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# Agricultural Waste Materials as a Potential Adsorbent for Removal of Heavy Metals in Waste Water

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## Abstract

The world has suffered a major threat in recent years as a result of discharge of heavy metals into the environment due to industrial development and suburbanization. Adsorptions of these aforementioned metals were studied by Atomic Adsorption Spectrophotometry (AAS) and it showed that adsorption was extreme at the 100$^{th}$ minute. These elements pollute the water resources, contaminate of the food chain and pose a menace to the ecosystem, leading to pure water shortage. There are countless technical approaches adopted in the elimination of these metals from waste water. They include adsorption, precipitation, ion exchange, reverse osmosis, electrochemical treatments, membrane filtration, evaporation, flotation, and oxidation and bio sorption processes, but most of these techniques have detriments such as inadequate metal elimination, great reagent and energy necessities and generation of toxic sludge or other waste products. As a substitute for using commercial constituents, the research used agricultural wastes (banana peels and peanut shells) as adsorbent. The results showed that banana peels and peanut shells can be used for the removal of heavy metals with a concentration range of 10-50 mg/100cm$^3$. Also, when the contact time was 100 minutes it showed maximum adsorption of lead and manganese for both adsorbents. It was found that the percentage removal of heavy metals was dependent on the adsorbent and adsorbent concentration.

**Keywords:** Agricultural Wastes; Heavy Metals; Waste Water; Adsorption; Adsorbent; Banana Peels; Peanut Shell

## Introduction

Pollution by heavy metal ions has become a major issue world over due to their possible toxic effects [1]. Heavy metal contamination occurs in aqueous wastes from many industries, such as metal plating, mining operations, tanneries, chloralkali, radiator manufacturing, smelting, alloy industries and storage batteries industries, they are harmful to aquatic life and water contaminated by them remains a serious public health problem to human health [2-4]. Heavy metal toxicity can result in damage or reduced mental and central nervous system, lower energy levels and damage to blood composition, lungs, kidneys, livers and other vital organs [5]. In recent years, the need for safe and economical methods for the elimination of heavy metals from waste water has necessitated research on low-cost agricultural waste by-products such as sugarcane bagasse, rice husk, sawdust, coconut husk, oil palm shell, Neem bark etc [6]. The technologies like electro floatation, electro kinetic coagulation, and coagulation combine with floatation and filtration, conventional oxidation methods by oxidizing agents, radiation and electro chemical processes etc., are the technologies which fall under chemical methods [7]. These techniques however, have disadvantages such as incomplete metal removal, high reagent and energy requirements and generation of toxic sludge or other waste products [8,9]. Recent studies have shown that heavy metals can be removed using plant materials such as empty palm oil fruit bunch, sour sop seeds, modified cassava, cassava fibre, coconut shell and Wolffiaglobosa(duck weed) [10-14]. The removal of lead and copper ions from aqueous solutions by sago waste was reported by Ho, et al. [15]. Also a range of other agricultural by-products used for metal removal include banana pith, tree fern, and Humuluslumpus (hop) [16]. Adsorption is basically a mass transfer process by which a substance is transferred from the liquid phase to the surface of a solid, and becomes bound by physical and/or chemical interactions [17]. It is a partition process in which few components of the liquid phase are relocated to the surface of the solid adsorbents. The adsorption procedure can be batch, semi-batch and continuous. This study also exposes the relevance of adopting an ecological contamination free-tactics for the elimination of heavy metals from water. Dry peanut shell and banana peels were used in this research as bio-adsorbents for the removal of heavy metal ions like lead, copper, zinc and cadmium.

## Materials and Methods

### Materials

Peanut shells and banana peels were collected from Ubani market in Abia State, located at latitude 5°36'0" North and longitude 7°30'0" West and solution of lead (Pb) and manganese (Mn) was prepared using distilled water. The peanut shells were thoroughly washed three to four times with distilled water to remove external dust particles after which it was sun dried for 10days. The shells were ground after drying using a grinding machine. The banana peels were allowed to dry in shade for 8days and a color change from yellow to brownish black was observed. The peels were ground manually, and different fractions of peels were obtained.

