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Research Paper

Heavy Metals Status on Irrigated Urban Farming Sites of Katsina City, Nigeria

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This study investigates the concentration of heavy metals in soil under urban irrigation farming in some selected sites in Katsina city. Soil samples were collected from 0-15 cm, 20-30 cm, and 40-50 cm and analyzed for heavy metals (Pb, Cd, Cu, Cr, Zn, Fe, Mn, and Ni) using atomic absorption spectrophotometry. T-test was used to compare the mean values of the various heavy metals, Product moment correlation was employed to assess the level of correlation among the investigated metals. Analysis of the soil samples collected show traces of heavy metals at different soil depth and there are variations of pollution index values in the selected irrigated sites. Cadmium (Cd), Copper (Cu), Manganese (Mn) and Nickel (Ni) were the dominant pollutants in the sites. It was concluded that the irrigated sites are polluted by waste water, though the pollution index value indicates moderate pollution level.

Key words: Wastewater, soil pollution, heavy metals, urban farming, Katsina city

INTRODUCTION

Human population growth, especially in the developing world has increased the demands for huge quantities of water for domestic and other uses. With the increasing scarcity of fresh water resources for crop cultivation, the use of urban wastewater for irrigation is increasing, especially in arid and semi-arid regions of the globe (Singh and Agrawal, 2012). The use of untreated wastewater is particularly common in areas where there is poor access to other sources of irrigation water (FAO, 1985). The shortage of fresh water sources has been increasing worldwide, particularly in the Middle East and North Africa. The scarcity is reaching crisis levels and chronic water stress is expected to continue to dominate the region (Al-Jabobi *et al.,* 2014). Abedi-Koupai, (2006) opined that, the shortages have led to the use of wastewater for agricultural production. Costs of chemical fertilizers, high plant nutrients in waste water, high cost of advanced water treatments required for other application and the availability of wastewater near agricultural lands have attracted many people to invest in wastewater irrigation agriculture. Presumably, there is an urgent need to conserve and protect fresh water and to use water of lower quality for irrigation (Al-Rasheed and Sherif, 2000). The practice of wastewater irrigation is widely adopted in Sub-Saharan Africa by resource-poor smallholder farmers without consideration of the potential health risks to the population, as it changes the chemical composition of the soil (Yaro and Umar, 2011).

Wastewater for irrigation serves as a valuable source of plant nutrients and organic matter needed for maintaining fertility levels of soils (Chandra et al., 2012). Reuse of domestic and industrial wastewater in irrigation appears to be a lucrative option. It serves as a potential solution to reducing fresh water demand, for zero water discharge and avoiding pollution loads in the receiving sources (Kiran *et al.,* 2012).

However, the use of wastewater for domestic, industrial, commercial, agricultural and other human activities, despite its obvious benefits, has some recorded human and environmental health concerns (Phung *et al.,* 2011). Many reports correlate the relationship between fresh vegetables and food borne diseases outbreaks that have led to the concerns about contamination of soils and vegetables with faecal pathogenic bacteria in the agricultural environment (Tauxe *et al*., 1997). Application of contaminated irrigation water to soils thus represents possible sources of contamination. The use of wastewater and sludge in agricultural lands was found to contaminate soils with heavy metals that may pose potential environmental and health risks in the long term (Sanchez-martin *et al.,* 2007). According to Shaiberge and Oster, (1978) the application of saline/sodic water results in deterioration of crop yields as well as deterioration of the physico-chemical characteristics of soils. Sridhara et al., (2008) asserted that, excessive accumulation of metals in vegetables poses serious threats to those who consume the crops or vegetables grown on such contaminated soils.While the cost of treating wastewater through recycling is too high in developing countries like Nigeria, harmful effects, like roots and growth inhibition and reduction of yields due to the accumulation of heavy metals in plants grown in wastewater irrigated fields were also reported (Singh and Agrawal, 2012). Long before the creation of Katsina state, many people were engaged in irrigation for vegetable crop production to supplement rain-fed crop production. However, the creation of Katsina state in 1987 resulted in a rapid increase in population a situation responsible for increased demand for food supply which eventually put more pressure on urban soil through increased irrigation activities. The use of wastewater in irrigation sites along Ginzo drainage improves soil fertility as it provides an essential macro and micro nutrients for plants growth and development. However, the use of wastewater for irrigation despites its' obvious benefits, many researchers have indicated that, continuous use of wastewater for crop production may lead to the heavy metals build up in soils which may pollute the soil and eventually the cultivated crops. Exposure to heavy metals can lead to mental deterioration, loss of memory, joint weakness, reproductive defects, kidney and liver damages, neurological complications, hypertension, cardiovascular disease (Wuana and Okiemen, 2011). Hence, this research was carried out in order to assess soil heavy metals condition as a result of irrigation activities along Ginzo urban drainage in Katsina city, Northern Nigeria.

MATERIALS AND METHODS

Description of study sites and sampling location

Katsina is the capital city of Katsina State. It is located between latitude 12° 45' and 13° 15' N, and longitude 7° 30' and 80° 00'E. The location of the study sites is along Ginzo drainage basin, in urban Katsina.

