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The effects of Heavy metals on Seed Germination and Plant Growth on *Coccinia, Mentha* and *Trigonella* Plant Seeds in Timmapuram, E.G. District, Andhra Pradesh, India

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Abstract

The present study deals with the effect of nickel and lead contaminated soil on growth and seed germination of Coccinia, Mentha and Trigonella plant Species were investigated in laboratory by conducting a general phytotoxicity test and growth inhibition assessment. Three Species of plants i.e., Coccinia (Coccinia indica - Cucurbitaceae), Mentha (Mentha viridis - lamiaceae) and Trigonella (Trigonella foenum-graecum – Fabaceae) were used in order to investigate plant's ability to germinate and survive in a gradient of contaminated soil with heavy metals like Lead (Pb) and Nickel (Ni). The concentration of Nickel and Lead (Pb and Ni) used were in the range of 100, 300 and 500 ppm. The study reveals that the seedlings exposed to high concentration (500 and 3OOppm) of Nickel and Lead exhibited substantial growth reduction while the plant growth decreased progressively with increasing concentration of Nickel and Lead metals (Pb and Ni) in soil compared to those in unamended soil (Control).

Keywords: *Coccinia indica, Mentha viridis, and Triginella foenum graecum,* Lead Nickel and Pot Experiment.

Introduction

Many soils especially those in hazardous waste sites are contaminated with heavy metal e.g. lead, Nickel, copper, chromium and cadmium. The free metal ion concentration not only depends on the total metal content in soils, but also on the pH of the soil[1]. Metals can also be transported from soil into groundwater resulting in to soil contamination and inhibiting growth of plants[2]. Metal contamination of agricultural soils by atmospheric deposition or by disposal of sewage sludge constitutes a risk of either leaching of metals into the groundwater or excessive accumulation in the top soil. They arrive in aquatic ecosystems as dissolved and solid waste from domestic, industrial, and agricultural runoff. Many industries, such as textile, metal producing, electroplating, battery and cable manufacturing, mining, tannery, steel, and automotive, textile, release heavy rnetals such as Cadmium, Copper, Chromium, Nickel and Lead in waste waters[3]. These heavy metals may be toxic to aquatic ecosystems and human health, and they also accumulate in plants. The accumulation of these heavy metals in plants causes physiological and biochemical changes[4,5]. Heavy metals such as Lead and Nickel are highly toxic pollutants. Inhibition of germination and retardation of plant growth are commonly observed due to heavy metal toxicity[6,7]. High concentrations of heavy metals in soils represent a potential threat to human health because it is incorporated in the food chain mainly by plant uptake[8]. Influence of heavy metal toxicity on germination and growth of some common tress were investigated by Iqbal and Mehmood[9].

The aim of present study was to investigate the effect of Nickel and Lead (Ni and Pb) on seed growth and germination of *Coccinia (Coccinia indica - Cucurbitaceae), Mentha (Mentha viridis - lamiaceae) and Trigonella (Trigonella foenum-graecum – Fabaceae)* plant species.

Study area: The Kakinada city is the capital of East Godavari District of Andhra Pradesh on the central east coast of India. The present study deals with the effect of Nickel and Lead (Pb and Ni) toxicity on growth and seed germination of *Coccinia, Mentha* and *Trigonella* Plant Seeds in Timmapuram Village, Andhra Pradesh, India. Kakinada is situated between the latitude 16˚57' North and longitude 82˚15' East. The study was carried out at the 3 plant species were taken from the neighbour "Village Timmapuram" to Kakinada, area of "East Godavari District''.

Material and Methods

Soil sample Collection: Top garden soil from JNTU Kakinada Campus was taken and was air dried, sieved to (<2mm) and thoroughly mixed, soil analysis was done by analyzing the physio-chemical parameters such as pH, conductivity (millimols), bulk Density, sulphates (mg/lit), phosphates (mg/lit), nitrates (mg/lit), organic matter (%) organic carbon (%), moisture content (%), chlorides (Mg/gm), heavy metals like nickel (Mg/Kg) and lead (Mg/Kg).

Figure-1
Location Map of the Study area

Soil Treatment: Pot culture experiment were conducted using soil spiked with Nickel sulphate and Lead nitrate solutions. The concentration of Ni and Pb added in soil were 100, 300 and 500 mg/kg each respectively and for comparison an unamended (control) were taken. Nickel and Lead solutions were uniformly mixed with soil, kept for 2 to 3 weeks to stabilize and filled in pots.

