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RESEARCH ARTICLE

INVESTIGATION ON THE ADSORPTION BEHAVIOR OF BANANA PEELS FOR XENOBIOTIC AND NON-XENOBIOTIC HEAVY METAL

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ABSTRACT

The adsorption of Pb(II),Cd(II),Zn(II) and Ni(II) on peels of banana has been studied in batch process using atomic adsorption spectroscopy for metal estimation. Concerned parameters like adsorbent dose, contact time, PH, and temperature were investigated. Langmuir and Freundlich isotherms were employed to describe adsorption equilibrium. The maximum adsorption was at 10-15 mg/L, when added different dosage of banana peel, and increase of PH value from 5-8 removal of heavy metal ion increase. When temperature was set between 27-600C amount of adsorbed metal was 150-200 mg/g. Adsorption of different metal ion vary between a contact time period of 80-120 minute. Study concluded that banana peels, a waste material, have good potential as an adsorbent for xenobiotic and non-xenobiotic heavy metal ion.

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INTRODUCTION

Banana (*Musa Sapientum*) is important food crops cultivated across the world with gross share of about 16% in universal fruit production. The cultivation, business, processing, harvesting and consumption of banana have significant impact on economy. The banana tree consists of pseudo stem with root, leaves and fruits. The average banana fruit weight is 120 gm which contains about 25% dry material and 75% water contents. The 30-40% by weight of banana fruit is peel. The raw banana and its extracts are used in various as medicines in all the branches of medical science including allopathic, homeopathic and ayurvedic etc. despite of its immense utility a lot of banana got spoiled during transportation as well as banana peel obtained after consuming banana are the waste material. Some of the biggest problems the world is facing today are gravitating around waste and pollution. Resources are extracted, processed, used, and ultimately stored as waste. At the end of the life cycle, the waste is usually incinerated (or heat processed) or stored in the field.

Circular economy tries to combat both these problems by applying the "3 Rs' reduction (demand and /or consumption of resources, materials, and products). Reuse and recycling (return of materials to another life cycle) (2).The banana peel (*Musa sp.*) contains lignocelluloses, the disposal of which is a serious environmental issue. Recently various applications of banana peel are production of ethanol, methane, livestock feed and low-cost adsorbents to purify water contaminated with heavy metals and dyes (1). Biosorbents are material from a biological source which can absorb pollutants from waste water. Heavy metals are considered as primary pollutant due to their toxicity and mobility in nature. For environment friendly cleansing, biological origin products are prime interest for environment scientist. Banana peels were selected as a low-cost adsorbent due to its characteristics. In literature, it is mentioned that functional groups like carboxyl, hydroxyl, phosphate, thiol and amino present on the walls of agricultural waste biomass results in binding the heavy metal. These functional group bind metal through ion exchange by transferring hydrogen ions or through complex formation by sharing electronpair.

Owing to industrialization and urbanization enormous amount of heavy metals is released into water causing a serious health problem. Some heavy metal is xenobioticand their adulteration even to trace amount is hazardous to human being. On the other hand, non-xenobiotic heavy metals are essential part of human physiology but their exposure in higher quantity turn toxic. Therefore, there is urgent need to removal of both type of heavy metals. Various physical and chemical adsorption methods have been tested to remove these hazardous heavy metals from aqueous solution. The major drawback traditional method is that they use costly chemicals and their processing and recycling cause adverse impact on environment. Recently agriculture waste and other similar organic compound have been investigated regarding their potential to remove heavy metals. Such adsorbents are cheaper in cost as well as eco-friendly in nature. This research work aims to investigate adsorption behavior of banana peel in reference to xenobiotic and non-xenobiotic heavy metals. For the optimization of various process parameter like pH, contact time, adsorbent dose and initial metal ion concentration, batch experiment study has been carried out. The maximum adsorption capacity of dried banana peel has been evaluated by using Langmuir adsorption isotherm equilibrium.

MATERIAL AND METHODS

Banana peels from banana fruit was collected from local market of near bus stand in Jhansi (India). Banana peels ere dried for 4 days in sunlight and cuts into small pieces then washed with distilled water and dried it in oven at 70^0C for 5 hours. Oven dried banana peels were grounded and sieved into different fraction using stainless steel.The materials used, include hydrochloric acid, sodium hydroxide, deionized water, respective metal salts were analytical grade and purchased from Sigma-Aldrich.

