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Analysis of Heavy Metal Degradation by Microfungi

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ABSTRACT

In the present investigation suggests that screening of heavy metal degradation by microfungi. Some of the microfungi were isolated from heavy metal contaminated soil samples. The percentage degradation was high in *Trichoderma viride* followed by *Aspergillus awamori, A.fumigatus, A.niger, Penicillium chrysogenum, Penicillium* sp, *P.citrinum, Fusarium* sp, *F.solani* and *Trichoderma harzianum* were screening. The specific heavy metal such as magnesium sulphate, zinc sulphate, copper sulphate and lead acetate with different concentration of 100, 200, 300, 400 and 500 mg/l was treated with PD broth. Among the four heavy metal degradation process with the maximum percentage of magnesium sulphate heavy metal degraded by potential microfungi. However less concentration of heavy metal was maximum percentage of degradation when compared with high concentration because molecular oxidation and reduction process was very easy. The potential microfungi T.viride was excellent degradation not only the low concentration but also high concentration of heavy metal due to the that native isolates of microfungi.

Introduction

Environmental pollution is nothing but a misplaced resource; it is truer in context of the heavy metal ions. Environmental pollution due to toxic heavy metals is the major issue of the twenty first century. Heavy metals such as iron, manganese, mercury, lead, zinc, cadmium, uranium, chromium and several others are corner stones of human progress; they are quite literally the pillars of all the major civilizations, past and present because they are used widely as part of materials construction, agriculture, transportation, and in processing of many industrial materials and commercial products (Spiegel *et al*., 1985). With the rapid development of many industries such as mining (Navarro *et al*., 2008, Brumelis *et al*., 1999) and agriculture (Vaalgamaa and Conley, 2008) as well as from natural activities, heavy metals have been discharged into the environment as a result of anthropogenic processes. Chemical and metallurgical manufacturing the main sources of metal ions in the environment (Cortes *et al*., 2003). Heavy metals present in contaminated soil may pose a threat to human health if these metals enter into the food chain.

Biosorption capacity may vary extensively and mainly it is depending upon the metal ions and biosorbent involved in the processes, the use of denatured biomass can be of great concern. With these dead biomasses, heavy metal ions were clearly accumulated on cell walls, while no specific molecules were found as particular sites for metal chelating. The metal recovery and biomass production is considered as essential to get rid of metals toxicity for microbial growth, or suppression of metal addition through nutrients or excreted metabolites (Fourest and Roux, 1992).

Filamentous fungi are employed in fermentation industries to generate diverse metabolites for example antibiotics and enzymes, etc.

The fungi showed a great affinity for metal ions as compared to other microbes. These can accumulate metals by means of biological and physiochemical mechanisms from their external environment (Cabuk *et al*., 2004 and Preetha and Viruthagiri, 2005). All filamentous fungi belonging to Zygomycetes group (Madigan, 2000), in addition to small quantity of protein, contain large amounts of polymer of N-acetyl, chitin and chitosan, and deacetylated glucose-amine on their cell wall. Therefore, large amounts of potential binding sites are showed by free hydroxyl groups, amine and carboxyl. The amine group containing nitrogen atom and the hydroxyl group containing oxygen atom have ability to bind a proton or a metal ion, respectively, follow the electron pair sharing phenomenon. However, the electro-negativity of oxygen is higher than that of nitrogen; therefore a lone pair of electrons donated from the nitrogen will be more facile than that of the oxygen atom in the formation of metal complex (Das *et al*., 2004).

Results and Discussion

In the present investigations suggests that the fungal population present in metal polluted environment have adapted with constant parameters. *T.viride* was maximum potential resource was 78, 83, 85, 76 and 71 percentage degradation with 100, 200, 300, 400 and 500 mg/L of magnesium sulphate heavy metal accumulated respectively. The higher concentration of heavy metal was not suitable for degradation process because low concentration was high percentage degraded (100mg/L) in four heavy metals. The other filamentous fungi of *A.awamori*, *A.fumigatus*, *A.niger*, *Fusarium* sp, *F.solnai*, *Penicillium* sp, *P.chrysogenum*, *P.citrinum* and *T.harzianum* was 20, 64, 75, 14, 12, 42, 51, 41 and 10 percentage of degradation in the low concentration (100mg/L) was maximum tolerance when compared to higher concentration of magnesium sulphate.

