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Removal of Heavy Metals [Ni^{+3}, Hg^{+2}, Pb^{+2}, Cd^{+2} and Zn^{+2}] Ions from Contaminated Soil by Combined Action-Borne Fungus, *Funalia trogii*

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Abstract

Remediation of overwhelming metal defiled soil stream is of extraordinary need as substantial metals are poisonous and posture unsafe biological effects. Minimal effort relief measures like phytoremediation and mycoremediation are ordinarily utilized. Mycoremediation utilizing full-scale parasites (mushroom *Funalia trogii*) have demonstrated to give viable resilience utilizing a productive gathering instrument as a part of expelling overwhelming metals from soil. The current study reports the substantial metal remediation capability of full-scale organisms on soil misleadingly defiled with 0.5, 1.0 and 1.5 ppm of five overwhelming metals [Ni^{+3}, Hg^{+2}, Pb^{+2}, Cd^{+2} and Zn^{+2}] particles. *Funalia trogii* within Polyporaceae family was observed to be powerful in expelling the overwhelming metal from the dirt under study during 35 days. This study demonstrated that white decay is effective in remediating substantial metal from contaminated soil and their remediation potential can be upgraded.

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Keywords

Bioremediation
Funalia trogii
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Introduction

Commercial enterprises, rural chemicals and the shameful transfer of waste are the real reasons for soil pollution. The most widely recognized soil contaminants are hydrocarbons, overwhelming metals, herbicides, pesticides, and chlorinated hydrocarbons. Among these, overwhelming metals are thought to be the major ecological contamination, as they are cytotoxic, mutagenic, and carcinogenic (Hamman, 2004; Mahavi, 2005). Soil and ground water quality information reported by the Focal Contamination Control Leading body of India revealed that overwhelming metals like cadmium, lead, mercury, zinc and nickel are key toxins, which require quick moderation measures (Kamyotra, 2009). Synthetic remediation procedures are more suitable from the researchers' point of view; however, they are not economically encouraged for substantial scale soil remediation, as they create a lot of spill, which needs promote treatment before transfer (Diels et al., 1999; Chen et al., 2009). Recently, biosorption has risen as a promising, promising cost-effective procedure for the expulsion of metals from the dirt, where organic parts are utilized to expel and recover overwhelming metals from dirtied soil (Schnoor, 1997; Morsy et al., 2010; Bardan et al., 2012). The microbial remediation of metals is a mind-boggling procedure that depends on the science of metal particles, cell division structure of microorganisms, cell physiology, and physicochemical variables like pH, temperature, time, ionic quality, and metal focus (Mishra et al., 2012). Writing review uncovers the wide utility of plants for the biosorption of overwhelming metals from soil.

A few instances, overwhelming metal defilement in riverbanks, agrarian fields, landfills are accounted for over the globe (Zhuang and Wang, 2000; Cheng, 2003; Milenkovic et al., 2005). The advantages of phytoremediation over compound remediation, impediments like selectivity and development of plant species; climatic hindrances, resistance to overwhelming metals and back sullying by depuration or from slag of kindling requests reception of a strong approach which can run as an inseparable unit with different procedures to remediate these zones more rapidly, adequately, and financially. Mushrooms or large-scale growths of *Funalia trogii* can be powerful biosorbent distinct options for plants by expelling lethal metals from soil. This procedure is eluded as mycoremediation. Mushroom mycelia can serve as natural channels subsequent to their ethereal structures. This fungus comprises huge biomasses that have anintense surface, which makes them potential sorbents (Volesky and Holan, 1995).Mushrooms are known not found high metal/metalloid resistance which resistance that helps them to grow up and amass collects metals from the defiled environment. They like wise have shorter life cycle (35 days) and better flexibility contrasted with plants; consequently mycoremediation can be viewed as an advanced remediation system.

The bioavailability of metals is influenced by various soil elements, for example, cation trade limit (Moore et al., 1998), pH (Hornburg et al., 1995; Reddy et al., 1995; Schmidt, 2003) and natural matter substance (Bliefert, 1994; Li and Shuman, 1996). Whatsoever, the metal's speciation, which is corresponded with the variables specified above the metal species itself, assume an essential part (Reddy et al., 1995; Atanassova, 1999). The proficiency of mycoremediation is specifically corresponding to the bioavailability of substantial metals (Evangelou et al., 2007). These nonpartisan structures can be effortlessly collected by inactive retention. In light of the phytoremediation studies reported in the previous decades, it is clear that the chelating operators assume a critical part in expanding the bioaccumulation effectiveness without lessening their yield.

