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Research Article

Assessment of Heavy Metal Status on Soil around Aquaculture Farmlands in Makurdi Metropolis, Nigeria

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Abstract

The present study has focused on the investigation of metal composition of soil used in earthen pond construction in Makurdi, Nigeria. Soil samples at two depths (0-20 cm, 20-40 cm) were collected at six fish farm locations and at a control site in Makurdi. Sample collection was done in March and August, 2018 to reflect both dry and rainy seasons. Samples were pre-treated, digested by aqua regia (Acid mixture of 10 ml HNO_3 and 3 ml $HClO_4$) and the resulting solution analyzed for the presence of iron, zinc, copper, manganese, lead, nickel, cadmium and chromium using atomic absorption spectrophotometer. Results indicated that all the metals were detected in the locations except for lead, nickel and cadmium which were not detected at Wadata, North Bank Market and Wurukum farm sites. The concentrations of the metals in soils in both seasons ranged from 12.61-21.80 ppm for Iron; 1.06-3.83 ppm for zinc; 0.76-2.98 ppm for copper; 0.79-3.29 ppm for manganese; 1.99-8.99 ppm for lead; 0.71-11.11ppm for Nickel; 0.64-3.18 ppm for Cadmium and 0.61-6.82 ppm for Chromium. Analysis of variance (ANOVA) at 5% significance level revealed that, there was no significant difference between dry and wet seasons results but some significant differences ($P<0.05$) were observed for Lead concentration in fish farms and the control while other metals show no significant differences. Finally, the concept of pollution index (PI) of soils was applied to determine the extent of multi-element contamination in pond water. Fish farm site along Naka road recorded the highest (8.64) PI value while the control site has the least (0.22). The results, however, revealed that the soils were predominantly slightly contaminated with these metals and could pose serious health hazard to aquatic organisms and human especially through food chain. Therefore, to minimize heavy metal load of soils used in pond construction and its consequent effect on aquatic organism, adequate test should be done to ascertain the current status of the soil. Provisions of enabling statutory regulations on waste management are also suggested.

Keywords: Heavy metal; Farmlands; Multi-element contamination; Pollution index.

Introduction

Environmental pollution by heavy metals which adversely affect soil quality and pose a threat for aquatic resources requires a rapid and comprehensive solution. Many pollutants of anthropogenic sources can contaminate the soil and water environment, including inputs from waste waters flowing from waste storage, mines, atmospheric deposition and runoff of pesticides from agricultural land [1].

Human activities create wastes and it is the way these wastes are handled, stored, collected and disposed off, that contributes risks to the environment and public health. In the urban areas, especially, in the rapidly urbanizing cities of the developing world, problems and issues of solid waste management are of immediate importance. This has been acknowledged by most governments. However, rapid population growth overwhelms the capacity of most municipal authorities to provide even the basic services [2].

Effect of Heavy metal contamination has become a serious challenge in Nigerian cities. The African Journal of Environmental Science and Technology reported lead poisoning as one of the top ten environmental challenges in Africa [3]. Soil, air and water Pollution has become a major factor in the introduction of heavy metals, such as lead, cadmium, and mercury in

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foodstuff. Advances in agricultural chemicals from rapid industrial growth or the urban activities of human beings contribute to the presence of heavy metals in the ecosystem [4].

Municipal solid wastes include wastes generated from residential, commercial, industrial, institutional, construction, demolition processes and municipal services. Residential single and multi-family dwellings generate food wastes, paper, cardboard, plastics, textiles, leathers, yard wastes, wood, metals, ashes, special wastes (such as bulky items, consumer electronics, white goods, batteries.) and household hazardous wastes. Commercial stores, hotels, restaurants, markets generate paper, cardboard, plastics, food wastes, wood etc [2]. Increasing industrialization has been accompanied throughout the world by the extraction and distribution of mineral substances from their natural deposits.

