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Variation in the Sources of Drinking Water in Idah and their Suitability on the Health of the Consumers; Kogi State, Nigeria

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Abstract

This Research Project was designed to analyse the variation in the sources of drinking water and how they affect the consumer's health in Idah. Water samples were collected from the various sources (Groundwater, River, Rain and Packaged water) of water and were subjected to laboratory analysis to detect the water parameters. One-way Analysis of Variance was employed to analyse the result of the laboratory test in order to determine the relationship between the water sample parameters for both wet and dry seasons. Correlation Analysis was also adopted to analyse the quality of the drinking water and the possible health problems that could emanate from the water sources. The analysis of variance carried out showed that there was no significant difference ($p>0.05$, $d=0.40$) between the BOD and COD for the water samples tested. Alkalinity was also found insignificant at 0.05 significant levels since the calculated F-value is 0.008. The coefficient of determinant ($r^2 = 0.74$) indicated 74% dependence of water-related disease on water sources. This helped to determine which amongst the various water sources is responsible for causing the possible health problems that were detected in the research; typhoid, diarrhoea, cholera, dysentery, gastroenteritis and vomiting. The result revealed the relationship among the different water-related diseases and the human activities as well as the environmental management system and their impact on water quality in the study area. The project however pinpointed the safety of the drinking water and the need for water to undergo scrutiny (test) the source notwithstanding at a prescribed interval (three months) and periodic monitoring (six months) to ensure proper hygiene and environmental management.

Keywords: Drinking water; Water samples; Health; Parameters; Water-related diseases

Introduction

Water is a unique resource, having no substitute on the surface of the earth and an essential resource for human survival. Its quantity and quality vary over space and time. According to the 2021 World Water Development Report released by UNESCO, the global use of freshwater has increased six-fold in the past one hundred years and has been growing by about one percent per year since the 1980s. With the increase in water consumption, water quality is facing severe challenges and has been linked to health outcomes across the world. Xu, Xi, Yang, Hi and Li **[1]** noted that industrialization, agricultural production and urban life have resulted in the degradation and pollution of the environment adversely affecting the water bodies.

The importance of water to man cannot be over emphasized, water is thus regarded as one of the most indispensable substances in life and like air, it is most abundant **[2, 3]**. The phenomenon of urbanization has exerted enormous pressure on the provision of safe drinking water especially in developing countries, hence most fresh water bodies world over are getting contaminated and as a result, decreasing the portability of water **[4, 5]**..

Sources of drinking water are subject to contamination and require appropriate treatment to remove disease-causing contaminants. Contamination of water supplies can occur in the water source as well as in the distribution system after water treatment has already occurred. There are many sources of water contamination, including naturally occurring chemicals and minerals, local and land use practices, manufacturing processes, and sewer overflows or wastewater releases. The presence of contaminants in water can lead to adverse health effects in both young and old **[6]**.Contaminated water and poor sanitation are linked to transmission of diseases such as typhoid fever, cholera, diarrhoea, dysentery, hepatitis A, skin disease, gastroenteritis, and vomiting. WHO **[7]** noted that inadequate or inappropriately managed water and sanitation services expose individuals to preventable health risks

One of the biggest challenges confronting the global society is the shortage of portable water **[8]**. In a Report by United Nations (UN), there is more contaminated water than portable water in the world water system. **[9]**. Water contaminated with certain chemicals can have serious impacts on humans, animals and even plants **[10, 11]**. This results to water-borne illnesses connected to the water contamination **[12]**.

It is noteworthy to emphasize that water is essential for human life and a key factor for the location of settlement in a place which has been in existence since the inception of civilization. Unfortunately, the availability and quality supply of this water is not guaranteed in many countries, hence the need for a better water quality to enhance the quality of life of the people and boost the socio-economic development of any place. This Research Project therefore studies the variation in the sources of water in Idah and their health implication on the residents.

Problem Statement /Justification

The challenges of water supply have constituted a major issue including conflicts in some parts of the world because the earth's fresh water is diminishing due to man's activities and climate change **[13]**. According to the World Bank, an estimated 70 million Nigerians do not have access to safe drinking water and at least 70000 deaths occur in children under the age of five each year from diarrheal diseases. Access to safe drinking water supply and sanitation services is fundamental to improving public health and meeting national poverty reduction objectives because good health increases productivity. As it is now known, lack of access to quality water contributes substantially to the high burden of disease that needlessly foreshortens and impairs the lives of far too many of the citizenry. About 80 percent of all diseases may be attributed to water and sanitation related issues and they contribute to the many child deaths each year from diarrhoea, dysentery, jaundice, typhoid and cholera **[14]**. In the works of Amazon Web Services (AWS) Accounts **[15]**, it was deduced that these water-borne agents can be detected by proper analytical tests of the water properties consumed by the people.

