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Effect of pH and temperature on the sorption of metals ions from aqueous solution on *Lonchocarpus Laxiflorus* stem bark

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Abstract
Heavy metals are most dangerous one as these are non–biodegradable and persist in environment. Human activities, such as mining operations and the discharge of industrial wastes, have resulted in accumulation of heavy metals in the environment. Removal of metals and their recovery is one of the major concerns in sewage and industrial effluent treatment. This paper attempts to present a brief summary of the role of Lonchocarpus laxiflorus Stembark (LLSB) in heavy metal removal from aqueous solutions. Encapsulated Lonchocarpus laxiflorus Stembark was evaluated for sorption ability for chromium, cadmium, nickel, lead and iron ions. It was found that stembark was able to decontaminate with good efficacy for Ni, Pb and Cr ions at pH 6, 4, 6 with 99% respectively. The maximum removal of the metals was seen at temperatures between 30 ºC to 40ºC. This will be advantageous for effluent treatment plant to recover important heavy metals with low cost.

KeyWords: Sorption, heavy metals, pH, Temperature, Lonchoarpus laxiflorus stembark

1. Introduction

Heavy metals in the environment have become a major threat to plant, animal and human life due to their bioaccumulating tendency and toxicity and therefore must be removed from municipal and industrial effluents before discharge. The rate at which effluents are discharged into the environment especially water bodies, has been on the increase as a result of urbanization, industrialization of many sectors such as food, pharmaceutical, leather, textile, cosmetics, paper, printing etc. and waste generated from these industries contain heavy metals which is the cause of the environmental contamination (Vijayaraghava *et al.*, 2004; Hasfalina *et al.*, (2012) [19, 4]. In recent years, a number of alternative adsorbents have been studied for water clean-up. They are inexpensive, efficient and practical to be utilized. Agricultural and industrial wastes, as well as natural minerals are widely used as alternative biosorbents for many years. Examples of materials reported as adsorbents for heavy metals are; tea waste (Mahvi *et al.*, 2005), palm pressed fibers and coconut husk (Tan, *et al.*, 1993) [16], water fern *Azolla filiculoidis* (Zhao and Duncan, 1997) [21], peat moss, duck weed *Wolffia globosa* (Upatham, *et al.*, 2002) [17], *Rhizopus migricans,* cork and yohimbe bark wastes (Singanan, *et al.,* 2008) [15] and leaves of indigenous biomaterials, *Tridax procumbens* (Singanan, *et al.*, 2006), Neem leaves(Vijay *et al.*, 2013; Innocent *et al.*,2009), hazelnut hull (Ali *et al.*,2012) [3], Acid modified and unmodified gmelina Arborea leaves (Jimoh *et al.*, 2011) [8]. Apart from the plant based material, wood wastes such as sawdust (Kumar and Dara, 1982) [9], agricultural byproducts such as maize cab and husk, sun flower stalk, sago waste Igwe and Abia, 2003 and so on. In this paper, we report the effect of temperature and pH on the sorption of Cr^{2+}, Cd^{2+}, Fe^{3+}, Ni^{2+}, and Pb^{2+} from single metal ion solution using the biomass of *Lonchoarpus laxiflorus* bark substrate in a temperature range of 25-60ºC.

The presence of Heavy metals in water poses serious environmental and human health hazard due to their toxicity (Samarth *et al.*, 2012) [13]. The main aim of the present work was to investigate the potential of the *Lonchocarpus laxiflorus gill and perr* to accumulate the heavy metals and to be used as bioremediating agent in situ. The effect of pH and temperature on metal removal was also studied. This study is an attempt to provide a multipurpose alternative for waste water treatment.

2. Materials and Methods

2.1 Plant Collection and Treatment

Samples of the stem bark of *Lanchocarpus laxiflorus* plant were separately collected from a tree behind Modibbo Adama Federal University of Technology Yola, Nigeria. All samples were washed thoroughly under running water to remove dust and any adhering particle and then rinsed with distilled water. The samples were air dried for 2 weeks and the dry roots, stem bark and the leaves were grinded in analytical mill and sieve to obtain adsorbent of known particle size range. The biomass powder was kept in an air tight bottle for further study (Igwe and Abia, 2006) [6].

2.2 Preparation of Heavy Metal Stock Solution

Heavy metals used in the study were Cr^{2+}, Cd^{2+}, Fe^{3+}, Ni^{2+}, and Pb^{2+} in the form their respective metal solutions, $Pb(NO_3)_2$, $K_2Cr_2O_7$, $Cd(NO_3)_2$ $Ni(SO_4).6H_2O$, $(FeNO_3)_3.9H_2O$ salts.

