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Studies on Biosorption of Lead by Living Biomass of Fungal Species

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Abstract: ***Heavy metal pollution of water bodies currently becomes a major environmental problem throughout the entire world.Conventional treatment methods for the removal of heavy metal ions from wastewaters are highly expensive, timeconsuming, less effective and are not environmental friendly because they produced large quantity of toxic chemical compounds. Biosorption is an alternative technology to conventional treatment method for the removal of heavy metal from aqueous solution. Biosorbent (biological materials) have been used as for the adsorption of metal ions from aqueous solutions. In the present study, the efficiency of living biomass of Aspergillusniger for the adsorption of lead metal was investigated. Living biomass of Aspergillusniger(100 mg and 200 mg) and contact time of 15 minutes showed that most appropriate dose and duration for the use in adsorption of lead metal ions. For the biosorption of lead metal solution, maximum adsorption capacity of 100 mg Aspergillusniger biomass was observed as 95.715% at 80ppm concentration. 97.192% metal removal was observed from the 80ppm metal concentration by 200 mg fungal biomass.In case of 100 mg biomass, the maximum specific uptake (Q value) was 38.286 at 80ppm concentration. In case of 200 mg biomass, the maximum Q value 19.4835 was observed at 80ppm lead concentration. This study indicates that 100 mg and 200 mg living biomass of Aspergillusniger acts as a good biosorbent for the adsorption of lead metal.***

Keywords: *Aspergillusniger*, biosorption, contact time, heavy metal pollution, lead metal, Q value

1. Introduction

Contamination of water bodies frequently occurred by organic pollutant and heavy metals as a result of human activities and become a major problem being faced by the world today. From industrial waste water and human activities several toxic metals such as Cd, Cu, Hg, Pb, As, Ni, Zn and Mn etc. are released directly or indirectly into the environment. For most of the organisms Cu, Fe, Mn and Zn acts as micronutrients, but not for all living organisms.Cations generally increases the stability of membranes and play specific role in maintaining the structures of nucleic acids, functional and metabolic activities. When the concentration of beneficial metals such as cadmium, lead and mercury increased in the environment, then they become much more toxic. Therefore, the removal of these heavy metals from the waterbodies or environment is highly essential for the protection of living organisms and environment.

Lead is a toxicheavy metal with atomic number 82, widespread use of lead has caused extensive environmental contamination and health problems in many parts of the world. It acts as a neurotoxin that accumulates in soft tissues and bones, damages the nervous system and causes blood disorder. Children are very prone to the neurotoxic effects of lead, and even relatively low levels of exposure can cause serious irreversible neurological damage.

The conventional methods for the removal of heavy metals from industrial discharge include chemical extraction, precipitation, ion exchange, reverseosmosis, electrochemical treatment (Blanco *et al*., 1999). Due to their toxicity and mutagenicity, these chemical methods create serious health and ecological problems. Most of these physio-chemical techniques are highly expensive especially for handling large amount of water and wastewater contains heavy metals in low concentration. Therefore, several innovative treatment technologies are needed for the removal of heavy metals from wastewater.

Khan et al. (1997) suggested that bioremediation techniques can serve as the alternative methods for removing the heavy metals from the contaminated soils or waters.Bioremediation is considered as an alternative method by which inorganic and organic waste biologically degraded or transformed into less toxic forms. The principles of bioremediation can be divided into various methods such as bioventing, biosorption, bioaugmentation, bioreactor, land farming and biostimulation. For the treatment of wastewater, adsorption is generally preferred for the removal of heavy metal ions due to its high efficiency, easy handling, availability of different adsorbents, and costeffectiveness.

Umrania(2006) suggested that microbiological processes have potential application in bioremediation of metal pollution and the biomass of microbes can be used for the decontamination of metal bearing wastewaters. Metals ions are bound with the surfaces of biological material, and then metabolism dependent intracellular uptake, whereby metal ions are transported across the cell membrane. (Costa, et.al., 1991, Gadd et.al., 1988, Gourdon et.al., 1990, Huang et.al., 1990., Nourbaksh et.al., 1994).*Aspergillus* sp. Proved to be capable of removing heavy metals from different substrate by the various workers.*Aspergillusniger* has been used for the removal of metal ion from environment either by complex

formation of metal ions with organic acids produced by the fungi or by the adsorption of metal ions to the component of fungal cell wall (Akhtar and Mohan,1995).Therefore, the present investigation is based on two objectives:

