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Study on phytoremediation of metal (cadmium, copper, lead and chromium) contaminated soil using *Canna indica* plant

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Abstract
Soil pollution due to heavy metal contamination has become one of the most serious issues today. Treatment of heavy metal contaminated soil is one of the most important areas of environmental restoration. Phytoremediation proves to be successful for the remediation of soil fundamentally dependent upon suitable plant species. The present study was conducted on a *Canna indica* belonging to the family of Cannaceae. A pot study was conducted and the plant was subjected to different concentrations of heavy metal i.e., control, 40 mg/kg, 80 mg/kg and 100 mg/kg, with the aim to assess metal uptake and accumulation factor. Mix metal treatments of heavy metal chromium, cadmium, copper and lead were given to the plant, and the exposure time of heavy metals on the plant was 30 days. After harvesting its heavy metal analysis was done from the leaves, stem and roots. It was found that treatments were highly significant ($p < 0.05$) under pot trials. It has accumulated 100.8 mg/kg of lead, 187.8 mg/kg of chromium, 153.4 mg/kg of copper and 25.76 mg/kg of cadmium. It can be concluded that *Canna indica* can accumulate Pb, Cr and Cu.

Keywords: *Canna indica*, heavy metals, bioconcentration factor, translocation factor, soil contamination

Introduction

The blooming population along with high industrial development is the source of environmental pollution. At great length, humans have supplemented a large number of pollutants into the air, water and soil as a result of industrialization, mining activities, pesticide application, agriculture activities and production of municipal waste (Shah, 2020) [13]. Lead, Cadmium, Arsenic, Nickel, Chromium, Mercury and Aluminium are the main toxic metals, these toxic metals have the potential to accumulate in the food chain and cause detrimental effects on the plants, animals as well as harm to humans (Nedjimi and Daoud, 2009) [11]. There are various decontamination methods for the removal of heavy metal such as heat treatment, excavation, electro remediation, precipitation and chemical leaching are considered expensive and can destruct soil structure (Nedjimi and Daoud, 2009) [11]. Change in the soil properties such as the risk of loss of fertility, its application is limited to small area and generations of a by-product are the chief disadvantages and limitations of these conventional methods. Phytoremediation techniques use the plant for extraction, detoxification or degradation of pollutants from the soil and wastewater (Raphael *et al*., 2020) [12]. Various macrophytes that have been tested as phytoremediators for the purification of soil and wastewater (Zhang *et al*., 2015) [19]. Plants use their distinct features which help them to absorb and accumulate the pollutants into the roots and precipitate pollutants in their rhizosphere (Karczewska, 2013) [5]. *Canna indica* belongs to the family Cannaceae. *Canna indica* is widely used as a garden plant and found in Caribbean and tropical Americas, their rhizomes are thick, medium-sized species and they are upto 3 cm in diameter, widely used for waste water treatment (Choudhary *et al*., 2011) [2]. The present study investigates the phytoaccumulative efficiency of *Canna indica* when grown on mixed metal contaminated soil. Accumulation of heavy metals in leaves, stems and roots of *Canna indica* were assessed. The uptake efficiency was determined by calculating the Translocation factor and Bioconcentration factor for heavy metals (Cd, Cu, Pb and Cr).

Statistical analysis

One-way analysis of variance (ANOVA) was performed using MS Excel and a value of $p < 0.05$ was considered. Data were means of three replications.

Material and Methods

Analysis of the soil

The soil used in this experiment was collected from the Nursery, Anand, Gujarat. The soil was air-dried and stored in the polyethylene bag and physicochemical properties of the soil were determined. Physical properties such as bulk density, pH, pore space and, moisture content were determined by (Maiti, 2003) [10]. The pH of the soil was measured by pH meter and electrical conductivity by conductivity meter by the method described in (Maiti, 2003) [10]. Estimation of organic carbon and organic matter was performed by the following method described in (Walkley and Black, 1934) [16].

Experimental design

Canna indica plant was grown in soil under greenhouse at ambient temperature in 5 kg polyethylene pots for 90 days. The plant was given mixed heavy metal treatment containing four heavy metals for 30 days. To make the desired quantity of metal solution, different quantity of salts was used and then applied to the plants. Cr, Cd, Cu and, Pb pure potassium dichromate, cadmium sulfate, copper sulphate and, lead sulfate salts of Merck (AR grade) were used. The soil was spiked with mixed heavy metal solutions of Cr, Cd, Cu, and Pb at different concentrations of 40, 80, and 100 mg/kg.

