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Phytoremediation of a Polluted Soil by Purple Plant (*Tradescantia pallida* L.) Under Different Organic Amendments

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ABSTRACT

Present investigation was performed to determine the ability of purple plant (*Tradescantia pallida* L.) for removing heavy metals from a contaminated soil particularly nickel, with the aid of different types of organic amendments. Results of soil heavy metal content after application of different fertilizers were: maximum values (ppm) of V, Cr, Ni, Mn, Cu, Zn, As, Mo, Cd, Pb and Ag were respectively: 275.437, 284.807 (control 1), 265.073, 1071.32, 60.0671 (control 2), 77.8288, 9.5162, 8.5267 (control 1), 5.7943 (control 1), 7.5076 (control 2) and 37.8868 (control 1). Whereas, the minimum values (ppm) of V: 104.644, Cr: 85.7222 (commercial fertilizer), Ni: 164.92, Mn: 711.155 (cow dung), Cu: 15.5141 (cow dung), Zn: 43.3929 (commercial fertilizer), As: 3.7819 (cow dung), Mo: 0.000 (plant residue compost and bird manure), Cd: 0.000 (plant residue compost and bird manure), Pb: 4.1535 (bird manure) and Ag: 2.9181 (plant residue compost). This indicate that the use of organic amendment induce the phytoremediation of polluted soils.

1. Introduction

Soil ecosystem is considered as a complex, living, seasonally changing and dynamic component that may get polluted from anthropogenic activities like industrial areas. When soil gets accumulated by the toxic metals, trace elements and other organic substances, the pollutants get deposited on the soil surface [4]. Today, the contamination of soil by heavy metals and metalloids has become a serious environmental issue. A number of metals like iron, chromium, zinc, cadmium, arsenic, mercury and copper are known to compromise the quality of soil significantly and cause adverse effects to human health and the wellbeing of other organisms that is exposed to such soils. Because of their non-biodegradability, heavy metals are extremely persistent in the environment and may not broken down by chemical oxidation [7].

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Nickel occurs widely in the environment, being released through both natural and anthropogenic sources. The toxic effects of Ni result from its ability to replace other metal ions in enzymes, proteins or bind to cellular compounds, and among animals, microorganisms and plants, Ni is reported to interact with at least 13 essential elements among them Cr, Co, Cu, Fe, Mg, Mn, Mo, Zn [5].

Phytoremediation is a set of ecological strategies for in situ removal of pollutants from the environment by utilizing plants to promote their breakdown and immobilization. The contaminant levels may directly affected by plants via phytoextraction, which concentrates the contaminants like heavy metals from the environment into plant tissues [8; 6]. Phytoremediation is a cost-effective remediation solution for removing pollutants at site level (mainly heavy metals and organic compounds) from contaminated soils and waters with little disturbance to the landscape. It also reduces the cost of hazardous waste disposal to a landfill or a storage facility located off-site [10].

Violet plant (*Tradescantia pallida*) is an economically important plant grown in the nursery and landscape trade. This plant is extensively commercialized as an ornamental plant which commonly grown in garden borders and yards as well as cover open spaces and it used as ground cover in tropical and subtropical regions. *T. pallida* also renowned for its ability of effective removal of volatile organic pollutant from the air [2]. *T. pallida* has the ability of fast growing and coexist in all seasons; it can clean air and inedible plant. The plant that have ability to carry out phytoremediation process use several mechanisms as: 1) *tolerance mechanisms* based on their ability to survive high heavy metal concentrations that are in general inhibitory or lethal to plants. 2) Detoxification mechanisms by the aid of photosynthesis and respiration processes which help in maintaining low cytoplasmic concentrations of heavy metals, thereby acting as a possible detoxifying mechanism [11]. Moreover, in Taiwanese traditional medicine, *T. pallida* has been used as an anti-inflammatory and anti-toxic supplement, as well as used for the improvement of blood circulation [3].

Organic fertilizers have important benefits not only regarding to Pollutant Trace Element (PTEs) immobilization, but also because of their essential nutrients additions for plant growth, increasing soil organic matter content, correcting soil's acidity and influencing soil's physical properties [1; 9].

The aim of this study is to determine the ability of the plant *T. pallida* for remediation of a contaminated soil with heavy metals particularly nickel under different types of organic amendments.

