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Assessment of Heavy Metals and the Prevalence of Waterborne Diseases in Rural Communities Located along River Ase in Southern Nigeria

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Abstract
The study examines the impact of heavy metals on the quality of water from River Ase and the prevalence of water borne diseases in rural communities located along the course of the river. It is an empirical research study of 6 communities located along the course of the river. Water samples were collected from the river and laboratory analysis carried out in line with WHO (2010) and NIS (2007) permissible standard for drinking water quality. From the analysis of the water samples, it was discovered that parameters such as calcium, sodium, potassium, lead and zinc were within the WHO (2010) and NIS (2007) threshold for drinking water quality. While magnesium and iron were above the recommended threshold for drinking water quality by the WHO (2010) and NIS (2007). The study also discovered that the prevalence of water borne diseases is influenced by the surface water quality at $R^2 = 0.510$ ($P > 0.05$). The paper recommends the boiling of the water to eliminate the excess iron and magnesium found in it.
Keywords: assessment, heavy metals, prevalence, water borne diseases, rural, communities, R. Ase.

Introduction

lean drinking water is essential to human and other life forms. Access to safe drinking water has been a problem over the last decades in almost every part of the world (Gallant, 2002; Nigel, 2001). However, some observers have estimated that by 2025, more than half of the world population will be facing water-based vulnerability (Public Health News, 2004). A recent report suggests that by 2030, in some developing countries of the world, water demand will exceed supply by 50 percent (Department for International Development (DFID), 2006). Water plays an important role in the world economy, as it functions as a solvent for a wide variety of chemical substances and facilitates industrial cooling and transportation.

However, surface water can become contaminated with many different substances that can harm human health and change the colour or odour of the water. Heavy metals from industrial processes can accumulate in nearby rivers. This causes slow development, result in birth defects and causes cancer when consumed by man (Egborge, 1971, Dublin-Green, 1990 and Dibia, 2006). Also microbial pollutants often result in infectious diseases that affect humans through the drinking of surface water. This is a major problem in developing countries, with diseases such as cholera and typhoid fever being the primary cause of infant mortality, which are as a result of the consumption of contaminated water. Also, suspended particles in freshwater reduce the quality of surface water. Thus, the nature of surface water has continued to generate debates among researchers especially hydrologists and environmentalists as to how they can manage and develop this resource for the benefit of mankind.

Surface Water and Evaluation of Surface Water Resources

A good number of rural communities in Nigeria are served by one form of surface water or the other. This surface water (river/stream) tends to serve as their major source of water supply. In the eastern part of Nigeria, one or more communities may claim ownership of a stream as their source of water supply for drinking and other domestic purposes. For example, communities in Ihitte Afoukwu and Ahiazu Mbaise Local Government Areas of Imo State, Nigeria are served by Nwangborogwu, Iyimbara and Nwangba streams (Iro and Chukwudi, 2009). The volume and quality of water obtained from the stream fluctuates with the season. It tends to swell up during the rainy season and recedes with the dry season. The water becomes so muddy that its use as a means of human consumption is questionable; yet it is the water which the rural and some urban communities depend on (Iro and Chukwudi, 2009). In the south-south geopolitical zone of Nigeria, most of the rural dwellers depend on water from rivers and streams, while at the same time serves as the final dumping sites for excreta and other human wastewater activities (Oluwande, 1985).

There is therefore the need to manage and develop this resource for the benefit of mankind. It is necessary to carry out an inventory of available water resources-sources, existing uses and characteristics of water, especially quantity, quality and its spatial and temporal distribution patterns (Mook, 2000). The hydrological appraisal of water resources is a fundamental requirement for the planning, design, construction and operation of water resource projects. Such an appraisal involves the collection and analysis of hydrologic data and information as well as data on socio-economic conditions that impinge on water utilization (Ayoade, 1988). Accordingly, the objective of such an appraisal is to determine the source, extent, adequacy and dependability of supply and other characteristics of water, which will form the basis of policy regarding control and utilization of water (Rozanski, Froehlich and Mook, 2000).