Materials and methods

A single type of surface soil sample was taken on 0 – 25 cm depth, which represented the active zone for pollution by heavy metal [Ni^{+3}, Hg^{+2}, Pb^{+2}, Cd^{+2} and Zn^{+2}]. Directly after collection, the samples were dried by air and kept until use.

Biological experiment

The soil samples were taken from the surface layer of (0 – 25 cm) depth. The sample dried by air, mixed, passed through (2mm) sieve, and stored in plastic bottle before it is used. For biological assessment, hay powder and sawdust were mixed with the soil sample and three soil types were made using different ratios [0.5:1 , 1:1 and 1:0.5] and polluted with three levels (0.5 , 1 and 1.5 ppm) of heavy metals [Ni^{+3},Hg^{+2}, Pb^{+2}, Cd^{+2} and Zn^{+2}]. Followed that by adding (10 ml) of *Funalia trogii* (Berk) in liquid media after mixing via high steer Machine to break the yarn of fungi. These samples are added to the three types of soil after (5, 10, 15, 20, 25, 30 and 35) days and each sample was oven dried at 70°C for 72 hrs. 0.5 g of each sample was digested using H_2SO_4 concentrated and H_2O_2 then determined by the Atomic Absorption method.

Laboratory experiment

Funalia trogii belongs to Polyporaceae family, has a white fleshy body. *Funalia trogii* was isolated from the mountains of northern of Iraq / Kurdistan region in Sidakan district area. This fungus developing inside the remains of dead trees in the study site, bioaccumulation efficiencies of *Funalia trogii* rot by mycelium body stages are studied.

Heavy metal concentration

After digestion 0.5 g of sample in (10ml) of H_2SO_4 with (10 ml) H_2O_2, the concentration was measured by atomic absorption spectroscopy.

Statistical analysis

The data were analyzed after testing the assumption of analysis of variance using revised least significant different test [Student-Newman-Keuls] for comparing between treatments (Milton and Jessic, 1995). All data were analyzed using Static Graph (version 21) programme.

Results and discussion

Mycoremediation studies

Parasitic species having a place with Polyporaceae gang, life cycle, consequently both mycelia and assemblages of the life form were observed for their bioaccumulation potential. Mycelium spreads over the accessible zone and accumulates metal particles into their cytosol (Bothe et al., 2010; Sheoran et al., 2010). The mycelia emulates the foundations of the plants in separating overwhelming metals from debased soil, known as mycofiltration that prompts compelling amassing of overwhelming metals from the dirt. The bioaccumulations of substantial metals in large-scale parasites are influenced by soil conditions and life cycle (Isildak, 2003). So all heavy metal ions were analyzed alone to know the period of growth amount of fungi in the contaminated soil with the measuring bioaccumulation concentration per day as follows:

Fig. 1: The body of *Funalia trogii* (Berk) grown in the remains of dried trees.

Growth of *Funalia trogii* in the contaminated soils by Ni^{+3} ions

The effect of sorbent amount on the removal yield of Ni^{3+} ions by *Funalia trogii* is shown in Fig. 2. The sorption yields of both sorbents increased by increasing the sorbent amount from 0.292 to 0.334 ppm.days^{-1} in the 1.5 ppm concentration of Ni^{3+} ($p<0.05$), and then remained almost constant ($p>0.05$) after (10 days). In this scale, Ni^{3+} biosorption yield of *Funalia trogii* cells increased from 10 days while the uptake yield of composite material increased from 15-35 days in the same rate of yield because the rot cannot grow in the polluted sample for long time.

