Assessment of Impact of Some Waste Dumpsites on the Groundwater Quality in Parts of Akure Metropolis, Southwestern Nigeria.

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ABSTRACT

Physico-chemical analysis was carried out on groundwater samples in the area around some selected dumpsites in Akure Metropolis, Southwestern Nigeria. The aim of the study was to determine the impact of the dumpsites on the quality of the groundwater. Seventy (70) water samples were collected from hand dug wells within the immediate vicinity and further away from the dumpsites, for analysis. The samples were analyzed for temperature, pH, conductivity, total dissolved solids (TDS), Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO_3^{-}, Cl^{-}, NO^{3-}, NH_3, SO_4^{2-}, PO_4, Fe, Pb^{2+}, and Zn^{2+}.

The temperature, pH and TDS ranged in values from 28.5-35.5^{o}C; 6.0-9.6 and 72.5-1056 mg/l respectively while the concentration levels of Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} were 23-179 mg/l; 94-141mg/l; 38.1-47.8 mg/l and 106-175 mg/l; 0.5-189 mg/l; 5.9-138 mg/l; 29.5-47.4 mg/l; 90.8- 136 mg/l, respectively, in the water samples collected from around and outside the dumpsites. The heavy metals (Fe, Pb^{2+}, and Zn^{2+}) gave concentration levels of 0.1-16.9 mg/l; non-detectable – 0.2 mg/l; non-detectable – 0.5 mg/l, and 0.1-15.8 mg/l; non-detectable – 0.1 mg/l and non-detectable – 1.4 mg/l, respectively. The pH, conductivity, TDS values and the concentration levels of Cl^{-}, NO_3^{-} were 6.9-9.6; 680-2361 µS/cm; 118.5-1056 mg/l; 103-819 mg/l and 1.4-30 mg/l respectively for water samples collected from within the immediate vicinity of the dumpsites. The upper limits of these values are higher than the WHO (2004) maximum permissible levels of 8.5; 1000 µS/cm; 500 mg/l; 200 mg/l and 10 mg/l respectively, for potable water and higher than the baseline concentration levels of 5.2-7.8; 19-909 µS/cm; 85-509 mg/l; 0.015-394 mg/l and 0.02-22.9 mg/l, respectively, from the basement complex terrain of Nigeria, indicating pollution from the dumpsites leachate. This study concluded that the leachate from the dumpsites had impacted the groundwater making it non-potable.

(Keywords: physico-chemical analysis, dumpsites leachate, groundwater quality)

INTRODUCTION

Proper management and protection of urban groundwater quality has been a major problem in Nigerian cities, Akure Metropolis inclusive. Degradation of urban groundwater sometimes results from infiltration of leachate generated from the waste dumpsites indiscriminately located within the developed area.

The rapid increase in population witnessed in Akure Metropolis since it became a state capital in 1976, has led to an increase in waste generation whose disposal has been poorly managed. Dumpsites were indiscriminately located within built-up areas in the metropolis. Some of the dumpsites are still active, and accept domestic wastes, incinerator ash, construction and commercial wastes from different sources within the metropolis.

The waste dumpsites were neither properly designed nor constructed as landfill sites. Consequently, wastes dumped at the dumpsites over the years were expected to have biodegraded and generated leachate which could have become a point source of pollutant into the soil and groundwater. It is suspected that the leachate may have impacted shallow aquifers and the contained groundwater. It is therefore important that the groundwater quality is assessed for possible impact of the dumpsites.

This study intends to use hydro-chemical analysis of the well water to assess the impact of

the dumpsites on the quality of the groundwater. Several works have been carried out on the environmental impact of waste dumpsites on the groundwater quality in a typical basement complex terrain of southwestern Nigeria (Abimbola et al., 1999; Olayinka and Olayiwola, 2001; Abimbola et al., 2002; Abimbola et al., 2005; Ayolabi and Daniel, 2005; Tijani et al., 2002; Obase et al., 2009 and Bayode et al., 2010).