Stock solutions was prepared by dissolving appropriate quantity 250 cm^3 of distilled water and made up to mark with in a 1000cm^3 volumetric flask

2.3 Effect of pH on encapsulated stem bark of LLSB

The effect of pH solution on the sorption capacity of encapsulated stembark of Lonchocarpus laxiflorus plant was investigated in this experiment at room temperature (30^0C) and equilibrium time of 2 h. 30 cm^3 of the prepared aqueous solution was measured in a conical flask, followed by the addition of 0.5 g of the sample in the flask. The pH was varied from 1 to 7. 0.1 M HCl or 0.1 M NaOH was used to adjust the pH of the metal ion solutions to the value of interest. The metal solutions containing the biosorbent in the conical flasks were well corked and shaken using Gallenkamp flask shaker for 2 h and thereafter the mixture was filtered, and the concentration of each metal ions removed was determined using Atomic Absorption Spectrometer, (Shimadzu 6800, Model)

2.4 Effect of temperature on sorption capacity of LLSB

Temperature is a crucial parameter in adsorption reaction, the effect of adsorption of metal on the substrate was determined at 30^0C- 80^0C. The result was used to investigate the thermodynamic of the sorption process according to (Micheal and Ayebaemi, 2005; Sarin *et al.*, 2006).

Procedure

A volume of $50cm^3$of metal ion solution ($100mg/cm^3$) was mixed with 0.5g of sample in a $125cm^3$ conical flask to obtain a suspension; the suspension was adjusted to pH 4.0. The whole flask was shaken at constant speed 100 x g in a shaking water bath at temperatures of 30, 40, 50, 60, 70, and 80^0C respectively. After shaking the flasks for 2hr, as the samples were undergoing agitation on the shaker, they were removed one after the other at different temperatures ranging from 30^oC to 80^oC. The suspepnsion was filtered using (no.42) whatman filter paper and then centrifuge at 2800 x g for 5min.The supernatant was collected in separate clean test tubes. The metal content at each temperature range was determined using AAS.

3. Result and Discussion

3.1 Effect of pH on the metal ion uptake

pH is the most important environmental factor. The pH value of a solution strongly influences not only the site of the biomass surface, but also the solution chemistry of the heavy metals: hydrolysis, complexation by organic and/or inorganic ligands, redox reactions, precipitation, the speciation, the biosorption availability of the heavy metals.

The state of metal ions in solution strongly depends on the pH. The acidity and basicity of the various solutions can influence the composition and the properties of the adsorbent surface. Therefore, in order to determine the optimum pH for metal adsorption, the adsorption was studied at various pH. The effect of pH in the range 3-7 on the binding of Cr, Cd, Ni, Pb, and Fe by LLSB sorbent was investigated. Table 1 shows the maximum pH values for each sorbent on different metalions.

Table 1: The pH for Maximum Sorption of the Metal ions Studied by Encapsulated LLSB, and the Corresponding % Removal are given below

pH for maximum sorption			
LLSB	Cd	3.0	85.84
	Ni	6.0	99.99
	Pb	4.0	99.53
	Cr	6.0	99.89
	Fe	3.0	37.90

Figure 1 shows the effect of pH on metal ion removal by LLSB biosorbent. From the graph the sorption of Ni, Cr, Pb and Cd slightly increase from pH 3 to 4 followed by a slight decrease of sorption capacity as pH values increases to 7. From the Figure it was observed that Fe has lowest sorption capacity of 37.90% at maximum pH value of 5. At certain point, some functional groups become positively charged and may not interact with the metal ions. The same observation was recorded by Jigar *et al.*, 2014. The low level of Fe uptake at low pH 5 value could be attributed to the increased concentration of H^+ and hydroxonium H_3O^+ ions competing for Fe III binding sites in the biomass (Shukla & Pai, 2005) leaving the metals ion in solution resulting to low level of metal uptake at lower pH values. The LLSB has high selectivity for Cr, Ni and Pb with percent adsorption of 99.9% for all the three metal ions.