The plant's pots were divided into four lots. The plant grown in the soil brought from the nursery served as control (only distilled water was added to the pot) and the other three pots were given a mixed metal supply. The periodical examination was done for visible changes in growth parameters and toxic symptoms, and plants were maintained till maturity. After 120 days plants were harvested for heavy metal analysis. Different parts of the plants were separated and washed using distilled water. 1 g of the soil from heavy metal treated pots were collected and different parts of the plant were oven-dried and digested by adding 3 ml H_2O_2 and 5 ml HNO_3 on a hot plate. Soil samples and plant samples were boiled till they reach half of their volume and cooled. The digested samples were filtered through filter paper and the filtered liquid was made into 25 ml volume using double distilled water. Heavy metal estimation was done by ICP-MS, at Sophisticated Instrumentation Centre for Applied Research & Testing (SICART), Anand, Gujarat, India.

Result and Discussion

Table 1: Physico-chemical analysis of the soil

Physico-chemical analysis	Control soil	After Treatment
pH	7.2	6.9
EC µS/cm	220	229
Organic carbon %	1.00	1.20
Organic matter %	1.72	2.06
Bulk density gm/cm^3	1.66	1.45
Pore space %	53.2	54.7
Moisture content %	39.34	40.0

The results of the physico-chemical characterisation of the soil before and after the treatments are shown in table 1. pH of the soil was found to be decreasing after the treatment. Electrical conductivity (EC) showed an increment. It was observed that the other two parameters also increased i.e., organic carbon and organic matter after metal treatment. Bulk density was slightly decreased, pore space and moisture content of the soil was increased. The pH of the soil is the most important factor and acidic soil also influences heavy metal absorption (Kabata-Pendias, 2000) [6]. When alkalinity increases it can cause heavy metal leaching and bioavailability of the metals for the plant's decreases and the presence of organic matter also inhibits the metal accumulation capacity of the plant from the contaminated soil (Bielecka, 2009) [1]. Particle size and its distribution determine soil texture, pore size, bulk density, moisture content are the most important physical parameters that affects root growth and development (Wang *et al*., 2013 [17]; Loades *et al*., 2013) [7]. Heavy metal concentration in control and a treated soil samples for Cr, Cd, Cu and Pb results have been shown in figure 1.

