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# Assessment of topsoil of some selected areas within Makurdi Metropolis.

**B.A. Anhwange[1], E. B. Agbaji[2] and E.C Gimba[2]**

*[1] Department of Chemistry, Benue State University, Makurdi, Nigeria*
*[2] Department of Chemistry, Ahmadu Bello University Zaria, Nigeria*

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**ABSTRACTS**

*Soil samples from ten locations within the town were sampled and assessed for pH, organic matter, nitrates, phosphates and some trace metals (zinc, lead, cadmium, copper and chromium) during two dry seasons. Results of the analysis indicate mean pH values to range between 6.20 - 7.10, organic matter content was observed to range between 2.39 - 4.74 (%). The mean nitrate content of the soil was observed to range between 10.07- 67.62 ($mgKg^{-1}$). Phosphate content was found to range between 0.90 - 7.26 ($mgKg^{-1}$). The mean levels of zinc in the soil was found to range between 0.24 -1.12 ($mgKg^{-1}$) and 0.35 - 2.60 ($mgKg^{-1}$) for the first and second year respectively. Lead levels in the soil during the first dry season ranged between 0.01-0.19 ($mgKg^{-1}$), while in the second dry season, the means values obtained, ranged between 0.06-0.18 ($mgKg^{-1}$). A range of 0.0 - 0.36 ($mgKg^{-1}$) was observed for Cd in the first dry season and 0.02 - 0.05 ($mgKg^{-1}$) was during the second dry season. 0.06–0.15 ($mgKg^{-1}$) and 0.05-0.29 ($mgKg^{-1}$) were observed for copper in the first and second dry seasons respectively. Chromium levels ranged between 0.03-0.10 ($mgKg^{-1}$) and 0.05-0.17 ($mgKg^{-1}$) in the first and second dry seasons respectively. The results indicate high accumulation of nitrates and phosphate in farmlands than in mechanic workshops and commercial areas. Among the heavy metals determined, zinc was found to be highest in all cases. The results of the study indicate that soils on the bank of the river are more susceptible to pollution than mechanic workshops and commercial areas, since the river bank act as a reservoir for sedimentation of most pollutants.*

**Keywords:** Soil, Heavy-Metals, contamination, pollutants, wastes, Makurdi

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## INTRODUCTION

The rapid urbanization of major cities in Nigeria has led to a serious environmental degradation arising from domestic and industrial wastes management. Waste management is the collection, transfer, treatment, recycling or disposal of solid waste with the intention of promoting environmental cleanness and maintaining good health. According to Enete [1], proper management of municipal wastes besides reducing the emissions of green house gases and improve the quality of life, promote public health, prevent water and soil contamination, conserve natural resources, and provide renewable energy benefits. Waste arising from electronic goods, electro-plating, painting, used batteries, etc., increased heavy metals content in municipal refused dumpsites. The slow leaching of these heavy metals under acidic environment during the degradation process leads to leachates with high metal concentrations. This may pollute ground water sources and crops that may be cultivated on contaminated sites [2].

Plants grown on polluted soil continuously absorb pollutant molecules. Since they cannot get rid of these molecules; the pollutants accumulate in the plant to level that may be higher than the levels in the soil. Animal that depends on these plants may acquire the pollutants; this situation may lead to transfer of pollutants within the food chain up to man.

Makurdi, the Benue State capital, is located on latitude 7$^{o}$ 44'N and longitude 8$^{o}$ 32′ E. It is situated in a valley in North Central Nigeria with an elevation of 100m above sea level [3]. Makurdi has an estimated population of about 500,797; and like any other urban town elsewhere among developing countries, it is faced with the problem of waste management arising from domestic, industrial, commercial and other human activities. Refuse dumpsites are found along the major streets, residential and commercial areas in the town.

Over the years, several attempts had been made by the State Government to address this ugly trend. The State task force on environmental sanitation which has now transformed to Benue State Environmental Sanitation Agency was established to ensure a healthy environment of the town, through the collection of solid wastes within the metropolis and the proper disposal of the wastes. The agency was also saddled with the responsibility of inspecting the general sanitary conditions of the town. The State Government in 2003 employed the services of consultants to survey and advised government on how solid waste could be managed in the town. According to the report of the consultancy, the rate of solid waste generated in kgm$^{-2}$ per day was found to be 0.54, 0.018, 0.014 and 0.47 for domestic, commercial, institutional and small medium scale industries respectively [4].

