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A COMPARATIVE STUDY OF SORPTION OF HEAVY METAL IONS BY GRANULAR ACTIVATED CARBON FROM COCONUT SHELL, SAWDUST AND GROUNDNUT SHELL

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ABSTRACT
The physico-chemical properties of wastewater effluent from the plants of Nigerian Breweries Plc. Lagos, Nigeria, have been analyzed. The capacity of removal of manganese, lead, zinc, cadmium and Vanadium ion by activated carbon from coconut shell, saw dust and groundnut shell was carried out, and their comparison was also made. Coconut shell, saw dust and groundnut shell which were wastes collected from Okada market, in Edo State, Nigeria were used as adsorbents for the removal of manganese, lead, zinc, cadmium and Vanadium ion from Brewery wastewater effluent. The results obtained showed that adsorbents made from groundnut shell were most effective for the removal of manganese ion, zinc ion and lead ion; cadmium was most effectively removed by adsorbents made from groundnut shell.
Keywords: Wastewater effluent, adsorbents, sorption, brewery

INTRODUCTION
Industrial activity is responsible for the generation of large volumes of effluents containing hazardous species. The species with the most toxicological relevance found in the industrial effluents are the heavy metals.

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].

Activated carbon is one of the most widely used adsorbents in the area of separation, storage and purification of gases and liquids, due to the high affinity and capacity displayed toward many substances [8]. These positive characteristics are the result of an energetically favourable, highly porous microstructure [8]. The microstructures of activated carbons are in turn dependent upon the choice of precursor (raw material), subsequent activation techniques and conditions used to evolve a pore structure. Therefore, a systematic study of the relative contribution of different precursors and activation techniques on the final microstructure is crucial if tailoring an activated carbon to a specific application is desired [9]. The purification of diluents, separation of products and recovery of solute from aqueous streams by adsorption onto adsorbed fixed beds is an important industrial operation. Adsorption is one of the most important percolation processes used in industry for the purification and separation of solutes form a fluid stream onto a surface, and especially important in advance wastewater treatment processes [10]. The adsorption of a single component from an aqueous solution onto porous media such as activated carbon has been modeled successfully. There has been an increasingly demand for activated carbon due to its use in solvent recovery, water and air purification, gasoline vapour emission control canisters in automobiles, and industrial waste.

The main objectives of drinking water treatment are to produce high quality water that is safe for human consumption, has aesthetic appeal, conforms to state and federal standards, and is economical in production. One of the tools that help to achieve this goal is activated carbon [11].

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. Because of the constrained environment, a particle composed entirely of micropores is likely to display a long diffusional time scale. Mesopores and macropores are therefore also required to provide rapid transport of species through the particle coordinate. For most sorption applications then, some mixture of macro-, meso-, and micropores will provide the optimum compromise between capacity and transportation rate [7].

MATERIALS AND METHODS

Sample Collection

Coconut shell and groundnut shell were bought from the local market on Mission road in Okada Community, Edo state, Nigeria. Saw dust was collected from the saw mill on Mission road in Okada Community, Edo state, Nigeria

The wastewater samples were collected from the post treatment reservoir of effluent from the plants of the Nigerian Breweries Plc., Lagos, Nigeria and physiochemical analysis was carried out using AOAC method of analysis (APHA, 1989). Atomic adsorption spectrometer (AAS) was used to determine the concentrations of Manganese (Mn), Zinc (Zn), Copper (Cu) ,Cadmium (Cd), Lead (Pb) and Vanadium (V) present in the brewery wastewater studied.

Preparation of Granular Activated Carbon

The sample materials were carbonized in the absence of air in a muffle furnace at a temperature of 550^oC for 60 minutes and were allowed to cool. 100g of carbonized sample was mixed with an aqueous solution of Zinc Chloride (activating agent) made by dissolving 56g of the Zinc Chloride in 300ml distilled water. The mixture was then subjected to heat at a temperature of 120^oC for 3 hours to vaporize the water. The dried mixture was subjected to

heat at a temperature of 650^oC in a muffle furnace to enable activation of the pores of the carbon sample.

Chemical Activation

The sample materials were carbonized in the absence of air in a muffle furnace at a temperature of 550^oC for 60 minutes and were allowed to cool. 100g of carbonized sample was mixed with an aqueous solution of Zinc Chloride (activating agent) made by dissolving 56g of the Zinc Chloride in 300ml distilled water. The mixture was then subjected to heat at a temperature of 120^oC for 3 hours to vaporize the water. The dried mixture was subjected to

heat at a temperature of 650^oC in a muffle furnace to enable activation of the pores of the carbon sample.

