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Full Length Research Paper

Use of *Chrysophyllum albidum* for the removal of metal ions from aqueous solution

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Heavy metals released by a number of industrial processes are major pollutants in marine, ground, industrial and even treated wastewaters. Some conventional methods of treatment, generate toxic sludge, hence the study of biomaterials as adsorbents. The residual metallic ion concentrations were determined. The results obtained after contacting for 120 min showed that *Chrysophyllum albidum* seeds achieved the percent removal of 76.2, 63.0, 56.4 and 42.3 for Cu^{2+}, Ni^{2+}, Zn^{2+} and Pb^{2+} ions respectively. The percent removal of Ni^{2+} ions was 66.5 with an effective dose of 1.0 g of dried *C. albidum* seeds at pH 7.0 shaken for 2 h at 300 r.p.m. The ability of *C. albidum* seeds to absorb metal ions as shown from the results can be used for the development of a cheap technology for effluent treatment.

Key words: Biomaterials, *Chrysophyllum albidum*, adsorbent, pollution, heavy metals.

INTRODUCTION

Heavy metals are toxic inorganic contaminants that, unlike organic contaminants that can be degraded by microorganisms, must be removed from wastewater before being discharged to the environment. A wide range of physical and chemical processes is available for the removal of heavy metal ions during wastewater treatment. These include ion exchange, electro-chemical precipitation, filtration and adsorption on activated carbon. Ion exchange and adsorption on activated carbon are efficient treatments but they are not largely used due to their high operational costs. Alternatively, aquatic plant materials have shown a remarkably high adsorption capacity for heavy metals from water (Ajmal et al., 2000; Kadirvelu et al., 2000; Oliveira et al., 2004; Wase and Forster, 1997), as well as from regular aqueous solutions of the ions.

Selection of a treatment process is dependent on the nature of the wastewater and the quality of the effluent desired. Adsorption is a physico-chemical process that generally occurs at the interface of fluid-solid phases and is sometimes used to remove certain species that cannot effectively be removed from the wastewater stream by other conventional technologies (Liu, 2007).

Some impurities affect the aesthetic qualities of the water, if they exceed secondary maximum contaminant levels (MCLs) established by EPA and the state, the water may need to be treated (Spellman, 2003a).

The removal of metal ions in industrial effluent using biosorption process has been an area of extensive research because of the presence and accumulation of toxic carcinogenic effect on living species. Some materials investigated for wastewater treatment were cotton (Zhao and Duncan, 1997); walnut waste (Gosset et al., 1986), peanut skins (Upatham et al., 2002) , sugar cane wastes and onion skin (Dupont et al., 2003); coffee grounds (Bai and Abraham, 2001), apple waste (Villaescusa et al., 2000) , wool fibre (Singanan et al.,

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2006), bark and other cellulosic materials (Swamiappan and Krishnamoorthy, 1984), cottonseed hulls, rice straw, linseed flax straw (Freeland et al., 1974), soybeans hulls (Verwilghen et al., 2004). These investigations were due to the need for low cost, high availability adsorbents that required no need for complicated regeneration process.

A study has been done with the shell of the seed of *Chrysophyllum albidum* carbon to adsorb lead (Pb) from aqueous solution (Amuda et al., 2007). *C. albidum* (G. Don) is a tropical edible fruit tree. It belongs to the family sapotaceae which has up to 800 species and make up almost half the order Ebernales (Ehiagbonare et al., 2008). It is primarily a forest tree species and its natural occurrences have been reported in diverse ecozones in Nigeria, Uganda, Niger Republic, Cameroon and Cote d'Ivoire. The plant often grows to a height of 36.5 m though it may be smaller. The African star apple fruit is a large berry containing 4 to 5 flattened seeds or sometimes fewer due to seed abortion. The plant has in recent times become a crop of commercial value in Nigeria. The fleshy pulp of the fruits is eaten especially as snack and relished by both young and old. The seeds are also used for local games. *C. albidum* fruit is common in both urban and rural centers especially during the months of December to April. The fruits are not usually harvested from the trees, but left drop naturally to the forest floor where they are picked (Amusa et al., 2003).

This study investigates the removal of toxic heavy metal ions by *C. albidum* seeds from their aqueous solution and shows its inexpensive, highly available, effective metal ion biosorbent nature as local replacements for existing commercial materials.

MATERIALS AND METHODS

Preparation of *chrysophyllum albidum* seeds

The seeds were gathered into a clean plastic bag. Other soluble dirty and coloured components were removed from the refuse seeds by washing with distilled water until colourless solution was observed at room temperature. The outer shells of the seeds were cracked open and the inner soft parts removed and dried at room temperature for a period of 3 days and afterwards ground. The ground seeds were sieved and were of particle size 0.25 to 0.5mm. This was to allow for shorter diffusion path, thus allowing the adsorbate (*C. albidum* seeds) to penetrate deeper into the effluent more quickly, resulting in a higher rate of adsorption (Adeyinka et al., 2007).