In the process of mining and smelting activities, many kinds of risk elements enter the environment, causing serious environmental problems. Groundwater contamination by heavy metals is often associated with waste from dump sites. Heavy metals enter the surface water in dissolved form and in association with substances washed off the ground, where they can migrate over long distances [5]. Polluted water sources may become the source of undesirable substances, which are dangerous for aquatic organisms and human health causing various cancers, cardiovascular or neurological diseases [6]. Water contamination by heavy metals is a significant problem, which leads to changes of water characteristics and limits productive and environmental functions. Polluted waters are no longer appropriate for aquaculture production, because they are unable to produce healthy food. Assessment of water pollution by heavy metals in Slovakia is determined by limit values of risk elements, which were set by law [7]. It has been repeatedly shown that heavy metals have a negative impact not only on the size, activity and diversity of aquatic microbial communities [8], but they also affect water enzymes [9]. Microbial activity is a reliable indicator reflecting the biological situation in water and it is possible to very quickly obtain credible results of water pollution.

Reaction of aquatic organisms to pollution is faster in comparison with monitoring of the chemical and physical properties [5]. Agricultural activities in the Makurdi area have influenced the geological landscape structure (formation of mines, heaps of waste material, and ponds of sewage sludge) but predominantly caused pollution of the environment. Produced waste material was stored on the numerous heaps and in the tailing pond. The aim of the study was to determine the level of soil pollution by heavy metals according to the index of geoaccumulation.

Material and methods

Study area

Makurdi, the capital of Benue state, is fast becoming a metropolitan centre with attendant health, social housing and environmental problems. The town lies between latitude 7^o 15' and 7^o 45' N and longitude 8^0 15' and 8^0 40' E. The town is also in the guinea savannah vegetative belt and on the bank of the second largest river in Nigeria, River Benue. The population of the town is fast growing, though without major industries and factories. The sudden influxes of commercial and developmental activities have resulted to rapid urbanisation and hence increase in population. This has led to high waste generation. The scaled map of Benue State is shown in Figure 1.

Sampling areas

Soil samples were collected from six farm sites located at various spots within the town, namely: Railway crossing, High level; North Bank Market; Federal University of Agriculture road, North Bank; Community Secondary School, Wadata; Naka road, Makurdi; and Awe Street, Wurukum. A control sample was collected from Federal University of Agriculture Fish farm. The sampling sites randomly spread across the town, reflects fish farm settlement patterns. The sampled sites are presented in Figure 2.

Field techniques

Sampling was carried out at two different periods in March and August 2018, representing the dry and wet seasons respectively. Six (6) sites within Makurdi town were chosen for sampling. Samples were collected at each sampling site by using a clean hand trowel at a depth of 0-20 cm and 20-40 cm. Sample sizes of about 250 g were collected at each sampling point. The samples were immediately stored in polythene containers and appropriately labelled for each site. A total of seven soil samples were collected at depths of 0-20 cm and seven also for depths of 20-40 cm. These gave a total number of 14 soil samples collected.

