# ASSESSING TOXICITY LEVELS IN LEACHATE FROM WASTE DUMPSITE IN MGBARAKUMA-UBAKALA, UMUAHIA, ABIA STATE, NIGERIA.

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**ABSTRACT**
The study was conducted at waste dumpsite in Umuahia, Abia State, Nigeria to ascertain its toxicity levels in relation to the surrounding environment. Five leachate samples ($L_1$ to $L_5$) were randomly sampled in triplicate from the actual leachate streams in the solid waste dumpsite using Complete Randomized Design to assess the toxicity in leachate in the waste dumpsite at Mgbarakuma-Ubakala. The physicochemical properties and heavy metals in the leachates were determined using standard methods. The leachate was slightly alkaline with pH of 8.98, low electrical conductivity: 5.72 µs/cm, DO value (3.38 mg/l), COD and BOD values of 18.48 mg/l and 47.80 mg/l respectively. The mean total hardness value (408±45.04 mg/l) was above the 200 mg/l FEPA Guideline for drinking . Total dissolved solids: 2852 mg/l and Chloride concentration: 1133.16 mg/l of the leachate was above the permissible limit for drinking water. The trend of heavy metal concentration in the leachate: Fe > Ni > Zn > Cu > Cd > Pb > Cr > As. Dissolved oxygens (DO)of the leachate was positively and significantly correlated with Cu ($r = 0.95$, $p \leq 0.05$) and Cd ($r = 0.95$, $p \leq 0.05$) while BOD was negatively correlated with Cu ($r = -0.95$, $p \leq 0.05$), Cd ($r = -0.97$, $p \leq 0.05$) and Ni ($r = -0.94$, $p \leq 0.05$). Equally, COD ($r = - 0.93$, $p \leq 0.05$) showed a significantly negative linear correlation with Pb. Alkalinity was also negatively and significantly correlated with Cu ($r = -0.92$, $p \leq 0.05$), Cd ($r = -0.90$, $p \leq 0.05$), Ni ($r = 0.90$, $p \leq 0.05$) and DO ($r = -0.92$) but positively and significantly correlated with pH ($r = 0.97$, $p \leq 0.05$) and TDS ($r = 0.93$, $p \leq 0.05$). Nickel showed significant positive correlation with Zn ($r = 0.91$, $p \leq 0.05$) and Cd ($r = 0.90$, $p \leq 0.05$) but was negatively correlated with pH ($r = -0.95$, $p \leq 0.05$). The result indicates high organic pollution in the dumpsite due to organic materials which could lead to pollution of both surface water and underground water and the surrounding agricultural land.

**Keywords:** Waste, Leachates, Wastewater, Toxicity, Heavy Metals, Dumpsites, Public Health

## INTRODUCTION

Increase in human population and rapid expansion of cities has given rise to the generation of waste, the manner these wastes are disposed constitute serious health and environmental problems (Awomeso*et al*., 2010). Waste generated in urban centres comprises of degradable materials which include garbage, textiles, stationeries, sludge from sewage, dead animals, ashes, wood, food and farm waste products and non - degradable materials including plastics, and metallic materials, from computers, electronics, damaged vehicles, cans, etc, (Adelekan and Alawode, 2011). Open waste dumpsite has long been used in repository for municipal, commercial and industrial waste in Nigeria. Accumulated urban municipal solid waste is decomposed by a combination of physical, chemical, and biological processes (Asadi*et al*., 2011a) which results in leachate generation. Leachate corresponds to rainwater that has percolated through waste over time while interacting with bacteriological activity and especially organic substances. Amina *et al*., (2004) explained that its composition is a function of the nature and age of the open waste dumpsite, as well as the type of wastes disposed, the geological nature of the site and the climate. Leachate is considered one of the types of wastewater with utmost environmental influence. Leachates from waste dumpsite have high concentration of organic and inorganic compounds, and sometimes toxic substances and contaminants including arsenic and chlorinated organic (Banar*et al*., 2009). These heavy metals may get into the food chain through uptake by plants and subsequently ingested either by animals or man. When animals and man inject such contaminated water or food, they develop various health problems like gastrointestinal disorder, chronic renal disease, structural alteration of membranes of endoplasmic reticulum, central nervous system disorders etc (Akhiobare, 2009). The absence of appropriate waste management, disposal skill and mechanism has resulted to huge land deterioration in Abia state, this is obvious at the study area which serves as the major open waste dump in the state where all waste generated from domestic and industrial activities are finally disposed off. It becomes necessary that the effects of leachate generated from waste dumpsite be assessed to determine their effects which can seep into aquifer or transformed via the food chain, thereby affecting agricultural production and water quality.

