International Journal of Earth & Environmental Sciences
Vol. 11, No. 1, 2026, pp. 77-93

http://ijees.ielas.org
ISSN: 2545-4161

PHYSICO-MICROBIAL EVALUATION OF NATURAL WATER SOURCES AROUND THE ENUGU METROPOLITAN DUMPSITE, SOUTHEASTERN NIGERIA

Ifeoma Linda Onyekwelu[1], Emmanuel Chibuike Iyi[2], Onyebuchi Innocent Ezeugwu[3]*, Ogonna Tochukwu Emenaha[4]

[1,4]Department of Geology, Nnamdi Azikiwe University, P.M.B. 01660, Awka, Nigeria
[2,3]Department of Geology and Mining, Enugu State University of Science and Technology, P.M.B. 01660, Agbani, Nigeria

*Corresponding author: Innocentezeugwu38@gmail.com

Received: 2026-08-05 Accepted: 2026-09-11 Published online: 2026-09-12

Abstract

This study was carried out to qualitatively assess the natural water sources in the Enugu metropolis of Southeastern Nigeria with a view to measure the impact of physico-microbial contaminants from Ugwuaji dumpsite leachates. A total of 12 samples, collected from leachate, groundwater and surface water sources in the metropolis were analyzed using various physical and microbial parameters. Results of the physical parameters show average pH values of 5.0, EC EC values of 67.4 µs/cm, total dissolved solid (TDS) values of 45.6 mg/l and total alkalinity values of 132 mg/l for surface waters and pH values of 5.2, EC values of 46.26 µs/cm, total dissolved solids (TDS) values of 55.03 mg/l and total alkalinity values of 51.1 mg/l for groundwater. On the other hand, the results of the microbial parameters show concentration values of 28.9mg/l and 21.51 mg/l for biochemical oxygen demand (BOD), 48mg/l and 20.11mg/l for chemical oxygen demand (COD) and 53 mg/l and 29 mg/l for total viable count (TVC) in the surface waters and groundwater respectively. The results indicate that all the measured physical parameters are within the WHO (2012) acceptable limits for drinking water. Both waters sources in the study area are also classified as fresh waters based on the proportion of TDS. All the microbial parameters, except for the Chemical Oxygen Demand, have values which are higher than the WHO desirable limits. This implies that the water is unsafe for consumption as there is a high level of proven microbial activity in the water.

Keywords: Dumpsite leachate, microbial contaminant, water quality, domestic water sources.

INTRODUCTION

The growing state of water-borne diseases and infections, especially in Sub-Saharan African, is becoming a source of global concern. It is currently estimated that about 1.8 billion people use contaminated drinking water sources globally with Sub-Saharan Africa contributing a huge percentage of this number (WHO, 2019). A wide range of potential water contaminants exist in nature; however, the most prominent and widespread causes of contamination are micro-organisms. Micro-organisms such as cysts, yeasts, mold and bacteria find good breeding ground in water and under favorable environmental conditions, they could grow rapidly in numbers until the water quality is completely compromised and rendered unsafe for human consumption. Consumption of such contaminated water could result in diseases such as cholera, typhoid, dysentery and other serious health problems (WHO, 2019).

Interests have therefore been directed towards assessing the microbial content of water especially in areas around dumpsites (Amuno, 2011). Studies have revealed that dumpsites yield a huge volume of highly concentrated liquids, called leachates, which contain harmful micro-organisms capable of contaminating natural waters on infiltration and migration from the site (Maiti et al., 2016). This is the case in most developing nations of the world where the only available means of waste disposal is by indiscriminate and open dumping of refuse (Sajjadi et al., 2017). Although most of these nations have begun to construct landfills to manage their wastes at municipal levels, most of them do not meet safety specifications (Mor et al., 2006).

The Ugwuaji dumpsite in Enugu metropolis is one of such dumpsites constructed below safety specifications. An estimated 200 litres of leachates is generated per day in the dumpsite owing to the amount of wastes deposited in the site daily (Onyekwelu and Aghamelu, 2019). These leachates may yield bacterial and other microbial constituents which can contaminate the natural waters occurring in the metropolis. Recent studies carried out by Osiemo et al., 2019 on the impact of micro-organisms on the quality of natural waters in some parts of sub-Saharan Africa buttress this point.

This work therefore is aimed at assessing the impact of physical and microbial contaminants from the Ugwuaji dumpsite leachates on the quality of natural water sources in the Enugu metropolis. The findings of this study will help considerably in the planning and management of waste and water resources.

DUMPSITE DESCRIPTION

The central dumpsite of the Enugu metropolis, southeastern Nigeria, is located in Ugwuaji Nike. The dumpsite serves as the final ground for waste disposal in the Enugu metropolis and hosts a wide range of waste material ranging from degradable to non-degradable components as shown in the chart in fig. 1.

The Ugwuaji dumpsite is situated at about 1.6km off the Enugu-Port-Harcourt expressway and slopes gently in all directions away from its centre (fig 2). The dumpsite covers an area of 0.8 sq. km with an average thickness of 6m. It was originally conceived as a landfill but has degenerated into a massive open dumpsite because of poor management. The bottom is not lined for leachate containment; hence, water leached from the dumpsite flows freely into the surrounding surface waters while some infiltrates the groundwater polluting them in the process. It is estimated that an average of about 200 l of leachate is produced daily in the dumpsite (Onyekwelu and Aghamelu, 2019).

