Phytoremediation of Lead, Cadmium and Chromium Contaminated Soils using Selected Weed Plants

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ABSTRACT

Human activities like mining, transport, agriculture, industrial waste disposal and military actions release inorganic pollutants in high concentrations that are toxic to natural ecosystems. Heavy metal pollution causes potential ecological risk. Heavy metals like Cadmium (Cd), Lead (Pb) and Chromium (Cr) when present in high concentrations in soil exert potential toxic effects on overall growth and metabolism of plants and bioaccumulation of such toxic metals in the plant poses a risk to human and animal health. The phytoremediation is one of the promising biosolution for soil pollution. The earlier studies emphasized the need for selecting more and more species for reclamation of soil quality through phytoremediation. The present study is an attempt to test the potential of the native species to remove heavy metals from the soil. Abutilon indicum, Catharanthus roseus and Canna indica species were tested for their ability of phytoextraction of lead, cadmium and chromium from the contaminated soils. Bioconcentration factor and translocation factor was also calculated. The experiments revealed that Abutilon indicum was a good accumulator of chromium, Catharanthus roseus was good accumulator of lead and chromium and Canna indica was good accumulator of chromium. The plant species was recommended for phytoextraction of lead and chromium contaminated soils.

Keywords: Phytoremediation, Heavy metals, Bioconcentration Factor, Translocation Factor

INTRODUCTION

Plants absorb the nutrients from the soil through the root system. The elements that are required for plant growth, development or reproduction are known as essential elements, viz. N, P, K, Ca, Mg, S, Fe, Zn, Mn, Cu, B, and Mo and are acquired either passively in the transpirational stream or actively through transport proteins associated with the root membrane. In addition to these essential nutrients, other nonessential elements, viz. salts, Pb, Cd, As, etc. with no defined metabolic role also enter the plant body. The non essential inorganic elements may often represent potential toxins at high concentrations. The plants have several mechanisms to sequester or stabilize these extraneous inorganics and prevent translocation into the more sensitive, terrestrial portions of the plant. One primary mechanism is to sequester the nonessential inorganics into the vacuoles which act as storage receptacles for the plant.

Pollution of the biosphere with toxic metals has accelerated dramatically since the beginning of the Industrial Revolution [1]. Heavy metal pollution of soils is widespread in many parts of the world and the cleanup of these soils is a difficult task. In recent years the use of repeated phytoremediation in managing contaminated sites has attracted considerable interest [2,3]. Many
metal-tolerant plant species, particularly grasses, escape toxicity through an exclusion mechanism and are therefore better suited for phytostabilisation than Phytoextraction [4]. Five main subgroups of Phytoremediation have been identified: phytoextraction, phytodegradation, phytostabilisation, phytovolatilisation and rhizofiltration. The uptake of contaminants in plants occurs primarily through the root system, in which the principal mechanisms for preventing toxicity are found. The root system provides an enormous surface area that absorbs and accumulates the water and nutrients essential for growth along with other non-essential contaminants [5].

Metal ions are commonly removed from dilute aqueous streams through chemical precipitation, reverse osmosis and solvent extraction. These techniques have disadvantages such as incomplete metal removal, high reagent and energy requirements, generation of toxic sludge or other waste products that again require disposal. The search for alternate and innovative treatment techniques has focused attention on the use of biological materials for heavy metal removal and recovery technologies (Biosorption) and has proved efficient in the removal of heavy metals and economically viable compared to conventional treatment. Phytoremediation is a technology that exploits a plant’s ability to remove contaminants from the environment or render toxic compounds harmless. Phytoremediation has been attracting attention as a rapidly developing, inexpensive plant-based remediation technology [6]. This technology exploits the natural ability of a green plant to accumulate a variety of chemical elements and transport them from the substrate to above ground parts. The ability to accumulate heavy metals to high levels and to tolerate elevated levels of toxic metals has been reported in a number of plants [7]. *Cyperus rotundus* accumulated high levels of lead and nickel in a pot culture experiment and the grass species was a good accumulator of lead and nickel [8].