Reconnaissance survey

A reconnaissance of the study area was carried out in February, 2015 to select appropriate sites for the study. Information collected included farm sizes, tenure history and type, cropping practices and use of inputs such as fertilizer, manure, pesticide and seeds.

Consequently, 15 farms were selected at different locations along Ginzo valley passing through three major neighbourhoods (Kofar Marusa, Kofar Durbi, Kofar Sauri) in Katsina urban area. The selected farms were those with adequate and reliable history of input use and consistency in cropping. The identity of the farmers, including their names and addresses were recorded. Soil samples were collected from these farmsteads.

Soil sample collection procedure

The farms of the selected farmers vary in size between 0.02 ha to about 0.05ha. To ensure uniformity in the soil sample collection, a quadrant of 20 × 20 m was selected in each farm. Every quadrant was divided into 16 equal-sized grid squares (by dividing every segment of the quadrant into four equal parts of 4 m each) and at midpoints of every grid square soil samples were collected from three different depths i.e. 0-15 cm, 20-30 cm and 40-50 cm using soil auger. A Selection of these depths was purposely made because the crops being grown in the area have about 45 cm as their maximum rooting depth. Also sampling from similar depth across the various sampling farms will help in making it possible for comparing different farms.

The soil samples collected from each sampling location were put in a sterile polyethylene bag, sealed, marked and labeled.

Soil samples analyses

The soil samples were digested using DTPA (diethylenetriaminepentaacetic acid) extraction procedures. The collected soil samples were first air dried. 1 g sub-samples were then taken from every air-dried samples which were then digested using 20 cm^3 of 1:1 nitric acid and heated to boil until the volume was reduced to 5 cm^3. 20 cm^3 of distilled water was added and boiled until the volume reduced to 10 cm^3. It was cooled and filtered and make up to the 50 cm^3 mark of volumetric flask.

Analytical procedures

Heavy metals (Pb, Cd, Cu, Cr, Zn, Fe, Mn and Ni) were determined using atomic absorption spectrometry

(Shimadzu AA-6200), with wavelengths of 283.3, 248.3, 324.7, 228.8, 213.9 and 232 NM for Pb, Cu, Zn, Cd, Ni, Mn and Fe respectively at slit widths of 0.7 NM for Pb, Cu, Zn, Mn and Cd, and 0.2 NM for Ni and Fe. Linear calibration curves were constructed for Pb, Cd, Cu, Zn, Mn, Fe and Ni with regression coefficient values (r) of 1, 0.9998, 1, 0.9998, 0.9998 and 0.9999, respectively.

Reagents used

Glassware and plastic ware used were soaked in 10% HNO_3 (v/v) for overnight, and washed thoroughly with soap and distilled water. All chemicals used were as reagent grade, high purity HNO_3 assay 69.5%, HCl assay 37% and pure HClO4 assay 60% (Scharlau, Spain). Calibration curves for Pb, Cu, Zn, Cd, Ni and Fe were prepared from standard solutions of 1,000 ppm (Panreac, Spain) with serial concentrations of each element.

Statistical analysis

The descriptive statistics were used in analyzing the data using SPSS version 16.. The result of the test showed that the analytical data was non-normally distributed. Students't-test technique was used to assess the significance differences in mean values of the various heavy metals between pairs of the three sampling locations and depths. It was also used to assess the significance difference in mean values of the various heavy metals in the three sampling locations. The Product moment correlation test was then used to assess the significance of correlation among levels of the investigated metals. The pollution index was calculated using the following formula:

$$PI = \frac{CI}{SI}$$

Where

PI= pollution index,
CI= heavy metal content in sample and
SI= Permitted standard of the same metal. Rai *et al.,* (2011).

Coefficient of variability percentages were determined using the following formula:

$$CV\% = \frac{100*SD}{X}$$

Where

SD = Standard deviation
X = Concentration of a particular metal

The CV% results obtained were compared to the classification given by Aweto, (1982)

RESULTS AND DISCUSSION

Table 1 shows the results of the soil heavy metals from the selected irrigation sites and control sites. The concentrations of heavy metals in the three sampling sites were subjected to paired t-test. In assessing the status of heavy metals among the sampling sites, (Table 1) Mean values, Standard Deviation, T-values, P-values, and Maximum Permissible Limits provided by the EU, USEPA and FEPA for the soil parameters were presented in (Tables 1 and 2).

Soil reaction

Soil pH measure of extent of acidity and alkalinity of the soil. The average soil pH values for the irrigated soil and control sites were 6.7 and 7.2 respectively (Table 1). The highest value of 7.40 was recorded at the control site while the lowest value of 6.7 was recorded at Kofar Sauri (KSC). The values of sampled soil and the control fall within the neutral class (6.6-7.3) as classified by USDA, (2000) as shown in (Table 2). Hassan and Umar, (2013) reported pH values of 6.9 for control site and 6.6 from the sampled sites.

