ANALYSIS OF THE DRINKING WATER QUALITY AND ITS HEALTH IMPLICATION ON THE PEOPLE OF IDAH, KOGI STATE.

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Abstract
Water is very essential for man's existence; it is the key to life hence ensuring a good water quality is a crucial issue. This study analyses the physicochemical components of drinking water in Idah and the attendant water-related diseases from its quality. The Principal Component Analysis and the Spearman's Correlation were employed to determine the most vulnerable component in the type of drinking water consumed by the people and the correlation between sources of drinking water and the incidences of water-related diseases in Idah. The Ecological, Socio-demographic and Clinical data were required for this study. Water samples were collected from rivers, boreholes, wells, packaged water (table water) produced from the study area and used for analysis. These samples were collected twice for each of the seasons (rainy and dry). The result of the analysis showed a high correlation (r=0.91), (r=0.76) and (r=0.58) between the water-related diseases variables. Hence, there is a positive correlation between sources of drinking water in Idah and the incidences of water-related diseases. The component loading from the analysis revealed that dysentery and gastroenteritis are the two major diseases resulting from drinking water with a component loading of approximately one. The study recommends that adequate treatment should be given to the water before use by the people.

Keywords: *Water Quality; Physicochemical Components; Water-related Diseases; Drinking Water*

Introduction

The importance of water to man is inexhaustible. An average man (of 53Kg-63Kg body weight), requires about three litres of water in liquid and food daily to keep healthy (Onweluzo and Akuagbazie, 2010, Fabrizi, 2016). This fact apparently accounts for why water is regarded as one of the most indispensable substances in life and like air; it is most abundant (Okonkwo, Ogunjobi, Adejoye, Ogunnisi and Olasogba, 2008). Urbanization has thus exerted an enormous pressure on the provision of safe drinking water especially in developing countries, hence most fresh water bodies world over are getting contaminated and thus decreasing the pot-ability of water (Chandra, Singh and Tomar, 2012; Etim, Odoh, Itodo, Umoh and Lawal, 2013). As stated by Kofi Annan in (Alhassan and Ujoh, 2012), fresh water is precious, we cannot live without it. It is irreplaceable; and human activities have profound impact on the quantity and quality of fresh water available. Of the many uses of water, the supply of safe drinking water is considered as having a significant impact on the prevention of transmissible water-borne diseases (Larson and Gnedenko, 1999). For instance, abundance of organic compounds, toxic chemicals, radio nuclides, nitrites and nitrates in potable water may cause adverse effects on human health, such as cancer, chronic illness and human body malfunctioning (Federal Government of Nigeria FGN, 2016).

The availability of a clean and safe water supply is essential for public health. Studies carried out in different parts of Nigeria (Yerima, Duara and Gambo, 2008; Waziri and Ogugbuaja, 2010; Akan, Abdulrahman and Yusuf, 2010) and other parts of Africa (Demeke, 2009; Meseret, 2012) have shown that various sources of drinking water have been contaminated at various scales. Lack of safe drinking water is considered a leading cause of many communicable diseases. Studies have estimated that the provision of clean water and basic sanitation alone would curtail the incidence of diarrhoea by 50 percent, sleeping sickness by 80 percent and guinea worm infestation by 100 percent (Anwar, 1993; Marks, 2018). Consequently, access to safe water is recognised to be the foundation for sound health (Kuma and Younger, 2000; Rakesh, 2006). The amount of water a person needs per day depends on many factors- climate, standard of living, hygiene awareness, and workload. Availability and distribution methods are also influencing factors.

