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AVAILABILITY AND DEGREE OF CONTAMINATION OF HEAVY METALS IN SOILS AND WATER OF BOMO AND GALMA IRRIGATION FARM LANDS, ZARIA,KADUNA STATE, NIGERIA

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ABSTRACT
This research was designed to assess the level of heavy metal (Lead {Pb} and Cadmium {Cd}) and degree of contamination in soils and water located in Bomo and Galma irrigation farm lands. Soil and water samples collected from Bomo Lake, River Galma and borehole (serving as control) were digested and analyzed using Atomic absorption spectrophotometer to determine the heavy metal concentrations. The results showed that concentrations of Pb in soil located in Bomo ranges from 1.82 mg/kg to 6.19 mg/kg while Cd concentrations range from 0.03 mg/kg to 0.12 mg/kg. Pb concentrations in soil located in Galma ranges from 1.62 mg/kg to 4.03 mg/kg and Cd concentrations ranges from 0.02 mg/kg to 0.10 mg/kg. Concentrations of Pb in Bomo Lake ranges from 1.47 mg/kg to 3.09 mg/kg while Cd concentrations in Galma borehole water ranges from 0.02 mg/kg to 0.09 mg/kg. Pb concentrations in River Galma ranges from 1.14 mg/kg to 2.82 mg/kg while Cd concentrations in Galma borehole water ranges from 0.01 mg/kg to 0.08 mg/kg. Pollution Load Index (PLI) in Bomo ranges from 0.92 to 6.39 while in PLI in Galma ranges from 0.32 to 4.96. The study suggests that there are high concentrations of Pb than Cd in Soil and water and high PLI. This calls for intervention of the site quality in order to prevent or reduce the level of pollution as it could be moved up the food chain through bioaccumulation and magnification since these locations are popular for vegetable cultivation.

Keywords: Availability; Degree of Contamination; Contamination Factors; Heavy metals; Pollution Load Index.

INTRODUCTION

The major characteristics of developed countries and primary desires of the third world or developing countries are industrialization and urbanization. These phenomena, known for development of developed countries however pose challenges whose bringing economic solution to its disadvantages has become a global problem (Salager-Meyer, 2008). The increasing degree of industrialization and urbanization has substantially enhanced the degradation of aquatic environments through the discharge of industrial wastewater and domestic wastes (Senthilkumaar *et al.*, 2000). In developing countries such as Nigeria, this has resulted in significant amounts of heavy metal ions deposited into natural aquatic and terrestrial ecosystems, which has also increased the biological cycling of toxic heavy metals (Nilanjana *et al.*, 2008). Modern industry is to a large degree, responsible for contamination of the environment. Lakes, rivers and oceans are being overwhelmed with bacteria and waste matter. Included among toxic substances reaching hazardous levels are also heavy metals (Mudhoo *et al.*, 2012).

Rivers and Lakes have been used by man since the dawn of civilization as a source of water, food, transport, defensive barrier and power to drive machinery and as means of disposal of waste (Mishra and Tripathi, 2007). Advancement in the level of industrialization has led to even more waste discharge in the form of effluents containing heavy metals into our aquatic environment (Jaramillo and Restrepo, 2017). In fact Industrial discharges have been identified as a major component of water pollution (Nasruallah *et al*., 2006).

Heavy metals are defined as those metals with densities greater than $5gcm^{-3}$. Heavy metals occur naturally in the ecosystem, most of them in trace quantities (Kidd *et al*., 2015). Depending on their concentrations, some of them like Zn, Fe, Mn and Cu are essential plant nutrients (An'ongo *et al*., 2005; Bako *et al*., 2005), others like Pb, Hg and Cr do not have any known use to plants. In Kaduna River, heavy metals such as Iron (Fe), Cobalt (Co), Cadmium (Cd), Mercury (Hg) and Argon (Ar) were recorded in the surface water in very high concentrations (Sani *et al*., 2011). The concentration of Fe, Cu, Zn and Pb in the upper Kubanni Basin in high concentrations above recommended standards for drinking have also been revealed

(Raji*et al*., 2010). River Galma and Bomo Lake in Zaria are good examples of aquatic ecosystems that are exposed to heavy metals contamination as they serves as locations were wastes and gabages were disposed which includes sources of these heavy metals. River Galma and Bomo Lake are used as sources of both domestic drinking water and water for irrigated agriculture over the years.

