

## ASSESSMENT OF HEAVY METALS CONCENTRATION IN SWAMPY AGRICULTURAL SOIL OF NASARAWA WEST, NIGERIA

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### ABSTRACT

**Aim:** This research was carried out to investigate the concentration of heavy metals in swampy agricultural soil of Nasarawa west, Nigeria.

**Study design:** To compare the swampy soil heavy metal concentrations with regulatory standard or allowable values by the World Health Organization (WHO) and other National and International standards.

**Place and duration of study:** Department of Physics, Nasarawa State University Keffi between January, 2018 and October, 2018.

**Methodology:** Ten soil samples from each of the five sampling locations (Karu, Keffi, Kokona, Nasarawa, and Toto) were randomly collected. A total of fifty (50) soil samples were collected within the period of one week. The collected samples were stored in polyethylene bag and labeled properly and taken to the Center for Energy Research and Development (CERD) at Obafemi Awolowo University Ile-Ife, Osun State, Nigeria. At CERD, elemental analysis was carried out for the fifty sample using X-ray fluorescent spectrometry analyzer.

**Result:** The range of mean concentration of Zn, As, Cd, Pb, Fe, Ni, and Cu (in KR, KF, KK, NS, and TT locations) are 243.60- 502.80mg/kg, 7.40- 37.00mg/kg, 260.90- 524.50mg/kg, 167.80- 336.60mg/kg, 20222.90- 58170.50mg/kg, 342.20- 555.10mg/kg, and 266.60- 515.90mg/kg respectively. The average mean of As (20.33mg/kg), Pb (289.54mg/kg), Cd (369.82mg/kg), Zn (375.96mg/kg), Fe (43989.96mg/kg), Ni (447.32mg/kg), and Cu (407.26mg/kg) in all the sample locations are found to be higher than the WHO allowable concentration limits of As (20mg/kg), Pb (100mg/kg), Cd (3mg/kg), Zn (300mg/kg), Fe (n.a), Ni (50mg/kg), and Cu (100mg/kg) respectively. There is high concentration Zn, As, Cd, Pb, Fe, Ni, and Cu in the swampy soil.

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**Conclusion:** The results indicate that the swampy agricultural soils of Nasarawa west (Karu, Keffi, Kokona, Nasarawa, and Toto) are contaminated with toxic metals (Zn, As, Cd, Pb, Fe, Ni, and Cu). It was observed that the crops grown on these swampy soils are mostly cereal plants: rice (*Oryza sativa*) which can take up this toxic metal.

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### INTRODUCTION

Heavy metals are common environmental pollutants and are released into soils from natural or anthropogenic sources. The main natural sources of metals in soils are weathering of parent material and soil erosion [1,2]. Mining, manufacturing, and the use of synthetic products (e.g. pesticides, paints, batteries, industrial waste, and land application of industrial or domestic sludge) can result in heavy metal contamination of urban and agricultural soils. Heavy metals released into the soil from natural sources are rarely at toxic levels. Potentially contaminated soils may occur at old landfill sites (particularly those that accepted industrial wastes), old orchards that used insecticides containing arsenic as an active ingredient, fields that had past applications of waste water or municipal sludge, areas in or around mining waste piles and tailings, industrial areas where chemicals may have been dumped on the ground, or in areas downwind from industrial sites [4, 14].

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The presence of toxic metals in soil can severely inhibit the biodegradation of organic contaminants [6, 13]. Heavy metal contamination of soil may pose risks and hazards to humans and the ecosystem through: direct ingestion or contact with contaminated soil, the food chain (soil-plant-human or soil-plant-animal-human), drinking of contaminated ground water, reduction in food quality (safety and marketability) via phytotoxicity, reduction in land usability for agricultural production causing food insecurity, and land tenure problems [7,8].

Excess heavy metal accumulation in soils is toxic to humans and other animals. Exposure to heavy metals is normally chronic (exposure over a longer period of time), due to food chain transfer. Acute (immediate) poisoning from heavy metals is rare through ingestion or dermal contact, but is possible [2, 13].

These heavy metals may adversely affect soil ecology, agricultural production or product quality, and ground water quality, and will ultimately harm to health of living organism by food chain. These effects are closely related to the biological availability of heavy metals, which in turn are controlled by the metal ion speciation in the soil [15]. Therefore, the determination of free metal ion concentrations in soil solution becomes important. The free metal ion concentration not only depends on the total metal content in soils, but also on the metal species that exist in the soil. In addition, some environmental conditions (e.g., pH, concentration of complexing ligands in solution, and the soil colloid) [3, 6, 8].

