PHYSICOCHEMICAL EVALUATION OF GROUNDWATER NEAR IKOT EFFANGA DUMPSITE, CALABAR, SOUTH EASTERN NIGERIA

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(Received 7 June 2021; Revision Accepted 30 June 2021)

ABSTRACT

The Ikot Effanga area of Calabar, Southeastern Nigeria, is located close to a municipal waste dump. The area is defined by latitudes 05°00′N and 05°25′N and longitudes 008°20′E and 008°25′E. The aim of the study was to assess the impact of the waste dump on the groundwater resources of the area. Groundwater samples were obtained from 10 boreholes located around the dump site. The samples were collected during the peak dry season and peak rainy season for comparison. Physicochemical parameters were analyzed. Static water level and surface elevation of the boreholes were used to determine the groundwater flow direction. Results obtained were compared with the NSDWQ and WHO standards. From the result, it was observed that groundwater in the area is acidic as the mean pH values were 4.03 and 3.57 for dry and wet season respectively. Other physicochemical parameters analyzed showed that there were no significant variations between the dry and wet season. Also, groundwater from the area was classified as fresh and suitable for domestic and agricultural purposes. The general flow direction of groundwater in the study area is NW-SE. While the present study showed that the dumpsite does not have significant impact on the groundwater resources either due to geology or natural attenuation.

KEYWORDS: Groundwaters Evolutions. Contamination. Dumpsite. Nigeria

INTRODUCTION

Rapid urbanization, increased population, advancement in technology and the general improvement in the standard of living in many countries of the world have led to generation of large amount of municipal wastes. Disposal of these wastes is a global concern, most especially in the developing countries across the world, where less attention is paid on waste management due to poor funding leading to improper design and poor waste management technique (Doan, 1998). Dumpsite is the simplest and most cost-effective method of wastes disposal both in the developed and developing nations of the world. However, there has been a reduction in the number of landfills and the amount of municipal solid wastes over the years due to “Re-use and recycle” approaches to wastes (Ken et al, 1996, Aderemi et al, 2011). In an unlined sanitary landfill and in a fairly wet climate, leachate containing hazardous chemicals like Lead (Pb) at concentrations above permissible values for drinking water have been reported. This could persist in the environment for several thousand years (Kumar and Alappat, 2003). Leachate varies widely in composition depending on many interacting factors such as the composition and depth of waste, availability of moisture and oxygen, landfill design, operation and age (Aderemi et al, 2011) as well as degree of waste stabilization. One important consideration on the quality of groundwater is the local geology (Edet et al, 2011). While sources, nature of waste, age of landfill and climate may be some important factors that affect the level of impact on groundwater, local geology, particle size, degree of compaction and site hydrology significantly affect groundwater quality around dumpsites. The disposal of wastes at Ikot Effanga dumpsite calls for concern due to the growing population which has led to the increased in the demand for potable

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water supply to meet their domestic and other uses. This has resulted in the indiscriminate siting of boreholes in the area regardless of the dangers of the percolating leachates on groundwater resources.

The aim of the present study is to;
1. Evaluate the groundwater quality and
2. Determine the level of contaminations around the environs of the dumpsite.
3. Identify major sources of contamination to groundwater resources
4. Prepare groundwater flow direction for the area to map out the direction of flow of contaminant plume.

PHYSICAL SETTING, LOCATION AND GEOLOGY OF STUDY AREA

Ikot Effanga and its environs where Lemna dumpsite is located is part of Calabar Municipal, Cross River State, South Eastern Nigeria. The geographic coordinate of the study area lies between latitude 05°00'N and 05°25'N and longitude 008°20'E and 008°25'E. The elevation lies between 27m to about 82m above mean sea level.

Amah et al (2012) noted that the area is well drained by three major rivers; Calabar River, Great Kwa and Akpayafe Rivers. Climatic data shows a monthly temperature between 23.1°C and 28.7°C with an average precipitation between 26.7mm (February) to 459.1mm (July).

The geology of the area comprises of Tertiary to Recent continental sands, characterized by alternation of clays, sands, gravel and alluviums. The Calabar Coastal Plain sand is very important groundwater reservoir that underlies more than half of the basin sedimentary area. It consist of continental sands and lenses of shales and clays and the water table is generally high (Edet, 1993, Edet and Okereke, 2002, Edet and Worden, 2009).

