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Physicochemical, Bacteriological and Risk-to-Health Analysis of Drinking Water Quality in some Oil Producing Areas of Akwa Ibom State, Nigeria.

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Abstract

Drinking water quality from four oil producing areas of Akwa Ibom State were examined for physico-chemical, microbiological parameters and their implications to the health of the inhabitant. Statistically based cluster sampling method was used to implement field analysis of some selected water sources. Physical, sensory, chemical and bacteriological parameters of water samples were examined and compared with the World Health Organisation (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ) guidelines to ascertain their quality and suitability for drinking and domestic uses. The results indicated that the trend in physicochemical parameters was such that it clearly showed how negatively the water regime was stressed by pollutant generated from activities of Oil and Gas exploration. Water samples examined were tasteless and odourless while one sample with cloudy appearance was observed at HA1¬ area. All the samples were acidic with the pH range of 4.8-5.5 which is a complete violation of WHO and NSDWQ guidelines. All samples analysed showed low content of total dissolved, and suspended solids and conductivity were all within the WHO and NSDWQ specifications. The total alkalinity and hardness ranging from 68.2-105.5mg/l and 5.0-6.8mg/l respectively were relatively low as compared to the standards. The concentration of Chloride, Sulphate, Nitrate and Phosphate fell within WHO and NSDWQ tolerable limit although some samples had an elevated chloride concentration. The concentration of metallic ions such as Lead, Iron and Aluminium were relatively high while that of zinc, copper and manganese were low. The concentration of Aluminium at 230mg/l in HA3 area strongly violates the WHO and NSDWQ specifications for drinking water quality. All water samples analysed contained a huge load of coliform counts which strongly violate the drinking water standard. Drinking water samples examined are classified under high risk category since they are found to be unsafe for drinking and domestic uses..

Key words: Akwa Ibom, Drinking water, Health, Standards, Bacteriological, Quality.

Introduction

Water of drinking quality is of basic importance to human existence. Water is present in all part of the earth constituting up to ¾ of the entire surface (Tebutt, 1998). Despite the abundance of water in the earth surface, UNICEF (2000), reported that over 1 billion people in the developing countries do not have access to portable drinking water, even in some areas where water is treated, the level of treatment may not be sufficient. The consequence of this is the high prevalence of water borne and other infectious diseases. It has been reported that over 50,000 people die daily due to water borne diseases and mortality in children under five years from water related diseases annually is estimated to be about 4 million in developing countries (WHO/UNICEF 2006). Worst still, 2.3 billion people worldwide have mortality and morbidity associated with water related ailment (WHO, 1997). These statistics though alarming definitely have impact on developmental efforts (Olshanky et al., 1997). According to Oyeku et al., (2001), the high incidence of health related problems associated with water makes it vital that water for public use must be wholesome, clean, safe and must meet the acceptable standard.

Akwa Ibom State is one of the states in the Niger Delta region of Nigeria located at Latitude 4032' and 5033' North and longitude 7025' and 8025' East along the Atlantic coastline which stretches over 129km. The state host multinational oil and gas company whose exploration and exploitation activities have serious distortion on the

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ecosystem. This has led to the introduction of toxic gases such as carbon (iv) oxides, sulphur (iv) oxide, carbon (ii) oxide, carbon disulphide and other solid waste into the environment. This has resulted in damaging the primary water such as springs, rivers, lakes and other reservoirs and non availability of portable water to these areas have necessitated their heavy reliance on other sources for drinking, domestic, agricultural or recreational purposes. The frequent out break of infectious disease like cholera, dysentery, diarrhea, typhoid fever and acute respiratory infections in these areas have been attributed to lack of portable water and inadequate sanitation (Ukwo et al., 2011).

The general neglect in the provision of portable water and other basic amenities to the people living in this coastal area of the Niger-Delta region of Nigeria despite high level of oil and gas exploration and exploitation has led to increase research on the well being of the people of these areas (Ajayi et al., 2009, Ololade et al., 2008). The objective of this work is to assess the physiochemical, bacteriological and risk-to-health analysis of drinking water quality in some of the oil producing areas of Akwa Ibom State and compared it to the WHO and other standards. It is believed that this research will provide informations on the type of water contaminants prevalent in this areas if any and whether or not it is associated with Microbial activities or the exploitative or explorative activities of oil and gas industries. It will also provide a baseline set of data for future monitoring of the water quality in this area.

