

Full Length Research Paper

Assessment of Heavy Metals Concentrations in Surface and Borehole Water in Core Crude Oil Producing Communities of Ibeno, Akwa Ibom State, Nigeria

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Physico-chemical and heavy metals analyses of surface and borehole water samples in core crude oil producing communities of Akwa Ibom State, Nigeria was carried out to ascertain the level surface and borehole water quality in the communities. The water samples were collected from (Mkpanak, Ukpenekeang and Inuayet Ikot communities in Ibeno Local Government Area of Akwa Ibom State. The parameters determined included: colour, odour, turbidity, temperature, pH, conductivity, alkalinity, Dissolved oxygen(DO), total dissolved solids (TDS), Nitrate, Chloride, Calcium and heavy metals such as Iron, Zinc, Manganese, Chromium, Lead and Cadmium using conventional equipment and standard laboratory procedures. Results obtained in surface and borehole water collected from core crude producing communities showed traceable pollution that were above the World Health Organization (WHO) and National Agency for Food and Drug Administration Control (NAFDAC) limits for consumption. The results indicate toxic pollution in surface and borehole water collected from core oil producing communities of Ibeno Local Government Area of Akwa Ibom State. Heavy metals concentrations recorded in surface and borehole water in core crude oil producing communities were above the WHO permissible level. This may be attributed to the activities of oil companies and indiscriminate dumping of wastes in their environment. The results showed that surface and borehole water in core crude oil producing communities (Mkpanak, Ukpenekeang and Inuayet Ikot) in Ibeno Local Government Area were all polluted and require urgent attention and high levels of treatment before use.

Keywords: Surface, Borehole water quality, Core Producing Communities, Ibeno LGA.

INTRODUCTION

Water is and has always been mankind's precious resource. It is recognized as the key environmental issue of the 21st century and a key to poverty alleviation (Hoffman, 2003). About 99% of the water on the planet earth is not suitable for human consumption and most of the water potential for drinking and domestic purposes are surface and underground water (Walter, 2011).

According to Macy *et al.*, (2007), water and sanitation are environmental health challenges facing developing countries. Lack of access to safe water and inadequate sanitation has an impact on individuals, households, communities and the countries. Where there is no clean water and proper sanitation in a community, millions of people suffer devastating diseases and millions of children die (Plate *et al.*, 2007). Diseases associated with unsafe water and inadequate sanitation affect poor people greatly. The gaps between the rich and the poor are attributed to the fact that environmental interventions have neglected sanitary needs. Interventions in water

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supply, sanitation and hygiene are the primary drivers of public health. They contribute greatly in the control of many diseases (Wordstone *et al.*, 2008). There is a link between poverty and water supply, for improvement of people's lives is not complete until there is provision of reliable, safe water supply. Most people living in crude oil producing communities in Ibeno are poverty stricken and do not have water security. They mainly rely on surface and borehole water sources for their daily needs. These surface and borehole water sources are under threat of pollution from oil exploration, exploitation and processing activities. Such pollution impact has remained unmeasured and ignored over the years in the core crude oil producing communities. The surface and borehole water in these communities are used without treatment, thereby posing serious health risk to the people (WHO, 2000). However, this study aim at examining the surface and borehole water quality in three different communities in core crude oil producing area in Ibeno Local Government Area of Akwalbom State (Mkpanak, Ukpenekeang and Inuayet Ikot) which are occupied by farmers, fishermen and petty traders.

MATERIALS AND METHODS

Study Area

Description of Study Site

The study area was conducted in three different communities of crude core crude oil producing communities of Ibeno Local Government Area of Akwa Ibom state. The communities are Mkpanak, Ukpenekeang and Inuayet Ikot. Ibeno, lies within latitude 5° and 6° N and longitude 4° and 5° E. Ibeno occupies the South-South part of Akwa Ibom State. It is bounded on the North by Esit Eket Local Government Area, on the West by Eket local government area and on the South by Atlantic Ocean. The area experiences the normal Niger Delta climatic conditions. The climate of the area is basically that of the equatorial tropical rainfall occurring almost through the year except in December, January and February, which are not completely free from rainfall in some years. The annual rainfall of the area is about 2,500mm (Bisong, 2011). Annual mean air temperature is 31.3°C; the highest monthly mean temperature was 29.7°C in (August), and the lowest monthly mean temperature is 27.5°C in (January). The major occupation of the people includes fishing and agricultural activities in the area. The four major oil companies operating in the area include Ashiland Nigeria Limited, Mobil Producing Nigeria, Shell development Company Nigeria and Nigeria Agip Oil Producing Company.