Hydrogeologic unit of the study area is mainly Coastal plain sands and alluvium which receives a significant amount of recharge from precipitation as well as the network of rivers around. Investigation within the study area show three aquiferous units with a depth range of 120-180m (Ekwere 2015)

METHODS AND METHODS

In an effort to study the level of groundwater contamination of the area, ten (10) water samples were collected from boreholes around the vicinity of the dumpsite (Table 1 and 2).

The samples were collected in clean 500ml plastic bottles, stored at temperature of 4°C and transported immediately to the laboratory for analyses. All samples were analyzed for relevant physicochemical parameters according to internationally acceptable procedures and standard methods (ALPH, 1994). The parameters analyzed include pH, EC, TDS, Total Hardness (TH), Na+, SO₄²⁻, NH₄⁺, Fe, Zn, Cd and Pb. The electric water logger (Dip meter) was used to determine the Static Water Level (SWL) of the cased boreholes while Garmin GPS map 78sc was use for surface elevation. The difference between the elevation and static water level gave the hydraulic head which is important in the determination of the groundwater flow direction. For us to achieve accuracy, we used three GPS in the field and took the average reading.

RESULTS

A statistical summary of the results of physicochemical parameters for samples from the study area taken at both dry and wet season, including the Nigerian Standard for Drinking Water Quality (NSDWQ, 2008) are presented in table 1 to table 4.
Table 1: Results of physico – chemical parameters obtained during dry season.

