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Quality of Drinking water Sources and Associated Health Problems in Calabar, Nigeria

***EMILE F. ASUQUO; EKAETE F. ASUQUO,**

*Chemical and Pollution Research Unit, Institute of Oceanography, University of Calabar., Calabar
Department of Medical Services, University of Calabar, Calabar , Nigeria

ABSTRACT: Water quality assessment of the different sources of drinking water in Calabar Municipality, South Eastern Nigeria, have shown that all the samples analysed were faecally contaminated . The samples also contained other pathogenic organisms such as *Vibrio Cholera* , *Salmonella typhi* and *Shigella dysenteria* in relative proportions. Results indicate that some of the samples had distinct colors (> 50 Pt Co units), high acidity (pH 4.0 - 5.5) and high coliform counts (3 or more *E. Coli* counts per 100 ml) when compared with the recommended limits. This suggests that consumption of water with high acidity (low pH) may lead to an increased gastric juice content of the stomach thereby predisposing victims to ulcer cases in addition to the dominant typhoid cases already prevalent among menfolk © *JASEM, 1999.*

Potable water for domestic use should be free from pathogenic micro-organisms (e.g V. *cholerae* , *S. typhi*) and toxic substances such as heavy metals, hydrocarbons and humic acids. For esthetic appreciation, drinking water should be odorless, tasteless , colorless and devoid of particulate matter . Good quality water for human consumption is scarce but it is a prerequisite for a sound and healthy living.

Calabar is one of the developing cities, south of the River Niger. The water resources potential of Calabar include the Cross river, Calabar river and Great Kwa river and a high ground water yield of 20 - 50 l/sec/km^2 (RUWASA, 1992). Oceans, streams and rivers are susceptible to environmental pollution arising from anthropogenic inputs of domestic sewage, agricultural and industrial wastes or through seepage (Reitler, 1955; Slanetz et al ,1965; Yoshpe-purer and Shuval ,1970) therefore not reliable for domestic use. Presently, there is no sewage treatment plant in the city. Domestic sewage percolating through the soil strata may return back to receiving water bodies thereby contributing to increased pollution. Water enriched with pathogenic organisms may in turn become a source of water for another community and this poses a health risk to the consumers.

There is a high demand for potable water which have not been met by the State Water Board as their services are irregular and when available can hardly be used for domestic purposes due to poor quality (Eja, 1998). The scramble for clean water exposes consumers to the hazard of fetching any available "clean" water regardless of the source. During the rainy season, only private boreholes and direct rain (rain water harvesting) are the principal sources of domestic water as most streams are rendered very turbid due to erosion of surface soils into them. On the other hand, water from most boreholes are sold without appropriate treatment. Shuval (1970) reported that most pathogens such as those which cause intestinal tract infections namely typhoid and paratyphoid fever, dysentery (bacillary and amoebic) and cholera are transmitted through water. Previous studies on quality of water bodies around Calabar are few (Asuquo, 1989; Akpan and Offem , 1993, Ejah , 1998). This paper presents the quality of drinking water sources (boreholes and stream) in Calabar , the associated health problems and the potential sources of contamination.

MATERIALS AND METHODS:

Physicochemical analysis:

Nine water samples were collected from 8 boreholes (BH) and 1 stream selected randomly between October and November, 1997 (Table 1). Dissolved oxygen (DO) was measured using Handy Oxyguard instrument, precision ± 0.1 mg/l. Temperature was measured using the same equipment and read to 0.1 °C. pH was determined with WTW pH meter, ± 0.01 units while conductivity and total dissolved solids (TDS) were measured using a conductivity meter with temperature sensor (HACH Company, USA) all insitu. Nutrients (nitrates, sulphates, phosphates and silicates) and Fe were measured using HACH 2000 spectrophotometer according to APHA (1985). All physicochemical measurements were carried out in duplicates for quality assurance (Coefficient of Variation, CV< 4 %).

*Corresponding Author

Microbiological analysis:

Samples for bacteriological analysis were collected in sterile 1liter plastic bottles and transported in an air-tight polythene bag to the laboratory for analysis within one to 1½ hours. Samples were collected in accordance with the recommended procedures (APHA ,1985). . Quantitative tests were conducted by adopting the membrane filtration method (APHA ,1985). All the colonies that developed on the membrane were counted and the number of bacteria per milliliter of sample calculated.