Soil Germination: The healthy seeds of *Coccinia, (Coccinia indica - Cucurbitaceae), Mentha (Mentha viridis - lamiaceae*) and *Trigonella (Trigonella foenum-graecum - Fabaceae)* seeds were collected from the neighbour **"Village Timmapuram" to Kakinada, area of "East Godavari District''**. Which are of hybrid variety. The top ends of seeds were slightly cut with clean scissor to remove any possible dormancy. The seeds were surface sterilized with dilute solution of Sodium hypo chloride to prevent any fungal contamination. 3ml of respective metal solution (treatment) was added to each set of Petri dish and at every third day, the old solution was sucked out and replaced with 2ml of new solution. The control received only 3ml of distilled water. There were five replicates per treatment and the Petri dishes were kept at room temperature (20+_2C) with 4 hour light period provided by 200 watt bulb and the germination rate was recorded.

Plant Growth: For growth studies three germinated seeds were sown in soil. Out of them only one uniform plant was allowed to grow in each pot. Pots were placed in net house shaded with transparent polythene sheet to protect from rain water leaching. Plants were grown at set time interval of 30 days under natural light and ambient temperature in order to keep all plants under conditions as similar as possible. Fertilizers or soil amendments were not added to enhance growth or metal uptake. Any symptoms of metal toxicity (ex: stunting, necrosis, yellowing, pigmentation, discoloration, Leaf blister, Rust, Black spot) exhibited by plants were visually noted during the experimental period.

Results and Discussion

For the present study physio-chemical parameter were analyzed for soil and the effect of heavy metal (Ni, Pb) on seed germination and the growth of vegetable plants were studied under laboratory conditions.

Table-1
Physical and Chemical properties of the studied Soil

S. No	Soil Properties	Concentration
1	pH	6.5
2	Conductivity (Millimols)	0.13
3	Bulk Density	1.216
4	Sulphates (mg/lit)	0.71
5	Phosphates (mg/lit)	1.52
6	Nitrates (mg/lit)	1.38
7	Organic matter (%)	1.55
8	Organic carbon (%)	0.98
9	Moisture Content (%)	2.2
10	Nickel (Mg/Kg)	1.80
11	Lead (Mg/Kg)	1.516
12	Chlorides (Mg/gm)	54.99

The PH of the soil samples measured averaged 6.5, which is slightly acidic. Soil pH generally plays an important role in metal bioavailability, toxicity and leaching capability to surrounding areas. Heavy metals are mostly soluble and leached out in acidic PH. Soil PH of 6.5 indicates that heavy metals may remain in the soil for long time exposed to plants that come into contact with them[8].

The Conductivity (Millimols) of the studied soil was 0.13,

Bulk density 1.216, High bulk density is an indicator of low soil porosity and soil compaction. It may cause restrictions to root growth, and poor movement of air and water through the soil. Compaction can result in shallow plant rooting and poor plant growth, influencing crop yield and reducing vegetative cover available to protect soil from erosion. By reducing water infiltration into the soil, compaction can lead to increased runoff and erosion from sloping land or waterlogged soils in flatter areas. In general, some soil compaction to restrict water movement through the soil profile is beneficial under arid conditions, but under humid conditions compaction decreases yields. Sulphates (mg/lit) 0.71, phosphates (mg/lit) 1.52, Nitrates (mg/lit) 1.38 observed in the soil.

The organic content of the studied soil was 1.55% Organic matter (OM) is usually the organic fraction of decomposed plant and animal residues which play an important role in water retention, aggregation and soil structure. It is a measure of soil fertility and could affect the mobility of metals from soil to plants. Typical amounts of OM in soil vary from <1% to 20% in mineral soils. OM values obtained signifies that the metals are known to from complexes with organic matter which influences their availability[11].

The organic carbon of the studied soil was 0.98 (%) observed. The moisture content of the studied soil was 2.2 (%) observed. The chloride content of the studied soil was 54.99 (Mg/gm) observed.

Control and treated plants growth were observed for a time period of 30 days. Control plants were not spiked with heavy metals (Pb, Ni) and the treated plants were spiked with heavy metals (Pb and Ni) in the concentration of 100 ppm, 300 ppm and 500 ppm. Any symptoms of metal toxicity (eg: 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). Le[12] investigated lead pollution near the road side soil. The results indicate that concentration of lead in road side soils range from 23-90 mg/kg with an average value of 37.11mg/kg, exceeded environmental background value.

The results indicate that seed germination and growth of three vegetable plants (Coccinia, Mentha and Trigonella plant species) were reduced in all treatments (100, 300 and500 mg/ppm) of lead and nickel as compared to control.