## MATERIALS AND METHODS

The study was carried out at the open dumpsite in Mgbarakuma-Ubakala, Umuahia, Abia State Nigeria. The state is located on Latitude $5^0$25N and Longitude $7^0$30E (Ubuoh*et al.,* 2019).. The state covers an area of about 5,243.7 sq.km with a population of

2,833,999 (NPC, 2006). It has an average annual rainfall that ranges between 1900 - 2200mm, almost evenly distributed throughout the wet season while temperature ranges between 21-27$^0$C (NRCRI, 2014).

Ubakala is a large town in Umuahia South Local Government Area of Abia State, Nigeria. Their occupation is agricultural farming/livestock production, trading /business. The leachate samples were randomly collected from actual leachate streams in the solid waste dumping site. A total of five leachate samples ($L_1$ to $L_5$) with triplicates were collected for monitoring purpose. The leachate corresponds to rainwater that has percolated through waste, interacting with bacteriological activity and especially organic substances. Its composition is a function of the nature and the age of the waste dumpsite, the type of wastes, the geological nature of the site and the climate (Amina *et al*., 2004). To study the physical and chemical composition of leachate, the leachate samples were collected from actual leachate streams at the solid waste dumping site using 5 L polypropylene container that was rinsed out thrice prior to sample collection using distilled water and transported to the laboratory, stored at 4 °C and was analysed within 2 days after (Amadi*et al*., 2012).

**Plate 1: Study Location for the waste dumpsite at Mgbarakuna-Ubakala, Abia State**

**Plates 2: Sample collected from a pool of leachate at the waste dumpsite**

The physical and chemical parameters of the leachate such as pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total hardness, total dissolved solids, major cations such as $Ca^{2+}$,

$Mg^{2+}$, as well as $Cl^{-}$ were determined. All the analysis in this study was repeated three times until concomitant values obtained, and all the tests were carried out according to the standard methods (APHA, 1998). In addition, the determination of heavy metal concentration in leachate performed. Fifteen (15) leachate samples from the dumping area were collected, filtered, and preserved for soluble heavy metal analysis using concentrated nitric acid. 500 ml of each leachate was reduced to 25 ml by heating the samples in a water bath in other to concentrate the metals in the leachate to readable levels. The heavy metals (Pb, Cd, Cr, Zn, Cu, Ni, Fe and As) in the concentrated leachate samples were determined using Atomic Absorption Spectrophotometer (AAS) with D2 background correction lamp. Acetylene–air flame was used for higher concentrations (mg/l) (ASTM D3987, 2006).