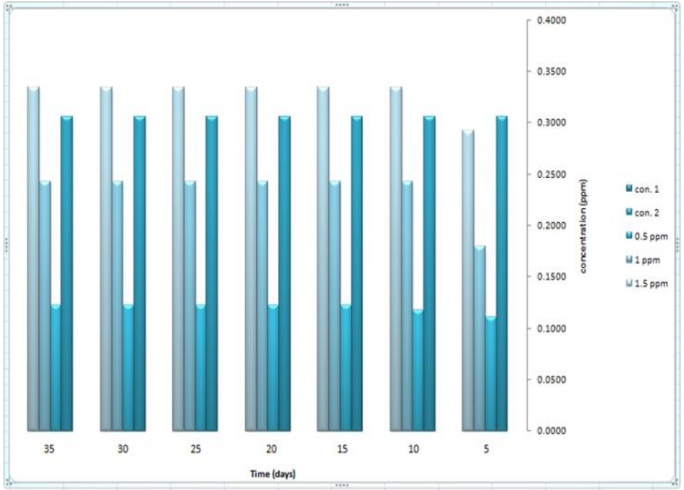

Fig. 2: The interaction effect of adsorbent Ni^{+3} element concentrations by the fungus, *Funalia trogii* grown in the polluted soil during the time periods measured in days (ppm.days^{-1})

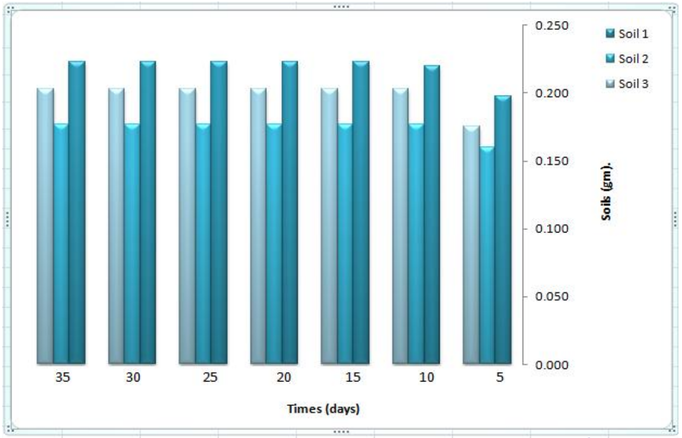

Fig. 3: The interaction effect of adsorbent Ni^{+3}element concentrations by the fungus, *Funalia trogii* grown in three types of polluted soils (ppm.g^{-1})

Growth of *Funalia trogii* in the contaminated soils by Hg^{2+}ions

The sorbent amount effect on the removal yield of Hg^{2+} ions showed in Fig. 4. The sorption yields of both sorbents increased by increasing the sorbent amount from 0.330 to 0.332 ppm. Days^{-1} in the 1.5 ppm concentration of Hg^{2+} ($p<$ 0.05), and then remained almost constant ($p>0.05$) after 10 days. In this scale, Hg^{2+} bio sorption yield of *Funalia trogii* cells increased from 10 days while the uptake yield of composite material increased from 15-35 days is the same rate of yield as the root is not able to grow in the polluted sample for long time. In addition, to know which soil is the best and the fungi showed best growth in soil type 1 contained 0.5g soil + 1g cellulose materials. Therefore this type showed a maximum rate of adsorption of Hg^{2+} (Fig. 5).

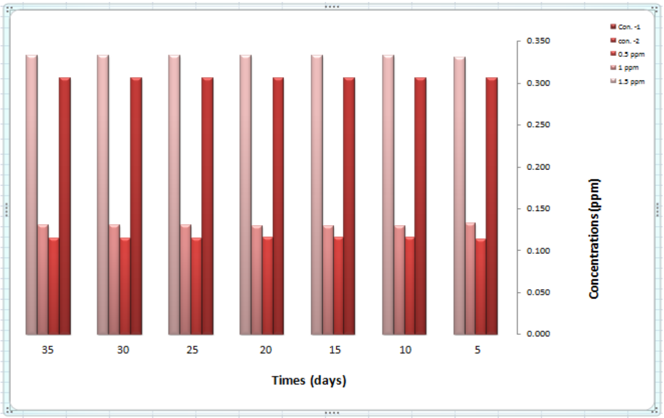

Fig. 4: The interaction effect of adsorbent Hg^{2+} element concentrations by the fungus, *Funalia trogii* grown in the polluted soil during the time periods measured in days (ppm.days^{-1})

