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Biosorption of Lead and Nickel by *Medicago sativa* (alfalfa) and *Datura* from Contaminated Solution

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A series of batch adsorption experiment carried out to determine alfalfa and *Datura* (died biomass) biosorption capability to Pb and Ni removal from contaminated solution. Data showed that these adsorbent could remove about 94-99 % Pb and 30-50 % Ni that exist in polluted solution. However, *Datura* has a great affinity and capacity to metal binding compared with alfalfa. For all the metal studies, binding speed to adsorbent is high and occurred within 5 min.

Key Words: Biosorption, Freundlich equation, Heavy metal.

INTRODUCTION

The entrance and accumulation of heavy metals into soil and water ecosystems from different industrial activities become a concern due to growing health risk of the public. Hence, there has been a large interest in the removal of heavy metal ions from contaminated environment. Methods that traditionally employed for water remediation consist of removal of heavy metal by filtration, flocculation, activated charcoal and ion exchange resins[1-4]. However, because of the high cost of these methods, development of a more cost effective remediation system is required[1,5]. Many studies have shown that biosorption of heavy metals, as result of interaction with anionic ligand in biological material, has many advantages[6-10]. These include high efficiency of metal removal and the low operational cost compared to other conventional physicochemical metal removal technologies[5-7]. Thus the majority of the recent works was focused on the phytofiltration as a new method for heavy metal removal[7-10]. Since chemical functional groups are most likely responsible for metal binding, it is likely that higher plant cell also be capable of metal binding[11-13]. Investigation by scientist has showed binding capacity of died biomass of plant to heavy metal. For examples Iqbal *et al.*[11] showed that Petiolar Palm could adsorbed 11/4 mg/g Pb and 6.89 mg/g Ni from contaminated solution. Gardea *et al.*[9] revealed that Hops ability for Pb banding is 74.2 mg/g.

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EXPERIMENTAL

Plant collection and preparation: Alfalfa and *Datura* plant samples were collected from the field study in Ferdowsi University of Mashhad. The plants were removed from the soil separately, washed and the roots were removed from shoot material and then oven dried at 70 °C for 4 days. Dried samples were ground to pass through a 70 mesh sieve. After sieving plant's biomass separately was washed twice with 0.01 M HCl to remove any debris or soluble bimolecular that might interact with metal ions and then oven dried at 70 °C. In all the experiments, the solution pH is maintained to 5, which is best pH for biosorption[7,9,13].

Time dependence studies for metal binding: 2.5 g of prepared samples separately were added into 50 mL of Ni and Pb solution (50 mg/L, pH = 5) in three replications, then incubated in the 25 °C for 5, 10, 15, 20, 30, 45, 60, 120 min. After finishing each time treatment period, 1 mL from each sample was picked up and centrifuged, then residual metal concentration determined by atomic absorption spectrophotometer (Shimadzu AA-670).

Initial concentration studies for metal binding: 0.5 g of prepared samples separately was added into 20 mL of 5 different levels of Ni and Pb solution (30, 50, 100, 150 and 200 mg/L, pH = 5) in 3 replications and incubated in 25 °C. In maximum adsorption time (5 min), residual concentration was determined similar to time dependency experiment.

Competitive effects of studies for metal binding: 2.5 g of prepared samples were added to 50 mL of synchronous 50 mg/L solution of Pb and Ni (pH = 4) in 3 replications and incubated in 25 °C. Then, concentration of each metal was measured after 5, 10, 15, 25, 35, 45, 60 and 120 min similar to pervious experiments.

Freundlich isotherm equation: $\ln H = (1/n) \ln C_e + \ln K_d$ was used to obtain adsorption coefficient, where H is the adsorption capacity in absorbed heavy metal per unit biosorbent (mg/L), C_e is metal ion concentration in equilibrium (mg/L), n and K_d are constant of Freundlich related to affinity and capacity, respectively.