Preparation of Adsorbate

The adsorbate used was effluent water which was obtained from the effluent water tank of the Nigerian breweries Plc, Iganmu. The concentration of the heavy metals in the water sample was determined using the atomic adsorption spectrophotometer (AAS).

Adsorption Process

200mls of the adsorbate solution was measured and contacted with varied masses (4, 8, 12, 16 and 20g) of the adsorbent (coconut shell, groundnut shell and saw dust) for an equilibrium adsorption time of 2hrs at room temperature followed by intermittent stirring. The solution was filtered with Whatmann No. 1 filter and the aliquot solution was taken for AAS analysis to ascertain the equilibrium concentration in order to determine the amount of metal ion adsorbed.

Amount adsorbed (g/g) = $(C_0 - C_e)\, V/W$

Where

C_0 = initial concentration of metals in sample solution (g/l)

C_e= equilibrium concentration of metals in solution (g/l) at time t.

V = Volume of solution taken

W = Weight of the adsorbent used (g)

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). The pH of the effluent water collected was 8.1 and after it was contacted with the adsorbent, the value of observed to drop to 4.7. All the AAS test sample of the effluent water after contact with adsorbent was carried out at pH of 4.7.

RESULTS AND DISCUSSIONS

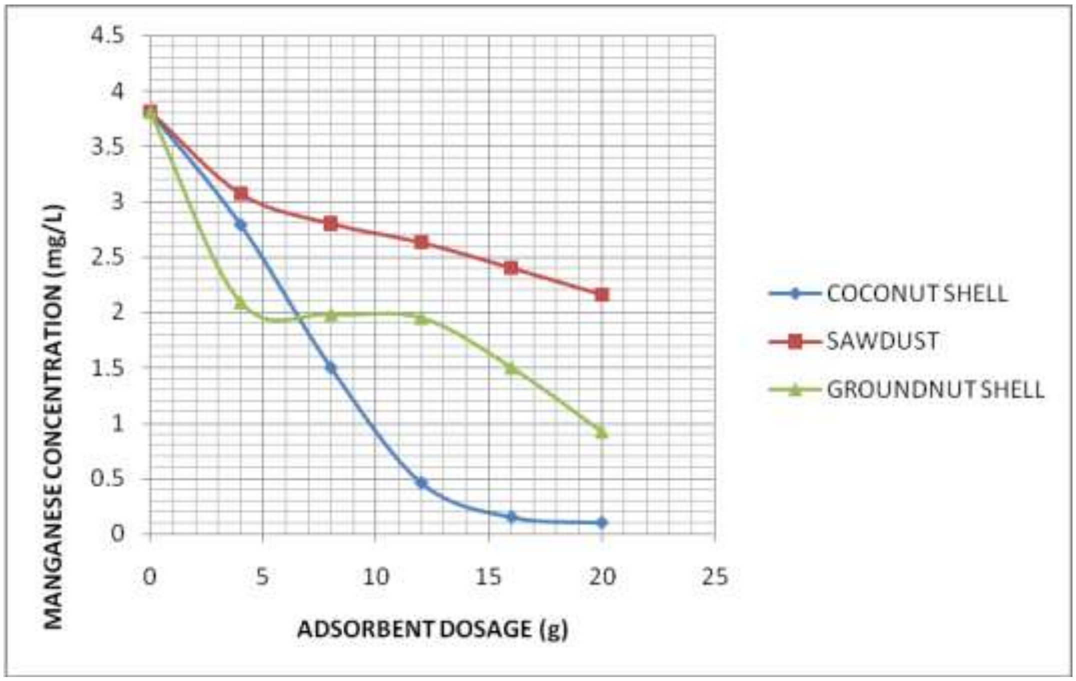

Fig 3.1: Variation of Manganese concentration with varying dosages of different adsorbates