SITE DESCRIPTION

The study area is situated between Latitudes 7^{o} 13^{1} N and 7^{o} 17^{1} N and Longitudes 5^{0} 09^{1} E and 5^{o} 14^{1} E in Akure Metropolis, Southwestern Nigeria. It covers an areal extent of about 13 km^{2}. The area is drained by River Elegbin and River Alore (Figure 1). Rivers Elegbin and Alore are seasonal. The two rivers dominate the drainage system of the study area and were dry during the data acquisition.

The selected five dumpsites in the study area are the Odopetu dumpsite, Eyinke dumpsite A and B, Isinkin (Igbo-Osun) dumpsite and the St. Thomas dumpsite (Figure 1). The dumpsites contained vegetable matters, domestic wastes, human and animal wastes, organic and inorganic matters, wood, paper, cloth, glass, plastic of various types, unclassified metal scraps, empty cans of various chemicals and other house hold trash. The dumpsites are being operated as open dumps with intermittent open-air incineration.

GEOLOGY AND HYDROGEOLOGY

The Akure Metropolis is underlain by the Precambrian Basement Complex Rocks of southwestern Nigeria. The rock units include migmatite gneiss, quartzite, granite gneiss and granitic rocks (Figure 2). The structural trend is north-south and which is typical of the Nigerian Basement Complex rocks (Rahaman, 1976).

Migmatite gneiss is the predominant rock unit that underlies the waste dumpsites. In basement complex area, groundwater is contained within the weathered and or fractured/jointed basement columns. The unconfined nature and the near-surface occurrence of the aquifer system makes it vulnerable to surface/near surface pollutants such as leachate from a waste dump.

METHODOLOGY

Water samples were collected from seventy (70) hand-dug wells located within a radius of about 600 m around the dumpsites (Figure 1). Water samples were collected during the dry season from the month of February to March. Each water sample was collected and stored in two (2) liter plastic container (sample bottle). The containers were previously thoroughly washed with 1M HCl, and then rinsed three times with the sampled water at the site before the water samples were collected. After sampling, each sample container was securely corked with a plastic lid. The samples were then stored in a refrigerator for analysis within 24 hours.

Physical parameters such as pH, temperature and electrical conductivity (EC) were however, determined in the field using portable digital Conductivity and pH meters. The major cations (Ca, Mg, Na and K) and anions (Cl, NO_3, SO_4 and PO_4) were analyzed. In addition trace metals and heavy metals such as iron, zinc, and lead (Fe, Zn, Pb) were also analyzed using UV-visible spectrophotometer. Flame-photometric and atomic absorption/emission spectrophotometer methods were used for the determination of the cations, while conventional colorimetric method and UV-visible spectrophotometer/colorimeter, gravimetric and titrimetric methods were used for the determination of the anions.

RESULTS AND DISCUSSION

Physico-Chemical Analysis

The summary of the results of the physico-chemical analysis are presented in Table 1. The results are presented in two groups – results of water analysis from a radius of about 250 m (considered close) to the dumpsites and results for sampling locations at distances > 250 m from the dumpsites (considered further away). The table shows that the temperature values of the water samples ranged from 28.5 – 35.5 ^{o}C, and 28.5 – 35.1 ^{o}C, respectively, for samples collected in the area around the dumpsites and samples collected beyond a radius of 250 m from the dumpsites.

The range of pH values were 6.9 – 9.6 and 6.0 – 7.9, respectively, for the area around the dumpsites and for samples that were collected further away from the dumpsites (Figure 3).

