JASEM ISSN 1119-8362

Full-text Available Online at
www.bioline.org.br/ja

J. Appl. Sci. Environ. Mgt. 2005
Vol. 9 (1) 135 - 141

Potability of Drinking Water in an Oil Impacted Community in Southern Nigeria

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ABSTRACT: Microbiological and physicochemical analyses of borehole water samples from Eastern Obolo Local Government Area of Akwa Ibom State were conducted to ascertain their potability. Seven bacterial species were isolated and identified. These included *Bacillus subtilis, Enterococcus faecalis, Staphylococcus aureus, Clostridium perfringens, Pseudomonas aeruginosa, Micrococcus varians* and *Escherichia coli.* The viable bacterial count ranged from $5.2x10^4$cfu/ml to $15x10^4$cfu/ml while the total coliform count of the water samples ranged from 2 cfu/100ml to 51 cfu/100ml. The most frequently occurring bacterium was *Enterococcus faecalis* (22%) while *Escherichia coli* was the least (7%). Some physicochemical parameters like iron and mercury in some boreholes did not meet World Health Organization (WHO) standard for potable water. High counts of indicator bacteria also constitute a threat to public health. @JASEM

Water for human consumption must be free from all objectionable odour, turbidity, taste, enteric pathogenic bacteria or their indicators and must not fluctuate in its quality (Dawson and Sartory, 2000). Okafor (1985) reported that the sanitary quality of water is the relative extent of the absence of suspended matter, colour, taste, unwanted dissolved chemicals, bacteria indicative of faecal pollution and other aesthetically offensive objects. In safeguarding public water supplies therefore, public health authorities and engineers rely on information obtained from the results of frequent bacteriological test. Itah *et al.,* (1996) reported that in bacteriological water analysis, the recovery of conventional indicator bacteria such as the coliforms, *Escherichia coli* (faecal coliform), faecal enterococci and anaerobic endospore forming *Clostridium perfringens* (Welchii) provides a reliable means of assessing the extent of pollution as their presence is indicative of a possible presence of enteric pathogenic bacteria in such waters. These views have been shared by earlier investigators (Wheather *et al.,*1980 and Okafor, 1985). Apart from biological pollution, toxic chemicals from domestic and industrial waste are discharged into these water bodies. In this way underground waters become contaminated by chemicals like pesticides, herbicides and fertilizers applied by farmers on the farm. Poisonous chemicals and heavy metals generated from oil exploration activities are known to percolate the layers of the earth and terminate in underground waters. Such contaminated water constitutes public health hazard when consumed. A number of water borne epidemics have been documented in both European and tropical countries (Kim and Stone, 1980, Itah *et al.,* 1996). In Europe, for instance, Hamburg cholera epidemic of 1982 and Croydon typhoid fever outbreak of 1937 were each spread by contaminated town water supply systems.

This work aims at establishing the potability of drinking water sources in a known Crude Oil Impacted Community, the Eastern Obolo Local Government Area of Akwa Ibom State.

MATERIALS AND METHODS

Description Of The Study Area: Eastern Obolo Local Government Area is a coastal community in Akwa Ibom State under great tidal influence from the Bight of Bonny (Figure 1). Before its creation in December 1996, it was part of Ikot Abasi Local Government. It is bounded by Oruk Anam L.G.A. in the North, in the South by Mkpat Enin L.G.A., in the East by Ikot Abasi L.G.A. and the West by Onna L.G.A. The area is mostly riverine and the residents are artesanal fishermen principally involved in offshore pelagic fishing and peasant farming (Personal Communication with Chief Douglas George Ekperikpe, compound chief and Community leader in Iko Town). The chief confessed total absence of fresh water in the entire L.G.A. making them to totally depend on locally made water borehole as their only source of water for drinking and domestic uses. It was also gathered that the water is usually salty particularly in the dry season due to serious tidal influences as the communities are located quite near the Atlantic Ocean. A visit to these areas will reveal a total neglect of a people whose mineral resources have been exploited by government.

