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Analysis of Heavy Metals Levels in Locally produced Rice Fumigated with Cypermethrin (Pyrethroid) Pesticide Grown in Auyo Rice Field of Jigawa State

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ABSTRACT

There is a growing public concern over the potential accumulation of heavy metals in agricultural soils owing to rapid urban and industrial development and increasing reliance on agrochemicals in the last several decades. Excessive accumulation of heavy metals in agricultural soils may not only result in environmental contamination, but elevated heavy metal uptake by crops may also affect food quality and safety. The present study aims to study heavy metal concentrations in rice parts (root, stem, leaf, seed and corresponding soils in the Auyo rice field. Specimens of rice plant parts from different locations in 10 × 10 m were sampled with their corresponding soils. Soil and plant specimens were analysed by using Atomic Absorption spectrometry. It was found that metal concentration in soil was highly variable while the concentration of metals in plants directly depends on the concentration of metal-based pesticide applied. Roots showed the highest metal concentration, followed by leaves, stem and seeds. The physicochemical parameters of the soil from the study area revealed that the pH of the soil sample is within the alkaline range. Similarly, the electrical conductivity was less than 4 (0.51 to 0.65 dSm^{-1}), indicating the presence of soluble salts within average, dissolved Nitrogen at a range of 179.4 to 221 kg/Ha, showing low in nitrogen content, Phosphorus levels in the study region range from 29.00 to 42.33 kg/ha, while potassium level in the soil varies from 126.22 to 250 kg/ha. In general, the soil in the study area was found to be very rich and fertile for the cultivation of rice. The accumulation of some heavy metals in some rice parts may be due to the effects of cypermethrin pesticides.

INTRODUCTION

Heavy metal contamination is a major environmental health challenge. It is potentially dangerous because of bioaccumulation through the food chain, which arises from rapid industrial growth, advances in the use of agricultural chemicals, and the urbanizing activities of man [1]. This has led to the dispersion of heavy metals in the environment, resulting in the impaired health of the population, mainly by the ingestion of food crops contaminated by these harmful elements. Uptake of heavy metals by plants through absorption and subsequent accumulation along the food chain is a potential threat to animal and human health [2].

Human activities, such as mining, fertilisers, pesticides, and sewage sludge, can cause heavy metal contamination in crops [3]. The primary sources of heavy metals in soil and agriculture are atmospheric pollution, animal manure, wastewater or polluted water drainage, Metallo-pesticides or herbicides, phosphate-based fertilisers and modifications to wastewater sludge [4]. The sources of metal pollution come from manufacturing, agriculture, sewage and motor vehicle emissions. The few reliable studies on metals in water indicate that some rivers were contaminated with Pb, Cu and Zn [5]. Rice (*Oryza sativa*) is a staple food in many African and other developing countries. It is the important staple food for approximately half of the world's population. Rice is the most important food, with over half of the world's population relying on it for around 80% of their food needs. In Nigeria, it is becoming a more important crop. It is relatively simple to grow and is grown for both commercial and domestic use. Although rice farming has a long history in some locations, rice has long been regarded as a luxury dish reserved for special occasions. Rice has become more widely available in Nigeria, and it has become a staple of many people's diets. Heavy metals are found in nature, but only in harmful trace amounts. Because heavy metals are stable, they cannot be easily decomposed or eliminated, making them persistent environmental pollutants[6] [7]. Plants absorb them from the air, fertilisers, insecticides, and the deposition of urban and industrial waste on the soil and water used to irrigate the plants. In addition, mechanical farming, fertilisers and chemicals are current agricultural techniques [8].

These strategies are used in the cultivation of local rice in Nigeria to ensure food security. The environment is contaminated by heavy metals from fertilisers, chemicals, and machine fumes due to these practices. Crops cultivated on soils contaminated with heavy metals accumulate more heavy metals than crops grown on soils that are not affected. As a result, when people ingest any dietary sources, they are almost certain to absorb some of these heavy metals [9]. Excessive levels of heavy metals in the environment have toxicological consequences for humans, plants, and other species.