According to WHO (2005), water of poor quality is a significant global issue, and it is responsible for most diseases and deaths hence water of good quality is of paramount importance to human physiology and man’s continued existence depends much on its availability. Therefore, ensuring good water quality is a basic factor in guaranteeing public health, the protection of the environment and sustainable development (Raniji, Roland, John and Vincent, 2010). Going by Galadima, Garba, Leke, Almustapha and Adam (2011), water related diseases such as cholera, diarrhoea, and bilharzias have been reported to be on the increase among poor local people who lack potable water and have resorted to using raw contaminated surface and underground water for drinking and domestic purposes in most parts of northern Nigeria. Unfortunately, about two million people globally live in areas where there is chronic shortage of water (AWS Accounts, 2016). Hence, the World Health Organisation had stressed that the single major factor adversely influencing the general health and life expectancy of a population in many parts of the world, particularly developing countries, is the lack of ready access to safe drinking water (Hoko, 2005; Obeta, Ocheja and Nwokocha, 2015). This paper however, analyses the physicochemical properties of water in Idah with a view to detecting their effects on water quality.

Statement of the Problem

The World Health Organisation (2000) had frequently and constantly noted that the single major factor adversely influencing the general health and life expectancy of a population in many developing countries is ready access to clean drinking water. Dada and Ntukekpo (1997) also pointed out that in the developing nations of the world, which the quality of drinking water contributes a lot to most diseases. Obviously, the usefulness of water depends not only on whether such water is timely and of adequate quantity, but also on its -quality. It has been estimated that about 1.2 billion people all over the world lack access to potable water (Oyeku, Omowumi, Kupoluyi and Toye, 2001; Ajewole, 2005). In Nigeria, potable water is often accessed from both surface and underground sources. High rates of water-related diseases have been reported in many parts especially among women and children (Chima and Okpe, 2007). The health burden of the consumption of poor water quality is enormous. In Idah for example, and a host of other towns in eastern Kogi, stream and borehole seem to be the major sources of water supply. In the case of the stream, the human activities that go on within the drainage basins are major sources of concerns to the water source. Such activities include; bathing, washing (clothes, vehicles and motorcycles), dumping of waste including human and animal waste, dipping of dirty materials and containers into the stream to fetch water.

More so are the pouring of sacrifices and ritual materials into the water sources (streams and rivers). All tend to pollute the water and introduce bacteria into the water thereby causing water borne diseases.

Hypothesis:

1. There is no possible relationship between water quality and the incidences of water-related diseases

Conceptual Framework

The "Water Quality Index" may be defined as a scheme that transforms (weighted) values of individual water pollution related parameters (e.g. BOD or suspended solids) into a single number or a set of numbers. Ideally, a water quality index is a numerical rating which reflects the composite influence of a number of individual quality characteristics on the overall water quality situation (George and Everett, 1977). A number of water quality indices are obtained by aggregating and summarizing available water quality data. For example, a water quality index proposed by Brown, Walsh, and Whecler (1974) takes the form:

WQIM (Multiplicate Water Quality Index).

$= \Pi^{9}_{i=1} T_i(P_i)^{W_i}$

$= \Pi^{9}_{i=1} Q_i^{W_i}$

Where:

P_i = Measured value of the i^{th} parameter,

T_i = The quality rating transformation (curve) of the i^{th} parameter value P_i, into a quality rating Q_i, such that $T_i(P_i) = Q_i$,

W_i = Relative weights of the i^{th} parameter such that ($0 \leq W_i \leq 1$ and $\Pi^{9}_{i=1} W_i = 1$)

The nine parameters (P_i in Equation 1) chosen for inclusion in the WQIM index are dissolved oxygen, fecal coliform density, pH, biochemical oxygen demand, nitrate, phosphate, temperature, turbidity and total solids. These nine parameters, the quality rating transformation T_i and the relative weight W_i in Equation 1 were established from opinion research which obtained information from a group of water quality experts.

The above example is a representative approach to the development of a water quality index. Essentially, the approach consists of four steps:

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a) Selection of parameters which are felt to be most important in revealing the quality status of a water body.
b) Scaling of the range of values for each selected parameter on a unit less scale (e.g. 0-100 for BOD_5 values 0-30mg/L).
c) Assigning weights for the selected parameters, with the weights assigned reflecting the relative significance of the selected parameters.
d) Combining the scaled values and the associated weights to give a numerical index value (e.g. multiplicative combination in Equation 1).

