

Biosorption capacity of *Lonchocarpus laxiflorus* Leaves biomass for adsorption of metal ions (Fe^{3+} , Pb^{2+} , Cr^{2+} , Cd^{2+} and Ni^{2+}) from aqueous solution

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Abstract- The adsorption capacity of *Lonchocarpus laxiflorus* leave (LLL) biomass for the removal of metal ions (Fe^{3+} , Pb^{2+} , Cr^{2+} , Cd^{2+} and Ni^{2+}) was investigated and the residual metal ion concentrations was studied using Atomic Absorption Spectrophotometer (AAS). The adsorption capacity was performed by batch experiments as a function of experimental parameters like effect of pH, contact time, initial metal ion concentration and temperature on biosorption of metal ions from aqueous solution. The metal ion sorption capacity by *Lonchocarpus laxiflorus* increases with increase metal ions concentration. The biomass sorption capacity increases, with increases in pH, reaches a maximum and then decreases steadily. The sorption rate was rapid for the first 30 – 40 min and equilibrium was reached within 120 min. The maximum sorption capacity for Fe^{3+} , Pb^{2+} , Cr^{2+} , Cd^{2+} and Ni^{2+} was found to be 61, 99, 98,85 and 100 % respectively. The results from these studies will be useful for removal of toxic metal ions from waste water and can be adopted for secondary treatment. It can also be turned into an environmentally friendly and cost effective sorbent for waste water.

Index Terms- Heavy metal ions, Immobilization, *Lonchocarpus laxiflorus*, Sorption capacity

I. INTRODUCTION

Despite the requirement for healthy environment, the environment has been found to be contaminated with various pollutants. This has now posed a great challenge to human wellbeing. Such pollutants may be found in air, water soil, coastal erosion, overfishing and deforestation as well as disposal of waste, which constitute several heavy metals. Heavy metals released into the environment by industrial and metallurgical process tend to persist indefinitely, circulating and eventually accumulating throughout the food chain (Vijayaraghava *et al.*, 2004). 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).

At present, these toxic metals have polluted our atmosphere, our water, our soil and our food, and have been reported to toxic

even at low concentration (Jimoh *et al.*, 2011). They accumulate in the food chain and once absorbed into bodily tissues cannot be easily excreted.

The heavy metals of widespread concern to human health are lead, copper, mercury, cadmium, arsenic, chromium and zinc (Jimoh *et al.*, 2011). Among the heavy metals, lead, mercury and cadmium are examples of heavy metals that have been classified as priority pollutants by the U.S Environmental Protection Agency (USEPA) (Keith *et al.*, 1997).

The available conventional treatment method or known as physico-chemical technique consisting of flocculation, ozonation, chemical coagulation, precipitation, evaporation, electrochemical treatment, ion exchange, reverse osmosis, adsorption, etc where each of them have limitations such as high cost and production of hazardous by-products are found expensive and sometimes ineffective, especially when metals are present in solution at very low concentration within the range 1-100mg/cm³ (Jimoh *et al.*, 2012). Therefore, these constraints have caused the search for alternative methods that would be efficient for metal sequestering. Sorption operations, including adsorption and ion exchange, are a potential alternative for water and wastewater treatment (Damirbas, 2008) Adsorption has advantages over other methods. The design is simple, and it is sludge free and can involve low investment in terms of both the initial cost and land (Viraraghvan *et al.*, 2007). Recently plants have been studied for the ability to remove contaminants from the environment (Chandra *et al.*, 2004). Researchers have recognized that immobilizing biomass in a ganular or polymeric matrix may improve biomass performance and facilitate separation of biomass from the solution (Chandra *et al.*, 2004) The American Bureau of Mines has investigated the use of biomass immobilized in porous poly-sulfonate beads (BIOFIX) for extracting toxic and heavy metals from dilute waste streams (Chandra *et al.*, 2004). Gardea-Torresdey *et al.*, 1996, have removed copper ions from aqueous solutions by silica immobilized *Medicago sativa* (alfalfa). Immobilized biomass appears to have a greater potential than raw biomass in packed bed or fluidized bed reactors with benefits such as control of particle size, better capabilities of regeneration, reuse and recovery without destruction of biomass beads (Shan *et al.*, 2002). Anaerobic sludge supplied from a wastewater treatment plant, acts as a novel biosorbent, for Pb^{2+} , Cu^{2+} , Cd^{2+} , and Ni^{2+} removal from aqueous solutions (Osemeahon *et al.*, 2013). Rice husk, a surplus agricultural byproduct, is used for the sorption of Cd^{2+} from aqueous solution. Some simple and low-cost chemical modifications resulted in increasing the sorption

