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QUALITY OF DRINKING WATER SOURCES IN IBENO LOCAL GOVERNMENT AREA OF AKWA IBOM STATE, NIGERIA

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ABSTRACT: Physicochemical and bacteriological analyses of drinking water samples from ten geo-referenced points in five communities of Ibeno Local Government Area of Akwa Ibom State, Nigeria, were conducted during the wet and dry seasons to ascertain their quality. Two sampling sessions were carried out in each season; totaling four different sessions. Physicochemical and bacteriological parameters were assessed for the drinking water samples and the results were compared with the World Health Organization (WHO) and Federal Ministry of Environment (FMEnv.) standards. Some physicochemical parameters namely; pH, temperature, electrical conductivity, alkalinity, total dissolved solids, total suspended solids, dissolved oxygen, nitrate, phosphate, nickel, cadmium and copper were within permissible limits recommended by WHO and FMEnv standards, while calcium, zinc, iron, lead and manganese exceeded the recommended standards. The levels of heavy metals in some samples did not meet the recommended standards for drinking water. The bacteriological quality of the drinking water samples in some areas did not also meet the WHO recommended standards. The study therefore recommends the establishment of good water works for provision of good quality drinking water; modern sanitary and sewage disposal facilities, creation of awareness to the people, enforcement by regulatory bodies and regular monitoring of drinking water quality and its impact on the health of the people of Ibeno Local Government Area.

INTRODUCTION

Globally, water is one of the most abundant and essential commodities of man and occupies about 97 percent of the earth's surface. About 70 percent of this volume of earth's water is contained in the oceans, 21 percent in polar ice and glacier, 0.3-0.8 percent in ground water, 0.009 percent in inland fresh waters such as lakes while 0.00009 percent is contained in rivers (Eja, 2002). Water plays a key role in sculpting the earth surface, moderating climate and diluting pollutants (Millers, 1998). It is a universal solvent.

The study area Ibeno LGA is one of the coastal LGAs in Akwa Ibom State as well as an oil producing area bordered by the Atlantic Ocean and has various environmental problems including pollution of available water sources. There are many types of water sources available for domestic, recreation, fishing and industrial uses in Ibeno Local Government Area. These include ponds, streams, rivers, ocean, hand-dug wells (shallow wells), and boreholes with hand pumps, and rain water, but they all seem to be polluted because of human and industrial activities in the area. The non availability of potable water source in most of the town, villages, hamlets and fishing settlements in Ibeno LGA is a major environmental problem that impacts on the health of the people, aquatic life and the entire ecosystem.

Water pollution is said to occur when a chemical, physical or biological substance exceeds the capacity of the water body to break down the substance that can cause harm to the aquatic ecosystem ((Daniel and Daniel, 2003). Anthropogenic and natural phenomena also affect water quality in the study area. Furthermore, human wastes from defecation are disposed indiscriminately on the ground surface (on the sands of the sandy beaches) and into water bodies. Other forms of water pollution sources include pit latrines and sanitary sewage lines which seep contaminants into groundwater, the common practice of the use of different contaminated containers to fetch water from the wells by the local people also contaminate the drinking water (Ham *et al.*, 1989; Hammer, 1992) in Ibeno LGA.

The implication is that dirty water spreads diseases and poses a variety of health threats (Daniel and Daniel, 2003), hence the need to assess the quality of available drinking water sources in Ibeno Local Government Area of Akwa Ibom State, Nigeria. The study was specifically carried out to: identify the major drinking water sources in Ibeno Local Government Area, determine the physicochemical and bacteriological properties, compare the results of the analysis with WHO and FMEnv regulatory standards in order to establish the trend in quality of drinking water sources available in the area.

MATERIALS AND METHODS

Study Area

Ibeno LGA (Fig. 1) has a coastal area of over 1,200 square kilometers. It is situated on the Eastern flanks of Niger Delta which in turn is part of the Gulf of Guinea (UNICALCONS, 2003). It is located at the south end of Akwa Ibom State with Latitude $4^{\circ} 32'$ and $4^{\circ} 34'$ North of Equator and Longitude $7^{\circ} 54'$ and $8^{\circ} 02'$ East of Greenwich Meridian. Ibeno LGA shares borders with Eket, Esit Eket, Onna and Mbo LGA areas in the North; Eastern Obolo LGA on the West and Cross River Estuary on the East (Daniel and Akpan, 2006). It occupies the largest Atlantic coastline of more than 129km in Akwa Ibom State (Akpan *et al.*, 2002). The communities on the west bank of the Qua Iboe River do not have access to the hinterland except by boat through the river and creek.