Preparation of stock solution: For preparation of 1000 mg/L stock solution of xenobiotic Pb (II), Cd (II) and non-xenobiotic Zn (II), Ni (II) metal ion, salt of these metal ion were dissolved in one liter volumetric flask and final volumes were made up to the mark with deionized water. The standard solutions of metals were prepared before use by the appropriate dilution of the stock solutions. The prepared solution will be used in treating the banana peel by soaking the banana peel in the solution for the adsorption of heavy metals.

Adsorption capacity and % removal efficiency were calculated using the following equations respectively.

$$q_e = \frac{(C_i - C_e)\,X\,V}{m} \quad (1)$$

$$Removal\ efficiency\ (\%) = \frac{(C_i - C_e)X\ 100}{C_i} \quad (2)$$

Where,q_e(mg/g) is the amount of metal ion adsorbed, Ci is the initial metal ion concentration, Ce is the concentration of metal ion at equilibrium, V is the volume of ions and m is the mass of adsorbent.

RESULTS AND DISCUSSION

The effect of various important physical parameters on the sorbent behavior of banana peel is investigated experimentally in laboratory of department.

The effect of pH, adsorbent dose, contact time, temperature and initial metal ion concentration is presentedbelow.

Effect of pH: The effect of pH on the amount metal ion was analyzed on pH range from 1-9. The amount of metal ion adsorption increases with pH Adsorption of metal depends on the nature of the surface of adsorbent and species solution. At lower pH, H^+ ions compete with metals ions for the exchange sites in the adsorbent material. The heavy metals are released in more amount in acidic conditions. The adsorption of metal ion was minimum in case of pH 2 but it increases with increasing pH (1, 7). The maximum adsorption occurs at pH 7 for banana peels after this precipitation of metal ions takes place with increasing pH The minimum adsorption at low pH = 2 may be due to the high mobility and high concentration of H^+. Due to this H^+ ions are adsorbed in more amount than the comparison of metal ions (Fig.1).

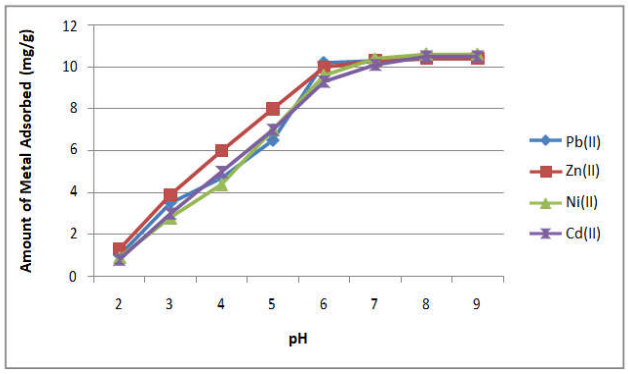

Figure 1. Effect of pH on Adsorption of Metal

Effect of Adsorbent Dose: The adsorbent dose is important parameter to control both availability and accessibility of adsorption sites. Figure 2 1visualize the variation of adsorption potential of both xenobiotic and non-xenobiotic heavy metals with adsorbent dose. Maximum adsorption of metal ions was achieved at a dosage of 1.6 g. The adsorption of metal ions increases with increase in adsorbent dose as it increases the surface area for adsorption.

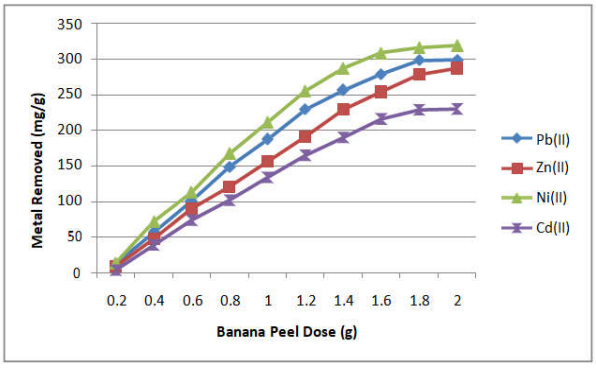

Figure 2. Effect of pH on Adsorption of Metal

Effect of Initial Metal Ion Concentration: The removable efficiency increases with increasing initial concentrations from 10-50 mg L^{-1}, and further decrease from 50-100 mg/L as shown in Figure 3 Maximum adsorption obtained at minimum concentration of metal ions. The metal solutions with concentration ranging from 10mg/l to 100 mg/l were agitated at 250 rpm for 100 minutes with adsorbent dose of 0.5 gm. The percentage adsorption of xenobiotic and non-xenobiotic