**RESULTS AND DISCUSSION**

The results from the study shows a temperature mean and standard deviation values of 27.34±0.45ºC, pH value of 8.98±0.21, Conductivity (μ/Scm) value of 5.72±0.97, Dissolved Oxygen (DO) mg/l value of 3.38±3.46, Chemical Oxygen Demand value of 18.48±3.34mg/l, Biological oxygen demand ($BOD_5$) mg/l value of 47.80±23.08, Acidity mg/l value of 20.80±6.88mg/l, Alkalinity mg/l value of 3136±783.26, Total Hardness (TH) mg/l value of 408±45.04, Dissolved Solid (TDS) mg/l value of 2852±488.24, Suspended Solid (TSS) mg/l value of 2148.16±577.55. Chloride ($Cl^-$) mg/l value of 1133.16±236.15 and Salinity (mg/l) value of 0.284±0.053. The migration of leachate into surface and underground water results in elevation of pH of the water. A pH value (8.98±0.21) confirmed slightly alkaline in nature as obtained in this study causes bitter taste of water, affects mucous membrane, causes corrosion, and also affects aquatic life (Lalitha and Barani, 2004). This moderately high pH value of the leachate may be attributed to the decrease in the concentration of free volatile acids due to anaerobic decomposition, as fatty acids can be partially ionized and contribute to higher pH values. El-Fadel*et al*. (2002) reported that alkaline pH is normally encountered at dumpsite after 10 years. However, the pH of leachate obtained in this study is within the permissible limit pH 6.0 to 9.0 (DoE, 2003). Alimba*et al*.(2006) reported pH values of 6.8-7.3 in Olushosun landfill in Ojota, Lagos while Huan-Jung *et al.* (2005)reported values of 7.74-7.91 in Taiwan. The lower the pHvalue, the higher the solubility of metals in the leachate. The low value of electrical conductivity (5.72 μ/Scm) of the leachate was far less than the FMENV standard of 125 μs/cm and indicates the presence of decomposed organic materials rather than dissolved inorganic materials in the dumpsite (Calli *et al*., 2005). The mean value of total dissolved solids (TDS) for leachate in this study was 2852 mg/l. The result shows that the TDS value of the leachate is above the permissible limit (2100 mg/l) (DoE, 2003). Haque *et al*. (2013) also reported a result for TDS of untreated leachate sample (7178 mg/l). A mean value of DO (3.38 mg/l) was recorded in the leachate in the study area. High amount of DO imparts good taste of water. The low DO value indicates organic pollution. Azim *et al*., (2011) observed lower value of DO in untreated leachate (0.9 mg/l) which is below the permissible limit (4.5 to 8) (DoE, 2003). The mean $BOD_5$ value of leachate in this study was 47.80±23.08 mg/l while the COD was18.48±3.34mg/l. These values contrast with the values of $BOD_5$ value ranges of 798 to 1,396 mg/l and 946 to 1,942 mg/l for COD reported by Salami *et al*. (2015). However, Agbozu and Nwosisi (2015) in their study reported much lesser ranges of 1.24 to 5.95 mg/l and 3.10 to 14.87 mg/l for $BOD_5$ and COD respectively. The mean value of $BOD_5$ (47.80 mg/l) of the leachates is greater than FMENV standard of 30.00 mg/l while COD with a mean value of 18.48 mg/l is than the FMENV of 75.00 mg/l. The $BOD_5$ and COD values indicate the presence of a high amount of decomposable organic matter in the dumpsite. The mean COD value (18.48 mg/l) of leachate in this study is also far below the permissible limit(250 mg/l) (DoE, 2003) which may lower the COD of any surface water if the leachate migrates into the water and consequently affect the aquatic life. This value was not in consonant with the value (1343 mg/l) for untreated leachate obtained by Esrat*et al*. (2016) and with Azim *et al*. (2011), where COD was found to be 1630 mg/l. The COD was lower than the $BOD_5$ concentration in the leachate because most of the constituent materials of the wastes are more subject to biological oxidation than to chemical oxidation and indicates the high organic content . This implies that majority of the organic compounds is biodegradable (Fatta*et al*., 1999). The mean total hardness value of the leachate was 408±45.04 mg/l was higher than FEPA (1991) guideline for drinking water (200 mg/l).The pH value (8.98±0.21) of the leachate confirmed slightly alkaline in nature and reflects the long-standing age of the dumpsite. The low values of electrical conductivity (5.72 μ/Scm) and DO value (3.38 mg/kg) of the leachate indicates organic pollution in dumpsite due to decomposition of organic materials in the dumpsite. The COD was lower than the BOD concentration in the leachate because most of the constituent materials of the wastes are more subject to biological oxidation than to chemical oxidation and indicating the high organic strength of the dumpsite. The mean total hardness value of the leachate was 408±45.04 mg/l was higher than FEPA (1991) guideline for drinking water (200 mg/l). In addition, the mean value of total dissolved solids (TDS) for leachate in this study was 2852 mg/l and is above the permissible limit (2100 mg/l) (DoE, 2003). The Chloride ($Cl^-$) concentration of the leachate was 1133.16±236.15 mg/l, resulting in the elevation of chloride content of surface water if the leachate migrates into the water.