Statement of the Problem

Water resources the world over are components of environmental resources that are under threat from over exploitation or pollution exacerbated by human activities on the earth's surface. The major sources of pollution in streams and rivers are the effluents from industries and untreated wastes. According to Remesh (1996), suspended particulate materials of the Krishna River Basin in India were found to be high in heavy metals such as manganese, iron, copper, zinc and lead. Walia and Mehra (1988) ascertained that fish ash effluents from ash ponds significantly increased the concentration of aluminum, cadmium, potassium, zinc and copper in the river water. Increases in cadmium have been reported also in the Newark Bay in New York (Adams, Oconor and Weibery, 1998). Saad, Rayis and El-Nady (1981) revealed the high concentration of copper, manganese, cadmium and zinc along the Mediterranean sea near Alexandria. Chemical variables related to the retention of heavy metals in river were also analyzed by Horsefall and Spiff (1999) in the Okrika River in River State, Nigeria.

These heavy metals have caused impairment to the rivers and quality of the water. Consequently, 2.2million people die each year from diseases related to drinking contaminated water (DFID, 2006). Diarrhea alone claims the lives of nearly 6000 children a day (DFID, 2006). Surface water has become scare in Nigeria despite its abundance. It is on this premise that this study assessed the quality of water from River Ase and incidences of water borne diseases in communities situated along its course in Southern Nigeria. Safe water is thus indispensable to the socio-economic development of a people. The surge in harnessing surface water for sustainable community domestic water in many parts of the world especially in Nigeria, underscores the need for this study.

Aim, Objectives and Hypothesis

The aim of this study is to assess the level of heavy metals and the prevalence of water borne diseases in rural communities located along River Ase in Southern Nigeria

The specific objectives are to:

i. assess the level of heavy metals in line with WHO(2010) threshold for drinking water quality
ii. investigate the relationship (if any) between the quality of water from the river and the prevalence of water borne diseases in the area.
iii. suggest ways on how to check the variation in water quality (if any) and hence achieve sustainable water quality supply for the communities located along the course of the river.`

Ho. The prevalence of water borne diseases (typhoid, cholera, dysentery, diarrhea) is not significantly dependent on the quality of water from the river.

Study Area

The area of study is River Ase in southern Nigeria. River Ase is located at approximately on latitudes 5^0 $17^\prime$ and 5^0 $53^\prime$ North of the Equator and longitudes 6^0 $17^\prime$ and 6^0 $31^\prime$ East of the Greenwich Meridian (Federal Surveys, Nigeria, Sheet 78 (Kwale), 1970). River Ase is a tributary of the Forcados River, the western branch of the River Niger (Figure 1). The river is approximately 292 kilometres in length and flows through such settlements as Asaba-Asa, Ase, Ibredeni, Ivorogbo, Awah, Ibrede, Igbuku, Ashaka, Kwale, Osemele, Iselegu among others (see figure 1).

