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BACTERIOLOGICAL AND CHEMICAL QUALITY OF SOME SOURCES OF DRINKING WATER IN AKWA IBOM STATE, NIGERIA – I. R. Udotong

Abstract

Three sources of drinking water namely: stream, tap and Directorate of Foods, Roads and Rural Infrastructure (DFRRI) bore holes water were analysed for their bacteriological and chemical quality in four Local Government Areas of Akwa Ibom State. Ragolis water was used as a control having been found in preliminary experiments to meet the world Health Organization (WHO) standards. Total bacterial and coliform counts were determined using standard plate count, most Probable Number (MPN) and membrane filter (MF) techniques. The results obtained from the MF technique indicated that apart from Ragolis water (control), other water sources sampled were heavily polluted with faecal coliform above the WHO standard for drinking water. Using the MF technique, while the total faecal caliform (CFU/100ml) ranged from 40 to 120 in stream, 5 to 15 in tap and 3 to 12 in bore hole, the total coliform (CFU/100ml) ranged from 216 to 500 in stream, 6 to 100 in tap and 10 to 70 in borehole. The feacal coliform isolated was Eschericia coli biotype 1. Non-faecal coliform and non-coliform organisms isolated were Enterobacter aerogenes, Bacillus sp., Pseudomonas sp., Proteus sp., Staphylococcus aureus and Micrococcus sp. Bacteriologically, it can be concluded that the presence of these organisms constitute a health hazard to consumers. Of the 20 parameters assayed, 3 exceeded the WHO standard in all the samples with values (in mg/L) of 1.2 for lead, 0.8 for iron and 1.1 for copper. Chemically, the risk of toxicity due to the metal contamination from long-term consumption cannot be ignored.

Introduction

Water is essential for a variety of human activities including drinking, sanitation, recreation, manufacturing processes in industries and the production of food and fibre (Sangodoyin and Osuji, 1990). In Akwa Ibom State, Nigeria, the government has often promised a conventional water supply system for urban and rural areas. Unfortunately however, communities are still without adequate supply of potable water. Consequent upon the government's inability to provide sufficient potable water for all needs especially for drinking purpose, residents in most communities resort to the available sources of drinking water. Some of the various sources of drinking water in Akwa Ibom State are stream water, well water, Directorate of Foods, Roads and Rural Infrastructure (DFRRI) assisted bore hole water, rain water, and public pipe-

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borne water supplies. In order to meet the high demand of water, people engage in private commercialisation of untreated water in areas where tap water is not readily available in Nigeria and sold under various brand names in the state. Few studies suggest that the microbiological quality of tap water supply to most of the communities in Nigeria is poor (Agbu et al., 1988). To date, no information is available on the bacteriological quality of water in Akwa Ibom State, using the acceptable standard methods. Also no information is available on the chemical quality and heavy metal concentration in water destined for human consumption in the State; and there are no previous studies on the quality of some other sources of drinking water (apart from tap water) available to the rural dwellers in the State.

After the United Nations declaration, in its 1980 General Assembly of 1981 – 1991 as the United Nations Water and Sanitation decade, it was important to assess the extent of success in Akwa Ibom State in particular, and Nigeria as a whole; and also to documei baseline data on bacteriological and chemical quality of some sources of drinking water in Akwa Ibom State.

Materials and Methods

Sampling and sample collection

Four (4) out of the 24 Local Government Areas in Akwa Ibom State were selected at random to represent the 3 Senatorial districts and the State Capital, Uyo. At each of the 4 sampling (Local Government Areas) points, 1 litre each of the following water samples were aseptically collected in sterile bottles and taken to the laboratory within 1 hour for analyses: (i) Stream water (ii) Tap water (from the State Water Board) (iii) DFRRI – assisted bore-hole water (iv) Ragolis (bottled spring water). Each of these water samp' were randomly obtained from 10 different sources in the Local Government Area between August and March, a period representing the later part of the rainy season and the beginning of the dry season in Nigeria.

Bacteriological analysis

(i) Total bacterial count

The total bacterial count per millilitre of the samples were determined using the standard plate count technique (Harrigan and McCance, 1976). Inoculated plates were incubated aerobically for 24 – 48h at 37^{0}C. A colony counter (Gallenkamp, England) was used for counting and the result was expressed as colony forming units (CFU) per millilitre of samples. The methods according to Collins and Lyne (1976) were employed in the identification of the bacterial isolates.

