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Original Research Article

Effects of Physicochemical Soil Properties on the Heavy Metal Concentrations of *Zea mays* L. from Thanjavur

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Abstract

Industrial wastes are a major source of soil pollution that originate from mining industries, chemical industries, metal processing industries, and the like. These wastes include a variety of chemicals like heavy metals, phenolics etc. The objectives of this study, was to investigate the effects of heavy metals on the growth of *Zea mays* L. plant to determine the loss of agricultural productivity of a very important cereal crop. The results showed that lead and chromium treatments in seeds produced toxic impact on germination and growth of *Zea mays* L. when compared to control. The plants treated with heavy metals not only losing its characters but also transforming the heavy metals on to the soil in which they are grown.

Keywords

Crop
Heavy metals
Zea mays L.

Introduction

Soil contamination due to dispersal of industrial and urban wastes is a major environmental concern. The cause of the contamination is a presence of wide range of inorganic and organic compounds. These compounds may be the combustible substances, heavy metals, explosives hazardous wastes and petroleum products (Ghosh and Singh, 2005). Heavy metals are the main constituent of the inorganic contaminants. The availability of these heavy metals for plant absorption depends on the physicochemical properties of soil, pH, organic matter, and metal concentrations (Bin et al., 2001). Plants readily assimilate elements through the roots, which dissolve in water and exist in ionic form (Lozak et al., 2002). High levels of toxic metals can also occur during medicinal preparations or processing when plants are used as active ingredients, as in the case of the presence of Pb and Hg in some Chinese, Mexican, and Indian medicines (Chan et al., 1993), or when plants are grown in polluted areas, such as near roadways or metal mining and smelting operations (Pip, 1991). In addition, high levels of toxic metals may occur when agricultural expedients are used, including Cd-containing fertilizers, organic mercury, lead-based pesticides, and contaminated irrigation water (Abou-Arab., 1997).

Medicinal plants are the raw materials for many herbal formulations of pharmaceuticals and neutraceuticals. The use of medicinal plants in therapeutics goes back to beyond record history, but it has increased during the last decades (Woods, 1999; WHO, 2002). High level of toxic metals occur in medicinal preparation when the plants are growing/cultivated in the fields polluted with heavy metals. A number of medicinal plants are herbaceous and grow wildly and many of them may be hyperaccumulators of toxic heavy metals. If medicinal plants are growing in polluted soil, the contaminants get accumulated in the plant body and reach the final marketable medicines leading to health hazard. Herbal medicinal products have been reported to contain toxic heavy metals such as lead, mercury, cadmium, arsenic etc. (Ernst, 2005).

Maize known in many English-speaking countries as corn, is a grain domesticated by indigenous peoples in Mesoamerica in prehistoric times. The leafy stalk produces ears which contain seeds called kernels. Maize spread to the rest of the world due to its ability to grow in diverse climates. Sugar-rich varieties called sweet corn are usually grown for human consumption, while field corn varieties are used for animal feed and as chemical feed stocks. Plantings for silage are even denser.

In the present study, we have to investigate the following methods. i. Collection of samples *Zea mays*. ii. To estimate the NPK in treated and control soil. iii. To estimate the heavy metals in treated and control soil. iv. Observation of plant growth measurement of treated and control plants.

Materials and methods

Collection of sample

The plant samples *Zea mays was* collected from Rajeshwari Nagar in Thanjavur dist. The samples were allowed to seed germination technology.

Seed germination

The seeds are soaked in different types of soils namely normal soil and treated soil. Then the seeds were incubated in tray and kept for incubation about 24 h. After germination, the seeds were transferred into the field. Every 15 days, the organic matter, heavy metals, nitrogen, phosphorus, qualitative tests were analyzed.

Determination of nitrogen

Nitrogen is measured by a spectrophotometric method (using chromotropic acid). Chromotropic acid spectrophotometric method is quite rapid, used originally for water and later for soils (Hadjidemetriou, 1982).