As reported by Water Sanitation Hygiene National Outcome Routine Mapping, 2021 (WASH NORM), only 10% of Nigeria's population has access to all essential WASH services, and the situation is even worse in remote and hard-to-reach communities. Access to safe, clean water is dependent on the community water system functions adequately. However, what happens when there are no water system? The water challenge in rural communities in Nigeria require adequate and urgent attention. Despite accounting for 46% of the nation's population, 39% of rural household lack access to at least a basic water supply. These pose a major concern in achieving Sustainable Development Goal 6 by 2030.

In Kogi State, the census and housing survey carried out by National Bureau of Statistics reported that only 7 percent of households in the State have adequate access to quality water supply (14 percent of households obtain water from vendors, 35 percent from rivers and streams and 27 percent from wells). The emerging scenario is that most households in Kogi East obtain water from pollution-prone sources.

The health burden of the consumption of poor water quality is enormous. In Idah and a host of other towns in eastern Kogi, Stream and Borehole seem to be the major sources of water supply. The human activities that go on within the drainage basins are major pollutants to these sources – bathing, washing, dumping of refuse, open defecation, use of chemicals on the land (fertilizers, pesticides) etc. The outcome of this is seen in the poor quality of water consumed by the people and the associated water diseases.

Objectives of the Study

1. To determine the sources and nature of drinking water in the study area.
2. To analyse the physico-chemical properties of the drinking water for both wet and dry seasons in the study area with a view to detecting the impact on the health of the people.

Literature Review

The Development of the Science of Hydrology

Water is the most vital resource for life. In the planet earth, approximately 97.2% water lies in oceans as salt water, while 2.15% in frozen ice form and the remaining 0.65% remains as fresh water either on surface or groundwater. Available fresh water resources are very limited **[16]** the distribution and availability of water have influenced the development of human society through the course of human history. The ancient Egyptians, the inhabitants of Mesopotamia and the Chinese possessed an excellent working knowledge of hydraulics and hydrology. The first known dam in the world was built on the Nile River in Egypt before 4000BC to provide water for use in the ancient city of Memphis **[17]**.

The real beginning of the science of hydrology had to await the end of the 15^{th} century and the beginning of the 16^{th} century with pioneering studies by Leonardo da Vinci (1452-1519) and Berdard Palissy (1509-1589) among others. Leonardo da Vinci and Bernard Palissy independently described the concept of the water cycle as we now know it. They envisaged the waters in the oceans, the atmosphere and the land as being linked together in a circulation system in which water is evaporated from the sea into the atmosphere where the vapour condenses and falls as precipitation on the land and it subsequently runs off the land surface into the sea.

Characteristics of Water Bodies

Water bodies can be fully characterised by the three major components: hydrology, physio-chemistry, and biology. A complete assessment of water quality is based on appropriate monitoring of these components.

Hydrodynamic Features

All fresh water bodies are inter-connected, from the atmosphere to the sea, via the hydrological cycle. This water constitutes a continuum, with different stages ranging from rainwater to marine salt waters. The parts of the hydrological cycle are the inland fresh waters which appear in the form of rivers, lakes or ground waters. These are closely inter-connected and may influence each other directly, or through intermediate stages. Each of the three principal types of water body has distinctly different hydrodynamic properties **[3]**. Rivers are characterised by uni-directional current with a relatively high, average flow velocity ranging from 0.1 to $1ms^{-1}$ (surface values). Therefore, water or element residence times, ranging from one month to several hundreds of years, are often used to qualify mass movement of material. Currents within lakes are multi-directional. Many lakes have alternating periods of stratification and vertical mixing; the periodicity of which is regulated by climatic conditions and lake depth.

Ground waters are characterised by a rather steady flow pattern in terms of direction and velocity. The average flow velocities commonly found in aquifers ranges from 10^{-10} to 10^{-3} MS^{-1} and are largely governed by the porosity and permeability of the geological material. As a consequence, mixing is rather poor and, depending on local hydro-geological features, the ground water dynamics can be highly diverse.