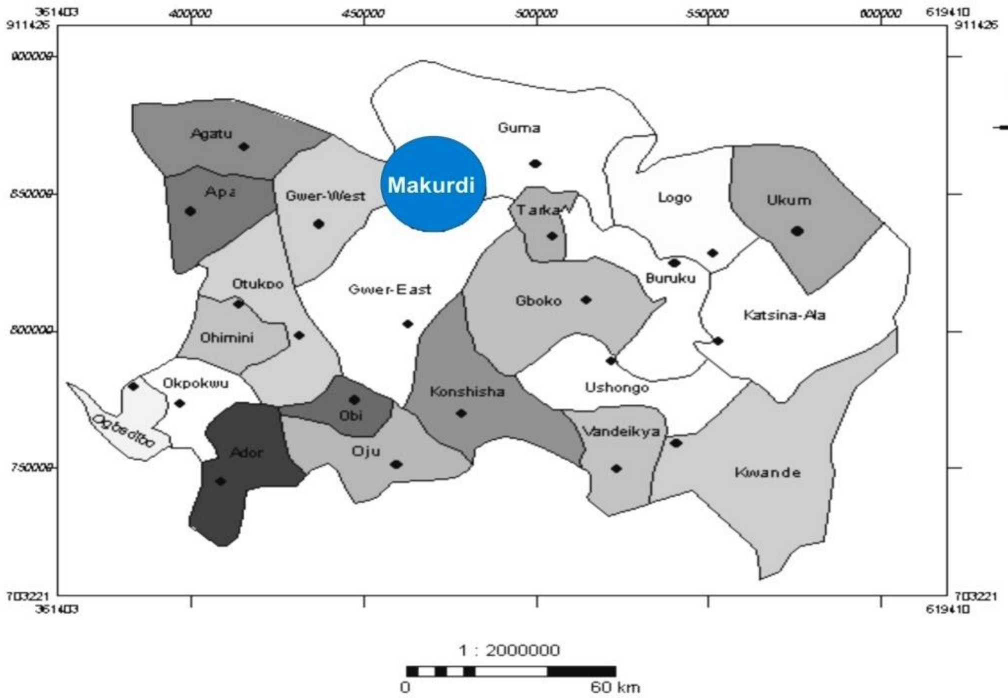

Figure 1. Map of Benue state showing Makurdi, the study area

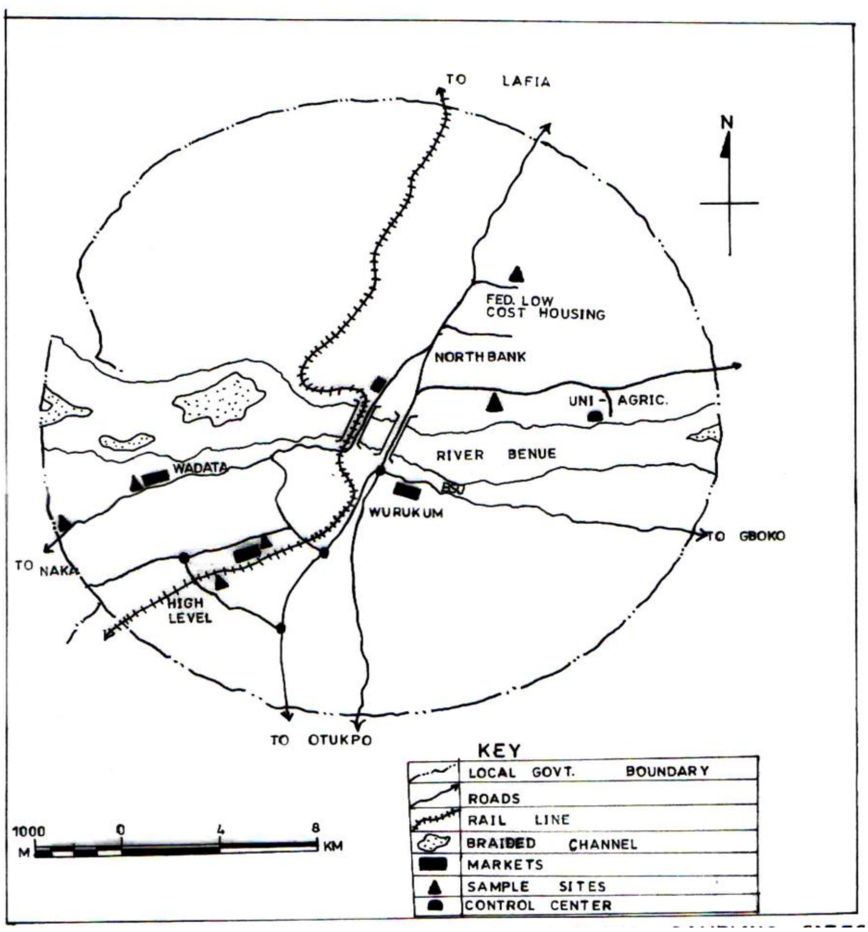

Figure 2. Map of Makurdi local government showing sampling sites
Source: Bureau of Land and Survey, Makurdi

Sample preparation

The soil samples were air dried by spreading the soil on polythene sheets placed on aluminium trays and allowed to dry in the laboratory (temperature of 20–30°C). The dried soil was further broken down into fine particles using mortar and pestle and then sieved using an aluminium sieve of 2mm mesh size. Exactly 20 g of the sample was taken and stored in polythene bags and taken to the laboratory for heavy metal analysis.

