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RESEARCH ARTICLE

Impact of Pollution on Groundwater (Well) Quality in Onitsha Metropolis, Anambra State Southeastern Nigeria

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ABSTRACT

The study examined the impact of pollution on groundwater quality in Onitsha Metropolis, Anambra State, Southeastern Nigeria. The specific objectives are to; examine the effect of air pollution on groundwater quality and assess the effect of land pollution on groundwater quality in Onitsha Metropolis. Arsenic levels in water samples from Onitsha were found using the atomic absorption spectrometry method. Water and soil samples were evaluated to understand the effects of dumpsite location on the quality of water in surrounding areas. Analysis of the physical characteristics of the groundwater samples reveals that turbidity, odor, and appearance were all found to be within the WHO standard limit in every sample location. The descriptive statistics for the physical parameters of groundwater include Temperature, Turbidity, Conductivity, Total solids, Total dissolved solids, Total suspended, and Distance accordingly. We observed that among these physical parameters. Conductivity recorded the highest mean value as (Mean = 307.79286; Standard Dev = 108.270188) while total suspended recorded the least mean value as (Mean = 0.32833; Standard Dev = 0.333192). We concluded that the research work on the effects of land pollution on groundwater in the study area established that biophysical, economic, and social factors cause pollution into land terrain, biodiversity loss, groundwater pollution, displacement of farmland, and threat to life. Physico-chemical data tell us how much the water is polluted using tests generated from laboratory analysis. We recommended that the inhabitants should be educated on the dangers of drinking contaminated water.

***Keywords**: Groundwater Quality; Pollution; Pollutants*

Introduction

A crucial natural resource with significant social and economic importance is groundwater (Zhao, 2015). It provides about half of the world's drinking water (WWAP, 2009) and is important for food production, making up more than 40% of the world's total consumptive usage for irrigation in agriculture (Siebert et al., 2010). With an average annual extraction rate of 980 km, groundwater is the most exploited raw material in the world. Groundwater, with percentages varying from 16 percent to 100 percent is the main source of abstraction for residential use. Deep wells are with depths above 100m and 150m in diameter especially in the sedimentary formations, they serve large communities due to their high yield, but with high cost and maintenance (Ojo, 2002). Hand-dug well as the name implies are constructed manually and are little more than an irregular holes in the ground intersecting the water table (Todd, 1980). The groundwater is essential to maintaining human life and activities, but overuse and deteriorating water quality put it in danger. Groundwater is under threat from a number of factors, including climate change, land use change, and population growth, which affect both water supply and quality.

The level of human health and agricultural production are both strongly influenced by water quality. After air, water is the second most essential component for life to exist. As a result, the scientific literature has written extensively about water quality. The phrase "it is the physical, chemical and biological qualities of water" is the most frequently used definition of "water quality" (Alley, 2007; Spellman, 2013). The condition of the water in relation to

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the needs of one or more biotic species and to any human need is referred to as its quality (Shah, 2017; Tchobanoglous and Schroeder, 1985).

The introduction of toxins into the environment that has a negative impact on it is known as pollution. Any substance (solid, liquid, gas) or energy can cause pollution (such as radioactivity, heat, sound, or light). Both naturally occurring contaminants and imported substances can be considered pollutants, which are the elements of pollution. Despite the fact that natural disasters can result in environmental contamination, the word pollution often suggests that the toxins came from an artificial source, or a source made possible by human activity. Point source and nonpoint source pollution are two common categories for pollution (Beil, 2017). The three main types of pollution are air pollution, water pollution and land pollution, which are often categorized by the environment.

Statement of the Problem

Groundwater pollution is a serious issue that gets worse when storage capacity is reduced. The use of fertilizer and pesticides results in the runoff of chemicals from agricultural fields into surface waters and the percolation of chemicals into groundwater, which causes the most serious degradation of water quality in agricultural zones. The use of fertilizer and pesticides results in the runoff of chemicals from agricultural fields into surface waters and the percolation of chemicals into groundwater, which causes the most serious degradation of water quality in agricultural zones. In agricultural areas, nitrate poisoning of groundwater is already a considerable problem.

Objectives of the Study

The main objective of the study is the impact of Pollution on Groundwater Quality in Onitsha Metropolis, Anambra State, Southeastern Nigeria. The specific objectives are to;

i. Examine the effect of air pollution on groundwater quality in Onitsha Metropolis.
ii. Assess the effect of land pollution on groundwater quality in Onitsha Metropolis.

Study Area

Onitsha is situated between latitudes 5°22^1 and 6°48^1 and longitudes 6°32^1 and 7°20^1 in the Anambra State of eastern Nigeria. Onitsha, which is in the Anambra State, sits on the east bank of the river Niger and occupies a region of roughly 49,000 km ^{2}. In addition to being a Nigerian transit city, it is one of the most significant commercial hubs in sub-Saharan Africa. There are reportedly one million people living there. The tertiary sector, which includes trade and services, employs around 75% of the labor force in Onitsha, according to its socioeconomic features. Manufacturing and industrial work account for the remaining 25% of the labor force's activity. Onitsha, however, serves as both a market for the selling of imported commodities and a hub for the manufacture of locally produced goods and services. The Onitsha main market, which is thought to be the biggest market in sub-Saharan Africa, has recently accelerated the pace of business activity in the city.