Biochemical tests were conducted on all samples. Qualitative examination involved the use of highly selective environments such as Macconkey agar for E. Coli, TCB (Thiosulphate Citrate Bile salt agar) for Vibrio and DCA (Deoxy Chocolate Citrate agar) for shigella and salmonella (APHA ,1985). A positive result was the presence of recognizable colonies such as yellow/green for vibrio, black for salmonella, white strips for shigella and pink for E. Coli on the plates. Standard cultures of *E. Coli* and *V. Cholerae* from Microbiology Laboratory of The Polytechnic , Calabar were used as controls.

RESULTS AND DISCUSSION:

Water quality for domestic use is better assessed by determining the levels of physicochemical parameters (Table 1) and bacteriological parameters (Table 2) and comparing the observed data with acceptable and recommended limits.

Physicochemical parameters:

The results indicate that the levels of physicochemical parameters determined were within acceptable limits (WHO ,1984) except pH . The mean pH values were low for Ekpo Abasi (pH 4.4) , Uwanse stream (pH 4.8) , Yellow Duke BH (pH 5.3) and Mbukpa BH (pH 5.4) indicating high acidity (Table 1). Demineralisation of buried organic matter in the soils releases CO_2 as a bye-product. Therefore, underground waters draining

through such substrates leach the trapped CO_2 thereby contributing to increased acidity of the aquifers. Free CO_2 may also be present as a result of erosion of $CaCO_3$ deposits by underground water. The low pH in the stream is attributed to the presence of humic acids . Consumption of acidic water (low pH waters) is potentially dangerous since it can increase the acidic content of the stomach which may result in peptic ulcer in some cases.

Table 1: *Physicochemical Quality of drinking water sources from Calabar Municipality (October to November 1997).

Location/ Parameters	pH	DO Mg/l	Temp °C	Cond. µS/cm	TDS mg/l	Salinity mg/l	E^H Mv	Color mg/l PtCo	NO_3 mg/l	SiO_2 mg/l	SO_4 mg/l	Fe mg/l
WQA-1	6.0	6.9	29.5	134.5	67.1	87.4	2	0	1.38	16.8	6.8	0.1
WQA-2	6-7	7.1	31.0	40.3	20.0	26.2	-73	0	0	28.34	2.03	0.1
WQA-3.	7.5	5.7	31.2	459. 0	229.5	298.4	-139	88	0	30.24	230.9	5.3
WQA-4	6.0	6.8	28.9	115.7	55.8	75.2	-34	0	0	28.35	5.8	0.1
WQA-5	7.2	0.9	28.5	396.0	198.1	257.4	-125	92	0.03	30.45	199.2	4.7
WQA-6	5.4	5.6	29.3	142.0	70.9	92.3	-25	21	1.38	31.5	7.14	0.3
WQA-7	4.2	6.2	29.9	254.0	127.0	165.1	36	42	0	10.5	196.6	0.5
WQA-8	5.3	5.7	29.8	198.1	98.7	128.8	-24	25	1.18	8.4	1750.0	0.3
WQA-9	4.8	4.3	28.5	141.5	71.0	92.0	11	10	1.35	25.2	7.12	0.3

Key: WQA : Water Quality Assessment; WQA - 1 = Ikot Ekpo BH (8 miles); WQA - 2 = Ikot Anisn BH ; WQA - 3 = Water Board Marian Road;
WQA-4 = Housing Estate BH Marian Road; WQA - 5= Housing Estate Tap Water ;WQA - 6 = Mbukpa BH; WQA - 7 = Ekpo Abasi BH ; WQA - 8 = Yellow Duke BH; WQA - 9 = Uwanse Stream .
(*Results were obtained from duplicate measurements and analysis. CV < 4%)

Table 2: Counts of pathogenic organisms in drinking water sources from Calabar Municipality.

Location	E. Coli counts/ 100ml H_2O	Vibrio counts/100ml	Salmonella counts/100ml	Shigella counts/100ml	Total Isolates/ sample
WQA - 1	4	2	3	1	10
WQA - 2	3	2	1	1	7
WQA - 3	2	4	3	2	11
WQA - 4	5	3	-	-	8
WQA - 5	3	2	2	3	10
WQA - 6	4	2	2	2	10
WQA - 7	2	3	2	3	10
WQA - 8	4	2	-	-	6
WQA - 9	3	4	3	3	13
* Σ Pi	30	24	16	15	-

* Σ Pi - Sum of individual pathogenic organisms.