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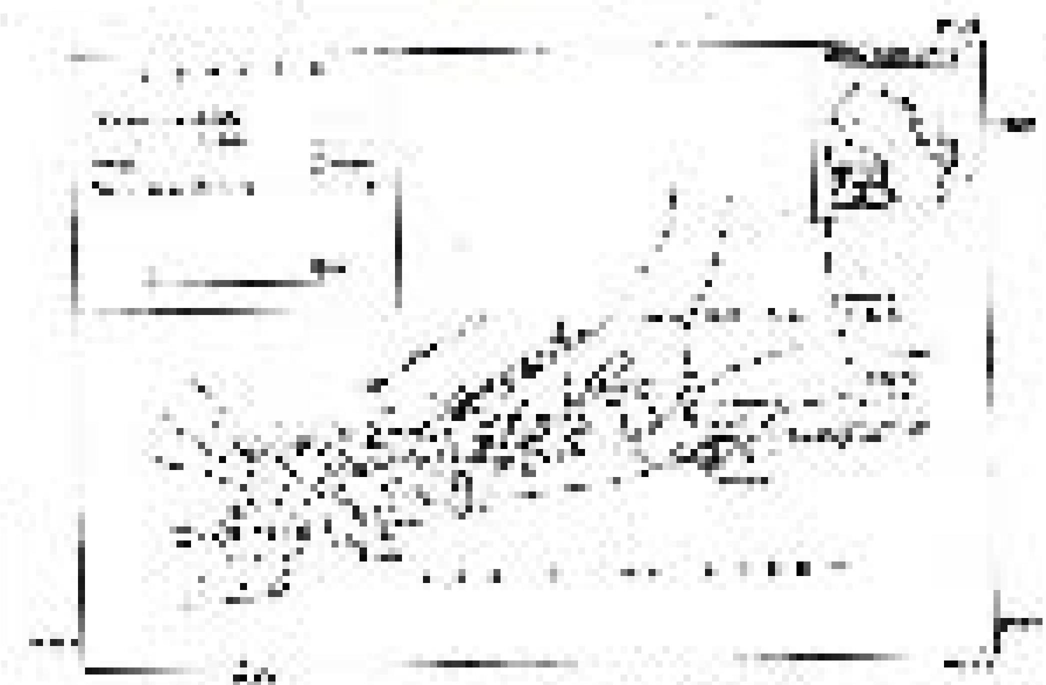

Sample Collection: Water samples for microbiological analysis were aseptically collected from bore holes in communities like Ayama, Elille, Utapate, Ikonta, Okoroete, Okoroiti and Iko Towns using sterile 1000cm^3 sampling bottles. Separate similar containers were used for samples meant for physicochemical analysis.

Physicochemical Analysis: This was carried out as earlier reported (American Public Health Association,1989; Itah *et al* ., 1996 ; Itah and Ekpombok , 2004).

Microbiological Analysis: The Membrane-filtration (MF) technique of Itah *et al.*, (1996) was employed in this work. Briefly, 100ml of each aseptically collected water sample was millipore-filtered using 0.45µm pore size membrane filter (Millipore Corporation, England). After filtration, bacteria were retained on the membrane filter. The whole filter for each sample was then aseptically transferred onto absorbent pad previously soaked in membrane lauryl sulphate broth (Oxoid Ltd, England) using sterile forceps. The culture plates were incubated upright at 37^{o}C for 24-48h and used for enumeration of total coliform organisms. Other plates were incubated at 44$\pm$0.5^{o}C in a thermostatically controlled water bath (Gallenkamp, England) for 48h. After incubation, bacterial growth colonies were counted using a colony counter and coliform density (cfu/100ml) expressed according to the relationship.

$$CD = \frac{CC}{V_w} x100$$

Where CD = Coliform density; CC = Coliform colonies and V_w = Volume of water sample

Direct microscopic count (cfu/ml) was also carried out on plate count agar (Oxoid Ltd, England) to determine the general pollution status of each sample using aliquots of diluted sample and the pour plate technique.

Purification, Characterization And Identification Of Isolates: 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

Viable Plate Count (VPC): The results revealed the presence of viable bacteria in the range of 5.2x10^4 to 1.5x10^{5}cfu/ml (Table 1) while the total coliform count ranged from 2 to 51 cfu/100ml (Table 2). The isolates were *Bacillus subtilis, Enterococcus faecalis, Staphylococcus aureus, Clostridium perfringens, Pseudomonas aeruginosa*, *Micrococcus varians* and *Escherichia coli*. The water samples from boreholes located at Iko Town were the most polluted as all the isolates were encountered. The only coliform organism encountered was *Escherichia coli*. The coliform density ranged from 2 cfu/100ml at Ikonta Town to 51 cfu/100ml at Ayama. The most frequently occurring organism was *Enterococcus faecalis* (22%) followed by *Pseudomonas aeruginosa* (19%) while the least was *Escherichia coli* (7%)(Fig.2).