## MATERIALS AND METHOD

This research work centered on Nasarawa West which consist of five (05) Local Government Areas, Karu, Keffi, Kokona, Nasarawa and Toto. In Nasarawa West, soils are found along the flood plains which are always swampy in nature due to availability of water all the year round. The forest soils are rich in humus and late rite soils. They are found in most part of the state and very good for crop production. Nasarawa West has arable land for commercial farming, fishery development, wild life and forestry conservation. Agriculture therefore, is the mainstay of the economy because majority of the populace are involved in subsistence farming.

Soil samples were collected from swampy agricultural soil in five major town of Nasarawa west namely Karu (KR), Keffi (KF), Kokona (KK), Nasarawa (NS) and Toto (TT). One Swampy agricultural soil farm land was identified at random from each of the location and 10 soil samples was taken at about 5 – 10m distances between the sample points from each sample location. The sampling sites are shown in (Fig. 1).

The soil surface was cleared with a hand trowel to a depth of approximately 10 – 15cm before the samples were collected using a plastic spoon at 10 – 15cm depth. After every collection, the hand trowel and spoon were washed with soap and rinsed with distilled water to avoid sample contamination [12]. The collected samples were air dried under ambient temperature, grinded, using agate pestle and mortar, and allowed to pass through 2.0mm sieved to remove stones and pebbles, packaged properly in a plastic container and labeled with code numbers for easy identification. The <2 mm fraction of the soil was used for all soil analyses.

Ten soil samples from each sampling location were randomly collected from each of the sample location. A total of fifty (50) soil samples were collected within the period of one week.

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The collected samples were stored in polyethylene bag and labeled properly and taken to the Center for Energy Research and Development (CERD) at ObafemiAwolowo University Ile- Ife Osun State, Nigeria. At CERD, elemental analysis was carried out for the fifty sample using X-ray fluorescent spectrometry analyzer.