Preparation of synthetic wastewater

The initial concentration used was 5.00 mg/l for copper, 4.00 mg/l for Nickel, 20.00 mg/l for Lead and 2.50 mg/l for Zinc and the contacting time was varied from 20 to 120 min. A stock solution of Nickel, Lead, Copper, Zinc and Aluminium was prepared in distilled water with Nickel (II) Sulphate, Lead (II) nitrate, Zinc (II) sulphate and Copper (II) sulphate. All working solutions of varying concentrations were obtained by diluting the stock solution with distilled water. The pH of the effluent was adjusted to a pH of 5 to prevent hydrolysis. The concentration of metal ions in effluent was analyzed by atomic absorption spectrophotometer. For quality control purpose, the diluted water was digested and analyzed for every sample group to track any possible contamination source. A duplicate was also analyzed for every sample to track experimental error and show capability of reproducing the results (Marshall and Champagne, 1995).

Adsorption experiment

The experiments were carried out in the batch mode for the measurement of adsorption capabilities. The bottles with 500 ml capacity were filled with 50 ml of the synthetic wastewater and 1 g of ground *C. albidum* seeds. The bottles were shaken for a predetermined period at room temperature in a reciprocating shaker for 2 h at 300 rpm. The separation of the adsorbents and solutions was carried out by filtration with whatman filter paper No. 42 and the filtrate stored in sample cans in a refrigerator prior to analysis. The residual metallic ion concentrations were also determined using an atomic absorption spectrophotometer (AAS).

RESULTS

The result are shown in Figure 1, 2 and 3.

DISCUSSION

Figure 1, shows the percentage removal of the various metal ions by the *C. albidum* seeds adsorbent. For all the metal ions present in the synthetic wastewater, there was a non linear rise in the percentage of metal ions removed with time. From the result of the adsorption experiment Cu^{2+} ions had the highest percent removal of 76.2 at the end of 120 min, followed by Ni^{2+} ions, Zn^{2+} ions and Pb^{2+} ions with 63.0, 56.4 and 42.3 respectively. Also, from Figure 1, it was observed that with increase in time, the percentage removal of the *C. albidum* seeds increased gradually as seen from the plot, but it was not linear. It was also observed that the rate of adsorption increased significantly as shown by the difference in the value of percent removal of ions at 20 and 120 min of contact time for some of the metal ions present in the synthetic wastewater. This result is important, as equilibrium time is one of the important parameters for an economical wastewater treatment system.

Figure 2 shows that for the adsorbent dose of 1.0 g there was an increase in the removal of metal ions. The larger the surface area, the larger the amount of metal ion adsorbed. This appears to be due to the increase in the available binding sites in the biomass for the complexation of the heavy metals (Gong et al., 2005) with corresponding increase in percent removal of the heavy metals. *C. albidum* seeds were able to achieve the percent removal of 76.2, 63.0, 56.4 and 42.3 for Cu^{2+}, Ni^{2+}, Zn^{2+}

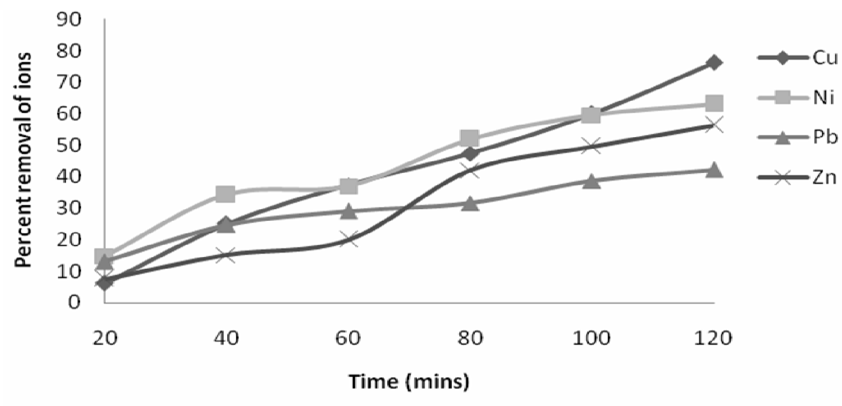

Figure 1. Variation of % removal of ion with time.