2. Matereal And Methods

2.1. Sample collection

A pot experiment was conducted in Botanical Garden in the College of Science, University of Salahaddin – Erbil in December 1, 2019. The experimental soil used in this study was taken from

Qaryataq village (Table 1 and Figure 1). According to [13], samples were taken from the upper soil layer (0-30 cm depth) at a random pattern around each area.

Table 1: Detailed sampling location of Qaryataq village.

Site name	*Coordination of locations*	
	North	*East*
Qaryataq	36° 09' 46.80"	43° 52' 40.80"

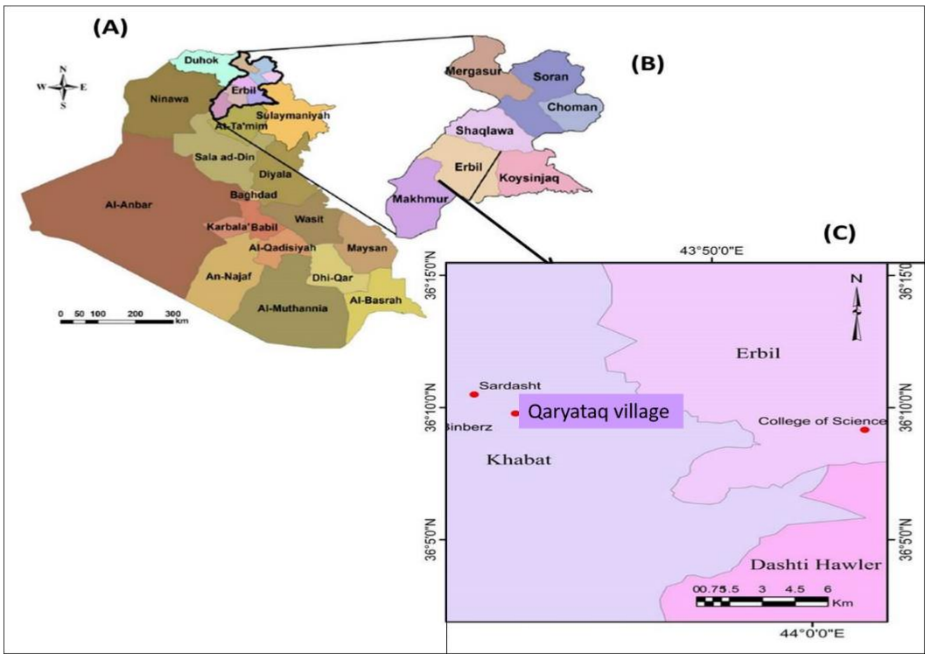

Figure 1: Map showing: (A) Iraq, (B) Erbil city and (C) the Qaryataq village.

2.2. Experimental layout

In the greenhouse, the soil was screened from gravel and stones, air-dried and 4-mm sieved. Eighteen experimental pots were placed in Completely Randomized Design experiment with three replications. Each pot was filled with four kilograms soil.

Figure 2: Experimental pots planted with purple plant (T. pallida L.) with different types of organic amendments.

2.3. Organic amendments

The treatments were placed according to the type of organic amendments used in amount of 50 grams per pot, and a set of pots remained without amendment and used as control to show the effect of fertilizers on the remediation process. Moreover, unpolluted soil from the greenhouse of the College of Science was used as a negative control and remained without amendment (Table 2). The types of organic amendment used during this study were: Plant residue compost which was prepared in the laboratory, Commercial fertilizer sold from the market, Bird manure and Cow dung collected from poultry houses.

Table 2: Pot experimental design for the present study.

Treatment No.	*Amendment type*	*Number of pots*
1	Plant residue compost	3 pots
2	Commercial fertilizer	3 pots
3	Bird manure	3 pots
4	Cow dung	3 pots
5	No amendment, polluted soil (control 1)	3 pots
6	No amendment, unpolluted soil (control 2)	3 pots

2.4. Plant selection and sowing

After organic amendment completion, each pot was planted with three seedlings of the purple plant (*T. pallida*) (Figure 2), then left for six months. Moisture content of the pots were remained at 60% field capacity.

