ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 9, September 2013

Phytoremediation of Zinc Contaminated Soils by *Physalis minima* Linn

V. Subhashini[1], Dr. A. V. V. S. Swamy[2]

Faculty, Dept. of Environmental Sciences, ANU, Guntur (AP), India[1]

Asst Prof, Dept. of Environmental Sciences, ANU, Guntur (AP), India[2]

Abstract: Contamination of the biosphere by heavy metals has increased sharply at the beginning of the 20th century, posing major environmental and human health problems worldwide. Metal pollution is considered hazardous to biological systems because of their oxidative and carcinogenic potential. Phytoremediation technology has been receiving attention lately as an innovative, cost-effective, and long-term alternative to the more established engineering methods used at hazardous waste sites. Plants have the ability to take up harmful substances and then store or metabolize them. This suggests the possibility of phytoremediation of soil contaminated with organic, inorganic, and radioactive substances, all of which are difficult to remove from soil with conventional methods. In the present study *Physalis minima* Linn a weed plant species used for zinc contaminated soils. This species belong to Solanaceae family of perennial herbs. The plant *Physalis minima* Linn was grown in pots filled with soil and solution of Zinc was administered to the plants for 60 days. The uptake of heavy metals was estimated at 20 days intervals in roots, stem and leaves. A set of control experiment without application of heavy metal solution was also maintained. The order of accumulation of Zinc in *Physalis minima* was recorded as root> leaves> stem. The Bioconcentration factor and Translocation factor was also calculated. Based on the BCF and TF the weed plant species is a zinc accmulator.

Keywords: *Physalis minima*, Heavy metals, Phytoremediation, Bioconcentration Factor, Translocation Factor.

I. INTRODUCTION

Contamination of the biosphere by heavy metals has increased sharply at the beginning of the 20th century, posing major environmental and human health problems worldwide. Since the Industrial Revolution, the production of heavy metals such as lead, copper, and zinc has increased exponentially. Excess level of heavy metals caused serious concern in nature as they are non- biodegradable and accumulate at high levels (1). The WHO has estimated that environmental exposures contribute to 19% of cancer incidence worldwide (2). Heavy metals such as Cu and Zn are essential for normal plant growth, although elevated levels of both essential and nonessential metals result in growth inhibition and toxicity symptoms. Common heavy metals like Cd, Pb, Co, Zn and Cr etc. are phytotoxic at low concentration as well as very high concentration are detected in waste water from mining operations, tanneries, electronics, electroplating, batteries and petrochemical industries as well as textile mill products (3). Soils can be contaminated with heavy metals from various human activities and a number of *ex situ* and *in situ* techniques have been developed to remove heavy metals from contaminated soils. Phytoremediation is a developing technology that aims to extract or inactivate metals, metalloids, and radionuclides in contaminated soils and chemical enhancements have been used to enhance soil heavy-metal availability to plants.

Phytoremediation is becoming an important tool for decontaminating soil, water, and air by detoxifying, extracting, hyperaccumulating, and/or sequestering contaminants, especially at low levels where, using current methods, costs exceed effectiveness. Phytoremediation is the direct use of living green plants for in situ, or in place, removal, degradation, or containment of contaminants in soils. Phytoremediation can be defined as “the efficient use of plants to remove, detoxify or immobilise environmental contaminants in a growth matrix (soil, water or sediments) through the natural biological, chemical or physical activities and processes of the plants”. Phytoremediation involves growing plants in a contaminated matrix, for a required growth period, to remove contaminants from the matrix, or facilitate immobilisation (binding/containment) or degradation (detoxification) of the pollutants. The plants can be subsequently harvested, processed and disposed. Economic and business impacts include accumulating liabilities for governments and mining companies, expensive remediation programs, increasing compensation payments and impacts on company reputation and future project approvals.

Zinc and copper are conservative or non-biodegradable elements with residence times between $10^3$and 10^5 years.They are readily incorporated into biogenic materials especially phytoplankton and thus may get transferred to human beings through the different trophic levels of aquatic food chain (4). Distribution of heavy metals in plant body depends upon availability and concentration of heavy metals as well as particular plant species and its population (5). For instance, roots usually show higher heavy metal concentration than shoots, because they are the origin, which comes into contact with the toxic metals present in the soil (6). In recent past, (7) investigated soil to plant transfer of heavy metals like, Cu, Pb and Zn by vegetables. Studies on heavy metal uptake revaeled that vegetables grown at environmentally contaminated sites in Addis Ababa, Tanzania, could take up and accumulate metals at levels that are toxic to human health. Metal uptake differences by leafy vegetables are attributed to plant differences in tolerance to heavy metals (8). Cu and Ni in different edible vegetables alongwith its soils on which they were grown were higher in industrial areas than those of the residential areas due to pollution. The ideal plant for use in phytoremediation *ex planta* should have the following traits: (1) a highly developed root system that has the ability to secret a substantial amount of the enzyme that can render the pollutants harmless; (2) tolerance to the pollutants at a concentration found in soil; and (3) fast growth and a relatively high biomass (large size). Poplar trees are now considered one of the most useful potential candidates for phytoremediation (9) most researchers are using the model plant *Arabidopsis thaliana* for pilot research. Zinc is the 23rd most abundant element in the Earth's crust. The dominant ore is zinc blende, also known as sphalerite. Other important zinc ores are wurzite, smithsonite and hemimorphite. Zinc is a very common substance that occurs naturally. Many foodstuffs contain certain concentrations of zinc. Drinking water also contains certain amounts of zinc, which may be higher when it is stored in metal tanks. Industrial sources or toxic waste sites may cause the zinc amounts in drinking water to reach levels that can cause health problems. Zinc occurs naturally in air, water and soil, but zinc concentrations are rising unnaturally, due to addition of zinc through human activities (20).