Although, there is no globally accepted composite index of water quality, some countries and regions have used, or are using, aggregated water quality data in the development of water quality indices. Most water quality indices rely on normalizing, or standardizing data, parameter by parameter according to expected concentrations and some interpretation of 'good versus 'bad' concentrations. Parameters are often weighted according to the perceived importance to overall water quality and the index is calculated as the weighted average of all observations of interest (Pesce and Wunderlin, 2000; Liou *et al.*, 2004; Tsegaye, Sheppard, Islam, Johnson, Tadesse, Atalay and Marzen (2006). Water Quality Index can be calculated as thus: $100 - \frac{\sqrt{F_1^2 + F_2 + F_3}}{1.732}$

Where F_1 = percentage of failed variables (scope).
F_2 = percentage of failed tests (frequency).
F_3 = amount by which failed tests exceed guidelines (magnitude).

Methodology

Data Requirement

The data required for this study are of three categories – Ecological, Socio-demographic and Clinical data. The Ecological data involved data on water samples from river, rain, packaged water and groundwater from surface well and borehole. The clinical data were on clinical records of patients, water related diseases occurrence in the areas, treatment measures and water treatment measures for the drinking water in the areas.

Methods of Water Sample Collection

Water samples were collected from rivers, boreholes, wells, packaged water (table water) produced from the study area and used for analysis. The water samples were collected in two seasons- the rainy and dry season. The rainy season samples were collected twice before the end of the rainy season (between May and October), while the dry season samples were collected twice before the rainy season sets in (between December and March). Samples for physicochemical analysis were collected in clean 100ml sterile bottles with corks and filled to the brim. The river water was collected using the grab sampling. The point sampling was employed in collecting the rain water from a specific collection point.

Method of Data Analysis

The Principal Component Analysis was employed to predict whether the health problems recorded in the study areas is caused by the water they consume. The Principal Component Analysis was also adopted to identify the most prominent health problems that result from the sampled water in the study area and to measure the orthogonal linear combinations of the various sources in order to explain the vulnerability on the health of the people. Again the Spearman's Correlation was carried out to determine the correlation between sources of drinking water and the incidences of water-related diseases in Idah.

PHYSICOCHEMICAL PROPERTIES OF THE DRINKING WATER IN KOGI-EAST

Table 1 shows the mean distribution of water parameters for both wet and dry seasons and their water standard permissible limit.

Table 1: MEAN VALUES OF ELEMENTAL COMPOSITION OF SAMPLED WATER IN IDAH

Water Property	Idah					
	Mean (Rainy)	Mean (Dry)	Composite Mean	WHO Mg/L	EPA Mg/L	NSDWQ Mg/L
Total Hardness	23.17	13.75	18.46			
Sulphate	0.22	0.52	0.37	150	120-180	150
Dissolved Oxygen	4.33	4.45	4.39	100	250	100
Chloride	12.25	24.5	18.375	250	-	200

Phosphate	4.63	18.59	11.61	250	250	250
Nitrate	0.83	9.48	5.155	250	-	
PH	5.93	5.96	5.945	50	10	50
Temperature	26.88	28.31	27.595	6.5-8.5	6.5-8.5	6.5-8.5
Alkalinity	20.83	18.75	19.79	Ambient	-	-
COD	0.15	0.01	0.08	150	-	-
BOD	5.2	36.03	20.615	50	25	
Manganese	1.27	3.47	2.37	250	200	
Calcium	0.95	46.13	23.54	0.2	0.05	
Lead	0.37	0	0.185	50	60-120	75
				0.01	1.5	0.01

Source: Researcher's Field's Survey, 2021

Access to safe drinking water and hygiene is of paramount importance to human health and survival. This is yet to be achieved in Nigeria and in Idah in particular. Table1 shows the statistical summary of the composite mean value of the chemical parameters of the water samples analysed in the study area and their permissible limit according to WHO (2011), EPA (2008) and NSDWQ (2007). The presence of Total Hardness (18.46) is because of the solvent action on the rain water coming in contact with soil and rock which is capable of dissolving Calcium and Magnesium and other ions that promote hardness. The existence of Total Hardness may be traceable to the local environment of the water points in terms of geology, soil and land use activities.