(a)The ability of living biomass of *Aspergillusniger* to adsorb lead metal solutions;
(b) The impact of different concentrations of lead (as lead nitrate) metal solutions on the biosorptive capacity of living biomass of *Aspergillusniger*

2. Materials and Methods

Approximately,1 kg of soils were collected (apparently free from pollution) from agriculture fields. The upper layer of soil was removed and then soil samples were taken into the laboratory in fresh sterile polythene bags. Dilution plate method was used for the isolation of soil fungi from soil samples.

2.1 Preparation of fungal biomass

Aspergillusniger isolated from the soil samples was selected for the biosorption studies of lead, pure culture of Aspergillus*niger was* prepared on PDA(potato dextrose agar) medium. MGYP broth medium was prepared for the biomass preparation of *Aspergillusniger* .

2.2 Preparation of lead solution of different concentrations

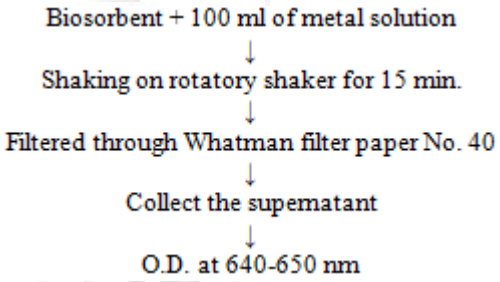
Lead as lead nitrate was used to evaluate the potential of fungal(*Aspergillusniger)* biomass to adsorb metal.Stock solutions of metal were prepared in a manner so as to obtain following different concentrations of metal solution i.e., 10ppm, 20ppm, 40ppm, 80ppm.

3. Biosorption of lead using living biomass of *Aspergillusniger*

The method followed by Bhole et al. (2004) was adopted with slight modification to determine the efficiency of living biomass of *Aspergillusniger* for the biosorption of lead as lead nitrate.
50 ml of 10ppm solution of lead was taken into each of 6 flasks. Similarly, a set of 6 flasks were used for each of the 20ppm, 40ppm, and 80ppm concentrations of lead.Fungal biomass was then added into these flasks as under:

1) 10ppm lead nitrate solution (control i.e., without fungal biomass) (3 flasks)
2) 10ppm lead nitrate solution + 100mg fungal biomass (3 flasks)
3) 10ppm lead nitrate solution + 200mg fungal biomass (3 flasks)
4) 20ppm lead nitrate solution (control i.e., without fungal biomass) (3 flasks)
5) 20ppm lead nitrate solution + 100mg fungal biomass (3 flasks)
6) 20ppm lead nitrate solution + 200mg fungal biomass (3 flasks)
7) 40ppm lead nitrate solution (control i.e., without fungal biomass) (3 flasks)
8) 40ppm lead nitrate solution +100mg fungal biomass (3 flasks)
9) 40ppm lead nitrate solution + 200mg fungal biomass (3 flasks)
10) 80ppm lead nitrate solution (control i.e., without fungal biomass) (3 flasks)
11) 80ppm lead nitrate solution + 100mg fungal biomass (3 flasks)
12) 80ppm lead nitrate solution + 200mg fungal biomass (3 flasks)

Now all these flasks were placed on a rotatory shaker for 15 minutes. After a contact period of 15 minutes, the biomass of fungi was separated by filtering the mixture using Whatman filter paper No. 40 to prevent the probable interference of turbidity. Thefiltrate was then further processed to examine the concentration of lead remaining in the solution. Now the content of 3 flasks of each set were mixed together to get a composite solution for visible spectrophotometery.With the help of visible spectrophotometer , the concentration of remaining lead in the supernatant was examined at wavelength of 640-650nm.