Materials and Methods

Study Area. This study was conducted in four (4) oil producing areas of Akwa Ibom State. These areas apart from being located outside the capital city, they also lie along the Southern Coastline with rivers and creeks adjacent to the Atlantic Ocean. The major primary occupation of people living in this area includes fishing, peasant farming, timber processing and water transportation. This area is noted for sea foods, which are consumed within and outside the state. The choice of the sampling area was based on the possible anthropogenic inputs from activities of oil and gas exploration and exploitation, transportation and farming activities.

Collection of Water Samples. These areas are mostly rural areas whose water supplies are boreholes with head pumps, and public stand pipes. Each stand pipe is generally intended to serve 250 people. For the purpose of this study, the area were classified into four (4) Hydrological Area (HA) (Table 1) in each area, cluster sampling were used to identify the number type and location of water supplies to be included in this assessment. Cluster sampling ensures that water supplies included in the study are geographically close to one another but are a representative of all water servicing stations. (Howard et al., 2003). Water samples were collected from serving points in 40 stations (10 from each area) into 2 litre bottles pretreated with 4M HNO3 and properly rinsed with de-ionised water and distilled water before used. The samples were properly labeled, stored in iced coolers (O0C) and transported to the laboratory where they were subjected to analysis within 24 hours of collection.

Table 1: Sampling Area and Code

Code	Sampling Area
HA_1	Okorette, Iko Town
HA_2	Uquo, Idung Okpokpo, Ebe Ekpi
HA_3	Inuayet Ikot, Owokpom, Ukpenekang
HA_4	Ewang, Okobo Ebughu, Udesi

Physical and Chemical Analysis Physical parameters such as colour, clarity, odour and taste were determined by the use of sensory evaluation panel according to the method of APHA (1992). Other parameters such as temperature, pH, conductivity were measured with pH meters and conductivity meters, respectively. The total Dissolved Solid (TDS), Total Suspended Solid (TSS) and Total Solid (Ts) were determined using standard methods. Total hardness and total alkalinity were also determine using standard methods (APHA 1992). The inorganic constituents such as nitrate, chloride phosphate and sulphate were also determined according to the method of APHA (1992). The level of metallic ions were determined for each sample by fixing 50ml of water sample in concentrated nitric acid to assist in digesting any particulate matter in the water sample releasing the metallic ions in a measurable form. Measurements were done using spectronic 2D spectrophotometer (APHA, 1992).

Microbiology Analysis Microbiological analysis included the identification, and enumeration of potential pathogens according to standard procedures (FDA, 2001). All the water samples collected were serially diluted with distilled water and plated on different media for enumeration of organisms. Total Viable Count (TVC) on nutrient agar, Total Coliform Count (TCC) on Violet red bile agar, Feacal Coliform Count (FCC) on eosine methylene blue agar, salmonella and xylose lysine deoxycholate agar was used for enumeration of salmonella. All plates were incubated under aerobic conditions at 36 ± 10C for 24hrs. The mean colonies counted were expressed as log colony forming units (cfu)/100ml.

Data Analysis Data obtained from physical, chemical and microbiological analysis were analysed by calculating the mean and standard deviation. The mean values were compared with water criteria of World Health Organisation (WHO) Akwa Ibom Water Company (AKWC) and Nigerian Standard for drinking water quality (NSDWQ).

Results and Discussion

The water samples collected for this study were used mainly for drinking and domestic purposes. The average

values for the physical and sensory parameters obtained in this study are reported in Table 2 for the four (4) hydrological areas. The result showed that sample HA1 was cloudy in appearance while other samples were clear in appearance. According to Goel (2006), the cloudy appearance of some water samples may be due to the presence of organic matter associated with the humus fraction of the soil. The cloudy appearance of some water samples was very visible in water samples collected in Iko town where "oil bunkering activities is very rampant. All the water samples were tasteless and odourless as specified by the standards of WHO, AKWC and NSDWQ.

The pH of all the water samples collected were low depicting water rich in organic matter, polluted and drainage from farm land, acid rain, and oil spillage due to oil and gas exploration and exploitation. Edu et al., (2010) reported similar result in her study on trace elements in ground and packaged water in Akwa Ibom State, Nigeria and suggested that the pattern of increased aluminium concentration and deposit may also be the cause of acidic ground water. The average pH range of 4.8 – 5.5 was obtained with lowest pH of 4.8 being quite lower than the WHO standard of 6.5 - 8.5.

Also the lower pH values can lead to corrosion of pipes, causing the release of toxic metals like Zinc, lead and copper in water. Higher acidity of water can also damage the mucous lining of tissues, increase scale formation in heating vessels, reduced the germicidal effect of chlorine and induced the formation of trihalomethanes (Nwidu et al., 2008).

