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REMOVAL OF METALIC IONS FROM AQUEOUS SOLUTION USING ZEA MAYS COBS

Science

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ABSTRACT

In the present work efficacy of Zea mays Cob (ZMC) as low-cost bio-sorbents for the removal of Pb ions from aqueous solutions was investigated. Batch adsorption studies were carried out to evaluate the effects of contact time, adsorbent dose and initial metal ion concentration on adsorption capacity. The optimum bio-sorption condition was found at 1.6 gm/100 ml biomass dosage, contact time of 90 minutes and 20 mg/l of initial lead concentration. The maximum adsorption capacities were estimated at different dose of bio-sorbent (0.2 to 1.6 gm/100 ml), time of agitation (10 to 120 min) and initial lead concentration (10 to 40 ppm). The study showed that all the bio-sorbent Zea mays Cob (ZMC) exhibited excellent adsorption capacities for the removal of Pb ions from aqueous solutions. The agro-wastes are rich in cellulose, hemicelluloses and lignin content which adhere to toxic pollutants on the surface.

KEYWORDS

toxic metal, bio-sorbent, agro-waste, waste water, low cost, batch adsorption

INTRODUCTION

Despite the natural occurrence of toxic elements within the earth's crust, anthropogenic activities such as mining, electroplating, smelting operations, domestic and agro-allied industries, and geogenic activities are responsible for environmental contamination and human exposure to toxic metals (He et al.2005). Among the major heavy metals in waste water include cadmium, lead, arsenic, iron and mercury, their toxicity can result in damaged or reduced mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidneys, liver, and other vital organs. Some of the heavy metals include lead and cadmium.

There are several ways that dissolved heavy metals can be removed from water that include ion exchange, reverse osmosis, precipitation, ultra filtration, electro dialysis and adsorption (Burton and Tchnobanoglous, 1991). Most of them require high energy and advanced operations that are out of reach to many low income earners. Consequently, new approaches based on the use of natural inexpensive adsorbents such as orange peels and rice husk for treatment have been reported (Badmus et al., 2007). Therefore there is a growing need for the development of new, innovative and cost effective methods for the removal of heavy metals from waste water (Sayeda et al., 2010). This study explores possibilities of developing cheap and reliable water treatment adsorbent from maize cobs derived products. Maize cobs are one of the agricultural wastes.

MATERIALAND METHODS

All the standard solutions were prepared from analytical grade compounds of Merck Company. All the glassware's used were of Borosil. Prior to all chemical analyses, the reagent bottles, beakers, and volumetric flasks were cleaned by soaking overnight in 2N hydrochloric acid, rinsed with water and oven dried at 60oC. Instruments used in the investigation are Orbital Shaker (MACR - MSW 132), industrial oven, fume hood, heating plate, weighing balance (A- KERN 572) and Atomic Absorption Spectrometer (Varian Model AA240).

Sample Collection and Preparation: The Zea mays Cob (ZMC) were collected from vegetable sellers of local market. The sample was thoroughly washed in de-ionized water to remove dirt particles contained in them. The sample was then chopped into small pieces and air dried in shade at room temperature for three (3) days. The plant material was further dried in the oven at 60°C for 04 hours in order to blend them into a powdery form in a food blender. The powder was then sieved using 2mm size and kept in an air tight sealed plastic/ glass container which were kept in desiccators in order to preserve it from humidity. To avoid sample contamination, all handling and preparation steps were carried out on clean benches.

The NaOH pre-treatment step was carried out according to the process stated by Subramani and Revathi (2015), which is mixing of bio-sorbent with 4 M NaOH and placing it on the shaker for 1 hr. In this regard, 25 g of each of the biosorbent was added to 200 ml of 4 M NaOH (32 g of NaOH dissolved in 200 ml of DDW). The solution was shaken on the orbital shaker for 1 h, next they were washed with distilled water (each bio-sorbent needed around 15 liter of distilled water) until the pH of the suspension reached neutrality. The modified bio-sorbent was placed on stainless steel plates and dried at 80oC for 24 h. The biosorbent then re- sieved to retain the 100-200 sieve fractions, and then placed in the oven for 1 h at 80oC to make sure they were free of moisture, and finally placed in desiccators.

Preparation of Synthetic Lead Solution: The synthetic lead solution used for conducting the batch equilibrium experiments was prepared from a lead stock solution of concentration 1000 mg/l, manufactured by MERCK, diluted in deionized distilled water (DDW) to the required concentration. The standard solutions that were utilized for the calibration of the atomic absorption spectrometer (AAS) were prepared from the same lead stock solution and were diluted using 0.5 % HNO3 in the same manner.

Batch Experiment: Batch experiments were performed for the bio-sorption of lead ions. The effects of different conditions i.e. amount of adsorbent, initial metal concentration and contact time on metal adsorption was evaluated in this study.

