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Decontamination of Nickel Toxicity of Soil by Chelate Assisted Remediation using Brachiaria Mutica (FORSSK.) STAPF

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Abstract: ***Phytoremediation is an environment friendly and cost effective method for remediation of heavy metals from contaminated soils by using plants. Chelate assisted metal uptake by plant has only been discovered in the sector of phytoremediation. It is a potential technology for accumulation of heavy metal by plants after application of chelating agents to soil which enhances the level of metal uptake in phytoremediation processes. Chelating agents are commonly used to form complexes with different metal contaminants within the natural environment. The novelty of this work is to reduce the pollution load by ecofriendly method. The research gap adresses in this study is the reduction of nickel pollution by using chelating agent. In this study two chelating agents namely EDTA (Ethylene diamine tetra acetic acid) and DTPA (Diethylene triamine penta acetic acid) were used along with the nickel treated soil and also with soil without containing nickel to determine the efficiency of decontamination by a wild plant "Para grass" [Brachiaria mutica (Forssk.) Stapf] towards phytoremediation of nickel. In this experiment it was observed that the plant which were subjected to grow in EDTA with nickel treated soil accumulated more nickel than the other two sets which were subjected to grow in nickel treated soil with DTPA and also without chelating agent.***

Key words: Nickel, Chelating agent, Para grass, Phytoremediation

I. INTRODUCTION

Heavy metal pollution can adversely affects in living organism led to a change in their efficient diversity and community structure [1]. The increase in amount of soluble and exchangeable nickel in soil results in increase in their elements in plant tissue [2]. Phytotoxicity of nickel has also been documented to its undesirable effects on the process of photosynthesis, mineral nutrition, transport of sugar and water retention. Several reports are on impact of chelating agents on chromium uptaken by plants and also the influence of organic acid on mobility of Cr^{+3} in wheat plant [3]. The present study was focused on the effects of nickel on plants and the role of chelated compounds on enhanced metal uptake on Para grass [*Brachiaria mutica* (Forssk.) Stapf] seedlings.

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The objectives of the present study is to investigate and study the varying degrees of effects of different concentration of nickel and chelated nickel compounds on seedling growth as well as the comparison between EDTA and DTPA as better chelating agent for removal of nickel.

II. MATERIALS AND METHODOLOGY

The seedlings at every ten days interval i.e. ten, twenty and thirty days old seedlings grown in soil supplemented with different nickel concentration along with chelating agents were used for study of various growth parameters (root length, shoot length, fresh matter and dry matter yield) . Both treated and control seedlings were incubated in an oven at 80° C for a period of three days or more (till constant weight was attained) for avoiding errors in determination of dry weight. All the dried samples were separately grinded to fine powder and then 1:10 of the nitric and perchloric acids were added to the plant powder samples (shoots and roots separately) and left if for overnight [4]. Then the plant samples were properly digested using MDS-8 (Microwave Digestion Unit) until complete digestion. The digested solutions were filtered and the final volume was made up to 50 ml. Nickel contents were estimated by using Atomic Absorption Spectrophotometer (Perkin Elmer, Analyst 200, USA).

After knowing the amount of nickel content present in the solution, Translocation factor is calculated as the ratio of metal content in the shoot part to that in the roots [5]. If the rate of translocation factor is greater than 1, then it indicates the translocation of the metal from root to above-ground part [6]. According to Yoon et al. (2006) [7], The plant species which showed translocation factor more than 1 can be used for phytoextraction.

III. RESULTS

A. Changes in growth parameters

Treatment of different concentrations of Ni with chelating agent showed considerable change in different growth parameters of ten, twenty and thirty days old "Para grass" seedlings (Table - A.1). Shoot length was found gradually increased in the soil treated with nickel up to 40 beyond which it was decreased markedly with increasing concentration of nickel (up to 100 ppm). Soil treated with EDTA containing nickel showed better growth than the seedling grown in the soil containing only nickel as well as nickel with DTPA. A gradual increase in root length of *Brachiaria mutica* was observed when grown in the soil treated with nickel up to 40 ppm beyond this concentration it was markedly decreased up to 100 ppm. Soil treated with EDTA containing nickel showed better growth than the seedling grown in the soil containing only nickel or nickel with DTPA.