The intense coloration of Water Board and State Housing samples (> 15 Pt Co units) are due to contributions from corroded storage tanks and metal pipes through which the water are circulated and distributed to consumers. Asthetically, colored waters are unacceptable and distasteful. It is unsuitable for either drinking and other domestic applications . Such waters are rich in particulate materials which can act as substrates for helminths, microbes and malaria vectors such as mosquitoes.

Dissolved oxygen (DO) levels above 5.0 mg/l are indicative of an oxidised state (Asuquo ,1998). The DO measured ranged from 0.9 to 7.1 mg/l. The lowest mean value of 0.9 mg/l measured in tap water (Housing Estate) showed that the water had stayed relatively long (overnight) in the pipelines without contact with air. Such can support the growth of anaerobic micro-organisms. Good quality water suitable for domestic use should be well aerated in order to reduce the incidence of bacterial infection.

Waters with conductivities above 2000 µS/cm (WHO ,1984) have an associated health risk except they are desalted by conventional methods (desalination). Higher conductivities of Water Board (459.0 µS/cm) , H. Estate tap water (396.0 µS/cm) and Ekpo Abasi BH (254.0 µS/cm) indicated a high proportion of the contamination of the aquifers by salt water intrusion . Elevated salt level in the body may give rise to hypertension due to increased blood pressure. This could worsen the condition of children with kidney affectation such as nephrotic syndrome.

Fe levels exceeded the permissible limit (0.3 mg/l) for drinking water (WHO ,1984). The most contaminated sources of water supply were Water Board (5.24 mg/l) and Housing Estate tap water (4.75 mg/l) respectively. Iron accumulation in biological system is dangerous as it could lead to iron intoxication (poisoning) and suffocation especially the reduced form (Fe^{2+}) . The redox potential , e^{H} of the water sources were particularly low (primarily negative) . The low value infers the higher potential and tolerance of the water sources to accumulate toxic materials such as divalent cations (Fe^{2+},Cu^{2+} etc) and pathogenic organisms . This deduction conforms with the highly positive and significant relationships between Fe / e^{H} , r = 0.92, pH / e^{H} , r = 0.80 ; salinity / e^{H} , r = 0.85 at $P < 0.01$, as observed during this study (Table 3).

Table 3: Regression Equation for the relationship between e^{H} (Y - variable) and selected water quality parameters (X - variable) for the water sources analysed.

Location	X- Variable	Correlation Equation	R
Cal. Municipality	pH	Y = - 160.5 + 36X	0.80*
"	DO	Y = - 30.7 + 13.5X	0.25
"	Temperature	Y = - 523.2 + 19.4X	0.38
"	Conductivity	Y = 35.5 + 0.02X	0.58
"	Fe	Y = 23.1 + 21.8X	0.92*
"	SO_4	Y = 25.2 + 0.23X	0.56
"	SiO_2	Y = - 12.1 + 2.75X	0.50
"	Salinity	Y = 22.4 + 0.03 X	0.85*

* Correlations were significant at $P < 0.01$.

Bacteriological Examination of Water samples:

The results and level of bacterial contamination of the water samples analyzed are shown in Table 2 for numerical estimates and Table 4 for biochemical characteristic of isolates.

By the international drinking water standard (WHO ,1984), potable water should contain zero *E. coli* and should not contain more than 10 total coliform per 100 ml. This study has revealed that all the samples analysed contained 2 or more *E. coli* indicating faecal contamination. Housing Estate BH samples contained more counts (5 coliform per 100 ml) than the other sources depicting a higher level of contamination. It was observed that all the water samples contained bacteriological parameters in relative proportions. Their presence were confirmed by biochemical examination of the water samples (Table 4).

Table 4: Morphological and Diagnostic biochemical characteristic of the isolates.

Organism/ Isolates	Colonial morphology	Gram Rxn	Motility	Catalase	Oxidase	Indole	Methyl Red	V.P	Glucose	Lactose	Mannitol
Vibrio	Yellow or green colonies on TCBs agar, 0.1-0.3mm	-ve curved rods	+	+	+	+	+w	±	+	-	+
Salmonella	Pale colonies with black dot on DCA, 0.2-0.3mm	-ve	+	+	-	-	+	-	+	-	+
Shigella	Pale colonies with white stripe on DCA, 0.2-0.3mm	-ve	-	+	-	-	+	-	+	-	±
E. Coli	Pink colonies on macconkey agar, 0.2-0.4mm	-ve	+	+	-	+	+	-	+	+	+

Key: -Ve = Gram negative (pink color); +ve = Gram positive (purple or black color); + = Positive;
- = Negative
+w = weakly positive ; ± = Variable
v.p = Voses Proskaver Test.