**Table 1: Mean concentration of heavy metals (µg/l) in leachates**

| Sampling Points | As | Zn | Cu | Cr | Pb | Cd | Ni | Fe |
|---|---|---|---|---|---|---|---|---|
| 1 | BDL | 26.40 | 6.30 | 0.70 | 0.30 | 1.10 | 32.10 | 54.20 |
| 2 | BDL | 30.75 | 7.10 | 0.30 | 0.05 | 1.90 | 21.30 | 48.10 |
| 3 | BDL | 18.48 | 11.48 | 0.84 | 5.74 | 2.94 | 26.88 | 78.96 |
| 4 | BDL | 58.32 | 18.96 | 0.48 | 1.44 | 6.72 | 75.36 | 118.44 |
| 5 | BDL | 40.18 | 21.28 | 2.24 | 5.60 | 6.72 | 57.68 | 155.96 |
| Range | | 39.84 | 14.98 | 1.94 | 5.69 | 5.62 | 54.06 | 107.86 |
| **Mean** | **BDL** | **34.83** | **13.03** | **0.91** | **2.63** | **3.88** | **42.67** | **91.13** |
| SD | | 13.68 | 6.10 | 0.69 | 2.53 | 2.39 | 20.55 | 40.77 |

The result shows that Arsenic (As) in the leachate sample was beyond detectable limit (BDL). Zinc (Zn) was found to have a mean and standard deviation values of 34.83±13.68, Copper (Cu) has value of 13.03±6.10, Cr (µg/l) has value of 0.91±0.69, Lead (Pb), Cadmium (Cd), Nickel (Ni) and Iron (Fe) has values of 2.63±2.53, 3.88±2.39 42.67±20.55 and 91.13±40.77 µg/l respectively. The leachate showed a low degree of metal solubilization, due to moderately high pH value (8.89) may be attributed to the decrease in the concentration of free volatile acids due to anaerobic decomposition, as fatty acids can be partially ionized and contribute to higher pH values (El-Fadel *et al.*(2002) and Mohan and Gandhimathi (2009). This increased pH value is also a function of the age of the dumping site. As the age of a dumpsite increases, there is consequent increase in pH value of the leachate that is produced causes a certain decrease in metal solubility (Mohan and Gandhimathi 2009).

**Table 2: Major cations and anion (mg/l) of leachates in the study area.**

| Sampling Points | $Ca^{2+}$ | $Mg^{2+}$ | $Cl^-$ |
|---|---|---|---|
| 1 | 468.98 | 603.14 | 1036.60 |
| 2 | 710.11 | 546.00 | 1604.60 |
| 3 | 549.73 | 411.33 | 994.00 |
| 4 | 613.15 | 478.06 | 1008.20 |
| 5 | 582.84 | 469.52 | 1022.40 |
| Range | 241.13 | 191.81 | 610.6 |
| Mean | 584.96 | 501.61 | 1133.16 |
| SD | 78.94 | 66.35 | 236.15 |

