ACCUMULATION PATTERN OF LEAD AND NICKEL BY *SPINACIA OLERACEA* LI

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ABSTRACT

Environmental pollution, especially soil contamination from anthropogenic activities tend to affect our health through the food chain. A laboratory scale pot experiment was conducted in this study to evaluate the metal uptake capacity of vegetable crop, Spinacia oleracea L. (African spinach) grown in Karu L.G.A of Nasarawa state. A composite sample derived from several sampling points was separated in eight (8) pots, treated with lead (Pb) and Nickel (Ni) concentrations and studied. Mean concentration levels of both lead (Pb) and nickel (Ni) indicated significantly higher concentrations of both metals were obtained in the roots of harvested crops compared to the stems and leaves and was confirmed by the hierarchical cluster analysis (HCA). The observed environmental pollution of the agricultural soil in the study area does not sufficiently concentrate in the edible parts (stems and leaves) of the crop.

Keywords: *Heavy metals, cluster analysis, spinacia oleracea*

BACKGROUND OF THE STUDY

Soil contamination and pollution through human actions is a growing problematic issue in the whole world today, menacing human well-being and injuring the environment. Soil is considered as a critical component of environment as it accumulates pollutants produced by various anthropogenic activities (Agrelli *et al.*, 2020). Hence, soils are considered as the main sink for pollutants (heavy metals) released by anthropogenic activities into the environment, (Ali *et al.*, 2019). Speedy industrialization and expansion have triggered environmental contamination of heavy metals, their extents of mobilization and transport in the agricultural soils and the whole environment has significantly accelerated (Okafor and PAC, 2015; Amanullah *et al.*, 2016). The source of heavy metals are either natural (volcanic eruptions, weathering of metal with bearing rock etc.) or by activities of man (agricultural activities, mining, manufacturing emissions, and smelting etc.) (Shafiuddin *et al.*, 2021; Wang *et al.*, 2020).
The interaction of metals with agricultural soil leads to heavy metal spreading through plant uptake through; ion exchange, adsorption, aqueous complexation, and desorption etc. (Vodyanitskii, 2016). Heavy metals accumulation occurs typically in plants edible parts, which may cause a decrease in the quality of crops and it yield, it's a risk to man's health and animal (Nagajyoti *et al.*, 2010). The toxicities potentials of different metals are because of the formation of stable coordination compounds with organic and inorganic ligands which function as poisons even at small concentrations level.

METHODOLOGY

Soil collection

Agricultural soil was collected from different farmlands around the study area to form composite samples. The homogenized soil sample was separated into eight (8) different study containers (P1-P7) and a control (CL). Relatively dry soil from various containers was treated with specified metal solutions of Pb and Ni from $Pb(NO_3)_2$ and $Ni(NO_3)_2.6H_2O$) as shown in table 1 and allowed to stay for a week to enable equilibration before planting (Yang *et al.*, 2019).

Table 1: Treatment levels of Pb and Ni in the studied agricultural soil (mg /kg)

Treatment	CL	P1	P2	P3	P4	P5	P6	P7
Pb	0.00	0.10	0.20	0.25	0.30	0.35	0.40	0.45
Ni	0.00	0.10	0.20	0.25	0.30	0.35	0.40	0.45

Crop planting

Vegetable crop, *Spinacia oleracea* L. (African spinach) was seeded into the various study soil samples and moisture content of the soil was maintained with tap water while cow dung was used as manure. The *Spinacia oleracea* L. plant was harvested after eight weeks of planting and cut into three different parts; leaves, stem and root. This was washed and dried to constant weight then grinded to size.The determination of lead and nickel concentrations was done in triplicates using Atomic Absorption Spectrometer while multivariate analysis was carried out on generated data using SPSS software at 95% significance level (Siaka *et al.*, 2016;Cheng *et al.*, 2011).

Table 2: Descriptive Statistics of Pb concentration in Root, Stem and Leave (mg/kg)

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Root	8	14.33	5.11	19.44	14.44	4.71
Stem	8	12.50	4.84	17.34	7.26	4.17
Leaves	8	16.66	0.00	16.66	7.14	6.13

The uptake of Pb in the root, stem and leave of *spinacia oleracea* l

Table 2. shows the descriptive statistic of mean values for Pb uptake in root, leave and stem of harvested crops from eight study samples. The highest mean concentration of Lead (Pb) obtained was 14.44 mg/kg found in the root, while both the stem and leaves had closely related concentrations as suggested in the hierarchical cluster analysis shown in figure 2. The mean concentration of lead in the root, stem and leaves shown in figure 1, and may be attributed to indiscriminate farm practices especially chemical applications such as pesticides, herbicides and insecticides etc. also the geological mining activities in the study area and lastly traffic along the roadside been a major motor high way linking the nation's capital city (Abuja) to other cities. Toxicol *et al*, (2015) observed similar trend in environmental and analytical toxicology of heavy metal concentrations in plants and soil along heavy traffic roads in north central Nigeria. Apart from the control soil sample, all other samples had concentration of Lead (Pb) above the permissible limit for plants.