One of the anthropogenic sources of metals in surface water includes domestic waste and garbage, therefore the metals find their way into the soil they may be bioaccumulated in the plants and the food chain (Jentschke and Godbold, 2000). Heavy metals occur naturally in the ecosystem with large variations in concentrations. In Bomo Lake and River Galma, anthropogenic sources of heavy metals, i.e. pollutions from the activities of humans such as deposition of wastes and contaminants which serves as sources of heavy metals have introduced some of these heavy metals into the water bodies.

Soil is considered as the upper part of the earth crust that supports plant growth (Ndiokwere, 2003). Heavy metals are persistent contaminants of irrigation soils in Bomo and Galma and water from Bomo Lake and River Galma. The soils and water polluted with such heavy metals in the locations can affect both the yield of crops and their composition (Rashad and Shalaby, 2007).

Many indices have been used to indicate the level of exposure to these heavy metals in plants and animals. These indices include; Contamination Factor, the degree of contamination (C_d), metal pollution index (MPI), the Pollution Load Index (PLI) and Nemerow pollution index (PI_N). These factors are associated with vegetables, soil and water (USEPA, 1989). World Health Organization (WHO) estimates that about a quarter of the diseases facing mankind occur due to prolonged exposure to environmental pollution which includes heavy metal contamination (Kimani, 2007).

The research was designed to assess the availability and degree of contamination of heavy metals in soils and water of Bomo and Galma irrigation farm lands, Zaria, Kaduna State, Nigeria.

MATERIALS AND METHODS

Study Area

The study was carried out at four irrigation farms located in Bomo (latitude 1º 11'N and longitude 7º 38' E) and Galma (latitude 10º 25' and longitude 7º 31') in Zaria (latitude 11º3' North and longitude 7º42' East and at about 660M above sea level) Kaduna State, Nigeria. The research was carried out for a period of six (6) months: three (3) months peak of dry season (February to April) and three (3) months peak of wet season (July to September), 2018. Heavy metal concentrations were compared between the two locations (Bomo and Galma) and the two seasons (dry and wet seasons). In this research, the following notations were used; B1- indicates Bomo irrigation farm treated with water from Bomo Lake. B2-Bomo irrigation farm treated with borehole water (Control). G1-Galma irrigation farm treated with water from River Galma. G2-Galma irrigation farm treated with borehole water (Control).

Soil Sample Collection and Preparation

Monthly soil samples were collected at a depth of 0-15 cm using a soil auger. The samples were packaged in clean polythene bags and properly labeled. The samples were collected in two replicates at distance of 0cm to 30cm as described by Bako *et al*. (2014). The samples were crushed with the aid of porcelain mortar and pestle and then sieved through a 2.0mm mesh as described by Iyaka (2007).

Water Sample Collection and Preparation

Monthly water samples were collected directly into plastic bottles (polyethylene) with a size of 500 mL. The samples were collected in two replicates. The samples were preserved by acidification to pH < 2 with 0.1M HNO_3 and stored in ice-packed coolers to prevent growth of micro-organisms for subsequent chemical digestion.

Soil and Water Samples Digestion

About 5.0 g of soil and 100ml of water samples were transferred separately to a 25 ml conical flask; 10 ml of concentrated HNO_3 acid and 5 ml of concentrated HCl in ratio 2:1 were added and heated on a hot plate making sure the sample did not boil, until the volumes were reduced to about 15ml. The samples were then allowed to cool, filtered and quantitatively transferred into a 100ml standard volumetric flask and made up to mark with distilled water and further analyzed using A.A.S. as described by APHA (2000).

Determination of Heavy Metal Concentrations in Soil and Water

Concentrations of Pb and Cd in the filtrate of digested soil and water samples were analyzed by using Atomic Absorption Spectrophotometer (A.A.S.). The Instrument conditions and specifications are: Lead – wavelength 283.3 nm, slit 0.7 nm, atomization 2000ºC, read time 3 s, sample volume 10 µl, modifiers volume 20 µl. Cadmium – wavelength 228.8 nm, slit 0.7 nm, atomization 1 550ºC, read time 3 s, sample volume 10 µl, modifiers volume 20 µl.

The Contamination Factor of the Heavy Metals

The Contamination Factor was calculated as the ratio between metals effectively measured by chemical analysis to the reference value as described by Obasi *et al*. (2012). The reference standards used in the calculation was the Federal Environmental Protection Agency (FEPA, 1997) target value.