| Parameter Unit | LOC 1 Lemna | LOC 2 Lemna Rd | LOC 3 Lemna Sch | LOC 4 Unique Sch | LOC 5 Northwest | LOC 6 Lemna Rd | LOC 7 Lemna Rd | LOC 8 Basin Guest House | LOC 9 ItuOkon | NSDWQ |
|----------------|------------|----------------|----------------|------------------|-----------------|----------------|----------------|------------------------|---------------|-------|
|                | LOC 10 | TEMP (°C) | 28.6 | 28.9 | 28.8 | 28.7 | 28.6 | 28.6 | 28.3 | 28.3 | 28.3 | 28.6 | Ambient |
| pH             | LOC 10 | 4.0 | 3.7 | 4.1 | 3.9 | 4.0 | 4.0 | 4.4 | 4.2 | 4.2 | 4.0 | 6.5-8.5 | |
| Conductivity (μS/cm) | LOC 10 | 6.3 | 158.5 | 58.4 | 86.9 | 110.0 | 53.0 | 25.8 | 48.5 | 26.8 | 30.0 | 500 | |
| Turbidity (NTU) | LOC 10 | 0.2 | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 | 0.3 | 0.1 | 0.1 | 0.03 | 5 | |
| Salinity (ppm) | LOC 10 | 0 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | |
| DO (mg/l) | LOC 10 | 13 | 17 | 19 | 24 | 14 | 16 | 13 | 23 | 13 | 14 | 14 | |
| TDS (mg/l) | LOC 10 | 37.8 | 95.1 | 35.0 | 52.1 | 66 | 31.8 | 15.5 | 29.1 | 16.1 | 18 | 1000 | |
| TSS (mg/l) | LOC 10 | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | 0.1 | |
| Iron (mg/l) | LOC 10 | 0.02 | 0.01 | 0.01 | 0.04 | 0.07 | 0.06 | 0.09 | 0.16 | 0.19 | 0.23 | 0.3 | |
| Mn (mg/l) | LOC 10 | 0.1 | 0.1 | 0.2 | 0.3 | 0.2 | 0.1 | BDL | 0.4 | 0.3 | 0.1 | 0.05 | |
| Nitrate (mg/l) | LOC 10 | 5 | 7.3 | 2.7 | 7.7 | 6.8 | BDL | 6.6 | 1.4 | 1.8 | 1.5 | 10 | |
| Nitrite (mg/l) | LOC 10 | 0.001 | 0.003 | BDL | BDL | 0.002 | BDL | BDL | BDL | BDL | BDL | 0.1 | |
| Ammonia (mg/l) | LOC 10 | 0.2 | 0.2 | 0.19 | 0.14 | 0.12 | 0.17 | 0.07 | 0.12 | 0.09 | 0.12 | 1 | |
| Sulphate (mg/l) | LOC 10 | 6.49 | 18 | 15 | BDL | BDL | 6 | BDL | BDL | BDL | 100 | |
| Phosphate (mg/l) | LOC 10 | 120 | 24 | 11 | 8 | 159 | 11 | 9 | 7 | 100 | |
| Potassium (mg/l) | LOC 10 | 2.5 | 6.3 | 5.02 | 3.3 | 2.1 | 12 | 2.6 | 3.8 | 3.7 | 3.7 | 100 | |
| Copper (mg/l) | LOC 10 | BDL | BDL | BDL | BDL | 0.01 | 0.09 | BDL | BDL | BDL | 1 | |
| Nickel (mg/l) | LOC 10 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.001 | |
| Cobalt (mg/l) | LOC 10 | BDL | BDL | BDL | BDL | 0.11 | 0.14 | BDL | BDL | BDL | 0.004 | |
| Zinc (mg/l) | LOC 10 | 0.09 | 0.52 | 0.09 | 0.11 | 0.14 | 0.13 | 0.09 | 0.08 | 0.12 | 0.11 | 5 | |
| Chromium (mg/l) | LOC 10 | BDL | BDL | 0.016 | 0.043 | BDL | BDL | BDL | BDL | BDL | 0.004 | |
| Calcium (mg/l) | LOC 10 | 5.28 | 5.68 | 10.62 | 11.92 | 20.88 | 14.56 | 16.4 | 11.6 | 17.6 | 13.12 | |
| Magnesium (mg/l) | LOC 10 | 1.61 | 1.14 | 2.39 | 0.87 | 2.06 | 0.89 | 0.48 | 2.26 | 0.59 | 0.05 | 20 | |
| Total Hardness (mg/l) | LOC 10 | 6.89 | 6.82 | 13.01 | 12.79 | 22.9 | 15.45 | 16.88 | 13.86 | 18.19 | 13.17 | 100 | |
| Cyanide (mg/l) | LOC 10 | BDL | 0.001 | 0.001 | 0.001 | BDL | BDL | BDL | BDL | BDL | BDL | |
| Ammonium (mg/l) | LOC 10 | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | BDL | 0.5 | |
| Lead (mg/l) | LOC 10 | 0.005 | 0.003 | BDL | BDL | BDL | 0.01 | 0.01 | BDL | BDL | BDL | 0.004 | |
| Fluoride (mg/l) | LOC 10 | 0.16 | 0.25 | 0.11 | 0.13 | 0.08 | 0.09 | 0.14 | 0.07 | 0.13 | 0.11 | 1.5 | |
| Chloride (mg/l) | LOC 10 | 3.08 | 10.7 | 3.11 | 6.4 | 9.71 | 2.5 | 2 | 4.6 | 2.06 | 3 | 100 | |
| BOD (mg/l) | LOC 10 | 9.3 | 12.5 | 12 | 14.7 | 9.6 | 12.5 | 8.3 | 8.1 | 7.2 | 9.1 | |
| THC/100ml | LOC 10 | TNTC | TNTC | TNTC | TNTC | TNTC | TNTC | TNTC | TNTC | TNTC | TNTC | 3 | |
| TCC/100ml | LOC 10 | TNTC | TNTC | TNTC | TNTC | TNTC | TNTC | TNTC | TNTC | TNTC | TNTC | 0 | |
| FCC/100ml | LOC 10 | TNTC | TNTC | TNTC | TNTC | TNTC | TNTC | TNTC | TNTC | TNTC | TNTC | 0 | |
| 1TNTC – Too Numerous To Count | LOC 10 | | | | | | | | | | | | |
| BDL – Below Detection Limit | LOC 10 | | | | | | | | | | | | |
| NSDWQ – Nigerian Standard for Drinking Water Quality, 2008 | LOC 10 | | | | | | | | | | | | |
Table 2: Results of physico–chemical parameters obtained during wet season.