**MATERIALS AND METHODS**

The present study on “Phytoremediation of Lead, Cadmium and Chromium contaminated soils using selected weed plants” has been carried out during 2012-2013. Three species have been selected for the present study to examine their potential to absorb the heavy metals from the soil and accumulate them in the above ground and below ground biomass. The species selected for the present study included: *Abutilon indicum*, *G. Catharanthus roseus* (L.) G. Don, and *Canna indica*, L. Of the three species *Abutilon indicum* and *Catharanthus roseus* was shrubs and *Canna indica* was herb species. *Abutilon indicum* belongs to Malvaceae family, *Catharanthus roseus* belongs to Apocynaceae family and *Canna indica* belongs to Cannaceae family. All the plants were affluent and native to the study area, i.e. Guntur District. These species were comparatively less studied except *Canna indica*. The most common species of the region are selected. The criteria followed for selection of species their biomass, commonness, tolerance to adverse climatic conditions.

**Preparation of Pots for Experimental Plants**

Five kgs of garden soil was filled in each pot. Ten seedlings were placed in each pot. A watering schedule was prepared and maintained throughout the study. Uptake of heavy metals by plants in a metal contaminated and normal soil was studied in pot culture experiment. The experimental plants were grown in pots and were irrigated with known heavy metal solutions in the concentrations of 5ppm, heavy metal solutions (Pb, Cd and Cr) were added to the pots alternate days for 60 days. In controls normal water was used. The plants were grown for a period of two months (60 days). While administering heavy metal laden water, care was taken to prevent leaching from the pot. Every 20 days the plant samples from each pot were collected. The collected samples were washed with distilled water remove dust particles. The samples were then cut to separate the roots, stems and leaves. The plant parts (roots, stems and leaves) were air dried and then placed in a dehydrator
for 2-3 days and then dried in an oven at 100°C. The dried samples of the plant were powdered and stored in polyethylene bags. The powdered samples were subjected to acid digestion. Samples (1gm) of each part (leaves, stems and roots) of the plant were weighed in digestion flasks and treated with HNO₃ and HCl in the ratio of 3:1. A blank sample was prepared applying 5ml of HNO₃ into empty digestion flask. The digestion on hot plate at 110°C for 3-4 hours or continued till a clean solution was obtained. After filtering with Whatman No. 42 filter paper the filtrate was analyzed for the metal contents in AAS. Calibration and measurements of elements were done on atomic absorption spectrophotometer. The calibration curves were prepared for each element individually. A blank reading was also taken and necessary correction was made during the calculation of concentration of various elements.

**Bioconcentration Factor (BCF)**

Metal concentrations in plants vary with plant species. The concentration, transfer and accumulation of metals from soil to roots and shoots was evaluated in terms of Biological Concentration Factor (BCF), Translocation Factor (TF). Biological Concentration Factor (BCF) was calculated as metal concentration ratio of plant roots to soil [9]. The Bioconcentration Factor (BCF) of metals was used to determine the quantity of heavy metal absorbed by the plant from the soil.

**Translocation Factor (TF)**

Translocation Factor (TF) was described as ratio of heavy metals in plant shoot to that in plant root [10]. This ratio is an indication of the ability of the plant to translocate metals from the roots to the aerial parts of the plant. Metals that are accumulated by plants and largely stored in the roots of plants are indicated by TF values <1, with values greater indicating translocation to the aerial part of the plant [9].

**RESULTS AND DISCUSSION**

**Accumulation of Metals in *Abutilon indicum***

Accumulation of Lead (mg/kg) in *Abutilon indicum*: The plant parts were analysed to estimate the accumulation of lead by 20th, 40th and 60th days. The accumulation of lead was lowest in the roots and highest in the stem. The lead that is absorbed from the soil by the roots is translocated to the above ground stem and leaves. The translocation of lead from roots to stem was higher compared to that of the stem to leaves. Most of the lead that is translocated to stem remained in the stem and gradually accumulated to the tune of 17.21 mg/kg. The accumulation was consistent throughout in the root system. The accumulation of lead showed a sudden increase by 20th day in the stem from 16.81 to 31.24 mg/kg and from then the accumulation was though marginal, it was consistent. Lead accumulation in the leaves also showed similar trend but with less concentration. Several species, such as hemp dogbane (*Apocynum cannabinum*), common ragweed (*Ambrosia artemisiifolia*), nodding thistle (*Carduus nutans*), and Asiatic dayflower (*Commelina communis*), were shown to have superior Pb-accumulating properties [11].

