Comparative Phytoaccumulation of Lead Uptake by *Oryza sativa* and *Zea mays L*

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Abstract: - The identification of chemical forms of lead (Pb) in agricultural samples is of interest for the evaluation of its mobility, bioavailability and ecotoxicity. Heavy metals are among the most important sorts of contaminant in the environment and metal pollution is a global concern and also health hazardous to human health. This research was carried out to determine and compare the level of heavy metal uptake (Pb) in both Oryza sativa and Zea mays planted on contaminated soil. A 6 kg of soil was contaminated with 20 g of $Pb(NO_3)_2$ which contains 12.51 g of Pb. Oryza sativa and Zea mays was planted on this contaminated soil. Germination begins after 5 days of plantation for both Oryza sativa and Zea mays. Plant growths continuous in three different containers each for 30 days. A similar trend was carried out for the uncontaminated soil which also germinates after 6 days of plantation. It was observed that contaminated one's germination was faster than uncontaminated (Control) and it has effect on the germination process of both Oryza sativa and Zea mays. The level of heavy metals in the soil and plant was determined using Atomic Absorption Spectrophotometer (AAS) analysis. Analysis of the plant and soil samples reveals that the concentration of Pb in Oryza sativa were, 0.425, 0.514 and 0.498, mg/dm^3, for plant and in soil were 0.855, 0.715, and 0.725 mg/dm^3 respectively. While for Zea mays were 0.329, 0.293 and 0.272 mg/dm^3 for plant and for the soil was 0.953, 0.982 and 0.978 mg/dm^3 respectively. It shows that the uptake of the metal is high. All the values obtained from the Soil analysis for Zea mays and Oryza sativa were below the permissible limit recommended by WHO. But in both plant Oryza sativa and Zea mays, it has exceeded the maximum permissible limit recommended by WHO/FAO which shows that the absorption is high. Therefore, the consumption of these plants, planted on contaminated soil as food may pose health hazards to humans and animals. The mean, standard deviation and transfer factor of both the plant and soil samples was all calculated. The result also shows that both Oryza sativa and Zea mays has the ability to phytoremediate to a very small extend. Farmers are advised to dig wells for irrigation as their source of water. The general public should be enlightened to avoid discarding solid waste dumps, garbage and animal excretions on agricultural lands because they are also sources of heavy metals. Further research should be carried out in the future in order to explore more plants that have higher ability to phytoremediation.

Key Words: —*Lead, Phytoaccumulation, Comparative, Transfer factor, Oryza sativa and Zea mays L.*

I. Introduction

Heavy metals are among the most important sorts of contaminant in the environment [1]. They are natural component of the earth crust. They cannot be degraded or destroyed, to a small extend they enter our bodies via food, drinking water and air [2].

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Heavy metals and metalloids are of environmental concern. In very small amount many of these heavy metals are useful to support life. However, in large amount they may build up in biological system and becomes hazardous to health. Heavy metals make significant contribution to environmental pollution as a result of anthropogenic activities such as mining, energy and fuel production, power transmission, intensive agricultural practice, sludge and industrial effluent, dumping and military operations [3]. Heavy metals are ubiquitous in the environment, as a result of national and anthropogenic activities, and humans are exposed to them through various pathways. Wastewater irrigation, social waste disposal and sludge application are the major sources of soil contamination with heavy metals, and increase metal uptake by vegetable grown on such contaminated soil is often observed [4]. Heavy metals pollution is a global concern and also hazardous to human health. Health effect caused by consumption of heavy metals in humans include; respiratory diseases, cancers, kidney disease, brain damage, heart attack, anemia, chronic nephritis, encephalopathy and disease in digestive system among others [5, 6 ,7].

Growth and grain yield of crops among the various heavy metals, Lead (Pb) is commonly spread throughout the environment, and reveals a comparatively high reactivity to plant cells [3].