| Parameter          | LOC 1 | LOC 2 | LOC 3 | LOC 4 | LOC 5 | LOC 6 | LOC 7 | LOC 8 | LOC 9 | LOC 10 | NSDWQ |
|--------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|-------|
| Ph                 | 3.6   | 3.33  | 3.6   | 3.69  | 3.41  | 3.02  | 3.9   | 3.38  | 3.76  | 3.96   | Ambient |
| Temperature (°C)   | 27    | 26.5  | 26.9  | 26.6  | 26.6  | 26.6  | 26.7  | 26.6  | 26.8  | 26.8   | 6.5-8.5 |
| Conductivity (μS/cm) | 453   | 580   | 378   | 360   | 745   | 1016  | 110.47| 423   | 131   | 142.98 | 500   |
| Turbidity (NTU)    | 0.53  | 0.436 | 0.429 | 1.08  | 0.491 | 0.424 | 6.31  | 0.454 | 0.496 | 6.83   | 5     |
| Salinity (ppt)     | 0.2   | 0.3   | 0.2   | 0.2   | 0.4   | 0.5   | 0.1   | 0.2   | 0.1   | 0.1    | 4     |
| DO (mg/l)          | 222   | 284   | 185   | 176   | 365   | 498   | 84    | 207   | 89    | 95     | 14    |
| TDS (mg/l)         | 271.8 | 348   | 226.8 | 216   | 447   | 609.6 | 66.28 | 253.8 | 78.6  | 85.788 | 1000  |
| TSS (mg/l)         | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | 0.285 | BDL   | BDL   | 0.331  | 0.1   |
| Iron (mg/l)        | 0.01  | BDL   | 0.03  | 0.02  | 0.01  | 0.03  | 0.36  | 0.26  | 0.08  | 0.67   | 0.3   |
| Manganese (mg/l)   | 0.02  | BDL   | 0.02  | 0.03  | 0.03  | 0.02  | 0.06  | 0.02  | 0.03  | 0.05   |       |
| Nitrate (mg/l)     | 7     | 7.9   | 7.93  | 5.5   | 11.7  | 6.8   | 1.8   | 5.8   | 1     | 3.2    | 10    |
| Nitrite (mg/l)     | 0.062 | 0.01  | 0.015 | 0.01  | 0.014 | 0.01  | 0.014 | 0.013 | 0.006 | 0.011  | 0.1   |
| Ammonia (mg/l)     | 0.78  | 0.5   | 0.21  | 0.19  | 0.25  | 0.17  | 0.16  | 0.36  | 0.23  | 0.13   |       |
| Sulphate (mg/l)    | 7     | 9     | 15    | 9     | BDL   | 26    | 5     | 3     | 55    | 5      | 100   |
| Phosphate (mg/l)   | 7.86  | 5.07  | 4.86  | 3.17  | 2.36  | 7.07  | 5.17  | 10.51 | 9.38  | 4.29   | 100   |
| Potassium (mg/l)   | 3.6   | 5.1   | 3.05  | 3.04  | 1.5   | 6.5   | 2.05  | 6.3   | 8.2   | 6.2    | 100   |
| Copper (mg/l)      | 0.02  | 0.03  | 0.1   | 0.01  | 0.11  | 0.05  | 0.07  | 0.04  | 0.03  | 0.1    |       |
| Nickel (mg/l)      | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL    | 0.001 |
| Cobalt (mg/l)      | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL    | 0.004 |
| Zinc (mg/l)        | 0.18  | 0.22  | 0.13  | 0.18  | 0.21  | 0.11  | 0.19  | 0.17  | 0.14  | 0.19   | 5     |
| Chromium (mg/l)    | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL    | 0.004 |
| Calcium (mg/l)     | 28.72 | 16.48 | 17.36 | 21.04 | 28.16 | 12.4  | 23.9  | 13    | 25.5  | 11.62  |       |
| Magnesium (mg/l)   | 2.54  | 2.01  | 1.39  | 1.17  | 0.26  | 4.7   | 10.3  | 4.1   | 8.7   | 5.5    | 20    |
| Total Hardness (mg/l) | 31.26 | 18.49 | 18.99 | 22.21 | 28.42 | 17.1  | 34.2  | 17.1  | 34.2  | 17.1   | 100   |
| Cyanide (mg/l)     | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL    |       |
| Alumimium (mg/l)   | 0.222 | 0.321 | 0.795 | 0.443 | 0.536 | 0.325 | 0.699 | 0.238 | 0.278 | 0.293  | 0.5   |
| Lead (mg/l)        | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL    | 0.004 |
| Flouride (mg/l)    | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL   | BDL    | 1.5   |
| Chloride (mg/l)    | 16.5  | 22.1  | 9.6   | 8.82  | 9     | 44.7  | 76.5  | 5.6   | 16.8  | 10.2   | 100   |
| BOD (mg/l)         | 7.05  | 7.1   | 6.4   | 7.32  | 6.98  | 7.19  | 6.01  | 6.95  | 7.48  | 6.09   |       |
| THC/100ml          | TNTC  | TNTC  | TNTC  | TNTC  | TNTC  | TNTC  | TNTC  | TNTC  | TNTC  | TNTC   | 3     |
| FCC/100ml          | TNTC  | TNTC  | TNTC  | TNTC  | TNTC  | TNTC  | TNTC  | TNTC  | TNTC  | TNTC   | 0     |
| TCC                | TNTC  | TNTC  | TNTC  | TNTC  | TNTC  | TNTC  | TNTC  | TNTC  | TNTC  | TNTC   | 0     |
| Alkalinity         | 6.11  | 5.79  | 6.11  | 6.11  | 5.89  | 5.36  | 6.41  | 5.86  | 6.28  | 6.46   |       |