Literature Review

Pollution

Pollution is defined by the United States Environmental Protection Administration as "Any substances in water, soil, or air that harm people's health, the environment's natural quality, or their senses of taste, smell, or sight. The presence of pollutants and toxins typically reduces the natural resource's usefulness (WHO, 2006). On the other hand, the United Nations views pollution as "the presence of substances and heat in environmental media (air, water, and land) whose characteristics, locations, or concentrations have a negative impact on the environment (Brindha and Elango, 2011). An aquifer frequently develops a contamination plume as a result of the pollutant. The contaminant is dispersed over a larger region via the movement of water and dispersion within the aquifer. Its expanding boundary sometimes referred to as a plume edge, may collide with surface water sources like seeps and springs and groundwater wells, making the water unfit for use by both people and wildlife (Costall et al 2020). A hydrological transport model or a groundwater model may be used to examine the plume's movement, known as the plume front. The analysis of groundwater pollution may concentrate on the geology, hydrology, hydrogeology, and hydrology of the location as well as the nature of the contaminants.

Different processes, such as diffusion, adsorption, precipitation, and degradation, affect how contaminants are transported in groundwater (Han 2014). Using hydrological transport models, the relationship between groundwater contamination and surface waters is investigated. Complex interactions exist between surface water and groundwater. For instance, groundwater supplies a number of rivers and lakes. This implies that rivers and lakes that depend on groundwater aquifers may be impacted by damage to those aquifers, such as that caused by fracking or excessive extraction. One illustration of such interactions is the intrusion of saltwater into coastal aquifers

(Michael, Adelana and Segun 2014). The precautionary principle, groundwater quality monitoring, groundwater protection land zoning, correctly situating on-site sanitation systems, and the use of laws are all examples of prevention strategies. When pollution develops, management strategies may include groundwater remediation, point-of-use water treatment, or, as a last resort, abandonment (Costall et al 2020). The main types of pollution and the specific contaminants that apply to each of them are given below:

Groundwater Pollution

When contaminants are released into the air or ground and find their way into groundwater, this is referred to as groundwater pollution or groundwater contamination. This kind of water pollution can also happen naturally as a result of a tiny and unwelcome element, contaminant, or impurity in the groundwater; in this case, contamination is more appropriate than pollution. Groundwater contamination can be brought on by onsite sewage systems, landfill leachate, wastewater treatment plant effluent, leaking sewers, gas stations, hydraulic fracturing (fracking), or excessive fertilizer use in agriculture. Natural pollutants like arsenic or fluoride can also cause pollution (or contamination) (Michael, Adelana and Segun 2014). Utilizing contaminated groundwater puts the general public at risk for illness (water-borne illnesses) or being poisoned (Michael, Adelana and Segun 2014).

Because groundwater can travel long distances through hidden aquifers, it is far more challenging to reduce groundwater pollution than surface pollution. By simple filtration (adsorption and absorption), dilution, and, in certain situations, chemical reactions, and biological activity, non-porous aquifers like clays can partially rid water of bacteria. However, in some cases, the pollutants merely change into soil contaminants. Because it is not filtered, groundwater that travels through tunnels and open fissures can be moved just as quickly as surface water. In fact, the propensity of people to dump waste in karst topographic areas near natural sinkholes can make this worse (Pantaleo et al., 2018). Groundwater can be made safe for use by removing pollutants and impurities using a variety of procedures. Techniques for treating groundwater (or remediating it) include biological, chemical, and physical treatment methods. The majority of groundwater treatment methods combine several different technologies. The biological treatment methods include phytoremediation, bioaugmentation, bioventing, biosparging, and bioslurping. Ozone and oxygen gas injection, chemical precipitation, membrane separation, ion exchange, carbon absorption, aqueous chemical oxidation, and surfactant enhanced recovery are a few examples of chemical treatment methods. Nanomaterials can be used to implement some chemical processes. Pump and treat, air sparging, and dual phase extraction is just a few examples of physical treatment methods.

Air Pollution

As a result of the presence of compounds in the atmosphere that are hazardous to human health and the health of other living things, or that impair the climate or materials, air pollution is the contamination of the air. Gases (such as ammonia, carbon monoxide, sulfur dioxide, nitrous oxides, methane, carbon dioxide, and chlorofluorocarbons), particles (both organic and inorganic), and biological molecules are just a few examples of the many diverse forms of air pollution. Humans can develop illnesses, and allergies, and even pass away due to air pollution. It can also impact other animals and food crops, as well as the built environment (due to things like climate change, ozone depletion, or habitat destruction) (for example, acid rain). Human activities and natural events both have the potential to generate air pollution(Manisalidis et al 2020). By contaminating precipitation and entering water and soil habitats, air pollution can have an impact on the quality of soil and water bodies (Maipa et al 2001; Kjellstrom et al 2017). Notably, acid precipitation can change the chemistry of the soil by influencing plants, cultures, and water quality (Pathak et al 2011). Additionally, soil acidity favors the flow of heavy metals, and as a result, metals are moving into the aquatic ecosystem. It is well known that fish and wildlife are poisoned by heavy metals like aluminum.Since soils with low calcium carbonate levels are more vulnerable to acid rain, soil quality appears to be significant. Rain, snow, and other precipitation don't stop there; they also seep into water bodies (Kjellstrom et al 2017; Bonavigo et al 2009).