The recommendation of the report was the establishment of a solid waste management plant. Although Government is yet to implement the full recommendations of the report, provisionally, a disposal site along University of Agriculture Road was established. Waste on this site are either incinerated or left to decompose. Since the site is on a sloppy land that led to a nearby stream, during wet seasons, runoff water carry most of the disposed wastes or the incinerated products into the stream and finally to the river or deposited on the banks of the river were dry season farming is usually practiced. Some chemicals like heavy metals etc may leach through the soil and get absorbed by crops grown near the disposal sites or on the banks of the river. According to our earlier report, Anhwange [5], vegetables grown on the banks of the river are contaminated with varying concentrations of trace metals, although, the concentrations were found to be below the WHO threshold values. It is a fact that continuous accumulation of the metals in the plants and the subsequent dependant of animals and even man may upshot into some health thread to both animals and man.

This study therefore considers the analysis of soil along the banks, major mechanic workshops and some selected commercial area in the town. The study is aimed at assessing the levels of pollution of the topsoil of the selected areas and estimating the possible effects on biological systems and man.

## MATERIALS AND METHODS

*Collection of Soil Samples*

Soil samples were collected from ten (10) different sites (Table1.0); Two major mechanics sites (Apir and north bank), five locations along the river bank and three commercial areas (e.g. Wadata market, Modern market, Wurukum market).

**Table 1.0 Soil sample sites.**

| S/n | Samples Sites | Number of samples (n) |
|---|---|---|
| 1. | Air Force Base (AFB) | 5 |
| 2. | Benue Brewery Limited (BBL) | 5 |
| 3. | New Bridge (NB) | 5 |
| 4. | Saint Joseph Technical College (SJC) | 5 |
| 5. | Rice Mill (RM) | 5 |
| 6. | Apir Mechanic Village (AMV) | 5 |
| 7. | North Bank Mechanic Village (NMV) | 5 |
| 8. | Modern Market (MM) | 5 |
| 9. | Wadata Market (WM) | 5 |
| 10. | Wurukum Market KM | 5 |

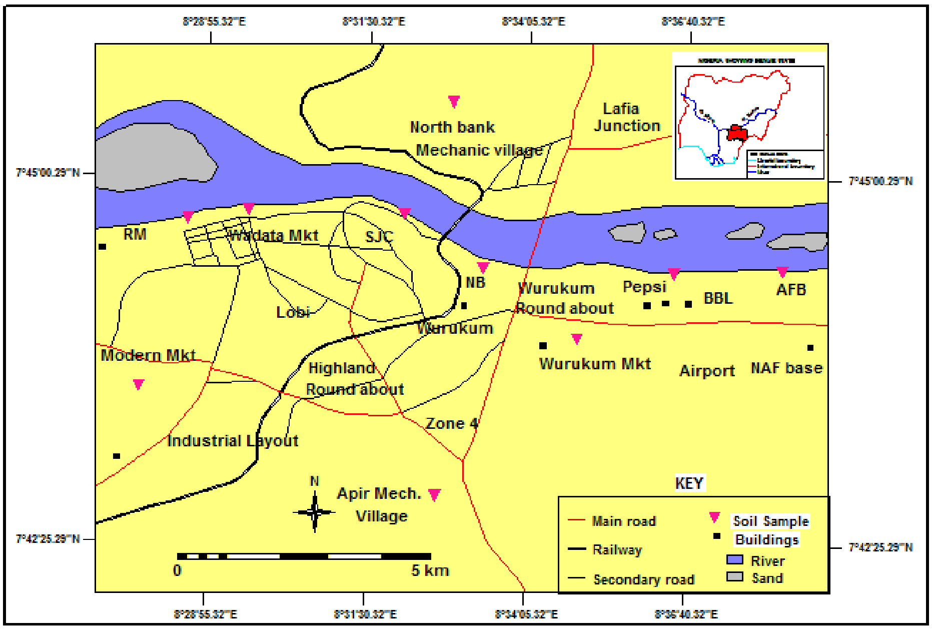


**Figure 1.0 Makurdi township showing sample sites.**

The samples were collected during two dry seasons, between January – February, 2009 and 2010. The areas of sampling include; farmland (those along the river Bank), mechanic workshops and major commercial areas within the metropolis as mentioned above. Samples were taken around refuse dumpsites (markets and mechanic workshops). At each site, five samples were randomly taken at 10 -15 cm depth of topsoil by scooping using stainless steel knives into polyethylene containers and taken to the laboratory for analysis.