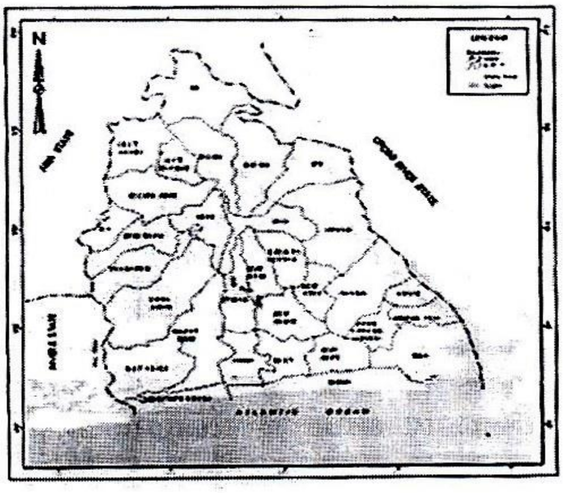


Figure 1: Location of Ibeno LGA on the map of Akwa Ibom State

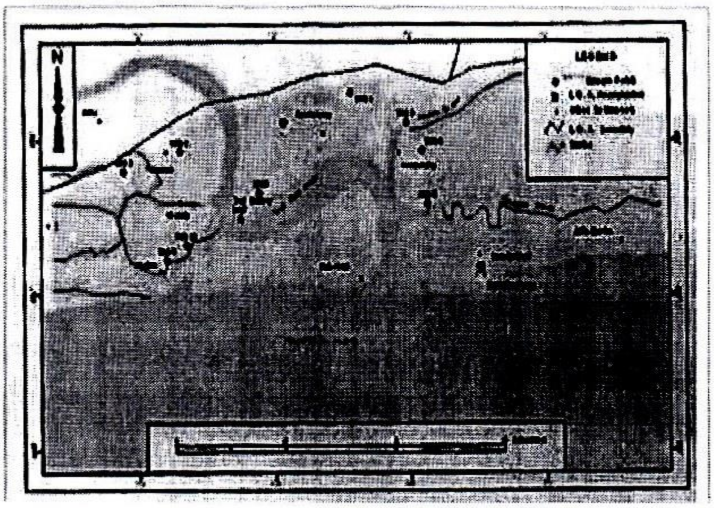


Figure 2: Map of Ibeno LGA showing sampling points

Qua Iboe River Estuary which lies within the study area coordinates has Douglas Creek emptying into it. This creek is about 900m long and 8m deep. It is the point where petroleum exploration and production waste from the Exxon Mobil Qua Iboe Terminal (QIT) tank farm are transferred to the lower Qua Iboe River Estuary and adjourning creeks through two 24' diameter pipes. The Exxon Mobil oily sludge dumpsite is located adjacent to this creek and the flare stack where gas is flared continuously is also situated a few meters from this creek (Akpan, 2003). The creek also serves as the boundary from Exxon Mobil Crude Expansion Project (Unilag Consult, 1997).

Collection and Treatment of Water Samples

Five communities were randomly selected and sampled, using a table of random numbers (Martin *et al.,* 1995). Two sample locations were taken from each of the five communities making up a total of ten water sampling points. The sampling locations were designated WS_1, WS_2, WS_3 – WS_{10} (Fig. 3) and are located within Mkpanak, Upenekang (LGA Headquarters), Iwuoachang, Ikot Inwang and Okorutip communities. The sampling points were geographically referenced using a hand-held Global Positioning System.

For this study, the wet and dry seasons sampling were used. The wet season sample was carried out between July and August 2008 while dry season samples were obtained between December, 2008 and January, 2009. A total of four sampling sessions were conducted.

At each location, samples for physicochemical parameters were collected using sterile 2- liter capacity plastic containers and labeled appropriately. Samples for bacteriological analysis were aseptically collected and stored in separate containers. It is important to note that most drinking water sources in the study area are underground water except water supplies at Mkpanak donated by ExxonMobil. To obtain groundwater samples the water was allowed to rush through the pipes or pumps for 5 minutes before collection.

Physicochemical Analysis of Water Samples

Portable analytical meters used for *in - situ* measurements were calibrated and standardized as recommended by the manufacturers. The temperature of water samples was obtained *in-situ* with the aid of mercury-in-glass Broth thermometer. The pH was also measured *in-situ* using portable pH meter (SUNTEX Model TS -2). Samples collected for *ex-situ* analysis were preserved in ice-packed coolers and immediately transported to the laboratory for analysis. In the laboratory the physicochemical properties (turbidity, electrical conductivity, phosphate, nitrate, chloride, dissolved oxygen (DO), alkalinity, total dissolved solids (TDS), total hardness (TH) and trace metals (Ca, Zn, Fe, Pb, Ni, Cd, Mn and Cu) of the water samples were determined using standard analytical procedures (APHA, 1995 & 1998).

The Membrane Filtration (MF) technique described by Itah *et al.* (1996), Itah and Akpan, (2005) was used for the estimation of total coliform counts in water samples. Direct microscopic count (cfu/ml) was also carried out on plate count agar to determine the general pollution status of each sample using aliquots of diluted sample and the pour plate technique (Itah *et al.,* 1996). Isolates from primary cultures were aseptically purified on fresh media by repeated subculture using the streak plate technique. Pure cultures were taken from slants, characterized and identified using the taxonomic schemes of Holt *et al.* (1994).

RESULTS

Tables 1- 3 show the mean values of the physicochemical and trace metal attributes of the water sources compared with WHO (1993) and FMEnv standards. Similarly, the total Coliform load of the water samples during the wet and dry seasons are presented in Table 4.

Table 1: Physicochemical and heavy metals properties of drinking water samples collected from Ibeno LGA during the wet season

Sample Points Code	Location / sources of drinking water	Coordinates	pH	T °C	Cond. µs/cm	Alka mg/L	TDS mg/L	TSS mg/L	Turb. mg/L	DO mg/L	TH mg/L	NO_3^- mg/L
WS_1	Tap Water, (Mkpanak)	N04^0 34’ 16.0” , E007^0 58’ 12.1”	5.70	25.1	266.7	0.6	126.1	123.4	2.80	0.65	3.3	1.58
WS_2	Tap Water, (Mkpanak)	N04^0 34’ 18.8” , E007^0 58’ 15.8”	5.60	25.0	264.6	0.5	125.3	125.2	3.10	0.80	3.3	1.58
WS_3	Hand pump, (Upenekang)	N04^0 33’ 56.9” , E007^0 59’ 01.0”	6.55	25.7	269.3	0.6	128.5	126.5	8.80	0.98	5.2	1.86
WS_4	Open well, (Upenekang)	N04^0 34’ 05.6” , E007^0 58’ 23.9”	6.65	25.9	269.7	0.9	129.7	130.6	26.20	1.01	50.7	6.89
WS_5	Borehole, (Iwuoachang	N04^0 33’ 808” , E008^0 00’ 132”	6.45	25.7	298.1	1.0	142.8	71.6	19.20	0.92	4.3	5.10
WS_6	Shallow well , (Iwuoachang)	N04^0 32’ 809’ , E008^0 00’ 130’	6.35	25.7	293.6	11.7	130.0	195.1	23.20	1.00	61.3	6.90
WS_7	Hand –dug well, (Ikot Inwang)	N04^0 33’ 58.9” , E007^0 57’ 32.1”	6.70	25.9	354.7	12.9	137.7	196.8	27.80	1.63	107.5	10.46
WS_8	Hand –dug well, (Ikot Inwang)	N04^0 32’ 58.6” , E007^0 57’ 30.1”	6.60	25.8	358.7	12.6	138.0	197.4	28.63	2.24	109.5	11.87
WS_9	Shallow Well, (Okorutip)	N04^0 33’ 24.4” , E007^0 56’ 23.8”	6.20	25.7	251.6	13.0	131.5	169.4	24.20	1.18	80.0	10.10
WS_{10}	Shallow Well, (Okorutip)	N04^0 33’ 19.0” , E007^0 56’ 23.8”	6.35	25.5	257.0	14.0	120.0	178.0	24.20	1.13	80.4	10.20
Mean			6.32	25.6	291.2	6.8	131.0	151.4	18.80	1.15	50.6	6.65
Min.			5.60	25.00	251.6	0.5	120.0	71.6	2.80	0.65	3.3	1.58
Max.			6.70	25.90	358.7	14.0	142.8	196.8	28.63	2.24	109.5	11.87

