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# Heavy Metals Contamination of Spinach (*Spilanthus oleracea L.)* in the Agricultural Crops: An Organic Approach

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**Abstract:** ***Heavy metals in spinach pose a potential risk to human health. organic farming practices can reduce heavy metal accumulation in spinach. organic amendments significantly reduce levels of lead and copper in spinach compared to conventional fertilization methods. Heavy metals can enter agricultural soils through the use of chemical fertilizers and pesticides. The criterion for significance in the procedures was set at p<0.05 (significant). All data were presented as arithmetic mean with standard error attached. All statistical analyzes were performed using the software Excel 2016. And all figures were prepared using Origin version 8.5 software (Origin Lab Corporation, USA). In plants exposed to heavy metal contamination, S. Oleracea caused severe poisoning. The results showed that Cu and Pb treatments even at low concentrations and Zn treatments at high concentrations significantly increased all growth parameters (length of shoots and roots, biomass and number of leaves) as well as S. oleracea significant reduction (p < 0.05) in total protein, fibre, moisture and mineral (Na, K, Ca, Fe, Mg, Mn and Cu) content.***

**Keywords:** Heavy Metal, spinach, organic farming, agricultural

## 1. Introduction

Numerous studies have investigated the impact of organic farming practices on heavy metal accumulation in spinach providing valuable insights into the potential benefits of this agricultural system. For instance a study conducted by Wang et al. (2018) investigated the effects of organic fertilization on heavy metal uptake in spinach and found that organic amendments significantly reduced the levels of lead and copper compared to conventional fertilization methods. The researchers attributed this reduction to the presence of organic matter in the soil which can bind heavy metals and reduce their availability to plants.

Heavy metals such as lead (Pb) Copper (Cu) Magnesium (Mg) and Zinc (Zn) are naturally occurring elements found in the Earth's crust. However human activities such as Agriculture emissions mining operations and agricultural practices have significantly increased the release of these metals into the environment. Heavy metals can enter agricultural soils through various sources including atmospheric deposition contaminated irrigation water and the use of chemical fertilizers and pesticides. Once present in the soil these metals can be taken up by plants and accumulate in their edible parts such as spinach leaves over time.

The accumulation of heavy metals in spinach poses a potential risk to human health. Consumption of contaminated spinach can lead to the ingestion of these metals which can have adverse effects on various organ systems. For instance lead exposure is associated with neurological disorders developmental delays in children and increased blood pressure in adults. copper ingestion can cause kidney damage while mercury and arsenic exposure can lead to neurological impairments and an increased risk of cancer.

In contrast heavy metals such as Copper (Cu) and lead (Pb) are toxic metals that negatively affect plant growth and productivity. These metals can impair leaf and root growth and inhibit enzyme activities ultimately leading to reduced plant production (Mustafa *et al*.2015). Cd is particularly notorious for its adverse effects on plant metabolism. It disrupts nutrient uptake and transport systems interferes with enzyme activities involved in photosynthesis and respiration and induces oxidative stress which can lead to cellular damage and reduced plant growth.

Copper (Cu) is considered phytotoxic due to its adverse effects on various plant growth parameters. It inhibits essential physiological processes such as respiration photosynthesis and the uptake of water and nutrients. Furthermore, Cu hinders new cell production and root growth resulting in decreased plant growth (Sharma *et al*.2017). Cu also interferes with the activities of antioxidant enzymes and induces oxidative stress in plant cells leading to cellular damage and reduced plant performance (Yuan 2009). Additionally, Cu induces changes at biochemical physical and genetic levels in plants contributing to decreased plant growth leaf chlorosis and necrosis in leaves or roots which ultimately leads to plant death (Danish *et al*.2019).

The phytotoxic effects of Cu and Pb highlight the importance of mitigating heavy metal contamination in agricultural systems particularly in the cultivation of green leafy vegetables like spinach. Organic farming practices with their emphasis on enhancing soil health and minimizing heavy metal bioavailability can play a crucial role in reducing heavy metal accumulation and its detrimental effects on plant growth. By promoting the use of organic amendments crop rotation and sustainable management techniques organic farming practices enhance soil structure nutrient availability and microbial activity thereby reducing the uptake of heavy metals by plants and alleviating the negative consequences on plant growth and productivity.

