STUDY ON HEAVY METALS CONCENTRATION IN IRRIGATED SOIL SAMPLES OF SOME SELECTED LOCATIONS ALONG RIVER KADUNA, NIGERIA

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ABSTRACT

The use of dumpsites for irrigation farming is a common practice in urban and sub-urban areas in Nigeria because of the fact that decayed and composted wastes enhance soil fertility. These wastes often contain heavy metals in various forms and at different contamination levels. This study was conducted to ascertain the level of contamination of heavy metals in irrigation soil. Thirty composite soil samples (0-30cm depth) representing irrigation soils in Karji, Gamji resort, Stadium-under the bridge, Tudunwada and Kudandan were sampled during November to April 2015/2016 (pick irrigation period) and heavy metals such as Chromium (Cr), Cadmium (Cd), Lead (Pb), Mercury (Hg) and zinc (Zn) were determined using Atomic Absorption Spectrophotometer, after digestion by nitric acid procedure. The heavy metal concentration in the soil ranged from: Cadmium, 17.89±3.13 to 31.75±1.27; Chromium, 37.32±12.32 to 88.14±4.34; Mercury, 0.01±0.00 to 0.32±0.50; Lead, 46.00±12.18 to 99.45±33.67 and Zinc, 26.34± 6.48 to 98.53±24.98 mg/kg. The concentrations of Cadmium and Lead were above standard limit set by E.U and DPR therefore advocating a health risk to the consumers of produce from these locations since plants absorbs heavy metals from soils through the root. The significant variations observe in concentration of heavy metals from one location of study to another was traced to different levels of pollution, caused by different degree of industrial and domestic waste dumps and other waste deposits on the soil.

Key words: Irrigation, Heavy metals, pH, Soil pollution, DPR and EU standards

1. INTRODUCTION

One of the identified greatest challenges facing the production of food through irrigation today is the contamination of water and soil (Hong *et al*., 2014). Soil being the main part of terrestrial ecosystem is a habitat for a great number of organisms, but at the same time, it is the most endangered component of our environment, open to effluents from a variety of pollutants arising from human activities (Djingova and Kuleff, 2000; Morton-Berme, 2002). Heavy meals enter into the environment from both natural and anthropogenic sources, they contaminate food source and accumulate in both agriculture products and seafood through water, air and soil pollution (Lin, 2004). Addition of heavy metals to soil may affect microbial proliferation and enzymatic activities, possibly leading to a decrease in the rates of the biochemical process in the soil environment. Worldwide increasing level of industrialization and urbanization has lead to environmental pollution with heavy metals (Filazi, 2003). Unlike organic contaminants which are oxidized to carbon four-oxide by microbial action, most metals do not undergo microbial or chemical degradation and their total concentration in soils persists for a long time after their introduction (Kirpichtchikova *et al*., 2006). The presence of heavy metals in the environment beyond acceptable limits calls for concern because of their deleterious effects (Caylak and Tokar, 2012). Long-term use of contaminated water for the irrigation of leafy and other vegetables, has resulted in the accumulation of heavy metals in soils and their transfer to the various crops under cultivation, with levels of contamination that exceed the regulatory maximum permissible limits (Mohsen, 2008). Vegetables cultivated in soils polluted with toxic heavy metals take up such metals and accumulate them in their edible and non-edible parts in quantities high enough to cause clinical problems both to animals and human beings consuming these metal-rich plants as there is no good mechanism for their elimination from the human body (Bhuiyan *et al*., 2011).

However, irrespective of the sources of these heavy metals in soils, their accumulation can degrade soil quality, reduce crop yield and the quality of agricultural products, and thus negatively impact the health of human, animals, and the ecosystem (Nagajyoti, 2010). Thus, it is important to study the level of heavy metal contamination in soils.

2. METHODOLOGY

2.1 Study area

This study covered five locations namely: Karji, Gamji, Stadium, T/wada and kudandan. The locations fall within three local government areas of Kaduna state which are; Kaduna- south, Kaduna north, and Chukun Local government area. The study area is explicit in figure 1.