Determination of Heavy Metals

The soil sample was digested following the method as recommended by Association of Official Analytical Chemist [10]. Exactly 1 g of dried and homogenized soil obtained from each of the sampled site was weighed into a 100 ml beaker and 10 ml of nitric acid was added and the mixture was heated. The heating was continued, followed by the addition of 10 ml of HNO_3, 3 ml of $HClO_4$ at intervals. $HClO_4$ was added and the solution filtered and diluted with water to 50 ml mark. A blank digest was also prepared without the soil sample. The sample solution and the blank solutions were aspirated into UNICAM 919 Atomic Absorption Spectrophotometer after zeroing with de-ionized water. A series of standard solutions of each element under investigation was used to calibrate the instrument prior to the introduction of sample and blank solution. The absorbance readings were those obtained at the wavelength of each element. The concentrations of each element in the soil sample solution were obtained by extrapolation from the standard curve.

Pollution Index (PI)

Metal contamination in the soil is associated with a cocktail of contaminants rather than a single metal. Thus the concept of pollution index (PI) was employed to identify the multi-element contamination resulting in increased overall element toxicity per sampled site. In the present study, the pollution index of soils was computed by the average ratio of elements concentration of soil sampled to tolerate levels of soils for plant growth as suggested by [23]. The modified equation is (1).

$$PI = [(Cd)/0.3 + (Cr)/0.3 + (Cu)/1 + (Pb)/1 + (Zn)/3]/5 \quad (1)$$

Statistical analysis

Analysis of variance (ANOVA) at 5% significant level was used to compare the extent of pollution of heavy metals in the sampled sites under study and the control sites.

Results and discussion

Heavy metal content of the soils

Table 1 shows the results of the heavy metal contents of the soil samples under review collected during the dry season (March, 2018). The results indicated a wide variation in the levels of heavy metals within the soils of the farm sites and with depths. Of all the heavy metals, Lead (Pb), chromium (Cr), nickel (Ni) and cadmium (Cd) were not detected at some of the sites. There was also a wide variation in the levels of metals among the soils sampled. The concentration was more in 0 - 20cm depth and decreases down the profile in both dry and wet season samples. Iron (Fe) was detected in all the sites under study. The least level of concentration was at the control site with values ranging between 10.63 and 13.34 ppm.

The highest level of concentration was at Federal Housing North Bank with a range of 20.57 to 24.44 ppm, followed by the site at Wadata (10.69 to 22.37 ppm). Copper (Cu) was detected in all the sites were the metal was analyzed. The concentration of copper was lowest at the control site with values ranging between 0.33 and 1.52 ppm, followed by Wurukum site with values ranging between 0.84 to 1.57 ppm. Low concentration of copper was also recorded at the North-Bank Market with values ranging between 0.96 and 1.62 ppm. Farm sites at Wadata, Federal housing, North-Bank and High-level showed concentrations of 1.94 to 2.10 ppm, 1.16 to 2.45 ppm and 1.18 to 2.58 ppm. The highest level of concentration was along Naka road with a range of 1.32 to 3.21 ppm. Zinc (Zn) was also detected in all the sites under study. The least level of concentration was at the control site which value ranged between 0.14 and 1.17 ppm. Zinc showed high levels of concentration along Naka road (0.89 to 2.30 ppm), Wadata site (0.80 to 2.82 ppm), North-Bank, Market (1.79 to 2.84 ppm). The highest level of zinc was recorded at Wurukum site with a range of 2.02 to 5.07 ppm, followed by High-level waste site with a range of 0.13 to 3.58 ppm and lastly Federal Housing North-Bank with a range of 0.56 to 3.49 ppm.

Manganese (Mn) was detected in all sites under study. The least value of manganese was detected at the control site which ranged from 0.26 to 1.31 ppm, followed by site at North-Bank Market (0.89 to 1.29 ppm) and Wadata (0.47 to 1.44 ppm). Other sites had High-levels of concentrations such as High-level (1.40 to 2.58 ppm), Federal Housing North-Bank (1.39 to 2.78 ppm) and Wurukum (0.97 to 2.93 ppm). Farm site along Naka road had the highest level of concentration (1.97 to 3.64 ppm). Lead (Pb) was not detected at Wadata, North-Bank Market and at the control site. The least level of concentration was at Wurukum which value ranged between 1.52 to 2.51 ppm. Lead showed strong level of detection along Naka road (5.82 to 6.42 ppm) and at High-level (7.42 to 8.64 ppm). It was highest at Federal housing North-Bank with a range of 8.45 to 11.98 ppm. Nickel (Ni) was not detected at Wadata and Wurukum. It level of concentration was low at the control site with a range of 0.46 to 1.24 ppm.

