EFFECTIVENESS OF SUGARCANE BAGASSE IN THE BIOSORPTION OF LEAD (Pb^{2+}) IN WASTEWATER: A PRELIMINARY STUDY

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ABSTRACT

Water pollution has been considered a major environmental problem faced by modern society. Presence of contaminants given off by industrial processes like toxic heavy metals have brought serious hazard to the environment and to human health as well. Adsorption, being identified as a principal method used to eliminate heavy metals from aqueous effluents, is considered as the best wastewater treatment method because of its universality while being an easy process. The present study examined the effectiveness of sugarcane bagasse as biosorbent for the removal of Pb^{2+} *ions in wastewater. Specifically, it identified the effects of varying initial concentration using equilibrium test. Results have shown that the amount of lead adsorbed increases with an increase in initial concentration. The observation is reasonable because increasing the initial concentration of lead increases the gradient of concentration or the driving force of a diffusion of* Pb^{+2} *to the mass of the biosorbent. Hence, the percent removal of heavy metals depends on the initial metal ions concentration, thus; decreases with an increase in initial metal ions concentration. Similarly, the difference in percentage removal of different heavy metal ions at the same initial metal ions concentration may be attributed to the difference in their chemical affinity and ion exchange capacity with respect to the chemical functional group on the surface of the adsorbent (Meena, Mishra, Rai, Rajagopal, & Nagar, 2005).*

Keywords: *Biosorption, Sugarcane, Bagasse, Lead (*Pb^{2+}*), Percent Removal*

INTRODUCTION

The greatest public concern these days is the presence of heavy metal pollution in water and soil. Such contamination in water by the toxics given off by these heavy metals brings serious hazard to the environment and to human health as well. This type of pollution is due to the discharge of industrial wastewater. Since industrialization has increased, it has seriously contributed to the release of these toxic heavy metals to water streams. Mining, electroplating, metal processing, textile, battery manufacturing, tanneries, petroleum refining, paint manufacture, pesticides, pigment manufacture, printing and photographic industries (Kadirvelu et. al., 2001) are the main sources of heavy metal ion contamination.

Recently, much attention has given to prepare adsorbents from various wastes generated from forestry (Horsfall et al., 2006 as cited in Homagai et.al., 2010), fish culturation (Inoue and Yoshizuka, 1999 as cited in Homagai et.al., 2010) and products of agriculture (Ghimire et al., 2008; Lokesh and Tare, 1989 as cited in Homagai et.al., 2010). This has been a great concern because of their presence in the aquatic environment and for their toxicity level and non biodegradability. Metal ions are increasing poisons. They are capable of being absorbed and stored in the tissues of organisms that cause visible harmful physiological effects (Gupta & Ali, 2000). The toxic metals most likely to be found in waste water are copper, cadmium, chromium, nickel, zinc and lead, with the last one being toxic even at trace levels (M.M. Johns,W.E. Marshall, C.A. Toles, J., 1998).

Natural water sources may be polluted by metallic ions as a result of discharge from industrial plants or mining activities (Z. Reddad, C. Gerente, Y. Andres, P. Le Cloirec, 2002). Recently, such preparation of adsorbents from various wastes generated from forestry (Horsfall et al., 2006), fishery (Inoue and Yoshizuka, 1999) and by-products of agriculture (Ghimire et al., 2008; Lokesh and Tare, 1989) has been given attention because of their perceived harm.

Principal methods used to eliminate heavy metals from aqueous effluents are chemical precipitation, ion exchange, adsorption on activated carbon, membrane separation and electrolytic processes activities (Z. Reddad, C. Gerente, Y. Andres, P. Le Cloirec, 2002). Adsorption is considered as the best wastewater treatment method because of its universal application. It is also low-cost and easier to process. It can also remove soluble and insoluble organic pollutants. The removal capacity by this method may be up to 99.9%. Due to these facts, adsorption has been used for the removal of a variety of organic pollutants from various contaminated water sources (I. Ali et al., 2012).