Land Pollution

The degradation and contamination of the land as a result of human activity, both directly and indirectly, is known as land pollution. The pollution alters the landscape, causing things like soil erosion. While some of the modifications are permanent, others are not. The repercussions of land pollution don't always show up right away. It is the end result of sustained damage brought on by human activity. For instance, it may take months or even years before the entire extent of the chemical harm caused by an oil spill is understood. Contamination of the land can have devastating effects on the water, soil, and animals. Land contamination could have a number of negative effects on the ecosystem and animals. Chemicals may wind up in groundwater depending on the soil and whether they were inappropriately disposed of on the land. The procedure is referred to as leaching. It can take place on farms.

Water Pollution

Water pollution is brought on by the intentional or unintentional discharge of industrial wastewater from commercial and industrial waste into surface waters, the release of untreated sewage and chemical contaminants from treated sewage, such as chlorine, and the release of waste and contaminants into surface runoff flowing to surface waters (including urban runoff and agricultural runoff, which may contain chemical fertilizers and pesticides, as well as human feces from open defecation).

Groundwater Quality

In relation to the intended use of water, the physical, chemical, and biological qualities of groundwater are referred to as its quality. Human activities are the main factor endangering groundwater quality, while occasionally dangerous compounds are introduced by natural processes. Because prevention protects all resources, unlike treatment at the point of use, sustainable groundwater management must be based on both the prevention of pollution and the overexploitation of groundwater resources. However, economic activities (primary activities) that produce goods (mining, agriculture), as well as secondary or industrial activities (energy production, manufacturing, building), as well as services (including transportation) and household activities, generate a significant amount of waste that poses a threat to the environment and worsens groundwater pollution (Postigo et al 2018; Currell, and Han, 2017). Groundwater pollution is primarily caused by two types of sources: point sources and non-point sources (Kamarudzaman. et al 2011). In theory, waste sites can be sealed off from the surrounding area. This, however, is not conceivable with dispersed sources of pollution, which are either utilized in agriculture and partially seep into the subsoil or are delivered into the air and then rains out. These sources, along with mine tailings and unintentional chemical releases, pose serious risks to groundwater quality.

Degree of Pollution of Various Water Sources at Onitsha

Pollutants of all kinds from biological to chemical, may be found everywhere in Onitsha. The Nwangene Lake area, where many types of sewage and chemical effluent drain into, is one of the most polluted areas. Additionally, the largest garbage landfills are emptied here. In addition to polluting boreholes along Creek Road and Abatete Streets, this has produced significant pollution issues in the river Niger where it drains into the Otumoye Major Drain. The volume of solid and liquid waste that is dumped into local water bodies can be used to anticipate how polluted they will become. One hundred meters may have been affected by the inflow of this filthy water from the Nwangene Lake and River Niger. Therefore, the use of untreated borehole water poses a major health risk to hundreds of local residents. The level of heavy metals is substantially higher than what is recommended by the WHO.

One of the main sources of water for residents of Onitsha city, particularly during times of drought, is the river Niger. Currently, the River Niger is used to dispose of all trash and wastewater. River water and nearby groundwater are contaminated as a result of the rapid rise of new industry and urbanization. Urbanization and technological advancement cause an increase in the number of waste effluents produced, which are then released into water bodies, causing surface water pollution. The surface water that empties into the river Niger is eventually combined with waterborne sewage, storm drainage from the streets of Onitsha, effluents from smaller enterprises, flow from municipal outfalls in increasing amounts and agricultural runoff from the countryside. More groundwater is being used for domestic, industrial, and agricultural purposes because the public water supply is insufficient. In general, subterranean water is preferred over surface water due to its inherent advantages.