Heavy metal deposition in agricultural soils is a growing source of worry for the general public and government agencies, owing to food safety concerns and potential health risks and adverse effects on soil ecosystems [10]. Because of their toxicity, heavy metals such as arsenic, cadmium, and mercury are mainly concerned in soil and food contamination, particularly in rice cropping systems [11]. Mercury, lead, and cadmium have all been classified as hazardous heavy metals [12]. Even at low amounts, lead and cadmium can be extremely dangerous if consumed for an extended period [13]. The aim of this research, therefore, is to analyse the bioaccumulation effect of heavy metals (Cd, Pb and Cr) on different parts of rice treated with cypermethrin pesticides grown in the field.

MATERIALS AND METHODS

Study area

Rice parts root, stem, leaf, seed, and the corresponding soil were collected from the rice agricultural field in Auyo Local Government of Jigawa. Rice was planted and propagated for the sole purpose of this research. Cypermethrin pesticides was applied to the plant.

Sample collection

In a brown envelope, five separate samples (rice seeds, stem, leaves, roots, and sand) were collected and transferred to the laboratory, where they were allowed to dry under laboratory conditions. The air-dried samples were ground with a mechanical blender, and the powdered sample was kept in a laboratory container until it was needed [9].

Dilution of pesticides

Based on information acquired from farmers in the study region, about 37.5 mL of pesticides (Cypermethrin) was diluted with 2,000 mL of water. As a result, each 1 mL of pesticide was mixed with 53.3 mL of water. The pesticides were applied to the rice once weekly for four weeks.

Digestion Experiment

This approach involves treating a sample with a 5:1:1 solution of sulfuric (H_2SO_4), nitric (HNO_3), and perchloric acids. Nitric acid oxidises sulphide material and destroys organic stuff. The Aqua Regia digestion method will be used with minor modifications, as described in EN 13656 (2002) [14]. Following digestion, each of the five aliquots will be transferred to a container and diluted to 100 mL with water. After 30 minutes, the solutions will be filtered through Whatman filter paper.

Determination of soil physicochemical parameters

The collected sample was analysed for primary physical and chemical soil quality parameters like soil pH, electrical conductivity, available Nitrogen (N), phosphorous (p), potassium (K) and organic carbon (OC).

Table 1. Methods used for estimation of parameters.

No	Parameter	Method
1	pH	Potentiometer
2	EC	Conductometry
3	Organic carbon	Wet oxidation
4	Available Nitrogen	Permanganate
5	Available Potassium	AAS
6	Available Phosphorous	colorimetry

Statistical analysis

Analysis of Variance (ANOVA) will be used to determine whether there exists a statistical difference in the concentration of heavy metals between the five different samples (rice seed, stem, root, and soil). Correlation analysis will be used to determine the relationship between heavy metal and soil physicochemical parameters

RESULTS AND DISCUSSION

Table 2. Physicochemical Characteristics of the soil from the study area.

Sample	Colour	pH	ECdSm^{-1}	Available P kg/ha	Available N kg/ha	Organic carbon %	AvailableK kg/ha
1	Black	8.11	0.65	30.44	200.2	0.54	126.22
2	Black	7.90	0.51	42.33	221.0	0.45	250.00
3	Black	8.23	0.55	29.00	179.4	0.71	200.11

The pH value on the alkaline side, the pH of these soils is greater than 7. Alkalinity is a measure of saline or salt affected soil. If pH is less than 6.0, then soil type is acidic. The soil pH range from 6-8.5; its type is typical soil and more significant than 8.5, then it is said to be alkaline type soil.

The electrical conductivity of soil indicates the total soluble salts content of the soils. The conductivity values can vary with the chemical properties of soil. If EC is less than four (4), soil type is normal. The soil used for rice cultivation in this study EC's values ranges from 0.51 to 0.65dSm-^{1}. This shows that the soil samples were lower in EC values, hence normal [15].