Lead (Pb^{2+})

The heavy metal used for this study is lead, one of the most poisonous environmental contaminants. Human exposure to this metal produces a number of harmful and irreversible health effects because it can build up in the brain, bones, kidney, liver and muscles (Flora, Gautam, Kushwaha et al., 2012). It is commonly present in wastewaters because of its intensive industrial use. For example, in acid battery manufacturing, printing and painting pigments, petrochemicals, metal electroplating, and photographic material manufacturing.

Considering the serious effects of Lead, it is therefore necessary for it to be removed and treated in water and wastewater. There are various treatment processes available for metal-contaminated waste streams, such as chemical precipitation, coagulation, solvent extraction, ultra filtration, biological systems, electrolytic processes, and reverse osmosis, oxidation with ozone/hydrogen peroxide, membrane filtration, ion exchange, photo catalytic degradation, and adsorption. The technologies can be divided into three categories: biological, chemical and physical (M. Ahmaruzzaman, 2011).

Sugarcane Bagasse

Various raw materials have been used nowadays as an adsorbent for the wastewater treatment. This serves as an alternative for a more low-cost potential of these adsorbents. Sugarcane bagasse is one of an example of a low cost adsorbent. It mainly comes from the fibrous residue of sugarcane upon crushing and extraction of its juice. It is one of the largest agriculture residues in the world, (Pandey, Soccol, Nigam, Soccol, Vandenberghe, Mohan., 2000; Trejo-Hernándezet al., 2007; Mulinari, Voorwald, Cioffi, da Silva, Luz, 2009; Hernández-Salas et al., 2009). Literature shows the usefulness of sugarcane residue usages; through its conversion inclusive but not limited to paper, feed stock and biofuel (Hernández-Salas, Villa-Ramirez, Veloz-Rendon, Rivera-Hernandez, Gonzalez-Cesar, Plascencia-Espinosa, Trejo-Estrada, 2009; Pandey et al., 2000).

Given these literature, sugarcane bagasse is favourable in the manufacture of high quality green products. It also has low production cost. This is mostly recognized through the abundant availability of raw materials from the sugar processing plants. Furthermore, it has a low pre-treatment cost (Loh, Rahman, & Das, 2013). Moreover, sugarcane bagasse is said to be easily treated. It c an also be modified with chemicals. It also blends well with other materials to form new types of composite materials. Thus, due to its economic viability and origin of renewable sources studies have been done on the use of those agro industrial residues as alternative biosorbents of heavy metals in order to treat aqueous effluent (Tarley and Arruda 2003; Tarley and Arruda 2004; Karnitz Junior. et al. 2010). Furthermore, it also satisfies the greening requirements because it is biodegradable, recyclable and reusable (Loh, Rahman, & Das, 2013).The main objective of the study is to determine the effectiveness of sugarcane bagasse on biosorption, specifically in heavy metals, to determine the effects of varying initial concentration via equilibrium tests.

The significance of this study is to rest on the assumption that is can reduce the heavy metals, specifically Pb^{2+} in contaminated water. Moreover, the study wants to discover a low-cost and readily available biosorbent that would eliminate Pb^{2+} contaminants in the water.

This study has some limitations. Chemical modification was not performed. The present study utilized the biosorbent without any interaction with chemicals other than the nitric acid (HNO_3) used in preservation. Thus, there was no withdrawal of any impurity that could interfere in the effluent quality of sugarcane bagasse. The function of time was not observed provided that each sample was given equal amount of contact time during agitation. The researchers had no concern with the pH levels of the samples. Equilibrium loading through atomic absorption spectrometer was the only test implemented in this study.

METHOD

Materials

Lead Nitrate, Nitric Acid, distilled water and sugarcane bagasse were used for this experiment.

Sugarcane Bagasse preparation

The biomass was collected from a sugarcane juice store in SM Manila. Tap water was used to remove impurities and dust attached (Mariano, 2010). Sugarcane bagasse was dried at 110° C in an oven for 7 hrs until the fibers were brittle enough to be powderize using mortar and pestle.

Preparation of Artificial Wastewater

The artificial wastewater was prepared by spiking $Pb(NO_3)_2$ in the distilled water. The standard concentration of 1500 ppm was used. Nitric acid was added to adjust the pH of the solutions.