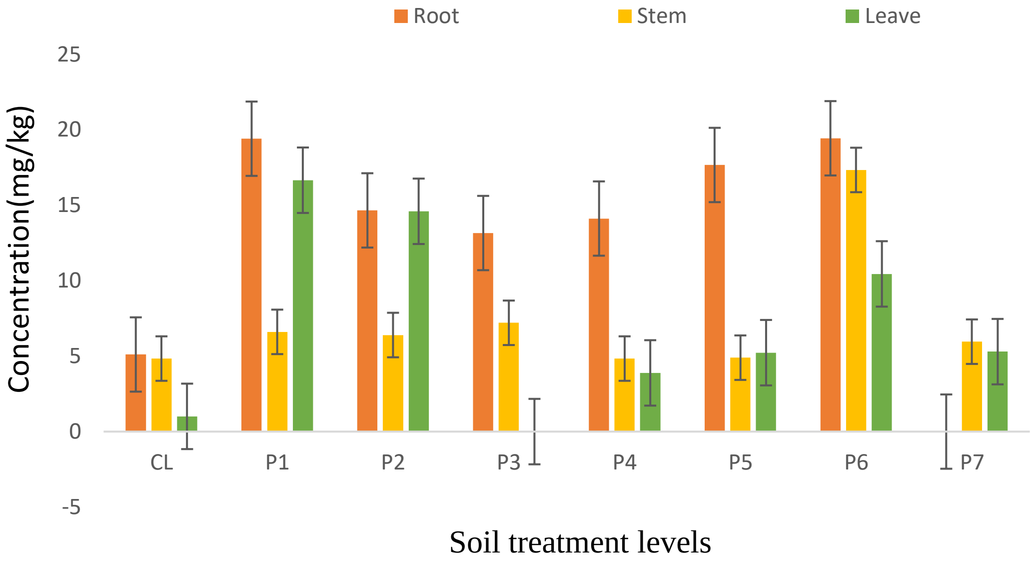

Figure 1: Pb uptake in root, stem and leaves

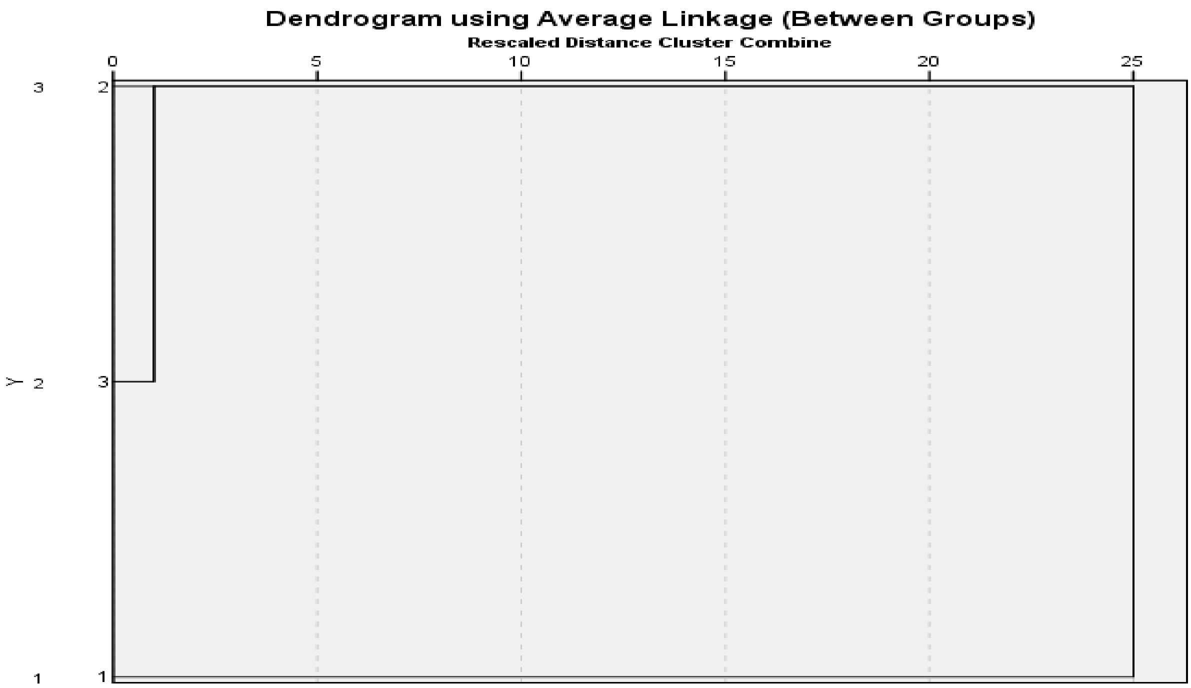

Figure 2: Hierarchical cluster analysis of Pb uptake in root, stem and leaves

Table 2: Descriptive statistics of Ni concentration in root, stem and leave (mg/kg)

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Root	8	4.90	0.00	4.90	0.83	1.68
Stem	8	0.50	0.00	0.50	0.14	0.17
Leaves	8	0.20	0.00	0.20	0.06	0.08

Uptake of Ni in the root, stem and leave of *spinacia oleracea* l

The highest concentration of Ni in the harvested crop was obtained as 4.90 mg/kg, found in the root, and the least concentration of 0.00 mg/kg (below detection limit) and also found in all the plant parts, it can cause reductions in yields of the vegetable (Chen *et al.*, 2009). Ni was observed to have higher concentrations in the root whereas the uptake by stem and leaves showed similarity as shown in the cluster analysis of figure 4. Figure 3. show levels of Ni uptake in the root, stem and leave of spinach in the different treatment levels of CL, and P1 to P7.