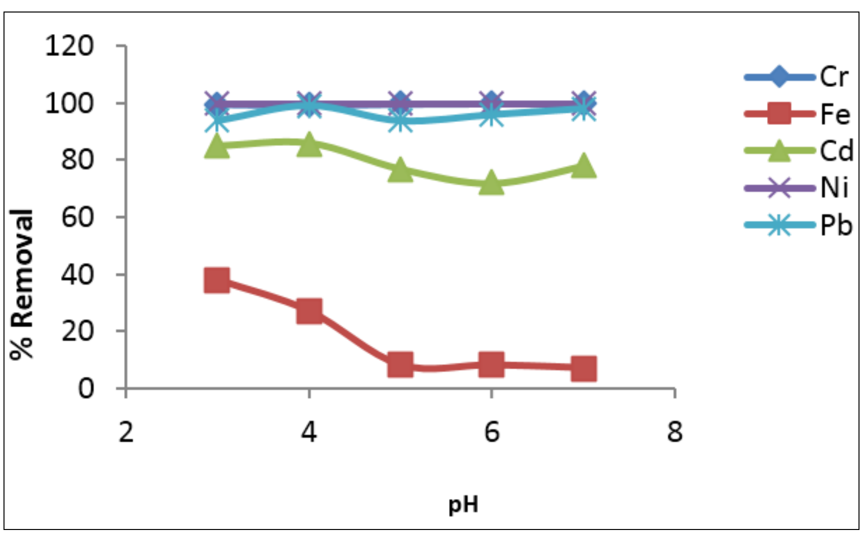

Fig 1: Effect of pH on Sorption of Metal Ions on LLSB

3.2 Effect of temperature

The effect of temperature on the biosorption capacity of metal ions on Lonchocarpus laxiflorus stembark was studied at different temperatures in the range 25^0C - 60^0C with an initial concentration of 100 mg/L and at maximum pH values as stated in Table 1. In general, the sorption of the metal ions increases slightly with increase in temperature up to 40^0C (313K) then started decreasing. However temperatures higher than 40^0C caused a change in the texture and reduced sorption capacity of the biosorbent. This is because with increasing temperature, the attractive forces between biosorbent surface and metal ions are weakened and the sorption decreases (Horsfall & Spiff, 2005) [12].

Figures 2 reveal that adsorption of metal ions by the biosorbents shows that maximum removal was observed at between the temperatures of 25ºC (298K) and 40ºC (313K). The decrease in adsorption with increasing temperature, suggests weak adsorption interaction between biosorbent surface and the metal ion, which supports physisorption. The effect of temperature on biosorption also depends on the heat of sorption. Usually for physical sorption, heat of sorption is negative and sorption reaction is exothermic preferably at lower temperatures. For chemisorptions, the overall heat of sorption is a combination of heat of various reactions taking place at sorption sites. This depends on type of metals and adsorbent. In this investigation temperature 30^0C and 45ºC are the optimal temperatures of adsorption for the selected heavy metals.

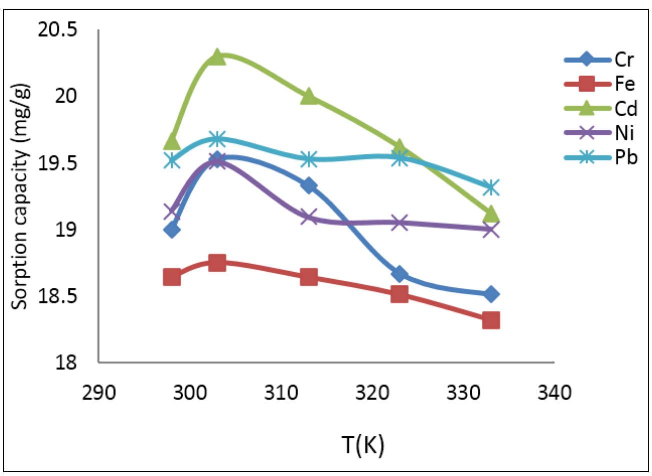

Fig 2: Effect of Temperature on Biosorption of Cr, Cd, Fe, Ni and Pb on LLSBB biosorbent at 100mg/ L Concentration and pH Values of 6,3,5,6 and 4 respectively

4. Conclusion and Recommendation

Adsorption has been used to remove many pollutants from wastewater, whether seawater or industrial wastewater, purifying drinking water, or as a polishing phase at the end of sewage treatment. These pollutants include heavy metals, which is the focus of this work. Heavy metals are toxic and hazardous to humans, marine life and the water body in which it is contained. The metals studied in this work include Chromium, Cadmium, Iron, Nikcel and Lead due to their abundance in water, in addition to their toxicity. The biomass play vital role in the biosorption of heavy metals. The present study demonstrated the use of Lonhoarpus laxiflorus in the wastewater treatment. The process would not only be economic but also ecofriendly and multipurpose as an alternative to conventional methods of biosorption of heavy metals. The potential of this biomass is enormous and is advantageous to mankind for a cleaner and healthier environment through biosorption. However, further research is needed to establish the process with specific attention.