Contamination Factor = $\frac{\text{Concentration of metal in soil}}{\text{Standard recommended maximum value in soil}}$ (Liu *et al*., 2005)

Contamination Factor is used to determine the contamination status of the soil. The intensity of contamination is reflected on a scale with zero indicating no contamination, 1 none to medium, 2 moderate, 3 moderate to strong, 4 strong, 5 strong to very strong, and 6 high contamination (Nafiu, 2010).

Pollution Load Index (PLI)

The Pollution Load Index (PLI) was described by Tomlinson *et al*. (1980) and was calculated as the geometric means of contamination factors (CF), using the formula;

$$PLI = \frac{(CF_1 \times CF_2 \times CF_3 \times \ldots\ldots \times CF_N)}{N}$$

Where Nis the number of metals studied and CF is the contamination factor calculated. The PLI is used to give an estimate of the metal contamination status and the necessary action that should be taken. A PLI < 1 denote perfection; PLI = 1 showed that only baseline levels of pollutants are present and PLI > 1 would indicate deterioration of site quality (Tomlinson *et al*., 1980). In this study, we proposed that a PLI value of ≥1 indicates an immediate intervention to ameliorate pollution, 0.5 ≤ PLI < 1 suggests that more detailed study is needed to monitor the site, whilst a value of < 0.5 indicates that there is no need for drastic rectification measures to be taken.

The Degree of Contamination (C_d) of the Heavy Metals

The degree of contamination in soil by metals was calculated based on the method described by Håkanson (1980) as shown below:

$$Cd = \sum_{i=1}^{N} CF_i$$

Where *N* is the number of elements analyzed and *CF* is the contamination factor calculated.

The aim of calculating contamination factor is to provide a measure of the degree of overall contamination of surface layers in sampled areas. However, the formula by Håkanson (1980) is limited to the seven specific metals (As, Cd, Cu, Cr, Hg, Pb, Zn) and the persistent organic pollutant.

The assessment of soil contamination was carried out using the contamination factor and the degree of contamination, based on four classification categories as described by Håkanson (1980) (Tables 1).

Table 1: Degree of Contamination Categories and Interpretation

C_d Classes	Interpretation
C_d<8	Low indicating low contamination
C_d≥8<16	Moderate
C_d≥16<32	Considerable
C_d≥32	Very high

Key: < -Less than. ≤ -Less than or equal to. ≥ - Greater than or equal to.

Nemerow Pollution Index (PI_N)

The overall pollution status of the surface soils by the heavy metals was assessed by the Nemerow pollution index (PI_N) (Cheng *et al*., 2007):

$$PI_N = \sqrt{\frac{PI^2_{ave} + PI^2_{i\max}}{2}}$$

Where PI_{ave} and $PI_{i\max}$ are the mean and maximum of the pollution indices for individual heavy metals, respectively. Pollution of the surface soils by the heavy metals was classified based on the corresponding PI_N.

Data Analysis

Data collected from the analysis of Pb and Cd in soil and water were subjected to Analysis of Variance (ANOVA) at 5% level of significance (p<0.05). The analysis was performed using SAS V. 9.2 (2008).

RESULTS AND DISCUSSION

Heavy Metal Concentrations in Soil

The results showed that there are variations in Pb concentrations between locations and seasons. Pb mean concentrations for soil in Bomo irrigation farm using Lake are 6.19 mg/kg and 5.91 mg/kg in dry and wet seasons respectively, mean concentrations higher than soil irrigated with Bomo borehole water which are2.31 mg/kg and 1.82 mg/kg in dry and wet seasons respectively. In soil irrigated using River Galma, mean Pb value are4.03 mg/kg and 3.34 mg/kg in dry and wet seasons respectively, while irrigated with Galma borehole had mean Pb concentrations of 1.67 mg/kg and 1.62 mg/kg in dry and wet season respectively.

Cd concentrations for soil in Bomo irrigation farm using Lake are 0.12 mg/kg and 0.10 mg/kg in dry and wet seasons respectively, mean concentrations higher than soil irrigated with Bomo borehole water which are 0.08 mg/kg and 0.03 mg/kg in dry and wet seasons respectively. In soil irrigated using River Galma, mean Cd concentrations are 0.01 mg/kg and 0.07 in dry and wet seasons respectively, while irrigated with Galma borehole water had Cd concentrations of 0.07 mg/kg and 0.02 mg/kg in dry and wet seasons respectively (Table2).