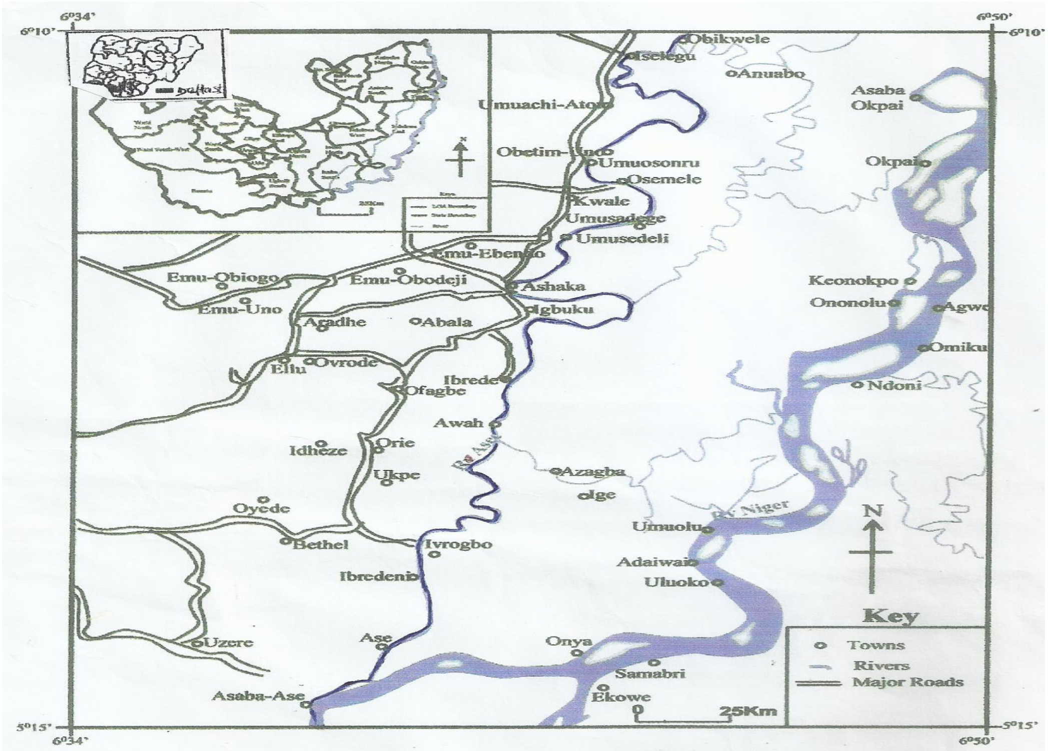

Fig. 1: River Ase (Study Area)
Source : Modified from sheet 78 (Kwale) Federal Surveys, Nigeria (1970)

Research Methods

Sampling Design

The study is an empirical research that involved field survey, collection of water samples and laboratory analysis of the water samples collected.

Method of Data Collection

The method of data collection was through direct field collection of water samples along the course of the river at varied measured distances using the topographical map of the area as guide (see figure 1) . The water samples were collected from the upper, middle and lower courses of the river. The water samples were collected early in the morning between 7am – 10am to reduce the effect of temperature on the collected samples. The water samples were collected from six points/settlements, at least one sample every month from the surface and sub-surface of the river for 12 months (from January, 2011 to December, 2011). The sampled points/settlements are Obikwele, Osemele (Upper course); Kwale, Igbuku (middle course) and Ivorogbo and Asaba-Ase (lower course). The water samples were collected using sterilized 2-litre plastic cans fitted with information tags for identification. Plastic cans were securely corked and stored in ice packed container before transporting them to the laboratory. This was done within six hours of collection. Epidemiological data on water borne diseases were collected from hospitals/health centres, local government headquarters for a period of one year (January – December, 2011).

Laboratory Procedure

The water quality parameters (heavy metals), materials and methods used in this study are those defined by the World Health Organization (2010), United States Environmental Protection Agency (USEPA, 2008), Nigerian Industrial Standard (NIS, 2007) and the American Public Health Association (APHA, 1999).

Iron concentration in the water samples was detected spectrophotometrically by the 1.10 phenanthroline method (APHA, 1999); while magnesium, sodium, potassium, lead and zinc were determined with a Seiko ANA 180 Atomic Absorption Spectrophotometer (AAS), after appropriate treatment and digestion. Calcium concentration was determined titrametrically using the Argentometric titration method.

Statistical Analysis

The multiple regression analysis was used to test the posited hypothesis. Here the number of persons who suffered from cholera, typhoid, diarrhea and dysentery attack in the last one year including the Water Quality Index (WQI) of each settlement were used for the analysis. It was calculated using SPSS package.

Results and Discussion

The mean concentration values of the heavy metals of River Ase are summarized in table 1.