Soil organic carbon is the basis of soil fertility. It releases nutrient for plant growth. , increasing soil organic carbon improves soil health and fertility. The data is presented in table 2. Organic carbon ranges from shows 0.45 to 0.71 %.

Nitrogen is an essential plant nutrient for canopy development. Nitrogen deficiency results in reduced growth of yellowish-green leaves and lower protein content and yields. All soil samples have low nitrogen levels[16].

The master critical ingredient in soil quality is phosphorus. It is a vital component of every live cell. Growth, cell division, root growth, elongation, seed and fruity development, and early ripening require it. It also aids in the storage and transmission of energy. Phosphorus levels in the study region range from 29.00 to 42.33 kg/ha. Potassium is essential for a variety of plant physiological functions. Potassium is an essential ingredient for growing high-quality crops. Its primary role is catalytic. The amount of potassium in the soil varies from 126.22 to 250 kg/ha. The majority of the soil samples demonstrate significant potassium availability. The soil has a moderate to medium level of readily accessible potassium.

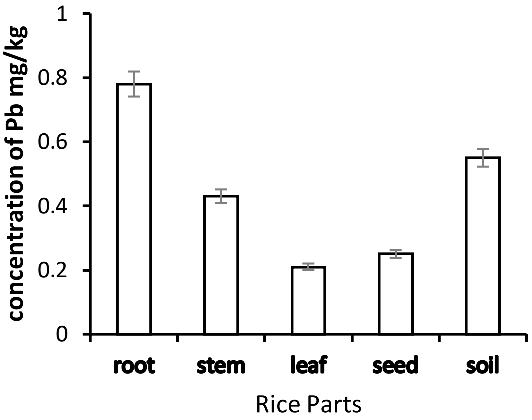

Fig. 1. Concentration of lead in soil and rice parts after treatment with Cypermethrin

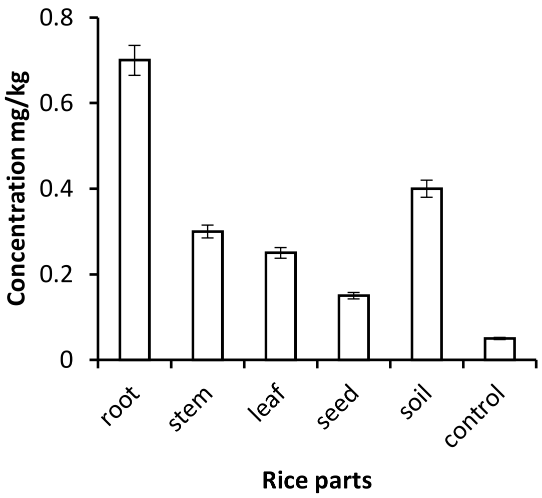

Fig. 2. Concentration of Chromium in soil and rice parts after treatment with Cypermethrin

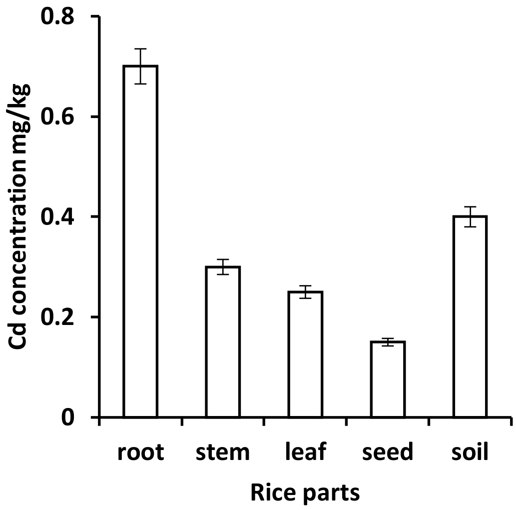

Fig. 3. Concentration of cadmium in soil and rice parts after treatment with Cypermethrin

Figs. 1 to **3** shows the effects of three heavy metals (Cadmium, Lead and Zinc) on soil and four different rice parts following treatment with Cypermethrin pesticides. The concentration of Cadmium, Lead and Chromium in the root was very high (fig 1 - 3). The range of concentration falls between 0 – 0.8 mg/l which accumulates heavy metals in the rice roots [17]. This finding also revealed that root is the first part of the rice to contact the heavy metal from metal-based pesticides, hence accumulating more of the metal ions.