The shoot fresh weight was found to be increased in the sample grown in the soil treated with nickel (0 ppm - 40 ppm) then it was decreased markedly with increasing concentration of nickel (40 ppm to 100 ppm). Soil treated with EDTA containing nickel showed better fresh weight than the seedling grown in the soil containing only nickel and also nickel with DTPA. Root fresh weight were found to be increased in the sample grown in the soil up to the soil treated with 40 ppm of nickel then it was decreased with increasing concentration of nickel (40 ppm to 100 ppm), while soil treated with EDTA containing nickel showed better fresh weight than the seedling grown in soil containing only nickel and nickel with DTPA. Similar growth trend values were found for dry biomass production as that of fresh weight values (Table - A.2).

B. Nickel uptake

Analysis of metal accumulation in root and shoot part in the nickel treated and untreated medium with different chelating agents like EDTA and DTPA after 10, 20 and 30 days of treatment. During the study it was observed that the rate of metal accumulation by root was much more than the vegetative part of all the seedlings grown in only nickel treated soil, whereas the rate of metal accumulation on shoot was found more than the root in the seedlings which were grown in the soil treated with EDTA accompanying with nickel.

C. Translocation factor

The result revealed that Translocation Factor (TF) was found more than 1 in the seedlings while seedlings grown in the soil treated with EDTA along with nickel, exhibited higher translocation factor as compared to seedling grown in soil treated with DTPA with nickel. However, the plant samples which were not treated with chelating agent showed the least Translocation factor.

IV. DISCUSSION

The heavy metal removal process in soil was contributed to the adhesion of metal in soil mineral with strain Z-90 and helps in the formation of a metal complex with biosurfectant [8]. Several studies on amelioration of different metal ions by different hydrophytes have shown that the deposition of most metals content was higher in roots than in other plant parts [9, 10]. Nickel has been considered as an vital micronutrient but at higher concentration it causes adverse effects on plants [11]. Nickel at lower concentration has a stimulating effect on the process of germination and seedling growth and will inhibit the same at higher concentration [12]. The present study showed the harmful effects of nickel chloride on growth of 'Para grass' seedling at higher concentrations. The study also revealed the role of both chelating agent (EDTA and DTPA) used in attenuating the toxic effects of nickel. Chelates are agents that render insoluble cations to its soluble form for their accessibility to the plants [13]. As EDTA causes less toxicity, so it is used to improve the bioavailability of heavy metals for plant uptake for its nutrition [14, 15]. The present study also revealed that the use of nickel on 'Para grass' led to reduced growth and metabolism but the use of nickel with chelating agent EDTA showed better growth as well as production of large biomass. The decrease of nickel concentration from the treated soil and increase in plant biomass suggests that 'Para grass' has the capacity to take up nickel and may be considered as a bioaccumulator. As bio remediation is a solution that should be evaluated for each individual case of pollution [16]. The process of phytoextraction is mainly depends upon the capability of the plant [17]. Hence 'Para grass' could be a better option for phytoremediation of nickel from contaminated soil. It was evident from the present study that nickel accumulation in plant sample was least in control and showed an increasing trend with the increasing concentration of the nickel. As 'Translocation Factor' was found more than 1 and also more accumulation rate in 'Para grass' grown in the soil treated with EDTA accompanying with nickel, hence EDTA could be taken as the best chelating agent for phytoremediation of nickel. Similar results were reported in extraction of zinc by DTPA, EDTA and NH_4NO_3 that absorbed by the plant *Sesamum indicum* (L.) var. T55 [18]. In another study, A species *S. plumbizincicola* also reported to enhance the accumulation of Cd and Zn concentration with EDTA by reducing the mobility of ions in soil [19].

Table A.1: Effect of Nickel with chelating agent on root and shoot length of 10, 20 and 30 days old *Brachiaria mutica* (Forssk.) Stapf. seedlings.