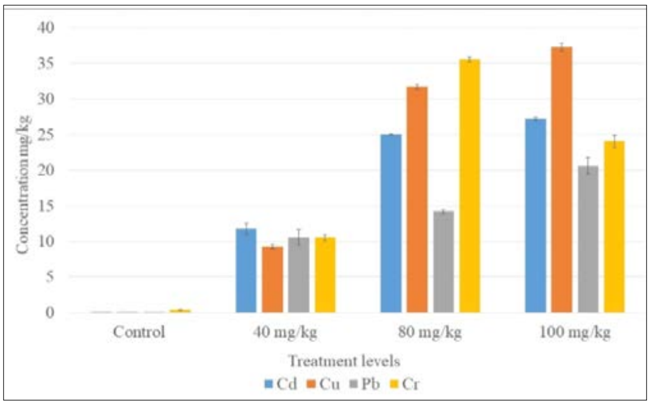

Fig 1: Heavy metal values of the soil before and after treatment

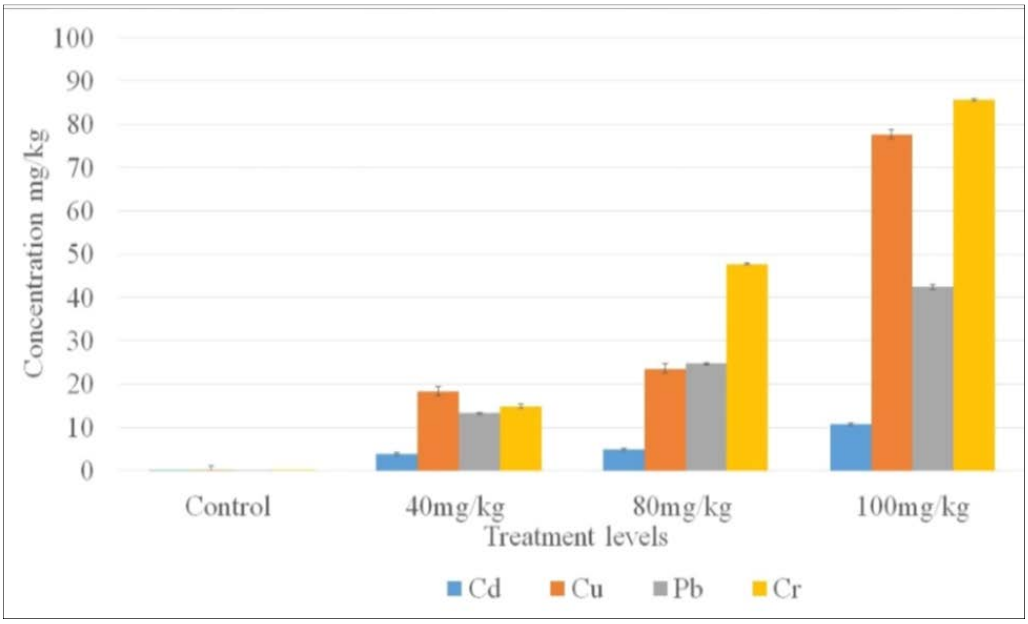

Fig 2: Heavy metal accumulation in Leaves

It was observed that uptake of heavy metals in the leaves for 40 mg/kg and 100 mg/kg were 3.823 and 11.03 mg/kg. Cu and Pb concentration 18.52 and 13.08 mg/kg for 40 mg/kg and 76.87 and 41.39 mg/kg for 100 mg/kg. Cr accumulation at 40 mg/kg was 13.96 and 84.26 mg/kg for 100 mg/kg shown in figure 2.

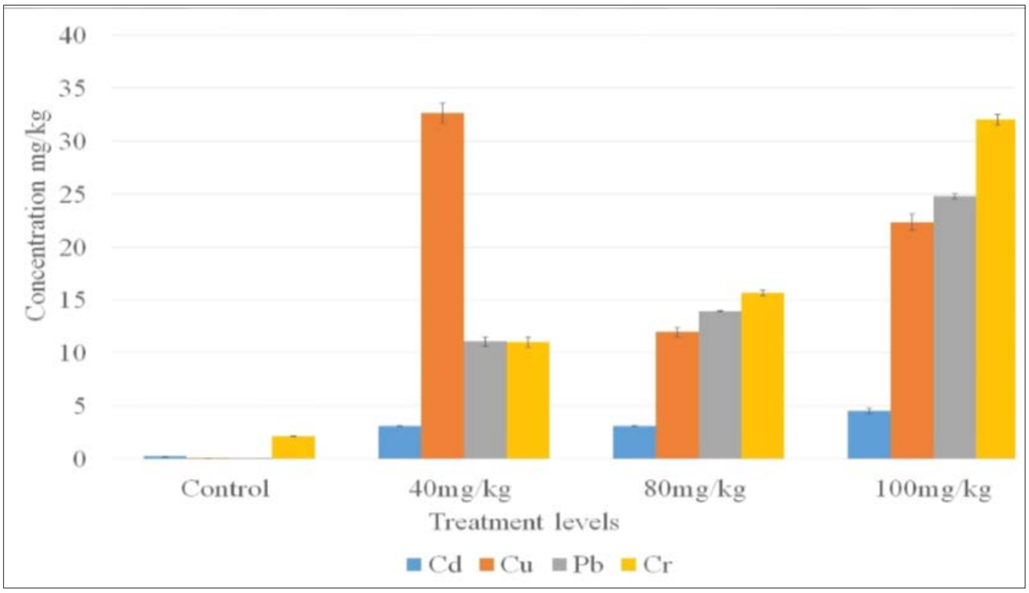

Fig 3: Heavy metal accumulation in Stem

As depicted in figure 3 Cd accumulation at 40 mg/kg was 2.389 and 4.12 at 100 mg/kg. Cu, Pb and Cr concentration at 40 mg/kg were 36.79, 11.96 and 12.92 respectively. When 100 mg/kg of treatment was given accumulation were 23.45, 23.43 and 30.75 mg/kg respectively.