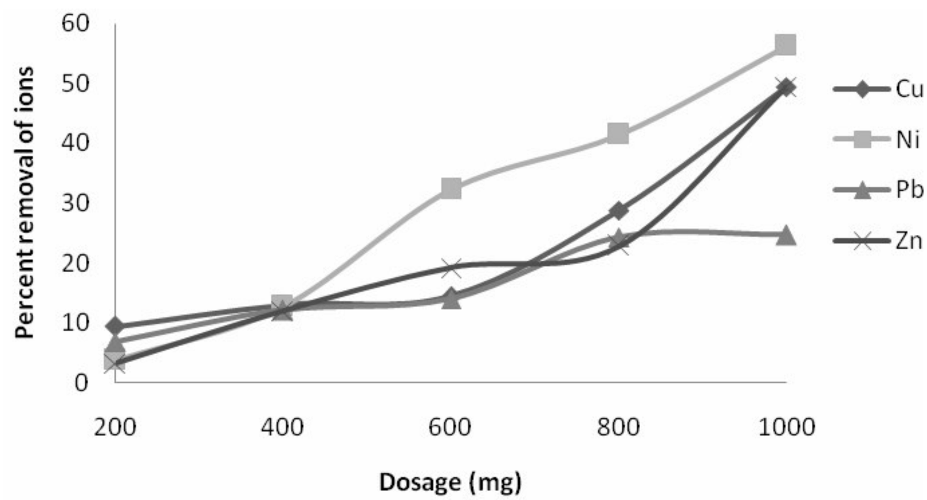

Figure 2. Variation of % removal of ion with adsorbent dosage.

and Pb^{2+} ions respectively.

Figure 3 shows that *C. albidum* seeds had a decrease in the removal of Cu^{2+} and Zn^{2+} ions and an increase in the removal of Pb^{2+} and Ni^{2+} ions when the pH of the aqueous solution increased from pH of 5 to 7. For an increased pH of 7 to 9 there was a decrease in the removal of ions of Cu^{2+}, Zn^{2+}, Pb^{2+} and Ni^{2+} in the synthetic waste water under the study by *C. albidum* seeds. Results obtained from the adsorption experiment showed that the highest percent adsorption by *C. albidum* seeds was 66.5% removal for Ni^{2+} ions in the synthetic waste water at pH value of 7.

With increase in pH from 5 to 9, the degree of protonation of the adsorbent functional group decreased gradually and hence removal was decreased. A close relationship between the surface basicity of the adsorbents and the anions is evident. This is in agreement with others (Leon et al., 1992; Radovic et al., 1997; Faria et al., 2004).

Many of the important properties of wastewater are due to the presence of weak acids and bases and their salts (Spellman, 2003b).

Conclusion

The removal of metal ions in synthetic wastewater by using biosorption technology was investigated. The results obtained, gave the following conclusions. The ground *C. albidum* seeds were found to be effective in the removal of Ni^{2+} ions from the synthetic waste water. The percent removal of Ni^{2+} ions was 66.5 with an effecttive dose of 1.0 g of dried *C. albidum* seeds (bioadsorbent) at pH 7.0.

For the contact time of 120 min 76.2% of Cu^{2+} ions

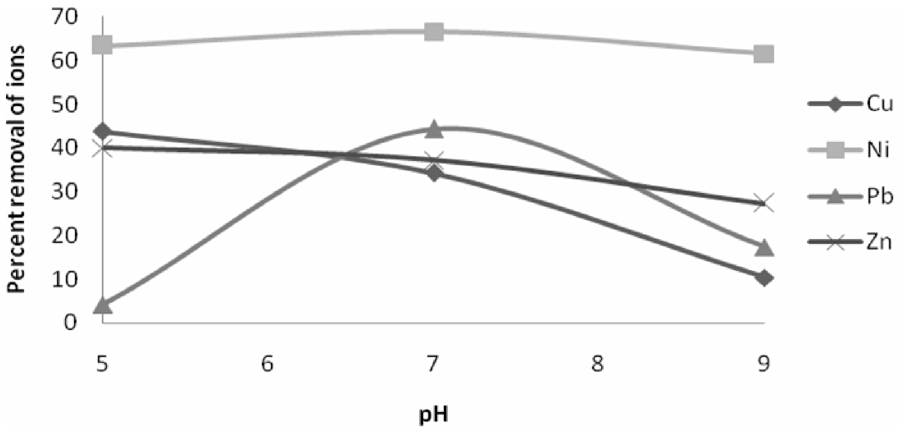

Figure 3. Variation of % removal of ion with pH.

were removed from the aqueous solution by *chrysophyllum albidum* seeds used as adsorbent.

C. albidum seeds can be an effective biomaterial for removal of some heavy metal ions from industrial wastewater.

REFERENCES

Adeyinka A, Liang H, Tina G (2007). Removal of Metal Ion form Waste Water with Natural Waste, School of Engineering and Technology. 33: 1-8.

Ajmal A, Rao RAK, Rais A, Jameel A (2000). Recovery of Ni(II) from electroplating wastewater, J. Haz. Mater. 79: 117-131.