From the result obtained, concentrations of Cd of all the soil samples under investigation were found to be below the maximum permissible concentration (< 0.2mg/kg) of Cd (FAO/WHO, 2001). This might be due to presence of little sources of Cd in the soil such as phosphate fertilizers, batteries, plating, pigments and plastics. This is in line with the findings of Mido and Satake (2003) that worked on Assessment of Selected Nutrients and Toxic Chemicals in Ethiopian Khat and discovered little concentrations of Cd in the soil which might be attributed to the few sources of Cd in Soil that causes decrease in its availability.

The high concentration of lead in the soil which was found to be above the recommended permissible limits in soils by FAO/WHO (2001) (>0.3 mg/l) could be attributed to the dumpsite and the busy roads in the study areas. This is because in the past lead was used in gasoline and hence a major contributor to lead in soil, and automotive exhaust emitted when gasoline contained lead. This is in line with the findings of Luilo and Othman (2006) who found high levels of lead in soil along the road in Dar es Salaam City, Tanzania. However, these heavy metals were found to be higher in dry season than wet season. This may be due to slow movement of water in the soil and the possible high absorption ability of the heavy metals by the soil.

Table 2: Mean Variations of Heavy Metal Concentrations (mg/kg) of Soil in Bomo and Galma

Locations	**B1**		**B2**		**G1**		**G2**	
Heavy Metals	**Pb**	**Cd**	**Pb**	**Cd**	**Pb**	**Cd**	**Pb**	**Cd**
Dry Season	6.19±0.97	0.12±0.00	2.31±0.23	0.08±0.00	4.03±0.79	0.10±0.00	1.67±0.00	0.07±0.00
Wet Season	5.91±0.97	0.10±0.00	1.82±0.02	0.03±0.00	3.34±0.79	0.07±0.00	1.62±0.00	0.02±0.00
Mean	**6.05±0.97**	**0.11±0.00**	**2.07±0.13**	**0.06±0.00**	**3.69±0.79**	**0.09±0.00**	**1.65±0.00**	**0.05±0.00**
FAO/WHO	**0.30**	**0.20**	**0.30**	**0.20**	**0.30**	**0.20**	**0.30**	**0.20**

KEY: B1-Bomo irrigation farm treated with water from Bomo lake.B2-Bomo irrigation farm treated with borehole water (Control). G1-Galma irrigation farm treated with water from river Galma. G2-Galma irrigation farm treated with borehole water (Control).

Pb-lead, Cd- cadmium. **-Highly Significant difference.

FAO/WHO (Food and Agricultural Organization/World health Organization) 2001- Permissible limit for soil.

Note: Means with the same superscripts along the same column are not significantly different (P≥0.05).

Heavy Metal Concentrations in Water

The results showed that there are variations in Pb concentrations between locations and seasons. Pb concentrations for water in Bomo Lake are 3.09 mg/kg and 2.07 mg/kg in dry and wet seasons respectively, mean concentration higher than water in Bomo borehole which are 1.54 mg/kg and 1.47 mg/kg in dry and wet seasons respectively. River Galma water had a mean Pb concentrationsof2.82 mg/kg and 2.13 mg/kg in dry and wet seasons respectively, while Galma borehole water had Pb mean values of of 1.18 mg/kg and 1.14 mg/kg in dry and wet season respectively.

Cd concentrations for Bomo Lake water are 0.09 mg/kg and 0.06 mg/kg in dry and wet seasons respectively, mean concentrations higher than water in Bomo borehole which are 0.07 mg/kg and 0.02 mg/kg in dry and wet seasons respectively. Water from River Galma had mean Cd values of 0.08 mg/kg and 0.03 in dry and wet seasons respectively, while Galma borehole water had Cd concentrations of 0.03 mg/kg and 0.01 mg/kg in dry and wet seasons respectively (Table 3).

The results obtained in this work both in the water from Bomo Lake and River Galma and borehole water (control) were higher than the maximum allowable limit for Pb in drinking water (>0.01 mg/l) (WHO, 1984) and were lower than recommended maximum concentrations of trace elements (heavy metals) in irrigation water for water continuously used on soil (<5.00 mg/l) as well as for water used up to 20 years on 5 textured soil (<10.00 mg/l). This shows that the water (water from lake, river and borehole water) are not suitable for drinking but are recommended for irrigation (FAO/WHO, 2001).