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Whereas zinc sulphate heavy metal of 100mg/L concentration was high percentage of degradation when compared to other concentration. It was 15, 72, 64, 37, 30, 06, 21, 26, 29 and 81 percentage degraded with 100mg/L of zinc sulphate treated medium growth of the fungi such as *A.awamori, A.fumigatus, A.niger, Fusarium* sp., *F.solani, Penciillium* sp., *P.chrysogenum, P.citrinum, T.harzianum* and *T.viride* recorded respectively.

Aspergillus niger and *Aspergillus flavus* play a vital role in removal of heavy metals from aqueous metal solution and metal contaminated effluent by bioaccumulation mechanism. Heavy metals accumulation ability of these fungi was studied in both paper effluent and aqueous medium contained six major toxic heavy metals such as Cu, Zn, Pb, Cr, Cd and Ni. The reduction of heavy metals by *A. niger* and *A. flavus* in effluent was found significant compared to industrial treated effluent. Heavy metals bioaccumulation was studied at different pH, temperature and growth period to determine an optimum conditions required by fungi for maximum heavy metals accumulation. The results showed maximum accumulation of heavy metals at 25°C temperature, pH 5.0 and growth period of 120 hr. Both fungi have shown maximum metals accumulation in single metal system compared to multi metal system. The observed heavy metals accumulation was less in fungal consortia compared to individual fungi (Shivakumar *et al*., 2014).

In the case copper sulphate heavy metal degraded by native fungi of *Aspergillus awamori* (23%) *A.fumigatus* (54%), *A.niger* (24%), *Fusarium* sp (22%), *F.solani* (12%), *Penicillium* sp. (3%), *P.chrysogenum* (13%), *P.citrinum* (15%), *Trichoderma harzianum* (17%) and *T.viride* (38%) at 100 mg/L concentration of heavy metal respectively.

The heavy metal ions are present in natural and industrial disposed wastewater. These metallic ions present on the surface and underground water resulted in soil contamination. Many conventional techniques have been practice to eliminate heavy metal ions including physical (membrane separation and ion exchange) and chemical (neutralization, precipitation) techniques16. However, these methods are only efficient to eradicate mass of heavy metal present at high or moderate concentration but ineffective at diluted or low concentration of metal ions (Guibal *et al*., 1992). Similarly the present study, the degradation heavy metal concentration at 100 mg/L was 11, 5, 7, 8, 10, 9, 11, 12,15and19 percentage with *A .awamori, A. fumigatus, A.niger, Fusarium* sp., *F.solani, Penicillium* sp., *P.chrysogenum, P.citrinum, Trichoderma harzianum* and *T.viride* of potential fungi involved in all aspects respectively but in the high concentration of 500 mg/L was degradation process except *T.viride* (8%) was recorded.

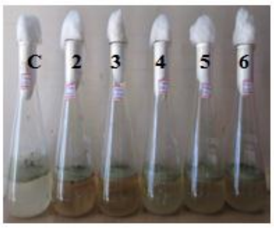
The biosorption capacity using different fungal isolates are influenced by the concentration of metal ions. The peak value was obtained for metal lead on all the metal ion concentration. The fungal isolate K3 of *Aspergillus fumigatus* exhibited the maximum biosorption rate (76.07) at 800ppm as moving towards higher concentration against the metal lead. The pattern of behaviour of isolates K3 and K26 was almost linear compare to K4 against metal lead. Alternatively, isolates K3 and K4 showed maximum absorption (69.6) against copper following lead. On observing the polynomial pattern, both isolates showed nonlinear behaviour (Shazia *et al*., 2013).