(ii) **Total coliform bacteria**

(a) The membrane filter (MF) technique as described by Lechevalier et al. (1983) was employed for the detection and enumeration of total coliform bacteria. MF – endo medium (Difco, USA) was used and inoculated plates were incubated at 37^{0}C for 18 – 24h. Colonies with green or gold metallic sheen on the MF plates were counted as total coliforms and expressed per 100ml of water sample (Wolf, 1972).

(b) Multiple tube fermentation technique: The most probable number (MPN) of total coliform bacteria present in the samples were determined using the MPN technique according to Harrigan and McCance (1976).

(iii) **Total feacal coliform**

A similar procedure to that employed for the detection and enumeration of total coliforms by MF technique was employed for the detection of faecal coliforms. Here, FC- medium (Difco, USA) was used and inoculated plates were incubated at elevated temperature of 44.5^{0}C in a water bath (Gallenkamp, England) for 18 – 24h. Light blue to dark-green colonies were counted as faecal coliforms and expressed per 100ml of water sample (Wolf, 1972).

Chemical analysis

Samples were analysed for the various parameters using the recommended standard methods (APHA, 1975). The pH of samples were determined using the digital pH meter (Corning, England) while electrolyte conductivity determinations were done using a conductivity set (Model MC-1, Electronic Switchgear Ltd., London). The pye Unicam 919 Atomic Absorption Spectrophotometer with air – acetylene flame was used for the detection of metals; whereas, the alkali metals (sodium and potassium) were determined using a flame photometer (Jenway Ltd., England).

Results

Bacteriological Analysis

Results of bacteriological analysis of various sources of water samples using standard plate count, most probable number and MF techniques are presented in Table 1. There was no bacterial isolate from the Ragolis water (control). The total coliform count obtained using the MPN technique ranged from 425 to 2620 MPN/100ml in stream water, 9 to 20 MPN/100ml in tap water and 24 to 350 MPN/100ml in DFRRI – assisted bore-hole water. The total coliform count using the MF technique ranged from 216 to 500 CFU/100ml in stream water, 6 to 100 CFU/100ml in tap water and 10 to 70 CFU/100ml in bore-hole water. No coliform organism was isolated from Ragolis water using both the MPN and MF techniques. Based on the total coliform count using the MPN and MF techniques, stream water samples from Ikot Ekpene were found to be the most polluted with human faecal wastes.

Table 1. Bacteriological count of various water sources using standard plate Count, (MPN MF techniques).

Source	L.G.A	Standard plate Count (CFU/ml) X 10^{-3}	MPN Technique Coliform (MPN/100ml)	Membrane Filter (MF) Technique	
				Total coliform CFU/100ml	Faecal coliform (CFU/100ml)
Stream	Uyo	46	425	216	40
	Eke	33	1,600	300	120
	Uruah	13	1,800	400	90
	Ikot Ekpene	35	2,620	500	50
Tap	Uyo	23	10	6	5
	Eke	49	25	100	15
	Uruan	33	9	9	6
	Ikot Ekpene	30	12	10	9
Bore-hole	Uyo	18	350	70	12
	Eke	10	25	16	5
	Uruan	10	24	20	3
	Ikot Ekpene	12	70	10	3

L. G. A: Local Government Area

On the basis of their morphological and biochemical characteristics, the bacteria isolated were members of 7 genera: *Escherichia coli biotype 1, Enterobacter earogenes, Pseudomonas sp., Bacillus sp., Proteus sp., Micrococcus sp.,* and *Staphylococcus aureus*. The frequency of occurrence of the isolates is presented in

Table 2. *E. coli* biotype 1 and *S. aureus* occurred in all the stream water samples analysed (100%). While *E. aerogenes, Proteus sp.*, and *Bacillus sp.*, occurred in 80% of the stream water samples, only *E. aerogenes* occurred in 80% of the tap water analysed. Also, while *Pseudomonas sp.*, and *Micrococcus sp.*, occurred in 50% of the stream water samples, *Bacillus sp.* occurred in 50% of the tap and bore-hole water samples. Stream water was the most polluted with all the bacterial isolates occurring. *E. coli* biotype 1 and *E. aerogenes* were the only coliform bacteria isolated from stream, tap and DFRRI assisted bore-hole water samples.

Table 2. Frequency of occurrence of isolates from various water sources.