**Preliminary treatment of soil samples**
The samples were air dried for one week to remove excess moisture, while the large soil clods were crushed to facilitate drying. The air dried samples were ground using a porcelain mortar and pestle and sieved to obtain fine particle size that could pass through a 2mm mesh and kept for analysis.

**Determination of soil pH**
The pH of samples was measured with a soil to water ratio of 1:2 using the Crison micro, 2000, pH meter. 10g of sample was weighed into a plastic container and 20 $cm^3$ of deionised water was added. The mixture was stirred severally for thirty (30) minutes. The suspensions were allowed to stand for 30 minutes undisturbed. The pH electrode was then inserted into the settled suspension and the pH of the soil was measured. Before use, the pH meter was calibrated with standard buffers of pH solutions of 4, 7 and 9 [6].

**Determination of organic matter, nitrates and phosphates**
Organic matter content of the soil was determined by the weight loss on ignition in a muffle furnace at 500$^oC$ for 1hour [7, 8]. Nitrates and phosphates were determined using the direct reading spectrophotometer (DR/2000).

**Sample Digestion**
0.5g portion of the ground sample was weighed into a 100$cm^3$ Kjeldahl digestion flask; 5ml of concentrated nitric acid ($HNO_3$) was added followed by 1ml each of concentrated sulphuric acid ($H_2SO_4$) and perchloric acid ($HClO_4$). The flask was heated in a fume cupboard until dense white fumes were observed. The flask was cooled and the content was diluted with distilled water and filtered into 100$cm^3$ volumetric flasks. The content was made up to the mark with distilled water and transferred to 120$cm^3$ plastic bottles and stored for metal analysis by AAS.

The AAS was operated in the air-acetylene flame mode and the hallow cathode lamps were operated at the following wavelengths in (nm) Zn 213.8, Pb 283.30, Cu 324.80, Cd 229 and Cr 357.90 according the manufacturer's instructions. Standards samples were also prepared at different concentrations for each element and calibration curves prepared from where concentrations of the metal in the sample was estimated [9].

**Quality Assurance for Metal Analysis**

30 ml of multi-element standard solution was drawn with a graduated pipette and used to spike 0.5g of the sample element into a $100cm^3$ Kjeldhal digestion flask; 5ml of concentrated nitric acid ($HNO_3$) was added followed by 1ml each of concentrated sulphuric acid ($H_2SO_4$) and perchloric acid ($HClO_4$). The flask was heated in the fume cupboard until dense white fumes were observed. The flask was cooled and the content diluted with distilled water and filtered into $100cm^3$ volumetric flask. The content was made up to the mark with distilled water and transferred into plastic bottles. The percentage recovery for each metal was calculated after the AAS analysis.

## RESULTS AND DISCUSSION

**Table 2.0 Percentage (%) recoveries of trace metal concentrations from spike samples**

| Metal | Percentage (%) recovery |
|---|---|
| Zinc | 98.45 |
| Lead | 97.45 |
| Cadmium | 91.53 |
| Copper | 97.26 |
| Chromium | 93.52 |

Table 2.0 shows the results of the quality assurance test conducted on the samples. The results show the order of recovery of the metals to be Cr < Cd < Co < Pb < Zn. The high percentage recovery is an indication of the validity of the sample treatment procedures used. Okunola *et al* [10], reported slightly different percentage recovery (97.30%, 88.9%, 96.7% and 95.7% for Zn, Pb, Cd and Cu respectively), this could be due to differences in reagents' grades.

The pH of soil along the river bank was found to be (Table 3.0) 7.10, 6.20, 6.47, 6.42 and 6.88 for AFB, BBL, NB, SJC and RM respectively during the first dry season, while in the second dry season, the mean values of pH obtained were; 7.58, 7.30, 7.54, 7.56 and 7.32 for AFB, BBL, NB, SJC and RM respectively (Table 5.0). There was no significant difference ($p<0.05$) in the values of pH for the two dry seasons.