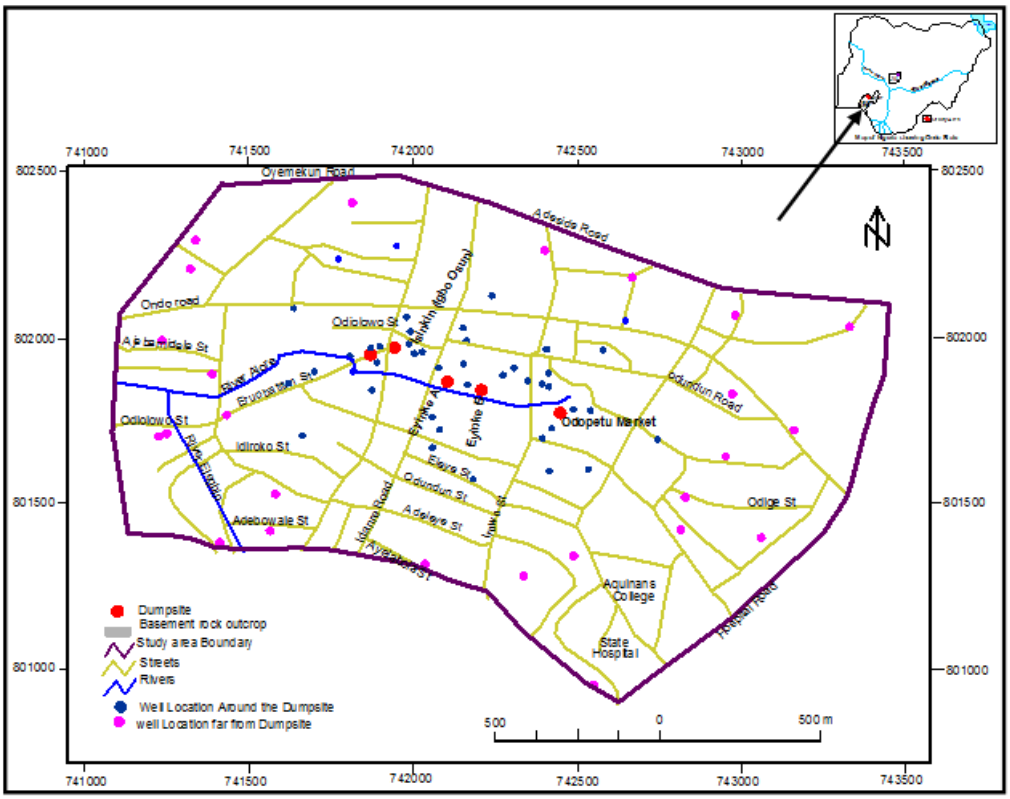

Figure 1: Location and Data Acquisition Map of the Study Area.

