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Adsorption of Heavy Metals using Banana Peels in Wastewater Treatment

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Abstract: Heavy metal contaminants are present in wastewater from many industries such as metal manufacturing, dye and paint, chemicals and fertilizer. Heavy metal removal has become the main priority for the environmental concern due to the toxic. Banana peels are a low-cost agriculture waste which could be used for the adsorption of heavy metals in wastewater. Hence, this study focused on the adsorption capabilities of dried banana peels powder under various conditions such as the effect of agitation speed, temperature and contact time for efficient adsorption rate by using agricultural waste adsorbents which is banana peel (treated by acid and alkali). Although banana is one of the most important commercial crops in the world, most of the edible parts are consumed for its nutrients purpose only rather than using adsorption properties. In that case, the banana peels are used in adsorption of heavy metals where it extract out the Cu and Pb from the waste water from the industries. The findings of this study will contribute to bridging up the gap in knowledge on the potential of using banana peels for promoting in the adsorption process and minimize the effect on the living things caused by the waste water released by the heavy industries.The results from the optimized method revealed the applicability of the method to environmental water samples. This study therefore confirms that banana peel is a promising adsorbent for the removal of heavy metals from industrial effluent.

Keywords: Wastewater

Introduction

Heavy metal contaminants are present in wastewater from many industries such as metal manufacturing, dye and paint, chemicals and fertilizer. Heavy metal removal has become the main priority for the environmental concern due to the toxic. Heavy metals can be a reason to human major health problem because they contain high level of toxicity. Heavy metals are also considered as trace elements because of their presence in trace concentrations in various environmental matrices (Asma et al. 2005).

Water pollution due to development in technology, continues to be of great concern. With increasing generation of heavy metals from technological activities, many aquatic environments face metal concentrations that exceed water quality criteria. Research has been designed to protect the environment, animal and humans. Metal production such as emissions have decreased in many countries due to strict legislation, improved cleaning or purification technology and altered industrial activities, in the recent years (Mridul & Prasad, 2013). Dissipate losses from consumption of various metal containing goods are of most concern, today and in the future. Therefore, regulations for heavy metal containing waste disposal have been tightened.

A significant part of the anthropogenic emissions of heavy metals ends up in wastewater. Major industrial include surface treatment processes contain elements such as cadmium, lead, manganese, copper, zinc, chromium, mercury, arsenic, iron and nickel, as well as industrial products that at the end of their life, are discharged in wastes. Heavy metals are highly dispersed in a wide variety of economically important minerals. They are released to the environment during mineral extraction process. Therefore, mining activities are considered as the primary anthropogenic source of heavy metals (Norton et al. 2004). Major urban inputs to waste water include household effluents, drainage water, business effluents, atmospheric deposition, and traffic related emissions, transported with storm water into the waste system.

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Plant materials are mainly comprised of cellulose materials that can adsorb heavy metal cations in aqueous solution. Numerous waste biomass sources are available in nature in which adsorption properties have been reported e.g. rice husk, saw dust, tea and coffee waste, orange peel, peanut shells, activated carbon, dry tree leaves and barks (Asma et al. 2005; Kishore 2008). Out of the wide range of adsorbents, banana peel seems to be good adsorbent and can be used as valuable material for cleaning of water. Biosorbent prepared from banana peels has been reported for the removal of chromium, cadmium and copper ions from aqueous solution. Adsorption of heavy metal ions occur as a result of physiochemical interaction, mainly ion exchange or complex formation between metal ions and the functional groups present on the cell surface.

A material having the capacity or tendency to adsorb other substances or materials is known as an adsorbent. Biosorbents are materials from a biological source which can absorb some things especially pollutants. This biological origin product is of prime interest for the environmental scientist for environment friendly cleansing. Adsorption, ion exchange, and chromatography are sorption processes in which certain adsorbates are selectively transferred from one phase to another phase. Strong biosorbents behavior of certain micro-organisms towards metallic ions is a function of the chemical make-up of the microbial cells. This type of biosorbents consists of dead and metabolically inactive cells (Friis & Myers-Keith, 1986).