Human exposure to heavy metals through the oral route particularly via food consumption is a significant pathway of concern (Abbas *et al*.2020). Spinacia oleracea commonly known as spinach belongs to the order Caryophyllales which includes a variety of broad leafy green vegetables with large surface areas relatively high growth rates and notable metal uptake rates. These unique characteristics have drawn scientific attention to *S. oleracea* and other members of the Caryophyllales order as they provide an opportunity to study their growth and toxicity responses to heavy metal contamination (Das *et al*.2016).

Materials and Method:

**Sample Collection:**

Spinach was cultivated in organic and inorganic soil in selected field in the month of September - October and after two months spinach leaf samples were collected.

**Digestion**

The cooled samples were then washed thoroughly and air dried. In this process, 0.5% of the pure powder sample was purified by adding 2 grams of pure catalyst 20% 1 (hot solution of $K_2SO_4$: $CuSO_4$) to 10 ml of pure water. Its main digestion tube was loaded into the digester unit and heated at the prescribed temperature. When the sample is colorless and does not change, the resulting colorless sample is subjected to 50°C reaction.

Heavy metal concentrations in plant leaves were determined using ICP - MS 100 Godel (as described above).

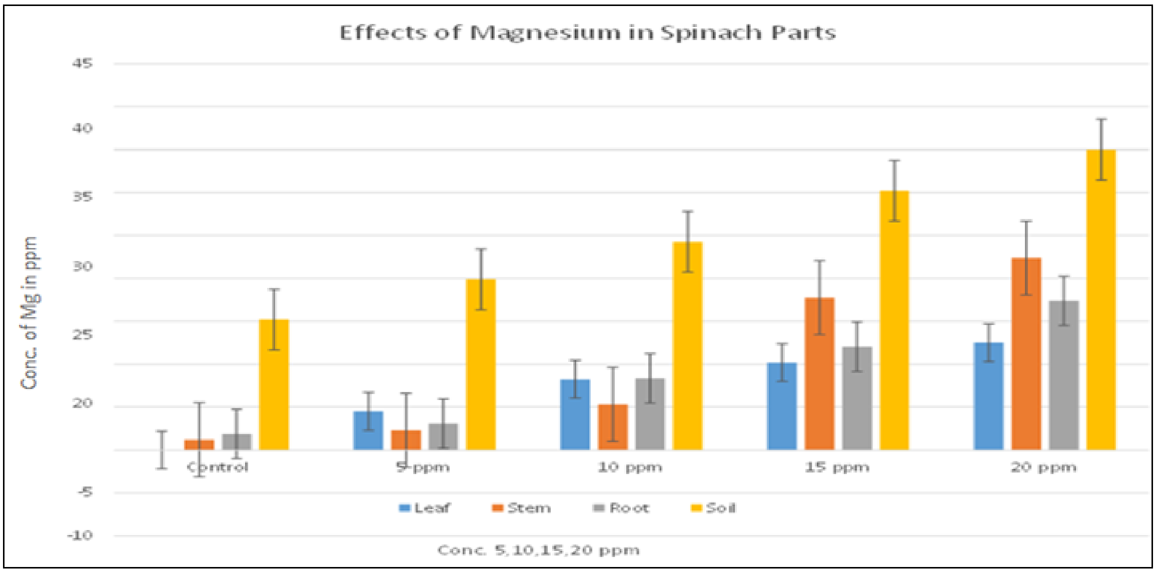
In the next phase, in the laboratory located at Nehru Nagar, spinach were grown in pots with different concentrations of these heavy metals: Zn, Cu, Mg and Pb) in ordinary soil, 5ppm, 10ppm, 15ppm, 20ppm.