The concentration of $Mg^{2+}$ and $Ca^{2+}$ were 584.96 mg/l and 501.61mg/l respectively. These levels of $Mg^{2+}$ and $Ca^{2+}$ in the leachate will result in elevation of soil alkalinity in the surrounding agricultural land and in areas where the leachate moved with runoff, hence reducing the acidity of the soil. The calcium and magnesium concentrations exhibited typical trends of constituents affected by the biological activity in the dumping site. The presence of magnesium in the leachate is due to the disposal of construction waste along with municipal solid waste (Al-Yaqout, 2003). The mean chloride concentration value of 1133.2mg/l was rather very high compared with FMENV standard of 100mg/l. Chloride in reasonable concentration is not harmful, but it causes corrosion in concentrations above 250 mg/l, while at about 400 mg/l, it causes a salty taste in water (McCarthy, 2004). The migration of leachate with this magnitude of $Cl^-$ value into water bodies may result in the pollution as excess chloride in water is usually taken as an index of pollution as well as is tracer for groundwater contamination (Loizidou and Kapetanios, 1993). High concentration of chloride gives salty taste to water and may result in hypertension, osteoporosis, renal stones, and asthma (McCarthy, 2004). Excessive chloride concentration also increases rate of corrosion of metals in distribution systems especially for deep wells. This can lead to increased concentration of metals in the supply and may result to laxative effects and gastro-intestinal irritation in humans (WHO, 2002).

**Table 3: Pearson correlation coefficients of parameters in leachates from the waste dumpsite**

| Variables | Zn | Fe | Cu | Cr | Pb | Cd | Ni | pH | TDS | DO | BOD | COD | Acidity | Alkalinity | Total Hardness | Ca | Mg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zn | **1.00** | | | | | | | | | | | | | | | | |
| Fe | -0.26 | **1.00** | | | | | | | | | | | | | | | |
| Cu | 0.69 | -0.67 | **1.00** | | | | | | | | | | | | | | |
| Cr | 0.05 | -0.23 | 0.65 | **1.00** | | | | | | | | | | | | | |
| Pb | -0.19 | -0.72 | 0.57 | 0.72 | **1.00** | | | | | | | | | | | | |
| Cd | 0.79 | -0.65 | **0.99** | 0.53 | 0.45 | **1.00** | | | | | | | | | | | |
| Ni | **0.91** | -0.48 | 0.86 | 0.31 | 0.14 | **0.90** | **1.00** | | | | | | | | | | |
| pH | -0.75 | 0.46 | -0.82 | -0.44 | -0.26 | -0.82 | **-0.95** | **1.00** | | | | | | | | | |
| TDS | -0.52 | 0.54 | -0.76 | -0.53 | -0.45 | -0.73 | -0.82 | **0.95** | **1.00** | | | | | | | | |
| DO | 0.75 | -0.41 | **0.95** | 0.69 | 0.39 | **0.95** | 0.87 | -0.83 | -0.72 | **1.00** | | | | | | | |
| BOD | -0.86 | 0.46 | **-0.95** | -0.54 | -0.30 | **-0.97** | **-0.94** | 0.88 | 0.75 | **-0.98** | **1.00** | | | | | | |
| COD | -0.08 | 0.76 | -0.74 | -0.77 | **-0.93** | -0.64 | -0.44 | 0.59 | 0.75 | -0.60 | 0.54 | **1.00** | | | | | |
| Acidity | 0.59 | 0.03 | 0.70 | 0.70 | 0.17 | 0.69 | 0.58 | -0.51 | -0.36 | 0.86 | -0.79 | -0.30 | **1.00** | | | | |
| Alkalinity | -0.72 | 0.52 | **-0.92** | -0.61 | -0.42 | **-0.90** | **-0.93** | **0.97** | **0.93** | **-0.92** | **0.93** | 0.70 | -0.64 | **1.00** | | | |
| Total Hardness | -0.55 | 0.73 | -0.86 | -0.53 | -0.58 | -0.83 | -0.84 | **0.92** | **0.96** | -0.77 | 0.80 | 0.83 | -0.36 | **0.94** | **1.00** | | |
| Ca | 0.31 | -0.03 | 0.10 | -0.24 | -0.20 | 0.19 | 0.00 | 0.31 | 0.52 | 0.11 | -0.13 | 0.35 | 0.27 | 0.22 | 0.35 | **1.00** | |
| Mg | -0.03 | **0.95** | -0.50 | -0.17 | -0.76 | -0.47 | -0.22 | 0.19 | 0.29 | -0.22 | 0.25 | 0.68 | 0.14 | 0.28 | 0.51 | -0.14 | **1.00** |
| Chloride | -0.15 | 0.55 | -0.50 | -0.43 | -0.54 | -0.43 | -0.52 | 0.74 | **0.91** | -0.39 | 0.41 | 0.76 | 0.00 | 0.70 | 0.85 | 0.77 | 0.36 |