Sample Points Code	Location / sources of drinking water	Coordinates	PO_4^{3-} mg/L	Cl mg/L	Ca mg/L	Zn mg/L	Fe mg/L	Pb mg/L	Ni mg/L	Cd mg/L	Mn mg/L	Cu mg/L
WS_1	Tap Water, (Mkpanak)	N04^0 34’ 16.0” , E007^0 58’ 12.1”	0.06	155.0	2.8	0.8	0.20	0.39	ND	ND	0.02	0.03
WS_2	Tap Water, (Mkpanak)	N04^0 34’ 18.8” , E007^0 58’ 15.8”	0.07	155.9	2.5	1.2	0.22	0.45	ND	ND	0.02	0.04
WS_3	Hand pump, (Upenekang)	N04^0 33’ 56.9” , E007^0 59’ 01.0”	1.2	160.7	4.9	2.5	0.74	2.10	0.01	0.001	0.03	0.05
WS_4	Open well , (Upenekang)	N04^0 34’ 05.6” . E007^0 58’ 23.9”	2.95	170.1	10.9	6.1	0.55	4.95	0.04	0.004	0.23	0.09
WS_5	Borehole , (Iwuoachang	N04^0 33’ 808” , E008^0 00’ 132”	2.65	164.0	5.7	3.9	0.55	2.95	ND	ND	0.04	0.04
WS_6	Shallow well, (Iwuoachang)	N04^0 32’ 809’ , E008^0 00’ 130’	3.20	191.5	9.6	7.4	0.75	2.75	0.04	0.004	0.06	0.05
WS_7	Hand –dug well, (Ikot Inwang)	N04^0 33’ 58.9” , E007^0 57’ 32.1”	3.55	199.5	12.9	7.6	1.65	5.45	0.06	0.005	0.09	1.15
WS_8	Hand –dug well, (Ikot Inwang)	N04^0 32’ 58.6” , E007^0 57’ 30.1”	3.65	215.9	11.9	6.9	1.95	5.85	0.06	0.004	0.08	1.35
WS_9	Shallow Well, (Okorutip)	N04^0 33’ 24.4” , E007^0 56’ 23.8”	3.35	199.9	7.9	6.5	1.15	4.75	0.04	0.002	0.06	1.05
WS_{10}	Shallow Well, (Okorutip)	N04^0 33’ 19.0” , E007^0 56’ 23.8”	3.15	201.3	9.5	7.3	1.15	4.85	0.03	0.003	0.06	0.95
Mean			2.38	181.4	7.9	5.0	0.89	3.45	0.03	0.002	0.07	0.48
Min.			0.06	155.0	2.5	0.8	0.20	0.39	0.01	0.001	0.02	0.03
Max.			3.65	215.9	12.9	7.6	1.95	5.45	0.005	0.06	0.09	1.35

Source: Author’s field work (2008).

Table 2: Physicochemical and heavy metals properties of drinking water samples collected from Ibeno LGA during the dry season

Sample Points Code	Location / sources of drinking water	Coordinates	pH	T°C	Cond. µs/cm	Alka mg/L	TDS mg/L	TSS mg/L	Turb. mg/L	DO mg/L	TH mg/L	NO_3^- mg/L
WS_1	Tap Water, (Mkpanak)	N04°34'16.0", E007° 58' 12.1"	6.40	26.1	214.2	0.6	126.6	81.8	1.3	0.15	2.7	1.23
WS_2	Tap Water, (Mkpanak)	N04°34' 18.8" , E007° 58' 15.8"	6.35	26.4	205.3	0.6	126.8	81.4	1.6	0.20	3.0	1.35
WS_3	Hand pump, (Upenekang)	N04° 33' 56.9", E007° 59' 01.0"	6.55	26.3	262.9	1.2	129.2	127.7	8.7	0.9	5.3	1.60
WS_4	Open well, (Upenekang)	N04° 34' 05.6", E007° 58' 23.9"	6.45	26.0	289.3	2.1	132.8	132.6	8.7	1.05	47.8	6.25
WS_5	Borehole, (Iwuoachang	N04° 33' 808" E008°00'132"	6.35	26.8	292.8	1.8	143.7	108.6	20.5	1.26	5.0	5.25
WS_6	Shallow well, (Iwuoachang)	N04° 32' 809' E008°00' 130'	6.55	25.9	292.7	12.6	125.2	197.2	8.9	1.13	55. 3	6.75
WS_7	Hand dug well, (Ikot Inwang)	N04 33' 58.9" E007°57'32.1"	6.80	26.7	339.1	14.2	138.2	194.2	19.9	1.59	79.8	9.50
WS_8	Hand –dug well, (Ikot Inwang)	N04° 32' 58.6", E007° 57' 30.1"	6.75	26.8	351.7	14.5	139.1	198.1	22.8	2.20	80.2	12.50
WS_9	Shallow Well, (Okorutip)	N04° 33' 24.4", E007° 56' 23.8"	6.50	26.3	245.2	13.8	271.9	163.9	22.4	1.09	75.4	7.50
WS_{10}	Shallow Well, (Okorutip)	N04° 33' 19.0", E007° 56' 23.8"	6.55	26.2	255.5	15.0	120.7	174.6	22.0	1.1	80.1	3.03
Mean			6.53	26.4	274.9	7.64	145.4	146.0	13.7	1.07	43.5	5.50
Min.			6.35	25.9	205.3	0.6	120.7	81.4	1.3	0.9	2.7	1.23
Max.			6.80	26.8	351.7	15.0	143.7	198.1	22.8	2.20	80.2	12.5