The National Fertilizer Centre (1988) reports pH values of 5-6 for the northwest zone savannah soils. The result obtained from this study shows that, the pH value is normal, as higher pH values make heavy metals unavailable to plants for bioaccumulation (Wuana and Okieimen, 2011).The Low pH value of the sampled soil is likely due to the decomposition of organic matter and the production of organic acid in the soils and this has corroborated the findings of Khai *et al.,*(2008). However, long period of irrigation activity results in increased soil pH value due to the application of fertilizer and insecticides (Hussein, 2009). Most plant nutrients are in their available state at between pH 6.0 and 6.5 and low soil pH has detrimental effects on soil quality (Mutengu *et al.,* 2007). Low pH values increased the metal availability for plant uptake (Singh and Agrawal, 2012).

Lead (Pb)

The mean concentration of Lead (Pb) in the irrigated soil and the control sites were 0.070 g/kg and 0.020 g/kg respectively (Table 1). The highest concentration of 0.103 g/kg and the lowest concentration of 0.020 g/kg were recorded at Kofar Marusa (KMA) and control site respectively. The standard deviation indicates that there are variation between the two sites. There is a significant difference at 0.05 levels. These values are below the maximum permissible limits provided by the USEPA, but

Table 1. Mean, standard deviation, T-values and P-values of heavy metals for the sample and control sites using paired t-test.

Soil Parameters	Soil Sampling sites Mean	Soil Sampling sites SD	Control Mean	Control SD	T-Value	P-value	Difference
pH	6.7	0.316	7.2	0.243	-2.193	0.060	NS
Pb (g/kg)	0.07	0.013	0.02	0.009	8.36	0.000	S
Fe (g/kg)	0.05	0.013	0.01	0.004	7.86	0.000	S
Cr (g/kg)	0.06	0.013	0.01	0.013	9.82	0.000	S
Cu (g/kg)	0.15	0.041	0.03	0.013	6.62	0.001	S
Cd (g/kg)	0.08	0.034	0.03	0.013	13.7	0.000	S
Mn (g/kg)	0.32	0.039	0.04	0.013	19.7	0.000	S
Ni (g/kg)	0.37	0.021	0.06	0.013	31	0.000	S
Zn (g/kg)	0.06	0.013	0.01	0.004	8.82	0.000	S

Source: Field Survey (2015). S=Significant and NS= Not Significant.

Table 2. Soil heavy metals compared with maximum permissible limits and control site.

Heavy metals	EU	USEPA	FEPA	Field survey	Control
Pb (g/kg)	0.3	0.3	0.05	0.07	0.02
Fe (g/kg)	-	-	-	0.05	0.01
Cr (g/kg)	0.180	0.40	0.05	0.06	0.01
Cu (g/kg)	0.140	0.05	-	0.15	0.03
Cd (g/kg)	0.003	0.003	0.1	0.08	0.03
Mn (g/kg)	-	0.08	-	0.32	0.04
Ni (g/kg)	-	0.05	0.1	0.37	0.06
Zn (g/kg)	0.3	0.20	-	0.06	0.01

pH values from USDA,(1998). pH =6.1- 6.5 = Slightly Acidic, Neutral = 6.6 - 7.3, Slightly Alkaline =7.4-7.8.

the concentration at the sampled site is a little higher than FEPA threshold (Table 2). This may be attributed to the waste deposited into the river valley and the nearby road network that discharges Lead from vehicle emission into the surrounding environment. Hassan and Umar, (2013) reported Lead concentration of 0.11 g/kg and 0.010 g/kg in wastewater irrigated soil and groundwater respectively.

The result obtained was in conformity with the findings of Dinkinya and Areola, (2010) who reported higher Lead (Pb) concentrations in irrigated soils than in soil under cultivation. Heavy metals tend to form complexes with organic matter in the soils and retained them in exchangeable form. Lead accumulation in body organs may lead to poisoning (plumbism) or even death (Sridhara et al., 2008). Lead exposure can cause impaired development in children, shortened attention span, hyperactivity and mental deterioration (Wuana and Okeiemen, 2011).

In case of adults, decrease reaction time, Loss of memory, nausea, Insomnia, Joint weakness, reproductive defects, irritation and tumor are caused by exposure to lead (Asio, 2009).

Figure 1 shows the variation of Lead (Pb) concentration among the irrigated and control soils.

Iron (Fe)

The mean concentration of the Iron (Fe) in the irrigated soil and the control sites were 0.05 g/kg and 0.01 g/kg respectively (Table 1). The highest concentration of 0.063 g/kg and the lowest concentration of 0.010 g/kg were recorded at Kofar Marusa (KMA) and Control site respectively.The standard deviation of the result indicates that there exists variation between the two sites.