Chelating agent	Ni concentration (mg/kg)	Shoot length (cm)			Root length (cm)		
		10 days	20 days	30 days	10 days	20 days	30 days
Nil	Control (0.0)	12.8 ± 0.943	16.4 ± 0.859	20.6 ± 0.479	14.6 ± 0.798	19.8 ± 0.608	23.6 ± 0.475
	20	13.2 ± 0.886	16.9 ± 0.628	20.9 ± 0.634	15.4 ± 0.646	20.2 ± 0.473	24.2 ± 0.986
	40	12.4 ± 0.681	16.6 ± 0.996	20.7 ± 0.745	15.2 ± 0.552	19.8 ± 0.653	23.4 ± 0.648
	60	12.2 ± 0.893	14.2 ± 0.462	17.6 ± 0.279	13.8 ± 0.583	17.6 ± 0.634	19.8 ± 0.837
	80	10.6 ± 0.648	11.9 ± 0.568	15.1 ± 0.849	12.1 ± 0.348	14.8 ± 0.639	16.7 ± 0.888
	100	8.9 ± 0.326	9.2 ± 0.746	11.8 ± 0.428	10.8 ± 0.647	11.4 ± 0.936	14.2 ± 0.463
	Control (0.0)	13.6 ± 0.448	17.1 ± 0.884	21.2 ± 0.864	15.8 ± 0.884	20.2 ± 0.785	24.4 ± 0.664
	20	14.4 ± 0.786	17.4 ± 0.567	21.5 ± 0.936	16.4 ± 0.766	20.5 ± 0.574	24.8 ± 0.546
EDTA	40	13.8 ± 0.842	17.3 ± 0.678	21.1 ± 0.258	16.1 ± 0.666	20.4 ± 0.563	24.5 ± 0.786
(10 mg/kg)	60	13.2 ± 0.659	15.6 ± 0.453	18.9 ± 0.496	14.8 ± 0.898	18.2 ± 0.387	21.2 ± 0.444
	80	11.9 ± 0.876	13.2 ± 0.866	16.2 ± 0.738	13.3 ± 0.348	15.3 ± 0.098	18.6 ± 0.658

	100	10.4 ± 0.548	10.8 ± 0.673	13.6 ± 0.932	11.6 ± 0.764	13.4 ± 0.764	15.8 ± 0.432
	Control (0.0)	13.2 ± 0.674	16.8 ± 0.538	20.8 ± 0.948	15.4 ± 0.546	20.1 ± 0.738	24.1 ± 0.948
	20	13.6 ± 0.962	17.1 ± 0.953	21.1 ± 0.886	15.9 ± 0.216	20.3 ± 0.274	24.6 ± 0.762
DTPA	40	12.7 ± 0.998	16.9 ± 0.854	21.0 ± 0.327	15.4 ± 0.493	20.1 ± 0.483	24.2 ± 0.446
(10 mg/kg)	60	12.4 ± 0.436	15.1 ± 0.739	18.2 ± 0.876	14.1 ± 0.462	17.9 ± 0.538	20.8 ± 0.642
	80	11.2 ± 0.708	12.4 ± 0.268	15.8 ± 0.629	12.6 ± 0.664	15.1 ± 0.839	17.4 ± 0.738
	100	9.3 ± 0.692	9.6 ± 0.392	12.4 ± 0.994	11.2 ± 0.995	11.9 ± 0.852	15.1 ± 0.438

Table A.2: Effect of Nickel with chelating agent on yield of biomass at 30 days of *Brachiaria mutica* (Forssk.) Stapf. seedlings.

Chelating agent	**Ni concentration (mg/kg)**	**Shoot fresh wt. (g)**	**Shoot dry wt. (g)**	**Root fresh wt. (g)**	**Root dry wt. (g)**
	Control (0.0)	8.646 ± 0.626	2.126 ± 0.026	3.432 ± 0.086	0.482 ± 0.004
	20	8.874 ± 0.342	2.198 ± 0.008	3.506 ± 0.012	0.496 ± 0.002
Nil	40	8.632 ± 0.128	2.084 ± 0.006	3.414 ± 0.022	0.478 ± 0.007
	60	7.542 ± 0.436	1.798 ± 0.009	2.826 ± 0.032	0.464 ± 0.006
	80	6.596 ± 0.286	1.646 ± 0.012	2.269 ± 0.022	0.337 ± 0.005
	100	5.684 ± 0.328	0.902 ± 0.006	2.198 ± 0.008	0.298 ± 0.005
	Control (0.0)	9.248 ± 0.216	2.245 ± 0.028	3.518 ± 0.006	0.584 ± 0.006
	20	9.334 ± 0.142	2.326 ± 0.011	3.536 ± 0.016	0.596 ± 0.004
EDTA (10 mg/kg)	40	9.286 ± 0.176	2.228 ± 0.007	3.512 ± 0.007	0.588 ± 0.002
	60	8.086 ± 0.421	2.046 ± 0.008	2.998 ± 0.008	0.408 ± 0.003
	80	7.126 ± 0.422	1.812 ± 0.024	2.654 ± 0.014	0.364 ± 0.003
	100	6.432 ± 0.098	1.682 ± 0.007	2.376 ± 0.006	0.326 ± 0.008
	Control (0.0)	8.841 ± 0.266	2.182 ± 0.008	3.486 ± 0.007	0.529 ± 0.006
	20	9.126 ± 0.086	2.248 ± 0.006	3.508 ± 0.006	0.547 ± 0.005
DTPA (10 mg/kg)	40	8.983 ± 0.049	2.136 ± 0.016	3.492 ±0.021	0.532 ± 0.005
	60	7.858 ± 0.136	1.857 ± 0.007	2.873 ± 0.005	0.421 ± 0.002
	80	6.736 ± 0.528	1.762 ± 0.008	2.482 ± 0.005	0.341 ± 0.007
	100	6.132 ± 0.096	1.308 ± 0.014	2.248 ± 0.012	0.314 ± 0.004