Reservoirs are characterised by features which are intermediate between rivers and lakes. They can range from large-scale impoundments, such as Lake Nasser, to small dammed rivers with a seasonal pattern of operation and water level fluctuations closely related to the river discharge, to entirely constructed water bodies with pumped in-flows and out-flow. The

cascade of dams along the course of River Dnepr is an example of the interdependence between rivers and reservoirs. The hydrodynamics of reservoirs are greatly influenced by their operational management regime.
Flood plains constitute an intermediate state between rivers and lakes with a distinct seasonal variability pattern. Their hydrodynamics are, however, determined by the river flow regime. Marshes are characterised by the dual features of lakes and pyretic aquifers. Their hydrodynamics are relatively complex.

Methodology

The Study Area

Idah town is one of the urban centres in Kogi State and also one of the oldest settlements in Igala land. It is the traditional and cultural headquarters of the Igala people as it holds the seat of the Monarch (Attah of Igala Kingdom). It is geographically located at the south eastern part of the State and on the eastern bank of River Niger on Latitude 7.1138^0N and Longitude 6.7440^0E. It is lying beside the middle course of the River Niger. It is the Headquarter of Idah local government area of Kogi State. It has commercial routes (waterways) on the River Niger linking Lokoja to the north of the country; Onitsha in Anambra State to the south; Agenebode in Edo State to the west; and Enugu to the east. It is a homogeneous community dominated by the Igala's and few of other tribes.
The area has a high lying soil of the Plateau which is shallow and sandy. The town is under-laid by a false-bedded sand stone formation (sedimentary rock) which could provide a source of ground water through the tapping of aquifer. The population of the area from the 2006 census figure put it at 79,755 **[18]** and by projection using the geometric growth model ($P_t = P_0 (1+r)^t$ where r is the constant rate of change; P_0 is the initial population; P_t is the final population sought for) puts it at 108,698 for 2015. The climate and vegetation of Idah encourage agricultural practices. Hence much of cultivation is practised along the flood plains. It lies within the warm humid climate zone of Nigeria. The vegetation type is that of guinea savannah. The topography of the area is gently undulating and it slopes downstream (River Niger).

Climate and Hydrology

The tropical wet climate of Idah in Kogi State is influenced by the guinea savannah vegetation under which it lies and is characterised by two distinct seasons. The wet season which occurs roughly between 6-7 months of the year with moderate rainfall of about 200-300mm and the dry season which occurs within 5-6 months in a year. It has high temperature of over 27^oC during hot season and an annual range of temperature of about 6^oC **[19]**.