Materials and Methods

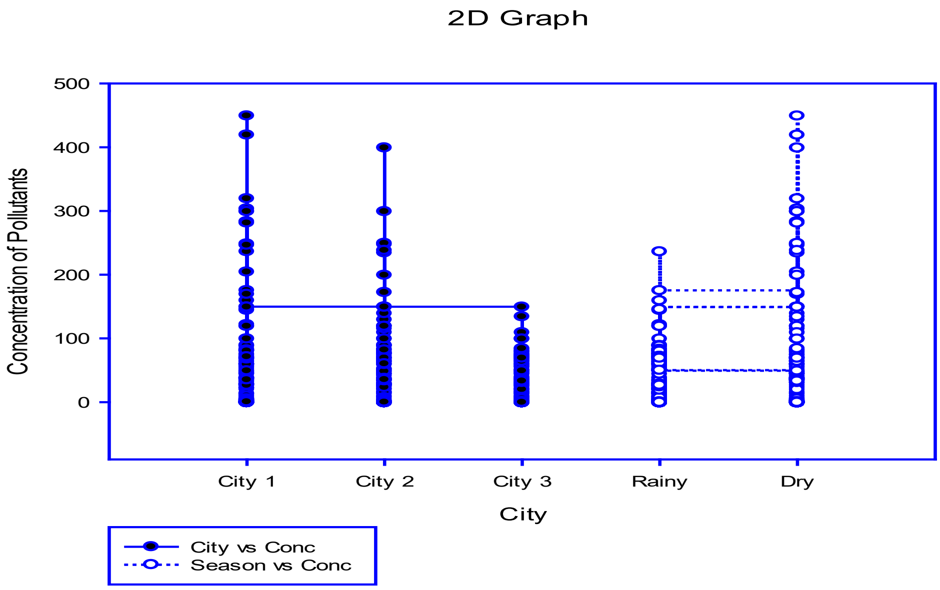
The Onitsha metropolitan city provided 18 water samples, 11 of which came from boreholes and 7 from groundwater sources. In locations where Onitsha's primary market/auxiliary drains and industrial effluents meet the rivers, surface water monitoring was done at a constant depth of 0.5 - 1.0 m. Borehole samples were taken relatively near the Niger River, usually less than 10 km from the bank. During the course of the study, research was done. Prior to the examination, water samples were held in 50cl PVC bottles that had been sterilized and acidulated. Arsenic levels in water samples from Onitsha were found using the atomic absorption spectrometry method. This technique relies on neutral atoms in the gaseous state absorbing radiant light, often in the ultraviolet and visible spectrum. Water samples were kept in 50 ml PVC bottles for analysis using an Atomic Absorption Spectrometer with the UNICAM 969 model. The use of analytical-grade chemicals was also made (HNO_3, Sigma chemicals, Australia, and standard heavy metal solutions). According to the APHA procedures, samples were digested with nitric acid, which has a purity level of 65%. (APHA, 1999).

Result and Discussions of Findings
Objective One:
Effect of Air Pollution on Groundwater in Anambra State
Table 1a: Concentration of Gaseous and Particulate Pollutants in Anambra State

s/n	Pollutants	Concentration (Season 1)	Concentration (Season 2)	W.H.O LIMIT
1	$P_{2.5}$(µg/m^3)	40.52±43.31	37.43±39.76	40-150 µg/m^3
2	P_{10} (µg/$m^{3)}$	36.57±36.65	32.83±30.32	40-150 µg/m^3
3	Co(ppm)	5.45±5.241	5.31±3.38	9ppm
4	SO_2(µg/m^3)	0.20±0.42	1.10±0.87	10-30µg/m^3
5	Voc(mg/m^3)	0.22±0.20	0.92±1.08	0.01-0.029mg/m^3
6	CH4(ppm)	0.00±.0.00	0.40±0.69	1,000ppm
7	H_2S((µg/m^3)	0.00±.0.00	0.00±0.00	7µg/m^3
8	NH_3(pmm)	0.00±.0.00	0.00±0.00	50ppm
9	O_3(pmm)	0.00±.0.00	0.00±0.00	0.2-10ppm
10	RH (%)	68.52±11.82	64.10±19.90	30-50%
11	WD (mp/h)	65.00±15.93	1.47±1.07	20mp/h
12	WS (mp/h)	1.07±.0.58	31.42±5.71	20mp/h
13	Temp(0_C)	29.62±1.66	78.62±15.75	$25^0{}_C$
14	Noise (Dba)	73.62±15.97	844.33±580.58	70dBA
15	Pressure(psi)	1003.43±4.63	81.00±36.21	25psi
16	Altitude	84.60±39.92	1.07±1.19	-
17	N02(µg/m^3)	0.07±.0.15	144.0±81.00	30µg/m^3
18	AQI(µg/m^3)	111.5±67.000	113.70±69.50	50-100 µg/m^3

Table 1a shows that in season 1(Dry season) the of Pm2.5 is [40.52 ± 43.31(mg/m^3)], Pm10 is [36.57±36.65(mg/m^3)], carbon monoxide (CO) is [5.45±5.241ppm], sulphur oxide concentration is [0.20±0.42(mg/m^3)]. the concentration of Volatile organic carbon is [0.22±0.20(mg/m^3)], Methane (CH4), Hydrogen sulphide, Ammonia, ozone(O_3) is [0.00±.0.00(mg/m^3)], relative humidity concentration is [68.52±11.82%], wind direction is [65.00±15.939mp/h)]. temperature concentration is [29.62±1.66(0_C)], noise [73.62±15.97(Dba)], pressure [1003.43±4.63(psi)], altitude is [84.60±39.92], NO_2 concentration is [0.07±.0.15(µg/m^3)] and AQI [111.5±67.00(µg/m^3)].