These suggest contamination from diverse sources such as discharge and seepage of domestic sewage into underground water, addition of contaminated surface soil to streams during periods of rainfall , use of flat and open water tanks which can serve as receptacles for bird faeces, another carrier of these pathogens apart from humans (Reitler , 1955), non-flushing and washing of reservoir water tanks for several months and faeco-oral contamination of drinking water marketed by roadside "pure water" hawkers. Contamination of water from these sources are often overlooked but they probably constitute a major threat to the suitability and acceptability of drinking water.

Assessment of the prevalence of water borne diseases between 1995 and 1997 (period of study) showed that typhoid cases were the most abundant (Table 5). Men were more susceptible than women and children. This could be possible because men tend to consume more fluid arising from lost of water from hard jobs and are the ones that greatly patronise roadside hawkers of "pure water" and "mama put" sellers. The water quality deterioration suggests contamination from nearness of boreholes to septic tanks which permits seepage of domestic sewage into underground water, addition of faecally polluted soils to streams during periods of rainfall and the use of flat and open water tanks which can serve aseceptacles for bird faeces. Most food sellers may be potential typhoid carriers since the sanitary standard expected of such ventures are often not met by the food sellers and also food quality cannot be guaranteed. Therefore, regular monitoring and certification of commercial borehole operators in addition to proper screening of water and food sold by roadside hawkers are recommended since the latter can be potential typhoid carriers. The drinking water sources require the services of a water works treatment facility.

Table 5. Typhoid occurrences in males, females and children in Calabar between 1995 and 1997.

Months	No. Of Males	No. Of Females	No. of Children.	Tested Positive
August '95	31	19	-	+
September '95	25	9	-	+
October '95	36	22	9	+
December '95	9	6	3	+
November '96	31	20	-	+
December '96	29	22	5	+
January '97	51	47	13	+
February '97	47	46	11	+
November '97	25	15	3	+

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REFERENCES:

Akpan ER., Offem JO (1993) Seasonal variation in the water quality of Cross River, Nigeria. Rev. Hydrobiol. Trop. 26,95 - 103.

American Public Health Association (1985) Standard methods for the examination of water and waste water. 16th Edn. APHA. Washington.

Asuquo F E (1999) Physicochemical characteristics and anthropogenic pollution of the surface waters of Calabar river, Nigeria. Global J. Pure and Applied Sc., 5, 595 - 600.

Asuquo F E. (1989) Water quality of the Calabar river, Nigeria. Tropical Ecology 30, 31-40.

Eja ME. (1999) Seasonal occurrence of enteric bacterial pathogens in Calabar Municipal Water supplies. Global J. Pure and Applied Sc., 5 , 37 - 40.

Federal Environmental Protection Agency (FEPA) Decree (1988) National Guidelines and standards for industrial effluents, gaseous emissions and hazardous waste management in Nigeria, 15-34.

Reitler R (1955) Salmonellosis in migratory birds. Acta Med. Orient. 14, 52.

RUWASA (1992) Water Supply Status and requirements of rural communities in Cross

River State of Nigeria by Rural Water and Sanitation Agency (RUWASA), 14p.

Shuval H (1970) Detection and control of entero-viruses in the water environment. In: Developments in water quality Research, Ann Arbor Humphrey Science Publishers, 47 p.

Slanetz L W., Bartley C H., Metcalf T G (1965) Correlation of coliform and fecal streptococcal

indices with the presence of salmonellae and anteri- viruses in sea water and shell fish. Adv. Water Pollution Res., 12(3), 27-41.

WHO (1984). Guidelines for Drinking water Quality (III). Health criteria and supporting information. World Health Organisation, Geneva, 62 - 315.

Yoshpe - Purer Y., Shuval H I (1970) Salmonellae and bacteria indicator organisms in polluted coastal water and their hygienic significance. FAO Technical conference on marine Pollution and its effects on Living resources and fishing, Italy, 15.