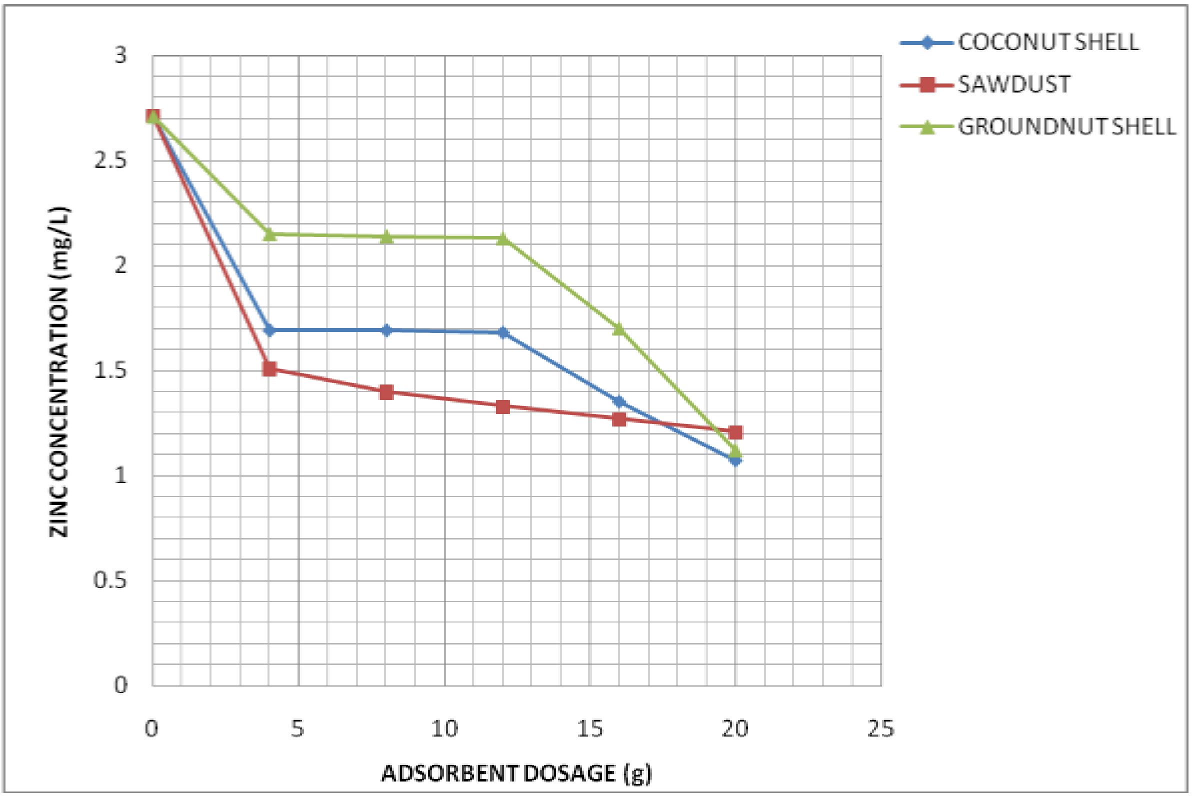

Fig 3.2: Variation of Zinc concentration with varying dosages of different adsorbates