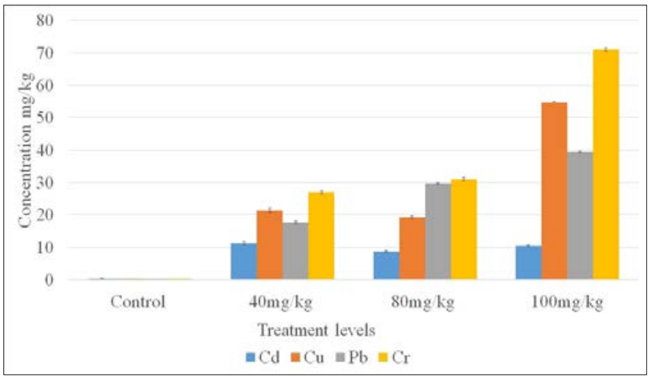

Fig 4: Heavy metal accumulation in Root

As shown in fig. 4 accumulation in roots of *Canna indica* for Cd at 40 mg/kg was 11.20 and 10.62 mg/kg for 100 mg/kg of treatment level. Cu and Pb were 20.46 and 16.99 mg/kg at 40 mg/kg and for 100 mg/kg of treatment level uptake of Cu and Pb were 53.15 and 36.06 mg/kg. Cr accumulation at 40 mg/kg was 25.78 and 72.85 mg/kg for 100 mg/kg. *Canna indica* effectively translocated the Pb and Cr to its aerial parts and roots can retain high quantities of Cd, Ni and Zn (Subhashini *et al*., 2013) [15]. Some plants can accumulate large quantities of heavy metals from the polluted soils, still, there are few species that can translocate heavy metals to the stems as well as leaves, rest of the heavy metal remains to immobilized into the root of the plant due to the defense reaction of the plants (Liu *et al*., 2017) [18].

Table 2: Translocation factor of the *Canna indica*

Heavy metal	40 mg/kg	80 mg/kg	100 mg/kg
Pb	1.4733	1.2637	1.7978
Cd	0.5546	0.8996	1.4258
Cr	1.0429	2.1350	1.5786
Cu	2.7038	1.8285	1.8872

Table 2 depicts the Translocation factor value obtained for *Canna indica* when different treatments were given it was observed that for 40 mg/kg treatment translocation factor was Cu > Pb > Cr > Cd. Trend for 80 mg/kg of treatment was Cr > Cu > Pb > Cd. TF value for 100 mg/kg was Cu > Pb> Cr > Cd. It has been studied that higher translocation factors in the plants are detected when a high amount of heavy metal is present in the soil, metal gets translocated to the root and thereby able to translocate it to the shoot parts in a good amount (El-Mahrouk *et al*., 2019) [3]. TF value >1 for plants is considered as good at phytoextraction (Hesami *et al*., 2018) [4].

Table 3: Bioconcentration factor of the *Canna indica*

Heavy metal	40 mg/kg	80 mg/kg	100 mg/kg
Pb	3.993	4.471	4.898
Cd	1.481	0.621	0.947
Cr	5.003	2.661	7.822
Cu	8.169	1.680	4.116

Bioconcentration factor obtained for 40 mg/kg of treatment was Cu > Cr > Pb > Cd whereas in case of 80 mg/kg of treatment was Pb > Cr > Cu > Cd and for 100 mg/kg of treatment trend was Cr > Pb > Cu > Cd shown in table 3. Phytostabilization technique involves the use of metal tolerant plant species which can immobilize the metals in the roots and reduce their bioavailability, therefore it prevents migration of heavy metal into the ecosystem and decreases the possibility of metals entry into the food chain. (Wong, 2003 [18]; Marques *et al*., 2009) [9]

Conclusion

This study was conducted to identify the ability of *Canna indica* for the removal of Cd, Cu, Pb and Cr from the contaminated soil. The obtained result indicates that *Canna indica* has the ability to accumulate Chromium up to 187.85 mg/kg, Copper 153.46 mg/kg and lead 100.88 mg/kg for 100 mg/kg of treatment level. The value for bioconcentration factor for copper, Lead and Chromium was > 1. Translocation factor for copper at 40 mg/kg and Chromium at 80 mg/kg of treatment was > 1 respectively. Further studies can be done to investigate the phytoremediation performance of the *Canna indica* using plant growth promoters and chelating agents to maximize the heavy metal removal efficiency.

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Conflict of interest
On behalf of all authors, the corresponding author states that there is no conflict of interest.