Calculation:

Concentrations were read directly from the instrument readout and multiplied by appropriate dilution factor if sample has been diluted. The result was reported in mg/L or mg/Kg (depending on the type of sample analyzed). Metal conc. in sample (mg/L) = Sample conc. from instrument (mg/L) X Dilution factor (if any). Equation below was used to calculate for the % removal: %Removal = amount added – amount found × 100 Amount added

RESULT AND DISCUSSION

Batch adsorption experiments were carried out in order to evaluate the use of Zea mays Cob (ZMC) as bio-sorbent for the removal of Pb ions from aqueous solutions. For these experiments, pre-weighed amount of the ZMC and a measured volume of Pb ion solution were taken in 100ml Erlenmeyer flask and stirred in an orbital shaker at a constant temperature (32±2oC) for 120 min to ensure equilibrium. In the present study effect of individual parameter of the adsorption process has been investigated maintaining other parameter constant at specified levels. After shaking the flasks for regular intervals, samples were withdrawn and filtered. The filtrates were acidified and analyzed for the concentration of Pb ions by flame Atomic Absorption Spectrophotometer; AAS (AA 240).

Effect of Biosorbent dosage: In this study, the biosorbent dosage is changed from 0.2 to 1.6 g and there is no change in other parameters is constant like concentration, time, rpm and pH. The figure 1 shows an increase in the biosorption percentage as dosage of biosorbent increases. This is because of the availability of more binding sites in the surface of the biosorbent for complexation of lead ions. The optimum dosage was found that 1.6 g/lit.

Increases in adsorbent weight resulted in increased percentage adsorption until equilibrium was attained. There were significant differences in percentage adsorption of Pb ions for different adsorbent weights. Similar results have been reported by Shukla and Pai (2005) who used coir, jute, sawdust and groundnut shells for Pb ion removal from aqueous solutions. Normanbhay and Palanisamy (2005) used chitosan coated oil palm shell to remove Cr 3+ and Cr 6+ from aqueous solutions while Mahvi et al. (2005) used tea waste for the removal of Pb 2+ , Cd 2+ and Ni 2+ from industrial wastewaters. They explained that increasing adsorption with adsorbent weight can be attributed to increased number of unsaturated active sites as well as high accessibility of Pb 2+ to the binding sites.

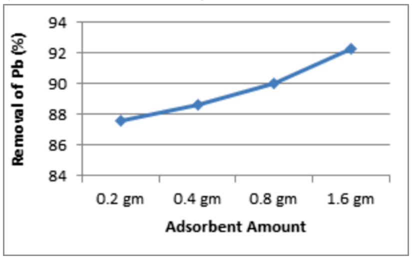

Fig. 1: Percent removal of lead ions after variable dose with Zea mays Cob (ZMC) as adsorbent

Effect of contact time: The data obtained from the biosorption of lead ions on the ZMC sample showed that a contact time of 90 min is needed to achieve equilibrium and the biosorption did not change significantly with further increase in contact time (fig. 2). The rate of adsorption is an important factor in wastewater remediation; it is therefore important to establish the time dependence of contaminant capture under process conditions (Brown et al., 2000). Various scientists have also reported trends of increased percentage adsorption as reported in this study (Engl and Kunz, 1995; Antunnes et al., 2003; Kadirvelu and Namasivayam, 2003; Kar and Misra, 2004).

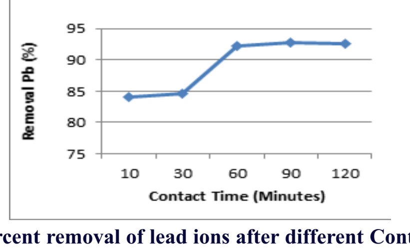

Fig. 2: Percent removal of lead ions after different Contact Time (minutes) with Zea mays Cob (ZMC) as adsorbent

Effect of initial metal concentration: The increase in metal adsorption capacity with increasing initial metal concentrations may be due to a higher probability of collision between metal ions and adsorbent particles (Tijani et al. 2011). Although high initial concentration leads to an increase in the affinity of the metal ions toward the active sites, at low concentration, adsorption sites took up the available metal ions more quickly (Saifuddin et al. 2005).

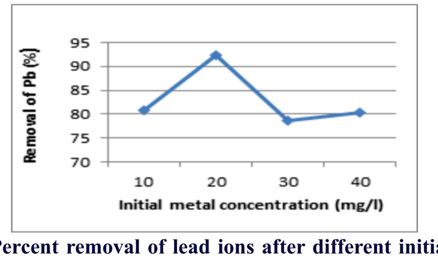

Fig. 3: Percent removal of lead ions after different initial metal concentration (mg/l) with Zea mays Cob (ZMC) as adsorbent

CONCLUSION

Present study shows that chemically treated maize cob is an effective adsorbent for the removal of lead ions from aqueous solutions. The maximum percentage removal was increased from 80 to 92%. Equilibrium was achieved practically in 90 min. It is found that maize cob which is available in abundance locally is the very economical low cost adsorbents. The result is not only important for the industries but also to the planet earth in general due to the resultant social and environmental benefits.

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