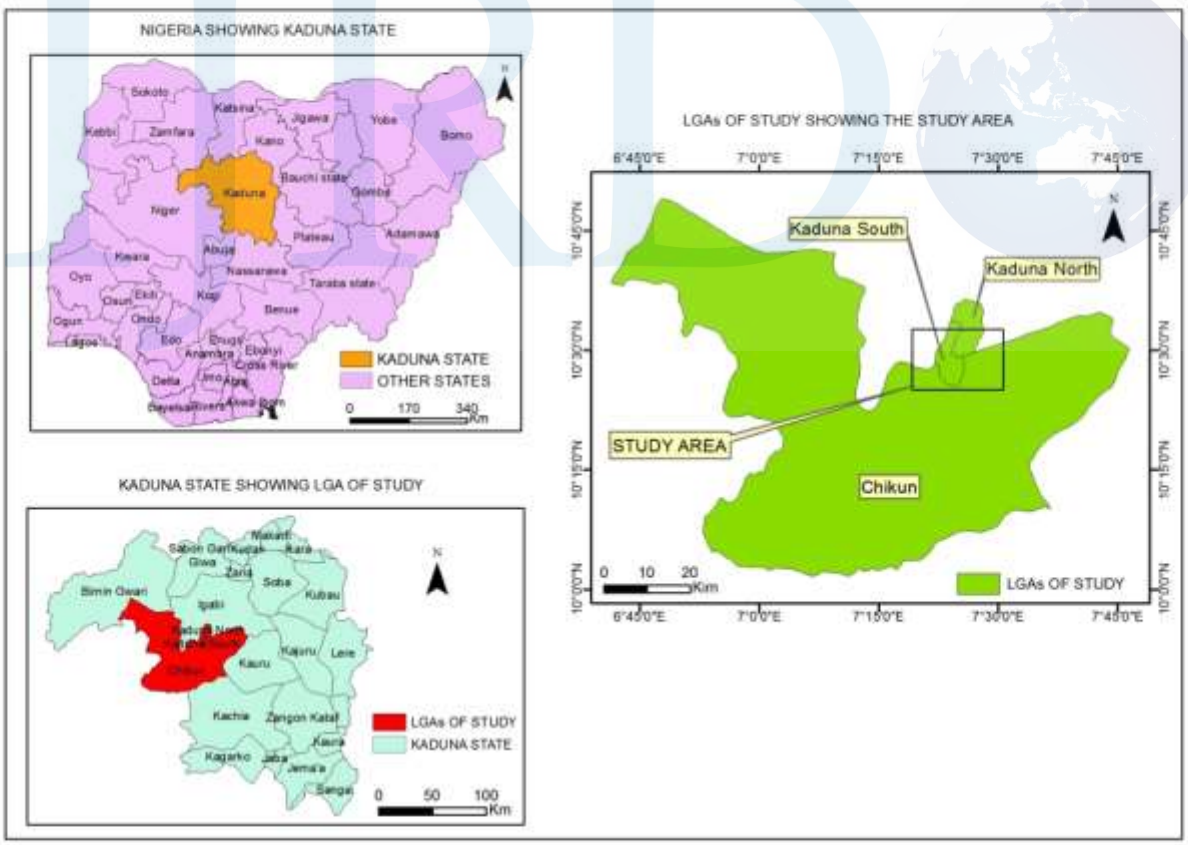

Figure 1: map of the study area

2.2 Soil sampling

Soil samples were collected from five locations namely; Tudunwa, Kudandan, Stadium-under bridge, Gamji-resort and Karji along river Kaduna in Kaduna metropolis at a depth of 0-30cm. The sites were a commercial vegetable farms and they are considered one of the most important site to supply vegetable markets within the town and beyond. 30 soil samples were randomly collected during November, 2015 to April, 2016 (months of peak irrigation activities). The soil samples were placed in polythene bags, ensuring that the natural soil moisture content was preserved and taken to the laboratory for analysis.