Chromium (Cr)

The mean concentration of the Chromium (Cr) in the irrigated soil and the control sites were 0.06 g/kg and 0.010 g/kg respectively (Table 1). The highest concentration of 0.073 g/kg and the lowest concentration of 0.050 g/kg were recorded at Kofar Sauri (KSC) and control site respectively. The standard deviation of the result indicates that there exists variation between the two sites. There is also a significant difference at 0.05 levels; this confirms that, wastewater irrigation has effect on the soil chromium concentration. The results indicate that, both concentrations are below the maximum permissible limits given by EU and USEPA but the concentration at the irrigated site is a little higher than

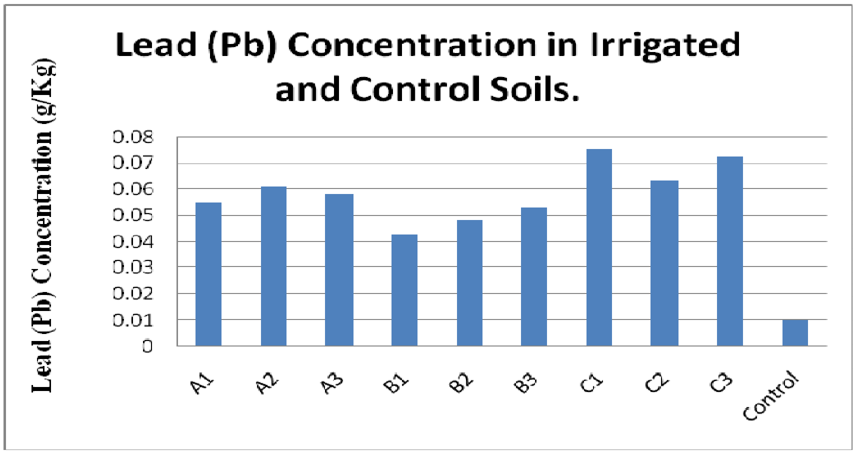

Figure 1. Lead (Pb) concentration in irrigated and control soils.

FEPA threshold (Table 2). This may be attributed to the use of wastewater which is believed to contain contaminants. Chromium is required for carbohydrate and lipid metabolism in animals and utilization of amino acids (Wuana and Okieimen, 2011). However, Chromium (VI) is the form of chromium commonly found at the contaminated sites and toxic levels are common in soil irrigated with wastewater (Asio, 2009). Figure 2 shows the variation of Chromium (Cr) concentration among the irrigated and control soils.

Copper (Cu)

The mean concentration of the Copper (Cu) in the irrigated soil and the control sites were 0.150 g/kg and 0.030 g/kg respectively (Table 1). The highest concentration of 0.180 g/kg and the lowest concentration of 0.030 g/kg were recorded at Kofar Sauri (KSC) and control respectively (Table 1). The irrigated site has values higher than the threshold given by EU and USEPA (Table 2).The result obtained may be attributed to the refuse dumping along the river valley and the use of wastewater which is believed to contain contaminants. Dinkinya and Areola, (2010) reported lower Copper concentration in wastewater irrigated soils than in soils under cultivation. In humans Copper helps in the production of blood hemoglobin while in plants it is used in seed production, disease resistance and regulation of water (Mutengu et al., 2007). High concentration in the vegetative biomass can cause anemia, liver and kidney damages, stomach and intestinal irritation, neurological complications, hypertension, and liver and kidney dysfunction (Wuana and Okieime, 2011).

Cadmium (Cd)

The mean concentration of the Cadmium (Cd) in the irrigated soil and control irrigation sites were 0.081 g/kg and 0.030 g/kg respectively (Table 1). The highest concentration of 0.267 g/kg and the lowest concentration of 0.030 g/kg were recorded at Kofar Marusa (KMA) and Control respectively (Table 1). Both values are above EU and USEPA threshold while control values were below FEPA threshold, in soil under wastewater irrigation, the higher values might be attributed to wastewater application and waste materials to improve soil fertility. The result indicates that, the two sites need remediation intervention as Cadmium is harmful regardless of its concentration (Hassan and Umar, 2013). Cadmium has relatively high adsorption capacity to clays than other heavy metals as well as higher mobility index (Asio, 2009). Cadmium (Cd) is one of the heavy metals that are of great concern to medical and environmental experts, because of its toxicity to animals and humans as it enters into food chain through bioaccumulation (Phung et al., 2011). Organic matter retains heavy metals in an exchangeable form, for example cadmium is retained in an exchangeable form and is more readily available to plants. WHO (2003) attributed current short life expectancy in developing countries to disease burdens caused by heavy metals in water, air and soil exposure to Cadmium can also cause bones and cardiovascular diseases, renal problems, severe pains in joints, kidney and lungs problems and anaemia (Adelekan and Abegunde, 2011).