Table 1: Total Viable Plate Count of Bacterial Isolates from the Borehole Water studied

Sample Locations	Bacterial Counts ($x10^4$ cfu/ml)
Ayama	12.0
Okoroete	13.1
Elile	11.0
Utapate	12.0
Okoroiti	5.2
Iko Town	15.0
Ikonta	8.0

Table 2: Total Coliform Count and Coliform Density from the borehole water samples

Sample	Volume of Sample Filtered (ml)	Coliform Count cfu/100ml	Colony Density
Ayama	100ml	51	51
Okoroete	100ml	18	18
Elille	100ml	11	11
Utapate	100ml	15	15
Okoroiti	100ml	34	34
Iko Town	100ml	25	25
Ikonta	100ml	2	2

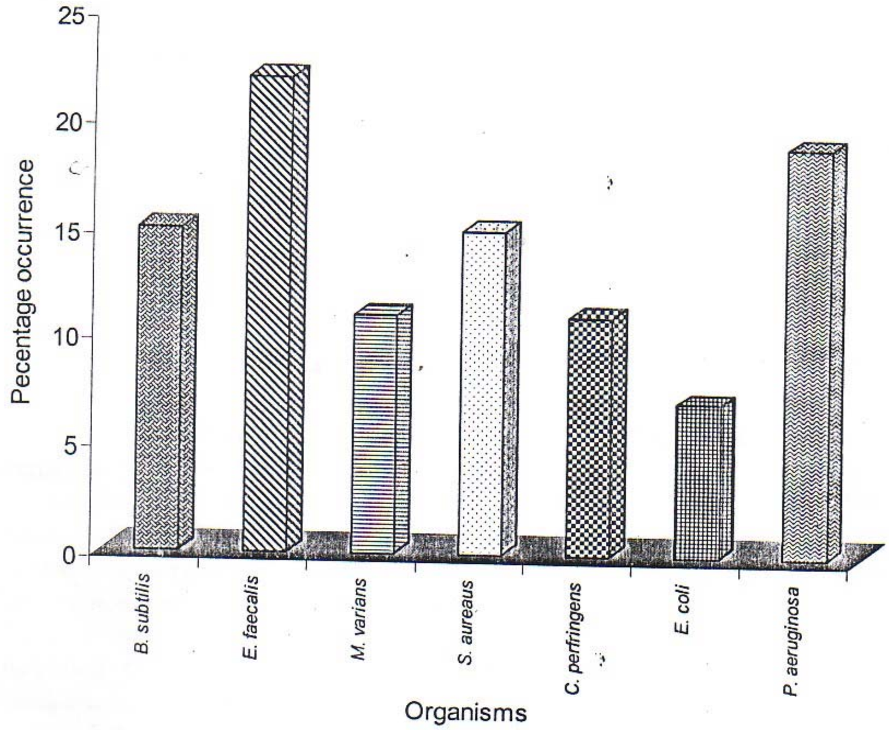

Fig. 2: Percentage occurrence of Bacterial isolates from borehole water samples in Eastern Obolo LGA

Physicochemical And Heavy Metal Analysis: The results revealed the marshy odour of water samples from Ayama, Okoro-Ette, Elille, Utapate, Okorotti, Iko Town and Ikonta against the odourless characteristics recommended by WHO (1993). While temperature, total hardness, BOD_5 at 20^oC, Dissolved Oxygen, pH, magnessium and chlorine were within normal ranges of 20^oC to 30^oC, 100mg/l, 10mg/l, 15mg/l, 6.7 to 8.5, 150mg/l and 200mg/l respectively for all the borehole water samples investigated. In appearance (visual observation) only water samples from Iko Town and Ikonta met the prescribed characteristics of clarity. While those from Ayama and Okorotti were pale with brown deposits, those from Okoroette, Elille and Utapate were pale without deposits. The turbidity level was high in samples from Iko Town (37.6^oH) as against the recommended standard of 25^oH minimum. The levels of calcium in Ayama (24.8mg/l), Okoroette (27.3mg/l), Iko Town (9.2mg/l and Ikonta (10.52mg/l) were higher than the WHO recommended standard of 7.5mg/l (Table 3). It can be seen from Table 4 that all the bore hole water samples contained all the heavy metals investigated at varying concentrations: They were Iron, Lead, Nickel, Copper, Cadmium, Manganese, Zinc, Vanadium and Mercury. The iron content of water from Ayama (2.01), Utapate (2.0) did not meet the minimum standard of 1.0mg/l. The cadmium content for Utapate (0.008), Okoroiti (0.01), Iko Town (0.01) and Ikonta (0.02) were also higher than the 0.005mg/l recommended. High levels of mercury were also detected in samples from Ayama (0.49), Okoroette (0.5), Utapate (0.5) and Iko Town (0.5) against the WHO recommended value of 0.05mg/l. High level of Vanadium was detected in samples from Ikonta (0.6) against the recommended 0.05mg/l. Other results were within the WHO (1993) standard.