capacity of raw rice husk (RRH) have been studied (Kumar *et al.*, 2006). Papaya wood was evaluated as a new biosorbent of heavy metal ions such as Cu^{2+} , Cd^{2+} and Zn^{2+} (Shama *et al.*, 2010)].

The use of non-living biomaterial containing metals-binding compounds would have the advantage of non-requiring care and maintenance as well as being useful in remediating areas with high levels of contaminants that would otherwise kill live systems (Kurrapati *et al.*, 2009). Hence a plant such as *Lonchocarpus laxiflorus*, that grows very well should show a greater ability to recover heavy metals and may be a good source for naturally occurring biological compounds that have potential for contaminant remediation might contain natural metal binding compounds and could be a possible source for bioremediation of heavy metals in waste water. The immobilization of *Lonchocarpus laxiflorus*, biomass involves the trapping of the biomass within the matrix with sodium alginate and calcium chloride solutions to give good biosorbent materials. However, biosorbents are hard enough to withstand the application of pressures, have water retention capacity, high and fast sorption uptake. (Osemeahon *et al.*, 2013). Also because of immobilization, the biosorbents so obtained offer easy and convenient usage compared to free biomass, which is easily biodegradable (Reza *et al.*, 2010). The target in this study is to immobilize the leaves of *Lonchocarpus laxiflorus*, with sodium alginate with the objective of using the products as a sorbent for the removal of metal ions in waste water.

II. MATERIALS AND METHODS

Analytical reagents of grade chemicals obtained from the British Drug House (BDH) and distilled water were used. The reagents are lead nitrate $\text{Pb}(\text{NO}_3)_2$, Potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$), Copper Nitrate $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$, Mercury(II) Chloride $\text{Hg}(\text{Cl}_2)$, Cadmium Nitrate $\text{Cd}(\text{NO}_3)_2$, Nickel sulphate ($\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$) and Ferric nitrate nonahydrate $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$, Sodium alginate, calcium chloride. Metal ion solutions of different concentrations were obtained by diluting their respective stock solutions ($1000\text{mg}/\text{cm}^3$). Standard acids and base solutions (0.1M HCl , 0.1M NaOH and 1M HNO_3) were used for pH adjustments.

2.1. PLANT COLLECTION AND TREATMENT

The leaves of *Lonchocarpus laxiflorus* plant were collected from a tree behind Modibbo Adama Federal University of Technology Yola, Nigeria. The plant was washed thoroughly under running water to remove dust and any adhering particles and then rinsed with distilled water. The sample was air-dried for 2 weeks and the dry leaves were ground in an analytical mill and sieved 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).

2.2 PREPARATION OF SODIUM ALGINATE AND CALCIUM CHLORIDE STOCK SOLUTION

Sodium alginate was prepared by weighing 4.00 g and making it up to 100cm^3 mark with distilled water in a volumetric flask and left overnight for complete dissolution. 0.12M calcium chloride was prepared by weighing 26.28 g in to 1000cm^3 volumetric flask and making it up to mark with distilled

water according to a standard procedure described by (Osemeahon *et al.*, 2012).