**Table 3.2:** Experimental layout of spinach plants and various parts of the plant containing different concentrations of heavy metals planted in pots

| | | Conc. | Zn | Cu | Mg | Pb |
|---|---|---|---|---|---|---|
| Spinach | Control (No Chemical) | 5ppm | ZnS - 5 | CuS - 5 | MgS - 5 | PbS - 5 |
| | | 10ppm | ZnS - 10 | CuS - 10 | MgS - 10 | PbS - 10 |
| | | 15ppm | ZnS - 15 | CuS - 15 | MgS - 15 | PbS - 15 |
| | | 20ppm | ZnS - 20 | CuS - 20 | MgS - 20 | PbS - 20 |

After 1 month, samples were taken from all the pots. The leaves, stem and roots of each plant were dried and ground in the same way as we used to do before. And finally the heavy metal concentrations in different samples were determined (ICP - MS)

## 2. Results and Discussion




**Graph 1:** Magnesium concentrations in spinach and ordinary soil

Magnesium results are shown in various concentrations and controls. Magnesium is simply absorbed by plants from the soil. Maximum Mg in spinach stem was found to be 21.86±0.14 with 1.2 control at 20 ppm while nickel in soil was found to be 34.85±0.14 with 15.2 control at 20 ppm as shown in Graph - 1.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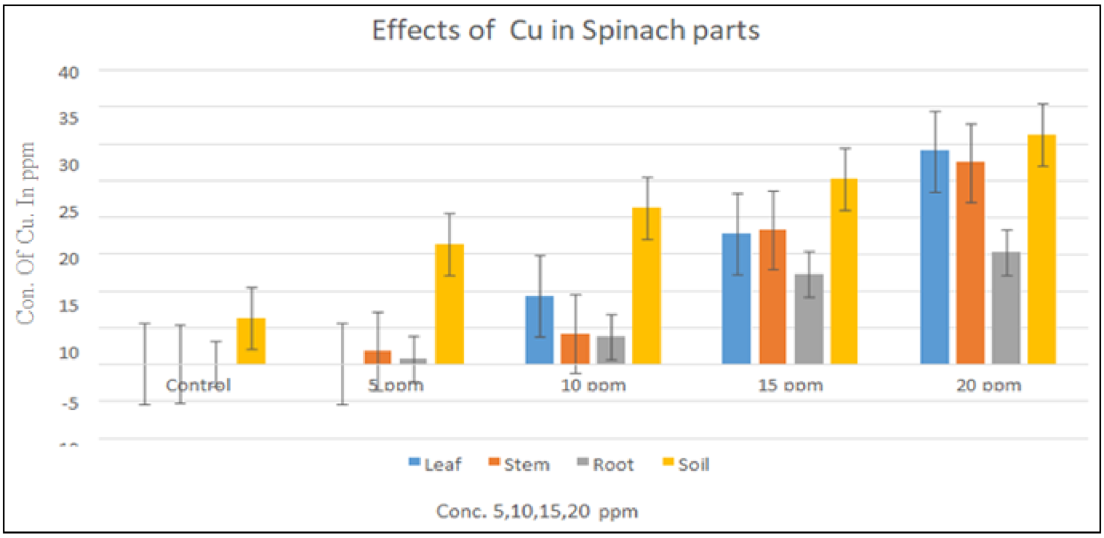
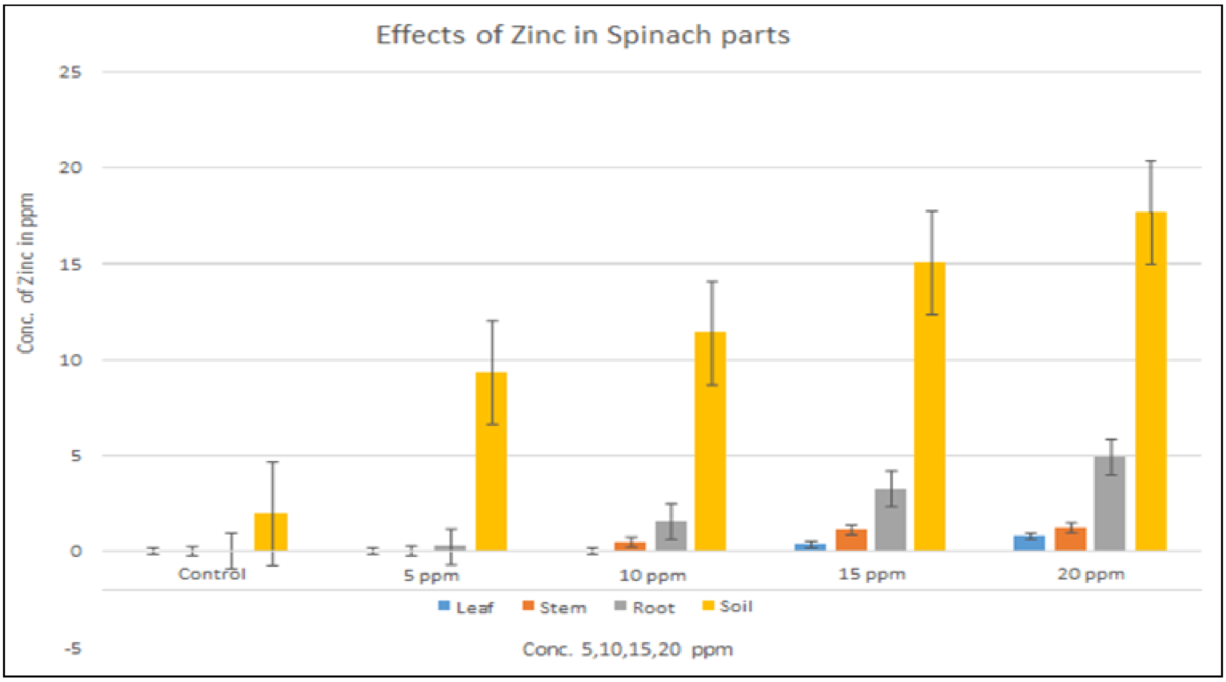