The mean values of pH obtained from the refuse dumpsites (Table 4.0); Apir mechanic village (AMV), North Bank mechanic village (NMV), Modern Market (MM), Wadata market (WM) and Wurukum (KM) were 7.47, 7.03, 7.10, 7.84 and 7.38 respectively for the first yea dry season. In the second dry season (Table 6.0), the values recorded were; 5.68, 5.46, 5.68, 6.00 and 5.70 respectively. There was significant difference in the pH values of the two year dry seasons. The results indicate lower values of pH in the second dry season. This could be due to environmental factors.

The pH of the soil is a dynamic quality that can have a tremendous effect on the ability of plants to grow and thrive in it. It had been known that both acidity and alkalinity of soil can be problems in all areas of the world. The pH of a soil is the function of the soil ability to be used as a medium for the cultivation of plants. Soil pH affects the uptake of essential nutrients by plants, soil microbial activity as well as the health of plants in general. For example, soil with a pH value of above 7.50 will cause iron, manganese, copper, zinc and boron ions to be less available to plants. (That is, pH values slightly above 7.0, less than 50% of the Fe is available to plants. At pH 8.0, no Fe is left in solution due to iron hydroxide precipitation $Fe(OH)_3$ which eventually converts to rust). As long as the pH is kept below 6.5, over 90% of the Fe will be available to plants. pH values below 6.00 will cause the solubility of phosphoric acid which may result to a drop in calcium and magnesium levels of the soil. pH values between 3 and 5 and temperatures above 26 $^oC$ encouraged the development of fungal diseases. Toxic elements like aluminum and manganese causes the failure of plants in acid soils. This is because these elements are highly soluble at low pH. Therefore, when the pH of soil is low (below 5.5), the presence of aluminum or manganese ion becomes very high. This situation may lead to a disease condition in plant known as "root pruning." That is, the deterioration of the plant's roots and sometime growth of the root may stop. When these happens, the plant is unable to absorb water and nutrients normally and in most cases the plant appear stunted and exhibit nutrient deficiency symptoms, especially those for phosphorus, the consequence of which is poor yields [11].

In Table 3.0, soil organic matter was found to be 2.39, 4.74, 4.84, 3.58 and 3.45 (%) in the first dry season while, in the second dry season (Table 5.0), the values obtained were; 3.10, 3.50, 4.39, 3.91 and 3.51 (%) for AFB, BBL, NB, SJC and RM respectively. The relatively high organic matter content observed at BBL and NB may probably be due to the high rate of organic materials like waste products from the brewery industry and animal dung, rubber materials used in the roasting animals at the abattoir.

The organic matter content of the dumpsites; Apir mechanic village (AMV), North Bank mechanic village (NMV), Modern market, (MM), Wadata market (WM) and Wurukum market (KM) was found to be 4.08, 2.66, 3.31, 3.69 and 3.09 (%) respectively in the first dry season (Table 4.0), while in the second dry season, 3.90, 4.02, 2.90, 3.66 and 4.12 (%) were recorded as the mean organic matter for AMV, NMV, MM, WM and KM respectively (Table 6.0). There was no significant difference ($p<0.05$) in organic matter levels of the sites and between the two dry seasons.

Soil organic matter is a vast array of carbon compounds in the soil. It is usually created by plants, microbes, and other organisms, these compounds play varieties of roles in nutrient, water, and biological cycles. For example, soil organic matter is known to increases the nutrient holding capacity of soil and also acts as a pool of nutrients for plants. It chelates or binds nutrients, preventing them from becoming permanently unavailable to plants. Soil organic matter also acts as food for soil organisms (bacteria, worms etc). It improves water infiltration and increases water holding capacity, especially in sandy soils. It also encourages the development of plant roots, besides improving aggregation, preventing erosion and increases the rate of pesticides decomposition in the soil [12]. Soils with high clay content generally have higher organic matter content, due to slower decomposition of organic matter. High organic matter content of soil is an indication of high water holding and cation exchange capacities. While soil with low organic matter content indicates high bulk density and the soil is more prone to nutrient leaching and low rate of biological activities.