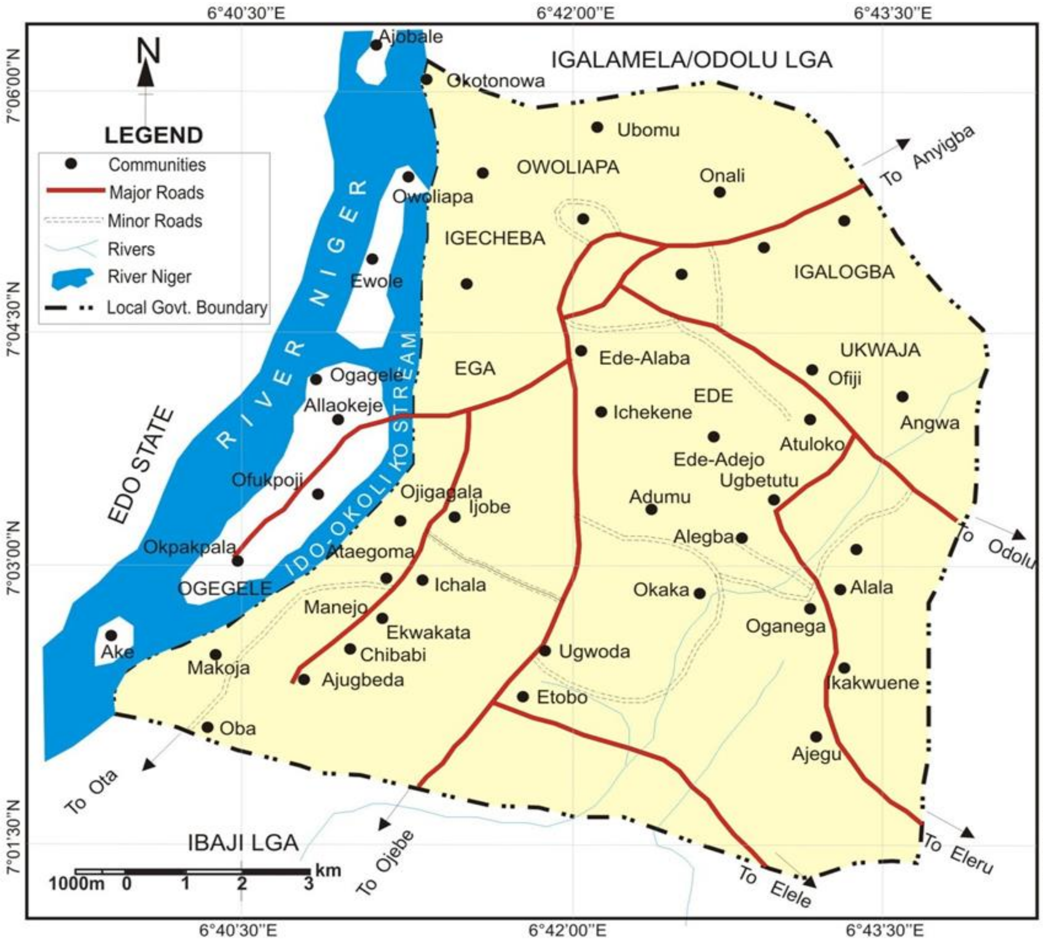

Fig.1: Map of Idah Local Government Area showing the Neighbourhoods
Source: GIS Lab, Department of Geography and Environmental Studies, KSU, Anyigba.

Table 1: Sources of Water in the Study Area (Proposed Survey)

Sources of Water	Frequency of Reliance	Percentage
Stream	17	5.2
Borehole	206	63.2
Well	12	3.2
Rain	31	9.5
Vendors	60	18.4
Total	326	100

Source: Authors' Field Survey, 2025

Table 1 shows the sources of water in Idah and the frequency distribution of the respondents. The survey revealed that more people (63.2% of the respondents) get their water more from boreholes rather than other sources. **[20].** In a similar study revealed that same is applicable in

Nsukka town. Due to the absence of surface water, there is heavy reliance on groundwater (borehole) as the main source of potable water supply. According to Malomo **[21]**, borehole water and well water are very vulnerable to contamination if not deep enough, as a result of capillarity seepage. This depends on the chemistry of the soil and the environment. If the borehole is dug in an area that is possibly receiving industrial fall-out like lead dusts, this can wash into the water thereby contaminating it. Though rain water is seasonal, most people are not deterred as they still depend on it as their source of water since it can safely be stored in tanks or reservoirs **[3]**.

Water samples were collected from the sources identified on Table 1 using the water sample specimen containers. On-spot reading of the pH value was taken for the water samples. Thereafter, the physico-chemical properties of the water samples were carried out in the Laboratory to detect the physical and chemical components of the water samples. One-way Analysis of Variance was conducted on the result from the Laboratory test to determine the relationship between the water sample parameters from the various sources and seasons of collection (wet and dry seasons). Correlation Analysis was also employed to analyse the quality of the drinking water and the possible health problems as detected in the research. This will help to reveal the relationship among the different water-related diseases and the human activities and their impact on the water quality.

For this study, water samples were collected from the sources identified on Table 1 and were subjected to Laboratory analysis to determine the nature of their parameters for both seasons (rainy and dry) of the year. The result is presented on Table 2.

Table 2: Mean Value of Water Quality Parameters in the Study Area

Water Quality (µg/l)	**Sources**					
	Groundwater		**River water**		**Table water**	
	Mean (Rainy)	**Mean (Dry)**	**Mean (Rainy)**	**Mean (Dry)**	**Mean (Rainy)**	**Mean (Dry)**
Total Hardness	36.57	38.86	36.67	12.00	30.00	13.18
Sulphate	.20	.44	.21	.30	.21	.35
Dissolved Oxygen	4.32	4.61	4.78	5.96	4.02	4.98
Chloride	12.00	33.00	11.67	25..67	28.08	25.71
Phosphate	5.66	16.11	3.95	13.90	5.10	15.12
Nitrate	.59	21.21	.63	10.67	.73	11.96
PH	5.96	5.41	7.10	6.43	6.35	5.52
Temperature	27.00	27.79	27.17	27.83	27.35	27.65
Alkalinity	40.00	14.29	21.67	21.67	25.88	18.53
COD	.89	.01	.18	.01	.10	.01
BOD	4.39	22.62	1.92	2.03	19.10	11.03
Manganese	.84	2.99	1.08	.53	1.13	3.40
Calcium	.46	56.00	.55	43.07	1.05	27.47
Lead	0.20	.00	.69	0.00	.43	.00