This may be the reason for poor growth and change in the colour of the entire plant. Ashraf [18] reported that high metal concentrations in the plant might reduce the plant's capacity to synthesize chlorophyll, increase oxidative stress, and diminish stomata resistance. Heavy metals such as chromium (Cr) and cadmium (Cd), which are naturally occurring heavy metals, can inhibit plant growth, whether the pollution comes from the soil or the air[19]. To live, plants have evolved some effective and precise methods to deal with high metal stress. Immobilisation, exclusion of plasma membranes, limitation of absorption and transport, production of specialised heavy metal transporters, activation of stress proteins, and chelation are some of the adaptive mechanisms plants have developed to deal with metal stress[20]. However, these processes resulted in plants accumulating toxic material, which may subsequently be transferred to a human.

Other parts of the rice accumulate a small amount of the heavy metals analysed when compared with the control (result not shown). The corresponding soils, on the other hand, have a high concentration of the analysed heavy metals (Cd, Pb and Cr). The usual Cd content is 0.1 and 0.41 mg/Kg in the earth's crust [19]. Cadmium is a significant contaminant that belongs to the class of heavy metal pollutants. Cadmium toxicity manifests itself in stunted development, chlorosis, root tip browning, and eventually plant death [21].

Leaf chlorosis can be caused by too much Cd in the growing soil, but it's also possible that it's caused by an iron deficiency or toxic metal interaction. Chlorosis can develop in leaves as a result of direct or indirect interactions with Fe. The presence of high cadmium in soils also suppresses plant iron uptake, according to [21]. Chromium's accumulation and mobilisation within storage tissue, on the other hand, is influenced by its ionic state; it accumulates primarily in roots and is poorly translocated to shoots. Cr inhibits the uptake of numerous vital elements, including Fe, Mg, Mn, Ca, P, and K, similar to cadmium, resulting in a variety of unfavorable plant growth impacts [22].

Although roots are better at accumulating Pb in plants, their subsequent transport to aerial portions is severely limited. The availability of lead in soil is significantly influenced by soil characteristics such as pH, particle size, and cation exchange capacity. Because the Casparian bands obstruct the endodermis, Pb accumulates predominantly in root cells after absorption. Furthermore, negative charges trap lead on the cell wall of the roots [23]. Lead buildup in plants has several negative impacts on plants' morphological, physiological, and biochemical activities, either directly or indirectly[10].

CONCLUSION

The result obtained for heavy metal analysis from soil and locally produced rice parts (root, stem, leaf and seed) fumigated with cypermethrin pesticides shows that, the root of the rice accumulates the heavy metal in higher concentration when compared with other parts of the plant. The heavy metal concentrations in the soil is less than that of the root. The result of the physicochemical analysis of the soil revealed the presence of all the nutrient and mineral element necessary for the growth of rice at right and normal range.