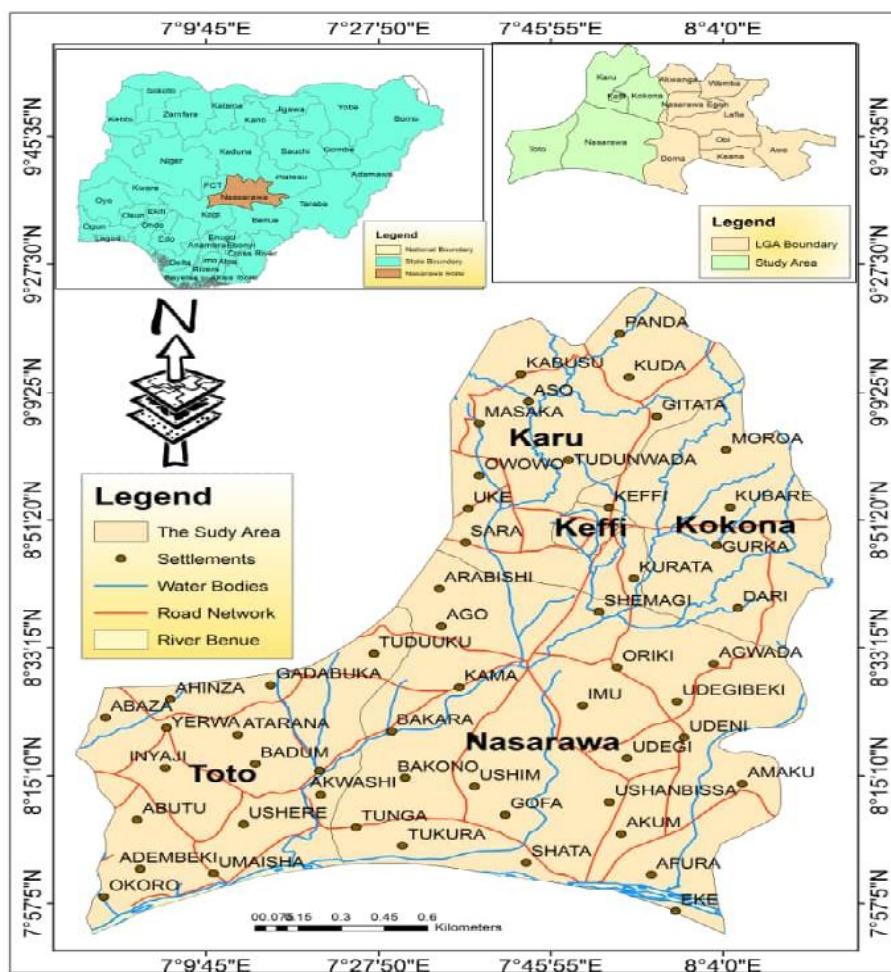


Figure 1. Map of the study area

Quality control measure was taken to ensure reliability of results. Samples were handled carefully to avoid contamination. Recovery test was carried out on the XRF machine by spiking analyzses.

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## RESULT AND DISCUSSION

Soil is a major sink for heavy metals released into the environment by industrial and human activities. Nonetheless, heavy metals above certain limits exhibit adverse ecological effects and are toxic to plants, animals and humans at large [9, 10, 11]. Heavy metals distribution: Zinc, Arsenic, Cadmium, Lead, Iron, Nickel, and Copper in swampy agricultural soil of Nasarawa west was analyzed and presented in Table 1. Figures 2- 6 shows the concentration of element in all the ten samples collected from each sample location and the WHO standard limits. The results indicates that the level of heavy metals in swampy agricultural soil of Nasarawa west are above the WHO and some other countries allowable limits.

Table 1. Mean Concentration of Elements in Swampy Agricultural Soils of Nasarawa west.

Location	Latitude	Longitude	Zn (mg/kg)	As (mg/kg)	Cd (mg/kg)	Pb (mg/kg)	Fe (mg/kg)	Ni (mg/kg)	Cu (mg/kg)
KR	8053158.906''N	7050146.444''E	339.1	37	331	336.6	46293.6	342.2	486.6
KF	8052116.506''N	7052122.801''E	367.6	23.625	260.9	323.89	48766.9	525	515.9
KK	8050122.62''N	7058180.33''E	502.8	16.88	524.5	328.33	58170.5	462.1	314.1
NS	8040126.084''N	7048135.844''E	243.6	16.75	387.3	167.8	20222.9	352.2	266.6
TT	803011.566''N	7031119.116''E	426.7	7.4	345.4	291.1	46495.9	555.1	453.1
Average (Nasarawa west)			375.96	20.33	369.82	289.54	43989.96	447.32	407.26

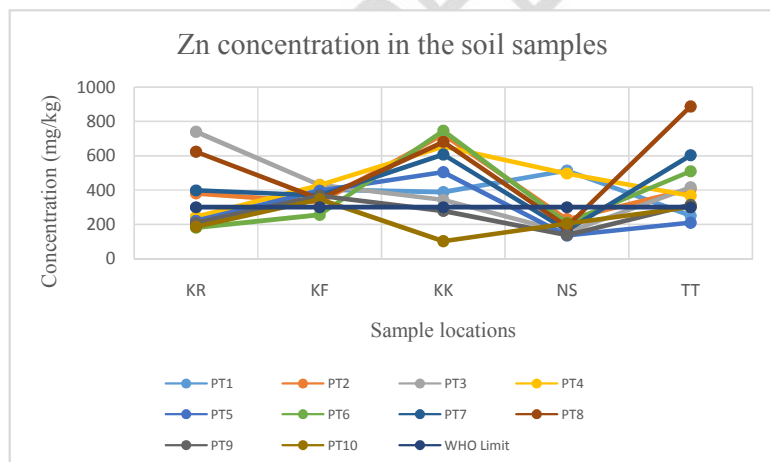


Figure 2. Concentration of Zinc in swampy agricultural soil of Nasarawa west.

### NOTE

Zinc was observed in the swampy soil samples with values ranging between 207-740mg/kg, 255- 230mg/kg, 103- 745mg/kg, 135- 514mg/kg, and 210- 887mg/kg

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for Karu (KR), Keffi (KF), Kokona (KK), Nasarawa (NS) and Toto (TT) L.G.A respectively (Table 2). The values recorded for all the swampy soil sample from the study areas exceed the 60- 300 mg/kg range accepted by WHO. Comparing the average concentration of Zn for all the 50 soil sample from Nasarawa west (375.96mg/kg) with WHO limit (60- 300mg/kg), it was found that the concentration of Zn exceed the permissible limit set by WHO and can cause health risk in humans and plants grown on the areas. High concentration values of zinc may be due to natural occurrence of zinc in soil with about 70 mg/kg in crustal rocks