Equilibrium loading test

2 gram of dried biosorbent was added into different initial concentrations, 100 ppm, 200 ppm, 300 ppm, 400 ppm and 500 ppm. The adsorption experiment was performed by constant stirring. Air pumps were used for the continuous circulation of Pb solution of known concentrations and an accurately known mass of the absorbent material at a room temperature for 24 hours was maintained.

The solutions were then filtered. For the preservation, 2 drops of Nitric acid was added to maintain the pH level of less than 2 for each solution. The initial and equilibrium concentrations of Lead were measured by Flame Atomic Absorption Spectrometer.

The adsorption efficiency and the amount of Pb^{2+} adsorbed per gram of adsorbent were calculated by using Eq. 1 and Eq. 2 respectively:

Eqn. 1

where:

C_i = Initial Concentration of the adsorbate, mg/L

C_e = Final Equilibrium concentration of the adsorbate (mg/L)

Also, the equilibrium loading was calculated using the equation:

$$qe = V(Ci - Ceq)/m \qquad \text{Eqn. 2}$$

where:

C_i = Initial Concentration of adsorbate, mg/L

C_e = Final equilibrium concentration of the adsorbate (mg/L)

V = Volume of the solution (L)

m = mass of the adsorbent (g)

(Equation 1 and Equation 2 in Mariano 2010, Biosorption of Cadmium Ion by boiled peanut shells, *Luz Y Saber Vol.4 no.1*)

RESULTS AND DISCUSSION

Effects of Varying Initial Concentration

The effect of different initial concentration of lead solution on the biosorption using sugarcane bagasse was studied.

Table 1: Equilibrium loading and % absorption of Pb^{2+} with varying inital concentration

C_{in}, ppm	C_{eq}, ppm	Percentage Adsorption (%)	Equilibrium loading (mg/g)
100	30.5	69.5	1.7375
200	66.5	66.75	6.675
300	139	53.67	12.075
400	202	49.5	19.8
500	261	47.8	29.875

It was observed from Table 1 that the amount of lead adsorbed by the sugarcane bagasse increased when there was an increased initial concentration of the different initial solutions. There was also an increased in the equilibrium loading of lead as the initial concentration of the solution increases.

Based on the results shown in Table 1, lead concentrations ranged from 30 to 261 mg/L. It can be seen from the table that the percentage removal decreases with the increase in initial heavy metal concentration. As lead concentrations increased, the removal efficiencies decreased from 69.5% to 47.8%. Thus, increasing the initial lead concentrations in the solutions decreased the removal efficiency. It is likely that a given mass of adsorbent material has a ? nite number of sorption sites, and that as metal concentrations increase, these sites become saturated (Martin-Lara et. al., 2010). The observation is reasonable because once there is an increase in the initial concentration, there is also an increases the gradient of concentration or the driving force of a diffusion of Pb^{+2} to the mass of the biosorbent. Hence, the percent removal of heavy metals depends on the initial metal ions concentration and decreases with increase in initial metal ions concentration. The difference in percentage removal of different heavy metal ions at the same initial metal ions concentration, may be attributed to the difference in their chemical affinity and ion exchange capacity, with respect to the chemical functional group on the surface of the adsorbent (Meena, A.K et al. 2005).

Moreover, considering that carboxylic groups that are present in natural adsorbents are usually weak acids and make negative sites in medium moderately acid, the interaction of cations in solution becomes easier. Karnitz, Jr el. al. (2007) claimed that a modified sugarcane bagasse presented a good adsorption capacity for Cu^2, Cd^2 and Pb^2. The composition of a sugarcane bagasse like cellulose (50%), polyposis (27%) and of lignin (23%). The presence of these three biological polymers causes sugarcane bagasse, that are rich in hydroxyl and phenolic group, means that these groups can be modified chemically to produce adsorbent materials with new properties (Hanafiah and Ngah, 2008).