T. pallida is a perennial herb with ascending stems, elongated decumbent and flowering sub-erected branches. The leaves is sheaths clasping, ciliate, about 1-2.5 cm long, oblong blades of about 10-18 cm long and about 23.5 cm broad and acute at apex, where upper one being somewhat smaller. The steams and leaves' upper surface are deep royal in color which becomes suffused with a faint dusty turquoise gunmetal undertone when the foliage grows older, while the undersides of the leaves are vivd violet shading towards pink in the place where the petioles clasp and encircle the stem [3]. The scientific classification of *T. pallida* is shown in (Table 3).

Table 3: Scientific classification of Tradescantia pallida (Taken from: [3]).

Domain	Eukaryote
Kingdom	Plantae
Phylum	Spermatophyta
Subphylum	Angiospermae
Class	Monocotyledonae
Order	Commelinales
Family	Commelinaceae
Genus	Tradescantia
Species	*Tradescantia pallida*

2.5. Sample preparation and treatment

Soil samples from each pot were air-dried, weighed and then oven-dried at 105°C to constant weight. Each oven-dried sample was ground in a mortar until it could pass through a mesh sieve. The samples were then stored in a clean, dry, stoppered glass containers before analysis.

2.6. Heavy metal analysis

The amount of heavy metal in the soils were determined by XRF device (Genius 5000 XRF) [12] as given in (Figure 3).

Figure 3: XRF device (Genius 5000 XRF).

2.7. Statistical analysis

Statistical analyses was performed for the obtained data during the present study by using SPSS version 23 and Microsoft Excel 2019. All data expressed as mean values, the difference among the means of heavy metals were compared by one-way ANOVA analysis with applying Duncan multiple comparison tests at level of significant 5%.

3. Result and Discussion

The result of the heavy metals in the polluted soil sample is presented in (table 4), and when compared with WHO standards, nickel content was more than the maximum permissible level of soil indicating that this soil is polluted by nickel (Ni).

Table 4: concentration of heavy metals.

Heavy metals	Concentration (ppm)	Heavy metals	Concentration (ppm)
Ti	4380.7469	Ni	201.8042
V	65.8510	Cu	37.270
Cr	96.0346	Zn	83.0569
Mn	317.2429	As	8.9808
Fe	3.2547	Se	0.0900
Co	11.5840	Cd	0.0920

The main obtained results during the present study are outlined in Figures 4-8. The maximum value of V was detected in the pots amended with commercial fertilizer (275.4343 ppm) when compared with control 1 (Figure 4), and the minimum value (104.6440 ppm) was in the pots with no amendment (unpolluted soil or control 2) and this indicate the impossibility of removing V in the soil by *T. pallida*.

Maximum Cr value (284.8070 ppm) was detected in pots with no amendment (polluted soil or control 1) followed by unpolluted soil (control 2). While, the minimum value (85.7222 ppm) was observed in the pots treated with commercial fertilizer followed by bird manure treated pots (Figure 4) and this indicate the possibility of greater growth of *T. pallida* after application of commercial fertilizer and greater removing of Cr in the polluted soil.

As shown in (Figure 4), the maximum value of Ni was detected in the pots treated with plant residue compost (265.0730 ppm). While, the minimum value was in the polluted soil (control 1) which was (164.9200 ppm). In comparing with the unpolluted soil control, commercial fertilizer treated pots followed by cow dung and bird manure treatments respectively have shown better ability of *T. pallida* for better removing of Ni in the polluted soil thus because of using the fertilizer.