On the other hand, during the second season (dry season) Pm2.5 concentration is [37.43±39.76(mg/m^3)], Pm10 is [32.83±30.32 (mg/m^3)], carbon monoxide (CO) is [5.31±3.38], sulphur oxide is [1.10±0.87 (mg/m^3)]. volatile organic carbon is [0.92±1.08 (mg/m^3)], Methane (CH4) is [0.40±0.69 µg/m^3], Hydrogen sulphide and Ammonia, ozone(O_3) is [0.00±.0.00(mg/m^3)] respectively. Relative humidity concentration is [64.10±19.90%], wind direction is [1.47±1.07 (mp/h)]. temperature is [78.62±15.75 (0_C)], noise [844.33±580.58 (Dba)], pressure [844.33±580.58(psi)], altitude is [81.00±36.21], NO_2 is [144.0±81.00 (µg/m^3)] and AQI [113.70±69.50 (µg/m^3)]. The concentration of the parameters for both raining season and the dry season varies slightly between the two seasons. When compared with the approved World Health Limit, it is evident that the concentration of the parameters is all below the approved World Health limit except for wind speed for dry seasons, Noise for the dry season, temperature for both seasons, pressure concentration for both seasons, $N0_2$ for the dry season and AQI concentration for both seasons. This result is in line with findings made by Obuka, et al (2019) that the temperature of surface water from runoff pollution was significantly lower the in the rainy season (29.46 ± 1.35) than in dry season (32.29 ± 1.26), (t = 4.608, P < 0.001). Similarly, the pH of surface water from runoff in the rainy season (5.97 ± 0.17) was significantly lower when compared to the dry season (7.56 ± 0.73), (t = 7.885, P <0.001).



Graph 1a: Graphical Representation of the Concentration of Pollutants in all the Cities Considered in Anambra State

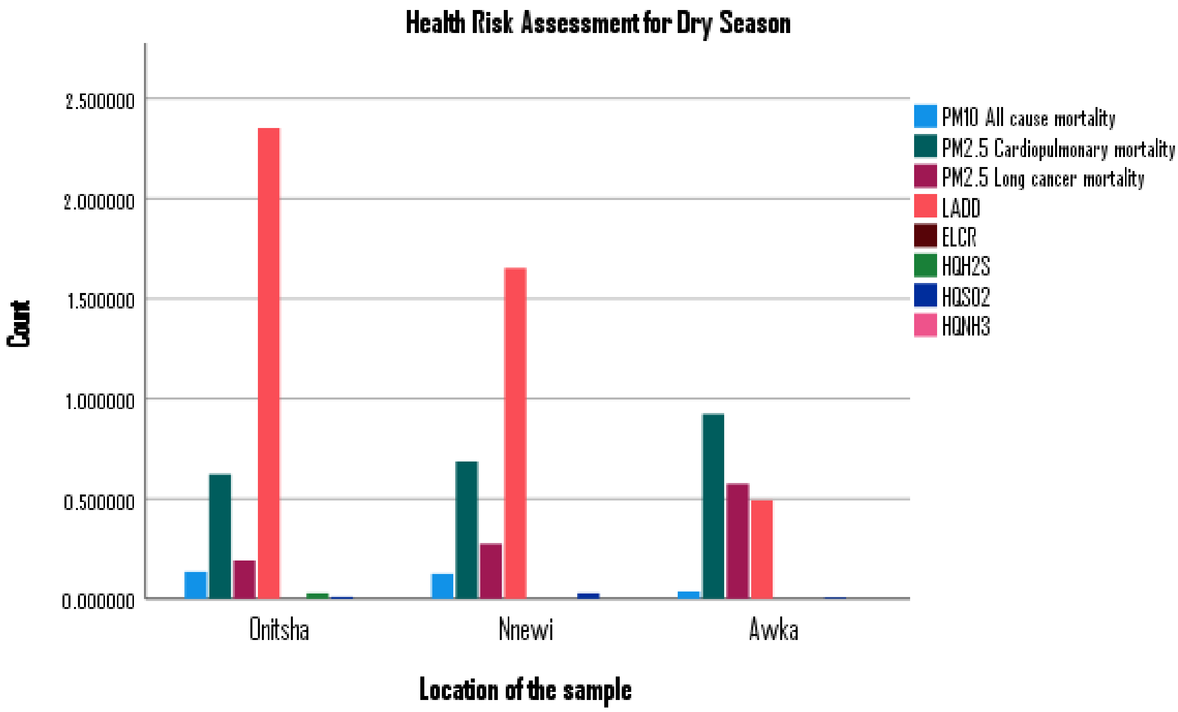
Table 1b: Risk Assessment

Location	**Parameter**	**AF**	**LADD**	**ELCR**	**HQ**	**W.H.O Acceptable Limit**
Onitsha	Pm2.5	0.77	61.89	-61.88	2.8	40-150 µg/m^3
	Pm10	0.017	58.15	-58.11	2.7	40-150 µg/m^3
Nnewi	Pm2.5	0.85	94.04	-93.9	4.22	40-150 µg/m^3
	Pm10	0.11	177.4	-177.21	7.98	40-150 µg/m^3
Awka	Pm2.5	0.25	19.09	-19.08	0.85	40-150 µg/m^3
	Pm10	4.09	31.22	-21.95	1.40	40-150 µg/m^3

