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Ground water pollution in Okpai and Beneku, Ndokwa-east local government area, delta state, Nigeria

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This study has assessed the probable contamination of ground water resources in Okpai and Beneku area of Delta State, Nigeria. The ground water samples were collected in the dry season (December, January and February) and wet season (June, July and August) seasons from Okpai (experimental site) and Beneku (control site). The water samples were analyzed for Physico -Chemical and biological parameters using standard procedures. The results show that both Okpai and Beneku ground water contained high amounts of magnesium (1.173mg/l in the dry season and 1.277mg/l in the wet season) and iron (0.036mg/l in the dry and 0.021mg/l in the wet) for the former while cadmium (0.002mg/l in the dry and 0.005mg/l in the wet), iron (0.676mg/l in the dry and 1.062mg/l in the wet), magnesium (1.21mg/l in the dry and 1.437mg/l in the wet) and lead (0.004mg/l in the dry and 0.005mg/l in the wet) for the latter. Apart from these specific cases, other values corresponded to the approved maximum permissible level (i.e. maximum permissible limits for drinking water set by NAFDAC, USEPA and WHO). The ground waters therefore, were more impacted upon by chemical parameters, than physical and biological parameters. In conclusion, this study recommends for the Bio-Physico-Chemical assessment extension to other new areas of the Niger Delta region of Nigeria.

Key word: Gas flaring, Oil spillage, Ground water, Pollution

INTRODUCTION

The usefulness of water depends on whether such waters are timely, quantitatively and qualitatively available. According to Bhatia (2010), of over 70% of the earth's surface covered by water, about 97.57% is salt water from oceans while the remaining less than 3% are contained in soils, rivers, lakes, ground water as well as ice and glaciers. Since salt water cannot be readily consumed by humans or freely used for various industrial and domestic purposes, humans and other living organisms depend and compete for the limited fresh water sources available to them.

The availability of quantitative and qualitative fresh water supplies for humans have over the years influenced settlement patterns of people in certain geographical regions in preference for others. For water to be adequately utilized, it has to be reasonably free from contaminants. Otherwise, such waters could pose serious health and environmental risks to living organisms that depend on them (Underwood, 1977). Portable water is a fresh water body that is unpolluted, suitable for drinking, odourless and tasteless (Enger and Smith, 2010). Such water boils at 100ºC, freezes at 0ºC, is neutral to litmus and has an atmospheric pressure of 760mmHg (Kolo, 2007). Groundwater is commonly understood to mean water occupying all the voids within a geologic stratum (Deborah et al, 1996). It is not usually static but flows through the rock (Adekunle et al, 2007). The ease with which water can flow through a rock mass depends on a combination of the size of the pores and the degree to which they are inter-connected (Neilson, 1991). Odukoya et.al (2002) described groundwater as the main source of potable water supply for domestic, industrial and agricultural uses in the southern part of Nigeria, especially the Niger Delta, due to long retention time and natural filtration capacity of aquifers. Pollution of groundwater has gradually been on the increase especially in our cities with lots of industrial activities, population growth, poor sanitation, land use for

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commercial agriculture and other factors responsible for environmental degradation (Egila and Terhemen, 2004). Groundwater usually flows toward, and eventually drains into stream, rivers, lakes, creeks, ponds and boreholes but the flow of groundwater in aquifer does not always reflect the flow of water on the surface (Adekunle et al, 2007 and Otutu, 2011).

It is therefore necessary to know the direction of groundwater flow and take steps to ensure that land use activities in the recharge area will not pose a threat to the quality of the groundwater (Freeze and Cherry, 2007). Ground water contaminants could depend on the level and type of elements introduced to it naturally or by human activities and distributed through the geological stratification of the area. Some of these wastes could contain toxic components such as the polynuclear aromatic hydrocarbons (PAHs), which have been reported to be the real contaminants of oil and most abundant of the main hydrocarbons found in the crude oil mixture (El-Deeb and Emara, 2005). The study area consists of a network of badly managed pipelines criss-crossing the entire region, gas flare sites and an Independent Power plant. Ground waters are more difficult to pollute and mitigate (Enger and Smith, 2010).