Nickel showed strong level of detection at Federal Housing North-Bank with a range of 5.24 to 7.40 ppm, High-level (2.05 to 4.53 ppm) and North-Bank market (0.98 to 2.08 ppm). Sites along Naka road showed strong nickel presence with values ranging from 10.60 to 12.52 ppm. Cadmium (Cd) was not detected at Wurukum and at the control site. The least level of cadmium concentration was at Wadata (0.45 to 1.06 ppm) and North-Bank Market (0.71 to 1.52 ppm). Cadmium showed High level of concentration at Federal housing North-Bank (0.86 to 2.41 ppm), High-level (1.54 to 3.01 ppm) and along Naka road (1.91 to 3.25 ppm). Chromium (Cr) was not detected at the control site. In other sites were the metal was analyzed, it showed low level of concentration, with the lowest at North-Bank Market (0.43 to 0.87 ppm). At Wurukum, the level of concentration ranged from 0.13 to 0.98 ppm, Wadata (0.94 to 1.16). Chromium showed high concentration at Federal housing North-Bank with a range of 3.09 to 5.42 ppm and at High-level (4.30 to 6.96 ppm). The Highest level of chromium concentration was along Naka road with a range of 5.14 to 7.36 ppm.

Table 1. Heavy metal concentration (ppm) of soils at the various sampled sites collected in March, 2018 (dry season)

Sample Sites	Soil depth cm	Heavy metals (ppm) Fe	Zn	Cu	Mn	Pb	Ni	Cd	Cr
Federal Housing N/Bank	0 – 20	24.44	3.49	2.45	2.78	11.98	7.40	2.41	5.42
	20 - 40	20.57	0.56	1.16	1.39	8.45	5.24	0.86	3.09
Wadata	0 – 20	22.37	2.82	2.10	1.44	ND	ND	1.06	1.16
	20 - 40	10.69	0.80	1.94	0.47	ND	ND	0.45	0.94
Along Naka Road	0 – 20	23.53	2.30	3.21	3.64	6.42	12.52	3.25	7.36
	20 - 40	19.31	0.89	1.32	1.97	5.82	10.60	1.91	5.14
Wurukum	0 – 20	18.67	5.07	1.57	2.93	2.51	ND	ND	0.98
	20 -40	16.29	2.02	0.84	0.97	1.52	ND	ND	0.13
High Level	0 – 20	19.16	3.58	2.98	2.58	8.64	4.53	3.01	6.96
	20 - 40	15.84	0.13	1.18	1.40	7.42	2.05	1.84	4.30
North Bank Market	0 – 20	17.76	2.84	1.62	1.29	ND	2.08	1.52	0.87
	20 - 40	13.94	1.79	0.96	0.89	ND	0.98	0.71	0.43
Uni- Agric (Control)	0 – 20	13.34	1.17	1.52	1.31	ND	1.24	ND	ND
	20 - 40	10.63	0.14	0.33	0.26	ND	0.46	ND	ND

ND = Not Detected (Below instrument detection limit)

Table 2 shows the concentration (ppm) of analyzed metals of Sample sites in Makurdi collected in August, 2018. Iron (Fe) was detected in all the soils analyzed for this study. The least level of concentration was at the control site with a range of 8.63 to 13.41 ppm; followed by Wurukum (14.51 to 16.74 ppm). At North-Bank Market, the level of concentration ranged from 15.02 to 18.45 ppm. Iron showed high levels of concentration at High-level (19.30 to 20.72 ppm), Wadata (17.98 to 20.66ppm) and along Naka road (18.14 to 21.42 ppm). The highest level of iron was detected at Federal housing

North-Bank with a concentration of 19.36 to 22.82 ppm.