Accumulation of Cadmium (mg/kg) in *Abutilon indicum*: Cadmium metal is not an essential element for the plant. But it enters in to the plant body along with other nutrients through the root system. The highest concentration of cadmium was recorded in the roots by 60th day showing a total accumulation of 14.08 mg/kg (55.6% of the total accumulation). Further it was observed that the maximum accumulation in roots took place between 40th and 60th day. From the beginning of the experiment, there was a consistent increase of the concentration of cadmium in leaves and stem
(Table 1). However, the total accumulation of cadmium in leaves and stem was much lower than in roots. The cadmium translocation was very poor from roots to stem and leaves in *Abutilon indicum*. An experiment was conducted to investigate the characteristics of Cd tolerance and accumulation of *Elsholtzia argyi* natively growing on the soil with high levels of heavy metals in a Zn/Pb mining site the results concluded that *E. argyi* was a Cd tolerant and accumulating plant species [12].

Accumulation of Chromium (mg/kg) in *Abutilon indicum*: *Abutilon indicum* showed a tendency of high absorption of chromium by the root system. The roots have accumulated 33.18 mg/kg (63.7%) of chromium during the experimental period and the accumulation in leaves and stem was low and consistent from 20th day upto 60th day. However, chromium was actively absorbed by the stem and leaves during the first 20 days of the experimental period. The chromium was not translocated to above ground plant parts and hence only 36% of the chromium was found in leaves and stem. An investigation was conducted to study the heavy metals Cd and Cr accumulation capacity in a fast growing weed plant *Physalis minima* Linn. The results showed that roots had higher concentrations of heavy metals when compared to the stem and leaves. The roots were found to accumulate highest concentrations of heavy metals. The results showed that *Physalis minima* L. has the ability to accumulate these heavy metals in their tissue. Based on the bioconcentration factor the plant *Physalis minima* L. as a high heavy metal accumulator [13].

**Accumulation of Metals in Catharanthus roseus**

Accumulation of Lead (mg/kg) in *Catharanthus roseus*: *Catharanthus roseus* absorbed Lead through root system in high quantities by 20th day itself and the lead was translocated in a slow manner through out the remaining period of experimentation. As a result by the 60th day only 50% of the lead that was absorbed was translocated to stem and leaves. There was lowest accumulation in leaves (0.92 mg/kg) and highest accumulation was recorded in roots (67.33 mg/kg) with a total accumulation of lead (77.05 mg/kg) in the whole plant. Pot culture experiments using radish (*Raphanus sativus* L.) was performed to investigate lead (Pb) phytotoxic effects on antioxidant enzymes and other early warning biomarkers of soil Pb exposure. Results demonstrated that efficient Pb uptake was observed by the roots in contaminated plants. Root growth was higher in control plants, as compared to the contaminated. The results of this research showed that radish are hyperaccumulator plants that can concentrate heavy metals in their different parts, thus they can be used for remediation of polluted area [14].

Accumulation of Cadmium (mg/kg) in *Catharanthus roseus*: The concentrations of Cadmium were very low in the initial stage. The accumulation of Cadmium was highest in the stem (13.17 mg/kg) followed by leaves (11.03mg/kg) and lowest in roots (3.25 mg/kg). The overall rate of accumulation in leaves, stem and roots increased consistently up to 40th day and there was a sudden increase from 40-60th day. The results revealed that as the plant continued to grow the absorption of Cadmium also increased but the Cadmium absorbed by roots was completely translocated to stem and leaves. Out of the total accumulated 27.45mg/kg of Cadmium roots retained only 3.25mg/kg and the remaining was translocated to stem (13.17 mg/kg) and leaves (11.03mg/kg). A study reports that Phytoremediation of Cd, Pb, Cu, and Zn by *Trifolium alexandrinum*, which is a suitable candidate plant species for this purpose. *T. alexandrinum* was grown in a simulated heavy metal-contaminated soil. Root bioconcentration factor values of *T. alexandrinum* for Zn, Pb, Cu and Cd were 4.242, 1.544, 1.071, and 0.604 respectively [15].

Accumulation of Chromium (mg/kg) in *Catharanthus roseus*: *Catharanthus roseus* is a good accumulator of Chromium. From the experiments conducted it was recorded that the roots have accumulated highest chromium content (6.7 to 36.73 mg/kg) and then the absorption of chromium was consistent throughout. The accumulation in stem was very less compared to leaves and roots.
Chromium accumulation in leaves was doubled from 20th to 40th day and threefold for 40th day to 60th day finally resulting in highest accumulation of chromium in leaves followed by roots and stem.

