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Hazardous Waste Management Approach for Heavy Metals in Soil by Phytoremediation

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Abstract*: There have been a lot of practical applications of phytoremediation in the last ten years, involving organic, inorganic, heavy metal, and radionuclide remediation. India would find this to be an excellent alternative to conventional remediation methods as it is a sustainable and inexpensive process. The huge retention of industrial waste in soil resulted in soil pollution which is more hazardous due to the long-term persistence of contaminants. A major source of hazardous waste products in Bhopal city is the industrial region. Near residential areas, industries produce pollution that can be very harmful to human health. The objective of this research was to determine which heavy metal accumulators are capable of absorption and translocation of heavy metals. In the Govindpura sampling sites, Cr and Ni concentrations were higher, while Cd concentrations were lower. Phytoremediation was conducted by comparing the heavy metal accumulation of Datura inoxia, Calotropis procera, Ricinus commmunis, and Polygonum in vitro cultures.

***Keywords*: Environment, Hazardous Waste, Heavy Metals, Pollution, Phytoremediation, Pollutants.**

I. INTRODUCTION

The Environment and the global ecosystem are affected by global industrialization. All living organisms are harmed by this corruption of the ecosystem. The problem of soil pollution affects the entire world. Polluted soil in industrial areas containing hazardous waste often contains a mix of contaminants [1]. Contamination occurs in a variety of inorganic and organic forms, including heavy metals, hazardous wastes, explosives, and petroleum products. Heavy metals present a different problem from organic contaminants because they pose the greatest threat to human health. Since the 1970s, the environment has rapidly degraded. Environmental quality and health problems are determined by the composition, quantity, and disposal of hazardous waste. One of the most important industrial hubs in the country is in Bhopal and nearby regions. The use of phytoremediation can solve this problem in a cost-effective and eco-friendly manner, which is particularly beneficial to develop countries and cities such as Bhopal. Phytoextraction of heavy metals can predict the amount of hazardous waste in industrially contaminated sites [2]. Metal Excluder protects metal entry into the aerial parts of plants over a wide range of metal concentrations [3] of contaminated and metalliferous soils. Accumulators may accumulate metals in above-ground tissues at levels much greater than those found in soils or adjacent non-accumulating species. A plant with more than 0.1% Ni, Co, Cu, Cr, or Pb on a dry-weight basis, or 1% of Zn on a dry weight basis, has been described as a hyperaccumulator based on a literature survey.

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II. METHODOLOGY

A study was performed to evaluate the phytoremediation capabilities of the entire flora and to examine in vitro studies of indigenous plants involved in phytoremediation, as shown in figure 1. In this research, we are exploring ways to remediate soils contaminated by heavy metals. A waste site along a roadside in an industrial area in Bhopal is the subject of this study. These roadside areas are being contaminated by industrial waste in the soil, traffic in the air, and urban refuse from different human activities. The overall contaminated area was sampled randomly 4 to 5 times.

A. Soil Sampling for Heavy Metal Analysis

Randomly selected industrially contaminated samples were analyzed. Samples of sediments were collected at every sampling location. By random sampling, soil samples were taken at a depth of between about 10 and 50 cm using stainless-steel collectors.

B. Sample Preparation for AAS Analysis

In this study, soil samples were collected from horizons in the surface layer (about 25 cm depth) of four soil locations of the industrial region [4] [5]. In the laboratory, samples were air-dried at room temperature and sieved using a 2-mm mesh sieve to pass. Various soil properties affect the bioavailability and mobility of heavy metals [6].

C. Sample Analysis by Atomic Absorption Spectrophotometer

The soil samples were dried at room temperature for seven days and sieved through (2 mm sieve). 0.5M Nitric acid (HNO3) was used for a cool extraction of the dried samples. Using atomic absorption spectroscopy, Pb, Cd, Ni, and Cr, as well as Cd, were determined.

D. Studies on in Vitro Culture Conditions of Native Plants

According to an extensive botanical survey of the industrially contaminated site, the following species survived in the majority at the polluted area:

- Datura innoxia
- Polygonam
- Ricinus communis
- Calotropis procera

These plants were studied in vitro in this research work. The in-vitro study used establishment, full as well as half-strength/ concentration of MS with 0.5 mg/L BAP in combination with 0.5 mg/l NAA and kinetin.