Table 2. Heavy metal concentration (ppm) of soils at the various sampled sites collected in august, 2018 (rainy season)

Sample Sites	Soil depth cm	Heavy metals (ppm)							
		Fe	Zn	Cu	Mn	Pb	Ni	Cd	Cr
Federal Housing N/Bank	0 - 20	22.82	6.32	3.32	3.04	8.04	6.98	3.82	4.23
	20 - 40	19.36	4.94	1.06	2.95	7.46	4.96	1.70	1.76
Wadata	0 - 20	20.66	2.84	1.90	1.64	ND	0.95	0.89	2.04
	20 - 40	17.98	1.14	0.94	0.52	ND	ND	0.12	0.52
Along Naka Road	0 - 20	21.42	5.52	4.43	4.48	6.86	11.60	4.65	8.97
	20 - 40	18.14	3.24	2.96	3.09	4.52	9.72	2.89	5.75
Wurukum	0 - 20	16.74	2.43	1.64	2.10	2.01	ND	ND	1.02
	20 -40	14.51	1.06	0.53	0.84	1.94	ND	ND	0.29
High Level	0 - 20	20.72	4.74	3.43	3.62	9.42	4.03	3.88	5.96
	20 - 40	19.30	2.34	1.94	1.54	7.23	3.23	1.62	3.74
North Bank Market	0 - 20	18.45	3.87	2.42	2.98	ND	2.10	1.84	1.29
	20 - 40	15.02	2.54	1.94	1.32	ND	1.06	0.65	0.93
Uni. Agric (Control)	0 - 20	13.41	1.98	1.05	1.42	ND	0.59	ND	ND
	20 - 40	8.63	0.93	0.12	0.18	ND	0.15	ND	ND

ND = Not Detected (Below instrument detection limit

Table 3 shows the results of the mean concentrations (ppm) of analyzed metals in waste dump sites and the control soils collected in March and August, 2018. The table 3 indicated that Fe had the highest mean value of 21.80 in soil sampled from Federal Housing North Bank, and the lowest mean value of 12.61 in Univ. of Agriculture. The same trend was observed in the concentration of Zn and Pb, as they are high in samples obtained from Federal Housing North Bank and low in Univ. of Agriculture. Cu, Mn and Cd were observed to be high in samples from obtained along Naka road. However, Pb was not detected in samples obtained from Wadata, North Bank Market and Univ. of Agriculture. All heavy metals tested during the study were detected in Federal Housing North Bank, Naka road and Railway crossing, High Level while one or more heavy metals were not detected in other sampled sites.

Table 3. Mean concentration (ppm) of analyzed metals in sampled sites in March and August 2018

Sample Site	No. of Samples	Heavy metals (ppm)							
		Fe	Zn	Cu	Mn	Pb	Ni	Cd	Cr
Federal Housing North Bank	4	21.80	3.83	1.99	2.54	8.99	6.15	2.20	3.63
Wadata	4	17.93	1.90	1.72	1.02	ND	0.95	0.64	1.17
Along Naka road	4	20.61	2.99	2.98	3.29	5.91	11.11	3.18	6.82
Wurukum	4	16.56	2.65	1.15	1.72	1.99	ND	ND	0.61
Railway crossing, High Level	4	18.76	2.70	2.39	2.29	8.18	3.46	2.59	5.24
North Bank Market	4	16.29	2.77	1.74	1.62	ND	1.56	1.18	0.88
Univ. of Agriculture	4	12.61	1.06	0.76	0.79	ND	0.71	ND	ND

Table 4 present the results of the pollution index (PI) values for the study sites in Makurdi. The values obtain indicates that all the site except for the control site have PI values greater than 1.00. Federal Housing North Bank had PI value of 6.33, Wadata (1.68), Along Naka road (8.64), Wurukum (1.21), North Bank Market (1.90). All have high PI values indicating their levels of pollution. However these values are higher than 1.00 and also the control site (0.22) which is not polluted. Soil sampled along Naka road recorded the highest PI value of 8.64.

The results of heavy metals' concentration in soils of samples farm sites in Makurdi are presented in Table 1, 2 and 3. The concentrations of metals in soils at the sampled sites and the control site indicated that there is an evidence of relative increase in the concentration of heavy metals in soils at other sampled sites compared to those in soils of the control site. The level of pollution varies from site to site. Some sites were found to be more polluted than the others. The extent of pollution was more on the surface soil (0 – 20 cm depth) than the sub-surface soil (20 – 40 cm depth).This is as a result of the continuous accumulation of the waste on the surface soil.