The rest of conditions like pH, temperature, time and revolution speed were kept constant throughout the experiment. In one such study the heavy metal biosorption and tolerance of filamentous fungus from the soil polluted with metal was evaluated (Zafar *et al*., 2006). The biosorption of lead (Pb) by indigenous fungal isolates at various concentrations and peak value for Pb removal was observed on 1000 mg/L (Faryal *et al*., 2007). Similarly, according to another study reported the investigation of *Aspergillus niger* biosorption that is reflecting the similar pattern of biosorption (Ahmad *et al*., 2005). Similar conducted work on biosorption of heavy metals by fungal dead biomass (Paraszkiewicz *et al*., 2002).

The finding depicted more sorption of lead at high metal solution concentration. Bairagi *et al*. (2011) demonstrated a viable option for the removal of lead from contaminated water with *Aspergillus versicolor* biomass (AVB). The maximum adsorption capacity of AVB has been found to be 45 mg Pb (II) per gram of the dry weight of the biomass. Similarly, Pang *et al*., (2011) showed that *Penicillium citrinum* can effectively remove uranium from aqueous solutions with maximum capacity of 127.3mg/g. The sorption of Cr(VI), Ni(II) and Zn(II) ions from synthetic solutions and electroplating effluent by immobilized *Trichoderma viride* biomass was studied and the fungal biomass recorded maximum biosorption capacities of 4.23, 7.41 and 6.27 mg/g for Cr(VI), Ni(II) and Zn(II); respectively (Kumar *et al*., 2011). Among 30 isolates fungi cultured, only *T. viride* is found able to grow at 6000 mg/L of zinc concentration on PDA. Accordingly, *T. viride* is the highest tolerance towards Zn.

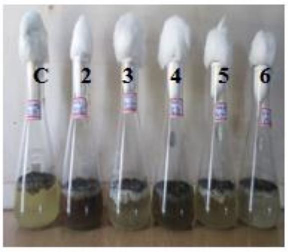
Table 1.Screening and percentage of degradation of heavy metal magnesium sulphate by native isolates of fungi.

S.No	Name of the fungi	Concentration mg/l				
		100	200	300	400	500
1	*Aspergillus awamori*	20	24	20	15	13
2	*A.fumigatus*	64	59	53	49	47
3	*A.niger*	75	29	16	24	22
4	*Fusarium sp*	14	8	5	4	3
5	*F.solani*	12	9	2	-	-
6	*Penicillium sp*	42	31	28	22	12
7	*P. chrysogenum*	51	30	22	19	18
8	*P. citrinum*	14	12	11	6	1
9	*Trichoderma harzianum*	10	5	2	4	2
10	*T.viride*	78	83	85	76	71



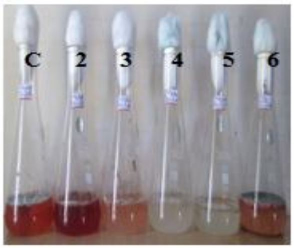
Aspergillus flavus

Aspergillus fumigatus



Aspergillus niger

Fusarium semitectum



Penicillium citrinum

Trichoderma harziarnum

Fig 1. Screening for determined the degradation of heavy metal zinc sulphate by native isolates of fungi.

Uptake capacity of *T. viride* is ranged from 18.1–26.7 mg/g in liquid media at Zn concentrations from 500–1000 mg/L. T. atroviride showed of 47.6– 64% adsorption in liquid media and 30.4–45.1% of absorption for Zn. Based on this study, 5.7–7.4% of Zn removal is observed due to biomass washing. The high adsorption, relatively low absorption and high uptake capacity of Zn suggested that T. atroviride is a potential bioremediator of Zn (Siddiquee *et al*., 2015).

It is concluded that the degradation of heavy metal investigation with provide information about heavy metal biosorption by filamentous fungi. The high capacity of fungi made well suited for removal of heavy metal in very low concentration. The information of present study will be helpful for further assessment and management of natural biosorbent which could serve as an economically good source of treating industrial effluents certain toxic heavy metal ions.

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