**Graph 2:** Copper concentrations in spinach and common soil

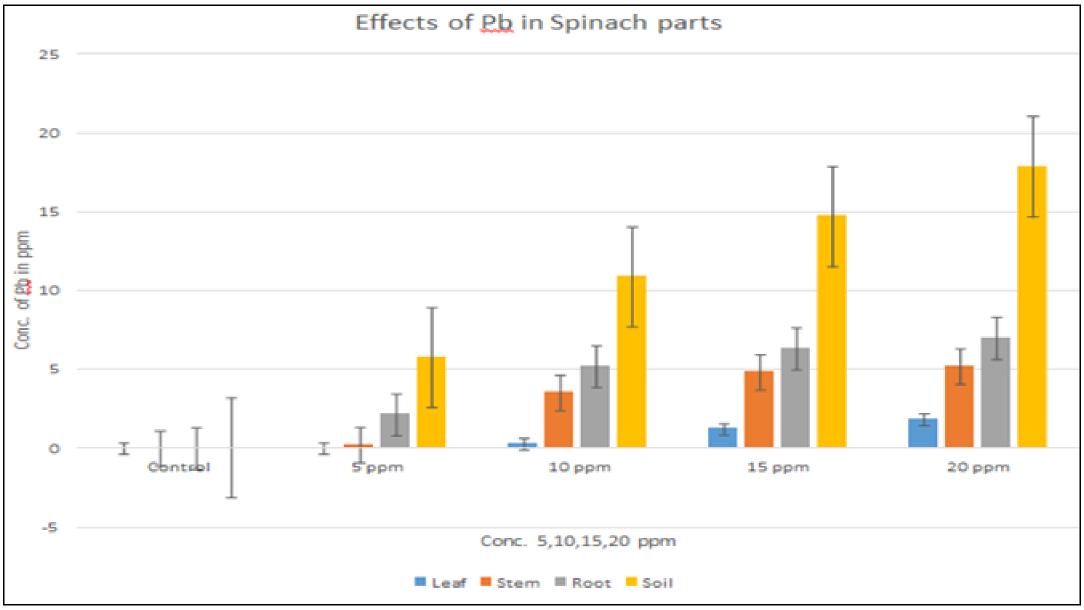
Copper results are shown in various concentrations and controls. Copper content, from ordinary soil to plants is absorbed.

Maximum Copper spinach leaf was found to be 28.0 at 20 ppm with lowercontrol limit while chromium in soil was found to be 31.09 at 20 ppm with 6.24control as shown in graph 2.



