Lead-cadmium accumulation in agricultural soils and health implications

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Abstract: The use of pesticides in farms has made agricultural soils often contaminated with heavy metals, excess of which the soils could pollute the environment and potentially damage human health through accumulation in the food chain. The geochemical compositions in agricultural soils from two commercial farms were analysed using ICP-MS. Trace elements are needed in minute quantities in soils but can be toxic to plants and humans with health implications at elevated rates. Soil samples from the study area were analysed and the result revealed that lead (Pb) and cadmium (Cd) concentrations in the study sites were within the FAO/WHO standard limits. The implications of elevated rates on crops and humans alike are highlighted in this paper.

Keywords: Pesticides, Lead, Cadmium. Agricultural soil, ICP-MS, Health

1. Introduction

The challenge of feeding the ever-increasing population and the preservation of the soil for generations unborn has become a global concern of the agricultural sector. The management of the agricultural soils so as to support plant growth is imperative. Trace elements and major elements are needed alike in agricultural soils for utmost plant growth. However, pollution of agricultural soils with lead and cadmium are serious threats to human health and food security [15]. They pose risks and hazards to both humans and the ecosystem through direct ingestion via the food chain (soil-plant-human or soil-plant-animal-human), via phytotoxicity, and reduction in land usability for agricultural production causing food insecurity, and land tenure problems [11]. Cadmium (Cd) and lead (Pb) have been listed as serious heavy metal pollutants with severe effects on the brain, kidneys, and cancer [4, 8, 14]. According to [1], adults take up to 10-15% of lead in food which may end up bounding to erythrocytes, and elimination is usually slow and mostly through urine. The symptoms of severe lead poisoning are headache, irritability, abdominal pain, and other symptoms related to the nervous system. [12] noted that lead (pb) has no beneficial properties for humans but a persistent toxic element. [16, 18, 19] also reported there's no known safe lead concentration in the blood, that behavioral difficulties, learning problems and decreased intelligence in children are associated to lead in blood at very low concentration of 3.5 µg/dL. Numerous studies indicate that even minimal exposure to Cadmium can result in harm to vital organs such as the kidneys, liver, skeletal system, and cardiovascular system, while also contributing to the deterioration of sight and hearing [3, 8, 9]. In addition to its potent teratogenic and mutagenic effects, Cadmium exhibits adverse impacts on human reproductive health at low doses, affecting both male and female reproduction as well as influencing

pregnancy outcomes [8, 10]. The aim of this paper is to underscore the concentration levels of these toxic metals in the agricultural soils of the two investigated farm sites.

2. Study Location

The study area falls within the two commercial farms of both Covenant and Landmark University in Ota and Omu-Aran respectively (Figure 1). Ota in Ogun Southwest Nigeria falls within the eastern Dahomey basin of southwestern Nigeria consisting of sedimentary rock sequence of Late Cretaceous to Early Tertiary [2]. On the other hand, Omu-Aran is within the Egbe-Isanlu schist belts emerging from Pan-African migmatite terrain consisting of Upper Proterozoic supracrustal rocks [13].