Amuda OS, Ojo OI, Edewor TI (2007). Biosorption of Lead from Industrial Wastewater Using *Chrysophyllum albidum* Seed Shell. Bioremed. J. 11 (4): 183- 194.

Amusa NA, Ashaye OA, Oladapo MO (2003). Biodeterioration of the African star apple (Chrysophylum albidum) in storage and the effect on its food value. Afr. J. Biotechnol. 2 (3): 56-59.

Bai RS, Abraham TE (2001). Biosorption of Cr (VI) from aqueous solution by *Rhizopus nigricans*. Biores. Technol. 79: 73-81.

Dupont L, Bouanda J, Dumoneeau J, Applincourt M (2003). Metal ions binding onto a lignocellulosic substrate extracted from wheat bran: a nica donnan approach. J. Colloid Int. Sci., 263: 35-41.

Ehiagbonare JE, Onyibe HI, Okoegwale EE (2008). Studies on the isolation of normal and abnormal seedlings of *Chrysophyllum albidum:* A step towards sustainable management of the taxon in the 21st century. Sci. Res Essay 3(12): 567-570.

Faria PCC, Orfao JJM, Pereira MFR (2004). Adsorption of anionic and cationic dyes on activated carbons with different surface chemistries. Water Res. 38: 2043-2052.

Freeland GN, Hoskinson RN, Mayfield RJ (1974). Adsorption of mercury from aqueous solutions by polyethylenamine - modified wood fibers. Environ. Sci. Technol. 8: 953-956.

Gong R, Ding Y, Liu H, Chen Q, Liu Z (2005). Lead biosorption and desorption by intact and pretreated *Spirulina maxima* biomass. Chemosphere 58(1): 125-130.

Gosset T, Traneart JL, Therenot DR (1986). Batch metal removal by peat: Kinetics and thermodynamics. Water Res. 20: 21-26.

Kadirvelu K, Faur-Brasquet C, Le Cloirec P (2000). Removal of Cu(II), Pb(II), and Ni(II) by adsorption onto activated carbon cloths, Langmuir, 16: 8404- 8409.

Leon Y, Leon CA, Solar JM, Calemma V, Radovic LR (1992). Evidence for the protonation of basal plane sites on carbon. Carbon 30: 797-811.

Liu S. (2007). Food and Agricultural Wastewater Utilization and Treatment. Blackwell Publishing, U.K. p. 73.

Marshall WE, Champagne TE (1995) “Agricultural Byproducts as Adsorbents for Metal Ions in Laboratory Prepared Solutions and in Manufacturing Wastewater”, J. Environ. Science sand Health, Part A: Environ. Sci. Eng. 30 (2): 241-261.

Oliveira LCA, Petkowicz DI, Smaniotto A, Pergher SBC (2004). Magnetic zeolites: a new adsorbent for removal of metallic contaminants from water, Water Res. 38: 3699-3704.

Radovic LR, Silva IF, Ume JI, Menendez JA, Leon CA, Leon Y, Scaroni AW (1997). An experimental and theoretical study of the adsorption of aromatics possessing electron-withdrawing and electron-donating functional groups by chemically modified activated carbons. Carbon,35: 1339-1348.

Singanan M, Vinodhini S, Alemayehu A (2006). Phytoremediation of heavy metals from industrial waste waters by using indigenous biomaterials. Indian. J. Environ. Prot., 26(5): 385-391.

Spellman FR (2003a). Handbook of water and wastewater treatment plant operations. CRC Press LLC. p. 480.

Spellman FR (2003b). Handbook of water and wastewater treatment plant operations. CRC Press LLC. p. 398.

Swamiappan N, Krishnamoorthy S (1984). Phenol-formaldehyde cationic matrices substitutes by bagasse – Charcoal. Res. Ind. 29: 293-297.

Upatham ES, Boonyapookana B, Kriatracjie M, Pokethitiyook P, Parkpoomkamol K (2002). Biosorption of cadmium and chromium in duck weed W*olffia globosa*. Inter. J. Phyto. 4(2): 73-86.

Verwilghen C, Guilet R, Deydier E, Menu MJ, Dartiguenave Y (2004). Lead and Cadmium uptake by sulphur-containing modified silica gels. Environ. Chem. Lett. 2: 15-19.

Villaescusa I, Martinez M, Miralles N (2000). Heavy metal uptake from aqueous solution by cork and yohimbe bark wastes. J. Chem. Technol. Biotechnol. 74: 812-816.

Wase DAL Forster CF (1997). Biosorbents for Metal Ions, Taylor and Francis: London.

Zhao M, Duncan JR (1997). Batch removal of hexavalent chromium by *Azolla filiculoides*. Biotech. Appl. Biochem. 26: 179-182.