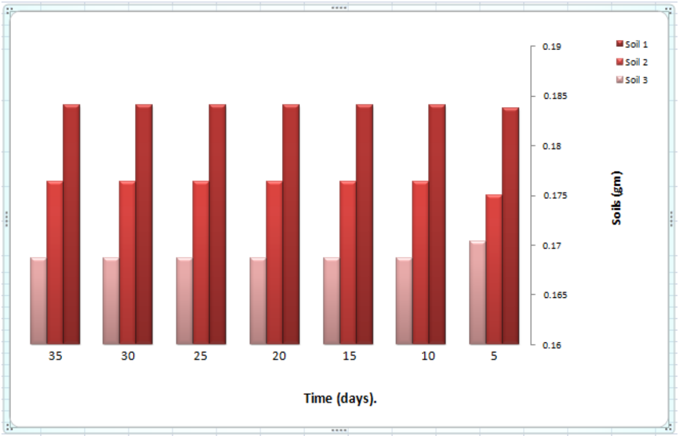

Fig. 5: The interaction effect of adsorbent Hg^{2+} element concentrations by the fungus, *Funalia trogii* grown in three different polluted soils ($ppm.g^{-1}$).

Growth of *Funalia trogii* in the contaminated soils by Pb^{2+}ions

The sorbent sum impact on the evacuation yield of Pb2+ particles showed in Fig. 6; the sorption yields of both sorbents expanded inside of expansion in the sorbent sum from 0.330 to 0.320 $ppm.days^{-1}$ in the 1.5 ppm convergence of Pb^{2+} ($p<0.05$), and afterward remained practically consistent ($p> 0.05$) for the next 10 days.

In this scale, Pb^{2+} bio sorption yield of *Funalia trogii* cells expanded from 10 days while the uptake yield of composite material expanded from 15-35 days is the same rate of yield in light of the fact that the decay cannot develop in the dirtied test for long time.

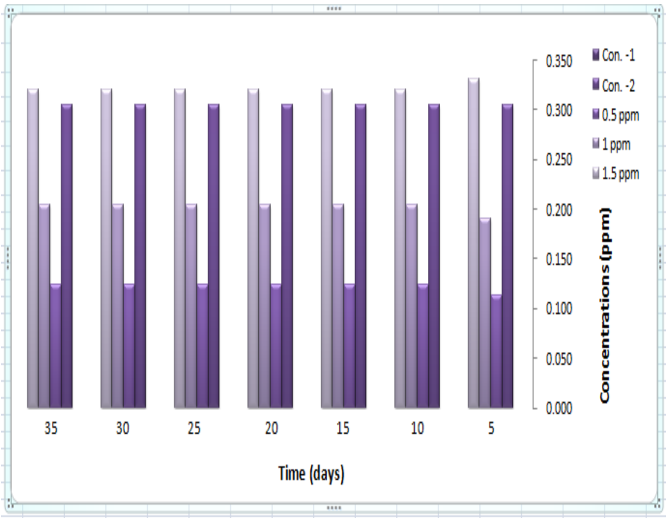

Fig. 6: The interaction effect of adsorbent Pb^{2+} element concentrations by the fungus, *Funalia trogii* grown in the polluted soil during the time periods measured in days ($ppm.days^{-1}$).

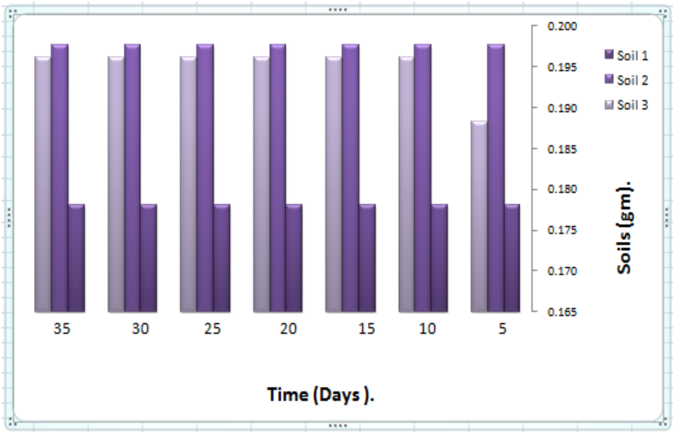

Fig. 7: The interaction effect of adsorbent Pb^{2+} element concentrations by the fungus, *Funalia trogii* grown in three different polluted soils ($ppm.g^{-1}$).