The amount of metal bound by the biosorbent was calculated as Follows (Hussein et al. 2004)

$$Q = V (Ci - Cf) / m$$

Where,
Q is the metal (Lead) uptake (mg lead per g biosorbent),
V is the liquid sample volume (ml),
Ci is the initial concentration of lead in solution (mg/l),
Cf is the final concentration of lead in solution (mg/l),
m is the amount of the added biosorbent on the dry basis (mg),

Similarly, biosorption efficiency (R %) of the particular biomass can be calculated as:

$$R = [(Ci – Cf)/ Ci] \times 100 \ \%$$

The biosorptive efficiency of a particular biomass of test fungi and its particular quantity was interpreted as under:

1. 0-10	Very poor
2. 10-20	Poor
3. 20-40	Moderate
4. 40-60	Good
5. 60-80	Very good
F. 80-100	Excellent

4. Result and Discussion

The present investigation was conducted to examine the biosorptive efficiency of living biomass of *Aspergillusniger* to adsorb lead from the solutions of different concentrations of lead(as lead nitrate).Different amount of living biomass of fungi as biosorbent i.e., 100 mg and 200 mg were allowed the lead from solutions of test metal solutions. After the contact period of 15 minutes, the observation were taken.The results obtained are presented in the Table 1.This study indicates that the living biomass of *Aspergillusniger* is quite effective material for the biosorption of lead metal.

A glance at the table 1 and fig. 1 reveals that:

As much as 95.715% could be adsorbed in 100 mg biomass after the contact period of 15 minutes at the higher concentration of metal in solution i.e., 80 ppm.While at the lower concentrations, from 10 ppm to 40ppm the biosorption of lead by living biomass of *Aspergillusniger* increased effectively from 31.28% at 10ppm, 68.90 % at 20ppm and 90.895 % at 40ppm.

The increase in living biomass of *Aspergillusniger* from 100 mg to 200 mg led to increase in the biosorption percentage up to 97.192 %. In case of 100 mg biomass, the maximum specific uptake (Q value) was noticed at 80ppm concentration i.e., 38.286, followed by 18.179 at 40ppm, 6.89 at 20ppm and 1.564 at 10ppm concentrations of metal (Table 1, fig.1).In case of 200 mg biomass of *Aspergillusniger*, the pattern of increase in biosorptionwas also noticed as in case of 100 mg biomass of fungi. About 97.192% metal removal was observed from the 80ppm metal concentration by 200 mg fungal biomass. A gradual increase in biosorption was observed, but exceptionally, a negligible reduction was noticed in the biosorption from 57.92% at 10ppm to 56.74% at 20ppm.Further increase in metal concentration was observed that gave a positive indication on the biosorption and led to increase in the efficiency of biosorption from 56.74% at 20ppm to 88.315% at 40ppm concentration of lead.

In case of 200 mg biomass, Table 2, fig. 2, showed that the maximum Q value 19.4835was observed at 80ppm lead concentration, followed by 8.8315 at 40ppm, 2.837 at 20ppm and 1.448 at 10ppm concentrations of metal solution. The Qvalues indicated that increase in biomass caused a great decrease in the specific metal uptake per mg of biomass. Some worker noticed that the initial concentrations of lead in the solution have a great influence on the sorption rate of metals by fungal biomass and it was also observed that the adsorption of metal ions increase upto a greater extent with the increase in initial concentration of metal ions. Fromthe present study it is cleared that the biomass amount for the biosorption of all the concentrations of test metal at a particular incubation period can be adjusted.Chauhan et al. (2002) reported that distance between the biosorbent particles is reduced due to the presence of higher concentration of biomass in the solution. Jaikumar and Ramamurthi (2009) reported that with the increase in biosorbent dosage the biosorption capacity decreased.

Table 1: Biosorption of Lead (as lead nitrate) from aqueous solution of different concentrations by living biomass (100 mg) of Aspergillusniger L.

Amount of Biomass	Initial Conc. of lead in the solution (ppm)	Final Conc.of lead in the solution (ppm)	Amount of lead adsorbed(ppm)	Percentage of lead adsorbed	Q-value
100 mg	10ppm	6.872	3.128	31.28%	1.564
	20	6.220	13.78	68.90%	6.89
	40	3.642	36.358	90.895%	18.179
	80	3.428	76.572	95.715%	38.286

Table 2: Biosorption of Lead (as lead nitrate) from aqueous solution of different concentrations by living biomass (200 mg) of Aspergillusniger L

