1.1

TABLE III. VARIATION OF COPPER CONCENTRATION

cu conc	groundnut shell dosages	sawdust dosages
0	1.02	1.02
4	0.02	0.01
8	0.24	0.2
12	0.12	0.1
16	0.13	0.11
20	0.02	0.01

TABLE IV. VARIATION OF CHROMIUM CONCENTRATION

cadmium conc	groundnut shell dosages	sawdust dosages
0	0.42	0.42
4	0.16	0.21
8	0.12	0.16
12	0.07	0.14
16	0.04	0.09
20	0.02	0.05

TABLE V. VARIATION OF LEAD CONCENTRATION

Lead conc	groundnut shell dosages	sawdust dosages
0	1.01	1.01
4	0.49	0.2
8	0.38	0.19
12	0.22	0.17
16	0.19	0.1
20	0.01	0.01

TABLE VI. VARIATION OF VANADIUM CONCENTRATION

Vanadium conc	groundnut shell dosages	sawdust dosages
0	0.1	0.1
4	0	0
8	0	0
12	0	0
16	0	0
20	0	0

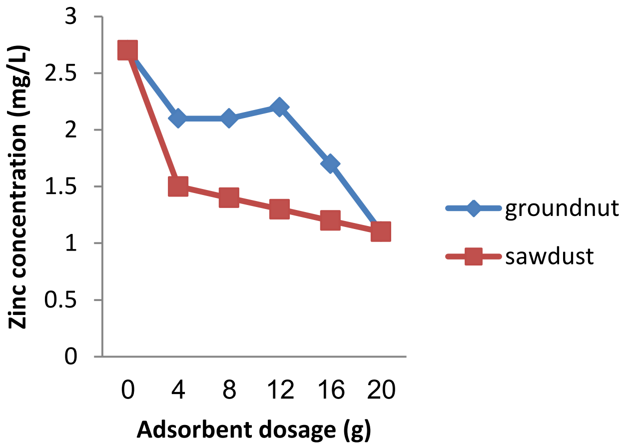

Figure 1. Variation of zinc concentration with varying dosages of different adsorbates.

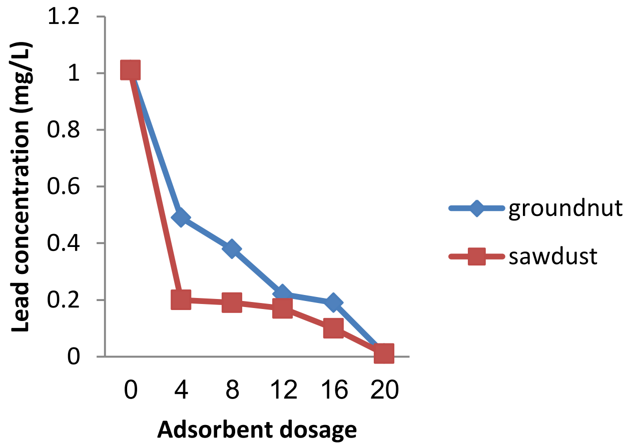

Figure 4. Variation of lead concentration with varying dosages of different adsorbates.

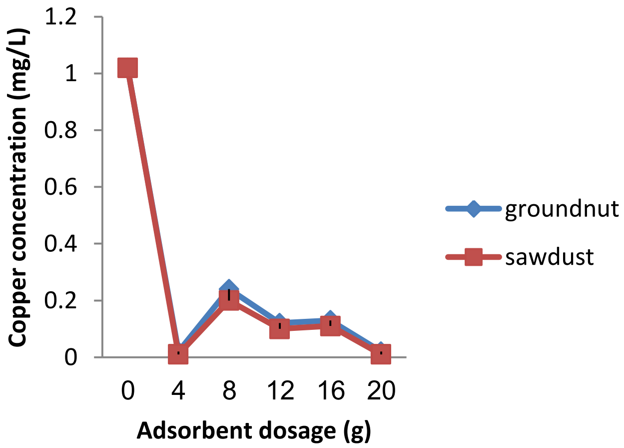

Figure 2. Variation of copper concentration with varying dosages of different adsorbates.

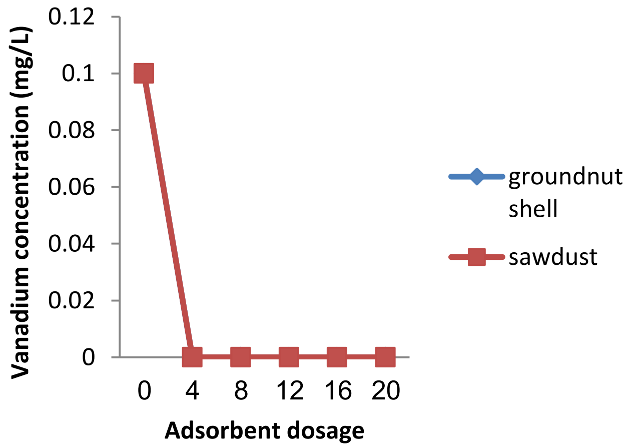

Figure 5. Variation of vanadium concentration with varying dosages of different adsorbates.

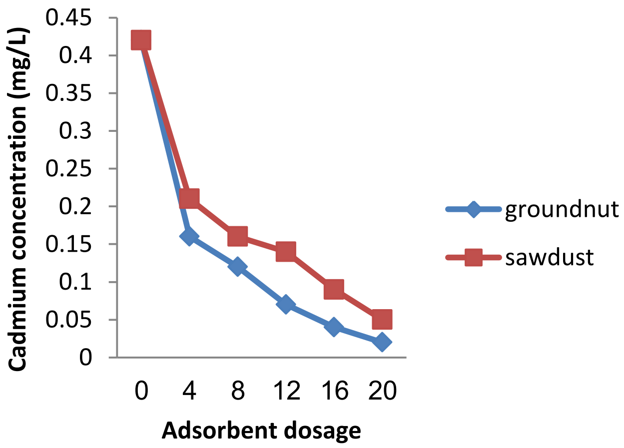

Figure 3. Variation of chromium concentration with varying dosages of different adsorbates.

Figure 4.2- Figure 4.6 show the effect of adsorbent dosage on heavy metal removal from effluent water. In the experiment, the dosage of the adsorbent was increased steadily by 4g and the effect on the same volume of water (200mls) was observed. Of the five heavy metal concentrations studied in the effluent waste water, one of them (Manganese) was found to be most effectively reduced by the groundnut shell adsorbent.

The concentration of Cadmium metal was also best reduced by groundnut adsorbent. The two adsorbents were found to compete strongly with one another in the removal of Zinc, copper and Lead metal.

The total concentrations of the heavy metal, Vanadium present in the effluent water sample was removed completely irrespective of the adsorbent dosage

V. CONCLUSION

This paper investigates the biosorption of heavy metals in leachate generated from OPM dumpsite, Port Harcourt City Rivers State. Nigeria. It is done by combining the adsorptive ability of inexpensive and largely available compound (sawdust and groundnut shell) used as adsorbent.

The removal of metal ions from effluents using sawdust and groundnut shell has shown to be efficient considering the level of drop of the metal ions over the period of study.

From results obtained from the experiments carried out on the effluent water to remove heavy metals by the use of locally sourced adsorbent materials, it can be seen that of the two adsorbent materials used, sawdust remained the better adsorbent because it was able to remove more heavy metals even when little quantities were used as compared to others.

However, sawdust is has more potential for metal removal efficiency than groundnut shell, and also more advantage due to its large availability at low or no cost

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