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Cultivation of *Hedychium spicatum* on Zn Amended Soil: A Phytoremedial Aspect

Research Article

Vinay Deep Punetha, Ganga Bisht, Deepak Chandra, Nanda Gopal Sahoo*

Department of Chemistry, DSB Campus, KU Nainital, Uttrakhand - 263002

***Corresponding author:** Nanda Gopal Sahoo, Department of Chemistry, DSB Campus, KU Nainital, Uttrakhand - 263002, Ph: +91-5942-235055; E-mail: ngsahoo@yahoo.co.in

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Abstract

Zingiberaceae family constitutes a vital group of rhizomatous medicinal and aromatic plants characterized by the presence of volatile oils and oleoresins of export value. This study reports capacity of Hedychium rhizomes to absorb Zn from the soil in order to evaluate its phytoremedial potential. 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. For this purpose soils were contaminated artificially by heavy metal Zn at different levels. Zn concentration was determined in various parts after 120 days. Heavy metal analysis was carried out by the help of Atomic Absorption Spectroscopy. Effect of Zn beside heavy metal plant nutrient in higher doses (300 ppm) was studied. This experiment was conducted to find out the resistance to such metal element at higher levels in soils and potential of plants to resist such soil's toxicity thereby showing normal or good growth in such metal contaminated soils.

Keywords: *Hedychium spicatum*; Phytoremediation; AAS Spectroscopy

Introduction

Heavy metals as manganese, cadmium, lead and zinc are naturally present in the environment. Their presence has gradually been increasing with the increase of industrialization. The mobilization of heavy metals by man (through mining from ores and processing for different applications) has led to the contamination of different environmental segments by these elements. Therefore the phytoremedation of heavy metals from soil is essential. Phytoremediation is defined as the use of green plants to remove heavy metals and contaminants from the soil [1-3]. It is adopted as it offers a low cost and an environmentally friendly approach for the treatment of soils. Excessive amount of Zn in soil may affect plant adversely as Zinc at high concentrations is documented as cell division inhibitor [4].

In present study *Hedychium* rhizomes were chosen to evaluate effect of heavy metal concentration on the plant of Zingiberaceae family. This family constitutes a vital group of rhizomatous medicinal and aromatic plants characterized by the presence of volatile oils and oleoresins of export value [5]. *Hedychium* is one of the plant species which is commonly used in preparation of indigenous medicine. The rhizome extract, contains essential oil, starch, resins, organic acids, glycosides, albumen and saccharides, which is administered for blood purification, bronchitis, indigestion, treatment of eye disease and inflammations [6]. Studies on phytoremedial potential and potential to resist heavy metal pollution beyond its nutritive value provides an opportunity to exploit Zn contaminated soil for the production of *Hedychium* cultivation.

The phytoremediation of metal-contaminated soils provides a cheaper way for soil remediation. Because the costs of growing a crop are minimal compared to those of soil removal and replacement, the use of plants to remediate hazardous soils was seen as having huge importance. In addition it will provide an opportunity to exploit contaminated soils for their agrarian utility. Phytoremediation generally has a low remediation rate, and usually require a longer period [7,8].

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Various factors can be calculated based on the concentration of heavy metal ion in different parts of the plants. Translocation Factor is a parameter which indicates the ability of the plant to translocate metals from the roots to the aerial parts of the plant [9]. Translocation factor is ratio of metal concentrations at the aerial parts and in the root respectively. Translocation factor is a key parameter which reveals affinity of metal ion for either aerial parts or root [10].

The aim of present study is to determine the effectiveness of phytoremediation for the removal of Zn using *Hedychium spicatum* rhizomes. Soil samples were collected at a depth of 20 cm from the project site Dhari, India. Pots were contaminated with different concentration of Zn. Experiment conducted in order to observe the tolerance of plant species toward the Zn contamination in the soil and to analyze efficacy of the plant for the detoxification of soil contaminated with Zn.

Material and Methods

Test Plants

Plants seedlings were purchased from regional centre of NBPGR situated in Bhowali (Distt. Nainital). After cultivating them into the nurseries (Figure 1) and were transferred into experimental pots in which Zn metal was amended at different concentrations.

Figure 1: Plants at various stages of experiment.

Collection of Samples

These samples were analysed before the Zn contamination. Samples were air dried, grinded into fine powder using pestle and mortar and passed through 2 mm sieve. The soil samples were prepared for physio-chemical analysis. In addition soil samples were also taken for evaluation of physiochemical properties. Inferences were drawn on the basis of evaluation of some parameters chosen like pH, organic matter, primary nutrients (N,P and K), secondary nutrients like (Ca) and micronutrients Zn, Cu , Mn in addition electrolytic conductivity, bulk density, water holding capacity (WHC), soil colour, texture were also evaluated. (this part of the study was conducted at soil analysis laboratory, Niglat, Bhowali). The fresh rhizomes of the plant material was collected from project site, during middle of October 2012 after 120 days of Zn amendments into the soil. Various parts of the plant were separated, and cleaned properly. These samples were later evaluated for the determination of phytoremidial potential by drying and grinding into fine powder.

Digestion of various collected samples

The samples of *Hedychium* spicatum were collected in the month of October 2012 seasonally with random sampling. Leaves, stem and roots were dissected. Digestion process was carried out according to Sasmaz and Obek. The plant samples were dried at 80 °C for 20 h and the ash contents were determined by heating at 480°C for 4 h. HCl (2.0 mL, Merck), HNO_3 (2.0 mL, 65%, Merck) and H_2O_2 (2.0 mL, 30%, Merck) were added to 2.0 g ash and the mixture was heated at 95°C hot plate for an hour [11].