RESULTS AND DISCUSSION

Time experiment: Time dependency of heavy metal biosorption experiment showed that Pb and Ni adsorption by alfalfa and *Datura* is very rapid and accrued within 5 min and was relatively stable there after (Fig. 1). The rapid uptake of Pb and Ni from solution probably suggests that the binding site are cell wall component and that the metal ions are not diffusing through the cell wall and cell wall functional groups has a strong affinity to heavy metal binding. This result in agreement with Gardea *et al*.[9] who reported that maximum biosorption of heavy metal by African alfalfa accrued in 5 min. Shekhar *et al*.[10] showed that Pb adsorption by *Hemidesmus indicus* performed at 15 min.

Fig. 1 also shows that both alfalfa and *Datura* have higher affinity to lead in respect to Ni and maximal and minimal adsorption in each adsorbent belong to Pb and Ni, respectively. Adsorption trend of Pb and Ni was similar in this two adsorbent.

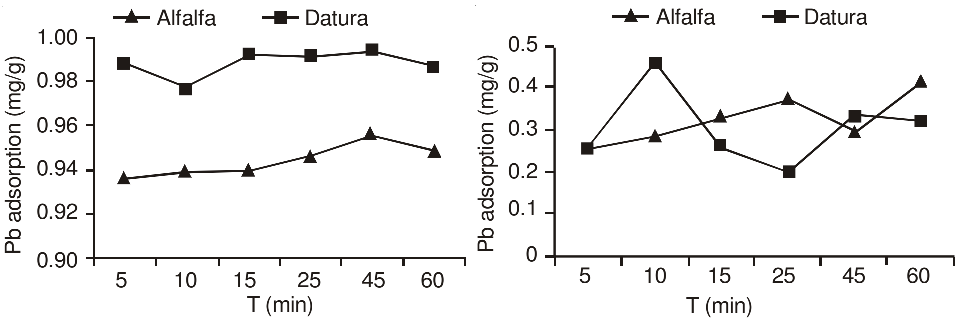


Fig. 1. Effect of time on Pb and Ni biosorption pattern by alfalfa and *Datura*

Competitive effects experiment: There was no interaction between Pb and Ni for adsorption by either alfalfa or *Datura*. Although it was reported that simultaneous presence of heavy metal can affect their adsorption pattern[3,6,8]. Shekhar *et al.*[10] reported that simultaneous presence of Pb, Zn and Cr increased Zn biosorption, decreased Cr biosorption by *Hemidesmus indicus* whereas Pb was not affected. Probably, these results derived from heavy metal competition for occupying bind site[6,7]. The result of this study might prove the existence of special functional groups on the biological matter of alfalfa and *Datura*, which have specific affinity to Pb and Ni.

Initial concentration effects experiment: Present results showed that the amount of Pb and Ni biosorption is dependent on their initial concentrations and the biosorption of both elements was increased with rising initial concentrations (Figs. 2 and 3). In the higher concentrations, Pb is adsorbed more than Ni in both alfalfa and *Datura* plants. Adsorption trend of Pb and Ni were similar in alfalfa and *Datura*. The increasing trend would continue until the active adsorbing sites became saturated. This increasing trend may depend on some properties of metal sorbantes

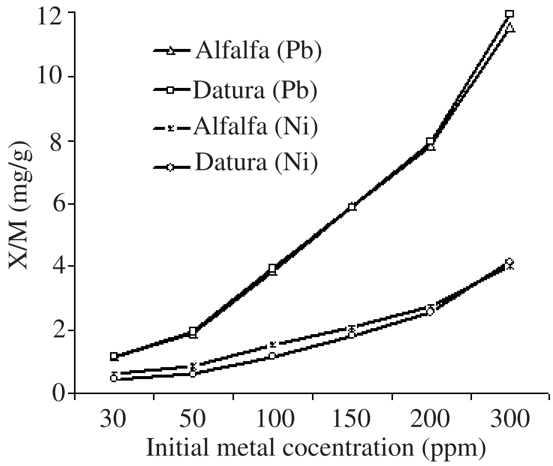


Fig. 2. Effect of initial concentration to Pb and Ni adsorption capacity by Alfalfa and *Datura*