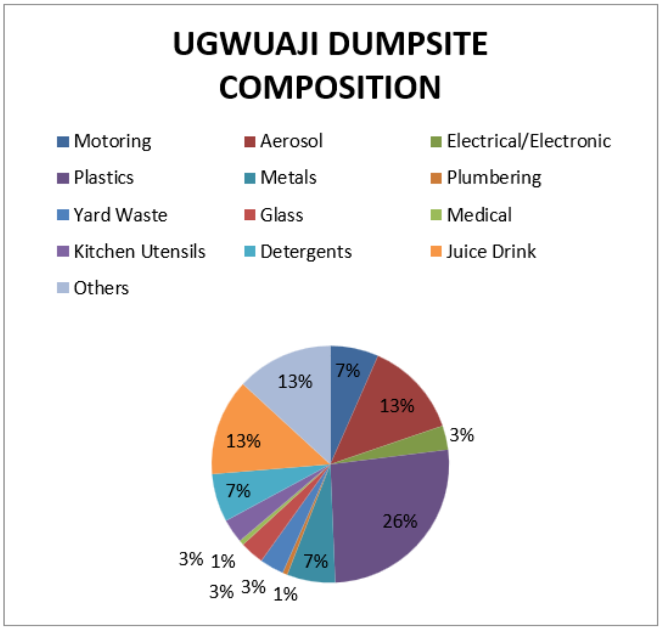

Fig 1: *Chart of waste distribution in the dumpsite.*

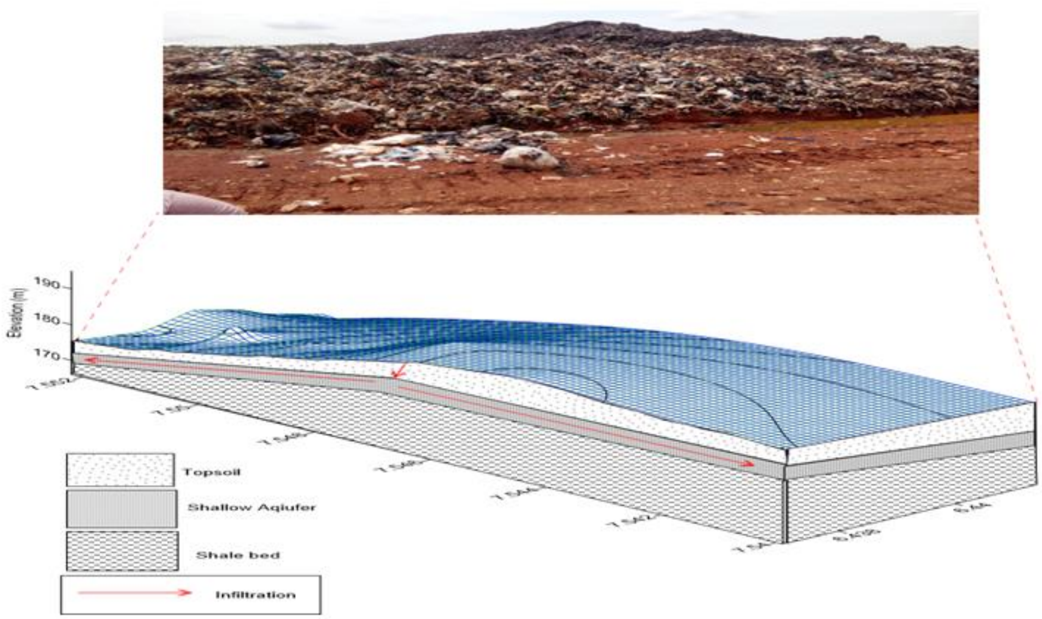

Fig 2: *Schematic diagram of the dumpsite showing its topography and infiltration pattern.*

International Journal of Earth & Environmental Sciences
Vol. 11, No. 1, 2026, pp. 77-93
http://ijees.ielas.org
ISSN: 2545-4161

LOCATION, GEOLOGY AND HYDROGEOLOGY OF THE AREA

The study area, Enugu Metropolis, lies within latitudes N6^{0}24'00" and N6^{0}30'00" and longitudes E7^{0}30'00" and E7^{0}36'00" (fig 3). It covers an area of about 96km^2 and is surrounded by prominent areas such as Emene to the north, Independence layout, Nkpologu and Ugwuaji, to the south. While the Enugu metropolis' dumpsite is sited in Ugwuaji, Independence layout is mainly residential and Emene area hosts a range of heavy and small scale-industries including the Nigeria National Petroleum Corporation (NNPC) mega station.

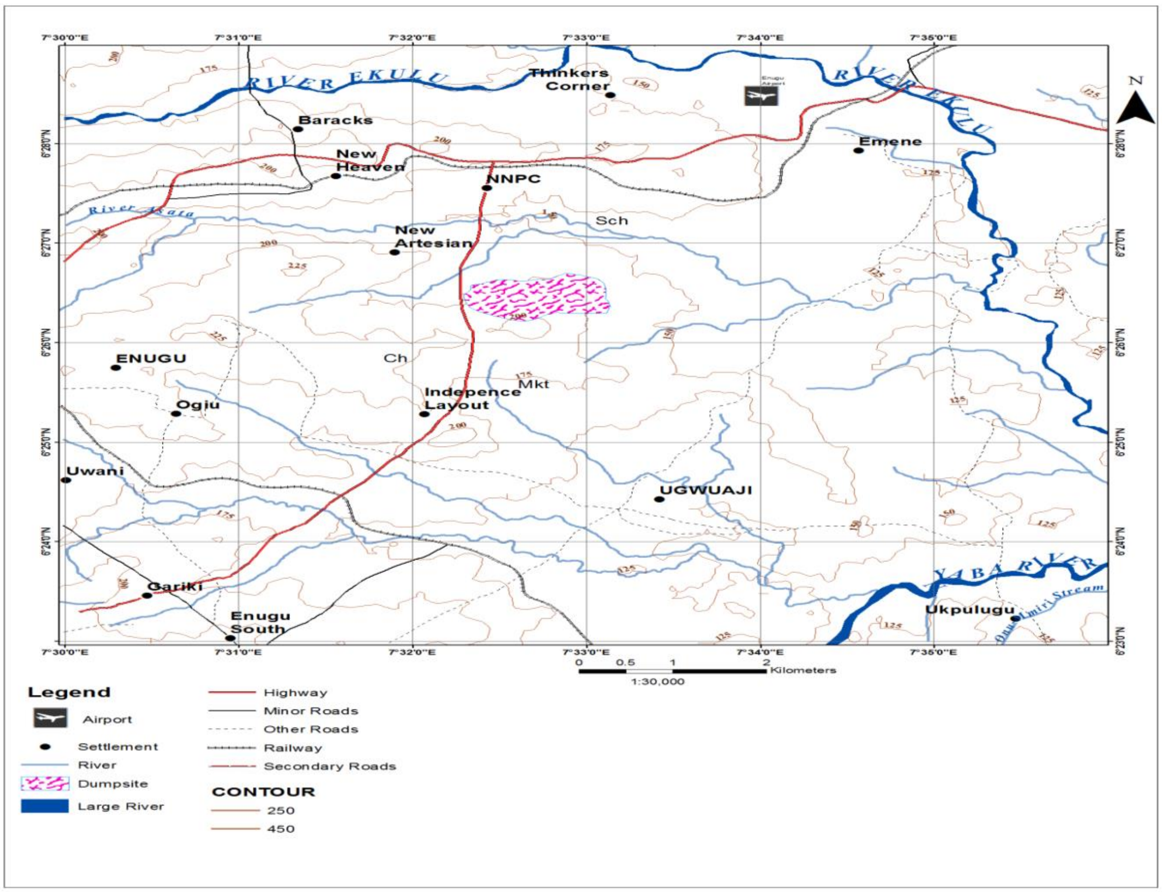

Fig 3: *Map of the study area.*

The area belongs to the hot and humid tropical climate zone of Nigeria with a daytime temperature range of 27 to 32^{0}C and night-time temperature range of 17 to 28^{0}C. the area is characterized by an alternation of rainy and dry season with the rainy season lasting between April and October and the dry season running from November to March (Inyang, 1974). The average annual rainfall in the area is about 1500mm while the average annual temperature is 26.6^{0}C (Duze and Ojo, 1982).

International Journal of Earth & Environmental Sciences
Vol. 11, No. 1, 2026, pp. 77-93
http://ijees.ielas.org
ISSN: 2545-4161

The high humidity and long wet season ensures a continuous supply of water in the area and is the major source of surface water volume and groundwater recharge in the Enugu Metropolis.