2.3 IMMOBILIZATION OF THE LEAVES OF LONCHOCARPUS LAXIFLORUS PLANT

Sodium alginate was used for immobilization of the leaves of *Lonchocarpus Laxiflorus* plant. 50cm^3 of sample solution prepared by dissolving 4g of each test sample in 100cm^3 of distilled water and mixed with 50cm^3 of 4% stock solution of sodium alginate and stirred vigorously in 250cm^3 beaker, to obtain a homogeneous mixture. After mixing, the solution was drawn through hypodermic needles and added dropwise to a stirred solution of 1M CaCl_2 . A retention time of 1 h was allowed for the reaction to obtain complete precipitation of the immobilized leaf powder of *lonchocarpus laxiflorus* plant. The beads thus formed i.e. sodium alginates were kept in fresh CaCl_2 solution. Before sorption studies, the beads were removed and allowed to dry at room temperature. The dried solid mass was stored in a polythene bag for further use. (Mishra S. P. 2013).

2.4 PREPARATION OF SYNTHETIC WASTE WATER.

The following metal solutions were prepared:

(i) Lead solution of $1000\text{mg}/\text{cm}^3$ concentration was prepared by dissolving 1.6g lead(II) nitrate $\text{Pb}(\text{NO}_3)_2$ in 250cm^3 of distilled water and make up to mark with distilled water in a 1000cm^3 volumetric flask.

(ii) Chromium solution of $1000\text{mg}/\text{cm}^3$ concentration was prepared by dissolving 2.827g Potassium dichromate $\text{K}_2\text{C}_2\text{O}_7$ in 250cm^3 of distilled water and make up to mark with distilled water in a 1000cm^3 volumetric flask.

(iii) Cadmium solution of $1000\text{mg}/\text{cm}^3$ concentration was prepared by dissolving 2.103g of $\text{Cd}(\text{NO}_3)_2$ in 250cm^3 of distilled water and make up to 1000cm^3 in a volumetric flask.

(iv) Nickel sulphate $\text{Ni}(\text{SO}_4) \cdot 6\text{H}_2\text{O}$ solution of $1000\text{mg}/\text{cm}^3$ was prepared by dissolving 0.4478g in 250cm^3 of distilled water and make up to 1000cm^3 in a volumetric flask.

(v) Iron solution of $1000\text{mg}/\text{cm}^3$ concentration was prepared by dissolving 7.21g of ferric nitrate nonahydrate ($\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$) in 250cm^3 of distilled water and make up to 1000cm^3 in a volumetric flask.

III. BATCH SORPTION STUDIES

The experiments were carried out in the batch mode for the measurement of adsorption capacities. From 100 ppm of each metal ion solution, 50ml was taken into a 25ml conical flask and 0.2g of the LLL was added, corked with a rubber bung and shaken with a flask shaker for 2 hours at room temperature (30°C) at 180rpm. The separation of the adsorbents and solutions were carried out by filtration with Whatman filter paper No 42 and the filtrates were stored in sample cans for use. The residual metal ion concentrations were determined using Atomic Absorption Spectrophotometer AAS. Pyeunicam Model SP]. The percentage adsorption was calculated using the following equation:

$$\% \text{Adsorption} = [(C_i - C_f) / C_i] \times 100$$

Where C_i = Initial metal ion Concentration and C_f = Equilibrium metal ion Concentration (mg/l)

3.1 EFFECT OF pH ON IMMOBILIZED LEAVES OF LLP

The effect of pH solution on the sorption capacity of immobilized LLL was investigated in this experiment at room temperature (30°C) and equilibrium time of 2 h. 30 cm³ 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 desired value of interest. The metal solutions containing the biosorbent in the conical flask were well corked and shake using Gallenkamp flask shaker for 2h and thereafter the mixture was filtered, and then the concentration of each metal ions removed was determined using Atomic Absorption Spectrometer, (model, Shimadz 6800).