### Methods

Sieve Analysis, Atomic Adsorption Spectrophotometry (AAS) and Scanning Electron Microscopy (SEM) where adopted in the course of this research.

## Results and Discussion

The adsorption of heavy metal ions by the banana peels and peanut shells was assessed by changes in concentration of heavy metals, effect of variation time and effect of concentration. The optimum removal condition was also identified for each metal ion. The powdered peanut shells and banana peels were subjected to sieve analysis, after which fractions of 600μm, 425μm and 300μm were used for adsorption studies. The powdered peanut shells and banana peels of maximum sizes obtained after sieve analysis were not taken up for the experiment, as they will possess much surface area for adsorption. Tables 1 & 2 show the effect of variation of contact time in the adsorption of $Mn^{2+}$ and $Pb^{2+}$ using peanut shell and banana peel respectively at 33°C, while Figures 1 & 2 show the graph of conc. of Mn (II) against time of banana peel and peanut shell adsorption respectively at 33°C. Tables 3 & 4 show the conc. of Mn (II) and Pb (II) bound by various concentration of peanut shells and banana peels respectively at 33°C for 90mins, while Figures 3 & 4 show the graph of Mn (II) and Pb (II) adsorption by bound against concentration of peanut shells and banana peels respectively at 33°C for 90mins.

| Concentration of Mn (II) (mg/100cm3) | 1 | 2.2 | 3.4 | 4 | 3.75 | 2.75 |
|---|---|---|---|---|---|---|
| TIME (min) | 175 | 150 | 125 | 100 | 75 | 50 |

**Table 1:** Effect of variation of contact time on the adsorption of $Mn^{2+}$ on peanut shell starch at 33°C.

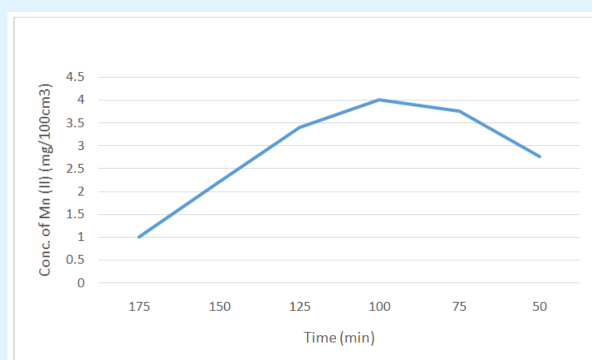


**Figure 1:** Graph of conc. of Mn(II) against time of peanut shell.

| Concentration of Mn (II) (mg/100cm3) | 1.8 | 2.2 | 2.7 | 2.75 | 2.6 | 1.75 |
|---|---|---|---|---|---|---|
| TIME (min) | 175 | 150 | 125 | 100 | 75 | 50 |

**Table 2:** Effect of variation of contact time in the adsorption of $Mn^{2+}$ on banana peel starch at 33°C.

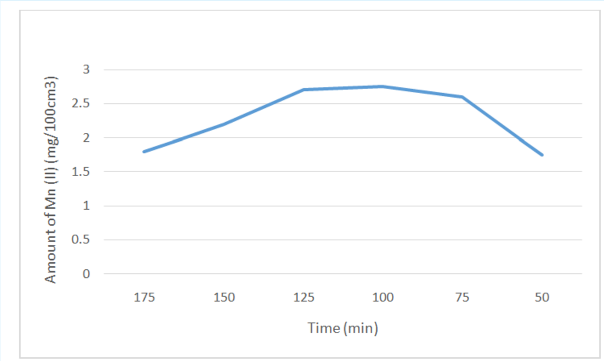


**Figure 2:** Graph of conc. of Mn(II) against time of banana peel.

| Concentration of Mn (II) bound (mg/100cm³) | Concentration of Pb (II) bound (mg/100cm³) | Concentration of peanut shell (mg/cm³) |
|---|---|---|
| 8.9 | 5 | 10 |
| 23 | 12.4 | 20 |
| 35 | 18.7 | 30 |
| 44.5 | 22 | 40 |
| 78 | 35 | 50 |