Method

Some research about adsorption of heavy metals using low-cost adsorbent carried out. The data was collected from some related topic in websites. The banana peels are selected as a low-cost adsorbent due to its characteristics. The research stated that banana peels contain nitrogen, sulphur, and carboxylic acids; the acids are responsible for the peels' ability to bind the toxic metals and remove them from the water. Because of the high number of these acids in the peels, not only can banana peels remove the contaminants, but they can do it just as well, and in some cases better, than more expensive technological options. Stock solutions (100ppm) and standard solution (5ppm)should be prepared for each copper and lead. The standard solution is prepared fromthe stock solution that had been done initially with a high concentration of copper and lead. The standard solutions are prepared by adding 1000 ml deionised water to 50 ml of stock solutions. Then, the preparation of solutions should be done with the correct concentration. Solutions that should be prepared are Ethanoic acid at 0.1mole concentrations and sodium hydroxide at 0.1 mole concentration. These solutions will be used in treating the banana peels by soaking the banana peel in the solutions separately for a better adsorption rate on the heavy metals.

Results and Discussion

The effect of temperature on adsorption of copper (II) and lead (II) was studied using different temperature in the range of 30°C to 50°C. Figure 1 shows an increase in percentage removal of copper and lead for treated banana peel with the increase in temperature. Maximum removals of copper were 27.74% for acid treated banana peel and 15.78% for alkali treated banana peel respectively. Therefore, the optimum lead removal efficiency for acid treated banana peels recorded at 40°C with removal percentage of 53.28% while for alkali treated banana peels at 30°C with 26.94%. Therefore, the optimum temperature was selected as 40°C for both treated banana peel in the removal of copper and lead. According to the bold result in table 2,3,and 4, it is the highest among the other even there is reading below it. Some of them are been bold at the first part. The reason for this phenomenon is because the bold part shows the highest reading and it reaches the maximum adsorption at that particular point. In additions, when the rate of the adsorption reaches its maximum point there won't be any adsorption process occurs. Moreover, the value of the adsorption also decreases but not so obvious but slightly due to the absent of the adsorption process.

Table 1. Percentage removal of Cu (II) on treated banana peel (Acid) at various temperature

Variables	Initial Concentration (5ppm)	Contact Time (min)	Temperature (^{0}C)	Final Concentration (ppm)	Removal Percentage (%)
Beaker 1	5	30	30	3.744	25.12
Beaker 2	5	30	40	3.662	26.76
Beaker 3	5	30	50	3.613	27.74

Table 2. Percentage removal of Cu (II) on treated banana peel (Alkali) at various temperature

Variables	Initial Concentration (5ppm)	Contact Time (min)	Temperature (^{0}C)	Final Concentration (ppm)	Removal Percentage (%)
Beaker 1	5	30	30	4.649	7.02
Beaker 2	5	30	40	4.211	15.78
Beaker 3	5	30	50	4.239	15.22

Table 3. Percentage removal of Pb (II) on treated banana peel (Acid) at various temperature

Variables	Initial Concentration (5ppm)	Contact Time (min)	Temperature (^{0}C)	Final Concentration (ppm)	Removal Percentage (%)
Beaker 1	5	30	30	2.399	52.02
Beaker 2	5	30	40	2.336	53.28
Beaker 3	5	30	50	2.381	52.38

Table 4. Percentage removal of Pb (II) on treated banana peel (Alkali) at various temperature

Variables	Initial Concentration (5ppm)	Contact Time (min)	Temperature (^{0}C)	Final Concentration (ppm)	Removal Percentage (%)
Beaker 1	5	30	30	3.653	26.94
Beaker 2	5	30	40	3.801	23.98
Beaker 3	5	30	50	3.825	23.50