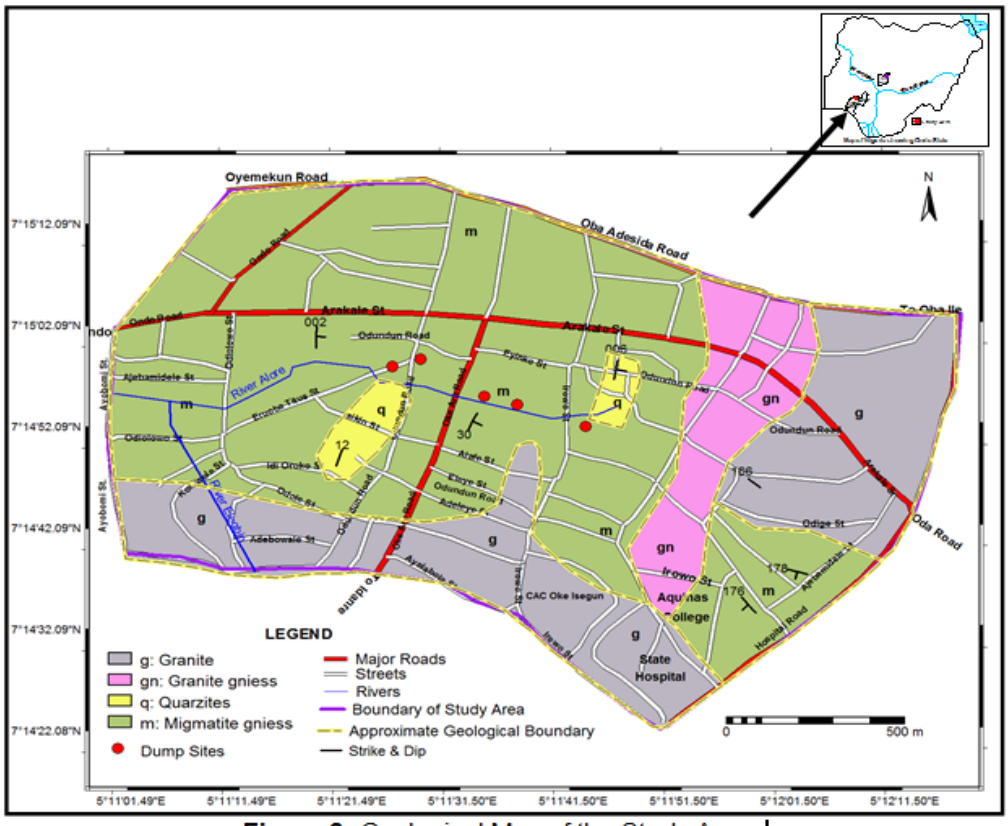

Figure 2: Geological Map of the Study Area

Table 1: Summary of Analytical Results of the Hydro-Chemical Parameters Considered.

Parameters	Samples around the Dumpsites.	Samples at distance > 250 m from Dumpsites	WHO (2004) Standard
	Range	Range	MPL (mg/l)
Temp. ^{o}C	28.5 – 35.5	28.5 – 35.1	-
pH	6.9 – 9.6	6.0 – 7.9	8.5
EC (µS/cm)	680 – 2361	145 – 1500	1000
TDS (mg/l)	118.5 – 1056	72.5 – 750	500
Ca^{2+} (mg/l)	23 – 179	0.5 – 189	75
Mg^{2+} (mg/l)	94 – 141	5.9 – 138	30
Na^{+} (mg/l)	38.1 – 47.8	29.5 – 47.4	200
K^{+} (mg/l)	106 – 175	90.8 – 136	-
HCO_3^{-} (mg/l)	100 – 1040	45 – 540	-
Cl^{-} (mg/l)	103 – 819	46 – 468	2050
NO_3^{-} (mg/l)	1.4 – 30	2.2 – 5.6	10
NH_3 (mg/l)	0.3 – 18.3	0.1 – 12.6	1.5
SO_4^{2-} (mg/l)	2 – 180	4 – 130	200
PO_4 (mg/l)	0.2 – 19.6	2 – 49	10
∑Fe (mg/l)	0.1 – 16.9	0.1 – 15.8	0.3
Pb^{2+} (mg/l)	ND – 0.2	ND – 0.1	0.01
Zn^{2+} (mg/l)	ND – 0.5	ND – 1.4	3

MPL = Maximum permissible level, ND = Non Detectable

The range of pH values obtained for samples in the area around the dumpsites was slightly higher than those obtained from samples collected further away from the dumpsites. The range of values (6.9 – 9.6) obtained around the dumpsites showed that the pH values for some of the sampled waters were slightly higher than the WHO (2004) recommended maximum permissible save level of 8.5 while the range of values (6.0 – 7.9) obtained for samples collected further away from the dumpsites fell within the WHO maximum save permissible level.

The groundwater in the area around the dumpsite could be classified to be neutral to slightly alkaline while those that were collected further away from the dumpsites were slightly acidic to neutral. The higher values (> 8.5) of the pH obtained in some of the sampled waters in the area around the dumpsites could be indicative of the influence of leachate from the dumpsite.

