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ASSESSMENT OF HEAVY METALS BIOACCUMULATION IN RICE (*Oryza sativa* L.) SEEDS GROWN ALONG ZARIA-KANKARA ROAD, NORTHWESTERN NIGERIA

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ABSTRACT
Heavy metal contamination of farmlands is one of the major threats to food security in Nigeria. Cereal crops have the ability to absorb these heavy metals which when consumed by human and animals manifest several clinical symptoms. This research was carried out to determine the level of heavy metals concentration in the soil and seeds of rice (Oryza sativa) grown along Zaria-Kankara road. Soil and rice seeds samples were collected at a distance of 5, 10, 20m, 40and 60 m away from the road sides. The samples were analyzed for Zinc (Zn), Lead (Pb), Manganese (Mn) and Cadmium (Cd) concentrations in a Completely Randomized Design with three replications. The data obtained were analyzed using Analysis of variance with Duncan's Multiple Range Test used to separate significant means at 5% levels. The result obtained revealed significant difference (P≤0.05) in the levels of Zn, Pb and Mn in the soils and seeds of rice which decrease with increase in distance from the road side. High heavy metals concentrations in the soil and seeds of rice above exceed limits indicated the relative abundance of such elements in relation to vehicular density and anthropogenic activities such as fertilizer and pesticides application. The values of the heavy metals accumulated in the rice seeds showed that consumption of rice seeds grown close to the road sides is hazardous and posed threat to public health. Therefore, it was recommended that, rice should be grown at a distance of not less than 40-60 m from the road sides.
Keywords: Barbashi, Distance, Lead, Zinc

INTRODUCTION

Heavy metals are metallic chemical elements with relatively high density greater than 4g/cm^{3}. They are non-biodegradable and persistent environmental contaminants causing human health problems (Haware and Pramod,2011), commonly found in places such mining sites, industrial wastes, vehicle emissions, lead-acid batteries, paints, treated woods, aging water supply infrastructures, microplastics floating in the world's oceans, agricultural fertilizers and pesticides (Harvey *et al.,* 2015). Roads which serve as major link among communities also served as a source of heavy metals environmental pollution source on soils (Bai *et al.,* 2009). Major heavy metal pollutants of the roadside environments are released from fuel burning, wear out of tyres, leakage of oils and corrosion of batteries and metallic parts such as radiators (Awoke *et al.*, 2018). Motor vehicle emissions are a major source of airborne contaminants including arsenic, cadmium, cobalt, nickel, lead, antimony, vanadium, zinc, platinum, palladium and rhodium (Maity *et al.*, 2016).

Rice (*Oryza sativa*) is one of the crops grown along roadsides in the savanna agro-ecological zone of Nigeria and the most common staple food for over 150 million people in Nigeria. The intake of heavy metal-contaminated cereal crops therefore poses a public health concerned as a risk to human health (Elbagermi *et al.*, 2012). Many findings on heavy metals in plants grown along various roadsides soils in Zaria have been reported (Lawal and Audu, 2011; Garba *et al.*, 2019; Nimyel and Namadi, 2020). This study aimed at assessing the levels of heavy metals bioaccumulation in soil and seeds of rice plants grown along Zaria-Kankara road.

MATERIALS AND METHODS

Study Site

The research was conducted at Barbashi (Latitude 11°21´N and Longitude7°38´E) Danja Local Government Area of Katsina state, Northwestern Nigeria (Figure 1).

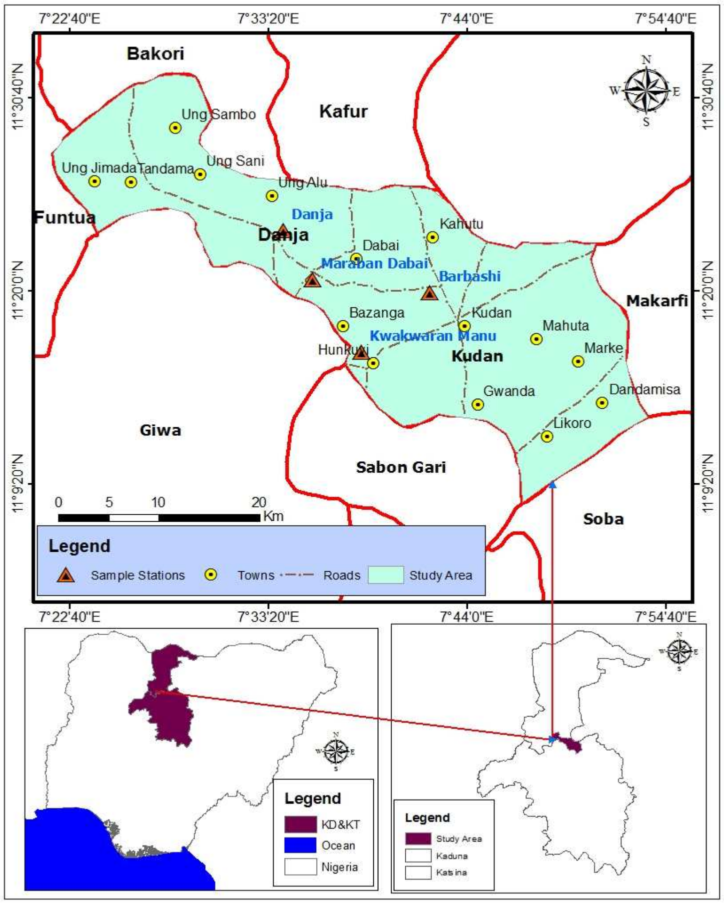

Figure1: Map of Study Area Showing Sample Location
Source:GIS and Remote Sensing Software Arc Map 10.1 Department of Geography ABU, Zaria