Table 1: Mean values of analysed (heavy metals) parameters (January - December 2011) along River Ase

Field code	Na (PPM)	K (PPM)	Mg (PPM)	Ca (PPM)	Pb (PPM)	Zn (PPM)	Fe (PPM)
Jan	**7.50**	**4.85**	**4.35**	**3.72**	**<0.001**	**1.61**	**4.56**
Feb	**7.35**	**5.14**	**4.93**	**4.08**	**<0.001**	**1.87**	**4.05**
March	**7.14**	**5.48**	**5.01**	**4.02**	**<0.001**	**1.72**	**4.08**
April	**5.08**	**3.49**	**1.58**	**1.96**	**<0.001**	**0.67**	**4.74**
May	**5.08**	**3.51**	**1.57**	**1.97**	**<0.001**	**0.66**	**4.43**
June	**5.00**	**3.49**	**1.70**	**1.90**	**<0.001**	**0.76**	**4.33**
July	**5.05**	**3.39**	**1.80**	**1.88**	**<0.001**	**0.77**	**4.09**
Aug	**6.00**	**4.32**	**3.61**	**2.38**	**<0.001**	**0.67**	**3.65**
Sept	**7.88**	**4.95**	**4.75**	**4.59**	**<0.001**	**0.84**	**2.57**
Oct	**8.11**	**5.19**	**5.49**	**4.62**	**<0.001**	**0.95**	**2 .35**
Nov	**7.96**	**5.33**	**5.45**	**4.73**	**<0.001**	**0.92**	**2.27**
Dec.	**7.91**	**5.44**	**5.10**	**4.48**	**<0.001**	**0.92**	**2.09**
Range	**3.11**	**2.09**	**3.92**	**2.85**	**<0.001**	**1.21**	**2.65**
$\bar{X}$	**6.67**	**4.55**	**3.78**	**3.36**	**<0.001**	**1.03**	**3.60**
WHO 2010	**200**	**NA**	**0.20**	**75**	**0.01**	**3.00**	**0.30**
N15 2007	**200**	**-**	**0.20**	**-**	**0.01**	**3**	**0.30**
USEPA 2008	**-**	**-**	**-**	**-**	**0.051**	**5**	**0.30**

Source: Fieldwork, 2011.

As shown in table 1, iron content in the water samples ranged between 2.09ppm in December to 4.74ppm in April along River Ase. These high mean values are also in line with the findings of Aisien, Gbegbaji-Das and Aisien (2010) along River Ethiope in the Niger Delta where heavy metal concentration such as iron ranged from 0.04ppm – 5.12ppm. These values also corroborate the findings of Egborge (1994) along the Warri River.

Lead concentration in the water samples in all the sampled stations (settlements) was less than 0.001 (<0.001ppm). This implies that there was a complete absence of lead poisoning in the area as no trace of lead was found in the water samples. This can best be attributed to the low industrial and mining activities in the area. This value is less than the 0.01ppm recommended by the WHO (2010) and the NIS (2007). However, the above findings on River Ase contradict the results of Aisien Gbegbaje-Das and Aisien (2010) who carried out similar studies along River Ethiope in the Niger Delta of Nigeria and got values that ranged between 0.001ppm-2.12ppm from sampled stations in their analysis. There is generally low zinc concentration along the course of River Ase in the area. This can best be attributed to low industrial waste generation in the area. However, zinc concentration along River Ase varies from a mean value of 0.66ppm in May to 1.87ppm in February. These mean values are however lower than the 3.00ppm WHO (2010) and NIS (2007) permissible value for drinking water quality. These low values of zinc concentration in the analyzed water samples are in agreement with the findings of Aisien, Gbegbaje-Das, and Aisien (2010), Egborge (1994) in similar studies along the course of River Ethiope and Warri River respectively in Southern Nigeria.