The other concern for acidic ground water is that all the samples fall below the WHO standard for drinking water and based on this guidelines, non of the surveyed water sources are suitable for drinking. Other physical parameters like conductivity, total solid, dissolved solids and suspend solid were within the acceptable range for drinking water quality, although water sample from HA1 was higher than others.

According to Goel (2006), solid particle in water is an indication of contamination. He suggested that it may originate or may be introduce into the water as a result of human activities. This strongly suggests the need for proper treatment and filtration before the water is used.

Table 2: Average values for physical and sensory parameter of water

Parameter	HA_1	HA_2	HA_3	HA_4	AKWC	NSDWQ	WHO
Appearance	Cloudy	Clear	Clear	Clear	Clear	Clear	Clear
Taste	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless
Odour	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless
Temp (^OC)	28.7 ± 0.22	27.2± 0.11	28.5± 1.20	28.3± 0.24	Ambient	Ambient	Ambient
pH	4.8 ± 0.12	4.9 ± 0.10	4.8 ± 0.13	5.5 ± 1.15	5.01	6.9 – 9.0	6.5 - 8.5
Conductivity (us/cm)	69.5 ± 3.26	60.6± 5.85	63.8± 1.28	55.3± 6.32	19.4	4000	3000
Total Solid (mg/l)	48.2 ± 0.53	15.8± 0.12	18.7± 0.12	32.3± 0.42	100	500	200
Dissolved Solid (mg/l)	20.1 ± 0.22	7.2 ± 0.23	2.4 ± 0.33	18.0± 1.21	100	200	200
Suspended Solid (mg/l)	28.7 ± 0.51	6.6 ± 0.12	16.1± 0.23	13.4 ± 222	< 10	< 10	< 10

WHO = World Health Organisation
AKWC = Akwa Ibom Water Company treated portable water
NSDWQ = Nigerian Standard for Drinking Water 2007

Table 3: Average Values for chemical parameters of water samples

Parameter (mg/l)	HA_1	HA_2	HA_3	HA_4	AKWC	NSDWQ	WHO
Total Hardness ($CaCo_3$)	78.3 ± 0.31	68.2± 2.3	105.0 ± 0.81	75.5 ± 1.82	-	200	250
Total Alkanity	5.0 ± 2.2	7.2± 0.30	5.8 ± 0.52	6.8 ± 0.22		6.5-8.5	6.5-8.6
Chloride	102.2 ±1.51	85.2± 0.32	105.5 ± 0.33	25.5 ± 5.20	5	250	250
Sulphate ($S0_4$)	25.0 ± 0.32	17.5 ± 0.31	15.5 ± 0.32	29.3 ±1.82	100	100	100
Nitrate (NO_3)	5.2 ± 0.31	4.8 ± 0.20	3.8 ± 0.32	4.0 ± 1.50	50	50	50
Phosphate (PO_3)	0.5 ± 0.12	0.3 ± 0.24	0.6 ± 0.22	0.4± 1.00	3.50	3.50	3.50
Lead (Pb)	2.0 ± 0.32	2.2 ± 0.32	2.5 ± 0.36	2.3 ± 0.23	4.5	10	10
Iron (Fe)	25.5 ± 0.82	18.7 ± 3.2	27.5 ± 4.2	28.0 ± 2.40	17.7	300	500
Aluminum (Al)	185.0 ± 2.86	180.3± 8.73	230.2 ± 3.21	72.3 ± 2.62	9.1	200	200
Zinc(Zn)	75.5 ± 8.21	35 ± 12.23	25.3 ± 5.20	25.8 ± 2.52	2.1	300	300
Copper (Cu)	8.5 ± 3.2	9.5 ± 2.45	2.5 ± 0.65	15.0 ± 4.32	600	1000	1000
Manganase (Mn)	5.8 ± 3.45	6.23 ± 2.32	15.5 ± 2.30	20.4 ± 33	12.6	600	400

The average values for chemical parameters obtained in this study is reported in Table 3. The results indicated that the total alkalinity and total hardness ranges from 68.2 – 105.5mg/l and 5.0 – 6.8 respectively. These values fall below the standards recommended by WHO. Hardness of water is as result of metallic ions of calcium and magnesium which prevent leather formation and is unsuitable for brewing, and bottling of beverages as well as deposition of heat retarding scales on boiler equipments, thus resulting in higher energy cost (Tebutt, 1998).