The nitrate content of the soil along the river bank (Table 3.0) was observed to be 43.62, 46.71, 66.48, 63.77, and 64.38 ($mgKg^{-1}$) and 67.62, 67.47, 57.46, 51.18 and 56.87 ($mgKg^{-1}$) for first dry season and second dry seasons (Table 5.0 ) at AFB, BBL, NB, SJC and RM respectively. The result of nitrates obtained at the mechanics and markets dumpsites (Table 4.0) were; 10.07, 11.18, 22.93, 34.24 and 27.07 ($mgKg^{-1}$) for AMV, NMV, MM, WM and KM respectively in the first dry season while in the second dry season (Table 6.0), the values obtained were; 22.43, 19.33, 43.33, 24.53 and 20.14 ($mgKg^{-1}$) for AMV, NMV, MM, WM and KM respectively. Statistics analysis indicates significant difference at $p<0.05$ in nitrate content of the sample locations whereas there is there was no significant difference between the two years.

The high content of nitrates at the river bank for both dry seasons are in agreement with Adeyemo *et al* [13], who reported that high levels of nitrate are usually built up in the soil during dry seasons and can only be observed in water at the beginning of rainy seasons. Studies have shown that crops take up most of their nitrogen requirement during the vegetative growth stage. The uptake rate drops off quickly when the plant reaches the reproductive stages leading to nitrate accumulate in the soil. Nitrate accumulations are common during dry seasons or on non-irrigated crops, or even when the crops are irrigated, nitrate can accumulate above normal level as a result of hot weather which accelerates the mineralization of nitrogen at levels above crops nitrogen removal, and as such, the excess nitrate accumulates in the soil. Also the high levels of nitrate ($34.24mgKg^{-1}$) recorded at Wadata market (WM) dumpsites in the first dry season and $43.33mgKg^{-1}$ observed at modern market in the second dry seasons may be due to accumulation of nitrate from nitrate based fertilizers sold in the markets since nitrate remains in the upper soil profile simply because little or no leaching occurs during hot, dry conditions [14].

Results of phosphate content of soil at the river bank(Table 3.0) as obtained from AFB, BBL, NB, SJC and RM was 4.03, 7.09, 4.69, 4.51 and 4.16 ($mgKg^{-1}$) respectively in the first dry season, while the second dry season (Table 5.0) had 5.51, 6.70, 5.70, 5.51, 4.45 and 4.81($mgKg^{-1}$) respectively for AFB, BBL, NB, SJC and RM. Results of the refuse dumpsites (Table 4.0) indicate 1.06, 1.43, 0.90, 0.95 and 1.04 ($mgKg^{-1}$) during the first dry season at AMV, NMV, MM, WM and KM respectively. Higher values of 7.22, 6.6.45, 5.42, 6.30 and 7.26 ($mgKg^{-1}$) were observed for the same sample locations in the second dry season (Table 6.0). There was significant difference in the variation of phosphate content between the two dry seasons. The high levels of phosphate observed at the dumpsites may be from organic materials which include plant residues, manures and microbial tissues; and inorganic sources which may be complexes of iron and aluminum phosphate, and phosphate bind to soil particles. Most phosphate compounds have very low solubilities and as such very small amount of soil phosphates are in solutions. Therefore, leaching of phosphate in the soil is also very low. The implication of this is that it turns to accumulate in the surrounding soil. The result obtained compared favourably with those of Fagbote *et al* [15].

Zinc was observed to be 0.27, 0.24, 0.37, 0.24 and 0.38 ($mgKg^{-1}$) at AFB, BBL, NB, SJC and RM respectively in the first dry season of analysis, while the result of zinc in the second season was found to be 1.04 $mgKg^{-1}$, 1.27$mgKg^{-1}$,1.02 $mgKg^{-1}$, 0.35 $mgKg^{-1}$ and 0.20 $mgKg^{-1}$ for AFB, BBL, NB, SJC and RM respectively. The level of zinc in refuse dumpsites was 0.58, 0.87, 1.12, 0.57 and 0.70 for AMV, NMV, MM, WM and KM respectively during the first year of analysis, in second dry season, the levels of zinc found at AMV, NMV, MM, WM and KM was 2.32, 0.93, 3.07, 2.11 and 2.60 respectively. Statistics analysis of the mean values using two way anova without replications indicate significant difference at $p<0.05$ between the two dry seasons.