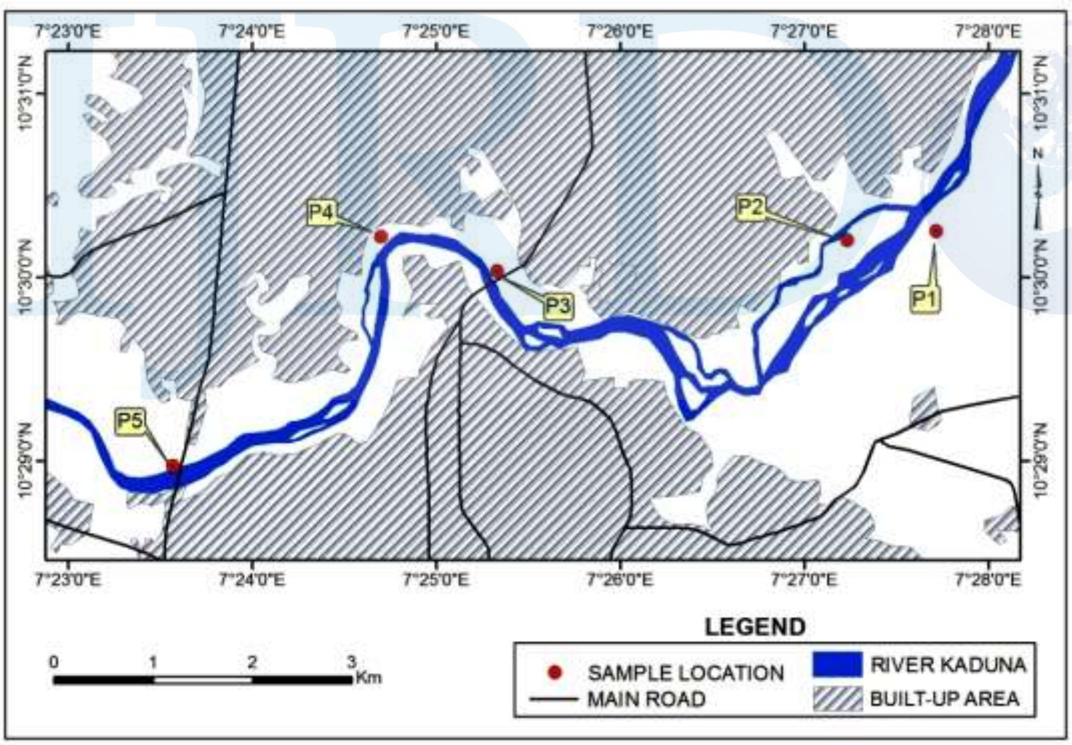

Figure 2: map showing the sampling locations

2.3 Preparation of the Soil Samples

In the laboratory, the soil samples were spread on glass plates and then dried in an oven at 100°C for 15minute. After drying, the non-decomposed vegetal remains, foreign materials and gravel were manually removed from the soil and larger earth clods were smashed as much as possible. The soil samples were then grounded using a mortar and pestle and passed through 0-5cm sieve. All metallic determination from soil samples was based on this fine particles obtained.

2.4 Determination of soil pH

The pH of the soil sample was determined with a pH meter, (3305 Jenway model.) according to the method of Joel and Amajuoyi (2009). 50ml beaker was half-filled with the soil samples. Some distilled water was added to just sufficient depth to allow immersion of the electrode. Thereafter, the mixture was stirred for a few minutes. The suspension was then allowed to stand for further 15 minutes, after which the pH electrode was immersed into the mixture and waited for reading to stabilize. The pH of the sample solutions were determined and recorded for each sample.

2.5 Heavy metals analysis

The soil samples were digested using a method adopted from Joel and Amajuoyi (2009). A measured quantity of the samples were transferred into a Kjeldahl flask; 20ml of concentrated nitric acid (HNO3) was added and the sample pre-digested by heating gently for 20mins. More acid was thereafter added and digestion was continued for 30-40mins. Digestion was stopped when a clear digest was obtained. The flask was cooled and the content transferred into a 50ml volumetric flask and made to the mark with distilled water. The resulting solution was analyzed for heavy metals using the Atomic Absorption Spectrophotometer (Wind light ICK 300 model).

2.6 Statistical Analysis

The data obtained from this study were statistically analyzed using Statistical Package for Social Scientist (SPSS) and Microsoft excel. All the statistical analysis was considered significant at the 0.05 level.