3.2 THE EFFECT OF CONTACT TIME ON IMMOBILIZED LEAVES OF LL PLANT

The effect of contact time was studied using an initial concentration of 20 mg L⁻¹. The time intervals chosen for this experiment were 30, 60, 90, 120, and 150 minutes. 0.5g of the immobilized leaves samples was separately mixed with 50cm³ solution of initial concentration 100 mg L⁻¹. The mixture was shaken constantly in a shaker at 180 rpm speed for the time period of 30, 60, 90, 120, and 150 minutes for all the metal ions. At the end of each contact time, the mixture was filtered and the concentration of the filtered was determined using AAS

3.3 THE EFFECT OF INITIAL METAL IONS CONCENTRATION ON IMMOBILIZED LEAVES OF LLP

The effect of initial metal ion concentration on adsorption was studied as well at equilibrium time of 90 minutes and varying the concentration from 10 - 80 mg cm⁻³. 0.5g of the immobilized leaves samples were each separately mixed with 50cm³ solution of aqueous solution from the prepared 100mg/cm³. The mixture were shaken constantly using a rotary shaker at 180 rpm for 90 minutes for all the metal ions. At the end of the 90 minutes, the mixture was filtered using Whatman filter paper (No:42) and their concentrations determined using the Atomic Absorption Spectrophotometer AAS (Shimadzu AA-680, Japan). The difference between the initial concentration and the final concentration was recorded as the amount adsorbed for each concentration. The result obtain were used to analyzed both Freundlich (1906) and Langmuir (1916) isotherms.

IV. THERMODYNAMIC STUDIES

4.1 EFFECT OF TEMPERATURE ON SORPTION CAPACITY OF LLL

Temperature is a crucial parameter in adsorption reaction, the effect of adsorption of metal on the substrate was determined at 30°C- 80°C. The result was used to investigate the thermodynamic of the sorption process according to (Micheal and Ayebeami, 2005; Sarin V *et al.*, 2006). A volume of 50cm³ of metal ion solution (100mg/cm³) was mixed with 0.5g of sample in a conical flask of 125cm³ to obtain a suspension; the suspension was adjusted to a 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°C 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°C to 80°C. The suspension was filtered using (no.42) whatman filter paper and then centrifuge at 2800 x g for 5min. The supernatants was collected in separate clean test tubes. The metal content at each temperature range was determined using AAS. The experiments were performed in triplicates. The results were used to investigate the thermodynamic of the biosorption process.

The thermodynamic constants such as Gibbs free energy change (ΔG°), enthalpy change (ΔH°) and entropy change (ΔS°) for the system and to ascertain the sorption mechanism. (Sarin *et al.*, 2006).

CALCULATION OF METAL UPTAKE

The amount of metal absorbed by the biosorbent.:

$$q_e = V(C_o - C_e) / M \quad (1)$$

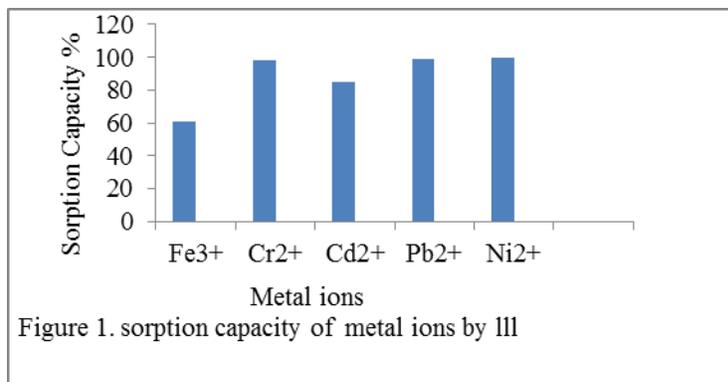
Where, q is the amount of metal ion adsorbed in mg/g; C is the initial metal ion concentration in mg/cm³; Ce is the final concentration in mg/cm³ V is the volume of metal ion solution in liters; M is the mass of the leaves, stem and root of *Lanchocarpus laxiflorus* powder used in gram. The percentage Removal of the metal ion was also determined using;

$$\text{Removal \%} = [(C_o - C_e) / C_o] \times 100 \quad (2)$$

Where, R% is the percentage of metal removed.

