

Adsorption of Pb^{2+} from waste water using modified and unmodified plantain pseudo stem waste as adsorbent

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Abstract

This study was carried out to evaluate the potentials of plantain pseudo stem waste as adsorbent in the removal of Pb^{2+} from aqueous solution. Filament obtained from Plantain pseudo stem were dried, cut into chips and ground using electric grinder. The powdered sample obtained was soaked in ethanol for 24 hours and wash with water several times to remove the extractive component. It was then dried in the oven. Modification reaction was carried out on the powdered sample using Fenton reagent (Fe^{2+}/H_2O_2). Both the modified and unmodified adsorbents were used for the adsorption of Pb^{2+} from aqueous solution. Factors considered were effect of contact time and effect of adsorbate (Pb^{2+}) concentrations. The results revealed that in all the adsorption studies, the adsorption capacity of modified adsorbent was higher than that of the unmodified adsorbent. However, adsorption capacities increase with increase in contact time and decreases with increase in the adsorbate concentration.

Keywords: Adsorption; waste water; plantain pseudo stem; Adsorbent

1. Introduction

Water is important for life and for processing of various materials in industry. Living organisms cannot exist without water and almost all industries require water to operate. However, in the 21st century the growing population and increase in industrial activities have contributed immensely to the alteration of water quality as a result of discharge of untreated waste water to the environment.

Environmental pollution has become a major concern not only in the developing countries but also in the developed nations. Amongst the environmental pollutions, water pollution is a matter of great concern. Increasing contamination of aquatic sources with large number of pollutants is not only endangering the aquatic life but also create a worldwide shortage of recreational water.

Sources of water pollution include domestic activities, mining activities, municipal wastes, modern agricultural practices, marine dumping, radioactive wastes, oil spillage, underground storage leakages and industries [1]. But the major agents of water pollution are different industrial units. Indiscriminate discharge of toxic chemicals through effluents from a wide range of industries (textile, steel, oil, tanneries, canneries, refineries, mines, fertilizers production units, detergent production units, electroplating units and sugar mills) into water bodies pollutes these resources and causes hazardous effects on humans [1].

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Among all the pollutants, heavy metals are the most dangerous as these are non –biodegradable and persist in environment. These enter into the water resources through both natural and anthropogenic sources. More attention is being given to the potential health hazards posed by heavy metals.

Heavy metal toxicity contributes to a variety of adverse health effects [2]. Bioaccumulation of heavy metals within human body can lead to a decline in the mental, cognitive, and physical health of the individual [1]. Global environmental changes have dramatically increased the overall environmental 'load' of heavy metals [3].

It is known that water polluted with low concentration or even trace levels of heavy metals can cause serious health problems to human body [4].

Several low-cost adsorbents using leaf powder of different trees such as bael tree [5], rubber Kamal, Cinnamomum camphora [6], have been reported for the adsorption of heavy metals from waste water. The use of modified adsorbent in the adsorption of heavy metals from aqueous solution have also been reported. Biosorption of heavy metals from aqueous solutions by chemically modified orange peel was reported by Feng, *et al.*, [7]. Moyo, and Chikazaza, [10] reported the bioremediation of Lead (II) from polluted wastewaters using Sulphuric acid treated maize tassel biomass.

The aim of this research is to utilize plantain pseudo stem waste as adsorbent in the adsorption of Pb²⁺ from waste water.

2. Material and methods

2.1. Sample collection and preparation

Plantain pseudo stem was obtained from a mature plantain after harvesting in Ikot Ekpene, Akwa Ibom State, Nigeria. The pseudo stem was beaten, washed several times to remove the debris the filament was sundried for 7 days to remove greater percentage of the moisture. It was then ground and sieved through a range of sieves and only the particles that passed through a 0.25mm mesh size were used for the adsorption study.

Fenton's reagent was used for the modification process to increase adsorptive property of the adsorbent. 40g sample of the ground adsorbent was shocked in ethanol and kept for 24 hours, it was filtered and washed several time with distilled water to remove extractive component, it was then oven dried in the oven at 85°C for 48 hours.

2.2. Modification with Fenton's Reagent

Fenton's reagent which is Fe²⁺/H₂O₂ was prepared in the ratio of 0.1g of Iron (II) Sulphate to 100ml of hydrogen peroxide, this was done in accordance with the research work reported by Argun and Durson [10]. 0.5M of HCl and NaOH were added to adjust the pH of the solution to 3.

25g of the sample was poured into 500ml conical flask containing 250ml Fenton's reagent solution and was stirred for 4 hours using magnetic stirrer, the adsorbent was filtered, washed with distilled water and dried in the oven at 85°C for 24 hours.