Drinking water problems in Ibeno Local Government Area is as a result of contamination of surface and underground water by oil companies. The high cost of treated bottled and sachet water in these communities,

make the poor farmers and fishermen to rely on surface and borehole water for their domestic and drinking purposes. Surface and borehole water serves as the major source of domestic and drinking water in the study area. The water is under threat of pollution due to crude oil activities, urbanization and industrialization that resulted from increase in municipal and industrial solid wastes.

Sample Collection and Preparation

At each of the three core crude oil producing communities studied (Mkpanak, Ukpenekeang and Inuayet Ikot), four surface and boreholes were randomly selected for water collection. The samples water was collected in triplicates from each borehole using white polyethylene bottles. The bottles were rinsed with water to be sampled prior to collection. Sufficient air spaces were left in all bottles except those for Dissolve Oxygen (DO) determination to allow for expansion of the water at increased temperature. In all cases, sampling bottles were used directly by holding the bottles horizontally and allowing the water to flow in gently, the bottles were gradually raised until it is sufficient. The pH was determined using the Hanna microprocessor pH meter. It was standardized with a buffer solution of pH range between 7.0. The temperature was determined in-situ at the site of sample collection using a mobile thermometer. This was done by dipping the thermometer into the sample and recording the table reading. The Dissolved Oxygen (DO) was determined by using the Winkler's Method (Ademoroti, 1996). The conductivity, Total Dissolved Solid (TDS) and salinity were determined in the laboratory using the Jenway Conductimeter model MC METTLER TOLEDO. The chloride was determined by argentometric method, and nitrate (NO₃) by UV spectrophotometric method (APHA, 1992). The Total Solids (TS), Dissolved Solids (DS) and Suspended Solids (SS) were determined gravimetrically (Ademoroti, 1996). Heavy metals in the borehole water samples were determined by atomic absorption spectrophotometry (ASS) (Unicam 919 model) (Skoog and West, 1980).

RESULTS AND DISCUSSION

The results of the physico - chemical properties of surface and borehole water samples collected from different communities in core crude oil producing areas in Ibeno, Akwa Ibom State of Nigeria is presented in table 1. The presence of colour and odour in water samples collected from these core crude oil producing communities (Mkpanak, Ukpenekeang and Inuayet Ikot) were an indication of pollution in surface and borehole water. According to (WHO, 2004) potable water must be colourless, odourless, tasteless and free from

Table 1. Mean values of Physico-chemical parameters of surface and borehole water samples collected in in three different core crude oil producing communities of Ibeno L. G. A

	MKPANAK		UKPENEKANG		INUAET IKOT		WHO	NAFDAC
	SURFACE WATER	BOREHOLE WATER	SURFACE WATER	BOREHOLE WATER	SURFACE WATER	BOREHOLE WATER		
Temperature (°C)	31.3	29.5	32.8	31.5	30.5	32.9	25-27	25-27
pH	5.10	5.30	4.90	5.00	5.20	5.5	6.5-8.5	6.5-8.5
Colour (TUC)	unobjectionable	unobjectionable	unobjectionable	unobjectionable	unobjectionable	unobjectionable	objectionable	objectionable
Turbidity (NTU)	7.20	6.50	6.90	7.10	7.15	6.70	5.00	5.00
Total dissolve solid (mg/l)	725.0	340.0	875.0	320.0	760.0	410.0	500	500
Dissolve oxygen (mg/l)	12.4	7.5	13.0	8.0	12.7	7.2	10	10
Biological Oxygen Demand (mg/l)	1.0	0.02	0.5	0.005	1.0	0.002	0.00	0.00
Calcium (mg/l)	96.6	78.0	87.2	72.5	90.0	68.0	75	75
Nitrate (mg/l)	14.4	5.7	12.9	7.5	13.5	6.25	10	10
Chloride (mg/l)	171.3	104.7	198.5	106.0	1555.6	100.5	100	100

objectionable and pathogenic organisms. The temperatures ranged of surface and borehole water samples Mkpanak community were (31.3°C and 29.5°C) respectively. While the temperature of surface and borehole water recorded in Ukpenekang community were (32.8°C and 31.5°C) respectively. The high temperature in surface and borehole water samples recorded in these communities signified presence of active microorganisms which resulted in the temperature increase. The high temperature values observed in these communities were above the acceptable range of 26.5°C to 27.5°C WHO and NAFDAC standard for drinking and domestic water, hence indicating the presence of foreign bodies in the water samples. Similar results were reported by (Akpabio and Ekpo, 2012) in their studies of water pollution in low income residential area of Uyo Akwa Ibom State, Nigeria. Pollution from crude oil spillage in the core crude oil producing communities may also be responsible for the high

values for temperature in the water samples analyzed. The turbidity readings of surface water samples in Mkpanak, Ukpenekang and Inuayet Ikot were 7.20, 6.90 and 7.15 NTU respectively. The turbidity readings in borehole water samples collected from these communities were above the WHO (2004) standards of 5.0 NTU. Presence of suspended particles and other materials are usually responsible for high turbidity values. The high turbidity values in surface water observed in the core crude oil producing communities may be an indication of crude oil pollution in the area. Adesina (2001) reported that high turbidity values in surface water may cause by erosion agent. However, it is sometime observed that organic materials may have found their way into surface from the surrounding environment thereby increasing turbidity of the surface water. The turbidity values of borehole water obtained from Mkpanak, Ukpenekang and Inuayet Ikot communities fall within the recommended

standards of 5.0 NTU (WHO, 2004)..