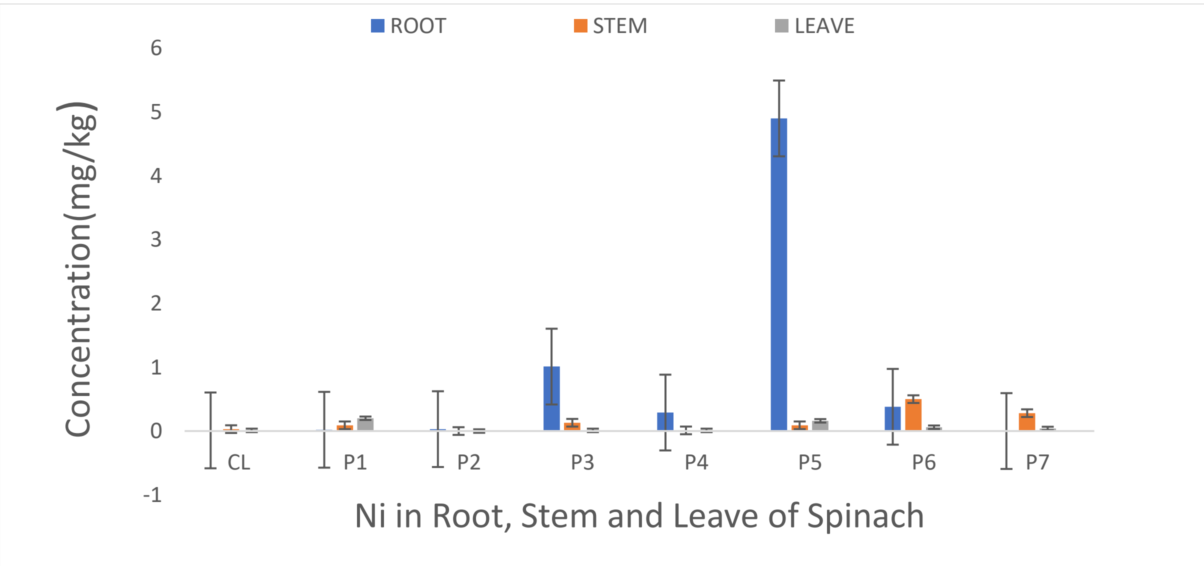

Figure 3: Ni uptake in root, stem and leaves

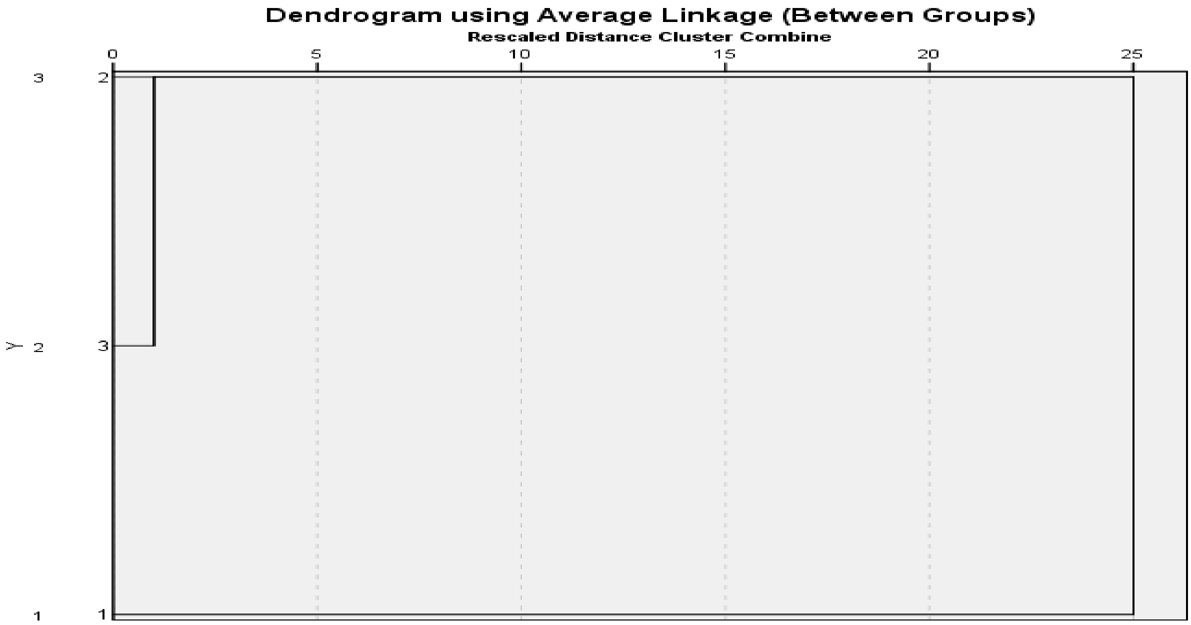

Figure 4: Cluster analysis for Ni uptake in root, stem and leaves

CONCLUSION

The effect of environmental pollution of agricultural soil on edible crops was studied using the laboratory scale pot experiment. The results from mean concentration and hierarchical cluster analysis all revealed most of the Pb and Ni to be concentrated in the roots of the planted *Spinacia oleracea* L. (African spinach) crop. The uptake of the metal concentrations on the plants edible parts was observed to be low.

REFERENCES

Agrelli, D., Caporale, A. G., and Adamo, P. (2020). Assessment of the bioavailability and speciation of heavy metal(loid)s and hydrocarbons for risk-based soil remediation. *Agronomy*, *10*(9). https://doi.org/10.3390/AGRONOMY10091440.

Ali, H., Khan, E., and Ilahi, I. (2019). Environmental chemistry and ecotoxicology of hazardous heavy metals: Environmental persistence, toxicity, and bioaccumulation. In *Journal of Chemistry* (Vol. 2019). Hindawi Limited. https://doi.org/10.1155/2019/6730305.

Amanullah, M., Ali, A., Ping, W., Quan, W., Feng, S., Lahori, A. H., Ronghua, L., Awasthi, M. K., Zengqiang, Z., and Öztürk, M. (2016). *Soil Amendments for Heavy Metal Immobilization Using Different Crops*. 371–399. https://doi.org/10.1007/978-3-319-34451-5