The results indicate relatively high content of zinc on the bank and in refuse dumpsites in the second dry season. The highest levels of 1.12$mgKg^{-1}$ and 3.07$mgKg^{-1}$ were observed in refuse dumpsites located at modern markets. This is can be traced to the fact large amount of zinc and zinc coated sheets sold in the market. Also a lot of buildings especially at the village market are made up of rusty zinc-sheet roofs that may be carried by rainfall into soil. It may also be due to improper disposal of galvanized scraps and electric utilities from the mechanic workshops and markets. In soil, most of the zinc stays bound to the solid particles. When high levels of zinc are present in soils, it can seep into the groundwater.

Rain and snow also can remove zinc dust from the air into lakes, rivers and streams, since it does not dissolve in this form, it settles to the bottom and this may lead its levels in the soil. Zinc can enter the body when foods, water and beverages contaminated by zinc are eaten or by breathing its dust or fumes. Zinc is an essential nutrient needed by the body for growth, development of bones, metabolism and wound-healing. Deficiency of zinc in the diet may lead to adverse health effects such as loss of appetite, decreased sense of taste and smell, lowered ability to fight off infections, slow growth, delay in healing of wounds and skin sores. Whereas a short-term illness called 'metal fume fever' may result when high levels of zinc dust or fumes are taken through breathing. Exposure to high levels of zinc through the intake of contaminated food lead to adverse health effects, such as stomach cramps, nausea and vomiting. Eating large amounts of zinc for longer periods may cause anemia, nervous system disorders, damage to the pancreas and lowered levels of "good" cholesterol. There is no evidence that zinc causes cancer in humans [15].
Lead levels in soil along the bank of the river was found to be 0.13 $mgKg^{-1}$, 0.16 $mgKg^{-1}$, 0.12 $mgKg^{-1}$, 0.13 $mgKg^{-1}$ and 0.19 $mgKg^{-1}$ for AFB, BBL, NB, SJC and RM respectively in the first dry season. Its levels in the second dry season were found to be 0.16$mgK^{-1}$, 0.17$mgKg^{-1}$, 0.07$mgKg^{-1}$, 0.06$mgKg^{-1}$ and 0.06$mgKg^{-1}$ respectively for the same sample sites. Lead content of refuse dumpsites was observed to be 0.15, 0.05, 0.07, 0.04, 0.01 ($mgKg^{-1}$) and 0.15, 0.26, 0.20, 0.18, 0.13 ($mgKg^{-1}$) for AMV, NMV, MM, WM and KM respectively in the first and second dry seasons. There as no significant difference at $p<0.05$ in lead content of the soil between the two dry seasons. The presences of high levels of lead from dumpsites lactated at the mechanic workshops may be traced to chipping and flaking of car paints, welding and cutting of lead materials, automobile exhaust and battery work. While its sources in refuse dumpsites found in the markets may be linked to the presence of pluming materials and lead glazed ceramics.

Cadmium level in soil along the river banks was found to be 0.13, 0.08, 0.09, 0.12 and 0.12 ($mgkg^{-1}$) and 0.03, 0.06, 0.05, 0.05 and 0.11$mgKg^{-1}$ for AFB, BBL, NB, SJC and RM respectively for the first and second dry seasons. The mean values of cadmium levels in the refuse dumpsites were found to ranged between 0.01$mgKg^{-1}$ - 0.36$mgKg^{-1}$ in the first dry season and 0.02 - 0.05 $mgKg^{-1}$ in the second dry seasons respectively. There was no significant difference ($p<0.05$) in cadmium levels between the two seasons. In the first dry season, the highest value of 0.36$mgKg^{-1}$ was observed at Wurukum market which may be traceable to disposal of unsold vegetables especially spinach and fruits, meat organs like liver, kidney and lungs. Trace amount of cadmium can also be obtained from plates, jewelries, stained glass. The disposal of cigarette filters could also be implicated in the presence of cadmium in the market dumpsites. The second dry season had the highest value of cadmium in north bank mechanic workshop. This can be linked to battery works, exhaust pipe etc.