TNTC – Too Numerous to Count
BLD – Below Detection Limit
NSDWQ – Nigerian Standard for Drinking Water Quality, 2008
Table 3: Mean, minimum, maximum and standard deviation of physico-chemical parameters for dry season.

| Parameters | Samples | Mean | Minimum | Maximum | Std. Dev |
|------------|---------|------|---------|---------|----------|
| pH         | 10      | 4.037 | 3.65    | 4.36    | 0.19368  |
| Cond       | 10      | 66.085| 25.77   | 158.5   | 42.06369 |
| Turb       | 10      | 0.1293| 0.029   | 0.321   | 0.07505  |
| Salinity   | 10      | 0.0    | 0       | 0.1     | 0.04216  |
| DO         | 10      | 16.6   | 13      | 24      | 4.14193  |
| TDS        | 10      | 39.651 | 15.46  | 95.1    | 25.23849 |
| Fe         | 10      | 0.088  | 0.01    | 0.23    | 0.07885  |
| Mang       | 10      | 10.18  | 0.1     | 0.1     | 31.55971 |
| NO₃        | 10      | 14.08  | 1.4     | 1.4     | 30.29422 |
| Ammo       | 10      | 0.142  | 0.07    | 0.2     | 0.04614  |
| SO₄        | 10      | 59.4   | 6       | 6       | 44.39519 |
| Phosphate  | 10      | 36.72  | 7.03    | 158.9   | 55.63084 |
| K          | 10      | 4.502  | 2       | 12      | 2.91243  |
| Ni         | 10      | 0.0957 | 0.071   | 0.13    | 0.02214  |
| Zinc       | 10      | 0.148  | 0.08    | 0.52    | 0.13214  |
| Cal        | 10      | 12.766 | 5.28    | 20.88   | 4.92935  |
| Mag        | 10      | 1.234  | 0.05    | 2.39    | 0.80674  |
| TOT_Hard   | 10      | 13.996 | 6.82    | 22.9    | 4.85821  |
| Pb         | 10      | 60.0028| 0.003   | 100     | 51.63616 |
| Fluoride   | 10      | 0.127  | 0.07    | 0.25    | 0.05143  |
| Chlo       | 10      | 4.716  | 2       | 10.7    | 3.18224  |
| BOD        | 10      | 10.33  | 7.2     | 14.7    | 2.43358  |

Table 4: Mean, Minimum, Maximum and Standard deviation of physico-chemical parameters for wet season.