Sampling of Plants and Soil Materials
At the sampling location, rice seeds were collected from plants grown on soil at both sides of the road. On each side rice samples were taken at a distance interval of 5, 10, 20 and 40 meters away from the main road along Zaria-Kankara road.. Similarly, the soil was sampled in the same way. The control samples were taken at a distance of 60 meters from the road.

Preparations ofsamples
The seed samples were labeled accordingly and the soils were collected using soil augur at a depth of 10 cm into labeled polyethylene bags. The samples were transported to the laboratory of the Department of Botany, Ahmadu Bello University, Zaria. The soil samples were carefully sorted to eliminate debris, air dry, washed with running tap water and de-ionized water and oven dried at 70^{o}C till constant weight was obtained (Otitoju *et al,* 2014). The plant samples were grounded into a fine powder using pestle and mortar and passed through 250 μm sieve (Munson and Nelson, 1990). The plant samples were oven dried at 110^{o}C to constant weight. The resulting powder was packaged in a 250 cm^3 screw capped plastic jar andused for the analysis of the heavy metals.

Digestion of Soil Samples
The soil samples collected were digested using the method described by Ogunfowokan *et al.* (2009). About 1.0 g of each soil sample was digested in volumetric flask with 30 mL aqua-regia (HCl: HNO_3, 3:1) on a thermostat hot-plate set at 150 °C until dense white fumes appears. The volumetric flask with its content was removed from the hotplate and allowed to cool down and then filtered. The filtrate was transferred into 50 mL sample bottle and top up to the 50 mL mark with distilled water and then analysed using Atomic Absorption Spectrophotometery (A.A.S., Perkin Elmer) machine.

Digestion of Plant Samples
0.5 g of the seeds sample was weighed out into a beaker mixed with 20 cm^3 of concentrated sulphuric acid, perchloric acid and nitric acid in the ratio 1: 4: 40 by volume and left to stand overnight. Thereafter, the beaker was heated at 70°C for 40 min and then, the heat was increased to 120°C. The mixture turned black after a while (Lawal and Audu, 2011).

The digestion was terminated when the solution became clear and dense white fumes appeared. The digest was diluted with 20 cm^3 of distilled water and boiled for 15 min. This was then allowed to cool, transferred into 100 cm^3 volumetric flasks and diluted to the mark with distilled water. The sample solution was then filtered through a Whatman No 42 filter paper into a screw capped polyethylene bottle.

All samples of plants and soil were subjected to Atomic Absorption Spectrophotometer (A.A.S., Perkin Elmer) equipped with photomultiplier tube detector and hollow cathode lamps was used for the determination of heavy metal concentrations (Cd, Zn, Ni and Pb). The instrument setting and operational conditions were done in accordance with the manufacturers' specifications. Working standards were also prepared by further dilution of 1000 ppm stock solution of each of the metals and a calibration curve was constructed by plotting absorbance versus concentration. By interpolation, the concentrations of the metals in sample digests were determined.

Data Analyses

Data obtained were subjected to analysis of variance (ANOVA) with three replications using SAS (2012) version 9.0. Significant differences between the means were separated using Duncan's Multiple Range Test (DMRT) at ($P \leq 0.05$).

RESULTS

The result for heavy metals concentration in the soil along Zaria-Kankara road is presented in Table 1. The result indicated significant difference ($P \leq 0.05$) in the heavy metals concentration in the soils of the study area. The result showed that the levels of Zn decreased from 246.00 mg/kg at a distance of 5 m from the roadside to 120.00 mg/kg at a distance of 40 m from the roadside. 159.00 mg/kg at a distance of 60 m from the roadside was observed. Similar trend was found in relation to Manganese concentration which decreases from 107.80 mg/kg at 5 m distance to 102.30 mg/kg at 60 m distance from roadside. The concentration of Lead decreases from 380-312 mg/kg between 5 and 20 m distance from road side. However, Cadmium levels were higher at distance of 60 to 20 m from the roadside while lower concentrations the heavy metal were observed at distances between 5–10 m from the roadside. The concentrations of heavy metals in the soils of the locations was in the following order: Pb > Zn > Mn > Cd (Table 1).