Table 3: Physicochemical Analysis of the Borehole Water Samples from Eastern Obolo L. G. A., A.K.S.

	Parameters	WHO Standard	Ayama	Okoro-Ete	Elille	Utapate	Okoroiti	Iko Town	Ikonta
1	Odour	Odourless	Marshy	Marshy	Marshy	Marshy	Marshy	Marshy	Marshy
2	Temperature	20°C-30°C	22.3°C	24.9°C	25.2°C	25.8°C	25.2°C	27.2°C	22.3°C
3	Appearance	Clear	Pale with brown deposit	Pale	Pale	Pale	Pale with brown deposit	Clear	Clear
4	Total Hardness	100mg/l	3.0	18.0	5.0	3.0	3.2	4.0	3.0
5	Biochemical Oxygen Demand (BOD_5)	10mg/l	3.4mg/l	0.9mg/l	3.4mg/l	4.2mg/l	0.16mg/l	1.8mg/l	2.0mg/l
6	Dissolved Oxygen	15mg/l	0.01	0.01	0.01	0.08	0.01	0.5	2.0
7	Turbidity	25(°H)	21	4.68	15.74	6.75	2.99	37.6	4.52
8	Phosphate		0.0mg/l	0.2mg/l	0.01mg/l	0.03mg/l	0.08mg/l	0.08mg/l	0.10mg/l
9	Acidity		0.35mg/l	0.24mg/l	0.32mg/l	0.29mg/l	0.30mg/l	0.32mg/l	0.29mg/l
10	pH	6.7 – 8.5	7.0	7.2	7.2	6.3	6.0	6.2	6.0
11	Mg (mg/l)	150mg/l	0.41	3.32	1.65	4.6	0.7	3.05	0.1
12	Calcium	7.5mg/l	24.8	27.3	3.0	3.0	2.40	9.2	10.52
13	Iron (mg/l)	2.0mg/l	0.9	1.20	1.4	2.0	0.07	1.3	1.2
14	Chlorine	200mg/l	6.0	6.00	6.0	4.15	2.9	6.2	4.5
15	Total Alkalinity		0.60mg/l	25.0mg/l	0.51mg/l	0.60mg/l	10.2mg/l	21.0mg/l	0.06mg/l

Table 4: Heavy Metals Analysis of the borehole Water Samples from Eastern Obolo L.G.A., A.K.S.

Metal Ion (mg/l)	WHO Standard	Ayama	Okoro-Ete	Elille	Utapate	Okoroiti	Iko Town	Ikonta
Iron (Fe)	1.0mg/l	2.01	0.03	0.04	2.0	0.07	1.98	0.04
Lead (Pb)	5mg/l	0.02	0.03	0.02	0.02	0.01	0.03	0.03
Copper (Cu)	1.00mg/l	0.01	0.009	0.009	0.01	0.08	0.04	0.007
Nickel (N)	5.0mg/l	0.02	0.01	0.01	0.02	0.02	0.03	0.01
Cadmium (Cd)	0.005mg/l	0.005	0.005	0.005	0.008	0.01	0.01	0.02
Manganese (Mn)	0.10mg/l	0.02	0.07	0.06	0.06	0.05	0.02	0.07
Zinc (Zn)	50mg/l	0.03	0.03	0.03	0.02	0.03	0.03	0.01
Vanadium	0.05mg/l	0.017	0.02	0.02	0.02	0.05	0.01	0.06
Mercury (Hg)	0.05mg/l	0.49	0.5	0.0003	0.5	0.003	0.5	0.0003

