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PHYTOREMEDIATION OF HEAVY METALS CONTAMINATED SOILS USING *PEROTIS INDICA*

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ABSTRACT

Phytoremediation is a technology that exploits plants ability to remove pollutants from the environment or render toxic compounds harmless. Heavy metals pollution causes potential ecological risk. Metals present high concentrations in soil effects on growth and metabolism of plants and bioaccumulation of such toxic metals in the plant poses a risk to human and animal health. As a plant based technology the success of phytoremediation is inherently dependent upon proper plant selection. Many metal tolerant plant species, particularly grass species escape toxicity through an exclusion mechanism and are therefore better suited for phytoremediation. The main objective f the present study is to assess the phytoaccumulation capacity of Perotis indica in an artificial contaminated soil. Perotis indica is also known as Indian comet grass. The heavy metals are lead, nickel, cadmium and chromium. Total accumulations of metals and Bioconcentration factor (BCF) were calculated. The result shows that the grass species was good accumulator of nickel, cadmium and chromium contaminated soils.

KEY WORDS - Industrialization, Heavy metals, Pollution, Phytoremediation

INTRODUCTION

Industrialization, urbanization and increase in human population in this centuary increase the environmental pollution. Heavy metal contamination of soil, water and air has posed various uncompromising and fatal effects on humans and stability of the ecosystem. Metals like cadmium, lead, nickel, zinc, arsenic and aluminium when present in high concentrations in soil exert potential toxic effects on overall growth and metabolism of plants. (Agarwal and Sharma, 2006). High levels of heavy metals disturb the normal physiology and biochemistry of living systems. The most dangerous heavy metals are Pb, Ni, Hg, As, Cd, Sn, Cr, Zn, Cu (Write, 2007). Chemical compounds that may be subjected to phytoremediation include metals (Pb, Zn, Cd, Cu, Ni, Hg), metalloids (As, Sb), Inorganic compounds (NO_3, NH_4, PO_4) radioactive elements (U, Cs, Sr) Petroleum hydrocarbons (BTEX), pesticides and herbicides(atrazine, bentazone, chlorinated and nitro aromatic compounds), explosives(TNT, DNT), chlorinated solvents(TCE, PCE) and industrial organic wastes (PCPS, PAHS), and others(Ensley, 2000).

Phytoremediation involves the absorbing of heavy metals from the soil and translocating them to the harvestable above ground plant tissues, which are finally removed from the contaminated area. Phytoremediation is alternative technology to conventional soil clean up technique by using the ability of certain plants, shrubs, herbs and grass species to remove, degrade or immobilize harmful chemicals from the contaminated soil (Chaney et al., 1997). Many metal tolerant plant species particularly grasses, escape toxicity through an exclusion mechanism and are therefore better suited for phytostabilization than phytoextraction (Baker, 1981, Ebbs et al., 1997).

Grasses belongs to the family Poaceae, according to recent studies 101 families which is known to be effective in metal hyper accumulation (Kramer 2010). They are thought to be excellent candidates in phytoremediation because of their fibrous root system, that can stabilize the soil and provide a large surface area for root-soil contact (Kulakow et al., 2000). In similar manner the use of grass species for phytoremediation were studied by Sigua et al., (2007) and Xia (2003). Grasses are potential plants for phytoremediation (Xia, 2004; Spiak and Gediga 2012; Abaya et al, 2014). Grasses can accumulate large amounts of heavy metals in both roots and shoots (Aibibu et al, 2010; Xu and Wang 2013; Zhang et al, 2014). Many authors have proved that grasses are growing on contaminated soils, they absorb much larger quantities of Cd and other metals. (Nan et al, 2002; Deran et al., 2006; Guo et al, 2014; Stanislawska-Glubiak et al., 2015; Quezaua- Hinojosa et al, 2015). *Cyperus rotundus* and *Echinochloa colona* grass species was good accumulators of Pb, Cd and Cr contaminated soils. These species can be recommended for the phytoextraction of Pb, Cd and Cr contaminated soils (Subhashini and Swamy, 2014; Subhashini and Swamy, 2015). High concentration of Cd recorded in *Vertiveria zizanioides* (Aibiby et al, 2010), *P. pratensis* grass species (Xu and Wand, 2013), and Napier grass was a good phytoextractors of cadmium reported by Yasuyuki ishiietal (2015). Cogon grass (*Imperata cylindrical*) and Carabao grass (*Paspalum conjugatum*) are also potential phytoremediators of Pb (Bautista, 2006). Vertivera grass was used for phytoremediation of sites contaminated with high levels of heavy metals particularly lead (Bautista, 2006). It is also tolerant to a wide range of soil acidity, alkalinity, salinity, elevated levels of Al, Mn, As, Cr, Ni, Pb, Zn, Hg, Se and Cu in soils (Troung and Baker (1998). Lemon grass (*Cymbopogon citrates*) is a potential phytostabilizers of Fe, Mn, Cu, Al, Zn, Cd, Pb, Cr, As and Ni from the roots to shoots (Soleimani et al., 2009; Gautam, et al., (2016) reported that tall fescue and Bermuda grass (*Cynodon dactylon*) are Pb accumulators.