| Parameters | Samples | Mean | Minimum | Maximum | Std. Dev. |
|------------|---------|------|---------|---------|-----------|
| temp       | 10      | 26.7 | 26.5    | 27      | 0.17      |
| pH         | 10      | 3.565 | 3.02    | 3.96    | 0.2857    |
| Cond       | 10      | 433.945| 110.47  | 1016    | 288.1027  |
| Turb       | 10      | 1.748 | 0.424   | 6.83    | 2.5518    |
| Salinity   | 10      | 0.23  | 0.1     | 0.5     | 0.1337    |
| Do         | 10      | 220.5 | 84      | 498     | 132.0852  |
| TDS        | 10      | 260.3668| 66.28   | 609.6   | 172.8618  |
| TSS        | 10      | 80.0616| 0.285   | 100     | 42.0338   |
| Fe         | 10      | 10.147| 0.01    | 100     | 31.5719   |
| Mang       | 10      | 10.083| 0.02    | 100     | 31.5941   |
| NO₃        | 10      | 5.863  | 1       | 11.7    | 3.198     |
| NO₂        | 10      | 0.0165 | 0.006   | 0.062   | 0.0162    |
| Ammo       | 10      | 0.298  | 0.13    | 0.78    | 0.2019    |
| SO₄        | 10      | 23.5   | 3       | 101     | 31.4015   |
| Phosphate  | 10      | 5.974  | 2.36    | 10.51   | 2.6541    |
| K          | 10      | 4.6    | 1.5     | 8.2     | 2.2       |
| Cu         | 10      | 0.06   | 0.01    | 0.11    | 0.04      |
| Ni         | 10      | 100    | 100     | 100     | 0         |
| Cobalt     | 10      | 100    | 100     | 100     | 0         |
| Zine       | 10      | 0.17   | 0.11    | 0.22    | 0.04      |
| Chro       | 10      | 100    | 100     | 100     | 0         |
| Cal        | 10      | 19.8   | 11.6    | 28.7    | 6.5       |
| Mag        | 10      | 4.067  | 0.26    | 10.3    | 3.3       |
| TOT_Hard   | 10      | 23.907 | 17.1    | 34.2    | 7.3       |
| Cyanide    | 10      | 100    | 100     | 100     | 0         |
| Al         | 10      | 0.4    | 0.2     | 0.8     | 0.2       |
| Pb         | 10      | 100    | 100     | 100     | 0         |
| Fluoride   | 10      | 100    | 100     | 100     | 0         |
| Chlo       | 10      | 22.0028| 5.6     | 76.5    | 22        |
| BOD        | 10      | 6.9    | 8.0     | 7.5     | 0.5       |
DISCUSSION

PHYSICAL CHARACTERISTICS OF GROUNDWATER FROM THE STUDY AREA

Temperature of groundwater from the study area ranges from 28.3°C to 28.6°C during the dry season but varies between 26.5°C to 27°C with mean of 26.7°C during the wet season. The elevated temperature during the dry season is as a result high evaporation as compared to the wet season. Temperature influences biological activities and equally affects chemical reactions. Increased temperature increases mineral dissolution in rocks/soils (Hems, 1986).

The mean value for pH was 4.04 for dry season and 3.57 for wet season. The increased acidity during the wet season is attributed to higher precipitation with increased weathering and dissolution of silicate, carbonate and sulphide minerals as well as contribution from the atmosphere into the groundwater (Ekwere, 2010). The pH of groundwater from the study area is generally lower than WHO/NSDWQ standards for drinking water which ranges from 6.5 to 8.5. Groundwater in the area is acidic. The pH represents acidic activity at locations with high human population density (Edet and Okereke, 2005, Edet and Ekpo, 2008). While low acidity in groundwater does not pose any health challenge to human other than sour taste, related effects include corrosion of well casings and pipes and release of toxic metals, some of which are carcinogenic. The mean value for EC in the study area was 66.08µs/cm while that of wet season was 433.95µs/cm. Generally, EC increases with temperature while corrosivity of groundwater increases with EC (Mona, 2013). Data on the study area indicate higher EC during the wet season which could be attributed to low evaporation and higher water-rock interaction (Edet and Worden, 2009). TDS in the study area gave values less than the 1000mg/l recommended by NSDWQ, 2008. This means the groundwater in the area can be classified as fresh. Increased TDS in wet season compared dry season is due to higher intensity of weathering. Dissolved Oxygen (DO) in the study area varied from 13-24mg/l with mean value of 16.6mg/l during the dry season and mean value of 220.5mg/l during wet season.