Low Cd in the water (water from lake, river and borehole water) may be due to the reuse of chip resistors, infrared detectors and semi-conductors at the markets. Therefore, few of the items containing Cd may be burned or discarded to e-waste dumps. The results also showed that both water from River Galma, Bomo Lake and borehole water (control) were higher than the maximum allowable limit for Cd in drinking water (>0.003mg/l) (WHO, 1993).

Table 3: Mean Variations of Heavy Metal Concentrations (mg/kg) of Water from Bomo and Galma

Locations	**B1**		**B2**		**G1**		**G2**	
Heavy Metals	**Pb**	**Cd**	**Pb**	**Cd**	**Pb**	**Cd**	**Pb**	**Cd**
Dry Season	3.09±0.03	0.09±0.01	1.54±0.00	0.07±0.00	2.82±0.03	0.08±0.00	1.18±0.01	0.03±0.00
Wet Season	2.07±0.03	0.06±0.00	1.47±0.02	0.02±0.00	2.13±0.04	0.03±0.00	1.14±0.02	0.01±0.00
Mean	**2.58±0.03**	**0.08±0.01**	**1.51±0.01**	**0.05±0.00**	**2.48±0.04**	**0.06±0.00**	**1.16±0.02**	**0.02±0.00**
FAO/WHO1	**5**	**0.01**	**5**	**0.01**	**5**	**0.01**	**5**	**0.01**
FAO/WHO2	**10**	**0.05**	**10**	**0.05**	**10**	**0.05**	**10**	**0.05**

WHO	**0.01**	**0.003**	**0.01**	**0.003**	**0.01**	**0.003**	**0.01**	**0.003**

KEY: B1-Bomo Lake water. B2-Bomo borehole water (Control). G1-Galma River water. G2-Galma borehole water (Control).
Pb-Lead, Cd- Cadmium **-Highly Significant difference, ns- Non- Significant.
FAO/WHO1 (Food and Agricultural Organization/World health Organization) 2001-Recommended maximum concentrations of heavymetals in irrigation water for water continuously used on soil.
FAO/WHO2 (Food and Agricultural Organization/World health Organization) 2001-Recommended maximum concentrations of heavymetals in irrigation water for water used up to 20 years on five texture soil, pH: 6.0-8.5.
WHO (/World health Organization) 1993-Drinking Water Quality guidelines.
NOTE: Means with the same superscripts along the same column are not significantly different ($P \geq 0.05$).

The Contamination Factors (CF) of the Heavy Metals

The CF of Pb using Lakes (20.18) and Rivers (12.29) were higher than using borehole waters (6.88 and 5.49), this showed higher contamination of Pb using open water as source of irrigation than borehole waters. While that of Cd were less than 1, indicating no contamination in Lake, Rivers and borehole waters (Table 6).

The Contamination Factor (CF) of the two study areas including the controls with contamination factor approximately less than zero (0) had no contaminations of cadmium in Bomo irrigation farm land treated with borehole water in the months of February to September (all the months), Galma irrigation farm land treated with water from River Galma in the months of July to September, Galma irrigation farm land treated with borehole water in the months of February to September (all the months). The result also showed that there was medium contamination of cadmium (with contamination factor of 1) in Bomo irrigation farm land treated with water from Bomo Lake in all the months. Galma irrigation farm lands treated with water from River Galma from February to April. There was strong to very strong contamination of lead (with contamination factor of 5) in Galma irrigation farm land treated with borehole water from July to September. While there was highly contamination of lead (with contamination values of 6 and above) in Bomo irrigation farm land treated with water from Bomo Lake and borehole water in all the months, Galma irrigation farm land treated with water from River Galma in all the months and Galma irrigation farm land treated with borehole water in the months of March and April. This suggested that areas with high contamination contain high level of pollution of the heavy metal. These results is in line with the findings of Nafiu (2010) who reported different contamination factors of trace metals in urban soil under long term waste water irrigation in Kano and discovered that the soil with CF values above 6 was regarded as highly contaminated.