The electrical conductivity (EC) ranged from 680 – 2361 µS/cm and 145 – 1500 µS/cm while the TDS values ranged between 118.5 – 1056 mg/l and 72.5 – 750 mg/l respectively (Figure 3) for samples collected from around the dumpsites and those that were collected further away from the dumpsites (Table 1). The electrical conductivity for some water samples collected closed to the dumpsites were higher (> 1000µS/cm) than the WHO recommended maximum permissible save level for potable water and also much higher than the baseline concentration values of 19 – 909 µS/cm obtained in the basement complex terrain of Nigeria (Table 2). These relatively high values of the electrical conductivity could be indicative of pollution of the groundwater from dumpsites leachate. The TDS in water samples collected from wells located around the dumpsites were generally higher than the TDS in water samples collected from well located further away from the dumpsites (Figure 3) and also higher than the baseline concentration values of 85.0 – 509 mg/l obtained in the basement complex terrain of Nigeria (Table 2). The relatively high EC and TDS values could be indicative of dumpsites leachate pollution of the groundwater.

Chemical Parameters

The results of the analyzed major cations and anions are contained in Table 1. For the water samples collected in the area around the dumpsites, the ranges of concentration levels for Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} were 23 – 179 mg/l, 94 – 141mg/l, 38.1 – 47.8 mg/l and 106 – 175 mg/l, respectively, while the concentration levels for samples collected further away from the dumpsites for the same cations were 0.5 – 189 mg/l, 5.9 – 138 mg/l, 29.5 – 47.4 mg/l and 90.8 – 136 mg/l, respectively (Figure 4). Concentration levels of the cations in the water samples collected from around and far from the dumpsites were generally low and within the WHO

maximum permissible level of 200 mg/l (Table 1). However, the ranges of concentration values obtained for Mg^{2+} and K^{+} around the dumpsites were generally slightly higher than those obtained for sample points located far away from the dumpsites. These values were generally higher than the range of concentration values (0.8 – 56.3 mg/l) for Mg^{2+} and (2.4 – 57.6 mg/l) for K^{+} obtained in the basement complex of Nigeria (Table 2).

The higher concentration values for Mg^{2+} and K^{+} obtained around the dumpsites could be indicative of leachate enrichment from the dumpsites. The Na^{+} concentration levels for water samples collected from the area around the dumpsites and beyond were within the same range of values of 38.1 – 47.8 mg/l and 29.5 – 47.4 mg/l respectively. The concentration values (23 – 179 mg/l) obtained for Ca^{2+} in the study area showed that some water samples displayed concentration levels that are higher than the WHO permissible level of 75 mg/l and the baseline concentration values of 0.8 – 90.0 mg/l recorded previously in the basement complex of Nigeria (Table 2), 180 mg/l and 0.2 – 19.6 mg/l respectively (Figure 5).