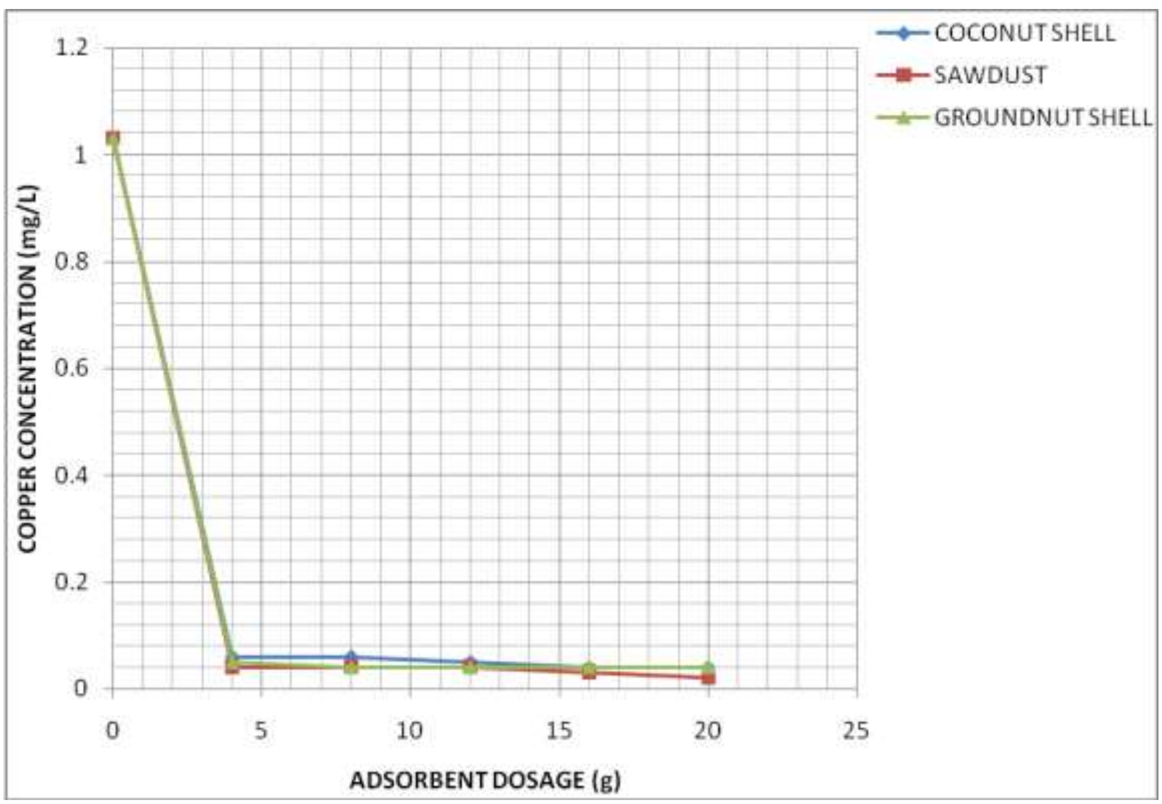

Fig 3.3: Variation of Chromium concentration with varying dosages of different adsorbates

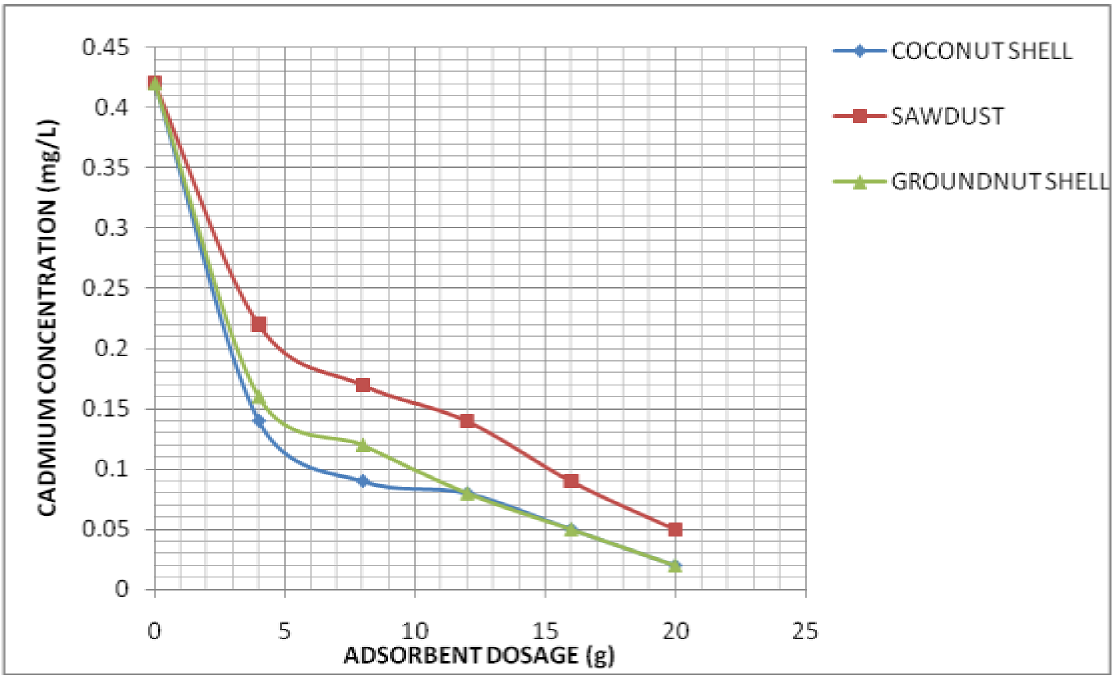

Fig 3.4: Variation of Cadmium concentration with varying dosages of different adsorbates