The pH values observed from surface and borehole water samples in core crude oil producing communities ranged from (4.90 to 5.50). The pH values in these communities were below the permissible levels of 6.50-8.50 recommended by NAFDAC and WHO. All surface and borehole water samples collected in core crude oil producing communities recorded some trace of alkalinity; alkalinity in water gives unpalatable taste (Goel, 2006). The chloride contents in surface water in the three core crude oil producing communities (Mkpanak, Ukpenekang and Inuayet Ikot) were 271.3mg/l, 298.5mg/l and 305.6mg/l) respectively. While chloride contents in borehole water in the three oil producing) communities (Mkpanak, Ukpenekang and Inuayet Ikot) were (264.7mg/l, 256.0mg/l and 270.5mg/l) respectively. Chloride contents in all the surface and borehole water analyzed in these communities were higher than the standards of WHO (250mg/L).

Udoessien (2009) reported that high chlorine concentration gives an undesirable salty taste to water and can cause health risk to the consumer. Conductivity values in surface water of the three crude oil producing communities Mkpanak, Ukpenekang and Inuayet Ikot in Ibeno Local Government Area were (1340.50 μ S/cm, 1400.00 μ S/cm and 1125.10 μ S/cm) respectively. While in borehole water the values of conductivity were 1250.65 μ S/cm, 1271.30 μ S/cm. and 1230.45 μ S/cm in Mkpanak, Ukpenekang and Inuayet Ikot respectively. These values were higher the maximum standards of domestic and drinking water of 1000 μ S/cm (WHO, 2000). All the surface and borehole water collected from core crude oil producing communities of Ibeno Local Government Area had high values for total hardness (75.00mg/l -100.00mg/L). The result was in line with work of Akpan (2004) for total hardness of surface and borehole water in Ibeno Local Government Area of Akwalbom State, Nigeria because of salinity intrusion from Atlantic Ocean.

Total Solid values in surface water obtained from Mkpanak, Ukpenekang and Inuayet Ikot were 725.0mg/L, 875.0mg/L and 760.0mg/L respectively. These values were higher than the maximum value allowed by NAFDAC and WHO of 500mg/L while the values recorded in borehole water in the oil producing communities Mkpanak, Ukpenekang and Inuayet Ikot were (340.0mg/l, 320.0mg/l and 410.0mg/l) respectively were below the acceptable standards (WHO, 2000). Presences of solid particles in surface water indicate contamination (Goel, 2006). Ogueke (2004) observed that presence of solid particles in water samples may be as a result of poor sanitation. The high values of total solid recorded in surface water may be as result of indiscriminate dumping of wastes and poor sanitary conditions in the communities. The concentrations of nitrate in surface water samples in Mkpanak, Ukpenekang and Inuayet Ikot were (14.4mg/l, 12.9mg/l and 13.5mg/l) respectively. While 5.7mg/l, 7.5mg/l and 6.25mg/l were observed in borehole water obtained from Mkpanak, Ukpenekang and Inuayet Ikot respectively. Nitrate is the most highly oxidized form of nitrogen compounds and it is commonly present in surface and ground waters because it is the end product of the aerobic decomposition of organic nitrogenous matter. The high values of nitrate observed in surface water in the core crude oil producing communities may be attributed to poor management of solid wastes in these communities. Nitrates are relatively short-lived because they are quickly used by plants and bacteria. In man nitrates react directly with hemoglobin in human blood to produce methemoglobin which destroys the ability of blood cells to transport oxygen. This condition is especially serious in babies under three months of age as it causes a condition known as methemoglobinemia or "blue baby" disease (Walter, 2011). Nitrate is a major ingredient in farm fertilizer and necessary for crop production. After rainfall, varying quantities of nitrate are

washed from farmland into nearby surface water and also to ground water table through infiltration, percolation and seepage. Nitrates also get into waterways from leaking septic tanks, leachate from landfills, manure from livestock animal wastes. The concentrations of Dissolved Oxygen (DO) recorded in surface water in core crude oil producing communities (Mkpanak, Ukpenekang and Inuayet Ikot) were 12.4mg/l, 13.0mg/l and 12.7mg/l. respectively. The high value of DO recorded in surface water in these communities showed that the surface water in these communities were unsafe for consumption. The higher DO value is an indication of oxygen depletion which also inferred the presence of pollutants that use up the oxygen in water. The DO values observed in borehole water were 7.5mg/l, 8.0mg/l and 7.2mg/l in Mkpanak, Ukpenekang and Inuayet Ikot respectively. Though the DO values recorded in borehole water are not up to maximum permissible level of WHO by showing traces of pollutants in the borehole water. But there were no evidences of borehole water being treated on regular basis in the communities. The results also showed a high level of pollution in the communities.