Maize (*Zea mays L.*) is a flowering plant in the family Gramineae and belongs to the grass family Poaceae [8]. In Nigeria, maize is the most important staple cereal after sorghum and millet with the widest geographical spread in terms of production and utilization among the cereals [9]. It is a cultivated plant with numerous valuable uses for human and animal [10, 11]. Its production during the period rose from 7.1 million tons in 2006 to 7.8 million tons in 2007. This figure could be doubled if the recommendations of the researchers are implemented [12, 13]. Maize are also serves as major source of proteins and carbohydrates consumed in Nigeria [14].

Rice (*Oryza sativa*) is one of the most important cereal crops, providing food for nearly a half of the world population [15] and contributing with one fifth of the calories consumed by human's worldwide [16]. About 90 percent of the total rice is cultivated in Asia [17]. Rice is recognized as a staple global food with over 400 million metric tons of milled rice being consumed each year. Approximately half of the world's population is reliant upon rice for sustenance [18]. Rice is the second largest produced cereal in the world. Nigeria has over 3 million out of about 60 million rural farmers who are rice farmers and has approximately 5 million hectares of arable land suitable for rice production [19].

The capacities of heavy metal uptake and accumulation, mechanisms of metal concentration, exclusion and compartmentation vary among different plant species and also between various parts of plants [20]. Heavy metals uptake by plants such as maize is a pathway into the food chain of human beings [21, 22, 23]. The speed of metal being taken up by a plant might be manipulated by aspects including types of metal, species of plants, age of the plant and part of the plant [24, 25, 26]. Both heavy metals uptake via roots from contaminated soils and vegetables, and direct deposition of contaminants from atmosphere onto plant surfaces can lead to plant contamination by heavy metals. Lead and cadmium are considered potential carcinogens and are associated with etiology of a number of diseases, especially cardiovascular, kidney, blood, nervous, and bone diseases. Both heavy metals uptake via roots from contaminated soils and vegetables, and direct deposition of contaminants from atmosphere onto plant surfaces can lead to plant contamination by heavy metals. Lead and cadmium are considered potential carcinogens and are associated with etiology of a number of diseases, especially cardiovascular, kidney, blood, nervous, and bone diseases [27].

Lead deposition interferes with plant growth and development, and can cause plant death. Crop and livestock farming is the major occupation of northern Nigerians. Maize (*Zea mays L*) are different plant species which serves as major source of proteins and carbohydrates consumed in Nigeria. Rice is one of the commonest staples produced in the northern region. In order of production level, Zamfara, Kebbi, Sokoto, Katsina, Jigawa and Borno states follow very closely, especially with specialization on processing facilities [19]. Rice (*Oryza sativa*) occupies an important place, being the staple food of Nigerians. According to government statistics, yearly consumption of rice is about 5.5 million tons with local production accounting for about 1.8 million tons [28]. Rice is the second largest produced cereal in the world. Nigeria has over 3 million out of about 60 million rural farmers who are rice farmers and has approximately 5 million hectares of arable land suitable for rice production [19]. Lead is the major component of those nutritional elements by seedlings and plants and causes deficiencies or adverse ion distribution within the plant [29]. Research about the effect of heavy metals on plant growth has been well documented [30, 31], including effects of lead pollution on under extreme conditions [32, 33]. Previous studies have shown heavy metal contamination of foods; such as rice containing lead, ranged from 0.00-61.17mg/kg and in other food crops and fruits consumed in Owerri [34]. In Maize lead inhibits imbalance, disturbed mineral nutrition, enzyme activities, change in hormonal status and membrane permeability alteration. Lead at high concentrations inhibits cellular activities thus causing cell death [35]. It has been reported that lead deposition in leaves of rice decreased the concentrations of chlorophyll contents. Lead produced highly significant effects on shoot, root lengths and seedling dry biomass of Lythrumsalicaria [36]. In Maize increase the lead concentration hampers the synthesis of chlorophyII because impaired uptake of iron magnesium through the plants. The photosynthetic apparatus is damage due to its affinity for protein and ligands. At high concentrations of lead, inhibition of respiration is observed [3]. In such conditions there is a strong need to investigate the effect of lead on maize and rice for their seed germination and seedling and plant growth by evaluating various physiological and biochemical attributes of