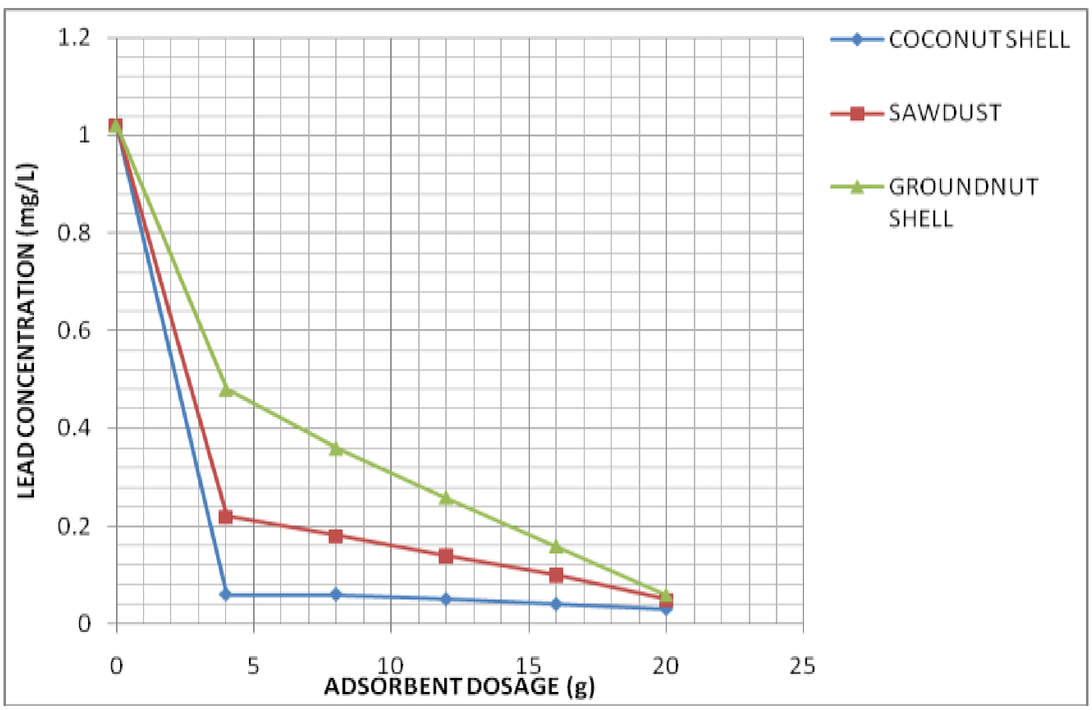

Fig 3.5: Variation of Lead concentration with varying dosages of different adsorbates

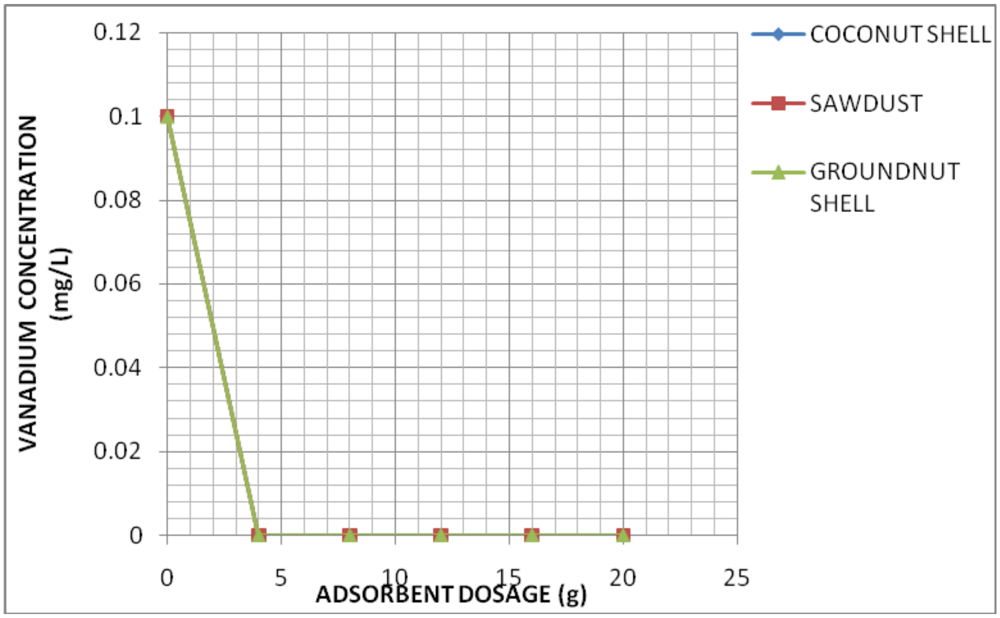

Fig 3.6: Variation of Vanadium concentration with varying dosages of different adsorbates

Figure 3.1- Figure 3.6 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 six heavy metal concentrations studied in the effluent waste water, one of them (Manganese) was found to be most effectively reduced by the coconut shell adsorbent.

The concentration of Cadmium metal was best reduced by groundnut adsorbent. The three adsorbents were found to compete strongly with one another in the removal of Zinc and Vanadium metal. The total concentrations of the heavy metal, Vanadium present in the effluent water sample was removed completely irrespective of the adsorbent dosage.

CONCLUSION

The removal of metal ions from effluents using coconut shell, saw dust and groundnut shell has been 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 three adsorbent materials used, coconut shell remained the better adsorbent because it was able to remove more heavy metals analysed even when little quantities were used as compared to others.

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