V. RESULTS AND DISCUSSION

The LLL was found to provide the lowest residual metal concentration in the case of Nickel, Lead and Chromium (of 0.1010mg/L, 0.0010mg/L and 0.0031mg/L) respectively with % removal from aqueous solution of 99.99, 99.98 and 99.89 respectively as shown on this “fig” 1



The Leaves part of the plant were found to provide the lowest removal capacity of iron 61%, followed by cadmium 85% ,lead 99% and nickel which gives removal capacity almost 100% , this could be due to the fact that heavy metal ion such as Ni (II) have

a strong affinity for protein of the cell wall(Kishore et al., 2012). The differences observed in the sorption for the various metal ions study, can be related to the differences in metal hydration free energy, and the type of functional groups present on the adsorbent and the metal chemistry of the solution (Shukla *et al.*, 2005), and the ability of metal to form covalent bond with ligand (Osemeahon *et al.*, 2012) and the nature of the surface sites available (Cooper *et al.*, 2002).

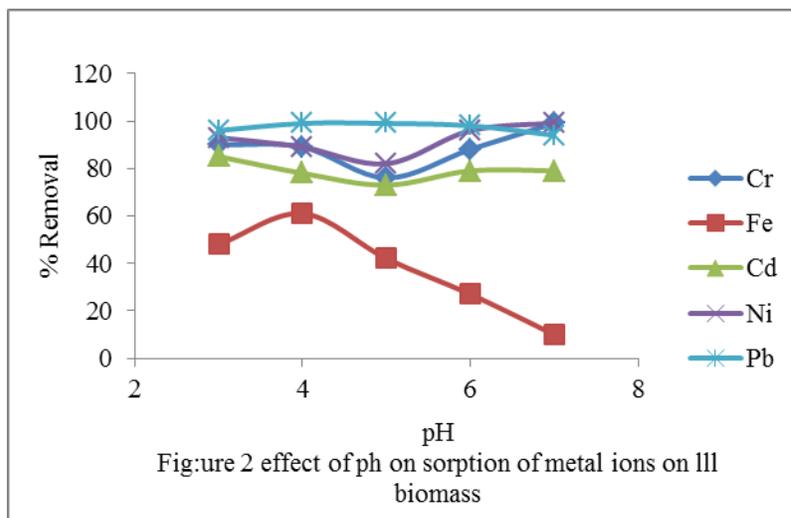
5.1 EFFECT OF pH ON THE METAL ION UPTAKE OF LONCHOCARPUS LAXIFLORUS LEAVE

For biosorption of heavy metal ions, pH is the most important environmental factor. The pH value of a solution strongly influences not only the site dissociation of the biomass surface, but also the solution chemistry of the heavy metals: hydrolysis. 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 on metal ion removal by LLL biomass was shown in figure 2. It can be seen that Fe was retained in solution at higher pH compared with other metal ions studied. The sorption capacity for Fe reaches a maximum at 60% at pH 4. The LLL sorption decreases sharply on further increase of the pH. As the capacity increases, reaches a maximum and then decreases steadily. The sorption capacity for pb increase steadily as the pH increased. Sorption capacity for Ni, Cr and Cd decreases sharply and increases as their pH values increases. At lower pH values below 5, there was excessive protonation of the active site at LLL surface and this often refuses the formation of links between metal ions and the active site (Jaber saleh, 2013). At higher pH values above 5-7, linked H⁺ is released from the active site and adsorbed amount of metal ions is generally found to increase. The LLL has a high selectivity for Pb, Cr and Ni with 99.86%, 98.75% and 99.49% at pH 5,7 and 7 respectively. For cadmium the sorption capacity was low compared to Pb, Cr and Ni.

Table 1: The pH for maximum sorption of the metal ions studied by LLL and the corresponding % removal are given below

Metal ion	pH for maximum Sorption	sorption capacity %
LLL		
Cd	3.0	85.08
Ni	7.0	99.49
Pb	5.0	99.86
Cr	6.0	98.75
Fe	7.0	61.00