Furthermore, to know which soil is the best and the parasites effortlessly in the earlier growth of *Funalia trogii* was short and was found in soil type 2 containing 1g soil + 1g Cellulose materials. Therefore, this short growth an extreme rate of adsorption of Pb^{2+} by the fungus is shown in Fig 7.

Growing fungi in the contaminated soils by Cd^{2+}ions

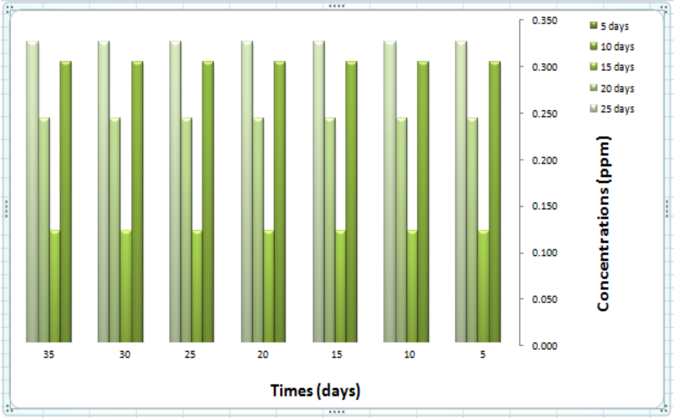

Fig. 8: The interaction effect of adsorbent Cd^{2+} element concentrations by the fungus, *Funalia trogii* grown in the polluted soil during the periods measured in days ($ppm.days^{-1}$).

The sorbent total effect on clearing yield of Cd^{2+} particles is shown in Fig. 8. The sorption yields of both sorbents extended within development in the sorbent whole from 0.326 $ppm.days^{-1}$ in the 1.5 ppm centralization of Cd^{2+} ($p<0.05$), and after that remained for all intents and purposes steady ($p>0.05$) after 5 days. In this scale, Cd^{2+} bio sorption yield of *Funalia trogii* cells extended from 5 days while the uptake yield of composite material extended from 10-35 days is the same rate of yield in light of the way that the rot cannot grow further in the contaminated sample for long time.

Additionally, to know which soil is the best and the organisms easily encounter youth in, it was observed in soil type 3 containing 1g soil + 0.5g cellulose materials. This showed a biggest rate of adsorption of Cd^{2+} during the growth of the fungus (Fig. 9).

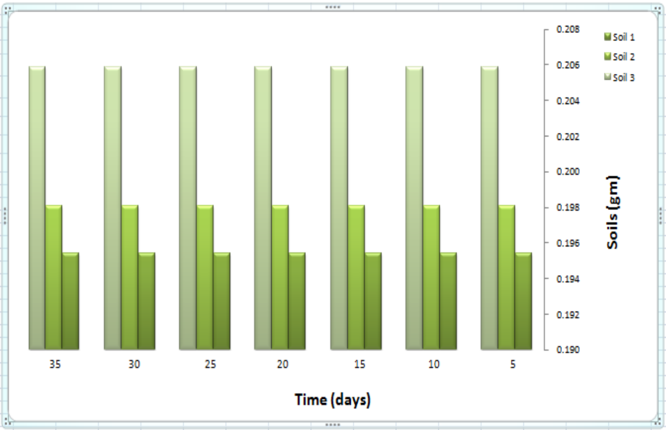

Fig. 9: The interaction effect of adsorbent Cd^{2+} element concentrations by the fungus, *Funalia trogii* grown in three different polluted soils (ppm.g^{-1}).

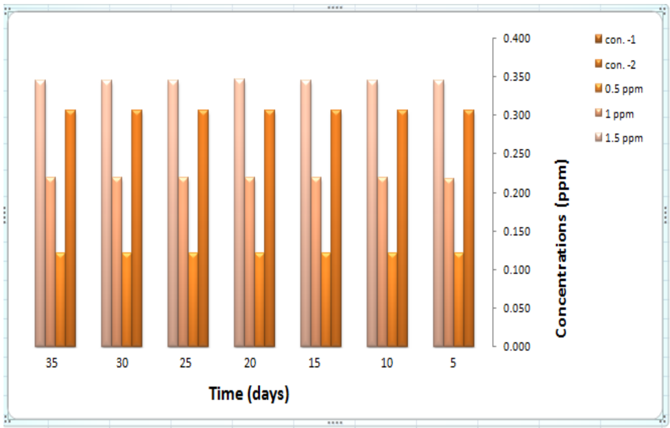

Fig. 10: The interaction effect of adsorbent Zn^{2+} element concentrations by the fungus, *Funalia trogii* grown in the polluted soil during the time periods measured in days (ppm.$days^{-1}$).