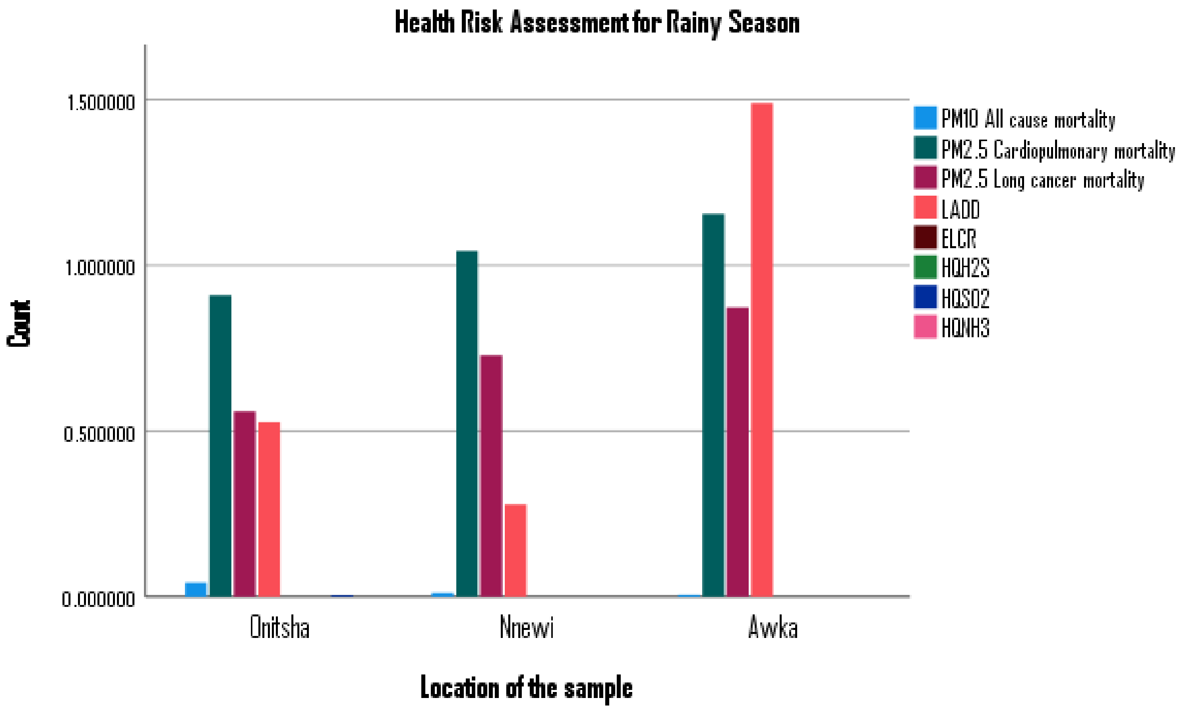
Table 1b shows that the health risk assessment due to the particulate matter as evident in attributed fraction (AF) is 0.77, for PM2.5 and Pm 10. These values are less than the W.H.O acceptable limit which is a clear indication that health problems caused by particulate matter in the Onitsha industrial area are less and not highly hazardous as indicated by the low value of 2.8 and 2.7 values of the hazard quotient respectively for Pm2.5 and pm10. The Lifetime average daily dose of particulate matter and gaseous pollutant (LADD) value for Pm 2.5 and Pm10 is 6.89 and58.15, and negative values of -161.88 and-58.11 for the excess lifetime cancer risk. These negative results depict that the carcinogenic effect of the gases and particulate matter in the Onitsha industrial area is very low and may have little or no health implications.

For Nnewi, the value of Pm 2.5 and Pm10 is 0.85 and 0.11. The lifetime average daily dose of particulate matter and gaseous pollutant (LADD) value is 94.04 and 177.4 for Pm2.5 and Pm10 respectively. Excess lifetime cancer risk involves Pm2.5 and Pm10 are-93.9 and -177.21. When compared to the W.H.O standard, the values ate less than the acceptable limit. Therefore, the negative value is an indication that the concentration of the particulate matter causing cancer is very minimal or may not even cause it all. Hazard Quotient of 4.22 and7.98 is less than the W.H.O limit is proof that the particulate matter is safe for humans and may not cause any health Hazard.

In Awka, health risk assessment due to particulate matter as evident in attributed fraction (AF) value is 0.25 and4.09 for PM2.5 and Pm 10 respectively. The Lifetime average daily dose of particulate Matter and gaseous pollutant (LADD) value for Pm 2.5 and Pm10 is 0.25 and 4.09 and excess lifetime cancer risk is -19.08 and-21.95 respectively. The negative value is an indication that the concentration of PM2.5 and PM10 does not exceed the limit that can cause health problems to man. e hazard quotient value of 0.85 and 1.40 for PM2.5 and Pm10 respectively is less than the W.H.O standard. Therefore, it implies that the concentration of the particulate matter is at its minimal level.



Graph 1b: Bar Chart for Health Risk Assessment in Anambra State for Dry Season.



Graph 1c: Bar Chart for Health Risk Assessment in Anambra State for Rainy Season

Objective Two

Water and soil samples were evaluated to understand the effects of dumpsite location on the quality of water in surrounding areas. The data is presented in the form of a table, figures, and text for effective data and results in presentation.