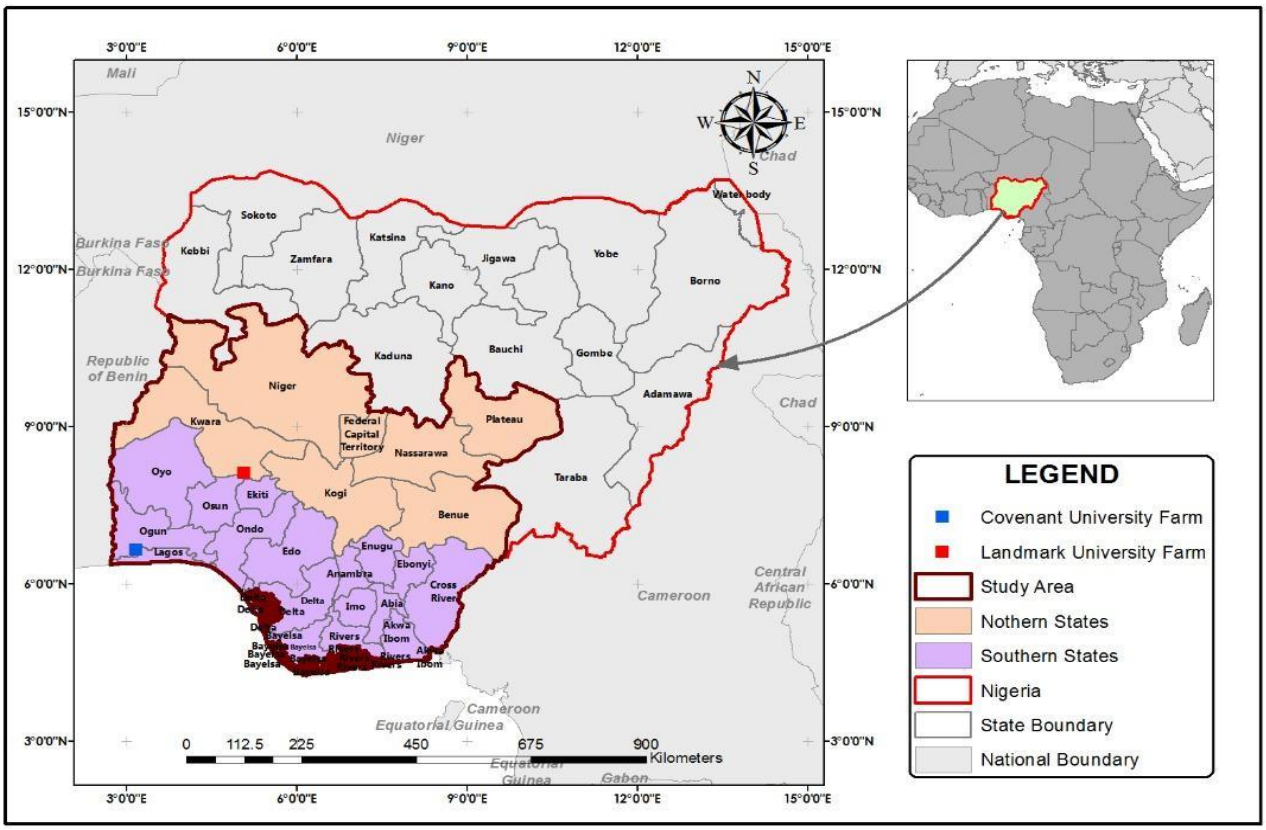

Figure 1: Map of Nigeria showing the study area.

3 Materials and Methods

Eight (8) soil samples from each farm location were collected from depth of 30 – 60 cm (topsoil)) at the farm sites. Soil samples were collected at 30.0 m interval with the aid of an Auger in each traverse line for the two farm sites. Samples were kept in an air tight sampling bags. A multi-acid elemental analysis of inductively coupled plasma mass spectrometry (ICPMS) was carried out on a 0.25 g split of each soil sample at the Bureau Veritas Laboratory Vancouver, Canada. The measurement detection limit (MDL) of 0.02 mg/kg was used for the two heavy metals that

is, cadmium (Cd) and lead (Pb) analysed. The analysis used STD OREAS25A and STD OREAS45E as standard reference materials. CUF represents Covenant University farm while, LUF represents Landmark University farm.

4. Results and Discussion

Table 1 shows the Cadmium concentration level range from 0.01 mg/kg to 0.04 mg/kg, with mean value of 0.0175 mg/kg in the Covenant University farm, and from 0.01 mg/kg to 0.3 mg/kg, with mean value of 0.1188 mg/kg in Landmark University farm. The maximum permissible limit of cadmium in soil is 1.4 mg/kg according to [5]. The minimum lead (Pb) concentration in the soil samples is 16.91 mg/kg, while the maximum value is 28.75 mg/kg, with mean value of 23.89 mg/kg at the Covenant University farm. Also, for the Landmark University farm, the lead (Pb) concentration ranges from 15.58 mg/kg to 49.85 m/kg with mean value of 25.0038 mg/kg. Table 3 presents the descriptive statistics of the lead (Pb) and cadmium (Cd) constituents of the soil samples from both farms under investigation. The mean values of cadmium concentration level in the two farms are lower than the maximum allowable limits of 0.8 mg/kg for cadmium and 50 mg/kg for lead in soils set by the Swiss Federal Office of Environmental, Forest and Landscape [6]. Figure 2 shows the box chart plots of cadmium (Cd) and lead (Pb) concentration levels in the two farm sites. It reveals that there is no outlier in the cadmium concentrations levels from the two farms, and the mean value is slightly higher than the median line. However, there are few outliers in the lead (Pb) concentration levels which are very much higher than the median line.