Source: Author's Laboratory Analysis, 2025

Pattern of the Water Quality Parameters

The descriptive analysis as shown on Table 2 highlights the various sources of drinking water and the mean of the properties for the various seasons in the study area. The mean for Total Hardness for ground water for the rainy season is 36.57 and that of the dry season is 38.86 while river water has mean 36.67 and 12.00 for rainy and dry season respectively. For Sulphate the ground water mean value for rainy season as represented on Table 2 is 0.21 and that of dry season is 0.30 while the table water mean value for rainy season is 0.21 and dry season mean value is 0.35 with F-value of 0.16 and 0.56 for both rainy and dry seasons respectively. Applying the critical value of 3.40 at a degree of freedom of 2 and 4, it is obvious that Sulphate is not significant in all the water samples analysed for both seasons.

The case of Dissolved Oxygen is similar to that of Sulphate. The mean value for ground water sample for rainy and dry seasons are 4.32 and 4.61 respectively; River water has rainy season mean value of 4.78 and dry season mean value of 5.96; table water is 4.02 for rainy season while dry season is 4.98. Operating with a Critical value of Dissolved Oxygen (3.40), at a degree of freedom of 2 and 4, the amount of Dissolved Oxygen is not significant in the water samples collected for both seasons in the study area. The mean value of Chloride in the ground water sample collected and tested for rainy season reads 12.0 and dry season mean value reads 33.0; river water sample mean for rainy season is 11.67 and dry season mean is 25.67 while table water sample for rainy season is 28.08 and 25.71 for dry season. The mean value for Nitrate in the ground water sample for rainy season reads 0.59 and that of dry season is 21.21; and the mean value of river water for rainy season is 0.63 and dry season is 10.67 while the table water mean value for rainy season is 0.73 and dry season is 11.96. Biological Oxygen Demand (BOD), Alkalinity, Temperature and Hydrogen Potency (pH) have similar results as they are all not significant in the water samples analysed for both seasons.

The three heavy metals (Manganese Mn, Calcium Ca, and Lead Pb) tested in the water samples collected in the study area for both seasons were not significant for both seasons as shown in Table 2. According to Green (2017), any water that has Manganese in significant amount, will pose a health condition of Neurological disorder. For Calcium, there is no much significant health condition associated with its much presence in water but Lead in very significant quantity in drinking water could result to cancer, interference with Vitamin D metabolism, affect mental development in infants and toxic to the central and peripheral nervous systems.

This result indicates that Total Hardness is not significant during the rainy season. This can be attributed to the fact that water containing calcium carbonate at concentration below 60mg/l is generally considered as soft, hence not significant, 120mg/l is moderately hard; 120-180mg/l is hard and more than 180mg/l is very hard **[3, 22]**. Comparing this to the result of the laboratory analysis for water hardness during rainy season as shown in Table 3 where the hardness value is 14mg/l with a maximum permit of 50mg/l. Total Hardness as shown on the Table 3 for dry season reveals that Total Hardness for groundwater statistically is significant during dry season with a mean of 38.86 and river water 12.00, table water 13.18 which has an F-value of 5.46 having the critical value of 3.40. Since the F-value is greater than the critical value, it is presumed significant for the dry season for the water samples collected and analysed at the degree of freedom of 2 and 4.

The Nigerian Standard for Drinking Water Quality **[23]**, permits chloride concentration of 250mg/l and any chloride concentration in excess of 250mg/l can give rise to detected taste in water, but the threshold depends upon the associated cat-ions. Consumers can however become accustomed to concentrations in excess of 250mg/l. **[14]**. Nitrate as shown on Table 3 is not significant for the various sources of water tested. The composite mean on Table 4 for Idah is 5.15. This is lower than the permissible nitrate content in water according to the Nigerian Standard for Drinking Water Quality; EWASH (2022). This implies that the nitrate content in the drinking in the study areas is safe as shown on Table 4 and will not result in cyanosis and asphyxia blue-baby syndrome) in infants under three months of age (Nigerian Standard for Drinking Water Quality; EWASH, 2022).