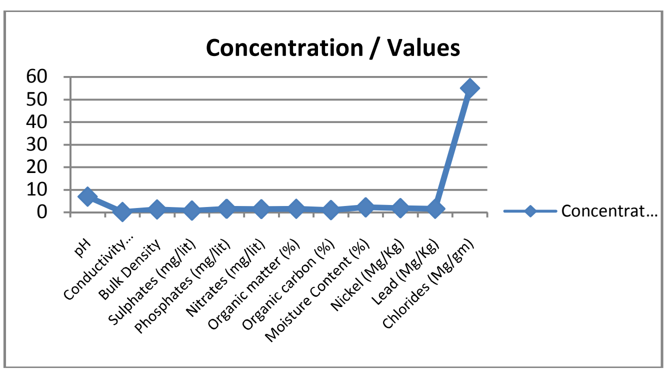

Figure-2
Physical and Chemical properties of soil and Concentrations

Lead and Nickel treatment at 500 ppm produced adverse effect on seed germination as compared to control while Pb and Ni treatment at l00 ppm significantly reduced seed germination but has no much effect than those of treatments at 300 and 500 ppm. Heavy metals (PbandNi) treatment at 100, 300 and 500 ppm markedly decreased high percentage of seed germination. Plant growth was consistently reduced with increased concentration of both metals and maximum suppression of plant growth was recorded at the highest concentration of heavy metals (Ni and Pb) at 500 ppm whose growth was reduced up to 65% as compared to control. The results for growth of the vegetable plants were not same but approximately of same range. The reason of reduced shoot and seedling length of three vegetable plants in metal treatments could be the reduction in meristematic cells present in this region and some enzymes contained in the cotyledon and endosperm cells become active and begin to digest and store food which is converted into soluble form and transported to the radical and plumule tips ex: enzyme amylase convert starch into sugar and protease act on protein. So when enzymatic activities were affected, the food did not reach to the radical and plumule and in this way rate of seed germination and plant growth were affected[13,14]. Lead and Nickel treatments were found responsible for marked reduction in seedlings growth of plants. It was also noted that inhibitory effects of Pb and Ni treatments at 500 ppm concentration were more severe. The elevated levels of Pb in blood of children (200 µg l-1) and dogs (250 µg l-1) of Indian megacities were reported. Khan et al.[15] reported that the motor vehicle resulted in deposition of lead as particular matter and also the road side surface soil, highest concentration of lead metal varying from place to place.

Conclusion

In the present investigation, it is concluded that Lead and Nickel treatments produced toxic impact on germination and growth of *Coccinia (Coccinia indica – Cucurbitaceae) Mentha (Mentha viridis –lamiaceae) and Trigonella (Trigonella foenum-graecum – Fabaceae)* Plants as compared to control. Increase in the concentration of both metals in the medium, brought up changes in most of the growth parameters of plants. Therefore there is a need to implement certain rules that help in the reduction of metal level from a wide range of sources such as from the metal processing industries and power generation plants. Seedling growth is considered as an indicator of metal stress on plant vigor. This shows that vegetable crops have the ability to uptake the heavy metals through their roots and transport them to the edible portion of the plant that are consumed by people or fed to animals. Their increased concentrations in human food chain over a long time can provoke detectable damage to health (Carcinogenic and mutagenic effect). Therefore there is a need to undertake further studies to establish the state of knowledge on the responses of plants to metal toxicities.