METHODOLOGY

The aim of the study was to analyze the phytoremediation potential of *Perotis indica*.

A brief description of the species selected for the present study, *Perotis indica*:

Scientific Classification:

Kingdom	:	Plantae (Angiosperms, Monocots, Commelinids)
Order	:	Poales
Family	:	Poaceae
Subfamily	:	Chloridoideae
Genus	:	*Perotis*
Species	:	*indica*
Binomial name	:	*Perotis indica*

Common name of *Perotis indica* is Indian Comet Grass, found in west tropical, west-central tropical, east tropical, and western Indian Ocean. China and eastern Asia. India, Indo-China, and Malaysia. The species is an annual grass with culms rising to 10–40 cm tall. Leaf-blades are lance shaped, or ovate; 1–3 cm long; 2–7 mm wide. Spikelet packing crowded or contiguous; irregular. Spikelets are spreading, or ascending; solitary. Fertile spikelets are stalked. Stalks are oblong. Indian Comet Grass is found growing on river banks and sandy places. (Gamble, 2008).

Preparation of pots for experimental plants:

Uptake of heavy metals by grass species in a metal contaminated and normal soil was studied in pot culture experiment. The grass species were grown in pots and were irrigated with known heavy metal solutions (Pb, Ni, Cd and Cr) for 60 days. In control normal water was used. The initial soil heavy metal concentration was analyzed. 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 air dried and then placed in a dehydrator for 2-3 days and then dried in an oven at 100^0C. The dried samples of the plant species 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. A blank sample was prepared applying 5ml of HNO_3 into empty digestion flask. The digestion on hot plate at 110ºc for 3-4 hours or continued till a clean solution was obtained. After cooling, the solution was filtered with Whatman NO.42 filter paper. After filtering the filtrate was analyzed for the metal contents in AAS.

Calculation of bioconcentration factor:

Heavy metals are currently of much environmental concern. They are harmful to humans, animals and tend to bioaccumulate in the food chain. Activities such as mining and smelting of metal ores, industrial emissions and applications of insecticides and fertilizers have all contributed to elevated levels of heavy metals in the environment (Alloway, 1994). Phytoremediation is one of the promising methods for reclamation of soils contaminated with toxic metals by using hyper accumulator plants (Baker *et al*., 2000; Ghosh and Singh, 2005; Lazaro *et al.*, 2006). Under normal growing conditions, plants can potentially accumulate certain metal ions an order of magnitude greater than the surrounding medium (Kim *et al.*, 2003). 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 (Yoon *et al*., 2006). The Bioconcentration Factor (BCF) of metals was used to determine the quantity of heavy metal 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 (Ghosh and Singh, 2005).

RESULTS AND DISCUSSION

Accumulations of heavy metals in grass species *Perotis indica*:

Lead:

Lead concentration in the control was 23.59 mg/kg. The absorption of lead was marginal up to 20 days. Thereafter from 40-60 days the increase of lead concentrations was only 1.25 mg/kg. The total accumulation in the whole plant by 60^{th} day was only 1.77 mg/kg.

Nickel:

The initial concentrations of nickel were 3.26 which increased to 8.98 mg/kg in the first 20 days. The accumulation increased to 14.99 from 20^{th} day to 40^{th} day. From 40^{th} day to 60^{th} day the nickel concentrations increased to 27.68 mg/kg. On the final day i.e. 60^{th} day the total accumulation reached to 24.42 mg/kg. The increase of nickel concentration in the plant body was highest from 40^{th} day to 60^{th} day.

Cadmium:

The initial concentration of cadmium was 0.83 mg/kg which has reached to 2.78 in first 20 days. The total accumulation of cadmium in 60 days was 8.52 mg/kg. The increase of concentration was highest from 20-40 days (2.78 to 7.2 mg/kg) and accumulation was slow from 40-60 days.