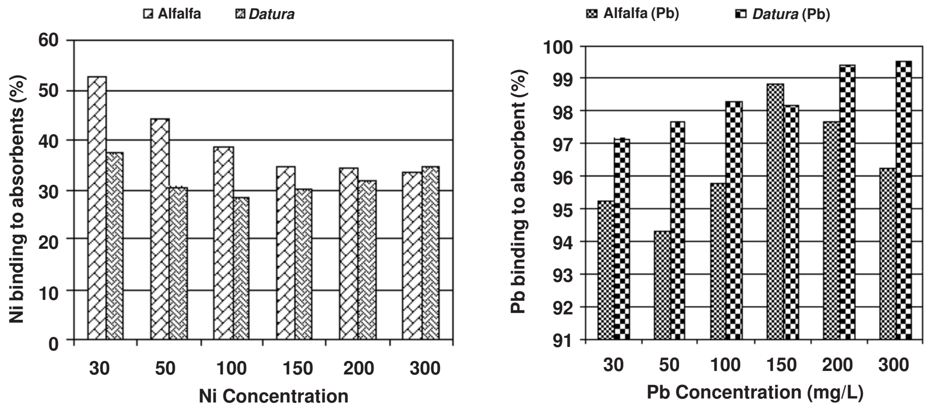
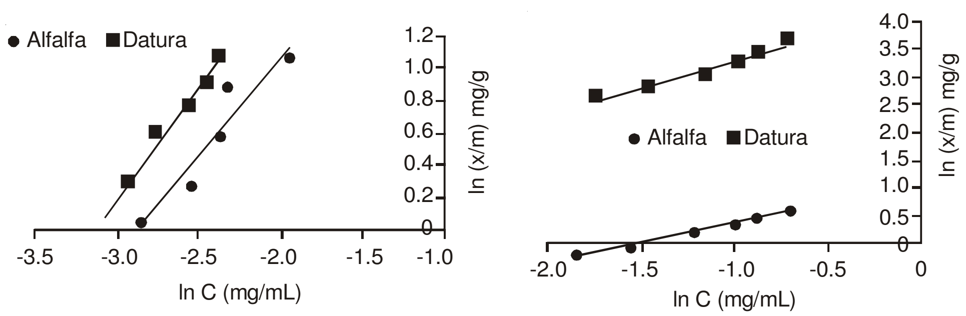


Fig. 3. Alfalfa and *Datura* binding capacity to Pb and Ni in different concentration

such as ionic size, reduction potential of metal and properties of the biosorbent (structure, functional group and surface area)[3-6]. Alfalfa and *Datura* could adsorb from 33-53 % of the existence Ni and from 94-98 % of Pb from the solution with different concentrations. *Datura* ability to Pb binding from their solution with same concentration higher than Alfalfa (Fig. 3).

Freundlich adsorption isotherm: Freundlich model plots for adsorption of Pb and Ni by alfalfa and *Datura* is shown in Fig. 4. These results can be explained by Freundlich and Longmuir models, which are used to describe the biosorption equilibrium[3,6,11]. The regression correlation coefficient for all metal in two absorbent are very high (Table-1). Different value of n between Pb and Ni showed that sorption affinity to biosorbents was differing and in Pb higher than Ni. *Datura* has great affinity to Ni adsorption compared with alfalfa. The higher K_d value for the two biosorbents indicated that there is more capacity to adsorption and thus more sorption sites available for metal uptake. K_d values in *Datura* was very higher than alfalfa and indicated that extraordinary adsorption capacity of *Datura* for Pb and especially Ni adsorption compared with alfalfa.



(a) (b)

Fig. 4. Fitting Freundlich model for Pb (a) and Ni (b) adsorption with Alfalfa and *Datura*

TABLE-1
COEFFICIENTS OF FREUNDLICH ADSORPTION FOR LEAD AND NICKEL BY ALFALFA AND *Datura*

Crop	Lead			Nickel		
	n	K_d	R^2	n	K_d	R^2
Alfalfa	0.832917	2928.20	0.89	1.433897	11.26419	0.98
Datura	0.726216	21252.01	0.98	1.05552	16504.41	0.97

Conclusion

In summary, died biomass of alfalfa and *Datura* have the potential to bind Pb and Ni from aqueous solutions. However, the binding capacity of *Datura* was higher than alfalfa. Hence, these crops could be a good agent for using in a more practical and economical method for heavy metal removal. Furthermore, the binding capacity of these species is depended on the initial concentration of Pb and Ni.

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