Physical Parameter

Table 2a: Physical Variables

Physical	**Appearance**	**Temperature**	**Odour**	**Turbidity**
WHO Standard	**Colorless**	**35 -40°C**	**Odourless**	5 NTU (mg/l)
Well1	Colorless	30°C	Odourless	**Clear***
Well2	Colorless	28°C	Odourless	====
Well3	Colorless	34°C	Odourless	====
Well4	Colorless	30°C	Odourless	====
Well5	Colorless	26°C	Odourless	====
Well6	Colorless	25.2°C	Odourless	====
Well7	Colorless	29°C	Odourless	====

Analysis of the physical characteristics of the groundwater samples (Table 4.2a) reveals that turbidity, odor, and appearance were all found to be within the WHO standard limit in every sample location. Temperatures between 25.2 and 34 degrees Celsius were below the normal range of 35 to 40 degrees, indicating the presence of foreign objects like live microorganisms (Akinbile and Yusoff, 2011; Jaji et al., 2007).

Table 2b: Descriptive Statistics for the Physical Parameters of Groundwater

Parameter		N	Mean	Std. Deviation	Std. Error Mean
Temperature (°C)	Well	7	42.47857	40.625606	15.355036
Turbidity (NTU)	Well	7	20.01286	50.507220	19.089935
Conductivity (μs/cm)	Well	7	307.79286	108.270188	40.922285
Total Solid	Well	7	191.01143	48.009347	18.145828
Total Dissolved Solid	Well	7	190.73000	47.716503	18.035143
Total Suspended	Well	7	.32833	.333192	.136025
Distance	Well	7	155.50000	41.317067	16.867622

Table 2b is the descriptive statistics for the physical parameters of groundwater. These parameters include Temperature, Turbidity, Conductivity, Total solids, Total dissolved solids, Total suspended, and Distance accordingly. We observed that among these physical parameters.

Conductivity recorded the highest mean value as (Mean = 307.79286; Standard Dev = 108.270188) while **Total Suspended** recorded the least mean value as (Mean = 0.32833; Standard Dev = 0.333192).

Chemical Parameters

The mean concentrations of chemical parameters, inclusive of heavy metals, of well water samples, are shown in Tables 2b and 3a compared with WHO and NSDWQ standards. Table 3b shows the descriptive statistics of heavy metals in the groundwater samples

Table 2c: Chemical Variables

	pH	Total Acidity	Total Alkalinity	Total Hardness	Chloride	Nitrates	Phosphate	Sulphates	Dissolved Oxygen	Compliance (%)
WHO STANDARD	6.5 - 8.5	NS	200	100	250	10	5	250	2	
NSDWQ	6.5 - 8.5	NS	NS	NS	250	50	NS	100	NS	
Well1	6.3	38	25	32	11	3.4	0	4.0	5.53	**84.72**
Well2	6.4	35	35	34	12	6.3	0	1.0	5.26	**84.72**
Well3	5.3	42	20	30	13	5.0	1.85	2.0	5.54	**84.72**
Well4	6.0	540	15	20	12	6.3	1.86	2.0	5.71	**84.72**
Well5	6.0	43	15	36	34	5.3	2.12	4.0	5.68	**84.72**
Well6	5.9	66	20	32	12	5.8	0	15.0	4.36	**84.72**
Well7	4.1	785	15	16	121	5	1.91	3.0	5.0	**84.72**
Compliance (%)	100 %	84.72 %	100%	100%	884.72 %	100%	100%	5.6		

Heavy Metals

Table 3a: Heavy Metals

Parameters (mg/l)	Magnesium	Zinc	Copper	Manganese	Iron	Lead	Chromium	Compliance (%)
WHO STANDARD	150	1.5	0.5	0.5	0.03	0.015	0.1	
NSDWQ	0.2	3	1	0.2	0.3	0.01	0.15	
Well1	0.12	0	0.00	0	0.03	0	0	**100**
Well2	0.19	0	0.00	0.0041	0.04	0.018	0	**71.43**
Well3	0.03	0	0.00	0.0107	0.02	0.016	0	**85.71**
Well4	0.05	0	0.00	0	0.07	0.005	0	**100**
Well5	0.09	0	0.01	0	0.03	0.011	0	**100**
Well6	0.12	0	0.01	0	0.04	0.002	0	**85.71**
Well7	0.16	0	0.03	0	0.06	0.004	0	**100**
Compliance (%)	100	100	100	100	72.22	88.24	100	

Table 3b: Descriptive Statistics

Parameters (mg/l)	Range	Mean Std. Dev
Magnesium	1.43	0.1950 ± 0.32960
Zinc	0.16	0.0089 ± 0.03771
Copper	0.10	0.0406 ± 0.03351
Manganese	0.01	0.0008 ± 0.00265
Iron	0.44	0.0456 ± 0.09995
Lead	0.38	0.0260 ± 0.08855
Chromium	0.00	0.0000 ± 0.00000
Nitrate	19.50	6.2300 ± 4.23568
Ph	4.00	6.1600 ± 0.99655
Dissolved Oxygen	3.83	4.8900 ± 0.97832
Chlorides	121.00	22.390 ± 34.1229

Chemical parameters of whose samples showed 100% compliance with WHO standards include: Total Hardness, Chlorides, Phosphates, Sulphates, Magnesium, Zinc, Manganese, and Chromium.