The Chemical Oxygen Demand for rainy season in the water samples tested is significant from the analysis carried out. This is reflected in the mean value of the water samples collected from different sources. For ground water, the rainy season mean value is 0.89 and dry season is 0.01; river water rainy season mean value is 0.18 and dry season is 0.01; Table water mean value for rainy season is 0.10 and dry season is 0.01. With an F-value of 4.46 which is greater than the critical value of 3.40, the decision rule shows that the COD concentration in the water samples for the rainy season is significant. But the COD concentration in the water samples collected for the dry season is not significant because the F-value of 0.81 is less than the critical value of 3.40 as computed on Table 3.

Table 3: One-way ANOVA for the Relationship between Water Parameters for Dry and Wet seasons

		Sum of Squares	Df	Mean Square	F	Sig.
Hardness	Between Groups	1404.667	2	702.333	3.547	.040
	Within Groups	6534.333	33	198.010		
	Total	7939.000	35			
Sulphate	Between Groups	.042	2	.021	43.158	.000
	Within Groups	.016	33	.000		
	Total	.058	35			
Dissolved Oxygen	Between Groups	52.108	2	26.054	5.275	.010
	Within Groups	162.985	33	4.939		
	Total	215.094	35			
Chloride	Between Groups	7619.755	2	3809.877	5.051	.012
	Within Groups	24889.433	33	754.225		
	Total	32509.188	35			
Phosphate	Between Groups	19.711	2	9.856	4.462	.019

		Sum of Squares	Df	Mean Square	F	Sig.
	Within Groups	72.896	33	2.209		
	Total	92.607	35			
Nitrate	Between Groups	8.880	2	4.440	.966	.391
	Within Groups	151.688	33	4.597		
	Total	160.568	35			
BOD	Between Groups	137.825	2	68.912	6.758	.003
	Within Group*s	336.496	33	10.197		
	Total	474.320	35			
pH Value	Between Groups	5.767	2	2.884	2.300	.116
	Within Groups	41.369	33	1.254		
	Total	47.136	35			
Temperature	Between Groups	2.347	2	1.174	6.217	.005
	Within Groups	6.229	33	.189		
	Total	8.576	35			
Alkalinity	Between Groups	634.722	2	317.361	1.541	.229
	Within Groups	6795.833	33	205.934		
	Total	7430.556	35			
Chemical Oxygen Demand	Between Groups	.067	2	.033	30.359	.000
	Within Groups	.036	33	.001		
	Total	.103	35			
Temperature	Between Groups	4.632	3	1.544	12.526	.000
	Within Groups	3.944	32	.123		
	Total	8.576	35			
Alkalinity	Between Groups	2280.556	3	760.185	4.723	.008
	Within Groups	5150.000	32	160.938		
	Total	7430.556	35			
Chemical Oxygen Demand	Between Groups	.004	3	.001	.375	.771
	Within Groups	.101	32	.003		
	Total	.105	35			
BOD	Between Groups	4826.675	3	1608.892	1.000	.406
	Within Groups	51505.174	32	1609.537		
	Total	56331.849	35			

Source: Author's Statistical Analysis, 2025.

The Sulphate concentration in the water samples collected during the rainy season in not significant at 0.05 significant levels as shown in Table 3. ANOVA. The same is for temperature which is not significant at 0.05 level of significant. The mean value of temperature recorded for the water samples collected during the rainy season is 27.0 for groundwater, 27.35 for Table water and 27.26 for rain water. According to Obeta and Ocheje (2013), Temperature is an important biologically significant factor which plays an essential role in the metabolic activities of organisms. It is also an important parameter in determining water quality as it influences pH, Alkalinity and Dissolved Oxygen. In line with the WHO Standard for Drinking Water Quality **[25]**, temperature is ambient; therefore the temperature values recorded were within the WHO standard for drinking water. From the above result of the ANOVA analysis for physico-chemical properties of the water samples collected from four sources during rainy season revealed that Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) were not significant amongst the other properties that were tested. COD is an important parameter for water quality assessment. According to WHO **[25]** and NSDWQ **[26]**, COD standard for drinking water is 50mg/L and 25mg/L respectively. The COD values obtained from this study ranges between 0.04-0.08mg/L. The possible reason for this result may be due to the fact the ground water samples were free of oxidable organic and inorganic pollutants. The values obtained for BOD ranges between 4.0-21mg/L with a mean composite of 12.89mg/L. The values are lower than the WHO **[25]** and NSDWQ **[26]** recommended standard of 250 and 200mg/L respectively, hence they constitute little or no threat in the water **[27].** Obtained values which range from 0.16-3.40mg/L in a similar study of borehole water samples from the oil impacted community in North-West District of Akwa-Ibom State. The result of this analysis shows similarity to that of Obeta, Ocheje **[28]** in their analysis of water samples from Imabolo Stream water in Ankpa. The analysis of variance carried out showed that there was no significant difference ($p>0.05$, $d=0.40$) between the BOD and COD for the water samples tested. Alkalinity was also found insignificant at 0.05 significant levels since the calculated F-value is 0.008.