Chromium:

The total chromium accumulated in the plant in 60 days was 65.63 mg/kg. the initial concentration was 9.61. *Perotis indica* was accumulated 30.83 mg/kg of chromium in first 20 days. The concentration of chromium continued to increase from 20th to 40th day (30.83 to 40.5 mg/kg). However, a substantial accumulation was observed from 40th day to 60th day (40.5 to 75.24 mg/kg). The results revealed that *Perotis indica* was a good accumulator of chromium.

Table 1: Accumulation of metals (Pb, Ni, Cd and Cr) (mg/kg biomass) in *Perotis indica* during the experimental period

Metal	control	20th day	40th day	60th day	Total accumulation
Lead	23.59±0.13	23.99±0.08	24.11±0.15	25.36±0.07	1.77
Nickel	3.26±0.13	8.98±0.08	14.99±0.15	27.68±0.08	24.42
Cadmium	0.83±0.13	2.78±0.08	7.2±0.15	9.35±0.09	8.52
Chromium	9.61±0.12	30.83±0.08	40.5±0.15	75.24±0.09	65.63

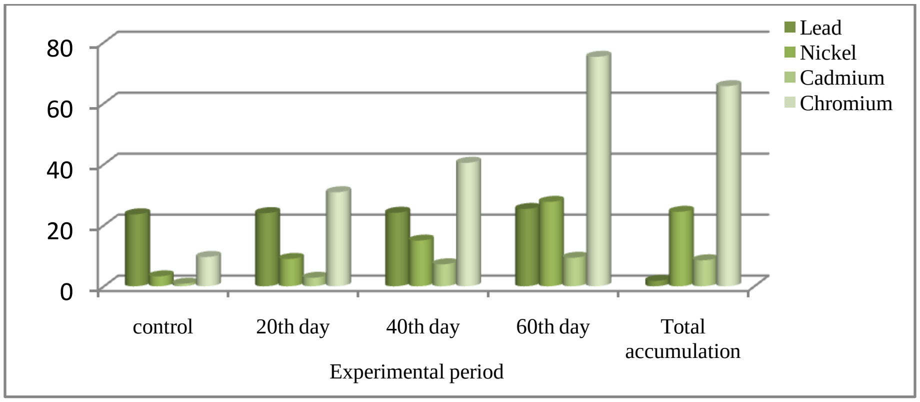

Fig 1: Accumulation of metals in *Perotis indica* during the experimental period

***Perotis indica*:** This grass species showed a very wide variation in the affinity to different metals. Highest total accumulation was recorded for chromium (65.63 mg/kg) followed by nickel (24.42 mg/kg), cadmium (8.52 mg/kg) and lead (1.77 mg/kg) in the descending order. *Perotis* can be considered as an effective absorber of chromium.

Table 8: Bio concentration factor of metals in the experimental plant species

Metal	Bioconcentration factor(BCF)
Lead	0.19
Nickel	2.89
Cadmium	23.28
Chromium	4.83

Phytoremediation is an eco-friendly approach using plants and their associated microbes (Cherian, et al., 2005) to remedy contaminated soils and water, sediments and groundwater. It is emerging as a cost-effective and environmentally friendly technology. Due in large part to its aesthetic appeal, this technology has gained increasing attention over the past 10 years. Phytoremediation uses different plant processes and mechanisms normally involved in the accumulation, complexation, volatilization, and degradation of organic and inorganic pollutants (Suresh and Ravi Shankar, 2004). According to Shah and Nongkynrih (2007), *Vetiveria zizanioides* is a Pb hyperaccumulator. Based on translocation and Bioconcentration factors, lemongrass acted as a potential phytostabilizers of Fe, Mn, and Cu in roots and was found efficient in translocation of Al, Zn, Cd, Pb, Cr, As, and Ni from roots to shoot (Gautam, et al (2016). *Cymodocea rotundata* is a good Phytoremediator of heavy metal contaminated soils (Annie et al., 2015). Plant species differ in their ability to accumulate heavy metals. The Alfalfa plants has more ability in absorbing lead and zinc in its root and shoot (Nascimento and Xing, 2006). Parsadoost et al. (2007) experiments showed that *Ebenus estellata*, *Astragalus glaucantus,* and Acantholimon sp. species had the highest lead concentration in their shoots. The present study shows that the experimental plant species was a good phytoextractor of nickel, cadmium and chromium from contaminated soil.

Conclusion:

The potential of a plant to be useful for phytoremediation is influenced by the mobility and availability of heavy metal in the soil and uptake by the plants. Phytoextraction involves repeated cropping of plants in contaminated soil, until the metal concentration drops to acceptable level. In the present study *Perotis indica* a grass species used for the phytoremediation of Pb, Ni, Cd and Cr contaminated soils. The result shows that the grass species was good accumulator of nickel, cadmium and chromium contaminated soils.

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