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References

1. Temminghoff, E.J.M., S.E.A.T.M and F.A.M. Dettaan, Copper mobility in a copper- contaminated sandy soil as affected by pH and solid and dissolved organic matter, *Environ. Sci. Tech.*, **31,** 1109-1115 **(1997)**
2. Sharma R.K., Agrawal M. and Marshall F.M, Heavy metal (Cu, Zn, Cd, and Pb) contamination of vegetables in Urban India: a case study at Varanasi, *Environ. Pollution,* **154**, 254-263 **(2008)**
3. Hartmann H.T. and Kester D.E., Plant Propagation, Principle and Practice 5th Ed 89:115, U.S.A, Prentice Hall **(1964)**
4. Davies A.G., An assessment of the basis of mercury tolerance in Dunaliellatertiolecta*, J. Mar. Biol.* Assoc., UK56: 9–57 **(1976)**
5. Rosko J.J. and Rachlin J.W., The effect of cadmium, copper, mercury, zinc and lead on cell division, grown and chlorophyll a content of the chlorophyte Chlorella vulgaris, Bull, Torrey Bot, Club., **104,** 226–275 **(1977)**
6. Fisher N.S., Jones G.J. and Nelson D.M., Effect of copper and zinc on growth, morphology and metabolism of *Asterionella japonica* (Cleve), *J. Exp. Biol. Ecol.,* **51**, 37–56 **(1981)**
7. Singh K.P. and Singh K., Stress Physiological studies on seed germination and seedling growth of source wheat hybrids, *Indian J. Physiol.,* **24**, 180-186 **(1981)**
8. Morzeck J.R.E. and Funicelli N.A., Effect of Zn and Pb on germination of sportama alterniflora loisel seeda at various salinities, *Environmental and experimental Botany.*, **22,** 23-32 **(1982)**
9. Odoemena C.S., Heavy metals uptake and yield performances of okra (*Abelmoschus esculentus*) grown in spent-creankcase- engineoil polluted soil, *J. Appl. Sci. Environ. Manage.,* **3**, 71 74 **(1988)**
10. Claire L.C., Adriano D.C., Sajwan K.S., Abel S.L., Thoma D.P., and Driver J.T., Effects of selected trace metals on germinating seeds of six plant species, *Water Air Soil Pollut.*, **59**, 231-240 **(1991)**
11. Iqbal M.Z. and Mehmood T., Influence of Cadmium toxicity on germination and growth of some common trees, *Pakistan Journal of scientific and industrial Research.,* **34,** 140-142 **(1991)**
12. Li Qi, Lead pollution and its assessment of road side soils in Suzhou city, Advanced material research, **534,** 235-238 **(2012)**
13. Goldbold D.L., and Kettner C., Lead influences on root growth and mineral nutrition of picea abies seedling, *Plant physiology.,* **139,** 95- 99 **(1991)**
14. Sharifah B.A., and Hishashi O., Effect of lead, cadmium and zinc on the cell elongation of impatiens balsmina, environ, experi. Bot., **32,** 439-448 **(1992)**
15. Khan M., Khan G.M. and AkbarS. (2011), Study of lead pollution in air ,soil and water samples of Quetta city, *J.Chem. Soc. Pak.,* **33(6),** 877-881 **(2010)**
16. Stohs S.J., Bagchi D., Oxidative mechanisms in the toxicity of metalions, Free Radic, *Biol. Med.,* **18**, 321–336 **(1995)**
17. Department of water Affairs and Forestry DWAF,"Water Quality Guidelines-Domestic use Vol.1, DWAF, Pretoria **(1996)**
18. Gardea-Torresdey J.L., Polette L., Arteaga S., Tiemann K.J., Bibb J. and Gonzalez J.H., Determination of the content of hazardous heavy metals on *Larrea tridentata* grown around a contaminated area. Proceedings of the Eleventh Annual *EPA Conf. On Hazardous Waste Research*, Edited by Erickson LR, Tillison DL, Grant SC, McDonald JP, NM: 660 **(1996)**
19. Goyer R.A., Toxic and essential metal interactions, *Ann Rev Nutr,* **17**, 37–50 **(1997)**
20. Saurre S., Me Bride M.B. and Hendershot W., Soil solution speciation of lead (II): effects of organic matter and PH, *Soil science, Journal.*, **62,** 618-621 **(1998)**
21. Nies D.H., Microbial heavy-metal resistance, *Appl Microbiol Biotechnol,* **51**, 730–750 **(1999)**
22. Shoukat S.S., Mushtaq M. and Siddiqui Z.S., Effect of Cadmium, Chromium and lead on seed germination, early seedling growth and phenolic contents of parkinsonia aculeated L. And *pennisatum americanum (L)* Schumann, *pakistan journal of biological sciences.*, **2,** 1307-1313 **(1999)**
23. Meagher RB., Phytoremediation of toxic elemental and organic pollutants, *Curr. Opin. Plant Biol*, **3**, 153-162 **(2000)**
24. Raskin I. and Ensley B.D., Phytoremediation of toxic metals: using plants to clean up the environment, John Wiley and Sons, N. York, 303 **(2000)**
25. Prasad M.N.V., Malec A., Woloszek A., Bojka M. and Strzalka K., Physiological responses of *lemna trisulca L,* (duck weed) to cadmium and copper bioaccumulation plant sci, **161,** 881-889 **(2001)**
26. Shavyrina L.D., Gapochka L.D. and Azovskii A.I., Development of tolerance for copper in cyanobacteria repeatedly exposed to its toxic effect, *Biol. Bull,* **28(2)**, 183–187 **(2001)**
27. Athar R. and Masood A., Heavy metal toxicity; effect on plant growth and metal uptake by wheat and on free living Azotobacter, *Water Air Soil Pollut.,* **138**, 165-180 **(2002)**
28. Kupper H., Setlik I., Spiller M., Kupper FC. and Prasil O., Heavy metal induced inhibition of photosynthesis: targets of *in vivo* heavy metal chlorophyll formation, *J. Phycol.,* **38**, 429-441 **(2002)**