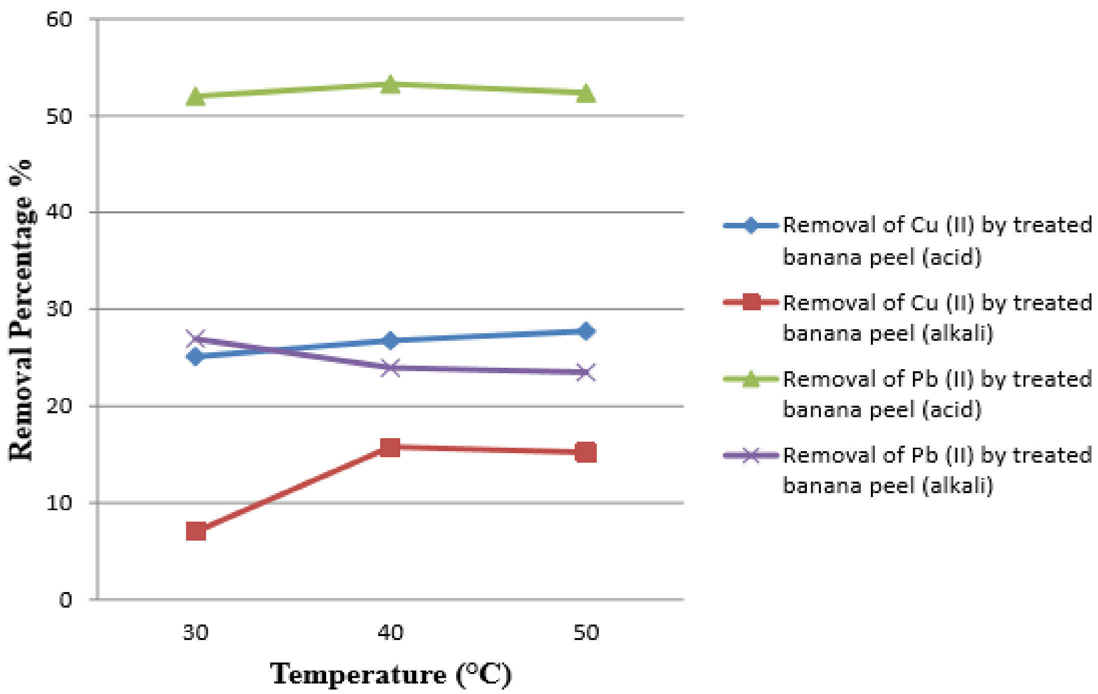


Figure 1. Percentage removal of Cu (II) and Pb (II) on treated banana peel at various temperatures

In Figure 2, it can be observed that agitation speed significantly affects the adsorption of copper (II) ion and lead (II) ion for both samples. The optimum copper removal efficiency for acid treated banana peels recorded at 100 rpm with removal percentage of 25.54% while for alkali treated banana peels at 150 rpm with 16.76%. The optimum lead removal efficiency for acid treated banana peels recorded at 50 rpm with removal percentage of 61.32% while for alkali treated banana peels at 100 rpm with 34.64%. It is proven that agitation speed plays an important role in adsorption efficiency.

