Introduction

Geological and anthropogenic activities are sources of heavy metal contamination [7]. Sources of anthropogenic metal contamination include industrial effluents, fuel production, mining, smelting processes, military operations, utilization of agricultural chemicals, small-scale industries (including battery production, metal products, metal smelting and cable coating industries), brick kilns and coal combustion. One of the prominent sources contributing to increased load of soil contamination is disposal of municipal wastage. These wastes are either dumped on roadsides or used as landfills, while sewage is used for irrigation. These wastes, although useful as a source of nutrients, are also sources of carcinogens and toxic metals. Other sources can include unsafe or excess application of pesticides, fungicides and fertilizers [25]. Additional potential sources of heavy metals include irrigation water contaminated by sewage and industrial effluent leading to contamination of soil and water. Phytoremediation of soil metals has been successfully carried out at military sites, agricultural fields, industrial sites and mine tailings. Application of phytoremediation for the clean up of industrial waste dump sites contaminated with toxic metals is another important area that has blossomed in recent years. Phytoremediation is the direct use of living green plants for in situ, or in place, removal, degradation, or containment of contaminants in soils, sludges, sediments, surface water and groundwater. Phytoremediation an environmentally sound technology for pollution prevention, control and remediation. An investigation was conducted to study the heavy metals Cd and Cr accumulation capacity in a fast growing weed plant Physalis minima Linn. The plant fed with to 5ppm heavy metal solution on alternate days for a period of 60 days in pot cultures. After 20, 40 and 60 days, the heavy metal concentrations in P. minima Linn and soil was estimated using atomic absorption spectrophotometer. Heavy metal concentrations increased in all plant parts viz. leaf, stem and roots. The experimental results are compared with those of control. 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. The Bio concentration factor (BCF) and Translocation factor (TF) was estimated. Based on the results the plant species Physalis minima L. is a high heavy metal accumulator.

Key words: Phytoremediation, hyperaccumulators, Bioconcentration factor, Translocation factor.
biochemistry of living systems. The most dangerous heavy metals are Pb, Hg, As, Cd, Sn, Cr, Zn and Cu [9]. Among these, Cd and Pb are the most dangerous metals for human health [21].

Currently, conventional remediation methods of heavy metal contaminated soils are expensive and environmentally destructive. Major component of inorganic contaminants are heavy metals [1] they present a different problem than organic contaminants. Soil microorganisms can degrade organic contaminants, while metals need immobilization or physical removal. Thus, metals render the land unsuitable for plant growth and destroy the biodiversity. Plants extract and accumulate metals from soil solution. Phytoremediation is seen as an alternative green solution to the problem. Phytoremediation refers to the use of green plants, soil amendments and agronomic techniques to remove contain or render the pollutants harmless [5] and phytoextraction refers to the use of pollutant accumulating plants that can extract and translocate contaminants to the harvestable parts. As a plant-based technology, the success of phytoextraction is inherently dependent upon proper plant selection. Plants used for phytoextraction must be fast growing and have the ability to accumulate large quantities of environmentally important metal contaminants in their shoot tissue [6]. Phytoremediation an environmentally sound technology for pollution prevention, control and remediation. Several researchers have screened fast-growing, high-biomass accumulating plants, including agronomic crops, for their ability to tolerate and accumulate metals in their shoots [2]. Phytoremediation, a fast-emerging new technology for removal of toxic heavy metals, is cost-effective, non-intrusive and aesthetically pleasing. It exploits the ability of selected plants to remediate pollutants from contaminated sites. Plants have inter-linked physiological and molecular mechanisms of tolerance to heavy metals. Improvement of plants by genetic engineering, i.e., by modifying characteristics like metal uptake, transport and accumulation and plant’s tolerance to metals, opens up new possibilities of phytoremediation. The major processes involved in hyperaccumulation of trace metals from the soil to the shoots by hyperaccumulators include: (a) bioactivation of metals in the rhizosphere through root-microbe interaction; (b) enhanced uptake by metal transporters in the plasma membranes; (c) detoxification of metals by distributing to the apoplasts like binding to cell walls and chelation of metals in the cytoplasm with various ligands, such as phytochelatins, metallothioneins, metal-binding proteins; (d) sequestration of metals into the vacuole by tonoplast-located transporters. [24]. Deep rooting plants could reduce the highly toxic Cr VI to Cr III, which is much less soluble and therefore, less bioavailable [11]. Most of the studies on candidate species are mainly based on the interpretation of the analysis of metal concentrations in their plant parts [18, 10].