CHEMICAL CHARACTERISTICS OF GROUNDWATER FROM THE STUDY AREA

Salinity measures the mass of dissolved salts in a given mass of solution. The ions include; Sodium (Na+), Chloride (Cl-), Nitrate (NO3-), Calcium (Ca2+), Magnesium (Mg2+), Bicarbonate (HCO3-) and Sulphate (SO42-). In the study area, salinity varied from 0.01ppt to 0.5ppt with the mean value of 0.2ppt for dry season and 0.23ppt for wet season. The salinity of groundwater from the area falls within the NSDWQ (2008) recommendation limit for drinking water. The slightly higher values observed during the wet season can be attributed to higher intensity of weathering and dissolution. Low salinity as observed in the study area equally suggest that groundwater in the area can be used for agricultural purposes. High concentration of nitrate in the study area though below the NSDWQ standard suggests anthropogenic sources.

Total hardness (TH) depends on the presence of dissolved calcium and magnesium salts or multivalent metal ions which dissolve in water. TH of water from the area varied from 6.82 to 22.9mg/l with the mean value of 13.9mg/l during dry season. The mean TH for wet season was 23.9mg/l. using the NSDWQ (2008) which gives total hardness as 100mg/l for drinking water, the water can be classified as soft Hem (1986). Potassium (K+) varied from 2.1 to 12mg/l with mean of 4.5mg/l for dry season and mean 4.51mg/l for wet season. K+ concentration for both dry and wet seasons was within the WHO (2009) standard for drinking water. Edet and Worden (2009) gave similar values for the area. Carbonate rocks like limestone and gypsum readily dissolve to add Ca2+ to water. The rate of dissolution may be higher when the precipitation available is acidic. In the study area, the mean value of Ca2+ was 12.77mg/l for dry season and 19.84mg/l for wet season. Mg2+ varied from 0.05 to 2.39mg/l with mean value of 1.23mg/l for dry season and mean of 4.07mg/l for wet season.

The trend of dominance of cations and anions in groundwater samples from the study area include; Ca2+ > K+ > Mg2+ > SO42- > NO3- > Cl > NH4+. The average content of cations and anions showed little variation for both seasons. However, slight variations observed are attributed to concentration of solutes resulting from higher temperature regimes and evaporation during dry season as well as dissolution effects from the influx of surface run-off in the wet season (Ekwere et al, 2011).

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The trilinear diagram (Piper, 1994) is used to determine the groundwater facies. It consists of two triangular describing the relative composition of cations and anions. From the plots (Fig 2 and 3), there were no significant variations in samples obtained from wet and dry seasons. This suggests that the groundwater originated from the similar source. The dominant groundwater facies within the study area were Na+K-Cl groundwater type and Mg+Ca-Cl type.
Fig. 2: Piper diagram generated using data obtained during Dry season

Fig. 3: Piper diagram generated using data obtained during wet season
GROUNDWATER FLOW DIRECTION

Groundwater flow direction was constructed to ascertain the direction of movement of plumes down gradient from the dumpsite. Table 5 gives borehole elevation and static water level (SWL) used in defining the flow direction. In the area, groundwater generally flow in the NW-SE direction (Fig 4 and 5).

Table 5: Borehole locations with elevations and static water level.

| S/N | Street Name                  | Longitude | Latitude      | Elevation(m) | Static Level (m) | Water  |
|-----|------------------------------|-----------|---------------|--------------|------------------|--------|
| 1   | De-event centre              | 008°22'00E| 05°01'38N    | 24           | 15.0             |        |
| 2   | Engr. Akptere’s residence   | 008°22'25E| 05°01'30N    | 44           | 35.4             |        |
| 3   | Pastor Ojehonnon’s residence| 008°22'12E| 05°01'35N    | 22           | 11.2             |        |
| 4   | Pastor Amu’s residence       | 008°22'17E| 05°01'46N    | 44           | 29.6             |        |
| 5   | Bar. ItaNdarake residence   | 008°22'16E| 05°01'58N    | 33           | 23.1             |        |
| 6   | Mr Akan’s residence          | 008°22'00E| 05°01'56N    | 20           | 10.1             |        |
| 7   | Mrs Duncan residence         | 008°21'37E| 05°02'15N    | 64           | 44.4             |        |

Fig. 4: 2 – D Map showing groundwater flow directions within the study area
Wells located around the SE parts of the study area may be prone to leachate contamination. However, study from the groundwater chemistry from the location shows that as at present, the groundwater is safe for domestic use. Natural process like attenuation and impermeable layer prevent the groundwater in the area from contamination.