Values of five replicates ± SEM

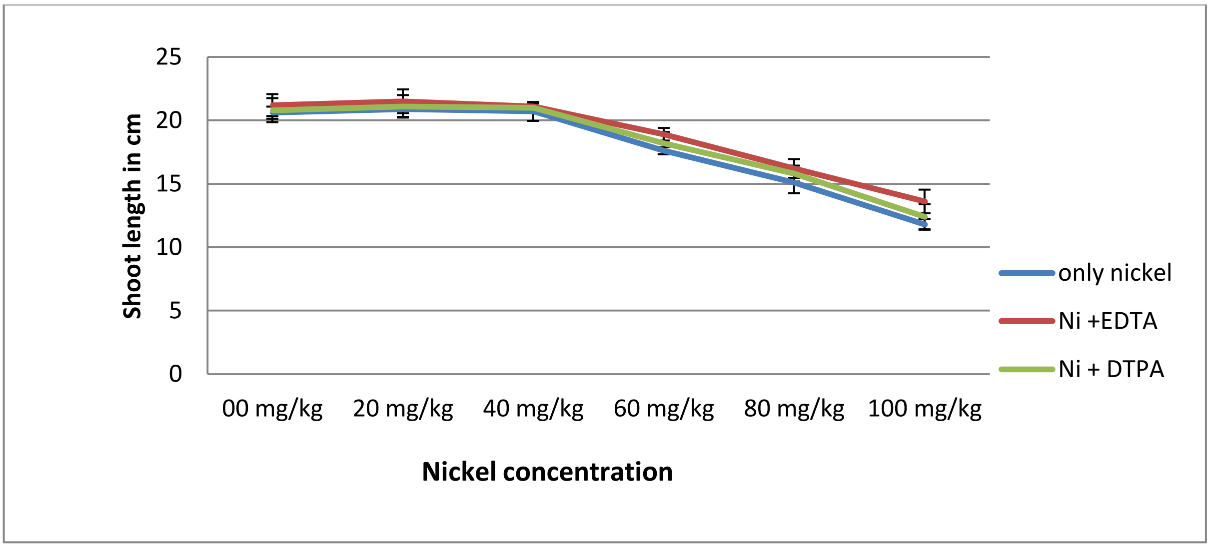

Fig. A.1: Impact of chelating agents on shoot length of 30 days old *Brachiaria mutica* (Forssk.) Stapf.

