BANANA PEEL AS A LOW COST ADSORBENT FOR THE REMOVAL OF Ni^{2+}, Cu^{2+} AND Fe^{2+} FROM INDUSTRIAL EFFLUENTS.

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Abstract
The use of banana peel as a cost effective and environmentally safe technique to adsorb Cu^{2+}, $Ni^{2+}$and Fe^{2+} from industrial effluents was investigated. The results show that banana peel was able to remove 78.38 – 87.84 % of Ni^{2+} and 66.67 – 83.33 % of Cu^{2+} from the effluents, while the concentration of Fe^{2+} was increased by 58.82% - 77.7 %. The increase in Fe^{2+} could be as a result of the presence of Fe^{2+} in banana peel. These results show that banana peel can be effectively used to remove Cu^{2+}, Ni^{2+} from industrial effluents.

Keywords: Adsorption, banana peels, metals ions, chelation, effluent.

Introduction

Industrial wastes which are not properly treated before discharge pollute our environment with heavy metals, which eventually reach man through the food chain. [1, 2]
Main anthropogenic sources of heavy metal or trace element contamination in our environment are mining, agricultural wastes, disposal of untreated and partially treated industrial effluents, fossil fuels, petroleum exploration, indiscriminate use of metal-containing fertilizer, pesticides in agricultural fields and oil spillage [3, 4, 5]. Investigating trace metals contamination is important due to their potential toxicity to the environment and human health when concentrations reach certain levels [6, 7]. Some trace metals like Co, Cr, Cu, Fe, Mn, Ni and Zn are essential as micronutrients which are beneficial to plants and animals, while others such as Cd and Pb have no known physiological activities [7].
The effect of heavy metals on man cannot be neglected because exposure to these contaminants even at low concentration in the environment can cause severe dysfunction in the renal, reproductive and central nervous systems [8].
Recently, adsorption has become one of the remediation treatment techniques for wastewater laden with heavy metals. This is an emerging field of interest which employs agricultural by-products as adsorbents for the removal of heavy metals from aqueous solution and wastewater. Many agricultural wastes that are available at low cost have been reported to be capable of removing substantial amounts of metal ions from aqueous solutions and some of these agro waste materials remove toxic heavy metals from aqueous solutions by adsorption, chelation and ion exchange [9, 10, 11].
Banana (*Musa sapientum*) peels contain nitrogen, sulphur and carboxylic acids. The acids are responsible for the peel's ability to bind metals and remove them from the wastewater because of the high number of these acids in the peels [10].
Several tons of banana peels are produced daily in market places and household garbage that constitute environmental nuisance, which is the primary reason why banana peels is been used as adsorbents for heavy metals from industrial wastewaters.
The main objective of this research is to determine the efficacy of agricultural low-cost waste like banana peel in removing Ni^{2+}, $Cu^{2+}$and Fe^{2+} from contaminated industrial wastewater in an eco-friendly method.

Materials and Methods

Sample Collection

Banana (*Musa sapientum*) was bought from local market in Port Harcourt, and taken to plant physiology and anatomy laboratory of the University of Port Harcourt for proper identification. The peels (mesocarp) were carefully washed with deionized water and sun-dried for seven days after which it was oven dried for six hours at 70° C. The banana peels were ground and sieved using 1.00 mm mesh size prior to analysis.
Six (6) effluent water samples were collected from three industrial discharge points within the Port Harcourt metropolis plastic containers which were pre-rinsed with trioxonitrate (v) acid. The effluent collection points are Pabod brewery, Coca-Cola and Paint industries respectively. The effluent water samples were then placed in a box containing ice packs, taken to the laboratory for analysis. The metal components (Ni^{2+}, Fe^{2+} and Cu^{2+}) of the effluents were detected using atomic absorption spectrometer (were determined using a Atomic Absorption Spectrophotometer (Spectra AA-100).

Adsorption of the metal cation from effluent water

A 0.5g each of ground banana peel was soaked in 50 mL of each of the effluent water in 250 mL stoppered reagent bottles at a constant shaking speed (250 rpm). All the experiments were carried out at room temperature (32°C ± 2°C). The pHs of the effluent samples were adjusted to constant values of 6.90. The suspensions were agitated with mechanical shaker for 3hrs and left to stand overnight. The samples were filtered rapidly and the filtrates were analyzed using Atomic Absorption Spectrophotometer (Spectra AA-100). The amount of the metal ions adsorbed was obtained by the difference between the initial metal ion concentration and the final concentration of metal ion after treatment as shown by equation 1.

The percentage (%) removal was determined using the equation:

$$\text{Removal}(\%) = [100 \times (C_o - C_e)]/C_o \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Where C_o = initial concentration of metal ion before treatment.; C_e = final concentration of metal ion after treatment with banana peel.