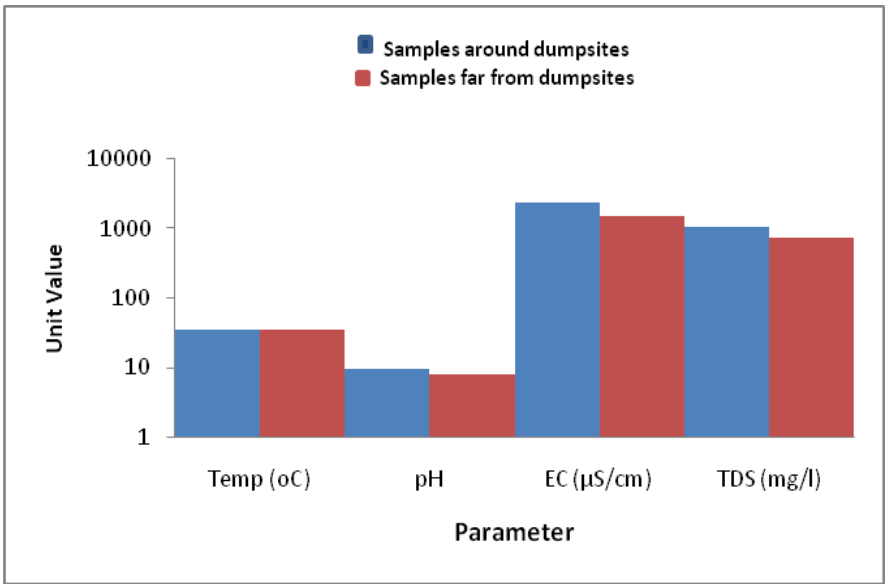

Figure 3: Plot of Ranges of Values for the Major Physical Parameters.

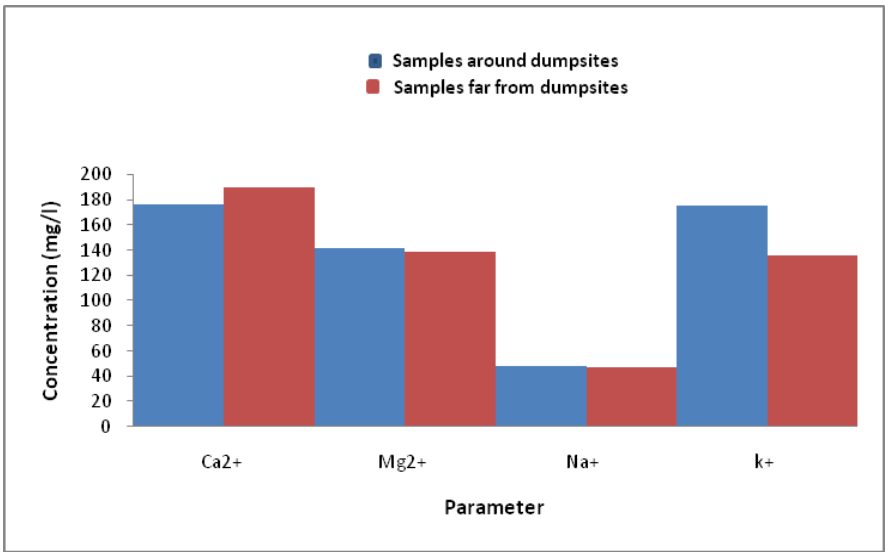

Figure 4: Plot of Ranges of Concentration Levels for the Major Cations.

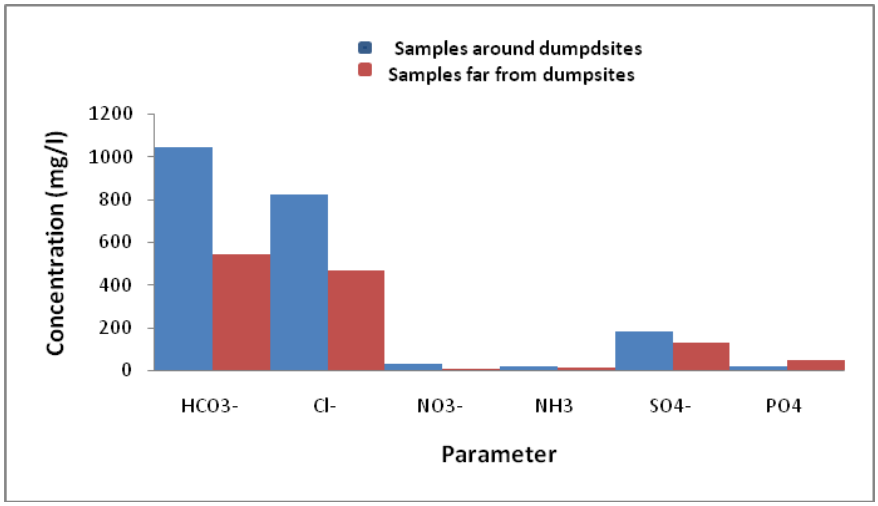

Figure 5: Plot of Ranges of Concentration Levels for the Major Anions.