II. MATERIAL AND METHODS

Physalis minima, L.belongs 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 (not furry), with entire or jagged margins, 2.5-12 cm long. (10). *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. Leaves, petiolate (4.1 cm long), ovate to cordate, pubescent, delicate, exstipulate, acuminate, having reticulate palmate venation and undulate margins; dorsal surface of the leaves, dark green and the ventral surface, light green; 9.7 cm long and 8.1 cm broad. Flowers, pedicellate having long pedicel, hermaphrodite, complete, solitary, small companulate. Fruit, a berry, enclosed within the enlarged, 10-ribbed, reticulately veined calyx. The fruit has a pleasant cherry-tomato like flavor when fully ripe. The fruits are juicy, mildly astringent and sweet with a pleasant blend of acid. The plant tends to have a weedy character, often found growing in disturbed sites. The fruit is said to be appetizer, bitter, diuretic, laxative and tonic. (11, 12). Extracts from the plant have shown anticancer activity. (13).

Physalis minima plants were grown in pots filled with 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 metal selected for the study was zinc, the uptake was estimatedin root, stem and leaves for every 20 days for a total period of 60 days. In addition a control blank set of experimental pots was also maintained. The heavy metal dissolved in distilled water to prepare stock solution of 1000 ppm. The calibration curve of the heavy metal was 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 ºc. 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 HNO3 and HCl in the ratio of 3:1. The digestion on hot plate at 110ºc 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.

Bioconcentration Factor and Translocation Factor: The movement of the heavy metal from the polluted sediments into the roots of the plant and the ability to translocate the metals from roots to aerial parts were assessed correspondingly by means of Bioconcentration Factor (BCF) and the Translocation Factor (TF). Bioconcentration factor is an index of the ability of plant to accumulate a particular metal with respect to its concentration in the sediment (14). Bioconcentration factor (BCF) was calculated as a ratio of concentration of heavy metal in plant roots to that of soil (15):

$$BCF = \text{Metal root} / \text{Metal soil}$$

The higher the BCF value the more suitable is the plant for phytoextraction (16).

Translocation Factor (TF) was described as the ratio of heavy metal concentration in plant shoot to that in plant root (17). This ratio is an indication of the ability of the plant to translocate metals from the roots to the aerial parts of the plant (18).

$$TF = \text{Metal (shoot)} / \text{Metal (root)}$$

TF>1 indicates that the plant translocate metals effectively from root to the shoot (19).

III. RESULTS AND DISCUSSION

Zinc plays a very important role in plant metabolism. Excessive amounts of zinc affects biochemical activities of the plants i.e enzyme activity, protien synthesis. High amount of Zn absorption effects plant growth and biomass production. The weed plant was a fast growing high biomass producing species. The plant species in the experimental period absorb high amount of zinc in their biomass compared to the control. In the first 20 days period Zn accumulationwas high in leaves than root and stem. In the 40th day stem concentration increased marginally than leaves and stem. On the 60th day Zn accumulation was high in root. After the total experimental period Zn concentration in the stem was 28.46mg/kg biomass, leaves concentration was 31.01mg/kg biomass and root concentration was 74.79 mg/kg biomass.After the experimental period zinc accumulated in the order root> leaves> stem. Bioconcentration factor was calculated using soil background concentration. Zinc background concentration was 13.08mg/kg. Leaf bioconcentation factor was 2.37, stem bcf was 2.17 and root bcf was 5.71. Translocation factor was calculated using above ground biomass and below ground biomass. Root to shoot transfer of heavymetals was expressed with translocation factor. After 20th day translocation factor was 1.66, 40th day translocation factor was 1.95 and 60th day translocation factor was 0.79. In the course of the study we have concluded that the plant species accumulated high levels of zinc. Based on the bioconcentration factor and translocation factor values the plant species was an accumulator of zinc.

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Table 1: Accumulation of Zinc (mg/kg) in *Physalis minima* During the Experimental Period

Plant part	Control	20th day	40th day	60th day	Total Accumulation	Bio concentration factor
Leaf	48.34	73.7	74.26	79.35	31.01	2.37
Stem	34.55	46.51	62.05	63.01	28.46	2.17
Root	29.93	52.32	56.69	104.72	74.79	5.71
Total Accumulation	112.82	172.53	193	247.08	134.26	10.26

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ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 2, Issue 9, September 2013

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BIOGRAPHY

Dr. A.V.V.S. Swamy, M.Sc., Ph.D., D.E.Sc., is the Coordinator of the Department of Environmental Sciences, Acharya Nagarjuna University, Guntur, A.P. So far published more than 70 publications in various reputed National and International Journals. . Two Ph.D.s and Four M.Phil. degrees are awarded under his guidance. Delivered a number of Radio talks in All India Radio. Organised Workshops to Lecturers, professionals and students. Organised two National Seminars and also contributes articles on Environmental Importance in Regional Language (Telugu). Contributed chapters in edited volumes. Prepared Study Material for Environmental Studies for the Centre for Distance Education, Acharya Nagarjuna University. Areas of specialisation are Ecology, Wildlife Conservation, Phytoremediation, Air Pollution impacts and adsosrption techniques.