decreases as the initial concentration of increased from 50 mg/l to 100 mg/l. Maximum adsorption obtained at minimum concentration of metal ions. Such behavior can be because of the unchanging number of available active sites on the adsorbent here the amount of adsorbent was constant.

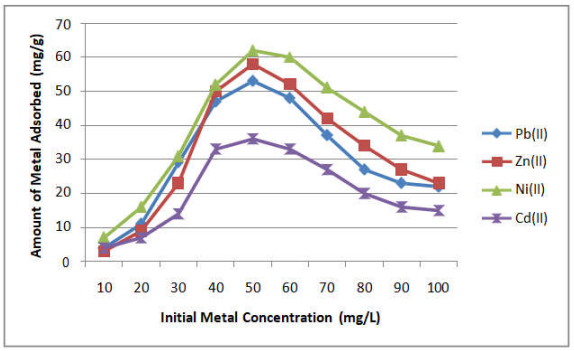

Figure 3. Effect of Initial Metal Ion Concentration

Effect of Contact Time: Effect of contact time was observed on adsorption of Pb(II), Zn(II), Ni(II), Cd(II) banana peel is used as adsorbent. Percent adsorption increase up to 100 min. after this it became constant., 100 minutes could be considered for whole batch experiments. The experimental observations were carried out for different contact times *viz* 20, 40, 60, 80, 100, 120, 140, 160, 180, 200 minutes. The maximum adsorption of metal ions is observed at 80-120 min and became constant afterward. The agitation speed was 250 r.p.m. It proves that the metal ions took 80-120 minutesto bind the banana peel. Figure 4 showed the effect of contact time on adsorption of xenobiotic(Pb^{2+}, Cd^{2+}) and non-xenobiotic (Zn^{2+}, Ni^{2+}) heavy metals.

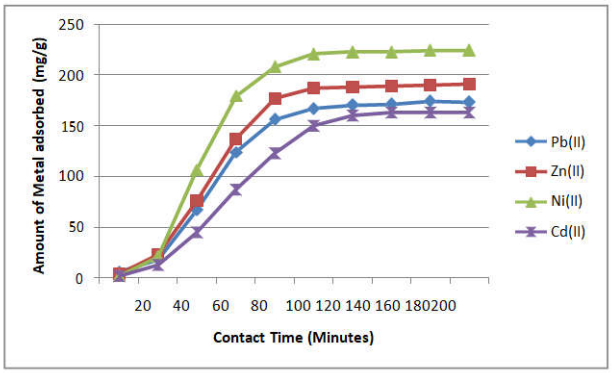

Figure 4. Effect of Contact time on Adsorption of Metal Ion

Effect of Temperature: Temperature is key parameter to control the adsorption process. Figure 5 presents the effect of temperature on adsorption of all the four heavy metals under study at pH value of 7. It is observed that maximum adsorption of metal ions takes place at 310 K

Adsorption Is otherms: Adsorption isotherm are useful in finding out the adsorption capacity of adsorbent. In the present study, the adsorption of xenobiotic (Pb^{2+}, Cd^{2+}) and non-xenobiotic (Zn^{2+}, Ni^{2+}) on banana peel was studied by Langmuir and Freundlich adsorption isotherm model. Experimental result of Langmuir isotherm has been shown in figure 6 According to Langmuir model uptake of metal ion occur at a homogeneous surface by monolayer adsorption.