Oryza sativa and *Zea mays L*. It was hypothesized that lead toxicity might induce physiological and biochemical changes in *Oryza sativa* and *Zea mays L*. To prove this hypothesis, the present study was designed [37]. Lead accumulator and anti-rust agents and the level of accumulation of lead in the soil is between 2-200mg/kg [38]. Therefore, the need to examine the safety of its consumption is of public health and toxicological importance. This research was aimed at comparative studies of heavy metal (Pb) uptake by *Oryza sativa* and *Zea mays L*

II. Material And Method

2.1 Study Location

The study was carried out at the Abubakar Tafawa Balewa University Bauchi, Bauchi state, Nigeria. The soil sample was collected from Kwankiyal, and it's located between Latitude 11º 9′ 0′′ North and Longitude 10º 28′ 0′′ East, Darazo LGA, Bauchi State, Nigeria.

2.2 Planting of seeds, germinations and growth studies

The soil collected from the sampling site was contaminated with the heavy metal (Pb), 20g of Pb $(NO_3)_2$ (12.51 g of Pb) was used in contaminating of 6 kg of soil into 3 separate containers. Both *Oryza sativa* and *Zea mays L.* was planted for the period of 30 days before harvesting. All the plantations were watered morning and evening throughout the period with tap water. During germination and growth, changes was observed and recorded throughout the period of 30 days.

2.3 Plant Analysis

After 30 days both plant *Oryza sativa* and *Zea mays* was harvested and store at an ambient temperature before digestion. The entire harvested plants *Oryza sativa* and *Zea mays* was taken to laboratory, washed with clean and tap water to remove the soil particles adhered to the sample of the plant. The samples were dried under shed, crushed and sieved with 20 mm mesh size sieve and weight until a constant weight achieved. The sample was stored at ambient temperature before digestion. Both plant and soil 2 g each was digested with 30 ml of tri acid mixture (HNO_3, H_2SO_4 and HCl in 5:1:1 ratio) at 80ºC until transparent solution was obtained [39].

The solutions were cooled and filtered using whattman filter paper no 42 and the filtrate was then diluted up the mark of 50 ml standard volumetric flask, and stored in polyethylene container until analysis by AAS (AA32).

2.4 Transfer factor

After undergoing (AAS) the metal uptake or transfer factor (TF) was determined using [4] method where:

$$\text{TF} = \frac{Concentration\ of\ metal\ in\ plant}{Concentration\ of\ metal\ in\ the\ Soil} \qquad (1)$$

[4] Defined it as the relative tendency of a metal to be accumulated by a particular species of plant this is dependent on the p^H and the nature of the plant itself.

2.5 Data Analysis

All experiments were done in triplicate and results expressed as mean ± standard deviation (SD). Analysis of variance was used to test for differences in the groups, while Duncan's multiple comparisons test was used to determine significant differences between means

III. Result And Discussion

Table.2. Result of plant and soil sample digested after they have undergone atomic absorption spectrophotometric (AAS) analysis.

Sample	Concentration of Pb (Mg/L)
Plant K	0.329 ±0.03
Plant L	0.293 ±0.01
Plant M	0.272 ±0.03
Control	0.00
Soil K	0.953 ±0.02
Soil L	0.982 ±0.01
Soil M	0.978 ±0.01
Control	0.00
Plant R	0.425 ±0.03
Plant S	0.514 ±0.02
Plant T	0.498 ±0.02
Control	0.00
Soil R	0.855 ±0.02
Soil S	0.715 ±0.02
Soil T	0.725 ±0.01
Control	0.00

The result shows the various concentration of lead (Pb) (Mean ± Standard deviation) of *Oryza sativa* and *Zea mays* of both plant and soil sample after AAS (**AAS** machine AA32 on Shangai General Analytical Instruments Factory Bauchi).
Zea mays plant is represented by Plant K, L and M
Zea mays soil is represented by Soil K, L and M
Oryza sativa plant *i*s represented by Plant R, S and T
Oryza sativa soil *i*s represented by Soil R, S and T

3.1 Comparative Pb Concentration (mg/kg) in Plant Sample

Table.3. Bellow is the comparative Pb concentration (mg/kg) in plant sample and compared with maximum permissible limit by WHO/FAO [40].