**Accumulation of Metals in Canna indica**

Accumulation of Lead (mg/kg) in *Canna indica*: The experimentations on absorption of lead in *Canna indica* revealed that stem has accumulated highest quantity of lead (18.37 mg/kg) out of total accumulation of 34.52 mg/kg. The absorption of lead was maximum within first 20 days in roots and stem. By 20th day lead concentration in roots reached 19.51 mg/kg from 12.26 mg/kg and by 60th day the concentration of lead reached to 20.59 mg/kg while in the stem the concentrations of lead in stem reached from 8.57 to 22.41 mg/kg by 20th day and increased to 26.94 mg/kg by 60th day. The increase of concentration of lead in leaves was slow and steady throughout the experimental period, i.e, 2.27, 4.79, 8.37 mg/kg for 20-40-60 days. 53.19% of lead remained in stems. Out of a total of 34.52 mg/kg of lead 26.17 mg/kg was accumulated in above ground plant parts and only 8.34 mg/kg remained in roots. The trend of translocation reveals that lead was effectively translocated from roots to stem while from stem to leaves the translocation was poor and hence the total accumulation in stem was more than the leaves and roots. A pot experiment was carried using *Canna indica* L. total accumulation as well as the translocation potential of heavy metals of this plant. The accumulation of metals (Cr, Fe, Cd, Cu, Ni, Zn, Mn and Pb) in different parts of *C. indica* L. grown on industrial sludge-amended soil increased with time and increasing doses of sludge amendments. The metal concentration in *C. indica* L. after 90 days of experiment started, was in the order of Fe > Cr > Mn > Zn > Ni > Cu > Cd > Pb and the metal translocation was found lesser in shoot [16].

Accumulation of Cadmium (mg/kg) in *Canna indica*: *Canna indica* accumulated a total of 34.62 mg/kg of cadmium in 60 days of experimental period. Out of which 75.07% of cadmium remained in roots and only 24.92% was translocated to above ground plant parts i.e. 6.04 mg/kg (17.45%) and 2.59 mg/kg (7.48%) in stem and leaves, respectively. The overall absorption during 20-40 days in leaves, stem and roots was slow and by 60th day the concentration reached maximum in all the plant parts (Table 3). One of the promising plants, which have several important characteristics suitable for Phytoremediation, is *Canna indica* L. [17]. Maize (*Zea mays* L.) is a widely cropped annual cereal that grows rapidly, produces extensive fibrous root system with large shoot biomass yield per hectare, with stands adverse conditions and produce abundant seeds with ease of cultivation under repeated cropping. The crop is heavy-metal tolerant, has high metal accumulating ability in the foliar parts with moderate bioaccumulation factor. Given these attributes, maize is capable of continuous phytorextraction of metals from contaminated soils by translocating them from roots to shoots. Certain metals (e.g. Cd and Pb) have been reportedly accumulated by the crop above the level used to define metal hyper accumulation. [18]. Though Maize (*Zea mays* L.) has hyperaccumulator property, because of high biomass and edible product derived from maize, it cannot be suggested for phytoremediation.

Accumulation of Chromium (mg/kg) in *Canna indica*: The accumulation of chromium in the stem of *Canna indica* was highest in the first 20 days of the experiment; subsequently from 20-40 and 40-60 the increase of concentration was low and consistent. However, the increase of concentrations of chromium did not show any increase in leaves. Only 5.05 mg/kg of chromium accumulated in leaves in 60 days period while the stem and roots showed equal accumulation.

**Total Accumulation of Metals in Experimental Plants**

Total accumulation of lead was highest in *Catharanthus roseus* followed by *Canna indica* and *Abutilon indicum*. The roots of *Catharanthus roseus* absorb highest concentration of lead followed
by *Canna indica* and *Abutilon indicum*. Stem concentration was highest in *Canna indica* followed by *Abutilon indicum* and *Catharanthus roseus*. Leaf concentration was highest in *Abutilon indicum* and *Canna indica*. Total accumulation of cadmium was highest in *Canna indica* followed by *Catharanthus roseus* and *Abutilon indicum*. The leaves of *Catharanthus roseus* accumulated highest quantity of cadmium followed by *Canna indica* and *Abutilon indicum*. The accumulation in the stem of *Catharanthus roseus* was highest followed by *Canna indica* and *Abutilon indicum*. The accumulation in root was highest in *Canna indica* followed by *Acalypha indica* and *Catharanthus roseus*. Cadmium total accumulations were highest in *Canna indica* followed by *Catharanthus roseus* and *Abutilon indicum*. Chromium accumulation was highest in *Catharanthus roseus* followed by *Abutilon indicum* and *Canna indica*. Chromium was highly accumulated in leaves of *Catharanthus roseus* followed by *Abutilon indicum* and *Canna indica*. The accumulation was highest in the stem of *Canna indica* followed by *Abutilon indicum* and *Catharanthus roseus*. The roots of *Catharanthus roseus* accumulated high concentrations of chromium followed by *Abutilon indicum* and *Canna indica*.