5. References

1. Abasi CY, Abia AA, Igwe JC. Adsorption of Iron (III), Lead (II) and Cadmium (II) Ions by Unmodified Raphia Palm (Raphia hookeri) Fruit Endocarp. Environmental Research Journal. 2011; (3):104-113.
2. Aksu Z, Kutsal TA. A bioseparation process for removing Pb(II) ions from wastewater by using C. vulgaris. Journal Chemical Technology and Biotechnology, 1991; 52(1):108-118.
3. Ali S, Farshid S, Mahdi V, Jaber S, Masoud S. Removal of heavy metals (pb^{2+}, Cu^{2+} and Cr^{2+}) from aqueous solution using five plants materials. African Journal of Biotechnology, 2012; 11(4):852-885.
4. Hasfalina CM, Maryam RZA, Luqman CA, Rashid M. Adsorption of Copper (II) From Aqueous Medium in Fixed-Bed Column By Kenaf Fibres. APCBEE Procedia. 2012; 3:255-263.
5. Hassan Rezaei, Satish D, Kulkarni, Praveen G. Saptarshi. Study of physical chemistry on Biosorption of hexavalant chromium by using Chlorella Pyrenoidosa. Der Chemica Sinica, 2011; 2(4):174-189.
6. Igwe JC, Abia AA. A bioseparation process for removing heavy metals from wastewater using biosorbent. African journal of biotechnology, 2006; 5(12):1167-1177.
7. Innocent Oboh, Emmanuel Aluyor, Thomas Audu. Biosorption of Heavy metals ions from aqueous solution using a biomaterials. leanardo, journal of sciences, 2009; 14:58-65.
8. Jimoh Oladejo Tijani, Muriana Musah, Izuelumba Blessing. Sorption of lead (11) and Copper (11) ions from Aqueous Solution by Acid Modified and Unmodified Gmelina Arborea (Verbenaceae) Leaves. Journal ofEngineering Trends in Engineering and applied Sciences, 2011; (JETEAS) 2(5):7-34-740.
9. Kumar P, DaraSS. Utilization of agricultural waste for decontaminating industrial/domestic wastewater from toxic metals. International journal of industrial chemistry, 1982; 4(1):213-223.
10. Kuyucak N, Volesky B. The mechanism of cobalt biosorption. Biotechnol Bioeng, 2012; 33:823-831.
11. Mahvi AH, Naghipour D, Vaezi F, Nazmara S. Tea waste as an adsorbent for heavy metal removal from industrial waste. Am. J Appl. Sci. 1989; 2:372-375.
12. Micheal Horsfall Jnr, Ayebaemi I. Spiff. Effect of temoerature on the sorption of Pb^{2+} and Cd^{2+} from aqueous solution by Caladium bicolor (Wild Cocoyam) biomass. Electronic Journal of Biotechnology 2005; 8(2):162-170.

13. Samarth DP, Chandekar CJ, Bhadekar RK. Biosorption of Heavy Metals from Aqueous Solution using Bacillus licheniformis, International Journal of Pure and Applied Sciences and Technology, 2012; X(2):12-19.
14. Sarin V, Paint KK. Removal of chromium from indusrial waste water by using eucalphus bark. Bioresource. Technology, (2006); 97:15-20.
15. Singanan M, Singanan V, Abebaw A. Biosorption of Cr (111) from aqueous solutions using indigeneous biomaterial, Bioresours Technology, 2008; 2(2):177-182.
16. Tan WT, Ooi ST, Lee CK, Removal of Chromium (VI) from solution by coconut husk and palm pressed fibers. Environ. Technol. 1993; 14:277-282.
17. Upatham ES, Boonyapookana B, Kriatracjie M, Pokethitiyook P, Parkpoomkamol K. Biosorption of cadmium and chromium in duck weed Wolffia globosa. Inter. J.Phyto. 2002; 4(2):73-86.
18. Vijay S Kumar, Prof. Pai KV, Sripathy M. Experimental optimization for Cu removal. From aqueous solution using Neem leaves Based on Taguchi method. International Journal of science. Environment and Technology, 2013; 2(1):1.3-114.
19. Vijayaraghevan Kuppusanily, Joseph Raj Jegen, Kandesany Punuvinelu Manickam. Velen Copper removal from aqueous solution by marine green alga ulra reticulate. Electronic Biotechnol. 2004; 7(1):61-67.
20. Vikran Sarin, Tony Sarvinder Singh, Pant KK. Thermodynamic and breakthrough column studies for the selective sorption of chromium from industrial effluent on activated eucalyptus bark. Bioresource Technology, 2006; 97:1986-1993.
21. Zhao M, Duncan JM. Batch removal of hexavalent chromium by azolla filiculoides. Appl. Biochem. Biotechnol, 1997; 26:179-183.