Manganese (Mn)

The mean concentration of the Manganese (Mn) in the irrigated soils and the control irrigation sites were 0.322 g/kg and 0.040 g/kg respectively (Table 1). The highest concentration of 0.40 g/kg and the lowest concentration of 0.040 g/kg were recorded at Kofar Sauri (KSC) and control respectively. Irrigated sites values were above USEPA permissible limit of 0.08g/kg while that of control

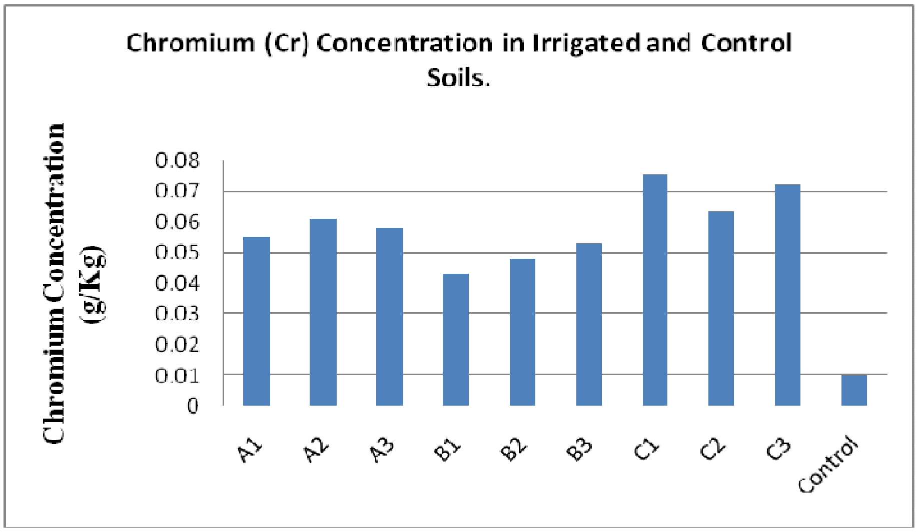

Figure 2. Chromium (Cr) concentration in irrigated and control soils.

is below the USEPA threshold (Table 2). Toxicity may adversely cause leaves distortion, yellowing and necrosis in some plants (Dinkinya and Areola, 2010). Exposure to Manganese (Mn) by humans through consumption of contaminated food materials can cause hallucinations, forgetfulness, Parkinson, bronchitis, nerve damage, and impotence in men.

Nickel (Ni)

The mean concentration of the Nickel (Ni) in the irrigated and the control sites were 0.37 g/kg and 0.06 g/kg respectively (Table 1). The highest concentration of 0.437 g/kg and the lowest concentration of 0.06 g/kg were recorded at Kofar Durbi (KDB) and control respectively. Both values are above USEPA maximum permissible limit of 0.05 g/kg but the control value was below FEPA threshold (Table 2). The higher values in irrigated soil may be attributed to wastewater use. Dinkinya and Areola, (2010) reported lower concentrations of Ni in soils under wastewater irrigated soil than in soil under cultivation. Nickel above recommended values can enter into vegetative biomass of vegetables and when consumed by humans can cause lung, liver and kidney damages. It can also cause cancer, respiratory failure, birth defects, allergies, nervous system and heart failure (Adelekan and Abegunde, 2011; Asio, 2009).

Zinc (Zn)

The mean concentration of the Zinc (Zn) in the irrigated soil and Control sites were 0.061 g/kg and 0.010 g/kg respectively (Table 1). The highest concentration of 0.067 g/kg and the lowest concentration of 0.01 g/kg were recorded at Kofar Marusa (KMA) and Control. The standard deviation of the result indicates that there exists variation between the two sites. There is a significant difference at 0.05 levels.

Both values are below EU and USEPA maximum permissible limit of 0.3 g/kg and 0.2 g/kg respectively (Table 2). Dinkinya and Areola, (2010) reported lower concentrations of Zinc in soils under wastewater irrigation than in soil under cultivation. Copper Selenium and Zinc are essential for maintenance of metabolism in the human body; however, at higher concentrations, Lead (Pb) can lead to poisoning. Higher zinc concentrations in soil can pollute the groundwater, increase the acidity of water and can negatively influence the activities of macro-organisms and earthworms thereby retarding the breakdown of organic matter (Wuana and Okieimen, 2011).

Coefficient of variability percentage (CV %) for the heavy metals among the sampled soils

The coefficient of variability percentage (CV %) was used to determined variation in heavy metals concentrations among the three irrigation sites as shown in (Table 3). A close look at Table 3 shows the spatial variability in all the metal distributions in the three sampling locations in urban Katsina as compared with their respective means. The investigated metals manifest a trend of decreasing mean values in this order: Ni > Mn > Cd > Cu > Pb > Zn > Cr > Fe (Figure 3).

Lead (Pb)

The coefficient of variability percentage (CV %) of Lead (Pb) in the three irrigation sites was 42.90 which is referred to as moderate variability as described by Aweto

Table 3. Descriptive statistical parameters for the distribution of heavy metals in the investigated nine soil samples.

Variable	Min.	Max.	Mean	SD	CV %	Variability Rating
Pb	0.04	0.10	0.07	0.03	42.90	Moderate
Fe	0.04	0.06	0.05	0.01	20.00	Low
Cr	0.05	0.07	0.06	0.01	16.67	Low
Cu	0.12	0.18	0.15	0.03	20.00	Low
Cd	0.17	0.27	0.21	0.05	23.81	Moderate
Mn	0.3	0.35	0.32	0.03	9.38	Low
Ni	0.25	0.44	0.37	0.10	27.03	Moderate
Zn	0.06	0.07	0.06	0.01	16.67	Low

CV% = Coefficient of variability percentage; SD = Standard Deviation
Source: Field work (2016).