Source	Organisms	Occurrence	Number sampled	Percentage of occurrence
Streaam	*Escherichia coli* biotype 1	10	10	100
	Enterobacter aerogenes	8	10	80
	Bacillus sp.	8	10	80
	Pseudomonas sp.	5	10	50
	Proteus sp.	8	10	80
	Micrococcus sp.	5	10	50
Tap	*Escherichia coli* biotype 1	2	10	20
	Enterobacter aerogenes	8	10	80
	Bacillus sp.	5	10	50
	Pseudomonas sp.	5	10	50
	Proteus sp.	2	10	20
Bore-hole	*Escherichia coli* biotype 1	2	10	20
	Bacillus sp.	5	10	50
	S. aureus	2	10	20
	E. aerogenes	2	10	20
Control (Ragolis)	*No. bacterial isolate*	0	0	0

Chemical Analysis

Table 3 shows the data on chemical analysis of water samples from the 4 sources in each sampling point (Local Government Area). Average values of the parameters assayed in all the water samples from the various sampling points were found to be within tolerable limits as specified by WHO (1971) with the exception of iron, lead and copper, whose values were found to be in excess of the WHO standards. No residual chlorine was detected in any of the water samples analysed.

Discussion

The bacteriological examination of stream, tap and bore-hole water from Uyo, Eket, Uruan and Ikot Ekpene Local Government Areas in Akwa Ibom State, showed *coliform* counts that far exceeded the 2.2 coliform per 100ml recommended for potable water by the United States Environmental Protection Agency, USEPA (Freedman, 1977) and the zero coliform per 100ml recommended by the WHO, (WHO 1971). It is evident, therefore that none of the sources of drinking water available to residents in these Local Government Areas in Akwa Ibom State is considered fit for human consumption for bacteriological reasons. Also, the fact that all the water samples from the (three) sources in the 4 Local Government Areas were contaminated with faecal coliforms suggests that these may have been contaminated by faeces.

It is however, interesting to note that the gross contamination of all the sources of drinking water in Akwa Ibom State with *Escherichia coli* biotype 1 is in agreement with the report of Olutiola *et al.* (1988). The results of the present study also agree with similar studies on private wells in Katsina (Adesiyun *et al.*1983) and Samaru and Zaria Cities (Agbu *et al.*, 1988). The prevalence of *E. coli* biotype 1 and *Enterobacter aerogenes* in tap water may have been due to the fact that most sanitary sewer lines are located in close proximity to water supply lines which pass the septic tank absorption field. The sewer and the cast iron pipe used for transferring water are subject to leakages and sometimes, there may be accidental backflow or back siphonage of contaminated water from toilet and wash bowls into the water supply pipe through leakages in supply lines passing through the drain field (Uraih and Izuagbe, 1990).

Also, location f the bore-hole in close proximity to pit latrines in the rural areas may have been responsible for the presence of these coliform organisms in bore-hole water. Moreover, the water from DFRRI -- assisted bore-hole has been shown to be at the same water level, in some areas, with pit latrines and sometimes the faeces in pit latrines may percolate through the soil to the bore-hole water, thus contaminating it (Uraih and Izuagbe; 1990). The high prevalence of these coliform organisms as well as *Staphylococcus aureus*, *Proteus, sp.*, *Pseudomonas sp.* and *Micrococcus sp.* in

Table 3. Chemical analysis of indigenous sources of drinking water in Akwa Ibom State, Nigeria