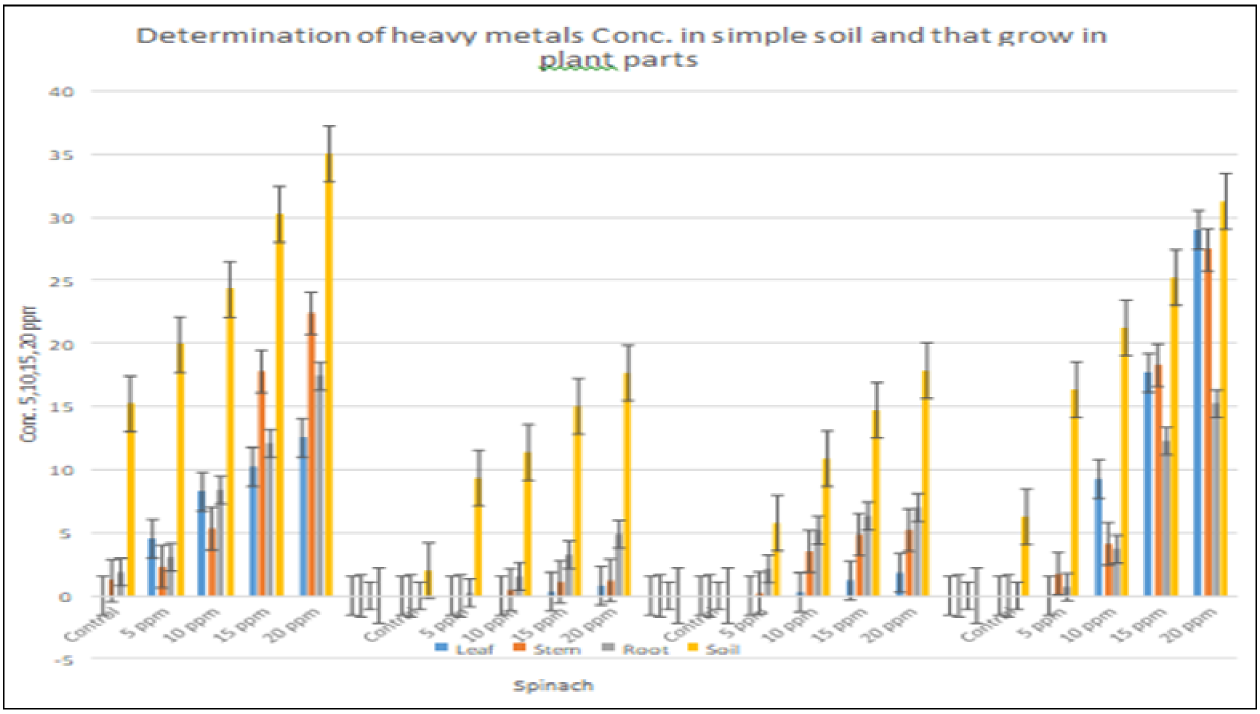

**Graph 3:** Zinc concentration in spinach and ordinary soil

**Zinc** – results shown in various concentrations and controls. Zinc is easily absorbed from normal soil to plants. The maximum Zinc found in spinach root was 4.470 with lower control limit at 20 ppm while in soil 17.1 was found at 10.22 ppm with lower control limit at 1.98, as shown in graph 3.




**Graph 4:** Lead concentrations in spinach and ordinary soil

Lead results are shown in various concentrations and controls. Lead is simply absorbed by plants from the soil. Maximum lead found in spinach root is 6.380 with lower control limit at 20 ppm while Lead in soil is 17.15 Found at lower control limit at 20 ppm, as Shown in Graph - 4.




**Graph 5:** Average concentrations of heavy metals in ordinary soil and spinach samples of the study

The relative abundance of heavy metals in the analyzed spinach samples followed the sequence in ordinary soil samples.
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Cu > Mg > Pb > Zn Maximum absorption in spinach from normal soil occurred in the plant leaf, which was at 20 ppm.