29. León A.M., Palma J.M., Corpas F.J., Gómez M., Romero-Puertas M.C., Chatterjee D.R., Mateos M., Del Río L.A., and Sandalio L.M., Antioxidative enzymes in cultivars of pepper plants with different sensitivity to cadmium, Plant Physiol. Biochem, **40**, 813–820 **(2002)**

30. Munzuroglu Ö., Geckil H., Effects of Metals on Seed Germination, Root Elongation and Coleoptile and Hypocotyl Growth in T*riticumaestivum* and *Cucumissativus*, *Ach. Environ. Contam. Toxicol.,* **43**, 203-213 **(2002)**

31. Pandey N., Sharma C.P., Effects of heavy metals Cu, Ni and Cd on growth and metabolism of cabbage, *Plant Sci.,* **163**, 753-758 **(2002)**

32. Perry A.R.R., Flammarion P., Vollat B., Bedaux J.J.M., Koorjman S.A.L.M. and GarrieJ., Using biology bored model (Debtox) to analyze bioassays in ecotoxicology; opportunities and recommendation environ toxicol, *Chemosphere,* **21,** 459-465 **(2002)**

33. Astolfi T., Zuchi S. and Passera C., Effect of cadmium on HAT Pase activity of plasma membrane vesicles isolated from roots of different s-supplied maize (*Zea mays* L.) plant, *Plant Sci.*, **169**, 361-368 **(2005)**

34. Palmieri RM., Pera L., Bella GD. and Dugo G., Simultaneous determination of Cd(II), Cu(II), Pb(II) and Zn(II) by derivative stripping chronopotentiometry in Pittosporumtobira leaves: a measurement of local atmospheric pollution in Messina (Sicily, Italy*), Chemosphere*, **8,** 1161-1168 **(2005)**

35. Reddy S.G., Kumar G., Jyonthsnakumari S., and Sudhakar C., Lead induced changes in antioxidant metabolism of horsegram (*Macrotyloma uniflorum* (Lam.) Verdc.) and bengalgram (*Cicerarietinum* L.), *Chemosphere,* **60**, 97–104 **(2005)**

36. Sharma P. and Dubey RS., Lead toxicity in plant Brazilian *J. Plant Physiol.,* **17**, 35–52 **(2005)**

37. Demirezen D., Aksoy A., and uruc K., Effect of population density on growth, biomass and nickel accumulation capacity of *lemna gibba* (Lemnaceae), *Chemosphere,* **66,** 553-557 **(2007)**

38. Alvarez-Ayuro E., Cadmium in soil plant systems: an overview, *Journal of environment and pollution.,* **33(2-3),** 275-291 **(2008)**

39. Tamas L., Dudikova J., Durcekova K., Huttuva J., Mistrik I. and Zelinova V., The impact of heavy metals: on the activity of some enzymes along the barley root, *Environ. Exp.* Bot, **62,** 86-91 **(2008)**

40. Smain Megateli., Saida Semsari. and Michel Couderchet., Toxicity and removal of heavy metals (Cadmium, copper and Zinc) by *Lemna gibba*, *Ecotoxicology and environmental safety.,* **72,** 1774-1780, **(2009)**

41. Kabir M., Zafar iqbal M., Shafiq M. and Farooqii Z.R., Reduction in germination and seedling growth of *Thespesia populnea L.,* caused by Lead and Cadmium treatments, *Pakistan journal of Biological sciences,* **40(6),** 2426 **(2008)**

42. Brewer G.J., Risks of Copper and Iron Toxicity during Aging in Humans, *Chem. Res. Toxicol.,* **23(2),** 319–326 **(2010)**

43. Nwajei G.E., Okwagi P., Nwajei R.I. and Obi-Iyeke G.E., Analytical Assessment of Trace Elements in Soils, Tomato Leaves and Fruits in the Vicinity of Paint Industry, Nigeria *Res. J. Recent Sci.,* **1(4)**, 22-26 **(2012)**

44. Chamon, A.S, Modd M.N, Faiz B., Rahman M.H and Elahi S.F., Speciation Analysis of Nickel in the soils of Tejgaon Industrial Area of Bangladesh, *Bangladesh J. Sci. Ind. Res.*, **44(1),** 87-108 **(2009)**