Table 2: Baseline Physical and Chemical Characteristics of Groundwater in Parts of the Basement Complex Area of Nigeria.

Parameter	**Basement Complex Area of Southwestern, Nigeria.** (Olatunji et al., 2001, Abimbola et al., 2002 and WATSAN Technical Reports from Ondo, Ekiti and Osun State).	**Basement Complex Area of North-Central, Nigeria.** (Olarewaju et al., 1997)	**Basement Complex Area of Northwestern, Nigeria.** (Bala and Onugba, 2001)	**Baseline Concentration Ranges for Basement Complex Terrain of Nigeria**
Temp. ^{o}C	22 – 30	-	25.0 – 29.5	22-30
pH	6.1 – 7.7	5.2 – 7.8	6.2 – 7.4	5.2-7.8
Conductivity (EC)	19 – 909 µS/cm	25 – 800 µS/cm	90 - 680 µS/cm	19-909
TDS (mg/l)	85.0 – 509		100 – 300	85-509
Ca^{2+} (mg/l)	2.0 – 90.0	0.8 – 69.2	22.85 – 57.92	0.8-90.0
Mg^{2+} (mg/l)	1.3 – 53.14	0.8 – 22	3.16 – 56.30	0.8-56.3
Na^{+} (mg/l)	9.0 – 50	-	6.21 – 51.06	6.2-51.6
K^{+} (mg/l)	2.40 – 57.6	-	2.74 – 19.55	2.4-57.6
HCO_3^{-} (mg/l)	11.5 – 201.3	-	63.01 – 290.48	11.5-290.5
Cl^{-} (mg/l)	0.0145 – 394 mg/l	0.3 – 22 mg/l	1.42 – 32.62 mg/l	0.015-394
NO_3^{-} (mg/l)	None detectable – 8.89 mg/l	0.02 – 2.5 mg/l	9.30 – 22.94 mg/l	0.02-22.9
NH_3 (mg/l)	-	-	-	-
SO_4^{2-} (mg/l)	0.20 – 45	0.2 – 6	20.66 – 145.08	0.2-145.1
PO_4 (mg/l)	1.2 – 7.2	-	-	1.2-7.2
∑Fe (mg/l)	0.04 – 2.9	0.02 – 1.4	-	0.02-2.9
Pb^{2+} (mg/l)	0.0 – 0.06	-	-	0.00-0.06

The concentration levels for samples located further away from the dumpsites were 45 – 540 mg/l, 46 – 468 mg/l, 2.2 – 5.6 mg/l, 0.1 – 12.6 mg/l, 4 – 130 mg/l and 2 – 49 mg/l. The ranges of concentration values obtained for samples around the dumpsites for Cl^- , NO^{3-} and NH_3 were 103 – 819 mg/l, 1.4 – 30 mg/l and 0.3 – 18.3 mg/l respectively. These ranges of concentration values were much higher than the ranges of concentration levels of 46 – 468 mg/l, 2.2 – 5.6 mg/l, and 0.1 – 12.6 mg/l, respectively, obtained for samples that were located further away from the dumpsites.

Many of the water samples collected close to the dumpsites and some located beyond gave concentration levels that were higher than the WHO (2004) recommended maximum permissible levels of 200 mg/l for Cl^-, 10 mg/l for NO_3^- and 1.5 mg/l for NH_3 and 10 mg/l for PO_4. These relatively high concentrations values obtained for Cl^- and NO_3^- around the dumpsites could be indicative of leachate pollution from the dumpsites.

The concentration levels for the heavy metals: Fe, Pb^{2+}, and Zn^{2+} for the area around the dumpsites ranged from 0.1 – 16.9 mg/l, non-detectable – 0.2 mg/l, non-detectable – 0.5 mg/l; while the concentration levels for some heavy metals for samples collected from far away from the dumpsites were 0.1 – 15.8 mg/l, non-detectable – 0.1 mg/l and non-detectable – 1.4 mg/l respectively. Zn^{2+} appeared to occur in low concentration levels for samples collected from the area around the dumpsites and beyond.