Geologically, the Enugu metropolis is underlain by two geological formations namely: the Coniacian Agbani Formation and the Campanian Enugu Shale (fig 4) with the Enugu Shale directly overlying the Agbani Formation. The west-northwest trending Agbani Formation is composed of medium to coarse grained, poorly sorted and consolidated cross-bedded sandstones with subordinated claystones and red earthly sands formed by the weathering and ferruginization of the formation. The overlying Enugu Formation is a component of the Nkporo Group and is chronologically and stratigraphically equivalent to the Lafia, Otobi and Owelli Formations in the Anambra Basin. It consists mainly of marine shales and sandstones interbedded with siltstones. The dominant depositional facies of the formation is dark grey (black when wet), carbonaceous, sideritic shale with plant fragments.

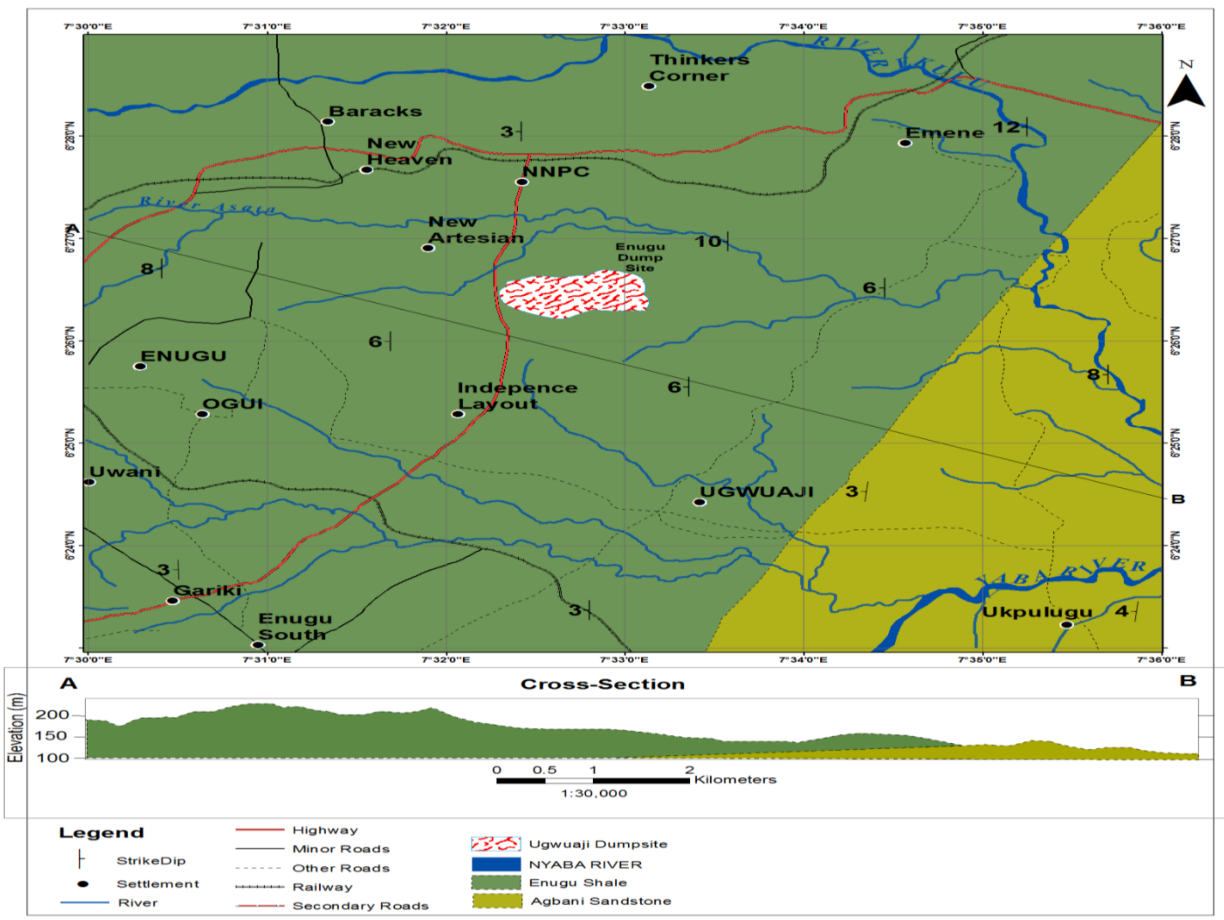

Fig 4: *Geologic map of the study area.*

The most striking topographic feature in the area is the Enugu-Udi enscarpment which is part of the south-north trending Nsukka-Okigwe cuesta formed by the resistant sandstones of the lower part of the Ajali Sandstone and Mamu Formation (Reyment, 1965). An elevation map of the study area (fig 5) shows that the dumpsite lies west of the enscarpment.