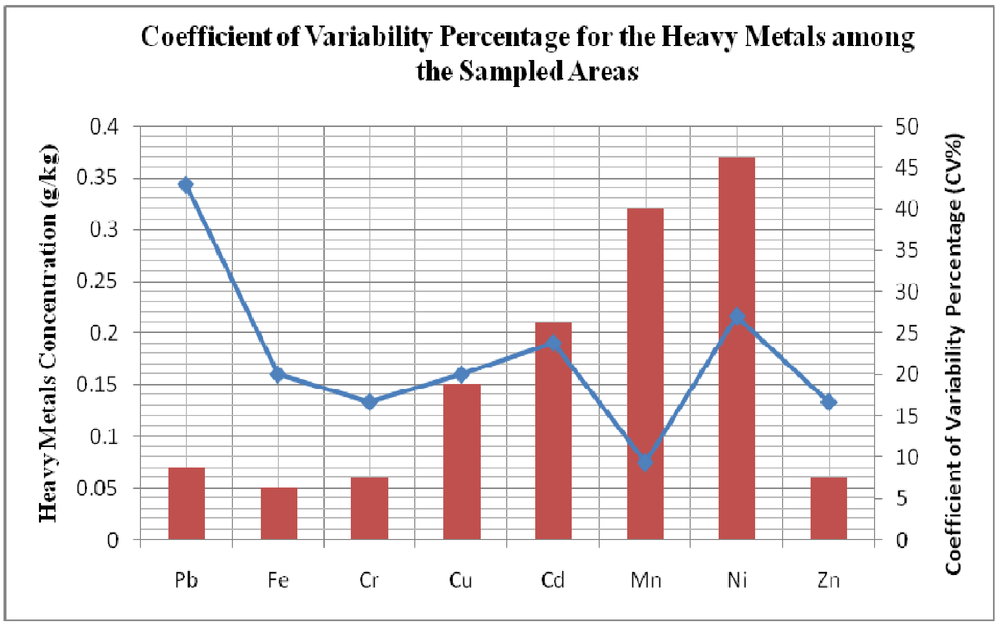

Figure 3. Coefficient of variability percentage for the heavy metals among the sampled areas.

(1982).

Iron (Fe)

The coefficient of variability percentage (CV %) of Iron (Fe) in the three irrigation sites was 20 which is referred to as low variability as described by Aweto, (1982). Isah, (2016) has reported Iron (Fe) CV % value of 47.11 which is greater than the results obtained in this study.

Chromium (Cr)

The coefficient of variability percentage (CV %) of Chromium (Cr) in the three irrigation sites was 16.67 which is referred to as low variability as described by Aweto, (1982). Jiantao *et al.* (2011) reported Chromium (Cr) CV % value of 0.40 which is far lower than the results obtained in this study.

Copper (Cu)

The coefficient of variability percentage (CV %) of Copper (Cu) in the three irrigation sites was 20.00% which is referred to as low variability as described by Aweto (1982). Isah, (2016) have reported a CV% value for Copper (Cu)of about 69.70% and 45.75%in urban soils respectively. These values are quiet below the result obtained in this research.

Cadmium (Cd)

The coefficient of variability percentage (CV %) value of Cadmium (Cd) in the three irrigation sites was 23.8 which is referred to as moderate variability as described by Aweto (1982). Isah, (2016) has reported Cadmium (Cd) CV% value of 52.78 which is greater than the results obtained in this study. While Jiantao *et al.* (2011) has reported Cadmium (Cd) CV % value of 0.12 which is far lower than the result obtained in this research.

Manganese (Mn)

Coefficient of variability percentage (CV %) of Manganese (Mn) in the three irrigation sites was 9.38 which is low variability as found by Aweto (1982). Isah, (2016) has reported Manganese (Mn) CV% value of 43.69 which is greater than the results obtained in this study.

Nickel (Ni)

Coefficient of variability percentage (CV %) of Nickel (Ni) in the three irrigation sites was 27.03 which is referred to as moderate variability as described by Aweto (1982). Isah (2016) has reported Nickel (Ni) CV% value of 63.38 which is greater than the results obtained in this study.

Zinc (Zn)

Coefficient of variability percentage (CV %) of Zinc (Zn)in the three irrigation sites was 16.67Which is referred to as low variability as described by Aweto (1982). Isah, (2016) reported Zinc (Zn) CV% value of 41.88 and 44.79 respectively.

Soil pollution status in the study area

Table 4 present results for total soil heavy metal pollution index values in the three sampling sites of Kofar Marusa (KMA), Kofar Durbi (KDB) and Kofar Sauri (KSC) and Control. The results indicate significant variation at irrigation sites and control site. All metals analysed were detected in the irrigated and control sites. Pollution index in (Table 4) is a simple comparative means for assessing the level of metal pollution.