Estimation of phosphorus

Phosphorus content is determined spectrophotometrically at 882nm at an acidity of 0.24 MH_2 SO_4 by reacting with ammonium molybdate using ascorbic acid as a reductant in the presence of antimony (Murphy and Riley, 1962) using manual or automated techniques

Analyses of some physico-chemical parameters of soil samples

Calcium (Ca) and magnesium (Mg) were determined by EDTA titration while potassium (K) and sodium (Na) were determined by flame photometry (Lindsay and Norvell, 1978).

Quantitative estimation of zinc, iron, mercury and lead

Cadmium, chromium, mercury and lead content of the root, stem and leaf tissues were analyzed using Atomic Absorption Spectrophotometer. Samples were prepared according to the method of Allan (1969). Different plant parts- root, stem and leaf tissues of treatments and control were sampled and were dried at 60°C in a hot air oven. Known weight of the dried sample were digested by refluxing in 10:4 ratio of nitric acid and perchloric acid until the solution become colorless using Kjeldahl's flask heated in a sand bath. Then the digest was transferred to standard flask and volume was made up to 50ml and kept in screw-capped containers. Atomic Absorption Spectrophotometer (PERKIN ELMER Model A, Analyst 300) was used for the estimation of heavy metals present in the digested samples.

Results and discussion

Seed germination test for *Zea mays* L.

Control and treated plants growth were observed for a time period of 30 days. Control plants were not spiked with heavy metals namely Pb, Cr and the treated plants were spiked with heavy metals namely Pb and Cr in the concentration of 100 ppm. Any symptoms of metal toxicity (e.g. stunting, necrosis, yellowing, pigmentation, discoloration) exhibited by plants were usually noted during the experimental period. But there are no symptoms of metal toxicity on the plant which are not spiked with heavy metals (control plants).

The results indicate that the seed germination and growth of *Zea mays* L. have been affected and the growth has been reduced in 100 mg/ppm of lead and chromium treated soil when compared to control. Also the Physical and Chemical properties of soil gets great influence by the infusion of lead and chromium at 100 ppm and produced adverse effect on seed germination (Table 1). From the growth observation, the plant grown in control soil heights nearly 4.5 cm and the plant grown in treated soil heights only 3.5 cm and 3.0 cm respectively.

Table 1. Height of germinated seeds of *Zea mays* L.

Name of the sample	Height of *Zea mays* L.
Control	4.5 cm
Chromium	3.5 cm
Lead	3.0 cm

Physicochemical analysis of control and treated soil

In the present investigation the following physico-chemical parameters of soil such as Organic matter, Nitrogen, Phosphorous, Potassium, lead, Mercury, Zinc, Nickel, Copper, Magnesium and Iron were analyzed by using a standard method and the results were tabulated in (Table 2.) Some of the important physico-chemical variables of Soil influence the growth and healthy status of heavy metals either positively or negatively and also the crop production. The summarized data reveals the following information's.

Table 2. Physicochemical analysis of control and treated soil

S. No	Parameters	Control soil	*Zea mays* L.	
			Chromium	Lead
1	pH	9.09	9.16	8.94
2	Calcium (mg)	34	38	40
3	Magnesium (mg)	38.96	43.83	51.13
4	Chromium (ppm)	0.458	0.668	0.963
5	Zinc (ppm)	0.19	0.29	0.39
6	Iron (ppm)	18.1	17.45	19.54
7	Mercury (ppm)	0.0001	0.0009	0.0001
8	Nitrogen (mg)	0.22	0.22	0.28
9	Potassium (mg)	335.7	414.2	382.1
10	Phosphorus (mg)	0.09	0.09	0.09
11	Organic matter (mg)	0.068	0.055	0.082
12	Organic carbon (mg)	0.030	0.024	0.036
13	Co2 (mg)	0.0022	0.0022	0.0022
14	Lead (ppm)	0.0001	0.0003	0.0004

The NPK are one of the essential nutrients for crop growth yield. They also increase the soil fertility and maintain the looseness of the soil thus results in better growth. The nitrogen, potassium and phosphorous are present in all sample. The initial and post level of NPK were estimated in control and treated plant soils. The results obtained clearly shows the difference in levels of NPK before and after treatment. They are , the amount of presents of NPK were decreased gradually namely the nitrogen level were decreased from 0.22mg/L to 0.119mg/L and the potassium level had been decreased from 333.5 mg/L to 107.1mg/L whereas the phosphorus level were decreased from 0.09 mg/L to 0.06 mg/L respectively in treated plant soil when compared to control. The results are tabulated in Table 2.