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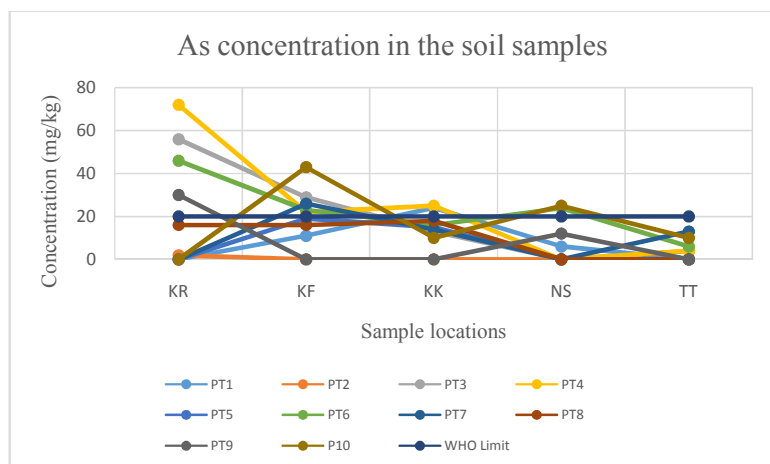


Figure 3. Concentration of Arsenic in swampy agricultural soil of Nasarawa west.

Arsenic detected in the soil sample from Karu (KR), Keffi (KF), Kokona (KK), Nasarawa (NS), and Toto (TT) L.G.A has concentration range of 2- 72mg/kg, 11- 43mg/kg, 10- 25mg/kg, 6- 25mg/kg and 4- 13mg/kg respectively. The average concentration of As in all the 50 samples analyzed for Nasarawa west is 20.33mg/kg and was found to be approximately equal to the WHO allowable limit of 20mg/kg. As is therefore within the permissible limit allowed by the WHO and may not cause harm to the inhabitant of that area.

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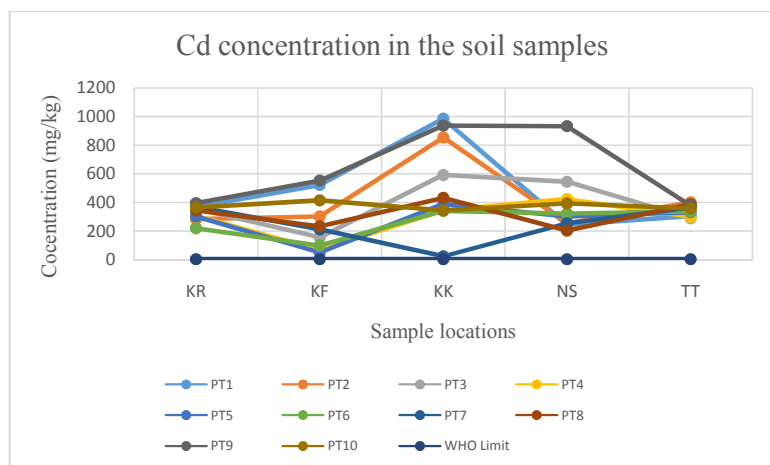


Figure 4. Concentration of Cadmium in swampy agricultural soil of Nasarawa west.

Cadmium was found in the sample with values ranging between 220- 395mg/kg, 68- 553mg/kg, 23- 985mg/kg, 204- 933mg/kg, and 289- 400mg/kg for Karu (KR), Keffi (KF), Kokona (KK), Nasarawa (NS), and Toto (TT) respectively. The overall average of Cadmium in the samples is 369.82mg/kg which is These values were found to be far above the WHO limit of 3mg/kg. The swampy soils in the area is highly contaminated with cadmium and can significantly affect the health of the humans, animals and plant.