Table 4. Pollution index (pi) values for sampled sites in Makurdi metropolis

S. No.	Sites	PI
1.	Federal Housing North Bank	6.33
2.	Wadata	1.68
3.	Along Naka Road	8.64
4.	Wurukum	1.21
5.	High Level	7.51
6.	North Bank Market	1.90
7.	Uni. Agric (Control)	0.22

PI > 1.00: indicates polluted or contaminated soil
PI < 1.00: indicates unpolluted or uncontaminated soil.

It was also observed from the results that some metals were not detected in some of the sites including the control site. Lead was not detected in Wadata, North-Bank market and the control site. Nickel was also not detected at Wadata and Wurukum. Cadmium and chromium were also not detected at Wurukum and the control site. Iron, zinc, copper and manganese were found to be present in all the sites under study. This variation is in agreement with the observation of [5] while working on the evaluation of heavy metal pollutants from soils at municipal solid waste deposit in Owerri, Imo State. This difference may be as a result of some sites receiving some specific pollutants while others may be devoid of them.

Iron concentration was observed to be high in all sampled sites. The high concentration of iron at the control site could be attributed to the geochemistry of the metal rather than anthropogenic sources. These high values most probably reflect the general abundances of iron in all environmental system [11]. Iron is fourth in abundance among elements in the earth crust. There was no significant difference between the concentration of iron in soil at all the sampled sites at P (<0.05) implying that the observed concentration of iron in the sites might be due to the natural background concentration of iron in the soil environment. It has been confirmed that natural soils contain significant concentration of iron [12; 13; 14]. Also, concentration of iron in water above 0.3ppm results into a reddish brown tinge, which can cause a bitter taste of beverages and staining of clothes during washing [15; 16]. Iron also forms scales in pipes and boilers, and is capable of blocking pipes or reducing conductivity of the boilers [17].

Manganese was detected in all the sites under review. The least value was recorded at the control site while samples along Naka road recorded the highest value. There was no significant difference between the concentrations of manganese in the sampled sites at 5% probability level. The observed low concentration of manganese in this study might have been largely due to natural concentration. [14] reported that manganese may be found in most soils since it is one of the elements in the earth crust. Deficiency in manganese intake can retard growth, lead to poor bone formation, impair fertility and can even cause birth defects in humans. Excessive exposure to manganese can lead to irreversible brain disease with prominent psychological and neurological disturbances known as Manganism [18].

Zinc (Zn) concentration was high at the Federal Housing and Wurukum. The high zinc concentration at this site could be as a result of the introduction of waste containing zinc such as tyre wear, motor oil, grease, brake emissions, corrosion of galvanized parts into the soil. There was no significant difference between the concentrations of zinc in soils at all the sites sampled at P (< 0.05%). Zinc is a trace element that is essential for human health; when people absorb too little zinc, they can experience loss of appetites, decreased sense of taste and smell, slow wound healing and skin sores [7]. Zinc shortages can even cause birth defects [19]. According to [20] very high levels of zinc can damage the pancreases and disturb the protein metabolism, and could cause arteriosclerosis.

Copper (Cu) showed appreciable presence along Naka road, Federal Housing, North-Bank and High-level sampled sites. The concentration of copper in some of the sites were high as compared to the control site but were not significantly different at P (< 0.05%). The appreciable presence of copper in some of these farm sites might be due to the indiscriminate disposal of copper containing waste [12], at the site. It has been reported by [14] that a biodegradable waste introduces metallic copper into soils at a level slightly above the natural level for soils. This might be responsible for high concentration of copper in soils at some sites. Copper is toxic to human if in high concentration and prolonged exposure can lead to liver damage, abdominal cramps, comma and even death [3].

Lead (Pb) was not detected in the control site, Wadata and North-Bank market. This indicates the absence or insignificant input from pedogenic sources. Lead showed high level of concentration at samples from Federal Housing North-Bank, along Naka road and at High-level environment. The concentration was high at 0 – 20cm depth and decreases down the profile. This may be due to the fact that the sites are situated close to a highway that harbours heavy traffic and also the repairs of motor vehicles resulting into the spilling and discarding of leaded gasoline, engine oils as well as leaded acid batteries. This view was also shared by [5] in their work on the evaluation of heavy metal pollutants from soils at municipal solid waste deposit in Owerri, Imo State. There was a significant difference between the concentration of lead in soils at sampled sites and the control site.