Copper level in the soil along the banks was found to range between 0.06-0.12$mgKg^{-1}$ and 0.05-0.24$mgKg^{-1}$ in the first and second dry seasons respectively. Here, the highest value of 0.26$mgKg^{-1}$ was recorded at NB where tyres and kerosene are used in the roasting of animals. The mean values of copper levels was found to range between 0.06–0.15$mgKg^{-1}$ in refuse dumpsites in the first dry season, while in the second dry season, it was found to ranged between 0.07–0.29 $mgKg^{-1}$. The highest level of copper (0.15$mgKg^{-1}$) was observed at north bank mechanic workshop while the lowest level (0.06mgKg$^{-1}$) was recorded at Apir mechanic village and modern market in the first dry seasons. In the second dry season, 0.29mgKg$^{-1}$ was recorded as the highest value at modern market. There was no significant difference in levels of copper between the two dry seasons. The presence of copper in refuse dumpsite around markets will not be unconnected to the presence of electrical wires and fittings, metal sheets, while in mechanic refuse dumpsite it may be as a result of automobile exhausts discharges.

Chromium level in the soil along the bank was observed to range between 0.03-0.07mgKg$^{-1}$ and 0.14-0.17mgKg$^{-1}$ in the first and second dry seasons respectively. The highest value was 0.22 mgKg$^{-1}$ was again observed at NB. Refuse dumpsites had the following ranges; 0.06-0.10mgKg$^{-1}$ and 0.05-0.14mgKg$^{-1}$ respectively in the first and second dry seasons. Here also, the highest value of 0.14mgKg$^{-1}$ was observed at Wurukum Market (KM). Statistics analysis of variance indicate significant difference at $p<0.05$ in the level of chromium in the soil between the two dry seasons The disposal of stainless steel, chrome plating and metal ceramics could be implicated in high level of chromium observed in refuse dumpsites around the markets. Similarly, automobile brake lining and catalytic converters could be responsible for its presence in refuse dumpsite found around mechanic workshops.

**Table 3.1 Result of chemical analysis of soil along the River bank during the first dry season**

| Sites / Parameters | AFB | BBL | NB | SJC | RM |
|---|---|---|---|---|---|
| pH | 07.10±0.16 | 06.20±0.10 | 06.47±0.08 | 06.42±0.16 | 06.88±0.08 |
| Organic Matter (%) | 02.39±0.26 | 04.75±0.17 | 04.84±0.12 | 03.58±0.09 | 03.45±0.03 |
| Nitrate (mgKg$^{-1}$) | 43.62±0.65 | 46.71±0.54 | 66.48±0.16 | 63.77±1.04 | 64.38±0.74 |
| Phosphate (mgKg$^{-1}$) | 04.03±0.20 | 07.09±0.18 | 04.69±0.26 | 04.51±0.11 | 4.16±0.11 |
| Zinc (mgKg$^{-1}$) | 0.27±0.31 | 0.24±0.09 | 0.37±0.35 | 0.25±0.12 | 0.38±0.06 |
| Lead (mgKg$^{-1}$) | 0.13±0.40 | 0.16±0.11 | 0.12±0.42 | 0.13±0.04 | 0.19±0.01 |
| Cadmium (mgKg$^{-1}$) | 0.13±0.40 | 0.08±0.03 | 0.09±0.04 | 0.12±0.05 | 0.13±0.09 |
| Copper (mgKg$^{-1}$) | 0.07±0.01 | 0.06±0.03 | 0.08±0.36 | 0.12±0.04 | 0.12±0.05 |
| Chromium (mgKg$^{-1}$) | 0.04±0.02 | 0.04±0.02 | 0.06±0.02 | 0.07±0.06 | 0.03±0.05 |

**Table 4.1 Result of chemical analysis of soil of refuse dumpsites during the first dry season**

| Sites / Parameters | AMV | NMV | MM | WM | KM |
|---|---|---|---|---|---|
| pH | 7.49±0.42 | 7.03±0.36 | 7.10±0.06 | 7.84±0.23 | 7.38±0.23 |
| Organic Matter (%) | 4.08±0.25 | 2.66±0.34 | 3.31±0.25 | 3.69±0.63 | 3.09±0.46 |
| Nitrate (mgKg$^{-1}$) | 10.07±0.19 | 11.18±0.25 | 22.93±1.40 | 34.24±1.32 | 27.07±0.01 |
| Phosphate (mgKg$^{-1}$) | 1.06±0.08 | 1.43±0.05 | 0.90±0.04 | 0.95±0.05 | 1.04±0.12 |
| Zinc (mgKg$^{-1}$) | 0.58±0.19 | 0.87±0.19 | 1.12±0.66 | 0.570±0.07 | 0.70±0.47 |
| Lead (mgKg$^{-1}$) | 0.15±0.01 | 0.05±0.02 | 0.07±0.02 | 0.04±0.03 | 0.10±0.01 |
| Cadmium (mgKg$^{-1}$) | 0.01±0.00 | 0.02±0.00 | 0.06±0.03 | 0.03±0.00 | 0.36±0.05 |
| Copper (mgKg$^{-1}$) | 0.06±0.02 | 0.15±0.05 | 0.06±0.01 | 0.07±0.02 | 0.08±0.03 |
| Chromium (mgKg$^{-1}$) | 0.06±0.04 | 0.10±0.05 | 0.06±0.03 | 0.08±0.02 | 0.08±0.01 |