According to WHO (2011), no health-based guideline value is proposed for hardness, as it is not considered to be of major health concern at levels found in drinking water, though it may affect its aesthetic acceptability (Okoro,Omeje and Osadebe, 2017). The occurrence of Calcium can be beneficial for the growth of children whereas high intake of Magnesium causes a change in bowel habits (diarrhoea) (Sengupta, 2013; Okoro *et al.*, 2017).

The composite mean for Sulphate of 0.3 is in line with the permissible limit of 100mg/l by WHO, EPA and NSDWQ. Water containing high concentration of Sulphate is known to cause dehydration and gastro-intestinal irritation as noted by Jidauna *et al.*, (2014). This Sulphate value in Idah corresponds with a similar study carried out in the Eastern part of Nigeria. For instance, in Nsukka Urban, Enugu State the Sulphate value ranged from 12.4 - 17.92mg/l which was also lower than the standard permissible limit. This is because Nsukka lies within the same geographical area with Idah (study area), implying that Sulphate in that environment is generally within tolerable limit.

COD value of 0.08 suggests a rather low organic content in the soil because organic matter is the major source of carbonaceous and nitrogenous substances in the soil and water bodies which arises from the use of fertilizers, animal and human waste and decaying plant matter all of which get to the aquifer through leaching as in the case of the study of groundwater quality on some selected areas of Delta State by Oyem, Oyem and Ezeweali, (2014).

The temperature range of the water samples collected was 27.1. UNICEF, 2008; and Oyem *et al.*, 2014, suggested that the water temperature is generally ambient and good for consumers and enhances the water quality; since high temperature negatively impact quality by enhancing the growth of micro-organisms which may increase taste, colour, odour and corrosion problems, it is important that the water temperature be not too high to avoid microbial proliferation (Oyem *et al*., 2014).

Interrelationship of water-related diseases and water quality

The degree of vulnerability of the people of Idah to the possible health problems (typhoid fever, cholera, diarrhoea, gastroenteritis, dysentery, vomiting) has been analysed, however the relationship between sources of water and incidences of water-related diseases in order to determine the effects of sources of water on incidences of water-related diseases need to be further analysed. This was done using Correlation and Principal Component Analyses. The result of the Pearson correlation of sources of water is shown on Table 2.

The Principal Component Analysis was employed to determine the most vulnerable component in the type of drinking water consumed by the people of Idah.

Table 2: Correlation Matrix of Water-related Ailment Parameters

	1	**2**	**3**	**4**	**5**	**6**
1	1.00					
2	0.02	1.00				

3	0.53	0.04	1.00			
4	0.28	0.08	0.53	1.00		
5	0.31	0.08	0.58	0.91	1.00	
-6	0.07	0.05	0.13	0.02	0.22	1.00

Where 1 = Typhoid
2 = Cholera
3 = Diarrhoea
4 = Dysentery
5 = Gastroenteritis
6 = Vomiting

Epidermology of diseases shows that tropical diseases are highly interrelated and such relationship could be complex (Nwabor, Nnamonu, Martins and Ani, 2016).the result shows that all inter-correlations are positive which may indicate that the severity of one illness may increase with another. Specifically a high and positive correlation was obtained between 1 and 6 (r = 0.91), 5 and 4 (r = 0.76), 5 and 3 (r = 0.53) and 6 and 3 (r = 0.58).
The relationship also shows low or weak relationships, thus the pattern of interrelationship between the different water-related diseases are not quite directional. This suggests that they may be related to each other in several and complex ways as in Table 2. To enhance the understanding of the structure and underlying pattern, Principal Component Analysis was employed both as a method of achieving data parsimony and to handle possible multi-co linearity problem.