DISCUSSION

The results of bacteriological analysis revealed the unsanitary condition of the water samples. The recovery of faecal coliform bacteria, *Escherichia coli* in some samples is of particular concern. The presence of *E. coli* in the samples implies faecal contamination of such samples and strongly suggests the possible presence of enteric pathogenic bacteria like *Salmonella typhi*, Salmonella paratyphi, *Vibrio cholerae*, *Aeromonas hydrophilla* and *Yersinia enterocolitica* (Itah *et al.,* 1996) as well as other parasites. The presence of *Enterococcus faecalis* in some water samples implies faecal pollution dating to remote period. The presence of *Clostridium perfringens* is similarly indicative of pollution for a very remote period as this organism is a microaerophilic endospore forming bacterium that can survive adverse environmental conditions for a long period unlike the extra enteral behaviour of *Escherichia coli* (faecal coliform). The results are in agreement with earlier reports by Itah *et al.,* (1996) in their studies on bacteriological and chemical characteristics of rural water supplies in Calabar and that of Agbu *et al.,* (1988) in Samaru, Zaria as well as Adesiyun *et al.,* (1983) in Katsina in terms of the high viable bacterial count and high coliform density obtained from this work. Samples containing indicator bacteria especially *E. coli*, high levels of coliform density and high viable bacterial count are unfit for human consumption. A special reference is made to samples from Iko Town which was found to be the worst contaminated. This is because according to WHO (1989), a coliform count of not more than 10 is recommended for unchlorinated water supplies while the presence of *E. coli* is intolerable and on no circumstance must it be found in water meant for consumption or domestic services. A high coliform index of 51 cfu/100ml and the presence of *E. coli* in some samples are therefore unacceptable.

Although some of the samples met physicochemical and heavy metal requirements, they failed to meet the minimum bacteriological standards, therefore were still declared unfit for human consumption, others like samples from Iko Town and Okoroiti failed to meet the minimum bacteriological and chemical standards having coliform counts of 25cfu/100ml and 34 cfu/100ml respectively. Other bacteria encountered were, *Bacillus subtilis, Enerococcus faecalis Staphylococcus aureus, Clostridium perfringens, Pseudomonas aeruginosa, Micrococcus varians* and *Esherichia coli* may have contaminated the water from various sources. This is because according to Uriah and Izuagbe (1990) most sanitary sewer lines are located in close proximity to water supply lines which traverse the septic tank absorption field. The sewer and the cast iron pipe used for transportation of water are subject to leakages. Sometimes accidental backflow or back sippage of polluted water from toilets and wash bowls may occur resulting in contamination of water supply pipes through leakages in supply line passing through the drain field. Faecal coliform (*E. coli*) may be introduced into borehole water in this way. In the same manner, water borehole located near pit latrines in the rural areas such as the one under investigation may receive high load of enteric pathogenic bacteria from the toilet through percolation to the borehole water level thus faecally contaminating the drinking water sources. Apart from enteric pathogens, *Staphylococcus aureus* encountered in this work is a known enterotoxin producer and food poisoning aetiologic agent (Itah and Opara, 1994 a; and 1997). They also exhibit multiple resistance to various antibiotics (Itah and Opara, 1994b).

Apart from the fact that most of the water samples failed to meet some aesthetic standards, the high level of chemicals and heavy metals in particular constitute a threat to public health. For instance a high level of Fe was obtained from this work. Humphries *et al.*, (1985) reported that Fe is a potent dietary antagonist of copper metabolism in ruminants hence may be injurious to health when found in above the WHO (1993) minimum recommended standard of 1.0mg/l as was the case in communities like Ayama, Utapate and Iko Town. However, within permissible limit, Fe is an important element required for the synthesis of haemoglobin during haemopoiesis in the bone marrow(Itah *et al.*, 1996). Mercury is known to bio accumulate (Cornell *et al.*, 1992) and therefore poses a great health risk to humans especially in the form of methyl mercury. In water it is often transformed by micro-organisms into toxic methyl mercury whose symptoms include acute pharyngitis, vomiting, gastroenteritis, nephritis and chronic poisoning which may result in liver and neural damages and tetratogenesis. Lead has been known to cause spontaneous abortion in humans when in excess (Horsfall and Spiff, 1998). Although none of the samples contained Mn in excess of the recommended standard, it is pertinent to point out that manganese contamination would result in neurological disorders in exposed persons (Tennant, 1981). It has been reported that headaches, involuntary movements, sleep, speech and gait disturbances as well as exaggerated reflexes significantly increase with increasing duration of exposure to Mn (Badawy and Shakour 1985).

The results of this work have revealed the unsanitary state of water consumed in this part of the country under study as most of the samples contained bacterial indicators of faecal pollution and harmful chemicals some of which were found to be above the recommended WHO (1989) and WHO (1993) standards for drinking water. They are therefore declared unfit for human consumption. It is relevant to recommend that concerned authorities should come to the aid of these helpless peasants by establishing at least a mini water works in the area for provision of potable water in view of the fact that these communities form part of the major off-shore oil producing coastal towns in Akwa Ibom State, Nigeria.

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