The presence of lead and cadmium in the soil samples is likely attributed to the application of agrochemicals, specifically fertilizers, aimed at enhancing the soil's crop yield potential. It is noteworthy that many fertilizers contain concentrations ranging from 0.0005 to 0.5 mg/kg of cadmium and 0.0008 to 0.93 mg/kg of lead [17]. Consequently, prolonged fertilizer use may lead to the buildup of lead and cadmium in the soil, potentially surpassing permissible limits. Inhaling cadmium particles poses a significant threat to life.

Table 1: Cadmium (Cd) concentrations in both farm sites

Unit	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
MDL	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Sample No	1	2	3	4	5	6	7	8
CUF	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.04
LUF	0.01	0.01	0.01	0.01	0.3	0.3	0.12	0.19

Table 2: Lead (Pb) concentrations in both farm sites

Unit	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
MDL	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Sample No	1	2	3	4	5	6	7	8
CUF	24.04	28.75	25.72	23.81	23.2	22.36	16.91	26.33

LUF	18.46	15.58	19.37	19.73	19.22	21.33	49.85	36.49

Table 3: Descriptive statistics

Unit	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
CUF Cd	8	0.03	0.01	0.04	0.0175	0.0389	0.00
CUF Pb	8	11.84	16.91	28.75	23.8900	3.47416	12.070
LUF Cd	8	0.29	0.1	0.30	0.1188	0.12988	0.017
LUF Pb	8	34.27	15.58	49.85	25.0038	11.87673	141.057

5. Conclusion

The concentration of lead and cadmium was evaluated in the soils from Covenant University and Landmark University farms. The concentration levels are adjudged to be within the permissible values set up by Swiss Federal Office of Environmental, Forest and Landscape and FAO/WHO. The fertilizers within the farm soils is suspected to be the primary source of the cadmium and lead concentrations. Excessive applications of fertilizer in these farms should be discouraged, because lead and cadmium play an etiological role in the carcinogenesis. The excessive presence of these metals in soils will also cause excessive uptake by crops, animals and thus affects food quality and safety. This contamination of the food chain is inimical to human health, posing high health risk or death.

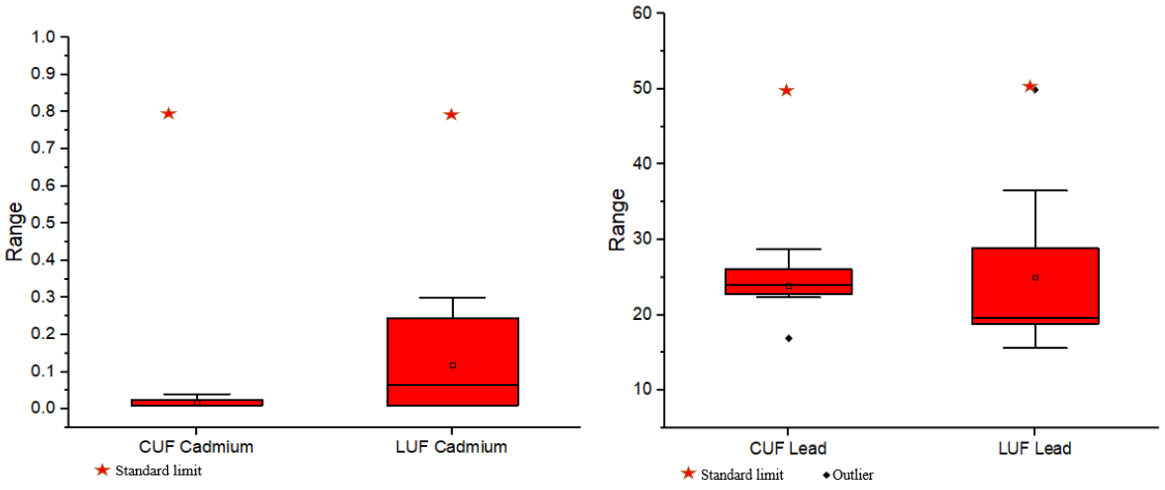

Figure 2: The box chart plots of cadmium-lead concentration levels in both farm sites.

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