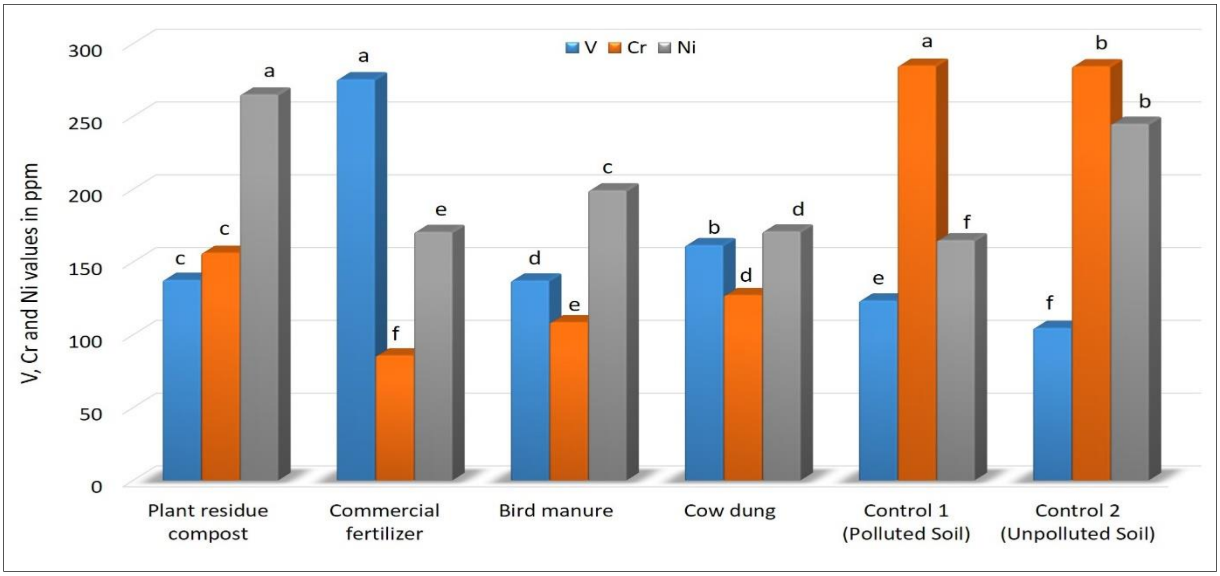

Figure 4: Values of V, Cr and Ni in different treatments after six months.

Maximum Mn value was detected in commercial fertilizer treated pots (1071.3300 ppm) (Figure 5), and the minimum Mn value was observed in cow dung treated pots (711.1550 ppm) when compared with both controls and this may refer to the ability of *T. pallida* for significant removal of Mn when cow dung is applied.

The maximum value of Cu (60.0671 ppm) was detected in the pots with no amendment (control 2) and the minimum value (15.5141 ppm) was observed in cow dung treated pots (Figure 6) and this may refer to the better removal ability of *T. pallida* for Cu after cow dung application. Moreover, bird manure, commercial fertilizer and plant residue compost have shown reducing amount of Cu in soil when compared with control 2.

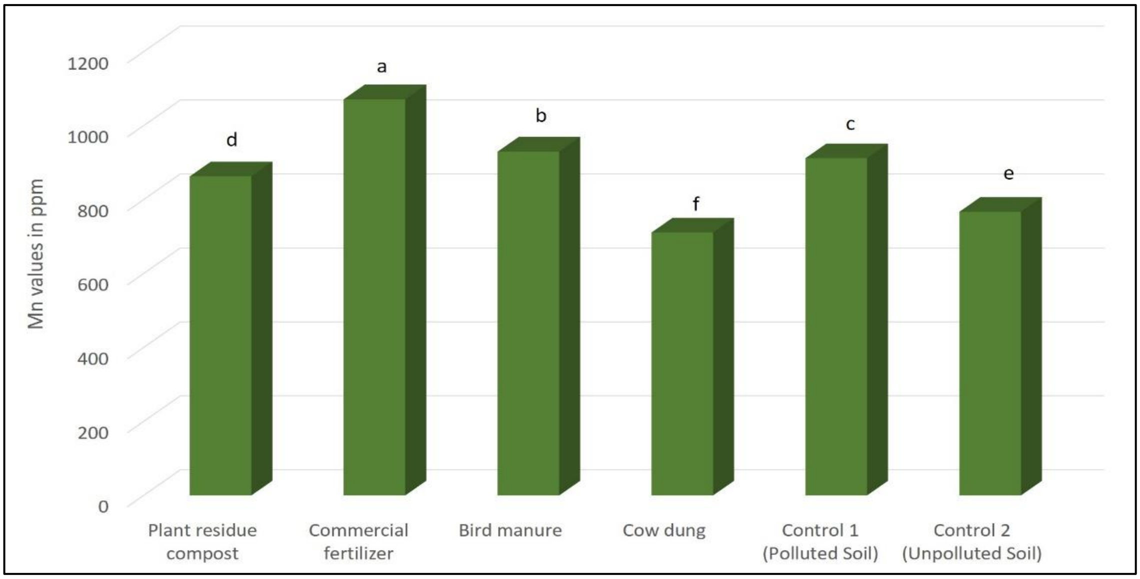

Figure 5: Values of Mn in different treatments after six months.