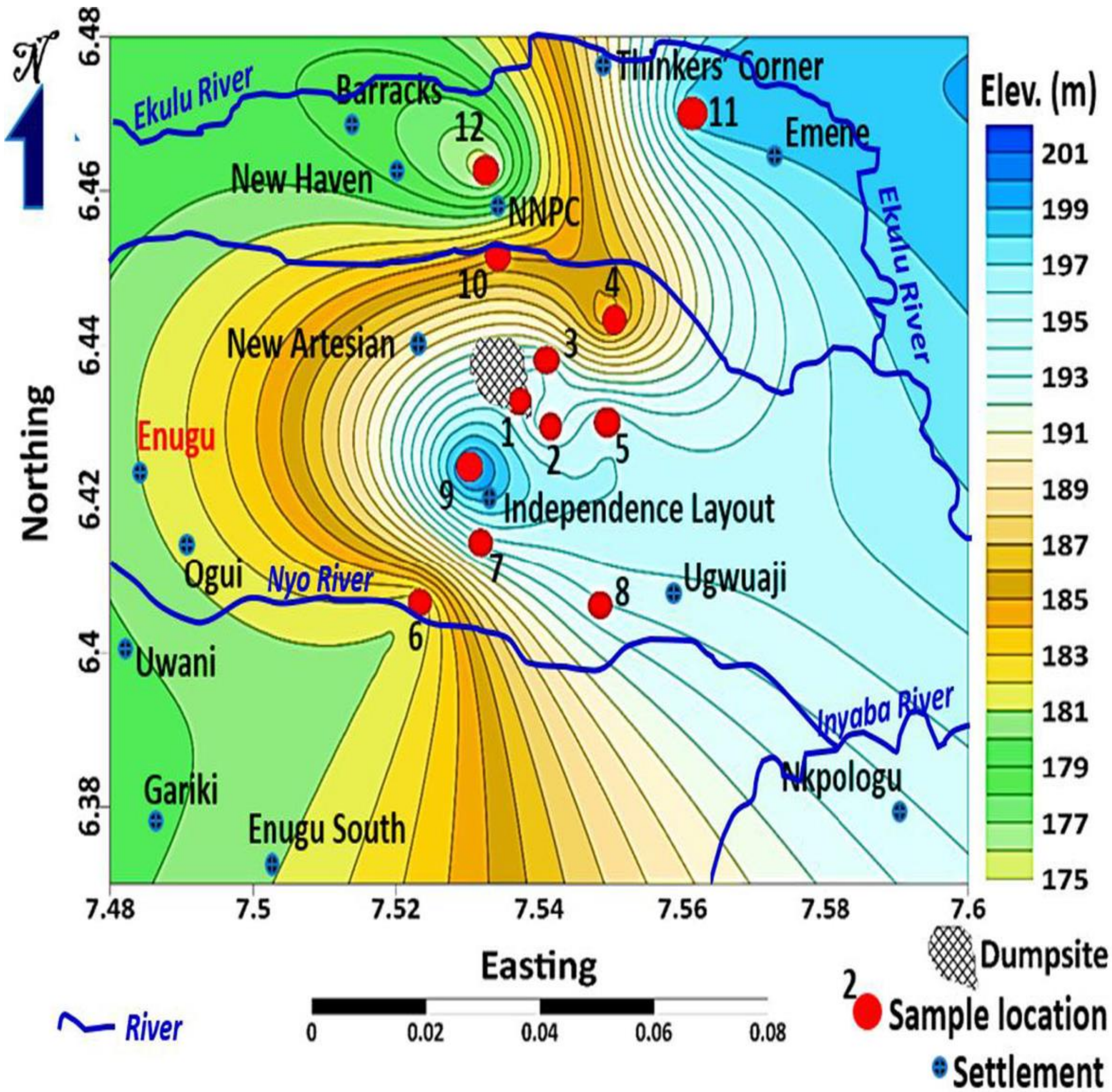

Fig. 5: *Contour elevation map of Enugu dumpsite area.*

The topography and geology of the area are critical factors that play a significant role in the drainage pattern of the surface waters in the area (Egboka, 1993). The surface water resources that drain the metropolis include rivers and rivulets which flow in a dendritic pattern. Some of the major rivers that drain the area are Ekulu, Inyaba, Nyo, and Asata rivers (fig 6).

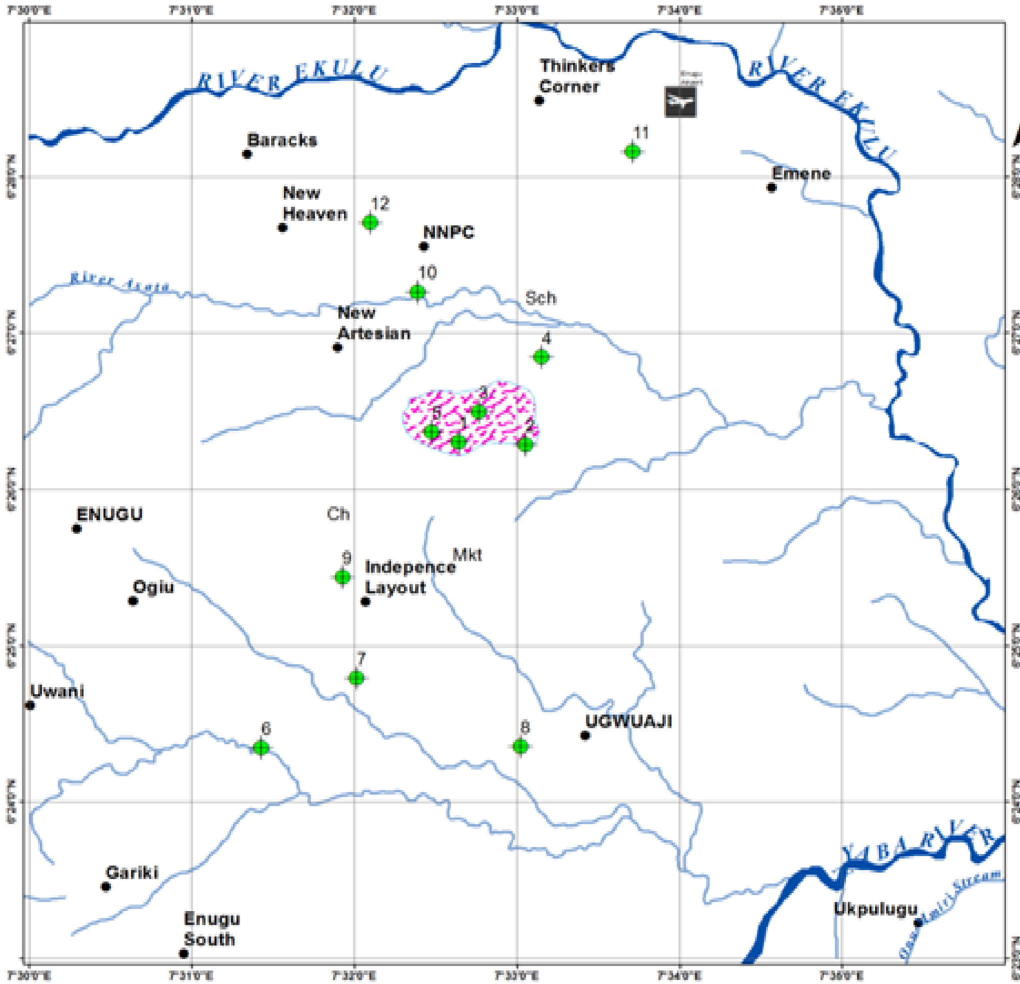

Fig 6: *Drainage map of the study area.*

Two aquifer systems have been identified in the area- the confined aquifer system which occurs in the sandy portion of the Enugu Shale and the unconfined aquifer system occurring in the areas underlain by Agbani Formation and the weathered parts of the Enugu Shale (Onyekwelu and Aghamelu, 2019). All other areas covered by the Enugu Shale units consisting sandy shales, shales and mudstones constitute aquitards.

Groundwater flow direction within the area is mainly influenced by a complex network of fracture zones. A lineament analysis of fractures, joints and veins occurring within the area (fig 7) combined with the hydraulic head map of the area (fig 8) reveal the impact of the structural framework of the area on the groundwater flow direction (Onyekwelu and Ahgamelu, 2019). The general groundwater flow direction in the area is northeast-southwest direction (Onyekuru et al., 2010), however, at the dumpsite, the infiltration pattern is radial (fig 2) owing to the site's topographic outline (Onyekwelu and Aghamelu, 2019).