Heavy metals concentrations in surface and borehole water samples collected in three different core crude oil producing communities in Ibeno Local Government Area of Akwa Ibom State is shown in table 2. The heavy metals analyzed in surface and borehole water were iron, lead, zinc, manganese, chromium and cadmium. The presence of these metals in high concentration was an indication that the surface and borehole water in these communities is polluted. The pollution may be due to oil spillage which is a common phenomenon in these communities. Also, indiscriminate dumping of wastes in water bodies, leachate from municipal and industrial wastes. The high concentration of these metals in surface and borehole water was a clear indication of presence of toxic wastes in the oil producing communities. The concentrations of iron in surface water were 3.01mg/l, 2.20mg/l and 2.70mg/l in (Mkpanak, Ukpenekang and Inuayet Ikot) oil producing communities respectively. While the concentration of iron in borehole water were 1.32mg/l, 1.60mg/l and 2.00mg/l in Mkpanak, Ukpenekang and Inuayet Ikot respectively. According to WHO (2004), the maximum permissible level of iron content in drinking water is 0.3mg/l, above which the water is unsafe for consumption. Shamer *et al.* (2001) observed that formation of goiter in adults in Kenya was as a result of consumption of water with quantity of iron above the specified values

The mean concentration of manganese in surface water obtained from core crude oil producing communities were 2.30mg/l, 2.28mg/l and 2.10mg/l (Mkpanak, Ukpenekang and Inuayet Ikot) respectively. The concentrations of manganese in borehole water collected from oil producing communities were above the tolerable level of 0.1mg/l (WHO, 2004). The values of

Table 2. Mean Concentrations of Heavy Metals (mg/l) in Surface and borehole water samples collected in three different core crude oil producing communities of Ibeno L. G/ A

	Mkpanak		Ukpenekang		Inuayet Ikot		WHO	NAFDAC
	Surface water	Borehole water	Surface water	Borehole water	Surface water	Borehole water		
Fe (mg/l)	3.01	1.32	2.20	1.60	2.70	2.00	0.3	0.3
Pb (mg/l)	1.53	0.50	1.00	0.35	1.22	0.10	0.01	0.01
Cu (mg/l)	1.00	0.10	1.15	0.25	1.00	0.10	0.05	0.05
Zn (mg/l)	7.00	5.50	10.55	5.10	7.70	4.55	5.0	5.0
Cd (mg/l)	0.50	0.10	0.98	0.07	1.00	0.09	0.005	0.005
Cr (mg/l)	1.05	0.27	0.90	0.003	0.55	0.006	0.05	0.05

Lead in surface water obtained in crude oil producing communities were 1.53mg/l, 1.00mg/l and 1.25mg/l (Mkpanak, Ukpenekang and Inuayet Ikot) respectively. The mean values of lead in surface and borehole water in the core crude oil producing communities of Ibeno Local government Area of Akwa Ibom State. The concentrations of lead recorded in all the samples obtained from these communities were higher than the recommended standard of 0.01 mg/L of lead in drinking water (NSDWR, 2001). The concentrations of zinc in surface and borehole water in core crude oil producing communities were above the maximum permissible level of drinking water. This indicates that surface and borehole water in these communities is polluted. The zinc contamination observed in water samples in core crude oil producing communities of Akwa Ibom State may be as a result of wastes containing zinc metals which were used in the communities. The presence of chromium and cadmium in both the surface and borehole water samples in core crude oil producing communities of Akwa Ibom State suggest pollution and a clear indication of the danger pose to consumers.

CONCLUSION

Water quality assessment in an environment is an important indicator to determine the level of pollution in that environment. This study revealed that surface and borehole water in core crude oil producing communities of Akwalbom State is not suitable for drinking and domestic purposes.. As the results of surface and borehole water collected from oil producing communities (Mkpanak, Ukpenekang and Inuayet Ikot) is above WHO and NAFDAC standards for drinking and domestic water. The study recommended that regular assessment of both physico-chemical, heavy metals and microbial analysis of surface and borehole water in these communities should be carried out. Water quality studies should be given a priority in these communities, since the inhabitants depend on these sources of water for their drinking and domestic purposes. Also, water quality

studies should be integrated into development plans of oil companies in these communities and be conducted on a regular basis to assess risks of contamination in water sources.

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