The values for chloride, sulphate, nitrate and phosphate fell within the specification of WHO. The concentration of phosphate and nitrate were quite low while chloride and sulphate were slightly significant especially with sample HA1 and HA3. Chloride and sulphate concentrations in this area depict negative impact from the mixture of saline water from the Atlantic Ocean into the underground water. According to Nwidu et al., (2008), an elevated concentration of chloride in water give an undesirable salty taste and may lead to corrosion by extracting calcium to form salts. The level of nitrate present in water in this area is of concern. High nitrate content in drinking water is the source of blue baby disease in infants. This condition is a manifestation of destruction of oxygen carrying capacity of haemoglobin which turns the baby pale-blue (Abdus-Salam et al., 2010). Nitrate has also been reported to react with nitrogen forming compounds which when accumulate in the body at high level act as a potent carcinogens (Goel, 2006).

The data obtained for chloride, sulphate, nitrate and phosphate are high compared to data recorded on ground water quality at Idu-Uruan water headwork and the adjoining environment in Akwa Ibom State, a non oil producing area of the state (Ukpong, 2011) signifying the effect of pollution resulting from oil and gas exploration and exploitation in the study area.

The concentration of metallic ions such as Lead, Iron and Aluminium were relatively high while that of Zinc, Copper and Manganese were generally low in the samples analysed. The concentration of Aluminium in HA3 (230mg/l) was higher than that of WHO standard while that of HA1 (185mg/l) and HA2 (180mg/l) were significantly high although not above the standard recommended. It is of great concern to note that metallic ions analysed are either in elevated concentrations or in violation compared to the WHO guidelines values.

These result indicated the level of pollution in this area. Edu et al., (2010) reported elevated concentrations of certain metallic ions in ground water in Akwa Ibom State and suggested that the concentrations and distributions of element in ground water were generally influenced by the type of geological formation associated with the area, the type of plumbing and pipes as well as storage tanks. Ukpong (2011) in his study on the ground water at Idu Uruan water headworks and the adjorning environment in Akwa Ibom State reported no physiocochemical pollution in this area. It is worthy to note that Idu Uruan and the adjorning environment is not an oil producing area and therefore results obtained in this study would be probably due to oil and gas exploration and exploitation going on in this area.

There were elevate concentrations of Iron in water samples analysed. This may be attributed to corrosion of steel and cast iron pipes during water distribution (WHO, 2006). The mean range and distribution of Iron was found to be 18.0mg/l – 28.0mg/l. A deficiency of iron causes anemia, while an excess yields undesirable taste and gastrointestinal irritation (Rao, 2008).

There was no violations for manganese in water samples analysed with respect to WHO guidelines of 400mg/l. Manganese is particularly harmful to newborns and children.

Table 4: Average values of (log cfu/100ml) for microbiological analysis

Parameter	HA_1	HA_2	HA_3	HA_4
TVC	4.32 ± 1.32	4.32 ± 1.32	4.20 ± 2.41	3.8 ± 1.42
TCC	2.54 ± 1.22	3.10 ± 1.44	3.25 ± 1.62	2.81 ± 1.42
FCC	2.20 ± 1.00	1.32 ± 1.20	-	2.10 ± 1.22
Sal. C	-	-	-	-

TVC = Total Viable Count
TCC = Total Coliform Count
FCC = Faecal Coliform Count
Sal.c = Salmonela Count

Their exposure to elevated Mn level in drinking water during pregnancy may hamper the intellectual development of children. Elevated concentrations of Lead in water sample may be due to plumbing systems containing Pb in pipes, solder and fittings. Adverse neurotoxic effects which may be cancerous has been linked with Pb, therefore continuous exposure of people from this area to these concentrations of Pb is of great concern.

The results of bacteriological analysis of water samples, as shown in Table 4, indicated a huge load of pathogenic bacteria. All the water sample analysed had total viable count and total coliform counts above the level recommended by WHO. Results from three areas were positive to faecal coliforms. Similar results were reported by Edema et al., (2001) and Nwosu and Ogueke (2004) in their separate studies on the microbiological and physico-chemical analysis of drinking water in different part of the country. The results as obtained in this study indicate that water used for this study can be classified under the high risk category. This is due to the present of huge load of pathogenic micro-organisms. This is also an indication that water sources used in this study were not given adequate

treatment posing serious risk of water borne disease such as cholera, typhoid fever, dysentery and other.

Conclusion

The quality of water in these areas under examination were generally found to be unsafe for drinking and other domestic purposes compared to these from the urban areas of the state. There is high level of pollution attributed to oil and gas exploration and exploitation by oil companies. The presence of pathogenic micro-organisms in domestic water supplies represents a potential threat of water borne disease to the inhabitant of these areas. It is recommended that mini water treatment plants with facilities for basic laboratory analysis should be built for the inhabitant of this area by government and Multinational Corporations.

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