The pollution index values from the three irrigation sites were in the following order Cd>Ni>Mn>Cu>Zn>Pb>Cr. The pollution index values indicate that Cadmium (Cd) was very high in all the sites measured; indicating that cadmium constitutes contamination hazards at the study sites.

Lead (Pb)

The pollution index values of Lead (Pb) in soils of these study sites were 0.37, 0.13 and 0.20 for KMA, KDB and KSC which were described as moderately contaminated, slightly contaminated and slightly contaminated respectively. The highest value of 0.37 was observed at KMA while the lowest value of 0.13 was recorded at KDB (Table 4). Nwaje *et al.* (2014) reported pollution index values of 1.05, 0.89 and 0.52 for irrigated soils of Agbor, Sapele and Warri respectively. The high value at KMA may be due to the use of wastewater for irrigation, waste deposition along the Ginzo drainage by nearby households and Aeolian deposits.

Chromium (Cr)

The pollution index values of Chromium (Cr) in soils of these study sites were 0.15, 0.13 and 0.18 for KMA, KDB and KSC respectively, all of which were termed as slightly contaminated (Lenntech, 2010) The highest value of 0.18 was observed at KSC while the lowest value of 0.13 was recorded at KDB. (Table 5). Nwaje *et al* (2014) reported pollution index values of 0.01, 0.01 and 0.03 for irrigated soils of Agbor, Sapele and Warri respectively. The high value at KSC may be attributed to the use of wastewater which is believed to contain contaminants. Chromium is required for carbohydrate and lipid metabolism in animals and utilization of amino acids (Asio, 2009). However, Chromium (VI) is the form of chromium commonly found at the contaminated sites and toxic levels are common in soil irrigated with wastewater (Asio, 2009; Wuana and Okieimen, 2011). Exposure to chromium can lead to bleeding of gastrointestinal tract, liver and kidney damages (Adelekan and Abegunde, 2011).

Copper (Cu)

The pollution index values of Copper (Cu) in soils of these study sites were 2.42, 2.95 and 3.60 for KMA, KDB and KSC respectively. The highest value of 3.60 was observed at KSC while the lowest value of 2.42 was recorded at KMA site. All these values were classified as moderately polluted. Nwaje *et al* (2014) reported pollution index Copper values of 0.72. 0.52 and 0.01 for Agbor, Sapele and Warri respectively. In humans Copper helps in the production of blood haemoglobin while in plants it is used in seed production, disease resistance and regulation of water. High concentration in the vegetative biomass can cause anaemia, liver and kidney damages, stomach and intestinal irritation, neurological complications, hypertension, and liver and kidney dysfunction (Lenntech, 2010, Wuana and Okieime, 2011).

Cadmium (Cd)

Pollution index levels of Cadmium (Cd) in the soils of these study sites were 3.5, 2.7 and 2.2 for KMA, KDB and KSC respectively. The highest value of 3.5 was observed at KMA while the lowest value of 2.2 was recorded at KSC. These values were classified as moderately polluted (Nwaje et al., 2014). Cadmium has relatively higher adsorption capacity to clays than other heavy metals as well as higher mobility index (Sanchez-martin et al., 2007). WHO, (2003) attributed current short life expectancy in developing countries to disease

Table 4. Pollution index values of the three irrigation sites and control.

Heavy metal	KMA	KDB	KSC	Control
Pb	0.37***	0.13 **	0.20 **	0.07*
Cr	0.15 **	0.13 **	0.18 **	0.025*
Cu	2.42******	2.95*****	3.60 ******	0.60****
Cd	3.5******	2.7******	2.2 ******	0.67****
Mn	3.95 ******	3.68 ******	3.31 ******	0.50****
Ni	3.92 ******	3.88 ******	3.50.******	1.2*****
Zn	0.33***	0.30***	0.28***	0.05*

Sources: Research data 2015

Key
*= very slightly contaminated
** = Slightly contaminated
*** = Moderately contaminated
**** Very severe contamination
***** = Slightly polluted
****** = Moderately polluted

KMA = Kofar Marusa irrigation sites
KDB = Kofar Durbi irrigation sites
KSC = Kofar Sauri irrigation sites

Table 5. Interpretation of pollution index.

Index	Significance
0.1 and Below	Very slightly contamination
0.10-0.25	Slight contamination
0.26-0.50	Moderately contamination
0.51-0.75	Severe contamination
0.76-1.0	Very severe contamination
1.1-2.00	Slight pollution
2.1-4.00	Moderate pollution
4.1-8.0	Severe pollution
8.1-16.0	Very severe pollution
16 and above	Excessive pollution

Source: Lenntech (2010).

Table 6. Summary of heavy metals pollution index values of the study area.