Lead is very toxic and has very chronic health implications even at very low concentrations. Ingestion of lead could cause mental retardation in children, colic anaemia and renal diseases [21]. People who have been exposed to lead for a long time may suffer from memory deterioration, prolonged reaction time and reduced ability to understand [20].

Nickel (Ni) was not detected at Wadata and Wurukum soil sites. Nickel showed high-level of concentration at Federal Housing North-Bank, along Naka road and High-level. This indicates that the likely sources of the nickel input is from anthropogenic sources which includes biodegradation of nickel containing wastes into the environment. The presence of Nickel in these sampled sites is an indication that there is likely a particular type of municipal solid waste available in these areas.

Cadmium (Cd) is another metal that was not detected at Wurukum and at the control site. This should be an indication of the absence of crystal rocks at surface soil horizon of the analyzed soils and as a result of little or insignificant input from pedogenic sources. Cadmium is high at Federal Housing North-Bank, along Naka road and at High-level. This might be as a result of the frequent burning of tyres, plastic rubbers and batteries in these sites.

Cadmium containing products are rarely re-cycled, but frequently dumped together with household wastes, thereby contaminating the environment. Acute exposure to cadmium fumes may cause flu-like symptoms including chills, fever, and muscle ache sometimes referred to as cadmium blues [3]. More severe exposures can cause tracheo-bronchities, pneumonities and pulmonary oedema [14].

Chromium (Cr) shows elevated levels at Federal Housing North-Bank, High-level and along Naka road. This might be as a result of the deposition of wastes containing metal alloys, cement paper and rubber. Chromium enters into the soil through leaching or by direct contamination. It is slowly absorbed into the body and produces both carcinogenic and mutagenic effects in humans and animals when inhaled over a long period of time [22]. Low-level exposure of chromium can cause skin irritation and ulceration [19]. Long-term exposure can cause kidney and liver damage, and damage to circulatory and new tissue [19]. There was no significant difference between the concentration of chromium in soils at sampled sites and at the control site at p (< 0.05). This shows that the observed concentration of chromium might have been largely due to natural concentration.

The concept of pollution index (PI) was employed to determine the multi-element pollution leading to overall element toxicity for each site. WHO reports as cited by [23] stated; when PI is less than 1.00, the soil is not polluted, but if it exceeds 1.00, the soil could be contaminated by anthropogenic inputs.

The pollution index (PI) for this study exceeded 1.00 in all the sampled sites except for the control site with PI value of 0.22. This is as a result of the absence of anthropogenic activities or absence of wastes from human activities. Soil samples along Naka road recorded the highest PI value of 8.64 followed by sample along railway crossing, High-level with PI value of 7.51 and

Federal Housing North-Bank (6.33). They are all polluted. This is as a result of high level of wastes deposited at these sites.

Analysis of variance (ANOVA) at 5% level of significance shows no significant difference for the values obtained in March and August, 2018 representing the dry and wet seasons of the year. This shows that heavy metal presence in soils of aquaculture farm sites in Makurdi is not influenced by seasonal variation. This observation agrees with the work of [24] on assessment of heavy metals contamination of Robertkiri oil fields soil.

Conclusions

The findings of this study have shown that municipal wastes contributed to the levels of heavy metals status of soils as depicted by the higher metal concentrations in soils at the various sampled sites in this study. The concentration of each metal decreased progressively down the depth, the surface soil at the sampled area was prone to contamination and heavily loaded than the sub – surface soil. The concentrations of lead and nickel in soils at the sampled sites are high enough and can become dangerous for aquatic organisms and human health causing various cancers, cardiovascular or neurological diseases and environmental pollution hazards as their concentration exceeds permissible limits, while the other metals do not constitute any environmental problem for now, but may gradually build up with time to become harmful to living systems. Also, the high PI values obtained indicated that the soils within sample areas are polluted and constitute hazards to living systems. Proper engineering designs that will enable testing of soil samples and treatment of wastes prior to sitting of aquaculture farms are hereby called for. This should be such that it will prevent the toxic metal pollutants from entering the hydrologic cycle.

Conflict of interest

Authors declare no conflict of interest.

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