Concentrations of magnesium in the water samples collected along River Ase and analyzed were generally high when compared to the NIS (2007) drinking water quality standard. These high mean values of magnesium corroborates the works of Aisien, Gbegbaje-Das and Aisien (2010) along the course of River Ethiope in the Niger Delta who obtained high mean values of 10.00pm in some sampled stations in the area. These high mean values were attributed to constant laundry and slaughtering activities in the abattoirs close by. Also, Ekakitie (2008) discovered high mean values of magnesium (1.6ppm and 1.2ppm) in his study of River Ethiope and River Ovwuvwe in Southern Nigeria. Abulude, Obidiran and Orungbemi (2007) achieved similar mean magnesium result in their analysis of water samples in Akure, Nigeria. Also, Okafor and Nwajei (2006) achieved similar mean magnesium (4.21ppm) results along the Ebe River in South-East Nigeria. Egborge and Onwudinjo (1988), equally discovered high magnesium values along the course of Warri River in their studies.

In the analyzed water samples along River Ase, calcium concentrations were generally low when compared to the WHO (2010) permissible standard of 75ppm for drinking water quality. A mean value of 1.88ppm was recorded in the month of July and ranges to 4.73ppm in the month of November along River Ase . These low values corroborate the works of Abulude, Obidiran and Orungbemi (2007) in Akure with calcium mean values of 17.40ppm in sampled water, Okafor and Nwajei (2006) along the Ebe and Ora Rivers in South – Eastern Nigeria with mean values of 5.11ppm and 1.86ppm respectively, Aisien, Gbegbaje-Das and Aisien (2010) along the River Ethiope with mean calcium values of 13.00ppm, and the findings of Ekakitie (2008) of mean calcium values of 8.8ppm and 11.9ppm along the Ethiope River and Ovwuvwe River respectively in Southern Nigeria. Also, the works of Olomukoro and Egborge (2004) recorded low calcium values along the Warri River.

Sodium values vary from 5.00ppm in June to 8.11ppm in October, with a mean value of 6.67ppm. These recorded values are within the WHO (2010) and the NIS (2007) threshold value for drinking water quality. While potassium concentrations in the water samples vary from 3.39ppm in July to 5.48ppm in March, with a mean value of 4.55ppm. These findings corroborate the results obtained by Egborge (1994) along the Warri River at Udu Bridge and Edjere axis of the river in Southern Nigeria.

Spatial Distribution of Water Borne Diseases in the Area

Treated cases of water borne diseases such as cholera, typhoid, dysentery and diarrhea were obtained from the health centres at Uzere, Ivorogbo, Kwale, Obetim-Uno and Iselegu from January, 2011 to December, 2011 and from local government headquarters at Obiaruku and Kwale.

In all, a total of 253 patients out of 1267 recorded patients that visited the health centres from January 2011 to December, 2011 were treated for water borne diseases. Out of this number, one person was treated for cholera at Kwale, typhoid recorded 10 persons at Asaba –Ase, 3 persons at Ivorogbo, and 12 persons at Kwale, while dysentery recorded 24 persons at Asaba-Ase, 9 persons at Kwale and 3 persons at Igbuku and diarrhea recorded 23 cases at Asaba-Ase, 15 cases at Ivorogbo, 49 cases at Kwale, 83 cases at Igbuku, 12 cases at Obikwele and 9 cases at Osemele (see table 2).

Table 2: Total Number of Patients treated for water borne disease (cholera, typhoid, dysentery and diarrhea) in the area in 2011

Settlements	Total Number of Patients who visited the centres	Cholera	Typhoid	Dysentery	Diarrhea
Asaba-Ase	181	-	10	24	23
Ivorogbo	367	-	3	-	15
Kwale	367	1	12	9	49
Igbuku	268	-	-	3	83
Obikwele	61	-	-	-	12
Osemele	28	-	-	-	9
Total	1267	1	25	36	121

Source : Health centres at Uzere, Ivorogbo, Kwale, Ibrede, Iselegu and local government headquarters (office of the National Programme on Immunization) at Obiaruku and Kwale, 2011;

Relationship between Water Quality and Water Borne Diseases in the Area.