Heavy metals	Mean heavy metals concentration in irrigated soil	Contamination Level
Pb	0.23	Slight contamination
Cr	0.14	Slight contamination
Cu	3.00	Moderate pollution
Cd	2.8	Moderate pollution
Mn	3.65	Moderate pollution
Ni	3.76	Moderate pollution
Zn	0.32	Moderate contamination

Source: Research data 2015.

burdens caused by heavy metals in water, air and soil exposure to Cadmium can also cause bones and cardiovascular diseases, renal problems, severe pains in joints, kidney and lungs problems and anaemia (Adelekan and Abegunde, 2011; Sridhara et al., 2008).

Manganese (Mn)

Pollution index values of manganese (Mn) of soils of these study sites were 3.95, 3.68 and 3.31. These values were classified as moderately polluted (Lenntech, 2010). The highest value of 3.95 was observed at KMA while the lowest value of 3.31 was observed at the KSC sites. According to Obodai et al., (2011) humans increases Mn concentrations in the air through industrial activities and burning of fossil fuels and enter surface water, ground water and sewage water through the application of pesticide. Manganese (Mn) toxicity may adversely cause leaf distortion, yellowing and necrosis in some plants (Dinkinya and Areola, 2010). Exposure to Manganese

(Mn) by humans through consumption of contaminated food materials can cause hallucinations, forgetfulness, Parkinson, bronchitis, nerve damage, and impotence in men (Obodai et al., 2011). At low pH, Manganese (Mn) deficiency is common while higher concentrations can cause swelling of cell wall and brown spots on leaves (Obodai et al., 2011).

Nickel (Ni)

The pollution index values of Nickel (Ni) in the soils of these study sites were 3.92, 3.88 and 3.50 for KMA, KDB and KSC respectively. The highest value of 3.92 was observed at KMA while the lowest value of 3.50 was observed at KSC. The high value at KMA may not be unconnected with the use of waste water for irrigation. Nwaje *et al.* (2014) reported Nickel pollution index values of 0.68, 1.16 and 0.28 for Agbor, Sapele and Warri sites.

Zinc (Zn)

Pollution index values of Zinc (Zn) in soils of the three sites were 0.33, 0.30 and 0.28 for KMA, KDB and KSC respectively. These values fall within moderate contamination as classified by Lenntech, (2010). The highest value of 0.33 was observed at KMA while the lowest value of 0.28 was recorded at KSC site. Zinc is an essential for maintenance of metabolism in the human body; however, at higher concentrations. Higher zinc concentrations in soil can pollute the groundwater, increase the acidity of water and can negatively influence the activities of macro-organisms and earthworms thereby retarding the breakdown of organic matter (Wuana and Okieimen, 2011). The pollution index value of Lead (Pb) in the irrigated soils was 0.23 which was described as very slightly contaminated (Lenntech, 2010). A chromium (Cr) index value of the irrigated soils was 0.14 which was described as slightly contaminated (Table 6).

The pollution index value of Copper (Cu) in the irrigated soils was 3.00 which was classified as moderate pollution as classified by Lenntech (2010).The Cadmium (Cd) pollution index values in the sampled soils were 2.8 which was moderate pollution. A manganese (Mn) pollution index value in the irrigated soils was 3.65 which were classified as moderately pollution (Lenntech, 2010). The pollution index value of Nickel (Ni) in the irrigated soil was 3.76 this is classified as moderate polluted soils (Lenntech, 2010). The Zinc (Zn) pollution index values in the irrigated soil was 0.32 which was moderately contaminated soils as classified by Lenntech, 2010).

Conclusion

The result shows that variations exist between the irrigation sites in terms of pollution index values. The index values range from slight contamination to moderate pollution, as classified by Lenntech (2000). The pollution index revealed that the three sites were polluted with Cadmium (Cd), Copper (Cu), Manganese (Mn), and Nickel (Ni). Lead has a slight contamination value in all the three irrigation sites. Slight contamination of Chromium was observed at Kofar Marusa (KMA) and Kofar Durbi (KDB) while moderate contamination of Chromium was recorded at Kofar Sauri (KSC), as classified by Lenntech, (2010). Moderate contamination of Zinc was observed at KMA, KDB and KSC and slight contamination was observed at control sites. The use of wastewater for irrigation, anthropogenic waste deposition along Ginzo drainage, urbanization could account for the high levels of potential toxic metals observed in this research.

Recommendations

Based on the findings obtained in this work, the following recommendations were proffered:

(a) For safety reasons, frequent monitoring of heavy metals levels in water, soil and plant vegetation should be carried out to ensure that their concentrations do not go beyond the limits of the regulatory bodies.
(b) Alternative sources of irrigation water, such as boreholes tube, wells should be made available to irrigation farmers some distance from the wastewater in the irrigation sites.
(c) Fertilizers of the right quantity and quality should be made available to irrigation farmers to discourage them from using wastewater as a source of nutrient for irrigation purposes.
(d) Public enlightenment campaigns should be intensified to discourage people from depositing waste materials along the river valley.
(e) Investigations into the effects of irrigation wastewater on the various crops under cultivation in the study area should be initiated and encouraged.
(f) Proper environmental monitoring and intervention on soil heavy metals pollution by ministries of agriculture and the environment should be put in place.

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