***Zea mays* plant Plant sample (mg/kg)**			***Oryza sativa* Plant Plant sample (mg/kg)**			**WHO Plant sample (mg/kg)**
K	**L**	**M**	**R**	**S**	**T**	
16.45	**14.65**	**13.60**	**21.25**	**25.70**	**24.25**	**2**

Mean ± SD and the value are significantly difference at (P=0.05).

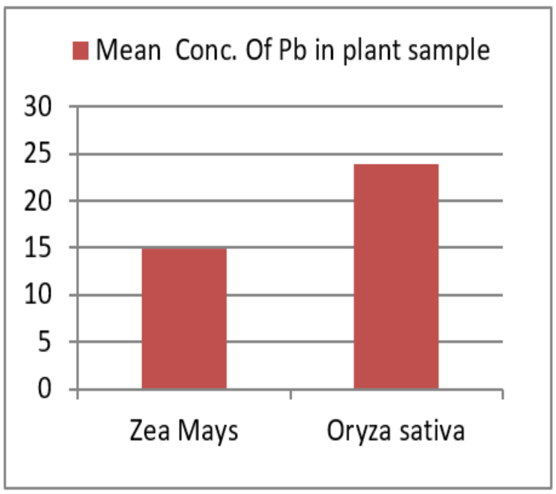


Fig.1. The result of Pb (above) in plant sample shows that concentration of heavy metal Pb in *Oryza sativa* is higher than in *Zea mays L.* and also this work was compared with the maximum permissible limit of the WHO/FAO [41]. The result shows variation with the one compared. Therefore, it has to be monitored in order to prevent further outbreak of Pb poisoning.

3.2 Comparative Pb Concentration (mg/kg) in Soil Sample

Table.4. The comparative Pb concentration (mg/kg) in soil sample and compared with maximum permissible limit by WHO/FAO [41].

***Zea mays* Soil sample (mg/kg)**			***Oryza sativa* Soil sample (mg/kg)**			**WHO Soil sample (mg/kg)**
K	**L**	**M**	**R**	**S**	**T**	
47.6	**49.10**	**48.90**	**42.75**	**35.75**	**36.25**	**85**

Mean ± SD and the value are significantly difference at (P=0.05).

The comparative heavy Pb study of soil (mg/kg) presented in Table 4 above showed a significant difference from the one analyzed in this research. The result in this study for *Oryza sativa s*oil sample and *Zea mays* is less than the permissible limit of metals in the soil given by WHO. The table also shows that all the concentration of soil K, L, M, R, S and T, are less than the permissible limit and this signifies that the soil is good for plantation.

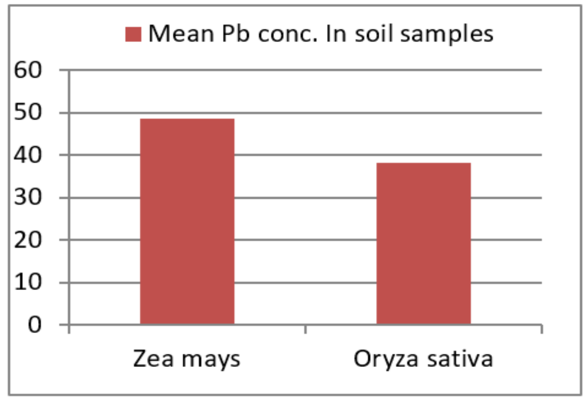


Fig 2. The above chat shows the mean concentrations of Lead (Pb) in both *Oryza sativa* and *Zea mays* soils and also this work was compared with the maximum permissible limit of the WHO/FAO. The result signifies that the soil is good for plantation.

3.3 Transfer factor of heavy metal

Transfer factor (TF) of different heavy metals from soil to *Oryza sativa* and *Zey mays* was calculated as the ratio between the concentration of heavy metals in plant and the soil (Table 5 and 6) below.