A total of 57 patients of all reported cases of water borne diseases representing 22.53 percent were from Asaba-Ase, 18 cases representing 7.11 percent were from Ivorogbo and 71 cases representing 28.07 percent were from Kwale. Also at Igbuku, 86 cases representing 33.99percent were reported. At Obikwele, 12 cases representing 4.74 percent were reported, while at Osemele 9 cases representing 3.56 percent were reported.

However, reported cases of water-borne diseases vary from areas of high concentration of heavy metals to areas of low concentration of heavy metals. In otherwords, areas of high concentration above the permissible standard of WHO (2010) and NIS (2007) tend to record more cases of water-borne diseases (with respect to the number of patients that visited the centre). This is in line with the calculated water quality index (WQI) of the sampled settlements recorded in the area. Thus, at Osemele and Obikwele, with WQI values of 54.92 and 58.05 have lower cases of water –borne diseases of 9 and 12 patients respectively. While settlements such as Igbuku and Kwale with reported cases of 86 patients and 71 patients have WQI values of 45.30 and 42.80 respectively. At Ivorogbo and Asaba-Ase, 18 patients and 57 patients with WQI values of 44.15 and 45.43 were recorded respectively (see table 3).

Tables 3: Cases of water-borne diseases and WQI of sampled settlements

Settlements	Cholera	Typhoid	Dysentery	Diarrhea	Total	Percentage	WQI
Asaba-Ase	-	10	24	23	57	22.52	45.43
Ivorogbo	-	3	-	15	18	7.11	44.15
Kwale	1	12	9	49	71	28.07	42.80
Igbuku	-	-	3	83	86	33.99	46.30
Obikwele	-	-	-	12	12	4.74	58.05
Osemele	-	-	-	9	9	3.56	54.92

Source: Fieldwork, 2011

The implication of this is that the settlements found in the upper course of the river such as Obikwele and Osemele with low concentration of heavy metals tend to record lesser cases of water borne diseases, when compared to those settlements found in the middle (Kwale and Igbuku) and lower (Asaba-Ase and Ivorogbo) course of the river. However, at Kwale and Igbuku, lesser WQI values are recorded most probably as a result of industrial activities caused by oil prospecting industries and other companies in the area, which have led to higher concentration of heavy metals in the water vis-à-vis more cases of waters-borne diseases recorded at Kwale and Igbuku.

Test of Hypothesis

The multiple regression was used to test the hypothesis, "that the prevalence of water-borne diseases (cholera, typhoid, dysentery and diarrhea) is not significantly dependent on the quality of water from the river. The test was conducted for the four identified water-borne diseases (cholera, typhoid, dysentery and diarrhea) in the area. The independent variable (X1 ……………X4) were the water borne diseases, while the dependent variable (Y) were the calculated water quality index (WQI) of the various settlements.

Ho: The prevalence of water-borne diseases (cholera, typhoid, dysentery and diarrhea) is not significantly dependent on the quality of water from the river.

Table 4: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.714[a]	.510	.359	5.44913	1.181

a. Predictors: (Constant), diarrhea cholera, dysentery, typhoid,
b. Dependent Variable WQI

From the model summary in table 4, the relationship between the water quality and water-borne diseases show that 51% of the water borne diseases (cholera, typhoid, dysentery and diarrhea) prevalent in the area is explained by the water quality of the river.