Cow dung amendment provided greater zinc amount to the pots, whereas, commercial fertilizer amendment showed the lowest Zn content (43.3926 ppm) followed by plant residue compost and bird manure when compared with control 1 (Figure 6) and this means that these fertilizers may induce the ability of *T. pallida* for removing Zn from polluted soils.

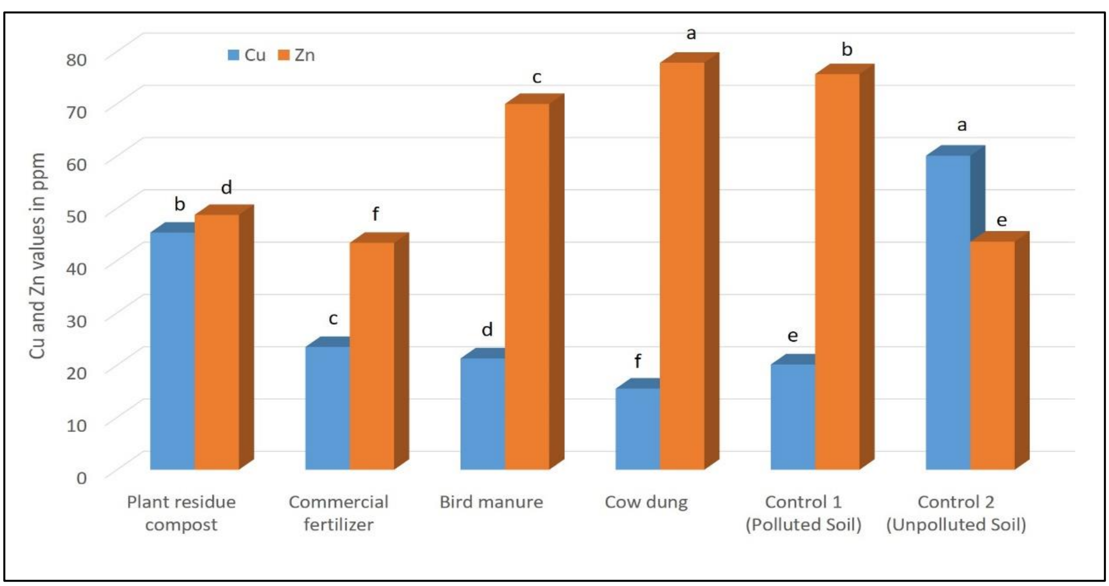

Figure 6: Values of Cu and Zn in different treatments after six months.

Maximum As was detected in bird manure treated pots (9.5163 ppm) and its minimum value was detected in cow dung treated pots (3.7819 ppm) followed by commercial fertilizer and plant residue compost treated pots when compared with control 1 (Figure 7). Cow dung, commercial fertilizer and plant residue compost showed good ability of *T. pallida* for removing As in polluted soil.

All of the amendment types showed best removal of Mo when compared the polluted soil control 1 (8.5267 ppm) (Figure 7), so the maximum removal was shown by bird manure and plant residue compost in which Mo value was (0.0000 ppm).

Moreover, all the used fertilizers have shown removal of Cd in polluted soil when compared with both controls the (Figure 7). The greatest Cd removal was shown by bird manure and plant residue compost in which Cd value was (0.0000 ppm).

Bird manure showed the best removal efficiency for Pb (4.1535 ppm) in polluted soil when compared with both controls. After comparing with unpolluted soil control (7.5076 ppm), the removal manner was bird manure following by commercial fertilizer and plant residue compost successfully (Figure 7).