**Bioconcentration Factor and Translocation Factor**

The metal concentration, transfer and accumulation of metals from soil to roots and shoots was evaluated in terms of Biological Concentration factor (BCF) or Bioconcentration Factor (BCF) and Translocation Factor (TF). The Bioconcentration factor (BCF) of metals was used to determine the quantity of heavy metals absorbed by the plant from the soil. This is an index of the ability of the plant to accumulate a particular metal with respect to its concentration in the soil. Translocation factor (TF) was described as ratio of heavy metals in plant shoot to that in the plant root. TF was calculated to evaluate the potential of the species for phytoextraction or phytostabilization.

Table 4. Bioconcentration factor and translocation factor of the selected plants.

<table>
<thead>
<tr>
<th>Name of the plant</th>
<th>Bioconcentration factor</th>
<th>Translocation factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lead</td>
<td>Cadmium</td>
</tr>
<tr>
<td><em>Abutilon indicum</em></td>
<td>3.22</td>
<td>69.52</td>
</tr>
<tr>
<td><em>Catharanthus roseus</em></td>
<td>8.13</td>
<td>74.99</td>
</tr>
<tr>
<td><em>Canna indica</em></td>
<td>3.64</td>
<td>94.61</td>
</tr>
</tbody>
</table>

The BCF values of the three plant species was >1. The three species have good potential to be used for phytoextractors of lead, cadmium and chromium contaminated soils. TF value of lead in *Abutilon indicum* was >1 the species was recommended for phytoextraction of lead contaminated soils and *Abutilon* was used for cadmium and chromium phytostabilization processes. In the case *Catharanthus roseus*, the TF values for lead was <1 and cadmium and chromium was >1 the plant species was used in phytostabilization of lead and phytoextraction of cadmium and chromium contaminated soils. *Canna indica* TF values for lead and chromium was >1 and cadmium was <1, the plant species was used for phytoextraction of lead and chromium and phytostabilization of cadmium contaminated soils.

**CONCLUSION**

Biosolutions are the best tools for all types of pollutions in the future. The phytoremediation is one of the promising biosolution for soil pollution. The earlier studies emphasize need for selecting more and more species for reclamation of soil quality through phytoremediation. The present study is an attempt to test the potential of the native species to remove heavy metals from the soil. From
Table 1. Total accumulation of metals (mg/kg biomass) in *Abutilon indicum*.

<table>
<thead>
<tr>
<th>Plant part</th>
<th>Lead</th>
<th></th>
<th></th>
<th>Cadmium</th>
<th></th>
<th></th>
<th>Chromium</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Final</td>
<td>Total accumulation</td>
<td>Control</td>
<td>Final</td>
<td>Total accumulation</td>
<td>Control</td>
<td>Final</td>
<td>Total accumulation</td>
</tr>
<tr>
<td>Leaf</td>
<td>5.69±0.32</td>
<td>17.76±0.16</td>
<td>12.07</td>
<td>0.21±0.09</td>
<td>5.96±0.19</td>
<td>5.75</td>
<td>3.75±0.19</td>
<td>12.55±0.19</td>
<td>8.8</td>
</tr>
<tr>
<td>Stem</td>
<td>16.81±0.13</td>
<td>34.02±0.08</td>
<td>17.21</td>
<td>0.47±0.13</td>
<td>5.96±0.08</td>
<td>5.49</td>
<td>7.87±0.13</td>
<td>17.95±0.08</td>
<td>10.09</td>
</tr>
<tr>
<td>Root</td>
<td>28.78±0.08</td>
<td>30.03±0.05</td>
<td>1.25</td>
<td>1.44±0.08</td>
<td>15.52±0.04</td>
<td>14.08</td>
<td>11.78±0.08</td>
<td>44.96±0.03</td>
<td>33.18</td>
</tr>
<tr>
<td>Total</td>
<td>51.28</td>
<td>81.81</td>
<td>30.53</td>
<td>2.12</td>
<td>27.44</td>
<td>25.31</td>
<td>23.4</td>
<td>75.46</td>
<td>52.07</td>
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</tbody>
</table>

Table 2. Total accumulation of metals (mg/kg biomass) in *Catharanthus roseus*.