Table 3: Component Matrix of Water-Related Diseases

	Component	
	1	2
Degree of Vulnerability (Dysentery)	.919	
Degree of Vulnerability (Gastroenteritis)	.918	-.113
Degree of Vulnerability (Diarrhoea)	.745	-.309
Degree of Vulnerability (Typhoid)	.508	-.351
Degree of Vulnerability (Vomiting)		.893
Degree of Vulnerability (Cholera)	.130	.215

Two components were extracted (Table 3), the component matrix showed how each of the two component fared with respect to each of the seven water-related diseases considered. The table revealed that dysentery and gastroenteritis are two major diseases resulting from drinking water with a component loading of approximately one.

Table 4: Total Variation of Disease Components

	Total	% of Variance	Cumulative %
1 (Typhoid fever)	3.167	45.237	45.237
2 (Cholera)	1.346	19.232	64.468
3 (Diarrhoea)	.924	13.198	91.612
4 (Dysentery)	.399	5.707	97.318
5 (Gastroenteritis)	.130	1.857	99.176
6 (Vomiting)	.058	.824	100.000

Table 4 shows the Eigen values associated with the water-related diseases in Idah. The table revealed that out of the six ailments, only two had Eigen value of one (1) and above. As seen from the table, the sizes (values) of the Eigen value represent the size of the components which accounted for 64.5% of the variation in the water-related diseases and therefore explained most of the variation in water diseases in Idah.

From Table 3, the matrix of the un-rotated component loadings shows that component 1 loads high dysentery – gastroenteritis – gradient. This component alone accounts for about 45% of the total variance into the data set.

The PCA carried out has shown that water-related diseases can be measured with a limited number of dimensions (diseases) which are adequate to account for majority of variations in water-borne diseases in Idah. Thus, we can say that water-related disease in Idah can be described along these two axes. These two components are the major underlying water-related disease in Idah.

Discussion of Findings

The correlation analysis carried out proved that there is a positive correlation between sources of drinking water in Idah and the incidences of water-related diseases. The water-related ailment variables revealed that the people in Idah had at various times suffered from the under listed water-related ailments in relation to their drinking water quality – typhoid, cholera, diarrhoea, skin disease, dysentery, gastroenteritis and vomiting. According to a study by Solidarities International (2020), various diseases result from poor water quality. Four large groups are linked to availability and quality of water, as well as the efficient management of water resources; such water-related diseases are associated with acute or chronic lack of clean water and or contamination by toxic agents and vector-borne diseases. Cholera being one of the water related diseases identified in Idah is caused by the consumption of food or water that has been contaminated by faeces of infected individuals.

The cases of dysentery and gastroenteritis as reported in the component matrix of principal component analysis carried out showed that they are the two major diseases resulting from drinking water with a component loading of approximately one. Typhoid fever is also a prevalent water-related disease in the study area as it records 46.5% of all the water-related diseases considered in this study. This could be traceable to poor hygiene and sanitation as reported by WHO, (2014).

The study also revealed that water sources from Idah are pointers to the incidences of water-related diseases. Based on the findings, there are more occurrence of dysentery and gastroenteritis in Idah than other water-related ailments. It was also deduced that there is a weak relationship among the different water-related diseases. Hence there is no directional relationship amongst them.

Recommendations

1 In the eventuality of any epidemic outbreak, proper test should be conducted to detect whether it has to do with the drinking water consumed by the people or not. If positive to water, adequate treatment should be given to the water before the people can continue to drink such. The cause should be detected and preventive measures should be strictly adhered to so as to curb the menace.

2 During rainy season, the rain water should be stored in clean tanks and should be washed regularly to avoid contamination. The water can also be collected or stored in wells (dug safety tanks) that are properly covered to avoid contamination. The bucket or any other material for fetching the water should be neatly kept and the users should ensure that it is clean before dipping it inside the well. The first set of rain water should

not be consumed because they are always filled with particles and dirty due to dust that has been accumulated during the dry season.

3 All the water from the various sources should possess the physical attributes of a drinking water which include – colourless, odourless, and tasteless, free of particles, and have a room temperature.

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 (CDC, 2019).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 (2019) noted that absent, inadequate, or inappropriately managed water and sanitation services expose individuals to preventable health risks.

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