Sample Points Code	Location / sources of drinking water	Coordinates	PO_4^{3-} mg/L	Cl mg/L	Ca mg/L	Zn mg/L	Fe mg/L	Pb mg/L	Ni mg/L	Cd mg/L	Mn mg/L	Cu mg/L
WS_1	Tap Water, (Mkpanak)	N04°34'16.0", E007° 58' 12.1"	0.03	97.5	2.7	1.1	0.06	0.39	ND	ND	0.03	0.04
WS_2	Tap Water, (Mkpanak)	N04°34' 18.8", E007° 58' 15.8"	0.04	102.8	2.5	1.3	0.06	0.44	ND	ND	0.04	0.04
WS_3	Hand pump, (Upenekang)	N04° 33' 56.9", E007° 59' 01.0"	0.55	161.8	5.0	2.6	0.21	2.13	0.09	0.003	0.06	0.06
WS_4	Open well, (Upenekang)	N04° 34' 05.6", E007° 58' 23.9"	1.75	171.0	10.5	6.3	1.04	5.20	0.55	0.004	1.02	0.06
WS_5	Borehole, (Iwuoachang	N04° 33' 808" E008°00'132"	2.25	165.2	6.6	4.1	0.44	3.4	ND	ND	0.03	1.03
WS_6	Shallow well, (Iwuoachang)	N04° 32' 809' E008°00' 130'	2.75	190.6	8.9	7.6	1.15	2.80	0.07	0.004	0.12	0.55
WS_7	Hand –dug well, (Ikot Inwang)	N04 33' 58.9" E007°57'32.1"	3.55	202.0	12.7	7.7	2.20	6.30	2.00	0.005	0.13	1.39
WS_8	Hand –dug well, (Ikot Inwang)	N04° 32' 58.6" , E007° 57' 30.1"	3.65	125.7	11.7	7.1	2.60	6.90	1.75	0.004	1.00	1.16
WS_9	Shallow Well, (Okorutip)	N04° 33' 24.4" , E007° 56' 23.8"	3.05	189.7	7.7	7.2	2.70	5.20	0.57	0.004	0.08	1.20
WS_{10}	Shallow Well, (Okorutip)	N04° 33' 19.0", E007° 56' 23.8"	3.03	193.0	9.5	7.4	2.40	6.20	0.05	0.004	0.09	1.25
Mean			2.07	168.9	7.8	5.2	1.29	3.90	0.51	0.003	0.26	0.68
Min.			0.03	97.5	2.5	1.1	0.06	0.39	0.05	0.003	0.03	0.04
Max.			3.65	202.0	12.7	7.7	2.70	6.20	2.00	0.005	1.02	1.39

Source: Author's field work (2008 – 2009).

Table 3: Physicochemical variables and trace metals load of the water samples during the wet and dry seasons

Parameter	Units	Mean for Wet Season	Mean for Dry Season	This Study Average Value (Mean for both Seasons)
P^H		6.53	6.32	6.43
Temp	°C	25.6	26.4	26.0
Elec. Cond.	µs/cm	291.2	274.9	283.1
Alkalinity	mg/L	6.78	7.64	7.21
TDS	mg/L	131.0	145.4	138.2
TSS	mg/L	151.4	146.0	148.7
Turbidity N.T.U	mg/L	18.8	13.68	16.2
DO	mg/L	1.15	1.07	1.11
Total Hardness	mg/L	50.6	43.5	47.1
Nitrate	mg/L	6.65	5.50	6.08
Phosphate	mg/L	2.38	2.07	2.23
Chloride	mg/L	181.4	168.9	175.2
Calcium	mg/L	7.9	7.8	7.9
Zinc (Zn)	mg/L	5.02	5.24	5.13
Iron (Fe)	mg/L	3.45	1.29	2.37
Lead (Pb)	mg/L	3.45	3.90	3.68
Nickel (Ni)	mg/L	0.03	0.51	0.27
Cadmium (Cd)	mg/L	0.002	0.003	0.003
Manganese (Mn	mg/L	0.07	0.26	0.17
Copper (Cu)	mg/L	0.48	0.86	0.67

Source: Author's Field Work, (2008-2009)

The mean values (Table 3) recorded for both the seasons parameters are respectively given as follows: pH, 6.32 and 6.53; temperature, 25.6°C and 26.4°C, electrical conductivity, 291.2 µs/cm and 274.9 µs/cm, alkalinity, 6.78mg/L and 7.64 mg/L, 7.21 mg/L; total dissolved solids 131.0mg/L and 145.4 mg/L, total suspended solids 151.4 mg/L and 146.0mg/L, turbidity, 18.8 mg/L and 13.68 mg/L, dissolved oxygen, 1.15mg/L and 1.07mg/L, and total hardness, 50.6mg/L and 43.5 mg/L. The values recorded for the anions during the wet and dry seasons respectively were as follows: NO_3^- 6.65mg/L and 5.5mg/L, PO_4^- 2.38mg/L and 2.07 mg/L, and Cl^- 181.4mg/L and 168.9mg/L. The mean concentration of the trace metals for both seasons were calcium 7.9 mg/L, zinc 5.13mg/L, iron 2.37 mg/L and manganese 0.17mg/L, Iron 2.3mg/L, lead 3.68mg/L, nickel 0.27mg/L, cadmium 0.003 mg/L and copper 0.67 mg/L

Table 4 shows that total coliform count ranged from 0 to 38 cfu/100 ml. The highest count of 38 cfu/100ml was recorded for sources collected from Ikot Inwang community while the least (0 cfu/100ml) was recorded for samples obtained from Mkpanak community.