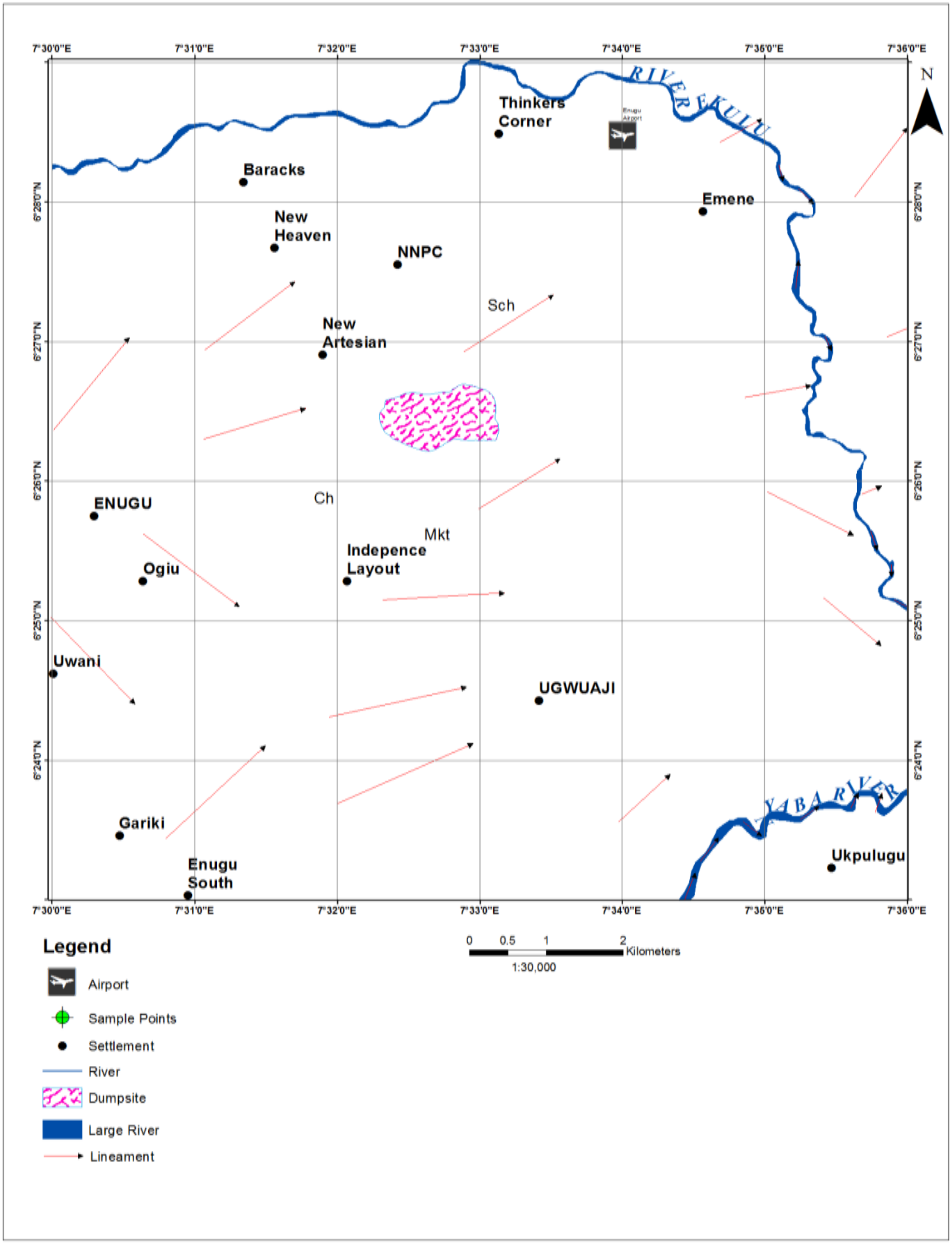

Figure 7: *Linearment map of the study area.*

International Journal of Earth & Environmental Sciences
Vol. 11, No. 1, 2026, pp. 77-93
http://ijees.ielas.org
ISSN: 2545-4161

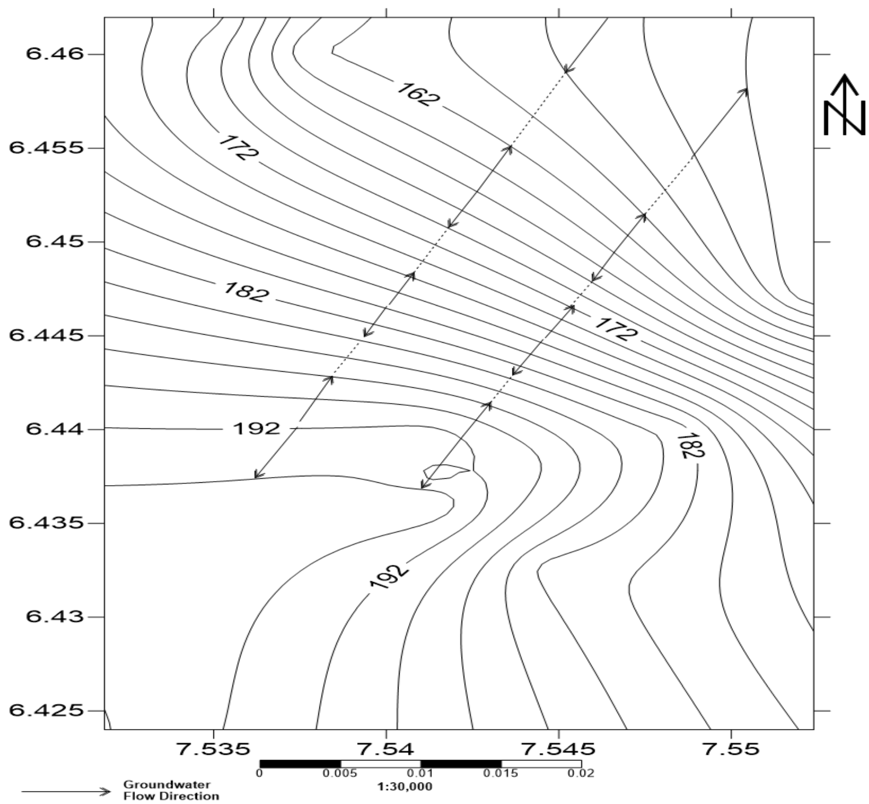

Figure 8: *Ground water flow direction based on hydraulic head distribution of the area*.

MATERIALS

Geological and Fieldwork Materials

Materials and equipment for geological data collection including Brunton compass, global positioning system (GPS), water level indicator, geologic hammer, hand lens, measuring tapes, water sample bottles, pencil, pen, permanent marker, masking tape, field notebook and a camera were utilized.

Laboratory Materials

The following laboratory equipment and materials were utilized: Hydrochloric acid(HCl), Hydrogen trioxonitrate acid (HNO_3), Heater, Nose mask, Burette and pipette, Measuring Cylinder, Syringe (10ml), Electronic weighing balance, De-ionized water, Sterile sample bottles, Filter paper, Conical flasks, Aliquot, Mercury-in-glass thermometer, Electrical conductivity meter (DDS 307 model), pH meter (Hanna model H1991300) and Energy dispersive X-ray fluorescence spectrometer (EDXRF).

METHODOLOGY

Desk Study

A comprehensive study of previous investigations of the study area was done and documented and similar works done outside the study area locally and internationally were compiled to make up a detailed literature review and guide for this study.

Geological Fieldwork

The project began with a preliminary site evaluation to assess site accessibility, well locations and overall geology of the area facilitating an efficient work strategy. Comprehensive geologic mapping was conducted and accomplished using conventional traverse and compass surveying techniques. The survey consisted of the identification of the various rock types (lithofacies) which underlie the study area, and collection of water samples from surface water and groundwater at various points of interest.

WATER SAMPLING

To evaluate groundwater contamination levels from the Ugwuaji dumpsite, leachate and groundwater quality analysis was conducted in the study area.