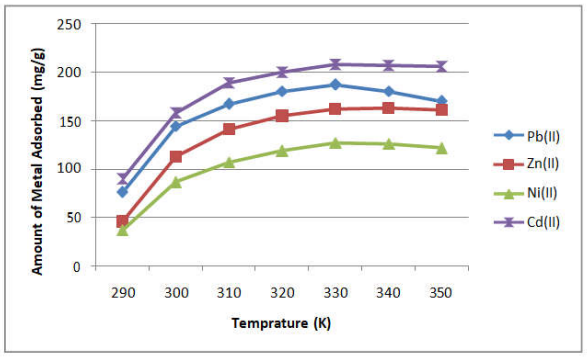

Figure 5. Effect of Temperature on Adsorption of Metal

The linearized form of Langmuir isotherm is represented following equation:

$$\frac{C_e}{q_e} = \frac{1}{K_l Q_m} + \frac{C_e}{Q_m}$$

Where q_e (mg g^{-1}) is the maximum amount of metal ions adsorbed perspecific amount of adsorbent, when all binding sites are occupied;

Ce (mg L^{-1} or mmol L^{-1}) is the equilibrium concentration;
Q_m (mg g^{-1}) is the amount of metal ions required to form a monolayer;

K_l is the Langmuir equilibrium constant related to the energy of sorption (L mg^{-1} or L $mmol^{-1}$).

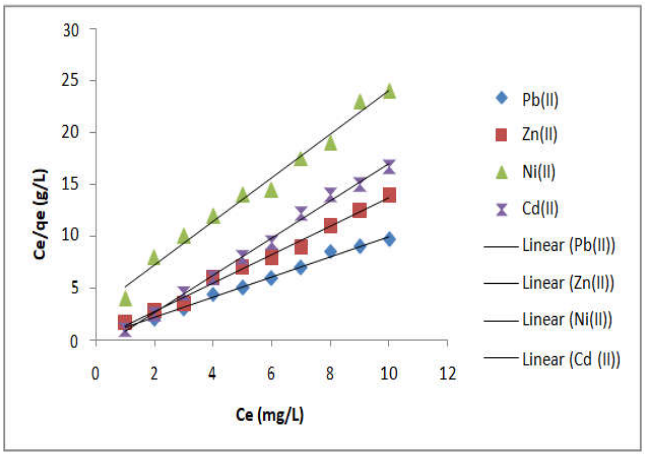

Figure 6. Langmuir Isotherm

For determination of the Langmuir parameters, Ce/qe can be plotted versus Ce. According to Freundlich adsorption isotherm, uptake of metal ion occurs atheterogenous surface by multilayer adsorption. Linearized form of Freundlich isotherm is represented by following equation:

$$\ln qe = \ln K_F + \frac{1}{n} \ln C_e$$

KF and 1/n are Freundlich constant related to adsorption capacity and intensity of adsorption. Freundlich parameter are obtained by plotting ln q_e versus ln C_e. The experimental result of Freundlich isotherm has been shown in Fig. 7

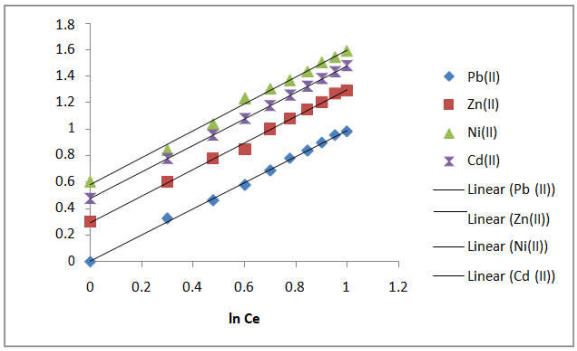

Figure 7. Freundlich Isotherm

CONCLUSION

Banana peels show a good efficiency for the removal of cadmium ion from aqueous solution. Based on the result obtained above, banana peel contains functional group such as carboxyl, hydroxyl and amine group and the surface of banana peel found to be having negative sites suited for the adsorption of positively charged heavy metals. For adsorption, the pH value of solution is in between 5 to 8. The result of this study show that maximum adsorption was at 10-50 mg/L when added different dosage of banana peel. With increase of pH value from 5 to 8 removal of heavy metal ion increase. When temperature was set between 27-60^{0}C amount of adsorbed metal was 150-200mg/g. Adsorption of different metal ion vary between a contact time period of 80-120minute. From the result it can be concluded that banana peel could be used as effective adsorbent for xenobiotic (Pb2+ and Cd2+) and non-xenobiotic (Zn2+ and Ni 2+) heavy metal ion.

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