Chen, C., Huang, D., Liu, J., and Ecology, G. (2009). *Review Functions and Toxicity of Nickel in Plants : Recent Advances and Future Prospects*. *37*, 304–313. https://doi.org/10.1002/clen.200800199

Cheng, Z., Lee, L., Dayan, S., Grinshtein, M., and Shaw, R. (2011). *Speciation of heavy metals in garden soils : evidences from selective and sequential chemical leaching*. 628–638. https://doi.org/10.1007/s11368-011-0351

Latif, A., Bilal, M., Asghar, W., Azeem, M., Ahmad, M. I., Abbas, A., Zulfiqar Ahmad, M., and Shahzad, T. (2018). Heavy Metal Accumulation in Vegetables and Assessment of their Potential Health Risk. *Journal of Environmental Analytical Chemistry*, *05*(01), 1–7. https://doi.org/10.4172/2380-2391.1000234

Masona, C., Mapfaire, L., Mapurazi, S., and Makanda, R. (2011). Assessment of heavy metal accumulation in wastewater irrigated soil and uptake by maize plants (Zea mays L.) at Firle Farm in Harare. *J Sustain Dev*, *4*(6), 132–137. https://doi.org/10.5539/jsd.v4n6p132

Nagajyoti, P. C., Lee, K. D., and Sreekanth, T. V. M. (2010). Heavy metals, occurrence and toxicity for plants: a review. *Environ Chem Lett*, *8*(3), 199–216. https://doi.org/10.1007/s10311-010-0297-8

Okafor, O. F., and PAC, O. (2015). *Risk Assessment of Selected Heavy Metals in Effluents of Fish Processing Industry in Apapa Lagos, Nigeria*. *5*(1), 112–119.