3. RESULTS

The Heavy metals analyzed were; Cadmium, Chromium, Mercury, Lead and Zinc. The mean concentration levels of these heavy metals were presented in the following ranges: Cadmium ranged from 17.89±3.13 to 31.75±1.27; Chromium 37.32±12.32 to 88.14±4.34; Mercury 0.01±0.00 to 0.32±0.50; Lead 46.00±12.18 to 99.45±33.67; Zinc 26.34± 6.48 to 98.53±24.98 mg/kg and the soil pH ranged from 6.18±0.56 to 6.99±0.57 respectively. See Table 1

Table 1: Heavy metals concentrations (mg/kg) in the irrigated soils compared to limited standards

Locations/metals	Cd	Cr	Hg	Pb	Zn	pH
P1 (Karji)	17.89±3.13[a]	37.32±12.32[a]	0.02±0.01a	46.00±12.18[a]	98.53±24.98[c]	6.78±0.57[a]
P2 (Gamji)	19.95±3.15[a]	41.15±2.79[a]	0.01±0.00a	51.31±13.34[a]	26.34±6.48[a]	6.49±0.83[a]
P3 (Stadium)	28.45±3.66[b]	51.42±8.23[b]	0.32±0.50b	46.69±5.96[a]	47.88±4.46[b]	6.67±1.02[a]
P4 (T/wada)	31.75±1.27[b]	88.14±4.34[c]	0.02±0.01a	99.54±33.67[b]	76.55±4.08[c]	6.18±0.56[a]
P5 (Kudenda)	29.64±2.54[b]	81.26±16.65[c]	0.01±0.00a	96.12±7.76[b]	82.09±2.25[c]	6.99±0.57[a]
DPR limit	08.00	100	3.00	85.00	140	6.5
E.U limit	3.00	180	300	200	300	6.5

**Values with same superscript along the vertical column are not significantly different at P=0.05

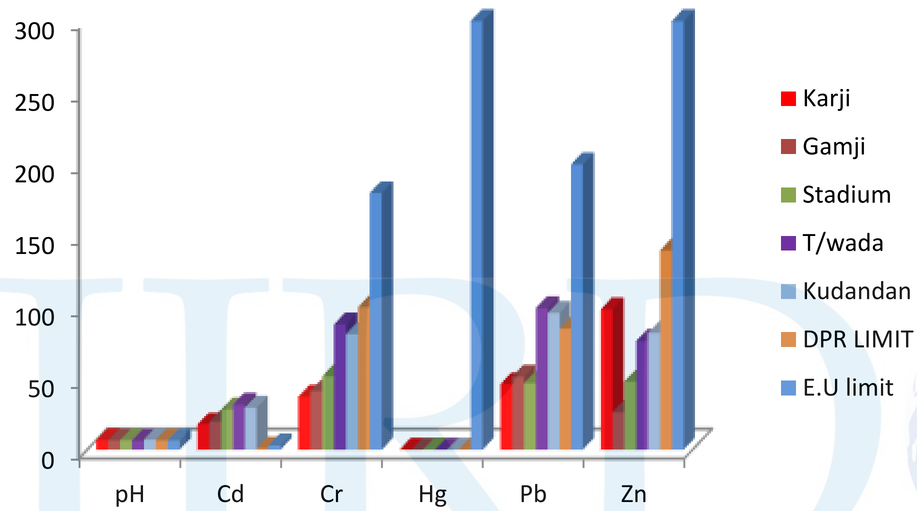

Figure 3: variation in metal concentration amongst the locations studied

3.1 Cadmium (Cd): The highest mean value of Cd was 31.75±1.27mg/kg recorded at T/wada and the lowest was 17.89±3.13mg/kg recorded at Karji as seen in Table 1. There were no significant variation between the concentration of cadmium in P3, P4 and P5 however, P1 and P2 varied significantly with P3, P4 and P5 (Table 1).

3.2 Chromium (Cr): P4 had the highest concentration of Cr 88.14±4.34mg/kg and the lowest concentration was 37.32±12.32mg/kg observed at P1 (figure1). The concentration of chromium at P1 and P2 varied with those of P3, P4 and P5.

3.3 Mercury (Hg): The concentrations of mercury were fairly uniform in all the locations, however the maximum concentration (0.32±0.50) was recorded at P3 and the lowest value was observed at P2 and P5 (0.01±0.00) respectively. Table1 revealed that only P3 showed significant variation; the other locations do not vary significantly (P<0.05).

3.4 Lead (Pb): Lead showed the highest mean concentration at P4 (99.54±33.67) and the lowest at P1 (46.00±12.18). Table1 revealed that P1, P2 and P3 differ significantly with P4 and P5.