Total Alkalinity

Concentrations in W_4 (540mg/l) and W_7 (785mg/l) exceeded WHO standards of water quality. Percentage compliance of 84.72% was recorded for samples taken. Alkalinity refers to the capability of water to neutralize acid and its importance is underscored by its ability to control pH changes. High alkalinity, while not detrimental to humans may cause drinking water to have a flat, unpleasant taste (Adams, 2001).

Dissolved Oxygen
All samples exceeded the standard limit except W_{13}. Dissolved Oxygen is essential to the survival of aquatic life (Lenntech, 2012).

Copper
Of the 7 groundwater samples, all were within stated WHO and NSDWQ limits. However, it remained within the standards and does not present any health concerns. A high intake of copper can cause liver and kidney damage which may eventually lead to death. It also causes stomach aches, dizziness, vomiting, and diarrhea.

Iron
Concentrations in W_2, W_4, and W_7 were found to exceed WHO standards. W_7 also exceeded the upper limit standards of the NSDWQ which is even higher (0.3) than the WHO standard. The average concentration of Iron was recorded at 0.412mg/l. Iron concentrations however do not pose a potential health risk as they fall well within the recommended daily dietary allowance (7mg – 18mg). Water with high iron concentrations may be discolored and stain-washed clothing (Adams, 2001).

Findings
Evidence has shown that there are some levels of pollution with admissible W.H.O limit of concentration emission in Awka, Nnewi, and Onitsha in Anambra state. Though the concentration may be quite below the risk level given by the world health organization over long-term exposure, its accumulation may or may not cause life to threaten situation. Among the three locations, biotic and abiotic pollution were observed to be high in Onitsha but less in Awka and Nnewi which is an indication that the high commercial and industrial activities in that area also contributes to the generation of pollutant which inversely has a similar effect to the groundwater. These pollutants though not yet posing serious health problems many times cause health implications over a long period of exposure. Therefore, it is obvious and evident from this study that within Anambra's environment, air pollution exists and adversely affects the groundwater which may cause health problems to its, residents, with time.

To compare the concentration of the studied variable with the WHO (2004) and NSDWQ (2007) regulatory limits, this research also looked at the quality of the groundwater near the three dumpsites in Awka, Nnewi, and Onitsha. Seven (7) water samples were obtained, and seventeen (17) parameters were evaluated. In several samples, it was found that the WHO standard limit for nitrate ($N0_3$), electrical conductivity (EC), total alkalinity (TA), iron (Fe), lead (Pb), and copper (Cu) had been exceeded. Groundwater in Anambra and its environs have higher concentrations of heavy metals and chemical elements like iron, lead, and copper. According to Obuka et al (2020) On effects of urban runoff pollutant load on surface water quality in Enugu urban area " findings from the hypothesis in which student t-test was used revealed that the urban runoff pollutant load present in the surface water significantly differ from the acceptable standard recommended by World Health Organization. The parameters that fell below the WHO standard includes: pH, Conductivity, Total Dissolved Solid, Total Suspended Solid, Nitrogen, and Chemical Oxygen Demand while parameters that fell above the limits were Total Solid, Turbidity, Nitrate, Nitrite, Dissolved Oxygen, Biochemical Oxygen Demand in rainy and dry season respectively. This means that there was a high pollutant load in runoff water which pollute rivers in the study area.

About waste decomposition, leachate formation, and migration, as well as groundwater contamination, it is obvious that time, the role of waste management strategy, soil stratigraphy, groundwater flow direction, landfill life span, distance from the leachate, Piezometric level, season, and underlying geology all play important roles in groundwater quality around dumpsites.

Conclusions and Recommendation
In conclusion, based on findings the physical characteristics of the groundwater samples (Table 4.2a) reveal that turbidity, odor, and appearance were all found to be within the WHO standard limit in every sample location. Temperatures between 25.2 and 34 degrees Celsius were below the normal range of 35 to 40 degrees, indicating the presence of foreign objects like live microorganisms which pollute the groundwater. The health risk assessment due to the particulate matter as evident in the attributed fraction is less than the WHO acceptable limit which is a clear indication that health problems caused by particulate matter in the Onitsha industrial area are less and not

highly hazardous as indicated by the low value of 2.8 and 2.7 values of the hazard quotient respectively for Pm2.5 and pm10. Air pollution also determines the quantity and quality of pollutants discharge into rivers and their effect on the ecological system.

The findings from literature and the research work on the effects of land pollution on groundwater in the study area established that biophysical, economic, and social factors cause pollution into land terrain, biodiversity loss, groundwater pollution, displacement of farmland, and threat to life. Physico-chemical data tell us how much the water is polluted using tests generated from laboratory analysis. Based on this study, the following recommendation was made

The inhabitants should be educated on the dangers of drinking contaminated water. There is a need for the protection of groundwater in Onitsha Metropolis Anambra State and Nigeria at large as millions of the populace rely on it for daily water supply. Water quality monitoring is pertinent for the provision of a data baseline that will be useful for policymakers and stakeholders to formulate policy that will favour the protection and management of groundwater resources.

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