Shafiuddin Ahmed, A. S., Hossain, M. B., Babu, S. M. O. F., Rahman, M. M., and Sarker, M. S. I. (2021). Human health risk assessment of heavy metals in water from the subtropical river, Gomti, Bangladesh. *Environmental Nanotechnology, Monitoring and Management*, *15*. https://doi.org/10.1016/J.ENMM.2020.100416

Takarina, N. D., & Pin, T. G. (2017). Bioconcentration Factor (BCF) and Translocation Factor (TF) of Heavy Metals in Mangrove Trees of Blanakan Fish Farm. *Makara Journal of Science*, *21*(2), 77–81. https://doi.org/10.7454/mss.v21i2.7308

Toxicol, J. E. A., Dt, O., Aa, A., and Oe, O. (2015). *Environmental & Analytical Toxicology Heavy Metal Concentrations in Plants and Soil along Heavy Traffic Roads in North Central Nigeria*. *5*(6), 6–10. https://doi.org/10.4172/2161-0525.1000334

Vodyanitskii, Y. N. (2016). Standards for the contents of heavy metals in soils of some states. *Annals of Agrarian Science*, *14*(3), 257–263. https://doi.org/10.1016/j.aasci.2016.08.011

Wang, F., Guan, Q., Tian, J., Lin, J., Yang, Y., Yang, L., and Pan, N. (2020). Contamination characteristics, source apportionment, and health risk assessment of heavy metals in agricultural soil in the Hexi Corridor. *Catena*, *191*. https://doi.org/10.1016/J.CATENA.2020.104573.

Yang, Y., Zeng, L., and Chen, L. (2019). Chemical speciation and bioavailability of cadmium and lead in the gray calcium soil. *Environmental Pollutants and Bioavailability*, *31*(1), 306–315. https://doi.org/10.1080/26395940.2019.1685908

SYNTHESIS AND CHARACTERIZATIONS OF ZnO QUANTUM DOTS NANOCRYSTAL WITH STRONG QUANTUM CONFINEMENT

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ABSTRACT

Quantum dots (QDs) are nanocrystal semiconductors that are remarkably tiny, with diameters typically ranging from 2 – 10 nm (equivalent to 10 – 50 atoms). Due to their extremely small sizes, QDs nanocrystals possesses distinctive properties, resulting in exceptional tunability in their structures and offering novel possibilities in science and technology. In this research, ZnO quantum dots (ZnO QDs) were successfully synthesized at different pH using a sol-gel method. The synthesized ZnO QDs were characterized through X-Ray Diffraction (XRD), Atomic Force Microscope (AFM), Ultraviolet-Visible Diffuse Reflectance Spectroscopy (UV-Vis DRS), and photoluminescence (PL) analyses. The X-ray diffraction patters of the produced ZnO QDs reveal that the ZnO nanocrystals formed the hexagonal Wurtzite phase. The average crystallite sizes as calculated by the Debye-Scherer equation were 10.66 nm, 6.63, and 4.45 nm, for the ZnO QDs synthesized at pH 10, 12 and 14, respectively. The optical Absorption studies showed that the band gap of the synthesized ZnO QDs has shifted toward the blue end of the spectrum when compared to bulk ZnO, which can be related to the strong quantum confinement induced by the nanoscale size. Furthermore, the effects of pH on the size and the photoluminescence emission spectra of the synthesized ZnO QDs were discussed.

Keywords: *Quantum dots, Zinc oxide, semiconductors, sol-gel, photoluminescence.*

INTRODUCTION

Quantum dots (QDs) are zero-dimensional semiconductor nanomaterials with the size of about 2-10 nm, composed of about 200 - 10000 atom (Kandi *et al.*, 2017). The most common QDs are the binary semiconductor compounds consisting of elements of group II-VI, such as lead sulfide (PbS), and cadmium selenide (CdSe). QDs composed of elements of group III-V, such as Indium phosphamide (InP), and gallium nitride (GaN) are also of enormous interest. Other QDs made of a single element (such as silicon or germanium), or of ternary elements (such as CdSSe, CdZnS, CdTeS etc.) have also been reported (Adegoke *et al.*, 2017). Lately, carbon-based QDs, made of carbon quantum dots (CQDs) or graphene quantum dots (GQDs) have been developed as a new class of semiconductor QDs (Xu *et al.,* 2020).