Table 1: Heavy Metals Accumulation in Soil along Zaria–Kankara Road

Distance (m)	Zinc (mg/kg)	Lead (mg/kg)	Manganese (mg/kg)	Cadmium (mg/kg)
5	246.00^{a}	380.00^{a}	107.80^{a}	14.70^{a}
10	173.00^{c}	364.70^{a}	105.10^{a}	14.90^{a}
20	211.00^{b}	312.60^{b}	105.30^{a}	16.00^{a}
40	120.00^{d}	341.10^{ab}	102.30^{a}	15.80^{a}
60	159.00^{c}	334.90^{ab}	102.70^{a}	16.30^{a}
Mean	181.8	346.66	104.64	15.54
SE	6.40	13.96	5.32	1.29

NB: Means with the same superscript(s) down a column are not significantly different ($P \leq 0.05$)

The result for the heavy metals accumulation in rice seeds grown along Zaria-Kankara road is presented in Table 2. The result indicated significant difference ($P \leq 0.05$) in the levels of all the heavy metals (except Cd) in the rice seeds with increase in distance from the roadside. The levels of Zn decrease from 52.00 mg/kg to 32.00 mg/kg with increase in distance. The level of Pb is found to be lowest (11.50 mg/kg) at a distance of 60 m from the roadside. However, the levels of Mn is highest (11.40-11.70 mg/kg) at the distance of 40 and 60 m respectively

Table 2: Heavy Metals Accumulation (mg/kg) in Rice Seeds Grown along Zaria–Kankara Road

Distance (m)	Zinc (mg/kg)	Lead (mg/kg)	Manganese (mg/kg)	Cadmium (mg/kg)
5	52.00^{a}	37.40^{b}	7.80^{b}	2.10^{b}
10	46.70^{c}	48.80^{b}	6.60^{b}	4.10^{a}
20	45.00^{a}	53.60^{b}	2.30^{c}	3.90^{a}
40	44.00^{a}	74.10^{a}	11.70^{a}	3.50^{a}
60	32.00^{b}	11.50^{c}	11.10^{a}	4.30^{a}
Mean	35.94	45.08	7.90	3.58
SE	3.75	6.14	0.61	0.42

NB: Means with the same superscript(s) down a column are not significantly different ($P \leq 0.05$)

DISCUSSION

The levels of heavy metals such as Zn and Pb decrease with increase in distance from the roadsides. This may probably be attributed to their source (fuel combustion and corrosion of vehicle parts, as well as battery and engine oil leaks) as reported by Pulles *et al.*(2012). This finding is in agreement with the work reported by Krailertrattanachai *et al.* (2019) who stated that Pb and Zn concentrations significantly decreased with increasing distance away from the roadside in a study on distribution of trace metals in roadside soils in Thailand. However, Cd had its highest value at a distance far away from the roadside. This may be due to the deposition of atmospheric particulate matter enriched with Cd, and Mn into the roadside soil as reported by Adamiec *et al.* (2016). Higher concentration of Zn in soil at all the sampling sites was observed when compared with the limits recommended by Denneman Robberse (1990) and Olofinko *et al*. (2018). However, Fosu-Mensah *et al.* (2017) reported Zn level lower than the permissible limit by WHO (2011) due to the occurance of dry cells in municipal waste and the burning of the-wastes materials in the area. The study also, agreed with the findings of Ogundele *et al.*(2015) who reported Zn concentrations from soil (219.23 mg/kg) was higher than 50 mg/kg permissible limit WHO (1996).

The high concentration of Lead in soils observed in this study was higher than that reported by Ametepey *et al*. (2018) and is higher than WHO (2011) permissible value for soil Pb. The higher concentration at the main study sites may be due to high traffic volume which attested to the overall high level of contamination of these metals in roadside soils (Sulaiman *et al*, 2018). The Mn level observed in the soil was low compared with the permissible limit of 200 mg/kg for manganese in agricultural soils (WHO, 2011). This may be due to the soil type being sandy and/or with high pH. This agrees with the report by Jaradat *et el.*(2005), Ekmekyapar *et al.*(2012) and Onyedikachi *et al.*(2018) who reported low Mn in soil. The Cd levels observed in the soil samples were above the average 0.02mg/kg (Edori and Kpee, 2017) as recommended by WHO (1996). This may presumably be due to other human activity (application of fertilizers and agrochemicals) and soil weathering Distance and location had no significant effect on Cd levels.

The results revealed a significant variation in the levels of the elements distribution in rice seeds with distance. The levels of the heavy metals in the seeds of rice were higher than the permissible limits by WHO (2011). This finding is similar to the report from Adelasoye and Oyeyiola (2014) who reported that the concentration of heavy metals, Pd and Cd in raw mangoes (fruits) were beyond the permissible levels given by WHO (2011) for human consumption. The high level of these metals may be as a result of uptake of the metals from the soil

CONCLUSION

It was concluded that heavy metals in form of Zn, Pb and Cd accumulated in high concentration at the road sides is above the recommended llimits. There should be restrictions to the location of farmlands close to the road for the safety of the consumers.

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