Water samples for heavy metal analysis

Method adopted for this purpose was EPA (Environmental Protection Agency) vigorous digestion method described by Gregg. Sample left after distillation of plants were transferred into 500 mL beaker containing 50 mL of conc. HNO_3. The sample were boiled slowly and then evaporated on a hot plate to the lowest possible volume. The beaker was allowed to cool and another 25 mL of conc. HNO_3 was added. Heating was continued with the addition of conc. HNO_3 as necessary until digestion was complete. The samples were evaporated again to almost dryness and the beakers were cooled, followed by addition of 1:1 v/v HCl solution. The solutions were then warmed with 5mL NaOH (5M), then filtered through Whatmann Filter Paper No. 42. The filtrate was transferred to 25 mL Volumetric flask with distilled water [12].

Results and Discussion

Observations made after analysis of the soil has shown (Table 1) that the soil "A" was slightly acidic in nature holding pH of 6.9, slightly acidic nature of the soil which has more H+ ions in the systems accounts for better cation exchange capacity (CEC), consequently making the metal to be more bioavailable to the plant. The percentage of organic matter in the soil was 9.19%, primary nutrients N,P,K present in the soil were 0.45, 0.01 and 0.02 total % respectively. Secondary nutrient Ca was 0.233% while micro nutrients Zn, Cu, Mn, were found to be 8.2, 5.0 8.58 ppm respectively. Bulk density of soil was found to be 0.95 g cm-3 while WHC was 95%. Micro nutrients like Cu, Zn, Mn were present 4.0, 2.6, 30.5 ppm respectively. Certain parameters such good amount of organic content, moderate water holding capacity and pH slightly in the acidic range (6.9) are the factors which are good for the cultivation of Hedychium spicatum.

Absorbed metal concentration was analyzed by Atomic Absorption Spectroscopy (Atomic absorbtion spectrophotometer, Model 4129, Electronic Corporation Limited). This study has shown that Rhizomes of the Hedychium spicatum can take up Zn metal and accumulate them in other parts of the plant. Metal distribution in various parts of the plant at different concentrations has shown that rhizome has capability to accumulate heavy metal. Though at high concentrations (300 ppm) leaves has shown effect of metal toxicity as they turn yellow. Concentration of heavy metal quantified in various parts of plant has suggested Hedychium rhizomes have more tendencies to accumulate

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Table 1: Physiochemical properties of soil before amendment of Zn.

S.N	Parameter		
1	Ph		6.90
2	Organic Matter (OM) %		9.19
3	Primary Nutrients (Total %)	N	0.45
4		P	0.01
5		K	0.02
6	Secondary Nutrients (In ppm)	Ca	0.23
7	Micro Nutrients (In ppm)	Zn	4.00
8		Cu	2.60
9		Mn	30.5
10		B.D. g/cc	0.59
11		WHC	95.0

Zn ions into their roots. As it is explicit from the experiment that in various Zn amended soils, concentration of Zn is always more in the rhizomes, which suggests metal availability and mobility in the rhizosphere gets influenced bioavailability of the metal ion. (Figure 2) The accumulation of heavy metals in roots, stems and leaves were estimated separately. Concentration of heavy metal quantified in various plant parts has suggested Hedychium rhizome has strong tendency to accumulate Zn ions into their roots. As it is explicit from the experiment that in various Zn amended soils, concentration of Zn is more in the rhizomes in each experiment. As the pH of soil is less and slightly acidic, it assists in the exchange of metal ions and more absorption of metal ion takes place from the soil. In all three concentrations Translocation Factor is less than one which indicates the ability of the plant to accumulate metals ions in the roots of the species in comparision to that of other baerial parts of the plant. On the basis of this study Hedychium spicatum could be classified as a hyperaccumulator for Zn metal, though other necessary parameters have to be evaluated experimentally in order to confirm this study. Roots have more accumulation capacity as compared to stem and leave, the metal ions present in the soil are in the direct contact of the roots, and hence their bioavailability for roots is more than that of other plant parts. As evidences suggest phyto-accumulation popularly also known as phyto-extraction could be the possible mechanism of metal absorption. (Figure 3) This study could turn significant as it shows applicability of Hedychium for the decontamination of Zn and its potential to survive on Zn contaminated fields which extends its applicability in the field of phytoremidation beyond its traditional use in the field of pharmaceutics.

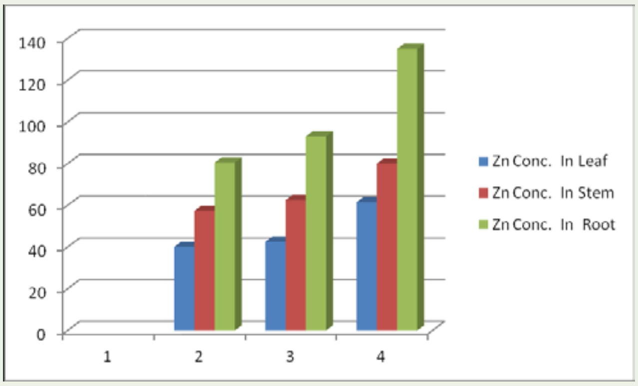

Figure 2: Zn concentration in various parts of the plants.

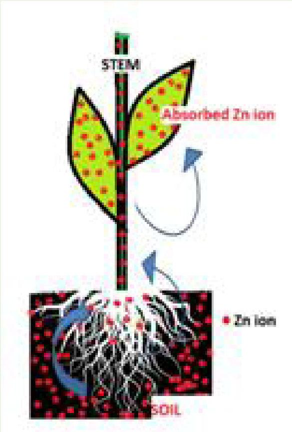

Figure 3: Schematic diagram Phytoextraction of the Zn metal from the soil.

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