Growth of *Funalia trogii* in the contaminated soils by Zn^{2+}ions

The sorbent aggregate impact on the clearing yield of Zn^{2+} particles showed in Fig. 10; the sorption yields of both sorbents reached out inside of improvement in the sorbent entire from 0.344 to 0.345 ppm.$days^{-1}$ in the 1.5 ppm concentration of Zn^{2+} ($p<0.05$), and after that stayed in every practical sense enduring ($p>0.05$) following (15 days). In this scale, Zn^{2+} bio-sorption yield of *Funalia trogii* cells reached out from 10 days, while the uptake yield of composite material stretched out from 20-35 days, which is the same rate of yield in light of the way that the decay cannot be made in the spoiled sample for long time.

In addition, to know which soil is the best and the living beings effectively experience young growth stage was found in soil type 2 containing 1g soil + 1g cellulose materials. This observation recorded a greatest rate of adsorption of Zn^{2+} as shown in Fig.11.

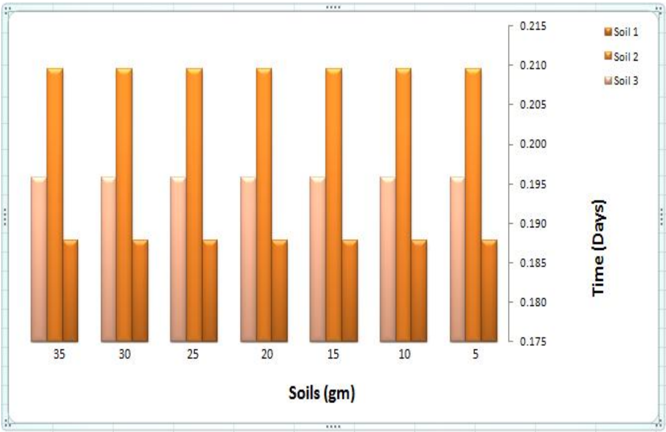

Fig. 11: The interaction effect of adsorbent Zn^{2+} element concentrations by the fungus, *Funalia trogii* grown in three different polluted soils (ppm.g^{-1}).

Moreover, the best supporting soil type for the easy growth of the fungus, *Funalia trogii* was soil type 3 which contained 1g soil + 0.5g cellulose materials. Consequently, this type showed a maximum rate of adsorption of Ni^{3+} as shown in the Figures. The ability to accumulate of trace elements are a characteristic of mushrooms (Tyler, 1980; Malinowska et al., 2004; Ita et al., 2006) which is a genetically coded feature (Kalac and Svoboda, 2000; Rudawska and Leski, 2005; Tamer et al., 2013). Although heavy metal accumulation by mushrooms species has already been studied by researchers, it is the first time that a multi metals accumulation efficiency of mushroom species are reported (Ferdinandi et al., 2009; Daryoush and Ndlufer, 2013; Dilna and Raj, 2013).

Conclusion

To remove (Ni^{3+}, Hg^{2+}, Pb^{2+}, Cd^{2+} and Zn^{2+}) metals from contaminated soil utilizing recently confined growths (*Funalia trogii* of Polyporaceae Family), were explored in single metal frameworks in the present study. The fungus showed productive bioaccumulation potential in uprooting most powerful substantial metals. *Funalia trogii* gathered higher fixation of all the concentrated overwhelming metals contrasted with its mycelia. Bioaccumulation productivity of the fungus was seen in the vicinity at distinctive soils concentrated on blending measure of cellulose materials.

Henceforth mycoremediation utilizing *Funalia trogii* (Polyporaceae) can be considered as a distinct option for other known strategies in substantial metal evacuation from the contaminated soil inferable from its short activity period and better collection proficiency. The outcomes recommend that the incorporation of this innovation with progressed agronomical and building abilities can change mycoremediation as an aggressive remediation tools.

Conflict of interest statement

Authors declare that they have no conflict of interest.

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