References
1. Bielecka A, Ryłko E, Bojanowska I. Zawartosc pierwiastkow metalicznych w glebach i warzywach z ogrodow działkowych Gdanska i okolic (Contents of metals in soils and vegetables from Gdansk and Straszyn allotments). Environmental Protection and Natural Resources,2009:40:209–216.
2. Choudhary AK, Kumar S, Sharma C, Kumar P. Performance of constructed wetland for the treatment of pulp and paper mill wastewater. World Environmental & Water Resources Congress, 2011.
3. El-Mahrouk ESM, Eisa EAH, Hegazi MA, Abdel-Gayed MES, Dewir YH, El-Mahrouk ME *et al*. Phytoremediation of cadmium-, copper-, and lead-contaminated soil by Salix mucronata (Synonym Salix safsaf). Hort Science,2019:54(7):1249–1257.
4. Hesami R, Salimi A, Ghaderian SM. Lead, zinc, and cadmium uptake, accumulation, and phytoremediation by plants growing around Tang-e Douzan lead–zinc mine, Iran. Environ Sci Pollut Res,2018:25(9):8701–8714.
5. Karczewska A, Lewinska K, Galka B. Arsenic extractability and uptake by velvetgrass Holcus lanatus and ryegrass Lolium perenne in variously treated soils polluted by tailing spills. J Hazard Mater,2013:262:1014–1021.
6. Kabata-Pendias A. Biogeochemia kadmu. Kadm w srodowisku - problemy ekologiczne i metodyczne. Zeszyty Naukowe Komitetu Człowiek i środowisko PAN,2000:26:17–24.
7. Loades KW, Benghough AG, Bransby MF, Hallet PD. Reinforcement of soils by fibrous roots. In “Enhancing, Understanding and Quantification of Soil-Root Interaction”. D. Timlin and L. R. Ahuja. American Society of Agronomy. Madison, W., 2013, 200.
8. Liu J, Xin X, Zhou Q. Phytoremediation of contaminated soils using ornamental plants. Environ Rev.,2017:26(1):43–54.
9. Marques AP, Rangel AO, Castro PM. Remediation of heavy metal contaminated soils: phytoremediation as a potentially promising clean-up technology. *Crit. Rev. Env. Sci. Technol.*,2009:39:622–654.
10. Maiti SK. Handbook of methods in environmental studies. ABD Publishers. Vol. 2 (Air, noise, soil, and overburden analysis), 2003.
11. Nedjimi B, Daoud Y. Ameliorative effect of $CaCl_2$ on growth, membrane permeability and nutrient uptake in Atriplex halimus subsp. schweinfurthii grown at high (NaCl) salinity. Desalination,2009:249:163–166.
12. Raphael OD, Ogedengbe K, Amodu MF. Effect of treated greywater irrigation and mulches on yield of Capsicum chinense under surface drip irrigation system. IOP Conf Ser Earth Environ Sci,2020:445.
13. Shah V, Daverey A. Phytoremediation: A multidisciplinary approach to clean up heavy metal contaminated soil. Environ Technol Innov.,2020:18, 100774.
14. Schierano MC, Panigatti MC, Maine MA. Horizontal sub-surface flow constructed wetlands for tertiary treatment of dairy wastewater. Int J Phytorem,2018:20(9):895–900.
15. Subhashini V, Rani C, Harika D Swamy, AVVS. Phytoremediation of heavy metal contaminated Soils using canna indica L., International Journal of Applied Biosciences,2013:1:09-13.
16. Walkley A Black I. A. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Science,1934:37(1):29–38.
17. Wang K, Huang H, Zhu Z, Li T, He Z, Yang X *et al*. Phytoextraction of metals and rhizoremediation of PAHs in cocontaminated soil by co-planting of Sedum alfredii with ryegrass (Loliumperenne) or castor (Ricinuscommunis). Int. J. Phytoremed.,2013:15:283-298.
18. Wong MH. Ecological restoration of mine degraded soils, with emphasis on metal contaminated soils. Chemosphere,2003:50:775–780.
19. Zhang DQ, Jinadasa KBSN, Gersberg RM, Liu Y, Tan SK, Ng WJ. Application of constructed wetlands for wastewater treatment in tropical and subtropical regions (2000–2013). J Environ Sci.,2015:1(30):30–46.