The variation in the bacteriological loads of the drinking water sources between communities is depicted in Figure 5, while the prevalence rates of the bacterial isolates are presented in Figure 6. The isolates encountered in the water samples were *Bacillus subtilis, Micrococcus varians, Escherichia coli, Streptococcus faecalis, Enterococcus faecalis, Salmonella typhi, Staphylococcus aureus, Closteridium perfringens, Proteus vulgaris* and *Pseudomonas aeruginosa*. Among the isolates, the most prevalent contaminants were *E.coli* (27%) and *C.perfringens* (20%).

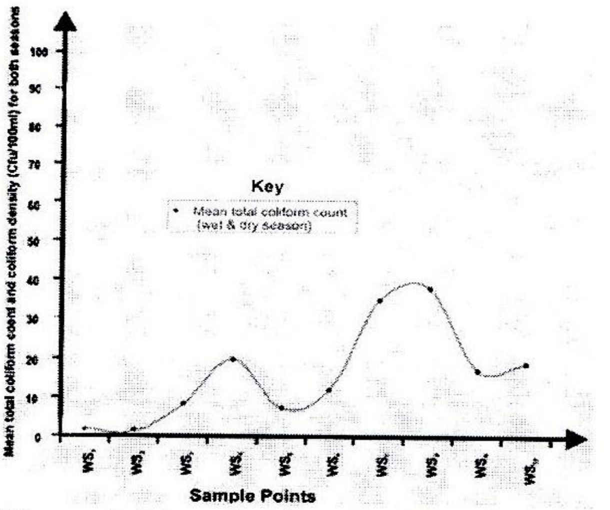


Figure 4: Mean density of coliform bacteria (cfu/100ml) obtained from the drinking water sources

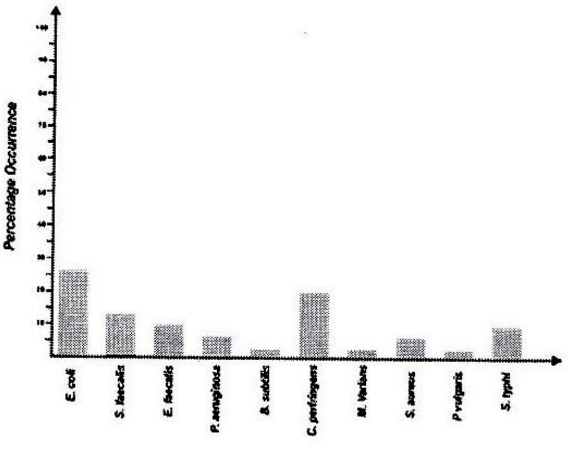
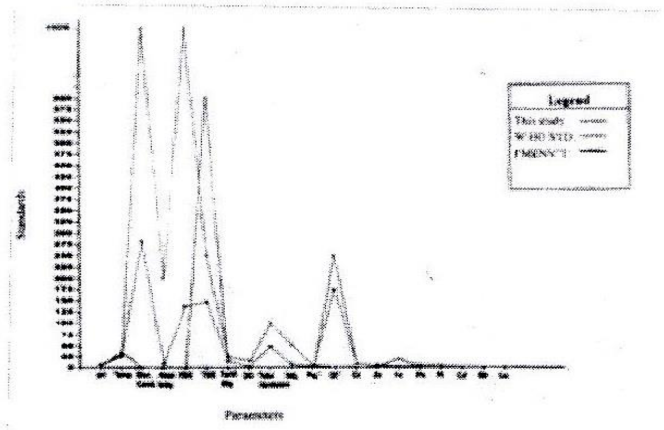


Figure 5: Prevalence of bacterial contaminants isolated from the drinking water sources

Figure 6 and Table 5 shows the compliance status of the water source average values compared with WHO 1993 and FMENV'T (FEPA 1991) standards.



Note that the green colour line represents the average values recorded in this study, WHO and FMENV'T standards are represented by red and blue lines respectively.

Figure 6: Compliance status of the drinking water quality compared with WHO and FEMEnv standards.

Table 4: Means value of the total Coliform Count and Coliform Density Investigated from Drinking Water Samples during wet and Dry Seasons.

Water sample/ location	Sample Points Code	Coordinates	Volume of Water Sample Filtered (Ml)	Coliform Count (cfu/100ml) in wet season	Coliform Co In D Season	Mean Total Coliform Count Wet & Dry Season	Coliform Density
Tab water (Mkpanak)	WS_1	N04° 34' 16.0" E007° 58' 12.1"	100	0	0	0	0
Tab water (Mkpanak)	WS_2	N04° 34' 18.8" E007° 58' 15.8"	100	0	0	0	0
Hand pump, (Ukenekang)	WS_3	N04° 33' 56.9" E007° 59' 01.0"	100	9	7	8	8
Open well (Ukenekang)	WS_4	N04° 34' 05.6" E007° 58' 23.9"	100	21	18	20	20
Borehole, (Iwuoachang)	WS_5	N04° 33' 808" E008° 00' 132"	100	8	6	7	7
Open well (Iwuoachang)	WS_6	N04° 32' 809' E008° 00' 130v'	100	13	11	12	12
Hand-dug well, (Ikot Inwang)	WS_7	N04° 33' 58.9" E007° 57' 32.1"	100	36	34	35	35
Hand-dug well , (Ikot Inwang)	WS_8	N04° 32' 58.6" E007° 57' 30.1"	100	39	38	38	38
Shallow well, (Okorutip)	WS_9	N04° 33' 24.4" E007° 56' 23.8"	100	17	17	17	17
Shallow well, (Okorutip)	WS_{10}	N04° 33' 19.0" E007° 56' 23.8"	100	19	19	19	19