*Values in bold are different from 0 with a significance level alpha=0.05*

Correlation coefficients of physical and chemical properties and the heavy metals concentration of leachate from the waste dumpsite in the study are as presented in Table 3. Cadmium and Cu (r = 0.99, $p \leq 0.05$) showed a good positive correlation. This result indicates a linear relationship between the two parameters. Nickel showed significant positive correlation with Zn (r = 0.91, $p \leq 0.05$) and Cd (r = 0.90, $p \leq 0.05$). This result implies that the presence of Ni in the leachate has great influence on the presence of Zn and Cd. However, correlation coefficient (r = -0.95, $p \leq 0.05$) indicates a significant negative correlation between pH and Ni. Equally, total dissolved solids (TDS) and pH (r = 0.95, $p \leq 0.05$) indicated significant positive correlation. This result shows that pH has significant influence on the dissolution of solids in the dumpsite. DO was also positively and significantly correlated with pH and Ni. Equally, Total dissolved solids (TDS) and pH (r = 0.95, $p \leq 0.05$) indicated significant positive correlation. This result shows that pH has significant influence on the dissolution of solids in the dumpsite. DO was also positively and significantly correlated with Cu (r = 0.95, $p\leq 0.05$) and Cd (r = 0.95, $p\leq 0.05$) while BOD was negatively correlated with Cu (r = -0.95, $p \leq 0.05$), Cd (r = -0.97, $p \leq 0.05$) and Ni (r = -0.94, $p \leq 0.05$). Equally, COD (r = - 0.93, $p \leq 0.05$) showed a significantly negative linear correlation with Pb. This shows a strong dependence Cu and Cd on DO. Alkalinity was also negatively and significantly correlated with Cu ($r$ = -0.92, $p \leq 0.05$), Cd ($r$ = -0.90, $p \leq 0.05$) and Ni (r = 0.90, $p \leq 0.05$) but positively and significantly correlated with pH (r = -0.97, $p \leq 0.05$) and TDS ($r$ = - 0.93, $p \leq 0.05$). Total hardness was also positively and significantly correlated with pH ($r$ = 0.92, $p \leq 0.05$), TDS ($r$ = 0.96, $p \leq 0.05$) and alkalinity ($r$ = 0.94, $p \leq 0.05$). Magnesium (r = 0.95, $p \leq 0.05$) was positively and significantly correlated with Fe. This implies that as the concentration of Mg in the leachate increases, the concentration of Fe equally increases. Similarly, chloride (r = 0.91, $p \leq 0.05$) showed a significant positive correlation with TSD.

## CONCLUSION

This study which was conducted to assess the heavy metal toxicity due to leachate in waste dumpsite at Mgbarakuma-Ubakala Umuahia reveal that the trend of heavy metal concentration in the leachate was as follow: Fe > Ni > Zn > Cu > Cd > Pb > Cr > As. Because of these concentrations, it is advisable that government should develop a recycling plant for the State to minimize the volume of waste generated and deposited at the study site. In addition, there should be a monitoring team in line with Vision 202:20 about proper management of waste in that location due to the presence of several biodegradable and non-biodegradable waste, which accumulates over a long period and posing health risks to the populace.

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