Thus, the coefficient of determination

$R = (0.714)^2 \times 100$

$R = 0.510 \times 100$

$R = 51\%$

The implication of this is that 51% of the water-borne diseases in the area are influenced by the quality of water from the river. This finding corroborates the findings of Nwidu, Oveh, Okonye and Valkosen (2008) in a similar study along Amassoma River in Southern Nigeria. While the remaining 49% may be attributed to the consumption of polluted water from shallow wells (Ushurhe and Origho, 2009), boreholes (Ohwo, 2009), consumption of uncooked food such as vegetables, fruits, poor handling of food vendors and hawkers and improper sewage disposal (Udoh et al, 1987). Also from the standardized beta coefficient values as shown in table 5, typhoid (0.607) has the greatest impact on the people, followed by diarrhea (0.509), dysentery (0.351) and cholera (0,266).

Table 5: Standardized Beta Coefficient Values

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	1	Sig
1. (Constant)	52.593	2.133		24.655	.000
Cholera	.691	.594	235	1.163	.266
Typhoid	.042	.079	.286	.526	.607
Dysentery	-.143	.147	-.495	-.967	.351
Diarrhea	-.038	.056	-.415	-.676	.059

a. Dependent Variable: WQI

Therefore, the prevalence of water borne disease (cholera, typhoid, dysentery and diarrhea) is significantly dependent on the quality of water, since $R^2 = 0.510$ at $P>0.05$.

Furthermore, from the zero order correlation as shown in table 6, there exist a relationship between the quality of water from the river and water borne diseases

Table 6: Zero –order correlations

		WQI	Cholera	Typhoid	Dysentery	Diarrhea
Pearson Correlation	WQI	1.000	.347	-.587	-.670	-.637
	Cholera	.347	1.000	-.199	-.217	-.147
	Typhoid	-.587	-.199	1.000	.893	.926
	Dysentery	-.670	-217	.893	1.000	.915
	Diarrhea	-.637	-.147	.926	.915	1.000
Sig. (1-tailed)	WQI		.079	.005	.001	.002
	Cholera	.075		.215	.193	.281
	Typhoid	.005	.215		.000	.000
	Dysentery	.001	193	.000		.000
	Diarrhea	.002	-.281	.000	.000	
N	WQI	18	18	18	18	18
	Cholera	18	18	18	18	18
	Typhoid	18	18	18	18	18
	Dysentery	18	18	18	18	18
	Diarrhea	18	18	18	18	18

As shown in table 6, as the water quality from the river decreases, the prevalence of water borne diseases increases in the area at $p>0.05$.

Conclusively, the prevalence of water borne diseases in the area is significantly dependent on the quality of water from the river. While a decrease in the water quality of the river results in increase in cholera, typhoid, dysentery and diarrhea diseases in the area.

Findings

Based on the aim and objectives of the study and the hypothesis posited, the following findings emerged:

I. The level of lead, zinc, calcium, sodium and potassium concentration along the course of the river is low and falls within the WHO (2010), NIS (2007) threshold for drinking water quality.
II. The amount of iron and magnesium concentration in the water samples examined is high when compared to the WHO (2010) and NIS (2007) threshold for drinking water quality.
III. The result of the multiple regression analysis conducted on the water borne diseases and regressed against the WQI of each settlement shows that $R^2 = 0.510$ ($P>0.05$); which implies that 51% of the water borne diseases is influenced by the water quality.

Recommendations

The following recommendations are precautionary measures for improving the present state of the surface water.

I. The water should be boiled before drinking in order to eliminate the temporary hardness created by the excess magnesium and iron found in it.
II. There should be routine monitoring of the water in order to check whether the heavy metals found in it are increasing or decreasing. Also, human activities along the course of the river be checked in order to address the factors responsible for the impairment of the water.
III. Water from the river should be purified through the state water boards and redistributed to the public as pipe borne water to prevent the spread of water borne diseases.

Conclusion

The water quality from River Ase with respect to the heavy metals examined is adequate in some of the parameters examined and inadequate in others. Also, the prevalence of water borne diseases in the area may have been influenced by the quality of the surface water consumed by the people. Routine monitoring of the water is recommended to check impairments and help improve the quality of the water for human use.

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