Source: Author's Field Work, (2008 - 2009)

Table 5: Compliance status of the physicochemical and trace metals compared with WHO and FMEnv. (FEPA) standards

Parameter	Units	Average Value	WHO STD	Deviation from WHO STD	FMENV'T STD	Deviation from FMENV'T STD
PH		6.41	6.5 - 8.5	+2.07	6.5	+0.07
Temp	°C	26.0	27 – 28	+2	35.0	+9
Elec. Cond.	µs/cm	283.1	1000	+716.9	-	-
Alkalinity	mg/L	7.21	100 – 200	+192.8	-	-
TDS	mg/L	138.2	1000	+861.8	-	-
TSS	mg/L	148.7	250	+101.3	600	+451.3
Turbidity N.T.U.	mg/L	16.2	25(°11)	+8.8	-	-
DO	mg/L	1.11	15	+13.89	-	-
Total Hardness	mg/L	47.1	100	+52.9	-	-
Nitrate	mg/L	6.08	10.0 – 50.0	+43.9	-	-
Phosphate	mg/L	2.23	3.50	+1.27	5.00	+2.8
Chloride	mg/L	175.2	250	+74.8	-	-
Calcium	mg/L	7.9	7.5	-0.4	-	-
Zinc (Zn)	mg/L	5.13	5.0	-0.13	1.00	-4.13
Iron (Fe)	mg/L	2.39	1.0	-1.39	2.00	-0.39
Lead (Pb)	mg/L	3.68	5.0	+1.32	<1.00	-2.68
Nickel (Ni)	mg/L	0.27	5.0	+4.73	-	-
Cadmium (Cd)	mg/L	0.003	0.005	+0.002	<1.00	+0.99
Manganese (Mn)	mg/L	0.17	0.10	-0.07	-	-
Copper (Cu)	mg/L	0.67	1.0	+0.33	-	-

Source: (WHO, 1989; FMEnv (FEPA, 1991); WHO, 1993; Itah and Akpan,, 2005)

DISCUSSION

Comparison of the average values of experimental results with WHO and FMEnv permissible standards was carried out. The parameters which had set limits in the guideline standards were compared and their deviation from standards was calculated. Based on the context of this study, any parameter whose deviation was positive (+) means that its values has not exceeded the guideline standard and vice versa (Table 4). In this study, the pH, temperature, electrical conductivity, alkalinity, total dissolved solids, total suspended solids, turbidity, dissolved oxygen, total hardness, nitrate, phosphate and trace metals such as Pb, Ni, Cd, Chloride and Cu showed positive deviation from the WHO (1993) standard. Similarly, all the parameters except Pb showed positive deviation from FMEnv standard. This implies that all the listed parameters Pb were within the permissible limit. On the other hand, Ca, Zn, Fe and Mn deviated negatively from WHO standards and exceeded the recommended standards for drinking water. The levels of Zn, Fe and Pb in the water samples also deviated negatively from FMEnv standards or exceeded the permissible limits. However, the average values recorded for pH, temperature, TSS, phosphate and Cd showed positive deviation, indicating compliance with FMEnv recommended standards.

The results of bacteriological analysis (Table 4) show the unsanitary condition (Plate 1) of the water sources in almost all the locations except Mkpanak. The recovery of faecal coliform bacterium, *E. coli* in most of the samples is of particular concern. The presence of *E.coli* in the samples implies faecal contamination of such samples and strongly suggests possible presence of other enteric pathogenic bacteria like *Vibrio cholerae, Aeromonas hydrophilia, Salmonella paratyphi and Yersinia enterocolitica* (Itah *et al.*, 1996) as well as other parasites. The results are in agreement with earlier reports by Adesiyun *et al.* (1983); Agbu *et al.* (1988); Itah *et al.* (1996); and Itah and Akpan (2005).

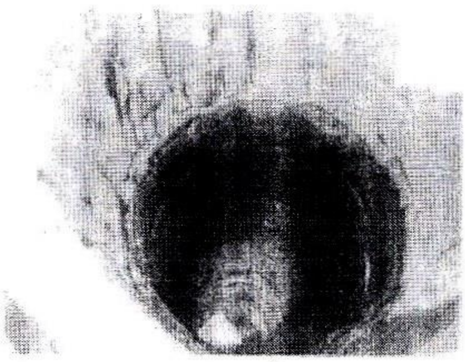


Plate 1: An open well serving as drinking water source at Iwuoachang showing rusty zinc drum used as casing materials

Water samples containing indicator bacteria especially *E.coli* and high levels of coliform density and high viable bacterial count are unfit for human consumption. A coliform count of not more than 10 is recommended WHO (1989) for unchlorinated water supplies while the presence of *E.coli* is intolerable and on no circumstance must it be found in water meant for human consumption or domestic services. Special reference is made to sample from Ikot Inwang, Upenekang and Okorutip which were found to be adversely contaminated. This is because most sanitary sewage lines are located in close proximity to water supply line which traverses the septic tank absorption field (Hammer, 1992). The sewage and the cast iron pipe used for transportation of water are subjected to leakages. Sometimes accidental back-flow or back seepage of polluted water from toilets and wash bowls may occur resulting in contamination of water supply pipes. Also, inhabitants of the riverine or coastal (Ibeno LGA) communities mostly defecate on the sandy beaches and this may be washed by run-off during rainy season into the well (water bodies) thereby contaminating it with faecal matters (UNICALCONS, 2003).