Physicochemical analysis of Control and treated plant

The higher the concentration of heavy metal in the soil, the greater was the toxic effect on the plant. The results in Table 3 shows that the effects of combinations of two metals were not catalyst in plant growth, rather the effects were only damaged the plants. The initial findings shown the levels of chromium , mercury, cadmium and lead in control plant were 0.22 ppm, 0.0009 ppm , 0.0001 ppm and 0.0001 respectively But it has seen a medium difference after treatment, the values are 0.65 ppm, 0.001 ppm, 0.0001and 0.0003 ppm respectively . Results in Table 4 shows that the difference in heavy metal levels in control and treated of *Zea mays* plant, respectively

The vegetation of an area is a prominent indicator of the deterioration of the soil conditions and natural habitat. The changes in the physicochemical properties of the soil, addition of waste disposal and industrial effluents alter the vegetation of an area to a great extent (Schuster and Diekmann, 2003). These reasons were found sufficient to alter the vegetation structure of both the contaminated and uncontaminated sites (Robinson et al., 1996). Reclamation and the remediation efforts have gained the world's considerable importance and mitigation measures are urgently needed (Buschmann et al., 2008). And now stress is on maximum utilization of native plant species to reclaim contaminated area (Yanqun et al., 2005; Zhuang et al., 2008).

Table 3. Physicochemical analysis of Control and treated plant

S. No	Parameters	*Zea mays* L.		
		Control	Chromium	Lead
1	Chromium (ppm)	0.22	0.44	0.65
2	Cadmium (ppm)	0.0001	0.0001	0.0001
3	Mercury (ppm)	0.0009	0.001	0.0001
4	Lead (ppm)	0.0001	0.0003	0.0002

The germination was found increased significantly under low level of chromium and lead with decreased in germination and reduction in the length of radical and plumule were observed in seeds of ragi and maize. These metals exhibit toxic effects on maize (*Zea mays*) plant contain due to highest amounts of heavy metals concentrations from polluted soil. There was observed remediate the concentration of heavy metals (Jayakumar et al., 2008).

Zhao et al. (2002) has reported rare hyper accumulation Cd. This may due to the reason that Cd poses some toxic effects on plants (Anderson et al., 2004). The possible explanation would be the lack of unavailability of Cd and Pb, due to the high affinity of these metals to organic matter (Merritt and Erich, 2003). So, the plants having metal resistance may be a better choice in this regard and the plants that are already growing on a soil contaminated with cadmium can be a better choice to grow on contaminated soils because such species are in fact showing metal tolerance.

Very little amount of Pb is extracted from soil. There found some complexity in the availability of this metal. The factors involved in the phyto availability of this metal are, organic matter, soil pH, plant roots and other soil conditions (Zimdahl and Hassett, 1977). But the limited potential of Pb phyto extraction is due to low soil mobility and little tendency for Pb uptake into root (Lasat, 2002). The unconventional behavior of Pb uptake and accumulation is well renowned. It may be due to the reason that plants respond differently to soil Pb content as compared to the other metals (Huang et al., 1997). Some other reason might be the high susceptibility of lead to change into sorption form in soil matrix. Moreover, root membrane barrier cannot be overlooked because the mechanism of Pb transport from soil to root tissue is not clear (Blaylock et al., 1997).

Conclusion

In the present investigation, it is concluded that Lead and Chromium treatments in seeds produced toxic impact on germination and growth of *Zea mays* when compared to control. Finally, the focus on the relationship between heavy metal contents in soil and plants, the effect of soil Physico-chemical properties, and the relationships and trends mentioned above were not exhaustive. From our findings, plants treated with heavy metals not only losing its characters but also transforming the heavy metals on to the soil in which they are grown. Moreover, the heavy metal content in the soil was correlated with the heavy metal content in the plants, but variation occurred, depending on the soil properties. Thus, the heavy metal distribution in the soil and plant samples should be monitored to help prevent environmental pollutions in terms of soil quality and ensure safe use of medicinal plants.

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