III. OBSERVATIONS AND RESULTS

The extraction of heavy metals from soil indicated that there was a higher concentration of toxic heavy metals that were hazardous for human health. In Table 1, the number of heavy metals in soil collected from sampling sites are listed. The order of decrease in heavy metals in sediment for contaminated sites was Lead > Chromium > Nickel > Cadmium. All the heavy metals analyzed in the soil sample analysis had Lead concentrations at the highest level, while Cadmium concentrations were at the lowest level. The concentrations of heavy metals at each sampling site except for lead differed significantly.

Table I: Heavy Metals Found in Different Soil Samples at Contaminated Sites

Soil Samples	Copper (mg/kg)	Chromium (mg/kg)	Lead (mg/kg)	Cadmium (mg/kg)	Nickel (mg/kg)
S-1	30.39	140.0	199.5	59.2	37.36
S-2	22.87	159.8	180.9	70.5	38.50
S-3	28.58	201.9	258.7	62.5	32.51

Sediment concentrations in industrial areas have high concentrations of lead and chromium. Results have shown that industrially contaminated sites contain toxic concentrations of lead and chromium as shown in Table 2. Increasing toxic levels of chromium in soil increase between 2 and 50 parts per million, critical levels of Cr for plants are 5 to 10 parts per million and 0.006 to 18 parts per million, and our results indicate that soil pollution is occurring in the investigation area. Various culture techniques allow for rapid regeneration in-vitro in tissue culture studies. A photograph of this in-vitro tissue culture study is shown in Figure 2. With in-vitro phytoremediation studies, it is easier to monitor and control results within a shorter time frame.

Table 2: Heavy Metals Extracted from Different Plant Samples at Industrial Sites

Plant Samples	Chromium (mg/kg)	Lead (mg/kg)	Cadmium (mg/kg)	Nickel (mg/kg)
Castor	58.92	84.35	18.71	23.58
Calotropis	76.50	74.71	20.52	25.01
Datura	82.50	92.48	21.53	25.03
Polygonum	84.71	96.12	32.48	29.12

Plant material rich in metals may be harvested without extensive mining, waste disposal costs, or losses of topsoil that would be required by traditional remediation practices [7]. The plants used in phytoremediation processes must produce sufficient biomass, while simultaneously accumulating a high concentration of the metal in question [8] [9] [10] [11].

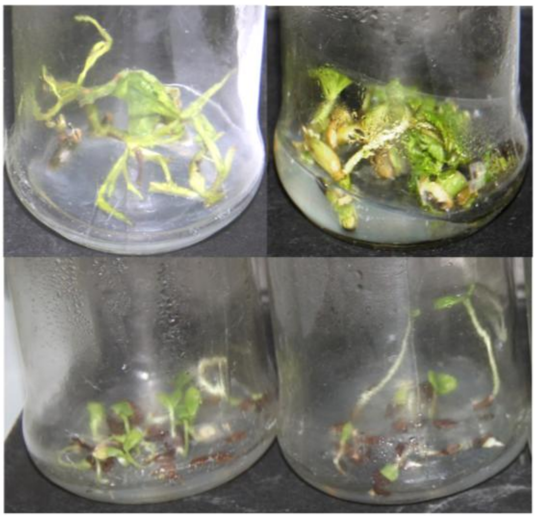

Fig. 1.Tissue Culture Studies on Plants

IV. CONCLUSION

It takes an interdisciplinary approach for the phytoremediation of pollutants and hazardous waste management in the case of heavy metals. Here natural plant physiology can be utilized as a tool to remediate soil pollution. Plantation in the industrial area is an aesthetic as well as an eco-friendly way to fight pollutants. The use of indigenous plants in phytoremediation doesn't violate the natural flora and fauna of the region and reduces the risk of spreading exotic species [12] [13]. Plant tissue culture can produce large amounts of fast-growing, genetically similar, and pollutant-tolerant plantlets in very little time, which can be used for phytoremediation [14] [15]. In the future, planting metal hyperaccumulator plants must be a vital part of government and industry's phytoremediation strategy plans.

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