**Statistical analysis**

One - way ANOVA was used to evaluate differences between the outcomes data found. The data obtained by the Bude Black method and ICP - MS method were used to detect significant differences between the means of classification of different soils and the metals detected or absorbed in the soil and vegetable leaves. The criterion for significance in the procedures was set at $p<0.05$ (significant). All data were presented as arithmetic mean with standard error attached. All statistical analyzes were performed using the software Excel 2016. And all figures were prepared using Origin version 8.5 software (OriginLab Corporation, USA).

## 3. Conclusion

In plants exposed to heavy metal contamination, *S. Oleracea* caused severe poisoning. The results showed that Zn and Pb treatments even at low concentrations and Cu treatments at high concentrations significantly increased all growth parameters (length of shoots and roots, biomass and number of leaves) as well as *S. oleracea* significant reduction ($p < 0.05$) in total protein, fibre, moisture and mineral (Na, K, Ca, Fe, Mg, Mn and Cu) content.

## References

[1] Abbas A., Azeem M., Naveed M., Latif A., Bashir S., Ali A., et al. . (2020). Synergistic use of biochar and acidified manure for improving growth of maize in chromium contaminated soil. *Int. J. Phytoremed.*22, 52–61.
[2] Bowell, R. J. (1994). Sorption of arsenic by iron oxides and oxyhydroxides in soils. *Appl. Geochem.*9 (3), 279–286.
[3] Bruins, M. R., Kapil, S., and Oehme, F. W. (2000).
[4] Chintakovid, W., Visoottiviseth, P., Khokiattiwong, S., and Lauengsuchonkul, S. (2008). Potential of the hybrid marigolds for arsenic phytoremediation and income generation of remediators in Ron Phibun District, Thailand. *Chemosphere* 70 (8), 1532–1537.
[5] Chmielewska - Bak, J., Lefèvre, I., Lutts, S., Kulik, A., and Deckert, J. (2014). Effect of cobalt chloride on soybean seedlings subjected to cadmium stress. *Acta Societatis Botanicorum Poloniae* 83 (3), 201 - 207.
[6] Choudhury, R., and Srivastava, S. (2001). Zinc resistance mechanisms in bacteria. *Curr. Sci.*81 (7), 768–775.
[7] Cooney, J. J., and Pettibone, G. W. (1986). Metals and microbes in toxicity testing. *Environ. Toxicol. Water Qual.1* (4), 487–499.
[8] Danish S., Kiran S., Fahad S., Ahmad N., Ali M. A., Tahir F. A., et al. . (2019). Alleviation of chromium toxicity in maize by fe fortification and chromium tolerant ACC deaminase producing plant growth promoting rhizobacteria. *Ecotoxicol. Environ. Saf.*185, 109706.
[9] Das N., Bhattacharya S., Maiti M. K. (2016). Enhanced cadmium accumulation and tolerance in transgenic tobacco overexpressing rice metal tolerance protein gene *OsMTP1* is promising for phytoremediation. *Plant Physiol. Biochem.*105, 297–309.
[10] Mustapha, M. U., and Halimoon, N. (2015). Microorganisms and biosorption of heavy metals in the environment: a review paper. *J. Microb. Biochem. Technol.7*, 253–256.
[11] Rich, C. I. (2016) "Elemental Analysis by Flame Photometry. " Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties, pp.849–65, 9.2. C3.
[12] Sharma, P.; Sirhindi, G.; Kumar, A.; Harpreet, S. Consequences of Copper Treatment on *Pigeon pea* Photosynthesis, Osmolytes and Antioxidants Defense. *Physiol. Mol. Biol. Plants* **2017**, *23*, 809–816.
[13] Yuan, M.; Chu, Z.; Li, X.; Xu, C.; Wang, S. Pathogen - Induced Expressional Loss of Function Is the Key Factor in Race - Specific Bacterial Resistance Conferred by a Recessive R Gene *Xa13* in Rice. *Plant Cell Physiol.*2**009**, *50*, 947–955.
[14] Zeng, L. S., Liao, M., Chen, C. L., and Huang, C. Y. (2007). Effects of lead contamination on soil enzymatic activities, microbial biomass, and rice physiological indices in soil - lead - rice (Oryza sativa L.) system. *Ecotoxicology Environ. Saf.*67 (1), 67–74.