Although the concentration levels for the analyzed heavy metals were virtually within the same range for samples collected from around the dumpsites and beyond, some of the water samples gave concentration levels that were generally higher than the WHO maximum permissible levels of 0.03 mg/l for Fe and 0.01 mg/l for Pb^{2+}. The relatively high concentration level of up to 0.2 mg/l for Pb^{2+} in waters collected from the area around the dumpsites could be attributed to leachate from the dumpsites.

CONCLUSION

Hydro-chemical analysis of hand dug well water samples collected from around five waste dumpsites in Akure Metropolis, Southwest Nigeria, gave relatively high electrical conductivity (680 – 2361 µS/cm) and TDS (118.5 – 1056 mg/l). Many of the water samples collected from wells located close to the dumpsites gave electrical conductivity and TDS values that exceeded the WHO (2004) recommended maximum permissible levels of 1000µS/cm and 500 mg/l respectively and were outside the baseline concentration values of 19 – 909 µS/cm and 85.0 – 509 mg/l, respectively obtained in the basement complex terrain of Nigeria. Although the cation concentration levels obtained were generally lower than the maximum permissible levels recommended by WHO, with the exception of Ca^{2+}, the upper limits of the concentration levels for $Ca^{2+,}$ Mg^{2+} and K^+ (23 – 179 mg/l, 94 – 141mg/l and 106 – 175 mg/l respectively) were higher than the baseline concentration values of 2.0 – 90 mg/l, 1.3 – 56.06 mg/l and 2.4 – 57.6 mg/l, respectively, obtained in the basement complex terrain in Nigeria.

The upper limits of anions concentration levels for Cl^-, NO_3^-, NH_3 and PO_4^{3-} (103 – 819 mg/l, 1.4 – 30 mg/l, 0.3 – 18.3 mg/l and 0.2 – 19.6 mg/l respectively) obtained for wells located close to the dumpsites were higher than the WHO (2004) recommended maximum permissible level of 200 mg/l for Cl^- , 10 mg/l for NO_3^- and 1.5 mg/l for NH_3 and 10 mg/l for PO_4, and were also generally higher than the baseline concentration values of 0.0145 – 349 mg/l for Cl^-, non-detectable – 8.89 mg/l for NO_3 and 1.28 – 7.2 mg/l for PO_4^{3-} obtained from basement complex underlain dumpsites in Ibadan, Southwestern Nigeria (Abimbola et al., 2002).

The concentration levels for the heavy metals: Fe and Pb^{2+}, were respectively 0.1 – 16.9mg/l and non-detectable – 0.2 for the area around the dumpsites and non-detectable – 0.1 for the area that are further away from the dumpsites. These values were generally higher than the WHO recommended values of 0.3 mg/l for Fe and 0.01 mg/l for Pb^{2+}. The record of relatively high electrical conductivity and TDS and concentration levels of cations/anions/heavy metals: Ca^{2+}, Mg^{2+}, K^+, Cl^-, NO^3, NH_3, $PO_4^{3-,}$ Fe and Pb^{2+} was an indication that the groundwater in the area around the dumpsites had been significantly polluted.

ACKNOWLEDGEMENTS

The authors are grateful to Prof. I. O. Amoo and Mr. G. Owoeye, who assisted with collection of

water samples, provision of technical support and analysis of the water samples.

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SUGGESTED CITATION

Bayode, S., M.O. Olorunfemi, and J.S. Ojo. 2012. "Assessment of Impact of Some Waste Dumpsites on the Groundwater Quality in Parts of Akure Metropolis, Soutwestern Nigeria". *Pacific Journal of Science and Technology*. 13(2):528-536.

Pacific Journal of Science and Technology