Cadmium is a chemical element with the symbol Cd and atomic number 48. Cadmium has no known useful role in higher organisms. Cadmium is an extremely toxic metal commonly found in industrial workplaces. Cadmium is an especially mobile element in the soil and is taken up by plants primarily through the roots. The major factors governing cadmium speciation, adsorption and distribution in soils are pH, soluble organic matter content, hydrous metal oxide content, clay content and type, presence of organic and inorganic ligands, and competition from other metal ions. Cadmium is a heavy metal with high toxicity and has an elimination half-life of ten to thirty years [12]. People are exposed to Cd by intake of contaminated food or by inhalation of tobacco smoke or polluted air [13]. Chromium (Cr) is one of the toxic metals widely distributed in nature. It has two forms found in the environment, trivalent and hexavalent. The latter form is considered to be the greatest threat because of its strong oxidizing ability as well as high solubility and availability to penetrate cell membranes [16]. Chromium is considered a serious environmental pollutant, due to its wide industrial applications. Toxic effects of Cr VI on plant growth and development include alterations in the germination process as well as in the growth of roots, stems and leaves, which may affect dry matter production and yield [22]. Chromium and its compounds have multifarious industrial uses. They are extensively employed in leather processing and finishing, production of refractory steel, drilling mud, electroplating cleaning agents and chromic acid. Hexavalent chromium compounds are used in industry for metal plating, cooling water treatment, hide tanning and until recently, wood preservation. These anthropogenic activities have led to the wide spread contamination that chromium shows in the environment and have increased its bioavailability and biomass [14].

II. Materials and Methods

The plant species belong to Solanaceae family of perennial herbs. *Physalis minima* L., is known by several names viz., native gooseberry, wild cape gooseberry and pygmy ground cherry. The vernacular names (Telugu, Andhra Pradesh) are kupanti, budda, budama. It is a pantropical annual herb 20-50 cm high at its maturity. Leaves are soft and smooth with entire or jagged margins, 2.5-12 cm long. [15]. *Physalis minima* L. is commonly found on the bunds of the fields, wastelands, around the houses, on roadsides, etc., where the soil is porous and rich in organic matter. It is an annual herbaceous plant having a very delicate stem and leaves. A small, delicate, erect, annual, pubescent herb, 1.5 meters tall; internodal length, 8.2 cm; more or less the whole plant is pubescent. The plant tends to have a weedy character, often found growing in disturbed sites [8].

*Physalis minima* L. plants were grown in pots filled with ten kgs of garden soil. The seedlings were collected from the uncontaminated soils. All the selected seedlings were of uniform size and free of any disease symptoms. The heavy metals selected for the study are Cadmium and Chromium. The uptake was estimated for every 20 days for a total period of 60 days, in total plant. In addition a control blank set of experimental pots...
was also maintained. The heavy metals were dissolved in distilled water to prepare stock solution of 1000 ppm for each metal. The calibration curves for each heavy metal were also prepared. A blank reading was also taken to incorporate necessary correction factor. The heavy metal solution of 5mg/L was prepared from the stock and administered to the plants and care was taken to avoid leaching of water from the pots. The metal uptake was estimated once in 20 days. The sample plants were removed from the pots and washed under a stream of water and then with distilled water. The collected plants were air dried, then placed in a dehydrator for 2-3 days and then oven dried for four hours at 100 °C. The dried samples of the plant were powdered and stored in polyethylene bags. The powdered samples were subjected to acid digestion. 1gm of the powdered plant material were weighed in separate digestion flasks and digested with HNO$_3$ and HCl in the ratio of 3:1. 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.

### III. Results and Discussion

Phytoremediation an environmentally sound technology for pollution prevention, control and remediation. The present study was designed to investigate the phytoextraction of cadmium and chromium from polluted soil by *Physalis minima* L.