Amount of Biomass	Initial Conc. of lead in the solution (ppm)	Final Conc. of lead in the solution (ppm)	Amount of lead adsorbed (ppm)	Percentage of lead adsorbed	Q-value
200 mg	10	4.208	5.792	57.92%	1.448
	20	8.652	11.348	56.74%	2.837
	40	4.674	35.326	88.315%	8.8315
	80	2.246	77.754	97.1925%	19.4835

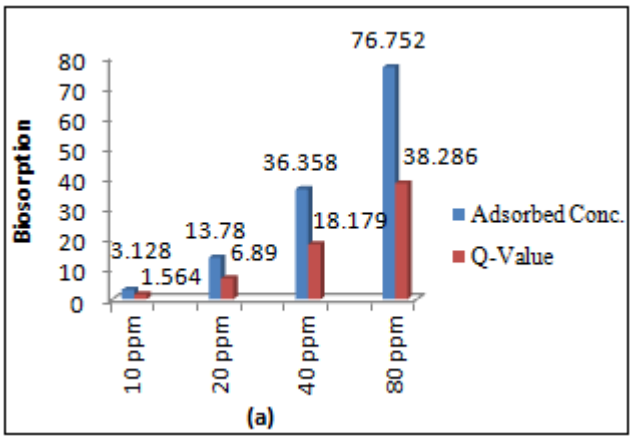


Figure 1 (a): Biosorption of Lead

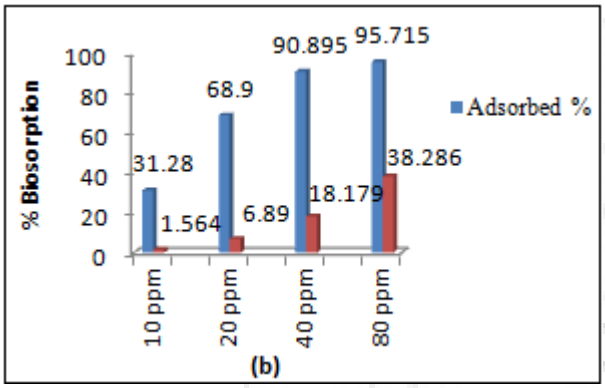


Figure 1 (b): Lead biosorption % profile of living biomass (100 mg) of *Aspergillusniger*L.

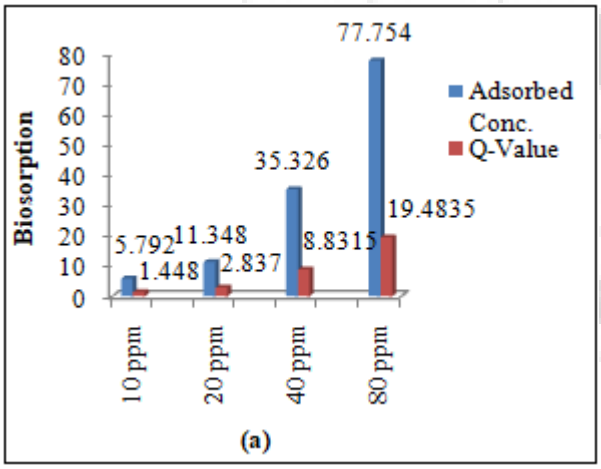


Figure 2 (a): Biosorption of Lead

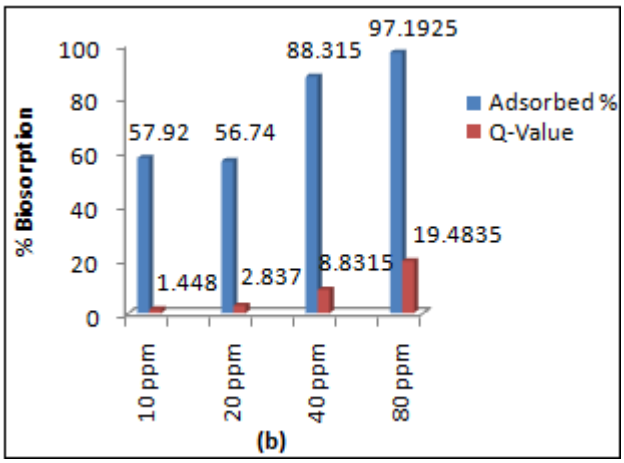


Figure 2 (b): Lead biosorption % profile of living biomass (200 mg) of *Aspergillusniger* L.