The study has also revealed the presence of enteric pathogens such as *S. aureus and Baccillus species* (Fig. 5) which are known entero-toxin producers and food poisoning aetiologic agent (Itah and Opara, 1994a; 1997) in the water samples. Jawetz *et al.*, (1995), reported that some strains of *C. perfringens* produce powerful enterotoxins that induces intense diarrhea in 6 – 18 hours. The action of *C. perfringens* enterotoxin involves a marked hypersecretion in the jejunum and ileum, with loss of fluids and electrolytes in diarrhea. Many of the isolates have been associated with the ability to exhibit multiple resistances to various antibiotics (Itah and Opara, 1994b; Jawetz *et al.*, 1995).

Apart from the fact that some water samples, except those at Mkpanak, failed to meet some aesthetic standards, the high level of chemicals and heavy metals in particular, constitute a threat to public health. (Wassen, 2001), Humpheries *et al.*, (1985), reported that iron is a potent dietary antagonist of copper metabolism in ruminants hence may be injurious to health when it exceeds the WHO (1993) minimum recommended standard of 1.0 mg/L as was the case in this study. Hardoy *et al.* (1992) in his work stipulated that Fe content in water must not exceed the recommended value otherwise it will cause blood disorder. However, within permissible limit, Fe is an important element required for the synthesis of haemoglobin during haemopoiesis in the bone marrow as earlier reported (Itah *et al.*, 1996). High level of Zinc (Zn) was also obtained in this study. The symptoms of Zn toxicity in human beings include dehydration, vomiting, abdominal pains, nausea, dizziness and lack of muscular coordination (Hardoy *et al.*, 1992).

High levels of Ca, Pb and Mn were obtained in this study when compared with WHO (1993) and FMEnv standards. High level of Pb in water bodies may result in possible neurological damage to foetus and young children if contaminated water is consumed (Hardoy *et al.*, 1992). Egereonu and Ozuzu, (2005) reported that lead excess causes spontaneous abortion in humans. It has been reported that relatively low levels of chronic exposure can produce adverse health effects that include interference in red blood cell chemistry, delays in normal physical and mental development in babies and young children and slight increase in blood pressure of some adults (Waakes *et al.*, 1992). Other effects of chronic poisoning by lead are gastrointestinal, neuromuscular, kidney, joints, reproductive system and renal signs and symptoms such as anorexia, headache, malaise, diarrhoea, lead-palsy, encephalopathy and insomnia. Excess intake could result in plumbism (Udosen and Orok, 1997). Mn in excess of the recommended standard would result in neurological disorders in exposed persons (Tennant, 1981). It has been reported that headache, involuntary movements, sleep, speech and gait disturbances as well as exaggerated reflexes significantly increase with increasing duration of exposure to Mn (Rodier, 1975; Cornell and Kennish, 1992; Akpan *et al.*, 2002). Although copper is an essential substance in human life, high doses (amount beyond 1.0 mg/L) can cause anaemia, liver and kidney problems and intestinal irritation; similarly the presence of Cl^- anion, in drinking water is essential in nutrition but harmful at concentration of 250 mg/l or above. Calcium in the form calcium sulphate causes diarrhea and also renders the water hard and unsuitable for drinking.

CONCLUSION AND RECOMMENDATION

The present study has revealed the quality of drinking water sources in Ibeno Local Government Area. Although, some of the water samples met the physicochemical and heavy metal requirements than others, they failed to meet the minimum bacteriological standards. Therefore the water from these sources are unsafe for human consumption. The bacteriological quality of the drinking water sources in parts of the area calls for a great concern and the people of the area should be enlightened on the need and how to protect the available sources of drinking water.

Since water is critical for survival, it is recommended that water works be established in Ibeno LGA for provision of good quality drinking water. Modern sanitary facilities should also be established for inhabitants at the riverine communities to reduce the rate of defecation on sandy beaches. This will help to improve the sanitary and hygiene conditions of the area and reduce the rate of contamination of drinking water with faecal matter.

REFERENCES

Adesiyun, A. A., Adekeje, O. J., Umoh, J. U. and Nadaraja, M. (1993). Studies on well water and possible health risks in Katsina, Nigeria. *Journal of Hygiene*. pp.199-201.

Agbu, A. A., Alaribe, H. C., Singh, K. and Adesiyun, A. A. (1988). Bacteriological studies and chemical analysis of public well water in Symaru and Zaria City of Northern Nigeria. *Journal of Microbiology*, 8(1-2): 88-98.

Akpan, E. R. (2003). Acidic precipitation and infrastructural deterioration in oil producing communities of Akwa Ibom State: A Case Study of Eket, South Eastern Nigeria. *Global Journal of Environmental Sciences,* 2(1):47-52.

Akpan, E. R., Ekpe, U. J. and Ekpo, H. E. (2003). Seasonal variation in water quality of the Calabar River Estuary: Influence of Coastal and Tidal Activities. *Global Journal of Environmental Sciences,* 2(2) in press.

Akpan, E. R., Ekpe, U. J. and Ibok, U, J. (2002). Heavy metal trends in the Calabar River. *Nigeria Environmental Geology,* 42(1):47-51.

Akpan, E. R., Offem, J.O. and Nya, A. E. (2002). Baseline ecological studies of the Great Kwa River, Nigeria 1: Physicochemical studies: *African Journal of Environmental Pollution and Health,* 1(1):83-90.

APHA (1995). *Standard Methods for the Examination of Water and Wastewater* 9th ed., Washington. D.C: *American Public Health Association*, p.5.

APHA (1989). *Standard Method for the Examination of Water and Waste Water 17th ed., New* York: American Public Health Association (APHA), pp. 203 - 226.

Botkin, D. B. and Keller, E. A. (1998). *Environmental Science: Earth as a Living Planet.* 2nd ed., Canada: John Wiley and Sons, pp. 290 - 293.

Cornell, U. T. and Kennish, C. P. (1992). *Groundwater Contamination by Heavy Metals, Water Resource Characterization*. New York: Department of Health, pp 1-8.

Daniel, E. and Akpan, P. (2006). *Akwa Ibom State Travel Guide*. Department of Geography and Regional Planning, University of Uyo, Nigeria, p. 2.