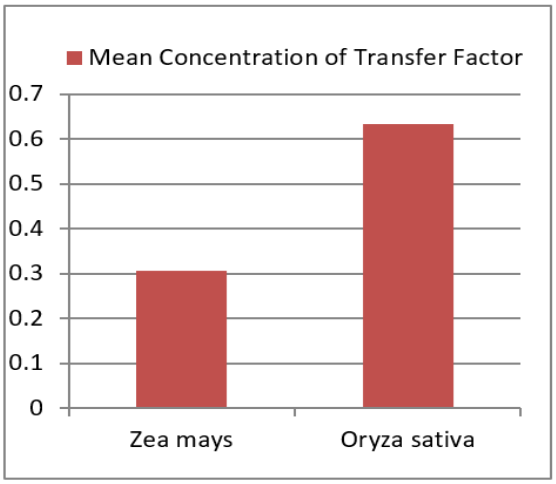
Table.5. Shows the Transfer factor of heavy metal (Pb) in *Zea mays.*

Concentration of Plant (mg/kg)		**TF (mg/kg)**
Plant K/soil K	16.45/47.65	0.345
Plant L /soil L	14.65/49.1	0.298
Plant M/soil M	13.60/48.90	0.278

Table.6. Shows the Transfer factor of heavy metal (Pb) in *Oryza sativa*

Concentration of Plant (mg/kg)		**TF (mg/kg)**
Plant R /soil R	21.25/42.75	0.497
Plant S / soil S	25.70/35.75	0.718
Plant T / soil T	24.90/36.25	0.687

Translocation factor (TF) values of (Table 5 and 6) help to identify the suitability of plants for phytoremediation (i.e., phytoextraction or phytostabilzation) by explaining the accumulation characteristics and translocation behaviors of metals in plants. Plants with TF values > 1 are considered promising phytoextractor, suitable for phytoextraction, while those with TF < 1 are not suitable for phytoextraction/phytostabilzation [42].



From the chart above we can deduce that the mean concentration of Pb in *Oryza sativa* plant has the highest TF value (0.634) compare to in *Zea mays* lowest TF value (0.3133). The transfer factor for *Oryza sativa* is higher Than the *Zea mays.* It is therefore means that the level of heavy metal (Pb) uptake in *Oryza sativa* tends to phytoaccumulate more than in *Zea mays*. It has been found that the trend concentration of Pb follows *Oryza sativa* plant > *Zea mays* Plant. This could be attributed to the high retention of the metal in the soil. The high TF for heavy metals through stem and root does not present the risk associated with the metals in any form [43].

The availability of a metal species in its different forms to migrate from the soil through the plants part and makes itself available for consumption was also represented by the transfer factor as seen in the tables (5 and 6) above. The transfer factor is a function of different factors such as soil, pH, soil organic matter, metal availability and soil particle size. However, plants with TF < 1 are considered potential phytostabilizers, suitable for phytostabilziation (immobilization) [20]. Therefore, it shows that both plants have the ability to phytoremidiate to small extend.

3.4 Germination and Growth

During plantation it was observed that, for both *Oryza sativa* and *Zea mays* planted on soil (6kg) contaminated with 20 g of $Pb(NO_3)_2$ which contain 12.5 g of Pb. There was germination and a perfect growth with very green leaves, greener than that planted on uncontaminated soil (control). The growth was also faster with very tall stem taller than the control also. All these are due to the presence of nitrate in the compound used. The nitrate is a source of nitrogen to the plant, which serves as protein to the plant [44].

The *Zea may* plant was more greenish and tall compare to *Oryza sativa* plant.

The plants planted on the uncontaminated soil (control) 6 kg also germinate, with normal growth observed.

IV. Conclusion

From this study, it has been concluded that the level at which both *Oryza sativa* and *Zea mays* absorb heavy metals (Pb) from the soil was known and compared. The transfer factor (TF) of these heavy metals was also calculated. The result also shows that both *Oryza sativa* and *Zea mays* has the ability to phytoremediate this heavy metal (Pb) to a small extends.

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