Table 6: Contamination Factor (CF) of the heavy metals

Locations	**B1**		**B2**		**G1**		**G2**	
Heavy Metals	**Pb**	**Cd**	**Pb**	**Cd**	**Pb**	**Cd**	**Pb**	**Cd**
Dry Season								
February	19.77	0.55	6.67	0.33	13.30	0.50	5.53	0.25
March	20.50	0.60	7.03	0.35	13.33	0.50	5.57	0.35
April	21.67	0.70	9.37	0.45	13.67	0.50	5.57	0.40
Mean	**20.65**	**0.62**	**7.69**	**0.38**	**13.43**	**0.50**	**5.56**	**0.33**
Wet Season								
July	19.73	0.55	6.33	0.20	11.97	0.45	5.47	0.15
August	19.70	0.50	6.13	0.20	11.13	0.35	5.40	0.15
September	19.70	0.50	5.73	0.05	10.33	0.30	5.37	0.05
Mean	**19.51**	**0.52**	**6.06**	**0.15**	**11.14**	**0.37**	**5.41**	**0.12**

KEYS- B1-Bomo irrigation farm treated with water from Bomo Lake. B2-Bomo irrigation farm treated with Borehole water (Control).G1-Galma irrigation farm treated with water from river Galma. G2-Galma irrigation farm treated with Borehole water (Control). Pb-lead, Cd- cadmium.

Pollution Load Index (PLI)

The PLI for Bomo and Galma using open waters were higher (5.68 and 2.71) than borehole waters (0.97 and 0.62). This is quite clear that open waters have higher concentrations of the heavy metals than borehole waters (Table 4).

The pollution load Index of the two study areas including the controls indicates that PLI< 1 showed perfection and this was found in Bomo irrigation farm lands treated with borehole water in the month of September and also Galma irrigation farm land treated with borehole water in the months of July, August and September with values ranged from 0.13 to 0.41. This suggested that more detailed study is needed to monitor the sites so as to prevent the contamination load. PLI = 1 was found in Bomo irrigation farm land treated with borehole water in the months of February, March, July and August. Galma irrigation farm land treated with borehole water in the months of February to April. This showed that only baseline level of pollutants is present and also an immediate intervention to ameliorate the pollution source. This finding is in line with tfindings of Alfred *et al*. (2013) who investigated the pollution load index of some heavy metals in Eastern Botswana and discovered PLI = 1 which was an indication of the baseline level of pollution in the soil. PLI> 1 was found in Bomo and Galma irrigation farm lands treated with water from Lake and River in all the months with values ranged from 1.55 to 7.58. This result (PLI> 1) indicates that there is need for intervention of the site quality in order to prevent or reduce the level of pollution as it will affect the plants and animals through direct or indirect contact with the source of the pollution. Alfred *et al*. (2013) reported similar findings of PLI> 1 and discovered that the heavy metals do not only becomes toxic to plants but also causes deterioration of soil quality.

Table 4: Pollution Load Index (PLI)

Locations	B1	B2	G1	G2
Dry Season				
February	5.44	1.10	3.33	0.69
March	6.15	1.23	3.33	0.97
April	7.58	2.11	3.42	1.11
Mean	**6.39**	**1.48**	**3.36**	**0.92**
Wet Season				
July	5.43	0.63	2.69	0.41
August	4.73	0.61	1.95	0.41
September	4.73	0.14	1.55	0.13
Mean	**4.96**	**0.46**	**2.06**	**0.32**

KEYS- B1-Bomo irrigation farm treated with water from Bomo Lake. B2-Bomoirrigation farm treated with borehole water (Control).G1-Galma irrigation farm treated with water from River Galma. G2-Galma irrigation farm treated withborehole water (Control).

The Degree of Contamination (C_d)

Open waters (Lakes and Rivers) are more contaminated (20.75 and 12.72) than borehole waters (7.14 and 5.71). This is an indication that open waters are exposed and borehole waters are not (Table 5).