Daniel, T. and Daniel, K. (2003). *The Environmental Planning Hand Book for Sustainable Communities and Regions* U.S.A. American Planning Assocaition, Chp. 3 & 4.

Egereonu, U. U. and Ozuzu,C. I. U. (2005). Physiochemical Analysis of the River Niger at Onitsha Bank, Nigeria. *Journal of Chemical Society of Nigeria,* 30(2): 197 – 202.

Eja, M. E. (2002). *Water Pollution and Sanitation for Developing Countries.* Calabar: Seasprint (Nig.) Co. Chapters. 2 & 5.

Federal Environmental Protection Agency (FEPA) (1991) *National Environmental Protection Agency Effluent Limitation Regulations* of Nigeria, (Cap 131 LFN). Geneva: WHO, pp. 2 - 5.

Glasstone, S. (1966). *Textbook of Physical Chemistry.* 2nd ed., London Macmillian and Co limited, p. 496

Ham, A. M., Ook, N., Mdorikawa, Y. and Shwe, S. (1989). Contamination of drinking water during collection and storage. *Trop. Geoge. Med.* 2(1): 3 - 4.

Hammer, D. H. (1992). Designing constructed wetlands systems to treat agricultural non-point source pollution. *Ecological Engineering*, 1: 49 -82.

Hardoy, J. E. Mflin, D. and Satterthwaite, D. (1992). *Environmental Problems in Third World Cities*. London: Earthscan, 20p.

Holt, G. H., Krieg, N. R., Sneath, P. H., Staley, J. T. and Williams, S. T. (1994). *Bergey's Manual of Determinative Bacteriology.* 9th ed., Baltimore: Williams and Wilkins, p. 787.

Humphries, W. R., Bremmer, I. and Philips, M. (1985). The Inference of Dietary Iron on Copper Metabolism in the Calf. *In:* Mills, C. F., Bremmics, I., and Chesters, J. K., Trace Element in Man and Animals. United Kingdom: *Common Wealth Agricultural Bureaux*, 371p.

Ikpe, L. U. (2004). *Comparative Seasonal Variation Studies of Trace Metals in Two Aquatic Organisms and their Sea Water Habitats in Qua Iboe River Tributaries.* M. Sc. Dissertation, University of Uyo, Nigeria.

Itah, A. Y. and Akpan, C. E. (2005). Portability of drinking water in an oil impacted community in Southern Nigeria. *Journal. Applied Science Environment Management,* 9(1) : 135 – 141.

Itah, A. Y., Etukudo, S. M. and Enomfon, H. (1996). Bacteriological and chemical analysis of some rural water supplies in Calabar, Nigeria. *West African Journal of Biological and Applied Chemistry,* 4: 41- 43.

Itah, A.Y. and Opara, A.A. (1994a). Enterotoxigenicity profile of *Baccillus cereus* strains isolates from canned foods in Calabar, Nigeria, using the Ligated Rat Heal loop technique. *Journal of Medical Laboratory Sciences,* 4: 91-06.

Itah, A.Y. and Opara, A.A. (1994b). Prevalence, characterization and antibigram of *Bacillus cereus* strains isolated from canned foods sold in Calabar, Nigeria, using the Ligated Rat Heal loop technique. *Journal of Medical Laboratory Sciences.* 4:87-90.

Itah, A.Y. and Opara, A. A. (1997). Enterotoxin production from *Staphylococcus aureus* Strains contaminating canned food in Calabar. *Journal* of *Science, Engineering and Technology,* 4:41-43.

Jawetz, E., Melnick, L.J., Adelberg, A. E., Brooks, F.G., Butel, S. J. and Ornston, N. L. (1995). *Medical Microbiology.* 20th ed., USA: Appleton and Lange Norwalk, Connecticuit. A Simon and Schuster company, 178p.

Martin, I. B., Mwangi, A.P. and Schlette. R. (1995). *Teach your Best – A Handbook for University Lecturers.* Bonn: German Foundations for International Development, p. 5.

Miller, G. T. (1998). *Living in the Environment. Principles, Connections and Solutions.* 10th ed., London: Wadsworth Publishing Company, Chapter 18 & 19.

Rodier, J. (1975). *Analysis of Water.* 5th ed., New York: John Wiley and Sons Inc., pp. 10 – 12

Tennant, D. R. (1981). Manganese. World Health Organization International Programme on Chemical Safety. *Environmental Health Criteria,* pp 218 - 220.

Udosen, E. D. and Orok, A. M. (1997). A comparative study of the quality of rural water in parts of Itu Area of Nigeria. *Journal of Science, Engineering and Technology,* 4(1): 651 - 663.

UNILAG CONSULT (1997). *Environmental Impact Assessment for the Proposed QIT 750 TBD (crude) Expansion Project Akwa Ibom State, Nigeria. Onshore Facilities.* Mobil Producing Nigeria Unlimited, Lagos, Nigeria, Vol. 1, pp. 12 - 13.

University of Calabar Consultancy Services (UNICALCONS) (2003). *Draft Final Report of Environmental Impact Assessment (EIA) of the Proposed Iko – Atabrikang – Akata – Opolom – Ikot Inwang – Okorutip – Iwuoachang Road Project* by NDDC, pp. 2 - 5.

Waakes, M. P., Coogan, T. P. and Borter, R. A. (1992). Toxicological principles and metal carcinogenesis with special emphasis on cadmium. *Crit. Rev. Toxicol.,* 1: 175 - 201.

Wassen, C. D. (2001). Heavy Metals and Metal Antagonist. In: Aardman, J. D., Limbrid, L. E. and Gilman, A. G. (Eds.) *The Pharmacological Basis of Therapeutics,* 12th ed. New York. Mc-Graw Hill, pp. 1851-1875.

WHO (1989). *Guidelines for International Drinking Water Quality.*

WHO (1993). *Guidelines for Drinking Water Quality.* Geneva: WHO.