5.2 effect of contact time

The effect of contact time on the uptake of metal ions chromium, Iron, Cadmium, Nickel and Lead by LLL, has been showed in “fig” 3. This was achieved by varying the contact time from 20-120 minutes. The adsorption of metal ions was increased at specific time and becomes constant when it reaches equilibrium. The initial rapid uptake was due to diffusion of metal ions onto the surface of adsorbent have reach equilibrium. In figure 3, the rapid uptake is about 89.94- 89.98% removal of chromium, 84- 90% removal of iron, 94.23- 94.42% removal of cadmium, 93.46-93.98% removal of nickel and 97.75- 98.41% removal of lead by LLL biomass. The fast initial uptake was due to the accumulation of metal ions on surface of adsorbent which is a rapid step. This may attributed to the highly porous structure

of adsorbents and the particle size, which provide large surface area for the sorption of metals on the binding sites (Nordiana *et al.*, 2013). The adsorption process was faster, it could be because of the largest amount of metal ions attached to the adsorbent within 30minutes. After the adsorption have increases up to 120minutes and almost constant that means it have reached equilibrium and the adsorption did not change with further increase in contact time. The constant stage probably due to the less abundant availability of active sites thus, the sorption becomes less efficient in constant stage (Singh *et al.*, 2006). The non uniform pattern of sorption observed could be attributed to non uniform surface area or binding of the biomass (Aderiah *et al.*, 2012).

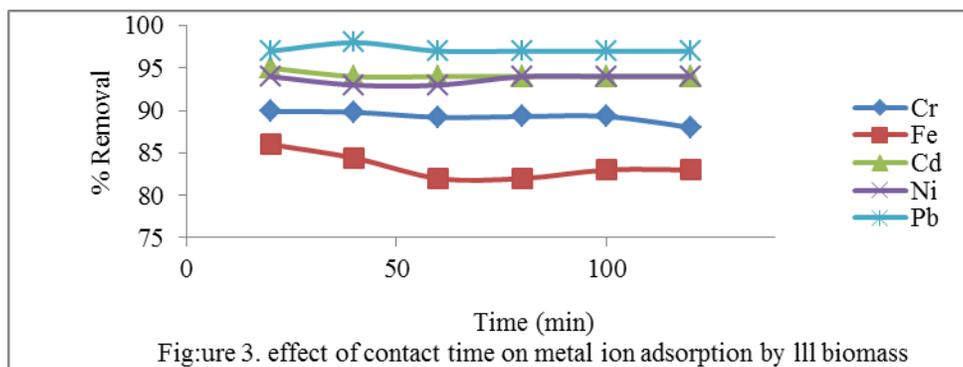
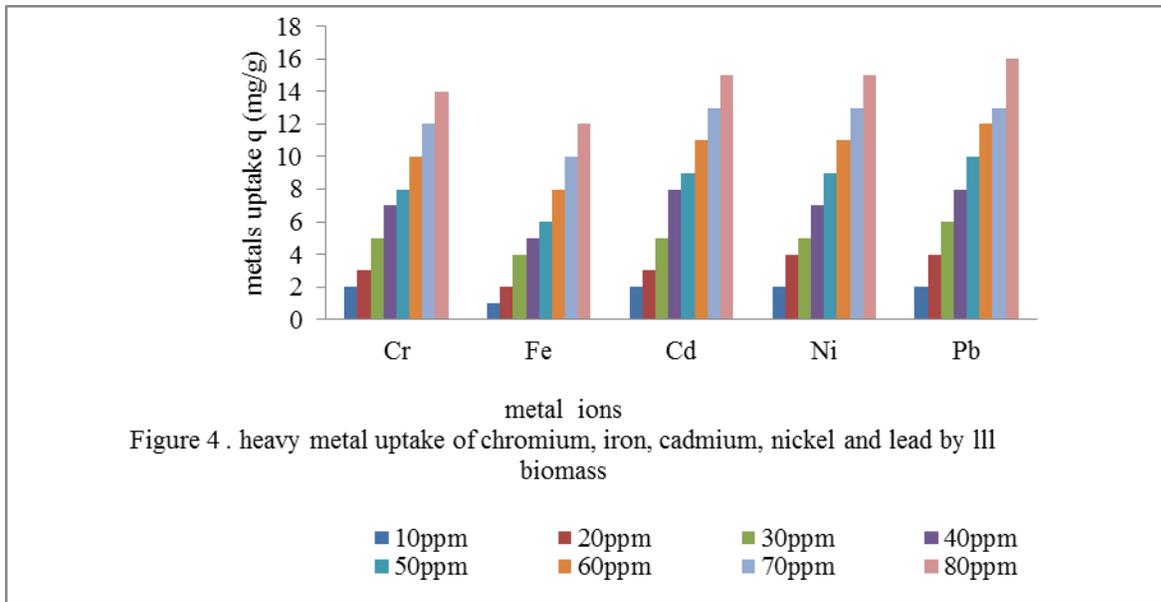