**Table 5.1 Result of chemical analysis of soil along the River bank during the second dry season**

| Sites / Parameters | AFB | BBL | NB | SJC | RM |
|---|---|---|---|---|---|
| pH | 07.58±0.33 | 07.30±0.14 | 07.54±0.42 | 07.56±0.14 | 07.32±0.19 |
| Organic Matter (%) | 03.10±0.22 | 03.50±0.26 | 04.38±0.23 | 03.91±0.18 | 03.51±0.23 |
| Nitrate (mgKg$^{-1}$) | 67.62±0.58 | 67.47±6.86 | 57.46±5.87 | 51.18±1.28 | 56.87±5.40 |
| Phosphate (mgKg$^{-1}$) | 05.51±0.09 | 06.70±0.i0 | 05.51±0.08 | 04.45±0.18 | 04.81±0.24 |
| Zinc (mgKg$^{-1}$) | 1.04±0.10 | 1.27±0.21 | 1.02±0.15 | 0.35±0.01 | 0.20±0.17 |
| Lead (mgKg$^{-1}$) | 0.16±0.04 | 0.17±0.11 | 0.07±0.01 | 0.06±0.09 | 0.06±0.01 |
| Cadmium (mgKg$^{-1}$) | 0.03±0.03 | 0.06±0.04 | 0.05±0.02 | 0.05±0.02 | 0.11±0.07 |
| Copper (mgKg$^{-1}$) | 0.05±0.08 | 0.24±0.05 | 0.26±0.04 | 0.07±0.028 | 0.11±0.02 |
| Chromium (mgKg$^{-1}$) | 0.16±0.04 | 0.17±0.05 | 0.22±0.02 | 0.15±0.02 | 0.14±0.13 |

**Table 6.1 Result of chemical analysis of soil of refuse dumpsites in the second dry season year**

| Sites<br>Parameters | AMV | NMV | MM | WM | KM |
|---|---|---|---|---|---|
| pH | 05.68±0.11 | 05.46±0.22 | 05.68±0.25 | 06.00±0.21 | 05.70±0.25 |
| Organic Matter (%) | 3.9±0.01 | 4.02±0.03 | 2.9±0.01 | 3.66±0.02 | 4.12±0.01 |
| Nitrate (mgKg$^{-1}$) | 22.43±0.06 | 19.33±0.33 | 43.33±0.02 | 24.53±0.12 | 20.14±0.04 |
| Phosphate (mgKg$^{-1}$) | 07.22±0.03 | 06.45±0.06 | 05.42±0.01 | 06.03±0.01 | 07.26±0.01 |
| Zinc (mgKg$^{-1}$) | 2.32±1.34 | 0.93±0.25 | 3.07±1.60 | 2.11±0.48 | 2.60±0.33 |
| Lead (mgKg$^{-1}$) | 0.15±0.06 | 0.26±0.04 | 0.20±0.88 | 0.18±0.02 | 0.13±0.05 |
| Cadmium (mgKg$^{-1}$) | 0.04±0.02 | 0.05±0.02 | 0.04±0.03 | 0.02±0.01 | 0.03±0.01 |
| Copper (mgKg$^{-1}$) | 0.17±0.10 | 0.08±0.03 | 0.29±0.27 | 0.08±0.02 | 0.07±0.01 |
| Chromium (mgKg$^{-1}$) | 0.07±0.01 | 0.05±0.01 | 0.13±0.06 | 0.10±0.02 | 0.14±0.05 |

## CONCLUSION

The results of the study indicate that the various areas analysed had different levels of pollution, but the soils on the bank of the river which is also an area for farmland is more susceptible to pollution than mechanic workshops and commercial areas, since the river bank act as a reservoir for sedimentation of most pollutants found within the town.

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