Results and Discussion

The effluent samples from different industries were subjected to initial analyses for trace metals concentration and noted. Metal adsorption depends on the nature of the adsorbent surface and species solution. The pH is another important factor that competes with metals for the exchange sites in the system. At lower pH, H^+ competes with metals thereby partially releasing the latter [12]. Table 1 shows the initial concentration of Ni^{2+}, Cu^{2+} and Fe^{2+} in industrial effluents before treatment while the percentage removal was calculated using equation 1.

Table1. Metal ions concentration (ppm) in effluent sample before treatment.

Effluent Sample points	**Fe^{2+}**	**Cu^{2+}**	**Ni^{2+}**
Pabod Brew1	1.68	0.06	0.74
Pabod Brew2	1.26	0.06	0.56
Paint 1	1.47	0.06	0.93
Paint 2	1.26	0.06	0.56
Coca-cola1	1.47	0.06	0.74
Coca-cola2	1.37	0.06	1.11

The banana peel was able to absorb 78.38 – 87.84 % of Ni^{2+} and 66.67 – 83.33 % of Cu^{2+} from the industrial effluents; this is probably due to interference by other ions. Result shows that Ni^{2+} has the greatest adsorption affinity. A mechanism involving intra particle diffusion and surface adsorption has been proposed for adsorption of Ni^{2+} onto adsorbent [13]. This may be in conformity with previous research and calculated thermodynamic parameters such as ΔH^o, ΔS^o and ΔG^o which indicate that the adsorption is spontaneous and endothermic and therefore adsorption of Ni^{2+} by banana peel could be a physiorption [13, 14, 15].

The percentage of copper (II) ion removal was between 66.67 – 83.33 % (Fig. 2). Researchers such as Horsfall et al., investigated the ability of cassava waste biomass to remove copper (II) and zinc (II) from single ion solution and wastewater. They found that metal ion uptake capacities in wastewater were found to be lower in single ion solution while uptake capacities of the metals on the biomass surface increased with acid treatment while that of Cu (II) showed higher uptake capacity in the solution [16]. The ionic size of copper (II) which is 0.72 Å was responsible [16, 17]. This assertion confirms the high percentage of Cu (II) adsorbed from the Industrial effluent and with other biological adsorbents [17]. Other low cost adsorbents such as rice husk, saw dust have shown similar effects of particle size on adsorption [18, 19].

At the end of the experiment, the concentration of Fe^{2+} increased by 58.82% - 77.7 %. (Fig. 1). The mineral content of the banana peel which includes, iron other elements such, potassium, calcium, sodium, manganese, bromine, rubium, strontium, zirconium and niobium may responsible for the increase in the Fe^{2+} concentration [20]. Other researchers such as FengLian et al., who studied the adsorption of Fe (II) and Fe(III) on Chitosan and its derivatives concluded that the adsorption of Fe^{2+} is pH dependent. When the pH value increased, the adsorption of Fe (II) usually increased, at lower pH, the adsorption of Fe (II) decreased because some amine groups were protonated to form $-NH_3^+$, reducing the number of binding sites available for the adsorption [21]. The saturation of the binding sites where adsorption should have taken place could also been the probable reason for the increase in the concentration of Fe^{2+} in the effluent.

Conclusion

The results indicate that banana peels as an adsorbent was able to remove a good concentration of Cu^{2+} and Ni^{2+} within the limits of experimental design.

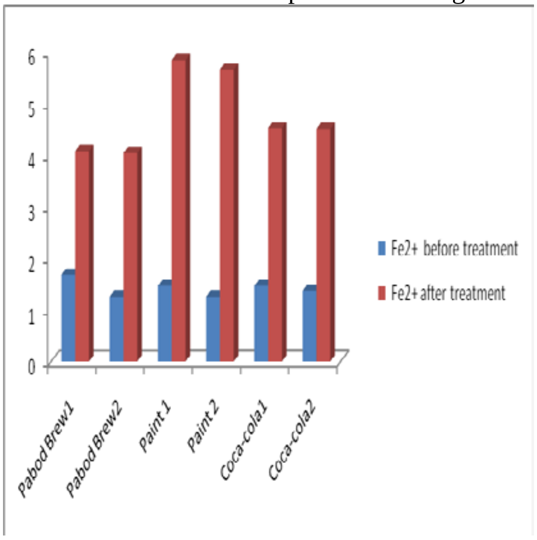

Fig 1. Comparison of percentage increase of Fe^{2+} from different effluent samples.

Although 100% metal ion adsorption was not attained in this analysis probably due to the interference of other metals at the binding sites, the result gives us a good indication of the utility of banana peel as a low-cost adsorbent in the adsorption of metal ions in effluents. It is therefore recommended that further research can use mono ionic solutions of various metal concentrations for initial experiment to ascertain if there will be an increase in the concentration of metal ions absorbed.

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