Figure 3. effect of contact time on metal ion adsorption by LLL biomass

5.3 EFFECT OF INITIAL METAL CONCENTRATION ON IMMOBILIZES LLL

The adsorption of metal ions concentration by immobilized *L.Laxiflorus* leaves biomass was studied at different metal concentration ranging from 10-80mg/cm³ at various (maximum) pH values. Sorption and removal of heavy metals by LLL biomass largely depend on the initial concentration of metals in the solution. In this study, metal sorption generally increases with increase in metal concentration in the solution and then became saturated after a certain concentration of metal (Nirmal and Cini, 2012). The differences in the metal ion removal could also be attributed to differences in the size (ionic radii) of the metals. For lead, the least metal uptake was observed at 10mg/L (90%) and highest percent removal at 60mg/L (98%). Metal uptake for Nickel was low at 10mg/L (90%) and exhibited constant values from 40-80mg/L (93%). The order of metal uptake for LLL biomass was found to be Pb>Ni>Cd>Cr>Fe.

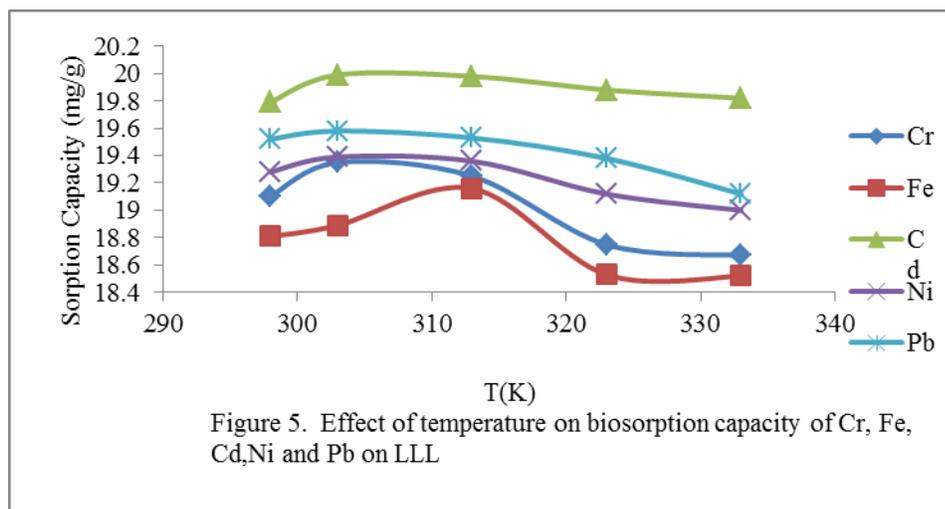
The rapid increases in the uptake of all the metal ions can be attributed to the interaction between the metal ions and the active sites of the adsorbent. This is because the higher the concentration of metal ions, the higher the amount of Cr, Fe, Cd, Ni and Pb present in the solution, thus the more adsorption of the metal ions occur on the adsorption site of the adsorbent. Otherwise at higher metal ion concentration/adsorbent ratio, metal ion adsorption involves higher energy sites. As the metal ion/adsorbent ratio increases result in the decreases adsorption efficiency (Nordiana *et al.*, 2013). These findings indicate that the biomass is effective in dilute metal solutions and also the ratio of sorptive surface of the biomass to metal availability is high. The same results were reported on immobilized biomass of *Rhizopus arrhizus* for chromium (vi) and Nickel biosorption (Prakasham *et al.*, 1999 ; Kumar *et al.*, 2012).