CONCLUSION
The results obtained in the study area shows that the dumpsite has minimal impact on the groundwater quality based on the current study. This may be as the result of geology which favours natural attenuation. A study of the relationship between the geology of the dumpsite and the quality of groundwater is recommended. It is also advised that the water from the wells sited in the vicinity be treated before drinking as biological contamination may be high. Leachate pollution study and geology of the area can be used to predict the groundwater quality of the area in the future. In conclusions Ikot Effanga dumpsite in Calabar has minimal impact on the groundwater quality of the Area due to underling Geology.

REFERENCES

Aderemi A. O., Oriaku A. V., Adewumi G. A., Otitoloju A. A., 2011. Assessment of Groundwater contamination by leachate near a municipal solid waste landfill. African Journal of Eviron. Science and Technology, 5(11): 933-941.

Amah E. A., Esu E. O., Oden M. I., Anam G., 2012. Evaluation of old Netim basement rocks (southeastern Nigeria) for construction aggregates. Journal of Geography and Geology, 4(3): 90-98.

APHA- AWWA – WPCF (15th Eds) 1994. Standard methods for the examination of water and wastewater. American Public Health Association, Washington DC.

Doan P. L., 1998. Institutionalizing household waste collection: the urban environmental management project in Cote d’ Ivoire. Habitat Int. 22(1): 27-39.

Edet A. E., Okereke C. S., 2005. Hydrogeological and Hydrochemical character of the regolith aquifer, Northern Obudu Plateau, Southern Nigeria. Hydrogeology Journal. 13(2): 391-415.

Edet A. E., Ekpo B. O., 2008 Hydrochemistry of a fractured aquifer in the Ogoja/Obudu area of SE Nigeria; In Applied groundwater studies in Africa. (Eds Adelana S and MacDonald A). IAH selected papers on Hydrogeol.,13: 391-403.

Edet A, Worden R. H., 2009. Monitoring of the physical parameters and evaluation of the chemical composition of river and groundwater in Calabar (South-eastern Nigeria). Environmental Monitoring Assessment, 157: 243–258.

Edet A, Nganje T. N., Ukpong A. J., Ekwere A. S., 2011. Groundwater chemistry and quality of Nigeria: A status review. African Journal of Environ. Science and Technology, 5(13):1152-1169.

Ekwere A. S., 2010. Hydrogeological and hydrogeochemical framework of the Oban Massif, South-eastern Nigeria. PhD Thesis, Dept. of Geology, University of Calabar, Calabar, Nigeria.
Ekwere A. S., Edet A, Ukpong A, Obim V., 2011. Assessment of seasonal variations of hydrochemical signatures of surface water quality using multivariate statistical methods. Journal of Sustainable Development in Africa. 13(8):51-64.

Ekwere A. S., Ekwere S. J., 2015. Heavy metal assessment of groundwaters in the vicinities of dumpsites in Calabar metropolis, South-eastern Nigeria.Earth Science Journal. 4(6): 261–265.

Hem J. B., 1986. Study and interpretation of chemical characteristics of natural water. US Geological survey water supply paper. 2: 245-263.

Ken WFD, Nicholas E, Stephen L., 1996. Municipal land filling practice and its impact on groundwater resources in and around urban Toronto, Canada. Hydrogeol. Journal, 4(1): 64-79.

Kumar D, Alappat B., 2003. Analysis of leachate contamination potential of a municipal landfill using leachate pollution index. Workshop on sustainable landfill management 3-5 Dec, 2003, Chennai, India. Pp. 147-153.

Mona A. H., 2013. Water quality assessment and hydrochemical characteristics of groundwater in Punjab, Pakistan. IJRRAS www.arpapress.com 16 (2):16-20.

NSDWQ 2008. Nigerian Standard for Drinking Water Quality. Nigerian industrial standard. NIS 554.Standard Organization of Nigeria. Pp. 30.

Piper A. M., 1944. A graphical procedure in the geochemical interpretation of water analysis. Am Geophys Union Trans. 25: 914-928.

WHO 2009. Guideline for Drinking Water Quality. Vol 12 Recommendations. Geneva. World Health Organization publications.