Sampling point	Uyo				Eket				Uruan				Ikot Ekpene			
Source	Stream	Tap	DFRRI	Regolis	Stream	Tap	DFRRI	Regolis	Stream	Tap	DFRRI	Regolis	Stream	Tap	DFRRI	Regolis
Parameter (pH)	6.36	6.01	6.00	7.20	6.30	5.98	6.02	7.15	6.33	6.00	6.01	7.20	6.35	6.01	6.02	7.10
Temperature (°C)	26.0	27.0	27.5	26.5	26.0	26.5	27.5	26.5	26.0	27.0	27.5	26.5	26.0	26.5	27.0	26.5
Turbidity (T.U)	1.0	2.0	2.5	0.5	1.5	2.0	2.5	0.0	1.5	2.0	2.5	0.0	2.0	2.0	2.5	0.0
Nitrate (mg/L)	5.5	4.0	4.0	BD	5.5	4.5	4.0	BD	5.0	4.0	4.0	BD	6.0	4.5	4.5	BD
Residual Chloride (mg/L)	BD	BD	BD	BD	BD	BD	BD	BD	BD	BD	BD	BD	BD	BD	BD	BD
Total Nitrogen (mg/L)	50.0	35.0	5.0	BD	50.0	55.0	45.0	BD	50.0	35.0	40.0	BD	55.0	35.0	45.0	BD
Total solids (mg/L)	245.0	200.0	210.0	24.5	238.0	204.0	207.0	21.0	240.0	205.0	234.0	20.0	247.0	200.0	220.0	21.0
Phosphate (mg/L)	4.2	5.8	4.0	BD	4.3	3.7	4.0	BD	4.7	3.8	4.0	BD	4.5	3.0	4.0	BD
Sulphate (mg/L)	35.0	38.0	41.0	30.0	35.0	38	41	30.0	35.0	38.0	41.0	30.0	36	38	42	10.0
Total hardness (mg/L)	70.0	75.0	80.0	20.5	70.0	76	82	21.0	70.0	78.0	85	21.0	70	80	85	20.5
Sodium (mg/L)	3.0	3.2	3.2	4.2	3.0	3.1	3.2	4.0	3.0	3.8	3.1	4.0	3.2	3.0	3.1	4.2
Potassium (mg/L)	0.6	0.5	0.5	0.7	0.7	0.5	0.5	0.7	0.6	0.5	0.5	0.7	0.6	0.5	0.5	0.7
Calcium (mg/L)	4.0	10.3	17.5	16.0	10.2	0.2	17.6	16.0	12.1	10.3	0.8	16.0	14.2	14.5	17.5	16.0
Magnesium (mg/L)	2.4	3.4	6.0	4.0	4.8	7.2	7.0	4.0	6.0	6.0	6.5	4.0	8.4	4.5	7.0	4.0
Iron (mg/L)	0.8	0.9	0.9	BD	0.8	0.8	0.9	BD	0.8	0.9	0.9	BD	0.8	0.5	0.9	BD
Zinc (mg/L)	BD	0.1	0.1	BD	BD	0.1	0.1	BD	BD	0.1	0.1	BD	BD	0.1	0.1	BD
Lead (mg/L)	1.0	1.0	1.0	BD	1.0	1.1	1.1	BD	0.8	1.1	1.2	BD	0.9	1.1	1.2	BD
Copper (mg/L)	1.1	1.2	1.2	BD	1.0	1.0	1.2	BD	0.9	1.0	1.1	BD	1.0	1.1	1.1	BD
Manganese (mg/L)	BD	0.1	0.1	BD	BD	0.1	0.1	BD	BD	0.1	0.1	BD	BD	0.1	0.1	BD
Bicarbonate (mg/L)	0.05	0.28	0.45	0.05	0.45	0.43	0.43	0.05	0.30	0.25	0.45	0.06	0.30	0.25	0.42	0.06

a: Values are expressed as average of 10 determinations
BD: Below detection level

stream water may have been due to the fact that the streams are located in areas exposed to domestic activities such as washing of dirty clothes, bathing and dumping of household refuse. Adeisyun *et al.* (1983) has attributed these factors amongst others to the contamination of private and public well water in Katsina. The fact that all the samples analysed were sources of drinking water available to the residents in the areas under study is of epidemiological significance as water-borne disease outbreaks may result from their consumption. This is because of the large population they serve compared to those that drink the Regolis water (control) which has been found in preliminary experiments and this study to meet the USEPA and WHO standards for potable water.

The results of chemical analysis of the samples of some sources of drinking water in Akwa Ibom State showed that apart from lead, iron and copper whose concentrations slightly exceeded the recommended levels for potable water (WHO, 1971), all other parameters were within acceptable limits. It has been shown that consumption of water contaminated by metals like lead, even in low concentration, may result in cumulative poisoning (Freedman, 1977). With increased concentrations of these metals (lead, iron and copper), the risk of chemical poisoning, which may result from the toxicity of these metals from long-term consumption cannot be ignored. Also, the fact that no residual chlorine was detectable in tap water indicated that tap water in the State is not chlorinated, hence the presence of the micro-organisms in the water samples.

It can be concluded therefore, that after the United Nations declaration of the 1981 – 1991 as the United Nations Water Sanitation decade, little or no impact has been made on the quality of the sources of drinking water in Akwa Ibom State, in particular and Nigeria in general. Strict adherence to the recommendations of the WHO and the US Environmental Protection Agency, as regards provision of potable water and the strict implementation of the recommendations of the UN General Assembly on the improvement of water and sanitation standards will help to eliminate the possible effect of consumption of substandard water.

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