REFERENCE

1. Ali H, Khan E, Sajad MA. Phytoremediation of heavy metals-Concepts and applications. Chemosphere. 2013.
2. Anguelov G, Anguelova I. Assessment of land-use effect on trace elements concentrations in soil solution from Ultisols in North Florida. Agric Ecosyst Environ. 2009;
3. Wang LK, Chen JP, Hung YT, Shammas NK. Heavy metals in the environment. 2009. CRC Press .
4. Alloway BJ. Sources of Heavy Metals and Metalloids in Soils. Heavy metals in soils. Springer, Dordrecht, 2013. 11-50.
5. Karaouzas I, Kapetanaki N, Mentzafou A, Kanellopoulos TD, Skoulikidis N. Heavy metal contamination status in Greek surface waters: A review with application and evaluation of pollution indices. Chemosphere. 2021. 128192.
6. Briffa J, Sinagra E, Blundell R. Heavy metal pollution in the environment and their toxicological effects on humans. Heliyon. 2020;6(9):e04691.
7. Wuana RA, Okieimen FE. Heavy Metals in Contaminated Soils: A Review of Sources, Chemistry, Risks and Best Available Strategies for Remediation. ISRN Ecol. 2011;2011:1–20.
8. Ayilara M, Olanrewaju O, Babalola O, Odeyemi O. Waste Management through Composting: Challenges and Potentials. Sustainability. 2020;12(11):4456.
9. Ali H, Khan E, Ilahi I. Environmental Chemistry and Ecotoxicology of Hazardous Heavy Metals: Environmental Persistence, Toxicity, and Bioaccumulation. J Chem. 2019;2019:e6730305.
10. Tchounwou PB, Yedjou CG, Patlolla AK, Sutton DJ. Heavy Metals Toxicity and the Environment. EXS. 2012;101:133–64.
11. Chibuike GU, Obiora SC. Heavy Metal Polluted Soils: Effect on Plants and Bioremediation Methods. Appl Environ Soil Sci. 2014:1–12.
12. Jaishankar M, Tseten T, Anbalagan N, Mathew BB, Beeregowda KN. Toxicity, mechanism and health effects of some heavy metals. Interdiscip Toxicol. 2014;7(2):60–72.
13. Azeh Engwa G, Udoka Ferdinand P, Nweke Nwalo F, N. Unachukwu M. Mechanism and Health Effects of Heavy Metal Toxicity in Humans. In: Karcioglu O, Arslan B, editors. Poisoning in the Modern World - New Tricks for an Old Dog?. IntechOpen; 2019. Available from: https://www.intechopen.com/books/poisoning-in-the-modern-world-new-tricks-for-an-old-dog-/mechanism-and-health-effects-of-heavy-metal-toxicity-in-humans
14. Husakova M, Dziedzinska R, Slana I. Magnetic Separation Methods for the Detection of *Mycobacterium avium* subsp. *paratuberculosis* in Various Types of Matrices: A Review. BioMed Res Int. 2017:1–15.
15. Sangita Changdeo Dandwate. Analysis of soil samples for its physicochemical parameters from Sangamner city. GSC Biol Pharm Sci. 2020;12(2):123–8.
16. King AE, Ali GA, Gillespie AW, Wagner-Riddle C. Soil Organic Matter as Catalyst of Crop Resource Capture. Front Environ Sci. 2020;8:50.
17. Neeratanaphan L, Khamma S, Benchawattananon R, Ruchuwararak P, Appamaraka S, Intamat S. Heavy metal accumulation in rice (*Oryza sativa*) near electronic waste dumps and related human health risk assessment. Hum Ecol Risk Assess Int J. 2017;23(5):1086–98.
18. Ashraf MA, Maah MJ, Yusoff I. Heavy metals accumulation in plants growing in ex tin mining catchment. Int J Environ Sci Technol. 2011;8(2):401–16.
19. Gimeno-García E, Andreu V, Boluda R. Heavy metals incidence in the application of inorganic fertilizers and pesticides to rice farming soils. Environ Pollut. 1996;92(1):19–25.
20. Kumar V, Singh J, Kumar P. Heavy metals accumulation in crop plants: Sources, response mechanisms, stress tolerance and their effects. In: Contaminants in Agriculture and Environment: Health Risks and Remediation. Agro Environ Media - Agriculture and Ennvironmental Science Academy, Haridwar, India; 2019;38–57.
21. Đukić-Ćosić D, Baralić K, Javorac D, Djordjevic AB, Bulat Z. An overview of molecular mechanisms in cadmium toxicity. Curr Opin Toxicol. 2020;19:56–62.
22. Oliveira H. Chromium as an Environmental Pollutant: Insights on Induced Plant Toxicity. J Bot. 2012;2012:1–8.
23. Attanayake CP, Hettiarachchi GM, Harms A, Presley D, Martin S, Pierzynski GM. Field Evaluations on Soil Plant Transfer of Lead from an Urban Garden Soil. J Environ Qual. 2014;43(2):475–87.