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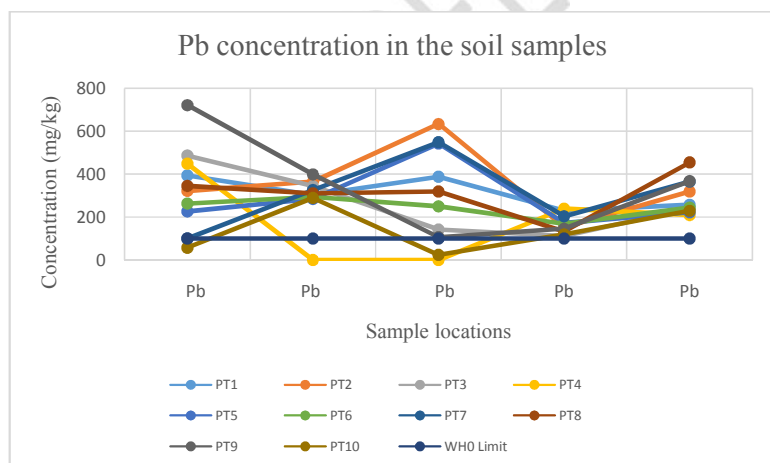


Figure 5. Concentration of Lead in swampy agricultural soil of Nasarawa west.

The determined concentration of Pb in the swampy soil samples showed a range of 57- 487mg/kg, 385- 399mg/kg, 24- 634mg/kg, 112- 239mg/kg, and 210- 455mg/kg for Karu (KR), Keffi (KF), Kokona (KK), Nasarawa (NS), and Toto (TT) respectively. The overall average of Pb concentration in the samples is 289.54mg/kg which is Pb was found to be higher than the

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WHO limit of 100mg/kg. The samples are therefore contaminated with Pb with can cause adverse health effect in humans.

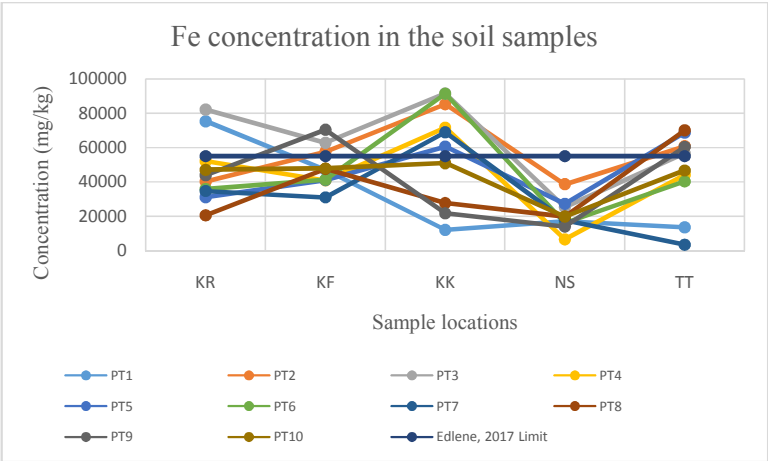


Figure 6.Concentration of Iron in swampy agricultural soil of Nasarawa west.

Iron (Fe) was observed to be the most abundant metal in the swampy soil of Nasarawa west with values between 31119- 82106mg/kg, 30991- 70441mg/kg, 12117- 91528mg/kg, 6577- 38604mg/kg, and 3392- 70086mg/kg for Karu (KR), Keffi (KF), Kokona (KK), Nasarawa (NS), and Toto (TT) respectively. The overall average of Fe concentration in all the samples is 43989.96mg/kg which is [These values were found to be above the FEPA guideline of 400mg/kg. The swampy agricultural soil is contaminated with iron (Fe) which is pollution level is excessive.

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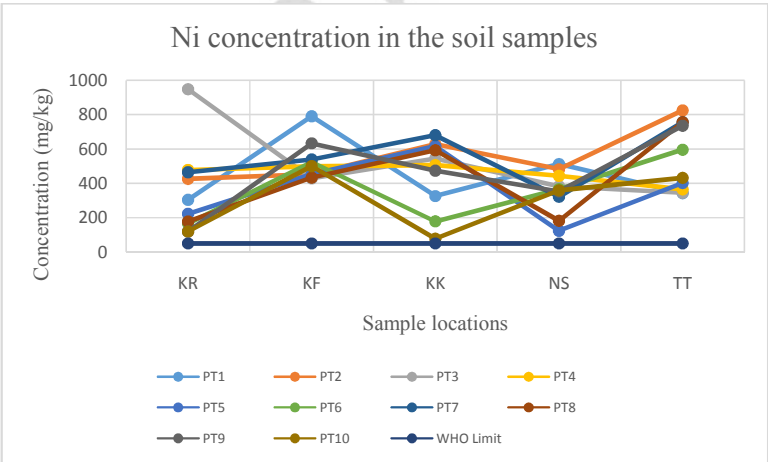


Figure 7.Concentration of Nickel in swampy agricultural soil of Nasarawa west.