Sources of Drinking Water and Occurrences of Water Related Diseases

An analysis of the interaction between the sources of water in the study area and the occurrence of different water related diseases was done using a cross-tabulation as shown on table 4.

Table 4: Sources of Drinking Water and Vulnerability of Water-Related Diseases

Sources of Water	Types of ailments						Total
	Cholera	Diarrhoea	Typhoid fever	Gastroenteritis	Dysentery	Vomiting	
Groundwater	11	20	150	10	40	70	401
River water	6	5	101	5	5	31	206
Rain water	6	5	101	5	5	31	200
Table water	3	5	81	2	3	10	123
Total	26	35	433	22	53	142	930

Source: Authors' Field Survey, 2025

Table 4 revealed that typhoid is the most prevalent water-related disease. The analysis of the respondents shows that typhoid accounts for 46.5% of all the water-related diseases considered in this study. Typhoid fever is also highly associated with groundwater sources. It accounts for 34.6% of the diseases due to water as indicated by the respondents in the health centres sampled in the study area. Groundwater especially borehole is expected to be a source of clean and potable drinking water **[29]**. The result obtained is suggestive of possible contamination of groundwater source which could be due to poor hygiene and sanitation (poor waste management) **[30]**. However, Obeta and Ocheje**[24]**, in their study of the assessment of groundwater quality in Ankpa Urban of Kogi State revealed that groundwater is a good source of drinking water as most of the parameters tested in their study returned values that fell within the acceptable limits set by both NSDWQ **[23]** and WHO **[31]**. On the contrary, they noted that the water obtained from the boreholes if used for drinking purpose could result to some health challenges such as renal arterial changes in kidneys **[24, 32]**, blue baby syndrome (also known as infant methenoglobinemia) in babies and goitre in adults **[33, 34, 35]**.

The general pattern of water-related diseases in the study area is Typhoid > Vomiting > Dysentery > Diarrhoea > Skin disease > Cholera > Gastroenteritis. Table 4 also revealed that groundwater is the highest source of water-borne diseases in the study area; this is closely followed by the river water, rain water and table water is the least. This is because, table water in most cases are treated hence the low association it has with water-borne diseases **[36]**.

Haseena **[37]** noted that untreated drinking water and faecal contamination of water is a major cause of diarrhoea. *Campylobactern jejuni* spread diarrhoea 4% to 15% worldwide. Fever, abdominal pain, nausea, headache are symptoms of diarrhoea. The disease cholera is caused by contaminated water, while the causative organism is *Vibrio cholerae*. The symptoms of this disease are watery diarrhoea, nausea, vomiting and watery diarrhoea leads to dehydration and renal failure.

The World Health Organisation estimates that 80% of diseases worldwide are water-borne. Alarmingly, groundwater in one-third of India's 600 districts is deemed unfit for drinking- with dangerous levels of fluoride, iron, salinity and arsenic. About 65 million people suffer from *fluorosis*, a crippling disease caused by excess fluoride – a condition commonly found in the Rajasthan state region, in Northern India. Poor water quality becomes inevitable when water gets contaminated with industrial waste, human waste, animal waste, garbage, untreated sewage, chemical effluents, etc. Drinking polluted water leads to water borne diseases and infections such as *amoebiasis, giardiasis* and *toxoplasmosis*.

Table 5 shows the correlation analysis of water sources and the prevalence of water-related diseases. The results indicated a strong association (r = 0.86) which means that occurrence or prevalence of water-related diseases is related to sources of water.