#### Table 1: Accumulation of Cadmium (mg/kg) in *Physalis minima* during the experimental period

<table>
<thead>
<tr>
<th>Plant Part</th>
<th>Control</th>
<th>20$^{th}$ day</th>
<th>40$^{th}$ day</th>
<th>60$^{th}$ day</th>
<th>Total Accumulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf</td>
<td>0.22</td>
<td>0.69</td>
<td>40.16</td>
<td>40.38</td>
<td>40.16</td>
</tr>
<tr>
<td>Stem</td>
<td>0.3</td>
<td>1.14</td>
<td>2.1</td>
<td>3.35</td>
<td>3.05</td>
</tr>
<tr>
<td>Root</td>
<td>0.39</td>
<td>6.26</td>
<td>6.73</td>
<td>20.29</td>
<td>19.9</td>
</tr>
<tr>
<td>Total Accumulation</td>
<td>0.91</td>
<td>8.09</td>
<td>48.99</td>
<td>64.02</td>
<td>63.11</td>
</tr>
</tbody>
</table>

The highest concentration of cadmium was observed in 20$^{th}$ day in roots followed by stem and leaves, respectively. In the 20$^{th}$ day observation the accumulations was higher in roots. In the second observation (40$^{th}$ day) Cd highly accumulated in the leaves than roots and stem. Highest accumulation from 20$^{th}$ to 40$^{th}$ day was observed in leaves. In the 60$^{th}$ day observation root concentration higher than the leaves and stem, while root concentration was increased in this period. Finally, it was observed that cadmium accumulated in the order leaf > root > stem. (Table 1).

#### Table 2: Accumulation of Chromium (mg/kg) in *Physalis minima* during the experimental period

<table>
<thead>
<tr>
<th>Plant Part</th>
<th>Control</th>
<th>20$^{th}$ day</th>
<th>40$^{th}$ day</th>
<th>60$^{th}$ day</th>
<th>Total Accumulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf</td>
<td>4.59</td>
<td>5.83</td>
<td>12.13</td>
<td>13.6</td>
<td>9</td>
</tr>
<tr>
<td>Stem</td>
<td>14.12</td>
<td>14.13</td>
<td>19.18</td>
<td>19.55</td>
<td>5.43</td>
</tr>
<tr>
<td>Root</td>
<td>19.43</td>
<td>24.36</td>
<td>42.7</td>
<td>49.12</td>
<td>29.69</td>
</tr>
<tr>
<td>Total Accumulation</td>
<td>38.14</td>
<td>44.32</td>
<td>74.01</td>
<td>82.27</td>
<td>44.12</td>
</tr>
</tbody>
</table>

In 20$^{th}$ day chromium concentration was highly found in roots, after stem and leaves. There is no much change compared with the control plants. 40$^{th}$ day chromium accumulated highly in the roots. During this period there is a much difference in the 20$^{th}$ day and 40$^{th}$ day accumulations by roots, stem and leaves. The chromium was translocated to roots to stem and leaves. By 60$^{th}$ day it was observed that chromium accumulation was high in the root than shoot. There no significant difference in the shoot accumulation, there was a small increase was observed in the shoot part. Finally it was observed that in the total experimental period roots have highly accumulated chromium. Chromium accumulated in the order roots > leaves > stem. The ability of plants to tolerate and accumulate heavy metals is useful for phytoextraction and Phytostabilization purpose, measured using Translocation factor (TF) and Bioconcentration factor (BCF), which are defined as the ratio of metal concentration in plant shoots to roots and the ratio of metal concentration in plant roots to soils, respectively. [3].
The identification of metal hyperaccumulators, plants capable of accumulating extra-ordinary high metal levels demonstrates that plants have the genetic potential to clean up contaminated soil. Hyperaccumulators are also characterized by a shoot-to-root metal concentration ratio (i.e., the translocation factor (TF) of more than 1), whereas non-hyperaccumulator plants usually have great metal concentrations in the roots than in the shoots. Several authors [19] include the bioaccumulation factor (BAF) as an element for classification as a hyperaccumulator species. The BCF refers to the plant metal concentration in root and the soil metal concentration ratio. This ratio should be greater than one for inclusion into the hyperaccumulator category. Bio concentration factor and Translocation factor was calculated after the experimental period. Cadmium and Chromium soil background concentrations were 0.39mg/kg and 13.58mg/kg respectively. Cadmium Bio concentration factor was 51.02 Chromium Bio concentration factor was 2.18. Cadmium Translocation factor was 2.17 and Chromium Translocation factor was 0.48. Based on the Bio concentration factor the plant Physalis minima L. as a high heavy metal accumulator.

### Table 3: Bioconcentration factor and Translocation factor for Cadmium and Chromium for Physalis minima.

<table>
<thead>
<tr>
<th>Heavy metal</th>
<th>Bioconcentration factor</th>
<th>Translocation factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadmium</td>
<td>51.02</td>
<td>2.17</td>
</tr>
<tr>
<td>Chromium</td>
<td>2.18</td>
<td>0.48</td>
</tr>
</tbody>
</table>

IV. References