Nickel detected in the soil sample from Karu (KR), Keffi (KF), Kokona (KK), Nasarawa (NS), and Toto (TT) L.G.A has concentration range of 119- 948mg/kg, 429- 790mg/kg, 78- 680mg/kg, 123- 512mg/kg and 342- 756mg/kg respectively. The average concentration of Ni in all the 50 samples analyzed for Nasarawa west is 447.32mg/kg and was These values were found to be above the WHO allowable limit of 5- 50mg/kg. Ni is therefore found to be above the permissible limit and may cause harm to the inhabitant of that area.

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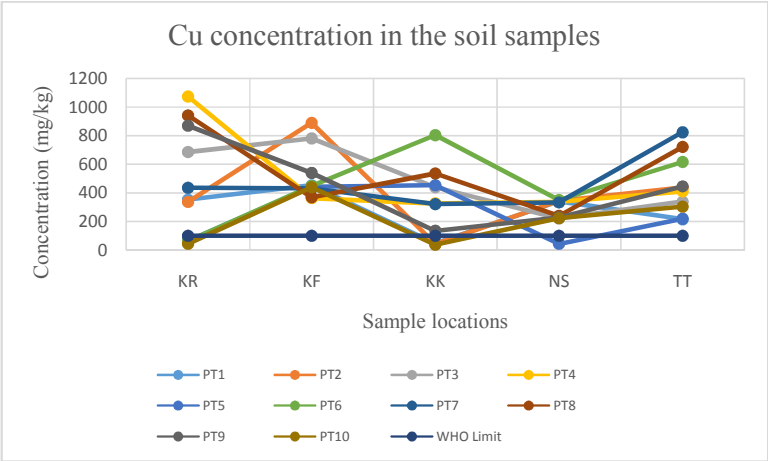


Figure 8. Concentration of Copper in swampy agricultural soil of Nasarawa west.

NOTE

Copper was found in the sample with values ranging between 62- 1074mg/kg, 364- 890mg/kg, 38- 804mg/kg, 44- 350mg/kg, and 215- 824mg/kg for Karu (KR), Keffi (KF), Kokona (KK), Nasarawa (NS), and Toto (TT) respectively. The overall average of Copper in the samples is 369.82mg/kg which is These values were found to be far above the WHO limit of 100mg/kg. The swampy soils in the area is contaminated with copper and can significantly affect the health of the humans, animals and plant in the area.

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Table 2. Maximum allowable limit of heavy metals concentrations in soil for different countries [16].

Countries	As mg/kg	Pb mg/kg	Cd mg/kg	Zn mg/kg	Fe mg/kg	Ni mg/kg	Cu mg/kg
Germany	50	70.0	1.0	150	Na	50.0	40
UK	32	70- 450	1.4	200	Na	130	63
Australia	20	300	3	200	Na	60	100
Canada	20	200	3	500	Na	100	150
China	30	80	0.5	250	Na	50	100
FAO/ WHO Guidelines	20	100	3	60- 300	Na	5- 50	100
EU Guidelines	n.a	300	3	300	Na	75	140
U.S. EPA	75	420	85	7500	Na	75	4300
U.S. Standard	Na	300	400	200- 3000	Na	Na	80- 200
FEPA Guidelines	Na	1.6		300- 400	400	Na	70- 80
<b>Present Study</b>	<b>20.33</b>	<b>289.54</b>	<b>369.82</b>	<b>375.96</b>	<b>43989.96</b>	<b>447.32</b>	<b>407.26</b>

Note: na = Not available

## CONCLUSION

The heavy metal contamination levels of swampy agricultural soil of Nasarawa west were analyzed and determined. Results indicates that the swampy soils of Nasarawa west contained considerable high levels of heavy metals (Zn, As, Cd, Pb, Fe, Ni, and Cu). The results indicates that the swampy agricultural soils of Nasarawa west (Karu, Keffi, Kokona, Nasarawa, and Toto) are contaminated with toxic metals. It was observe that the crops grown on these swampy soils are mostly cereal plants: rice (*Oryza sativa*). Fertilizer application and use of waste as manures to yield more farm produce has been the practice in the areas. Food crops grown in these areas can take up these toxic heavy metals which can adversely affect the health of plants, animals and humans. In addition, it was discovered that the consumption of vegetables grown along the drain, may in some instances constitute possible health hazards to humans.

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