2.3. Adsorption Study

Laboratory experiments were carried out in order to evaluate the adsorption efficiency of plantain pseudo stem adsorbent and modified adsorbent in the removal of heavy metal (lead) from waste water. The parameters evaluated include; effect of contact time of adsorption and effect of concentration of the adsorbate.

2.3.1. Effect of contact time

0.1g of the unmodified adsorbent was added to 5 different conical flasks containing 100ml of 100mg/l of Pb²⁺ solution. It was shaken for 30min, 1hour, 1hour 30min, 2hour, 2hour 30min respectively and filtered. Post adsorption concentration was determined using AAS analysis. And adsorption efficiency was determined using:

$$\text{Adsorption efficiency} = \frac{C_0 - C_1}{C_0} \times 100$$

Where C₀= Pre adsorption concentration of the adsorbate

C_1 = post adsorption concentration of the adsorbate

2.3.2. Effect of concentration

0.1g of the unmodified adsorbent was added into 5 different conical flask containing 50, 100, 150, 200 and 250mg/l of Pb^{2+} solution. It was shaken for 1hour using a mechanical shaker and filtered. The post adsorption concentration was determined using AAS and adsorption efficiency was determined using the formula stated above.

The same procedures were used for the adsorption studies using modified adsorbent.

3. Results and discussion

The adsorption of Pb^{2+} using unmodified and modified adsorbent prepared from plantain pseudo stem was examined under effect of contact time of the adsorption and effect of initial concentration of the adsorbate. The results obtained are presented in the Table 1 and 2 below.

Table 1 Effect of contact time

Time (Min)	Post adsorption Concentration		Adsorption efficiency	
	Un Modified (mg/l)	Modified (mg/l)	Un Modified (%)	Modified (%)
30	62.73	43.65	37.27	57.35
60	53.56	38.54	46.44	61.46
90	41.84	25.76	58.16	74.24
120	30.06	18.58	69.94	81.42
150	26.87	13.85	73.13	86.15

Table 2 Effect of concentration of the adsorbate

Concentration (mg/l)	Post adsorption Concentration		Adsorption efficiency	
	Un Modified (mg/l)	Modified (mg/l)	Un Modified (%)	Modified (%)
50	27.83	12.73	44.34	74.54
100	68.56	32.56	31.44	67.44
150	112.86	71.84	24.76	52.106
200	161.28	120.06	19.36	39.97
250	213.85	162.87	14.46	34.85

3.1. Effect of contact time

It was observed that the adsorption efficiency increased with increase in contact time. When the contact time increased, there was more time for the adsorbate (Pb^{2+}) to absorb onto the surface of the adsorbent thereby leading to high adsorption efficiency.

Comparatively, modified plantain pseudo stem tends to remove the metal ion (Pb^{2+}) from aqueous solution than the unmodified plantain pseudo stem irrespective of the time of contact. This may be due to the fact that during modification OH functional group in the adsorbent was changed by the modifying agent (Fenton's reagent) being oxidizing agent to COOH, so more lone pairs of electrons introduce helps to remove more Pb^{2+} from the aqueous solution. Surface morphology may also contribute to this high degree of adsorption [10].

3.2. Effect of Initial Concentration

The effect of initial concentration of the adsorbate on adsorption efficiency is presented in Table 2. It was observed that there was a decrease of the level of removal of Pb^{2+} with increase in initial concentration. At lower initial ion concentration, sufficient adsorption site is available for adsorption of the heavy metals but at higher concentration, most of the adsorption site of the adsorbent have been mask by the metal ion. Hence, the percent removal of heavy metals depends on the initial concentration and decreases with increase in initial metal concentration.

4. Conclusion

In this research, low-cost adsorbent was successfully prepared from agricultural waste material. The adsorption of the Pb^{2+} from simulated waste water using modified and unmodified plantain pseudo stem being locally available and low-cost adsorbent was studied. The results revealed that the adsorption efficiency of the modified adsorbent was higher than that of the unmodified adsorbent. Concentrations of the adsorbate and contact time of the adsorption also affect adsorption of Pb^{2+} from waste water. It was observed that the higher the concentration, the lower the adsorption efficiency, also adsorption efficiency increased with increased in contact time of the adsorption. However, bioadsorbent should be modified with oxidizing agent like Fenton reagent because this will increase the adsorption efficiency of the adsorbent.

Compliance with ethical standards

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Disclosure of conflict of interest

The author declares that there is no conflict of interest

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