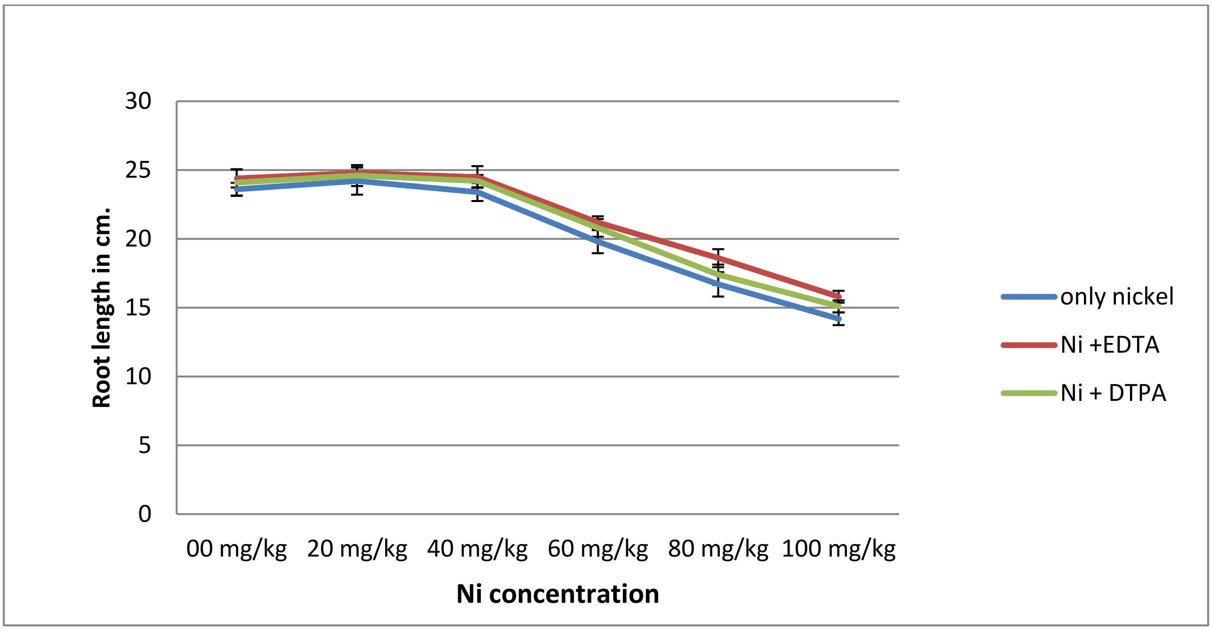

Fig. A.2: Impact of chelating agents on root length of 30 days old *Brachiaria mutica* (Forssk.) Stapf.

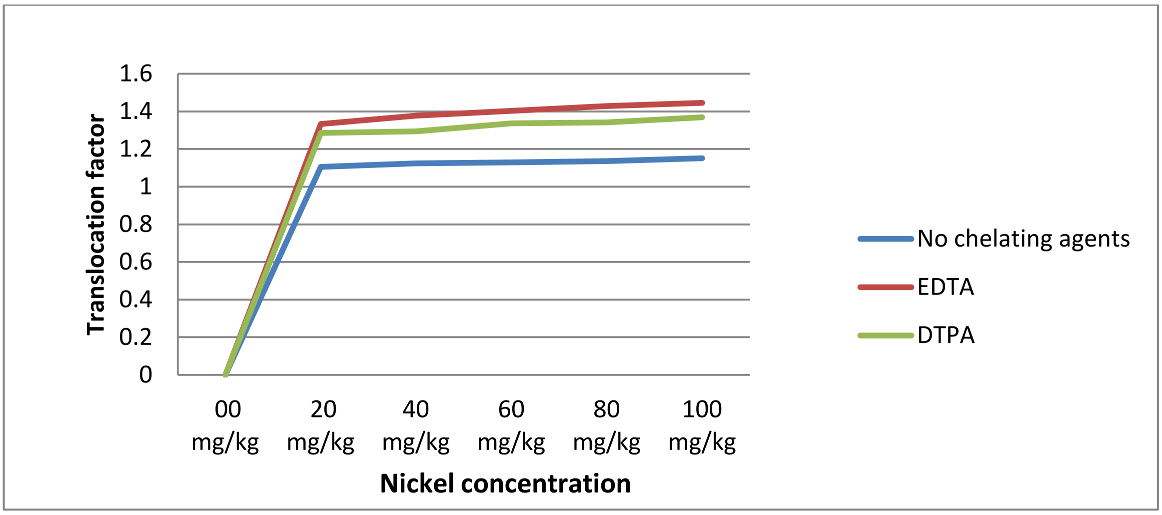

Fig. A.3: Impacts of chelating on Translocation Factor

V. CONCLUSSION

Chelate-enhanced phyto-extraction has received a lot of attention in the present times. This process can help in cleansing metal polluted soils by solubilising toxic metals and allowing them to be uptaken by plants and then removed from the soil. The present study with the application of metal ions along with chelators provided a direction towards phyto-detoxification or phyto-remediation techniques to be taken up in future experiments.

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