The distribution of the water samples in the area includes

1. Dumpsite leachate water (3 samples),
2. Shallow hand dug wells (7 samples),
3. Existing surface water (2 samples) (see table 1 below).

The number of samples per location is determined by the availability and proximity of a water source to the Ugwuaji dumpsite.

METHOD OF STUDY

12 water samples were collected comprising of 3 leachate samples, 7 hand-dug wells and 2 rivers Table 1). These hand-dug wells and rivers constitute the major sources of water supply to the inhabitants. The samples were collected from points within 2km radius of the dumpsite. This radius is taken to be the dumpsite-leachates influence zone (fig 9).

The groundwater and base flow gradients of the dumpsite were taken into consideration during the collection of the hand-dug well and river samples respectively in order to ensure that their qualities were not compromised.

The top film of the surface and groundwater were removed before the collection of the samples into clean plastic containers. The samples were labeled appropriately and preserved in refrigerators until they were taken to the laboratory for chemical analysis.

To ensure quality, all plastic bottles were prepared for sampling by washing with soap solution, rinsing extensively with purified water and a final rinse with the sample water from the shallow wells, and stream during sampling. Before collecting water samples, physical parameters of pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS) and Total Alkalinity were tested on the field using multiple EXTECH (341350A) PH/Conductivity/TDS/Salinity/ORP Meter. The electrode was calibrated with pH 7.0 ionized solution.

After sampling, the water samples were preserved and kept in a cool place and later transported to the Simuch Scientific Analytical Laboratories, Onuiyi Plaza, Onuiyi Link Road Nsukka, Enugu State Nigeria, to analyze physico-microbial parameters.

The microbial parameters of Total Organic Carbon (TOC), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Viable Count (TVC) were incubated in the laboratory for five days in other to grow micro-organisms. The number of growths was counted and the amount of oxygen needed for chemical reactions in a given sample was adequately measured.

Table 1
Showing locations of samples collected

LOCATION	GEOREFERNCE NUMBER		DISTANCE FROM DUMPSITE	SAMPLE TYPE
	Latitude	Longititude		
Sample 1	$N6^{0}26^{1}18.2^{11}$	$E7^{0}32^{1}37.6^{11}$	5m	**Leachate**
Sample 2	$N6^{0}26^{1}17.3^{11}$	$E7^{0}33^{1}02.2^{11}$	6m	
Sample 3	$N6^{0}26^{1}12.3^{11}$	$E7^{0}33^{1}20.2^{11}$	0m	
Ebenizer Ang. Ch. HDW	$N6^{0}26^{1}21.5^{11}$	$E7^{0}32^{1}28.8^{11}$	20m	**Ground Water**
Goshen Estate HDW	$N6^{0}26^{1}50.9^{11}$	$E7^{0}33^{1}08.8^{11}$	200m	
Ike Ekweremadu HDW	$N6^{0}25^{1}26.4^{11}$	$E7^{0}31^{1}54.6^{11}$	900m	
Umunaji Ngene HDW	$N6^{0}24^{1}48.3^{11}$	$E7^{0}32^{1}01.0^{11}$	950m	
Obeagu HDW	$N6^{0}24^{1}19.6^{11}$	$E7^{0}32^{1}59.2^{11}$	970m	
Vission Comp. HWD	$N6^{0}28^{1}9.57^{11}$	$E7^{0}33^{1}42.35^{11}$	500m	
Thinkers Corner HDW	$N6^{0}27^{1}43.1^{11}$	$E7^{0}32^{1}06.1^{11}$	1000m	
Nyo River	$N6^{0}24^{1}22.3^{11}$	$E7^{0}31^{1}27.0^{11}$	1000m	**Surface Water**
Asata River	$N6^{0}27^{1}18.7$	$E7^{0}32^{1}22.4^{11}$	300m	

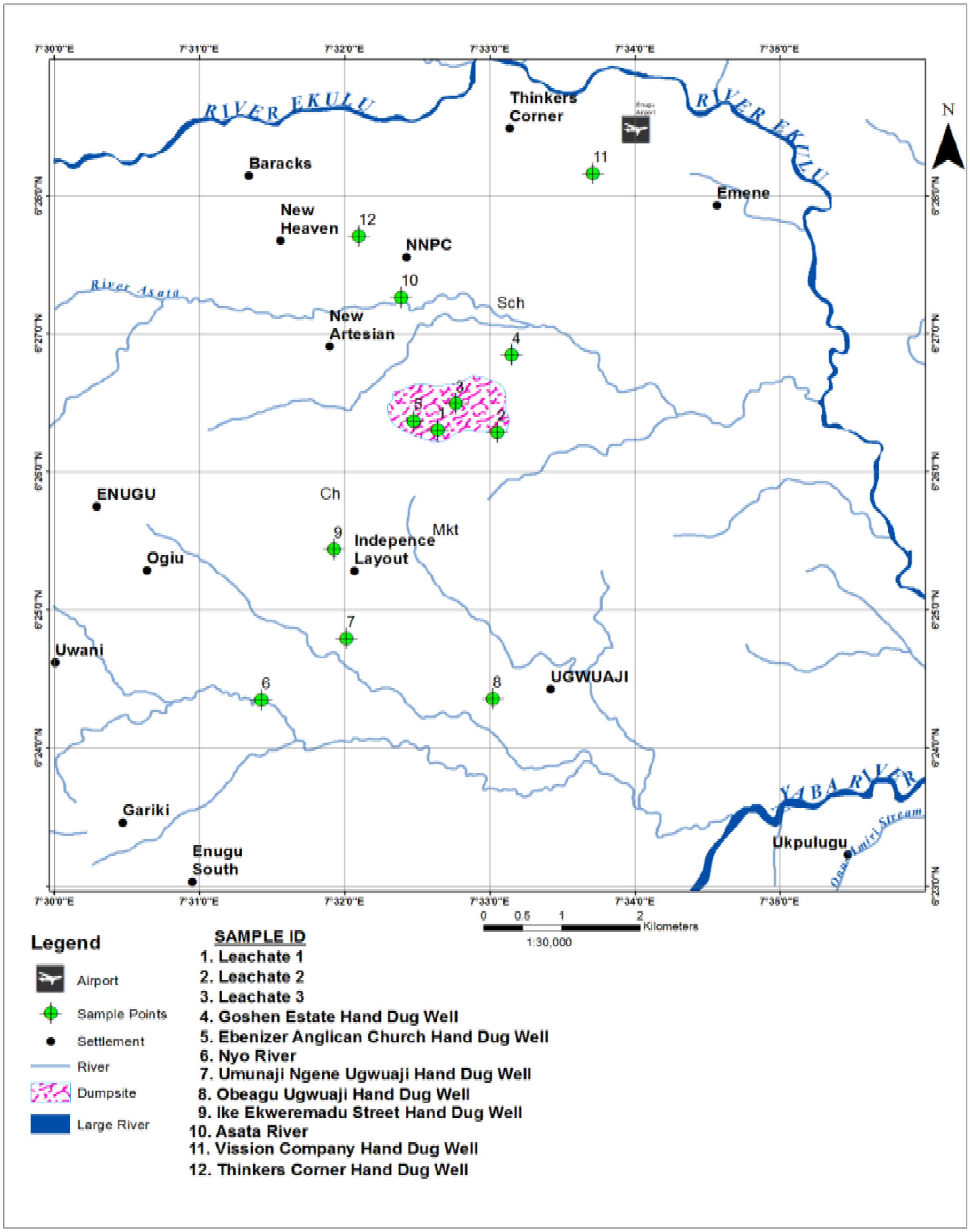

Fig 9: *Showing the Samples location map in the Study Area.*

Vol. 11, No. 1, 2026, pp. 77-93
http://ijees.ielas.org
ISSN: 2545-4161

DISCUSSION OF RESULTS

Physical parameters

The data for the physical parameters of the leachate, surface water and groundwater samples in the study area are presented in table 2.