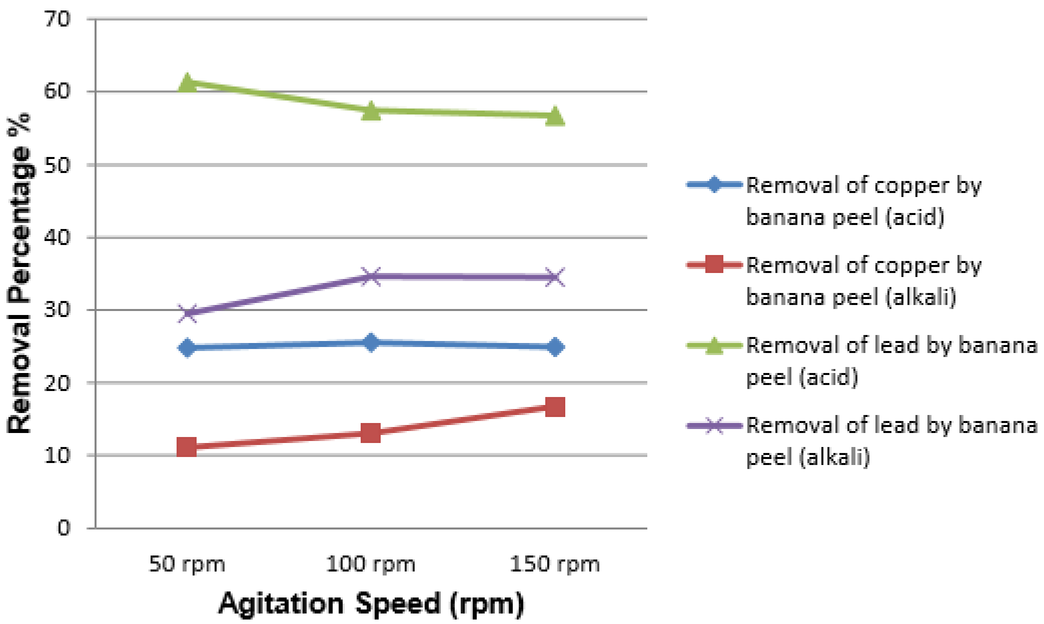
Removal occurs only by the above layers and the under buried layers does not take part in the process as they have no contact with copper and lead. This indicates that shaking rate should be sufficient to assure that all the surface binding sites are readily available for copper and lead uptake. Agitation speed of 100 rpm was chosen as the optimum speeds for acid treated banana peels and alkali treated banana peels respectively. According to the bold result in table 4.1(a), 4.1(c), 4.1(d), it is the highest among the other even there is reading below it. Some of them are been bold at the first part. The reason for this phenomenon is because the bold part shows the highest reading and it reaches the maximum adsorption at that particular point. In additions, when the rate of the adsorption reaches its maximum point there won't be any adsorption process occurs. Moreover, the value of the adsorption also decreases but not so obvious but slightly due to the absent of the adsorption process

Table 5. Percentage removal of Cu (II) on treated banana peel (Acid) at various agitation speed

Variables	Initial Concentration (5ppm)	Contact Time (min)	Agitation Speed (rpm)	Final Concentration (ppm)	Removal Percentage (%)
Beaker 1	5	30	50	3.759	24.82
Beaker 2	5	30	100	3.723	25.54
Beaker 3	5	30	150	3.753	24.94

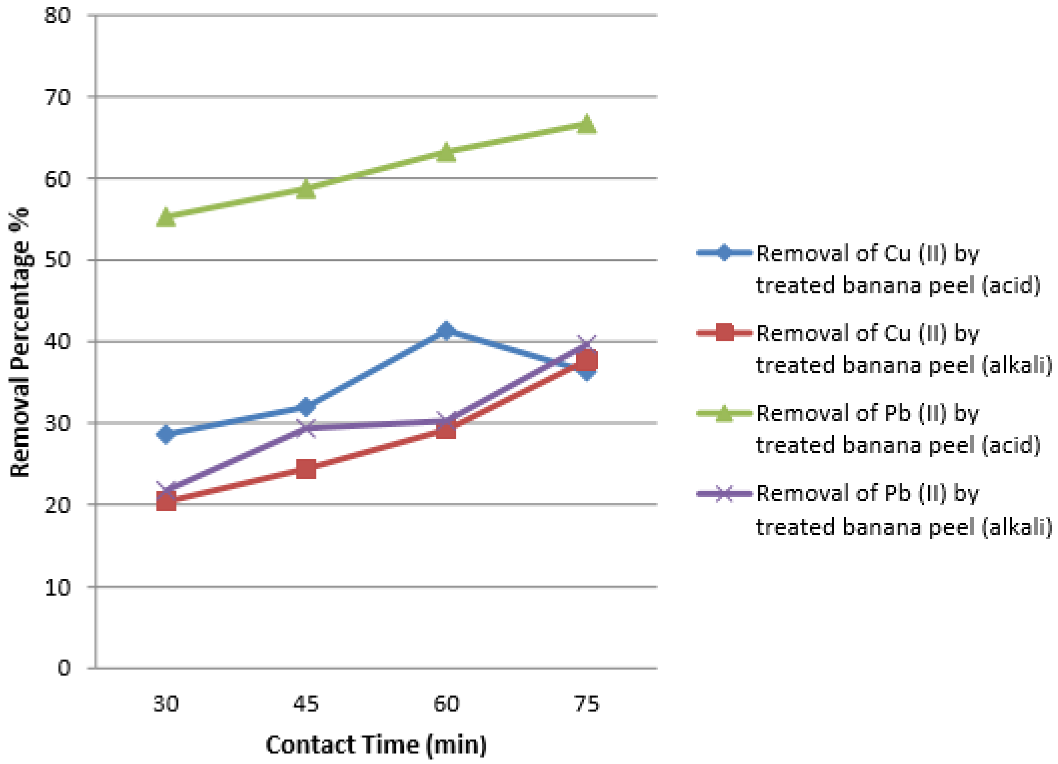
Table 6. Percentage removal of Cu (II) on treated banana peel (Alkali) at various agitation speed