Table 5: Correlation Analysis for Drinking Water Quality and the Possible Water-Related Ailments in Idah

		Sources of Water	Types of ailments
Sources of Water	Pearson Correlation	1	.86**
	Sig. (2-tailed)		.009
	Sum of Squares and Cross-products	836.065	140.419

		Sources of Water	Types of ailments
	Covariance	.900	.151
	N	930	930
Types of ailments	Pearson Correlation	.86**	1
	Sig. (2-tailed)	.009	
	Sum of Squares and Cross-products	140.419	3215.592
	Covariance	.151	3.461
	N	930	930
**. Correlation is significant at the 0.01 level (2-tailed).			

The coefficient of determinant ($r^2 = 0.74$) indicated 74% dependence of water-related disease on water sources. The study on water and water-borne diseases by Nwabor, Nnamonu, Martins and Ani, **[38]** corroborated this where it noted that the unavailability of pipe-borne water and the dependence of rural dwellers on surface waters which are often contaminated with faecal materials are undoubtedly the major causes of the rising prevalence of water-borne diseases. Since the correlation coefficient for the types of ailments is 0. 86 which is equivalent to 1.0, and the correlation for a two-tailed analysis is significant at 0.01, it therefore implies that there is a positive correlation between the sources of drinking water in Idah, and the possible water-related ailments in the areas.

Findings

1. Borehole is the major source of drinking water in the study area. A greater number of the people living in the study area get their drinking water from boreholes.
2. The source of the drinking water in the study area has significant effect on the quality of the water as shown from the result of the ANOVA carried out on Table 3 where the F-values of the various properties of the water samples were displayed. The acceptable threshold of the composite mean of the water properties explains why the physico-chemical properties of the drinking water do not constitute danger to the water. Hence the water is relatively safe for drinking.
3. Typhoid, cholera, diarrhoea, dysentery, gastroenteritis and vomiting are the possible health problems that could result from the drinking water in the study area. The study revealed that the drinking contributed to the occurrence of the ailments mentioned though no much death cases have been recorded.

The findings also revealed more occurrence of typhoid fever than other ailments and a weak relationship among the different water-related diseases. The study however reveals that the human activities and poor environmental management are the major causes of water pollution and the water quality varies with season. Dependence on other sources aside from rain is more during the dry season. Another factor which may not be affected by the human activities within the water sources is the geological composition of the area which is constant.

Plate 1: Inachalo River in Idah with activities leading to pollution of the water source.

Unsanitary and unhygienic environment and human activities lead to water pollution which cause most of the water-related diseases discussed earlier. Plates 1 and 2 below shows some of the unsanitary and unhygienic environmental conditions and human activities that could lead to human pollution.

Conclusion

Sources of drinking water are subject to contamination and require appropriate treatment to remove disease-causing contaminants. Contamination of water supplies can occur in the water

source as well as in the distribution system after water treatment has already occurred. There are many sources of water contamination, including naturally occurring chemicals and minerals, local and land use practices, manufacturing processes, and sewer overflows or wastewater releases. The presence of contaminants in water can lead to adverse health effects in both young and old **[6]**.Contaminated water and poor sanitation are linked to transmission of diseases such as typhoid fever, cholera, diarrhoea, dysentery, hepatitis A, skin disease, gastroenteritis, and vomiting. WHO **[7]** noted that absent, inadequate, or inappropriately managed water and sanitation services expose individuals to preventable health risks.
It however concludes that the drinking water from the various sources in Idah is relatively safe and has not caused any major dearth or epidemics.

Recommendations

The study however, established the fact that the quality of drinking water in the study area is affected by the presence of certain physical, chemical and biological properties found in the water. On this note therefore the following recommendations are made as to how to ensure that the people consume water that is not harmful to their health.

1. Though borehole is covered and more hygienic and most convenient to explore unlike the well water that is exposed to certain human influences, it however has its long term environmental implications. The government should reinstate the public water reservoir system where pipe-borne water is run through to various houses in a neighbourhood.
2. Every drinking water should undergo scrutiny (test) the source notwithstanding at a prescribed interval (three months) and periodic monitoring (six months) (by packaged water manufacturers, borehole owners and the individuals) for quality assurance is very essential. This is because the water source can be polluted at any time through the introduction of some certain elements into the water source especially river. This regular testing of water will help to ascertain the quality of the water at any point in time.
3. During rainy season, the rain water should be stored in clean tanks and should be washed regularly to avoid contamination.

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