Table 2
Results of physical parameters in the study area

Parametes	1	2	3	4	5	6	7	8	9	10	11	12
pH	4.3	3.8	4.1	5.2	6.2	5.4	5.8	4.8	4.9	4.6	4.8	4.6
EC µs/cm	127.0	109.8	167.9	98.6	63.9	78.7	45.2	39.5	14.8	56.1	43.2	18.6
TDS mg/l	94.1	96.4	101.1	100.0	91.6	38.5	13.3	78.9	43.7	52.6	27.0	30.7
Total Alkalinity mg/l	236.6	230.8	299.2	44.0	58.8	176.0	22.0	118.8	61.6	88.0	35.2	17.6

SAMPLE ID (1). Leachate (**2).** Leachate **(3).** Leachate **(4).** Back of Goshen Estate hand dug well **(5).** Ebenizer Anglican Church hand dug well **(6).** Nyo River **(7).** Hand dug well at Umunaji Ngene Ugwuaji **(8).** Hand dug well at Obeagu Ugwuaji **(9).** Hand dug well at Ike Ekweremadu Street **(10).** Asata River **(11).** Hand dug well at Vision Company **(12)**. Hand dug well at Thinkers Corner.

pH

The pH values from the three leachate samples, as shown in table 2, ranged from 3.8 to 4.3 while samples from shallow hand dug wells and surface water samples varied from 4.6 to 6.2. The low pH values in the dumpsite may be a reflection of an acid producing phase during the decomposition of wastes. Fatta et al., (1998) observed that the first stage of leachate formation is characterized by low pH values indicating that the leachate is undergoing an anaerobic or methanogenic phase.

Electrical Conductivity (EC)

Electrical conductivity serves as an important parameter that reflects the concentration of total dissolved solid (TDS) content. The electrical conductivity, is a summarizing parameter reflecting the total dissolved solid (TDS). The measured electrical conductivities of LCH1, LCH2, and LCH3 analyzed ranged from 109.8µs/cm to167.9µs/cm, while the shallow hand dug wells ranged from 14.8µs/cm to 98.6 µs/cm and surface water samples varied from 56.1 µs/cm to 78.7 µs/cm. The highest electrical conductivity measured in the leachates indicate decomposition of inorganic contaminants while the relatively high conductivity values obtained for the shallow hand wells near the landfill is an indication of the effect of the leachates on the water. According to WHO and NIS drinking water standard, EC should not exceed 1000 µs/cm. However, the EC values obtained from the study area were compliant with standard limits.

Total Dissolved Solid (TDS)

Elevated TDS levels may lead to adverse health effects like the central nervous system, such as paralysis of the tongue, lips, and face, as well as irritability and dizziness. The total dissolved solid (TDS) is a measure of the suspended, settlable and dissolved solids in water. The total dissolved solid in water might influence the general polluting potentials. The concentrations fluctuated in a small range among the samples in which the highest concentration content of 94.1mg/l to 101.1mg/l was measured in LCH1, LCH2 and LCH3, followed by 13.3mg/l to 100.0mg/l measured in the shallow hand dug wells and 38.5mg/l to 52.6 measured in the surface water samples. High TDS in leachate samples may be due to residential and industrial wastes in the dumpsite. These values reflect the large content of soluble ions particularly inorganic in the leachate samples. According to WHO, 2011, high level of TDS may be responsible for reduction in the palatability of water, inflict gastrointestinal inconveniences in humans, may cause laxative effect particularly upon transit and may be objectionable to consumers.

Total Alkalinity ($CaCo_3$)

The alkalinity of the leachates was highly variable and ranged from 230.8mg/l to 299.2mg/l at LCH1, LCH2 and LCH3, whereas, the values from the shallow hand dug wells examined varied from 17.6mg/l to 118.8mg/l and ranged from 88.0mg/l to 176.0mg/l in the surface water samples. The discharge of the leachates into the soil may have led to the increase in alkalinity of the groundwater in these areas. These concentrations observed in the area are typical for landfill leachates in the early phases of waste stabilization. The role of ammonia and alkalinity as potential toxicant in landfill leachates has been hypothesized by several authors including Kjeldsen, et al., (2000). The recommended maximum limit of alkalinity in drinking water is 120 mg/l by WHO (2017). The highest acceptable level is 600 mg/L.

Microbial parameters

The data for the measured microbial parameters of the leachate, surface water and groundwater samples in the study area are presented in table 3.

Table 3
Results of microbial parameters in the study area

Parametes	1	2	3	4	5	6	7	8	9	10	11	12
BOD mg/l	110.2	118.8	132.0	17.6	14.4	30.4	8.8	57.2	30.8	27.4	13.2	8.6
COD mg/l	114.4	111.0	108.8	16.0	32.0	64.0	8.0	43.2	22.4	32.0	12.8	6.4
Total Viable Count cfu/ml	54	87	48.6	12	62	67	33	27	22	43	21	26

SAMPLE ID (1). Leachate **(2).** Leachate **(3).** Leachate **(4).** Back of Goshen Estate hand dug well **(5).** Ebenizer Anglican Church hand dug well **(6).** Nyo River **(7).** Hand dug well at Umunaji Ngene Ugwuaji **(8).** Hand dug well at Obeagu Ugwuaji **(9).** Hand dug well at Ike Ekweremadu Street **(10).** Asata River **(11).** Hand dug well at Vision Company **(12).** Hand dug well at Thinkers Corner.

Vol. 11, No. 1, 2026, pp. 77-93
http://ijees.ielas.org
ISSN: 2545-4161

Biochemical Oxygen Demand (BOD)

Biological Oxygen Demand (BOD) is a measure of the oxygen used by microorganisms to decompose waste materials. If there is a large quantity of organic waste in the water supply, there will also be a lot of bacteria present working to decompose this waste. In this case, the demand for oxygen will be high (due to all the bacteria) so the BOD level will be high and as the waste is consumed or dispersed through the water, BOD levels will begin to decline. In the study area, the values of biological oxygen demand obtained ranged from 110.2mg/l to 132.0mg/l at LCH1, LCH2 and LCH3, while the concentrations in shallow hand dug well varied between 8.8mg/l to 57.2mg/l and ranged from 27.4mg/l to 30.4mg/l in the surface water samples. The maximum concentrations of BOD obtained from the leachate samples explained probably the microbial activity in the decomposing leachate yet to attain stability.