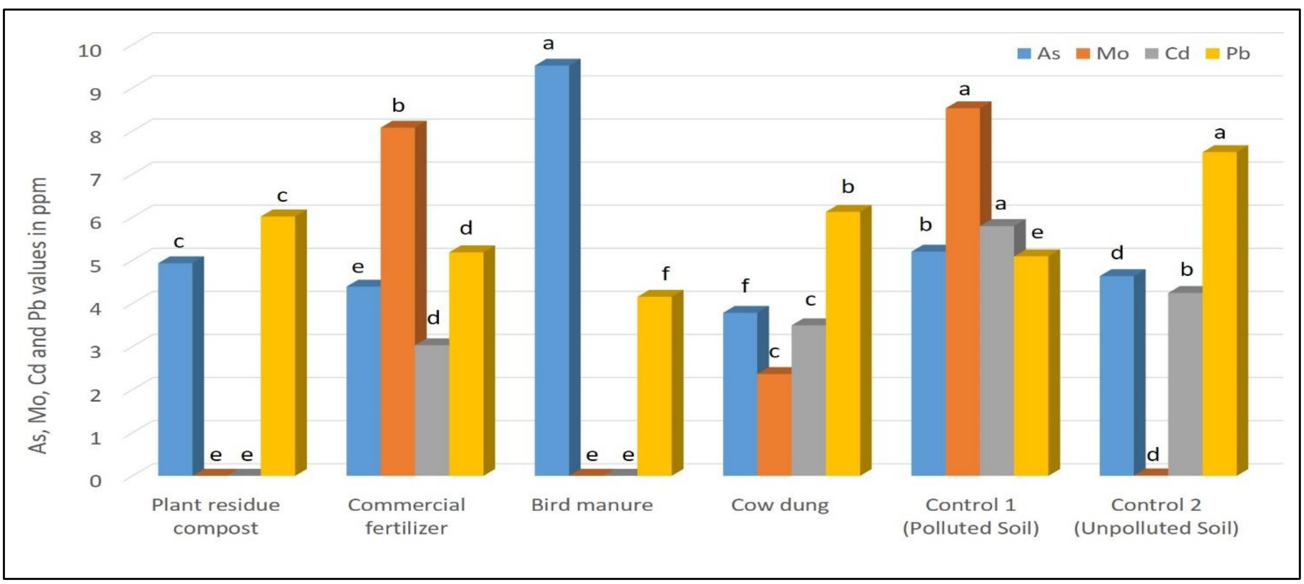

Figure 7: Values of As, Mo, Cd and Pb in different treatments after six months.

According to (Figure 8), iron uptake was good by all fertilizer types when compared with unpolluted soil control (35.2271 $g.Kg^{-1}$), however, the best removal was given by the commercial fertilizer (29.5140 $g.Kg^{-1}$).

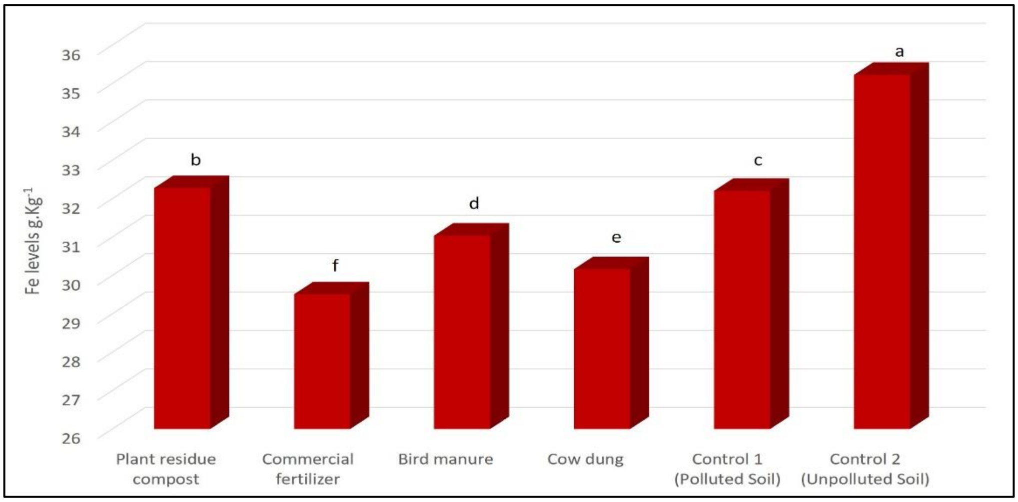

Figure 8: Values of Fe in different treatments after six months.

4. Conclusion

From the present results we concluded that the use of various types of fertilizers for cultivating the violet plant *T. pallida* in a polluted soil, have shown different reducing ability in removing of various heavy metals from the polluted soil. The nickel content of the studied soil was exceeded the maximum permissible level of soil given by WHO. Commercial fertilizer application followed by cow dung and bird manure treatments showed better ability of *T. pallida* in removing Ni from the polluted soil.

Conflict of Interest: The authors declare that they have no conflict of interest.

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