3.5 Zinc (Zn): figure1 revealed that the highest mean concentration of Zn was in P1 (98.53±24.98) and the lowest was 26.34±6.48, observed in P2. However, P1, P4 and P5 differed significantly with P2 and P3.

3.6 pH (concentration of hydrogen ions): The highest value of pH was recorded in P5 (6.99±0.57) and the lowest was 6.18±0.56 recorded in P1 (figure 2). The comparative analysis as seen in Table 2 showed that the pH of the soil did no vary significant at all the locations studied.

4. Discussion

The result obtained from this study revealed that irrigation farms along the bank of river Kaduna are contaminated with heavy metals. The levels of contamination may not only indicate the level of current contamination but can portray a history of activities over a long period of time since soil is a sink for these contaminants. The variation in concentration of the heavy metal amongst the locations studied could be traced to different levels of pollution caused by varying degree of industrial waste dumps and other waste deposit. Aliyu *et al*., (2015) states that Kaduna State has one of the largest concentrations of industries in Nigeria which discharge waste water, it is also a rapidly expanding city through urbanization; this means that several activities in addition to industrial discharge of waste water and municipal sludge which may contain heavy metal pollutants all of which pass through industrial drains, tributary streams and finally into River Kaduna. The bank of this river is a booming crop farming area in both dry and raining seasons. Mohammed *et al*., (2012) reported that many soils especially those in hazardous water sites are contaminated with heavy metals. The high concentration of Cadmium, Chromium and Lead observed at T/wada could be attributed to the proximity of the farm area to abattoir and other anthropogenic activities. Yahaya *et al.*, (2009) studied Seasonal Variations of Heavy Metals Concentration in Abattoir Dumping Site Soil in Nigeria and found that the levels of these metals in Yauri Abattoir dumping site soil were above the literature levels of a typical soil. The transfer of these metals from water to soils, vegetables, animals and humans can cause bioaccumulation and biomagnifications. High concentration of Heavy metals in agricultural soil may lead to death of plants as reported in seedlings of bean (Xu and Shi, 2003). Metal uptake by plants can be influenced by metal concentration in soils, soil pH, varieties of plants, and plant age. Heavy metals are easily absorbed by roots of vegetables and transported to shoots where it is uniformly distributed in plant (Sekara *et al*., 2005). Amongst the heavy metals analyzes, Pb and Cd were above acceptable limit (Table 1) as specified by DPR and EU while Hg, Cr and Zn were within acceptable limits. However, these concentrations pose a concern due to progression in accumulation of the metal in soil over a long period of time. High concentration of Cd observed in this study could be due to excessive use of phosphate based fertilizers containing high content of Cadmium as earlier reported by McLaughlin *et al*. (2000). Other past studies had witnessed significant increases in heavy metals in fertilized soils as compared to unfertilized ones (Mann *et al*., 2002). The mean pH value of 6.18 and 6.99 ranges obtained from this study are lower than the previously reported value by Iyaka and Kakulu (2012) in their study of cultivated farmlands in the vicinity of abandoned industrial sites in Niger State, but higher than the average pH value of 5.2 reported for some Nigerian soils. However, the pH values of this study falls within the established pH value by WHO and DPR, that at soil pH 6.5 major soil nutrients abounds and bacteria activities are optimum. These agreed with this study being that some locations where the pH values are lower; the levels of other parameters were optimum. The effect of pH on heavy metal availability to plant has been reported by many researchers and it is accepted that as pH decreases, the solubility of cationic forms of metals in the soil solution increases and, therefore, they become more readily available to plant (Mahmud and Jimoh, 2014).

5. CONCLUSION AND RECOMMENDATIONS

Irrigation farms along the bank of river Kaduna are contaminated with heavy metals. Although some of these heavy metals such as Zn and Cr are biologically essential and play an important role in the growth of plants, animal and man. They can also be toxic when found in high concentrations. Certainly, future studies should determine the health impacts of metals on the population living in these areas taking into account that metals can accumulate in plants, making their way to humans through the food chain. Government should develop stringent disposal regulations to prevent this wholesome attitude of industries, factories and residence. Due diligence in restoring polluted sites to base-line level is also recommended.

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