Chemical Oxygen Demand (COD)

The concentrations of chemical oxygen demand vary between 108.8mg/l to 114.4mg/l at LCH1, LCH2 and LCH3. However, shallow hand dug wells show COD values ranging from 6.4mg/l to 43.2mg/l while surface water samples ranged from 32.0mg/l to 64.0mg/l. The high concentration of chemical oxygen demand in the leachate samples may be due to rapid and continuous decomposition of waste by bacteria as more wastes are dumped into the dumpsite.

Total Viable Count (TVC)

This gives a quantitative idea about the presence of micro-organisms in a sample. A high concentration of TVC in water is usually attributed to poor quality. In the study area, the total viable counts (TVC) measured showed that there is a high significant difference in TVC between the samples in which LCH1, LCH2 and LCH3 ranged from 48.6cfu/ml to 87cfu/ml whereas, shallow hand dug wells varies from 6.4cfu/ml to 62cfu/ml and the surface water samples vary between 43cfu/ml to 67cfu/ml. The high concentrations of total viable count in the leachate samples may have been sourced from the organic materials dumped in the site.

Quality of natural water sources in the Enugu Metropolis

The quality of water is largely dependent on its chemistry which is defined by certain physical, chemical and biological parameters (Tijani, 1994). Hence, the chemistry of water determines its usability for any domestic, industrial or agricultural activity. Drinking water standards are generally based on two main criteria: presence of objectionable taste, odour and colour as well the availability of substances with adverse physiological effects (Elueze, 2004). Different drinking water standards have therefore been developed by different organizations and regulatory agencies (WHO, 1984).

The summary of the physical and microbial parameters examined in the study area, for both surface and groundwater, and their mean values as compared to the WHO (2012) acceptable levels are shown in table 4.

Table 4

Summary of the physical and microbial parameters and the WHO (2012) standards for drinking water

Measured parameters	Range	Surface water	Groundwater	Overall mean	Acceptable level
pH	4.6-6.2	5.0	5.2	5.14	6.5-8.5
EC µs/cm	14.8-98.6	67.4	46.26	50.96	1000-1400
TDS mg/l	13.3-100.0	45.6	55.03	49.59	500
Total Alkalinity mg/l	17.6-176.0	132.0	51.1	69.11	120-600
BOD mg/l	8.6-57.2	28.9	21.51	23.16	6
COD mg/l	6.4-64.0	48	20.11	26.31	255
TVC cfu/ml	6.4-67.0	55	29	34.78	0.5

The physical parameters such as pH, TDS, EC and total alkalinity fall within the WHO (2012) acceptable limits for drinking water. Also, from the work of Caroll (1962), both waters sources in the study area are classified as fresh based on the proportion of TDS which falls between 0 – 1000mg/l.

Aside the Chemical Oxygen Demand whose concentration in the natural waters of the study area is within the WHO acceptable limit, the other microbial parameters such as Biochemical Oxygen Demand and Total Viable Count have values which are higher than the desirable limits. This result implies that the water is unsafe for consumption as there is a high level of microbial activity in the water.

CONCLUSION

The following have been established by this study:

1. The Ugwuaji dumpsite in Enugu metropolis produces leachates which contain micro-organisms that have been released to the surrounding surface and groundwater.
2. The surface water and groundwater in the area are slightly acidic to neutral with electrical conductivity values revealing that the area is centrally made up of fresh water.
3. The microbial constituents of the leachates may have affected the quality of the natural water sources within the Enugu metropolis as shown by the Biochemical Oxygen Demand and Total Viable Count.
4. The surface and groundwater are not suitable for consumption because of the proven high microbial content and activity in them.

Therefore, to avoid any form of health risks associated with the intake of such contaminated water, it is recommended that the water should be treated properly before use. Also, there is need for an immediate action by the government to line the dumpsite at the base to stall any further infiltration of leachates into the ground and surface waters.

REFERENCES

Amuno, S.A., 2011. Trace elements analysis and contamination degree of soils affected by municipal solid wastes. Journal of Applied Technology in Environmental Sanitation, v. 1, pp.30-38.

Caroll, D. 1962. Rainwater as a chemical agent of geologic processes – a review of U.S Geological survey water supply paper 1535 – G, 18pp

Duze, M. and Ojo, A. 1982. Senior school atlas. Macmillian p. 113.

Egboka, B. C. E., 1993.Water Resources Problem in the Enugu Area of Enugu State," Nigerian Journal of Mining Geology, v. 20, pp. 1-6.

Elueze et al., 2004. Hydrogeochemical investigation of surface water and groundwater around Ibokun, Ilesha area, southwestern Nigeria. Journal of mining and geology, vol 40(1), pp. 57–64.

Inyang, P.E.B., 1974.Climatic regions. In Ofomata, G.E.K.(ed), Nigeria in maps; Eastern States. Ethiopian Publishing House, Benin, pp.27-29.

Maiti, S. K., De, S., Hazra, T., Debsarkar, A., & Dutta, A. (2016). Characterization of leachate and its impact on surface and groundwater quality of a closed dumpsite - a case study at Dhapa, Kolkata, India. Procedia Environmental Sciences, 35, 391–399. https://doi.org/10.1016/j.proenv.2016.07.019.

Mor, S., Ravindra, K., Dahiya, R. P., & Chandra, A. (2006). Leachate characterization and assessment of groundwater pollution near municipal solid waste landfill site. Environmental Monitoring and Assessment, 118, 435–456. https://doi.org/10.1007/s10661-006-15057.

Onyekuru, S. O., Nwankwor, G. I., & Akaolisa, C. Z. (2010). Chemical characteristics of groundwater systems in the southern Anambra Basin, Nigeria. Journal of Applied Sciences Research, 6, 2164–2172.

Onyekwelu and Aghamelu. 2019. Impact of organic contaminants from dumpsite leachate on natural water sources in the Enugu Metropolis, southeastern Nigeria. Environmental Monitoring Assessment. https://doi.org/10.1007/s10661-019-7719-2

Osiemo et al., 2019. Microbial quality of drinking water and prevalence of water-related diseases in Marigat urban centre, Kenya. Journal of environmental health insights, Vol 13. https://doi.org/10.1177/1178630219836988

Reyment, R. A. (1965). Aspects of the geology of Nigeria: The stratigraphy of the Cretaceous and Cenozoic deposits (pp. 145). Ibadan: Ibadan University Press.

Sajjadi, S. A., Aliakbari, Z., Matlabi, M., Biglari, H., & Rasouli, S.S. (2017). Environmental impact assessment of Gonabad municipal waste landfill site using Leopold Matrix. Electron Physician, 9(2), 3714–3719.

Tijani M. N., 1994. Hydrogeochemical assessment of groundwater in Moro area, Kwara state, Nigeria. Environmental Geology, vol. 24, pp. 194–202.