5.4 EFFECT OF TEMPERATURE ON THE SORPTION CAPACITY OF LLL

The effect of temperature on the biosorption capacity of metal ions on LLL was studied at different temperature in the range of 25^oC - 60^oC when initial concentration were 100 mg/L at maximum pH values as shown in figures 4. In general, the sorption of the metal ions increases slightly with increase in temperature up to 40^oC and then started decreasing. Temperature higher than 40^oC caused a change in the texture of the biomass and reduced its sorption capacity. This is because with increasing temperature, the attractive forces between biomass surface and metal ions are weakened and the sorption decreases (Horsfall *et al.*, 2005). Careful examination of figure 4 revealed that maximum removed was observed between the temperatures of 25

to 40^oC. The decrease in adsorption with increasing temperature, suggest weak adsorption interaction between biomass 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 and preferred at lower temperature. For chemisorptions, the overall heat of sorption is combination of heat of various reactions taking place at sorption sites. It depends on type of metals and adsorbent, which is the reason for having different behavior of Cr, Fe, Cd, Ni and Pb uptake with different temperatures. In this investigation temperatures of 30 and 45^oC is the optimal temperature of adsorption for selected heavy metals.



VI. THERMODYNAMICS PARAMETERS

The thermodynamic parameters such as standard Gibbs free energy, ΔG° , enthalpy, ΔH° and entropy, ΔS° changes were estimated to evaluate the feasibility and nature of the adsorption process. The values of enthalpy change (ΔH°) and entropy change (ΔS°) for the adsorption process for all the metals ion studied using *Lonchocarpus Laxiflorus* plant in aqueous solutions were obtained from the slope and intercept of the plot $\ln K_c$ versus $1/T$, and the calculated values of thermodynamic parameters are compiled in Table (2). As shown in the table, the negative values of ΔG° confirm the feasibility of the process and

the spontaneous nature of sorption. The values of ΔH° for the adsorption of the metal ions on LLL, are negative, indicating that the sorption reactions are exothermic and low temperature makes the adsorption easy. Moreover, the negative values of ΔS° and ΔG° demonstrated a decrease in adsorption energy and an increase in the feasibility of adsorption process at lower temperature. The positive values of ΔS° show the increasing randomness at the solid/liquid interface during the adsorption of heavy metals onto LLL, biomass. It also suggests some structural changes in the adsorbate and the adsorbent (Hassan *et al.*, 2011).

Table: 2 Thermodynamic parameters at various temperatures for Cr(II), Fe(III), Cd(II), Ni(II) and Pb(II) biosorption on LLL

Metal ions	- ΔG° (KJ/mol)					- ΔH° (KJ/mol)	ΔS° (J K ⁻¹ mol ⁻¹)
	298K	303K	313K	323K	333K		
Cr	6.7	6.8	6.8	8.3	8.5	8.48	0.52
Fe	6.2	6.45	6.56	6.59	8.3	21.9	4.75
Cd	5.42	11.46	13.31	18.35	22.14	152.32	43.37
Ni	7.58	7.92	8.42	8.74	8.83	19.78	3.60
Pb	9.39	9.39	9.46	9.5	9.61	11.41	0.62

VII. CONCLUSION

Based on the present investigation, it could be concluded that some low cost materials like *Lonchocarpus Laxiflorus* can be used efficiently in the removal of heavy metal ions (Fe^{3+} , Pb^{2+} , Cr^{2+} , Cd^{2+} and Ni^{2+}). The sorption of heavy metal ions by LLL has been shown to be dependent upon pH, with best sorption occurring between pH 3 and 7 and time was 20 -40 min . Also, the sorption mechanism for these metals is a stable, rapid process which implies that the sorption is taking place on the cell wall surface of the *Lonchocarpus Laxiflorus* . The studies have shown that *Lonchocarpus Laxiflorus* possessed the ability to bind appreciable amounts of Fe, Cr, Cd, Pb and Ni ions as compared with other biosorbents. This ability to remove heavy metals from solution indicates the tremendous potential that the *Lonchocarpus Laxiflorus* could have for cleaning the environment and industrial waste effluents from toxic metal ions. Therefore *Lonchocarpus Laxiflorus* could be used as an alternative, inexpensive material to remove high amount of toxic metals from wastewater.

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