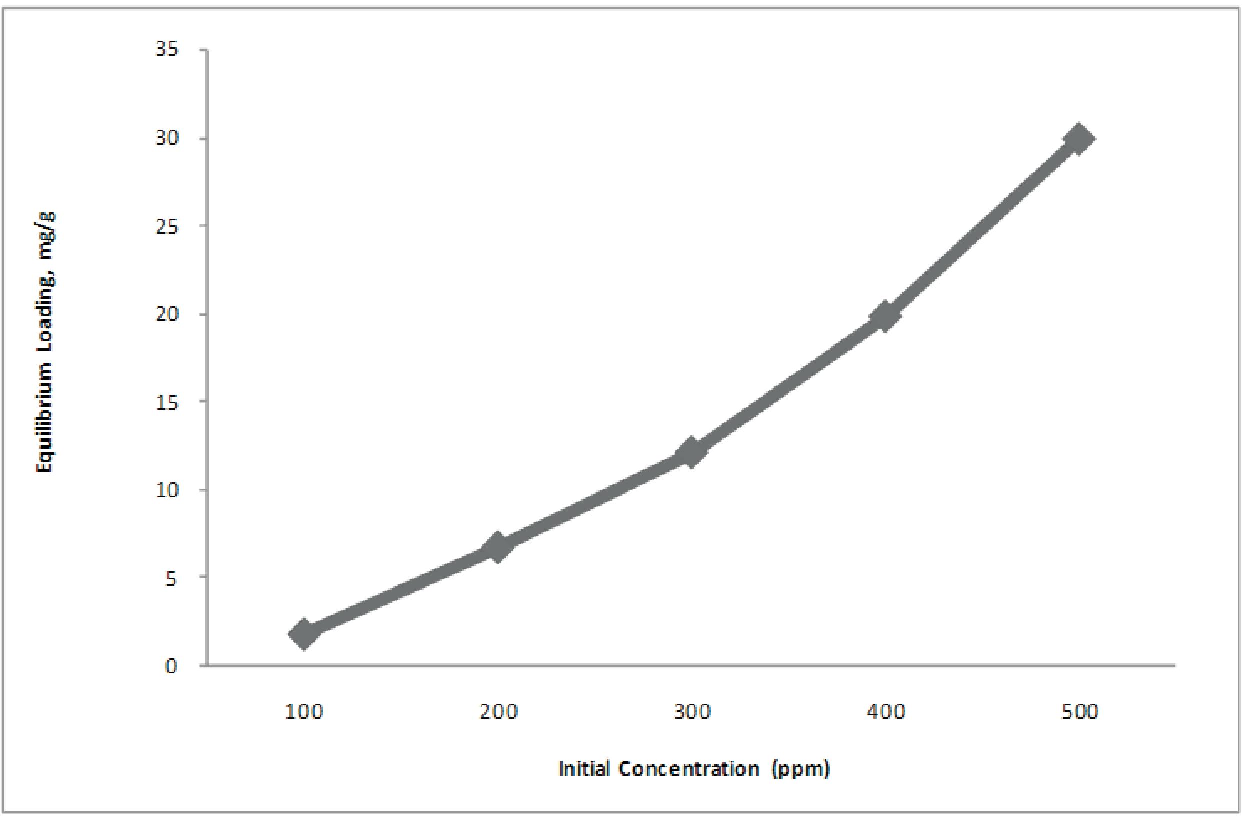

Figure 1: Initial concentration vs. Equilibrium loading

The initial concentration was plotted against the equilibrium loading for the adsorption of lead as shown in the Figure 1. The observation is reasonable because increasing the initial concentration increases the gradient of concentration or the driving force of a diffusion of Pb^{+2} to the mass of the biosorbent. The percent removal of the lead ranges from 47.8%-69.5%, this could mean that the sugarcane bagasse has the capability to absorb the lead.

CONCLUSION

The experimental data showed that the sugar cane bagasse was an effective biosorbent of lead in aqueous solution, given that for every initial increase in each concentration, the amount of lead adsorbed also increases. The percent removal of the lead ranges from 47.8%-69.5%. This could mean that the sugarcane bagasse has the capability to absorb the lead.

RECOMMENDATION

It is recommended that other heavy metals aside from Pb^{2+}; particularly the most commonly found heavy metals in wastewater be used. Varying contact time of the biosorbent and the heavy metal can also be used in order to know the effects of time in biosorption. Future researches on biosorption should use other indigenous raw material that can reduce the heavy metals for greater understanding. Additionally, future researchers could have a longer period of experimentation for the test of the effect of pH must be done.

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