**Table 3:** Varying Mn(II) and Pb(II) ion concentration on the adsorption of peanut shells at 33°C for 90mins.

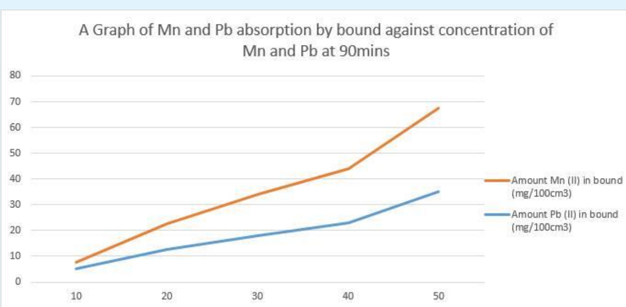


**Figure 3:** Graph of Mn(II) and Pb(II) adsorption by bound against concentration of peanut shells respectively at 33°C for 90mins.

From Table 3 & Figure 3 above, it is shown that increase in adsorption of Mn(II) and Pb(II)ion concentrations are directly proportional to the increase of peanut shell concentration. At 10 mg/dm³- 50 mg/dm³addition of peanut shell, the adsorption of Mn(II) and Pb(II) ions increased from 8.9 mg/100cm³-78 mg/100cm³ and from 5 mg/100cm³-35 mg/100cm³ respectively.

| Concentration of Mn (II) bound (mg/100cm³) | Concentration of Pb (II) bound (mg/100cm³) | Concentration of peanut shell (mg/cm³) |
|---|---|---|
| 5 | 2.5 | 10 |
| 12.5 | 10 | 20 |
| 18 | 16 | 30 |
| 23 | 21 | 40 |
| 29 | 32.5 | 50 |

**Table 4:** Varying Mn(II) and Pb(II) ion concentration on the adsorption of banana peels at 33°c for 90mins.

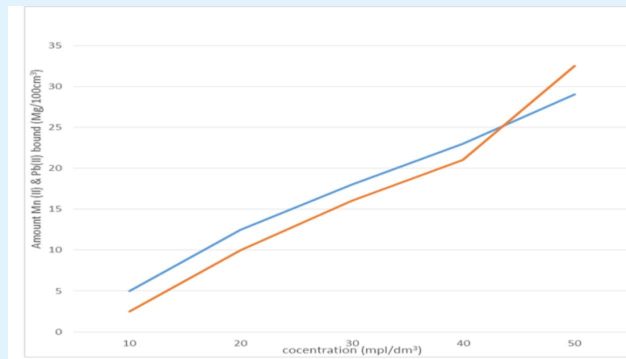


**Figure 4:** Graph of Mn(II) and Pb(II) adsorption by bound against concentration of banana peels respectively at 33°C for 90mins

From Table 4 & Figure 4 above, it is shown that increase in adsorption of Mn(II) and Pb(II)ion concentrations are directly proportional to the increase of banana peels concentration. At 10 mg/dm³ -50 mg/dm³ addition of peanut shell, the adsorption of Mn (II) and Pb (II) ions increased from 5 mg/100cm³ -29 mg/100cm³ and from 2.5 mg/100cm³ - 32.5 mg/100cm³ respectively.

The results showed that banana peels and peanut shells can be used for the removal of heavy metals with a concentration range of 10-50 mg/100cm³. Also, when the contact time was 100 minutes it showed maximum adsorption of lead and manganese for both adsorbents. It was found that the percentage removal of heavy metals was dependent on the adsorbent and adsorbent concentration. The contact time necessary for maximum adsorption was found to be 100mins.

## Conclusion

Using bio-adsorbents is an active technique to absorb toxic heavy metals from effluents and simultaneously employing the rejected open agricultural wastes in the surroundings for a beneficial purpose of waste water treatment. This technique does not only necessitate negligible energy input, less labor and low investment, but also attests to be economical, biodegradable and effective compared to man-made adsorbents and chemicals. The bio-adsorbent once used could be recycled for a definite period of time and this could be adopted commercially in prospect. In reaction to the problem of metals, whose toxic characteristics are being progressively emphasized on, health policy makers should relate the prophylactic principle at all level and inspire like researches for the profit of mankind and its environment.

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