<table>
<thead>
<tr>
<th>Plant part</th>
<th>Lead</th>
<th></th>
<th></th>
<th>Cadmium</th>
<th></th>
<th></th>
<th>Chromium</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Final</td>
<td>Total accumulation</td>
<td>Control</td>
<td>Final</td>
<td>Total accumulation</td>
<td>Control</td>
<td>Final</td>
<td>Total accumulation</td>
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<tr>
<td>Leaf</td>
<td>24.03±0.41</td>
<td>24.95±0.08</td>
<td>0.92</td>
<td>0.13±0.18</td>
<td>11.16±0.08</td>
<td>11.03</td>
<td>5.4±0.09</td>
<td>37.13±0.09</td>
<td>31.72</td>
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<tr>
<td>Stem</td>
<td>60.69±0.16</td>
<td>69.49±0.17</td>
<td>8.79</td>
<td>0.56±0.16</td>
<td>13.73±0.17</td>
<td>13.17</td>
<td>13.57±0.16</td>
<td>20.27±0.17</td>
<td>6.7</td>
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<tr>
<td>Root</td>
<td>21.47±0.17</td>
<td>88.81±0.16</td>
<td>67.33</td>
<td>0.84±0.15</td>
<td>4.09±0.18</td>
<td>3.25</td>
<td>6.07±0.15</td>
<td>36.96±0.16</td>
<td>30.89</td>
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<tr>
<td>Total</td>
<td>106.19</td>
<td>183.25</td>
<td>77.05</td>
<td>1.53</td>
<td>28.98</td>
<td>27.45</td>
<td>25.04</td>
<td>94.36</td>
<td>69.31</td>
</tr>
</tbody>
</table>

Table 3. Total accumulation of metals (mg/kg biomass) in *Canna indica*.

<table>
<thead>
<tr>
<th>Plant part</th>
<th>Lead</th>
<th></th>
<th></th>
<th>Cadmium</th>
<th></th>
<th></th>
<th>Chromium</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>Final</td>
<td>Total accumulation</td>
<td>Control</td>
<td>Final</td>
<td>Total accumulation</td>
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<td>Final</td>
<td>Total accumulation</td>
</tr>
<tr>
<td>Leaf</td>
<td>0.57±0.25</td>
<td>8.37±0.19</td>
<td>7.8</td>
<td>0.07±0.09</td>
<td>2.66±0.19</td>
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<td>9.2±0.19</td>
<td>14.29±0.19</td>
<td>5.05</td>
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<tr>
<td>Stem</td>
<td>8.57±0.09</td>
<td>26.94±0.017</td>
<td>18.37</td>
<td>0.52±0.19</td>
<td>6.56±0.18</td>
<td>6.04</td>
<td>1.8±0.09</td>
<td>23.64±0.17</td>
<td>21.75</td>
</tr>
<tr>
<td>Root</td>
<td>12.26±0.13</td>
<td>20.59±0.16</td>
<td>8.34</td>
<td>0.95±0.13</td>
<td>26.94±0.15</td>
<td>25.99</td>
<td>29.43±0.13</td>
<td>51.05±0.16</td>
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<tr>
<td>Total</td>
<td>21.39</td>
<td>55.91</td>
<td>34.52</td>
<td>1.54</td>
<td>36.16</td>
<td>34.62</td>
<td>40.56</td>
<td>88.98</td>
<td>48.41</td>
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the presented study it was concluded that *Abutilon indicum* was good accumulator of chromium, moderate accumulator of lead and poor accumulator of cadmium. The plant species was recommended for the phytoextraction of chromium contaminated soils. *Catharanthus roseus* was good accumulator of lead and chromium and moderate accumulator of chromium. The plant species was recommended for the phytoextraction of lead and chromium contaminated soils. *Canna indica* was good accumulator of chromium moderate accumulator of cadmium and lead. These plant species was recommended for chromium contaminated soils.

REFERENCES