Bomo irrigation farm lands treated with water from the Lake have considerable contaminations in all the months with degree of contamination value of less than or equal to 16 to less than 32. Håkanson (1980) uses similar degree of contamination scale to categorized the level of contaminations in his work and discovered degree of contamination values of 16 to less than 32 and suggested that the area has considerable contaminations which may be due to the recent increase in major industrial (in the coastal areas) and a minor harbor activity that involves movement of naval vessels throughout the year may increase the contamination levels in coastal areas. Therefore, the results obtained indicated that to some extent, there were considerable degree of contaminations with both lead (Pb) and cadmium (Cd) in the study Bomo irrigation farm lands treated with water from the Lake. Moreover, those study areas that have high and very high degree of contamination values suggests that the soil found in those areas may be polluted due to higher accumulation of heavy metals, this was similar with the findings of Alfred*et al*. (2013) who worked on the Assessment of heavy metal enrichment and Degree of Contamination around the Copper-Nickel Mine in the Selebi Phikwe Region, Eastern Botswana and discovered very high degree of contamination values in the study area which could be attributed to the high level of pollution of the soil.

Table 5: Degree of Contamination (C_d) of Heavy Metals

Locations	B1	B2	G1	G2
Dry Season				
February	20.32	7.00	13.80	5.78
March	21.10	7.38	13.83	5.92
April	22.37	9.82	14.17	5.97
Mean	**21.26**	**8.07**	**13.93**	**5.89**
Wet Season				
July	20.28	6.53	12.42	5.62
August	20.20	6.33	11.48	5.55
September	20.20	5.78	10.63	5.42
Mean	**20.23**	**6.21**	**11.51**	**5.53**

KEYS- B1-Bomo irrigation farm treated with water from Bomo Lake. B2-Bomo irrigation farm treated with Borehole water (Control). G1-Galma irrigation farm treated with water from river Galma. G2-Galma irrigation farm treated with Borehole water (Control).

Nemerow Pollution Index (PI_N)

The nemerow pollution index for Pb in Bomo and Galma were higher (4.57 and 3.60) in Lakes and River respectively than borehole waters (2.85 and 2.35). General findings also holds true for Cd (Table 7).

The soil from areas which had PI_N values ranged from 0.57 to 0.80 indicates that the soils were in good quality in general and these are soils that had cadmium concentrations in all the study areas irrigated with water from Lake, River and borehole water (control), while PI_Nvalues ranged from 2.35 to 4.57 indicates an overall slight pollution by heavy metals occurred in the areas and are the soils found to have concentrations of lead in all the study areas irrigated with Lake and River waters as well as borehole water (control). This shows that soil contaminated with lead from all the study areas irrigated with Lake and River waters and borehole water had high PI_N values and is polluted while soil with cadmium had low PI_N values and was unpolluted. The highest pollution level found in those areas contaminated with lead could be attributed to vehicular emissions and other pollutants that serve as a major source of heavy metal. These observations were in line with the findings of Yuanan *et al*. (2013) who worked on Assessing heavy metal pollution in the surface soils of a region that had undergone three decades of intense industrialization and urbanization in china and found out similar results and discovered some heavy metals such as Pb had high PI_N values and suggested that the soil is polluted with such heavy metals.

Table 7: Nemerow Pollution Index (PI_N)

Locations	B1		B2		G1		G2	
Heavy Metals	Pb	Cd	Pb	Cd	Pb	Cd	Pb	Cd
PI_N	4.57	0.80	2.85	0.60	3.60	0.69	2.35	0.57

KEYS- B1-Bomo irrigation farm treated with water from Bomo lake. B2-Bomo irrigation farm treated with borehole water (Control).G1-Galma irrigation farm treated with water from river Galma. G2-Galma irrigation farm treated with borehole water (Control). Pb-lead, Cd- Cadmuim.

CONCLUSIONS

The results revealed that Pb concentrations in soil were higher than the recommended permissible limit for soil while Cd concentrations were below in Bomo and Galma. Pb concentrations in irrigating water were found to be lower than recommended maximum concentrations of heavy metals in irrigation water for water continuously used on soil and recommended maximum concentrations of heavy metals in irrigation water for water used up to 20 years on five texture soil, but higher than drinking water quality guidelines while Cd concentrations in irrigating water were found to be higher than recommended maximum concentrations of heavy metals in irrigation water for water continuously used on soil, some below recommended maximum concentrations of heavy metals in irrigation water for water used up to 20 years on five texture soiland all lower than drinking water quality guidelines. Application of the pollution load indices, degree of contamination, index of contamination factor and Nemerow pollution indices clearly indicates that all of the soil samples were categorized in low to considerable degree of contamination and as such Bomo and Galma irrigation soil were polluted.

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CONFLICT OF INTEREST

There is no conflict of interest.

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