Variables	Initial Concentration (5ppm)	Contact Time (min)	Agitation Speed (rpm)	Final Concentration (ppm)	Removal Percentage (%)
Beaker 1	5	30	50	4.445	11.10
Beaker 2	5	30	100	4.347	13.06
Beaker 3	5	30	150	4.162	16.76



Based on Figure 4.3 the removal percentages for Cu (II) and Pb (II) on adsorbents are increasing as the contact time increase. The optimum contact time for acid treated banana peels in the removal of copper take place at 60th minutes with removal percentage of 41.36% while for alkali treated banana peels in the removal of copper take place at 75th minutes with removal percentage of 37.70%. In the removal of lead, the optimum contact time for acid treated banana peels take place at 75th minutes with removal percentage of 66.72% while for alkali treated banana peels take place at 75th minutes with removal percentage of 39.66%. The removal efficiency increased with increased of contact time for both samples. This can be attributed to the fact that more time becomes available for copper ions and lead ion to make an attraction complex with adsorbents.

Initial removal occurs immediately as soon as the copper or lead and adsorbents came into contact. But after some time, when some of easily available active site engaged, copper and lead needs time to find out more active sites for binding. Therefore, it is concluded that copper or lead and adsorbent should be contact for 75 minutes for acid and alkali treated banana peels respectively in order to get high removal percentage. According to the bold result in table 4.3(a), it is the highest among the other even there is reading below it. The reason for this phenomenon is because the bold part, which is the third beaker, it reaches the maximum adsorption at that particular point. In additions, when the rate of the adsorption reaches its maximum point there won't be any adsorption process occurs. Moreover, the value of the adsorption also decreases but not so obvious but slightly due to the absent of the adsorption process.



Conclusion

In conclusion, the researchers had explained the promising parameters and either acid or alkaline should be used over a banana peel so that it can act as a better low cost adsorbent to adsorb heavy metals (copper (II) and iron (II)) from the industrial wastewater. The procedures can be applied in most of the heavy metal industries to treat their wastewater before the discharged it into the big sea where it might affect the humans back.

Recommendations

The present study can be used to conclude that non-hazardous agricultural waste materials such as banana peel is excellent substitutes for non-economic adsorbents such as activated carbon and silica for removal of heavy metals. Therefore, more studies and research should be done to enhance the adsorption capacity using these adsorbents. The effect of temperature, pH and adsorbent size should be studied as it can alter the adsorption rate and mechanisms. Furthermore, the effectiveness of these adsorbents on removal of other types of heavy metals such as iron (II) oxide and zinc could be explored.

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