5. Conclusion

The present investigation indicated that the living biomass of *Aspergillusniger* is very effective biosorbent for lead metal and it can be used for adsorption based heavy metal treatment system. Present study indicated that the maximum dose of fungal biomass i.e., 200 mg was the most effective concentration for the biosorption of lead metal in comparison to the 100 mg fungal biomass. Present study clearly indicated that biosorption efficiency increase with the increasing amount of biomass and biosorption of lead metal ions by living biomass of *Aspergillusniger* is a cost-effective and eco-friendly technology. The living biomass of *Aspergillusniger* can be used as a major component for the management of heavy metal pollution.Conventional methods for the removal of heavy metal contamination from aqueous solutions are time consuming and are not economically and environmental friendly.An alternative to the conventional method, biosorption is quite effective solution for controlling the environmental pollutants and highly efficient for the removal of heavy metal pollutants from aqueous solution.

References

[1] Akthar,M.N. and Mohan,P.M.(1995). Bioremediation of toxic metal ions from polluted lake waters and industrial effluents by fungal biosorbents.*Curr.Sci*. 69: 1028-1030.

[2] Bhole, B.D., Ganguly, B., Madhuram, A., Deshpande, D. and J. Joshi (2004). Biosorption of methyl violet, basic fuchsin and their mixture using dead fungal biomass.*Curr. Sci*. 86: 1641–1644.

[3] Blanco, B.N. and Vardhan, V. (1999). Biosorption of heavy metals to immobilized *Phormidiumlaminosum* biomass. *Afr.J. Biotech*. **69:** 227-240.

[4] Chauhan, P., Mohan, M.,Sarangi, R.K.,Kumari,B.,Nayak,S.R. and Matandkar,S.G.P.(2002).Surface chlorophyll a estimation in the Arabian sea using IRS- P4 Ocean colour monitor (OCM) satellite data.*Int. J. Remote sensing*,23, pp.663-676.

[5] Chauhan, J. (2005). Effect of fungal pretreatment on the capacity of *Parthenium* leaves biomass to adsorb certain metals. M.Phil. Dissertation.
[6] Costa,A.A.A. and Leite,S.G.C.(1991).Metal biosorption by sodium alginate immobilized Chlorella homosphaera. *Biotechnol.Lett* 13: 559-562.
[7] Gadd,G.M., White,C., and Rome,de,L.(1988).Heavy metal and radio-nuclide uptake by fungi and yeast. In *Biohydrometallurgy: Proceedings of the international symposium*,(Eds.Norris, P.R. and D.P.Kelly) *Sci.Tech.Let*: Kew Surrey,U.K.pp.421-436.
[8] Gourdan,R.Bhande,S.,Rus,E. and Sofer,S.S.(1990). Comparison of cadmium biosorption by gram positive and gram negative bacteria from activated sludge. *Biotechnol.Lett.* 12: 839-842.
[9] Haung,H.,Cao,L.,Wan,Y.,Zhang,R.,andWang,W.(2012).B iosorption behavior and mechanism of heavy metals by the fruiting body of jelly fungus(*Auriculariapolytricha*) fron aqueous solutions. *Applied Microbiology and Biotechnology*.96(3):pp.829-8240.
[10] Jaikumar,V. and Ramamurthy,V.(2009).Effect of biosorption parameter kinetics isotherm and thermodynamics for acid green dye biosorption from aqueous solution by brewery waste.*Int. J. of Chemistry*.1, pp. 2-12.
[11] Khan,A.G., Bari,A.,Choudhary,T.M. and Qazilbash,A.A.(1997).phytoremediation strategy to decontaminate heavy metal polluted soils and to conserve the Biodiversity of Pakistan soils. *In: Mufti,S.A.,Woods,C.A.,Hasan,S.A.Biodiversity of Pakistan Museum of Natural History,Islamabad and Florida Museum of Natural History, Gainesville,Florida*.
[12] Nourbaksh, M., Sag, Y., Ozer, D., Aksu, Z. and Çaglar, A (1994).A comparative study of various biosorbents for removal of chromium(VI) ions from industrial wastewaters. *Process Biochemistry*. 29: 1-5.
[13] Umrania, V.V.(2006).Bioremediation of toxic heavy metals using acidothermophilicautotrophes.*Bioresource Technology*, 97, pp.1237-1242.