In April 1997, underground water samples taken from Luiwi in Ogoni land where oil exploration and exploitation activities have been on till production stopped in 1993, were analyzed in the United state
and it was discovered that such contained 18ppm of hydrocarbons; 360 times the level allowed in drinking water in European Union (E.U) while another sample from Ikwere in Rivers state, Nigeria contained 34ppm; 680 times the E.U standard for drinking water (Nwilo and Badejo, 1995); Nwankwo and Ogagarue (2011) and Dami et.al (2012) have examined the ground waters in Warri and Abraka and the effects of gas flaring on rain and surface water in Okpai and Beneku respectively in Delta State, Nigeria and established that while ground waters were relatively safe in both cases the rain and surface waters needed treatment before it could be consumed. Beneku and Okpai have been exposed to oil-related activities like gas flaring and oil spillage. Gas flares release contaminated fumes into the atmosphere while oil spillage leak oils into the environment either through accidental discharges, sabotage and the likes. When the contaminants get into water bodies, they interfere with the water quality and these could trigger health and environmental effects. Massive network of badly managed oil pipelines leak petro-chemicals into the environment with gas flares that burn constantly all contribute to serious environmental degradation of the region. “Speak Out Now” in its June 21, 2010 publication estimated that almost 11 million gallons of oil per year leak into the Delta’s marshlands from poorly maintained pipelines, some of which are over 40 years old. Gas flaring also releases non-combustible fumes or persistent organic and inorganic chemicals into the air. These could over time contaminate atmospheric water and when they fall as rain, they in turn contaminate soils and surface water bodies and subsequently, the underground aquifer also get contaminated (Amukali, 2012 and Dami et. al 2012). This study has evaluated the ground water pollution in the study area.

MATERIALS AND METHODS

Ground water samples were collected from two distinct locations. The first was within the Agip Gas Plant in Okpai area (experimental site) while the second was about 5km away at Benekuku (control site), both within Ndokwa-East Local Government area of Delta State, Nigeria. Samples were collected during the dry season (December 2010, January 2011 and February 2011) and wet season (June, July and August 2011). Three samples of Ground water each were collected from both Okpai and Benekuku in the study areas, making a total of six samples at different points. The samples were collected around 5.00 – 6.00pm of the day. The Ground water samples collected were analyzed. At every point, two sets of samples were collected: one for The Atomic Absorption Spectrometer Analysis and the other for anions like phosphate, sulphate and nitrate. No further treatment was needed for the anions, thus the samples were analyzed right away to minimize chemical changes in the sample and prevent losses to the environment (Radojevic and Bashkin, 1976).

Pretreatment of the water samples was necessary because of the likelihood of such samples containing suspended particles along with metals. Pretreatment involved addition of an acid to preserve the sample, destroying organic matter and bringing all metals into solution (Radojevic and Bashkin, 1976), A few drops of concentrated HNO_3 acid was added to water samples after collection to preserve the samples, destroy organic matter and minimize absorption on the walls of the container. Preparation of standard stock solutions and working standards were done following the methods by USEPA (1999) for calcium, magnesium, sodium, potassium, iron, copper, zinc, cadmium, lead, chromium and aluminium. McConkey broth single and double strengths were also prepared. Full details on preparation of stock solutions and working standards are contained in Amukali (2012). 100cm^3 of water samples were measured and put into a beaker. A 5cm^3 aqua regia (HNO_3 : HCl in ratio 3:1) was then added and the beaker containing the mixture was placed on a hot plate and evaporated on a fume chamber. As the beaker was allowed to cool, and the 5cm^3 aqua regia were added again but this time the beaker was covered with a watch glass and returned to the hot plate. The heating continued with continuous addition of aqua regia to

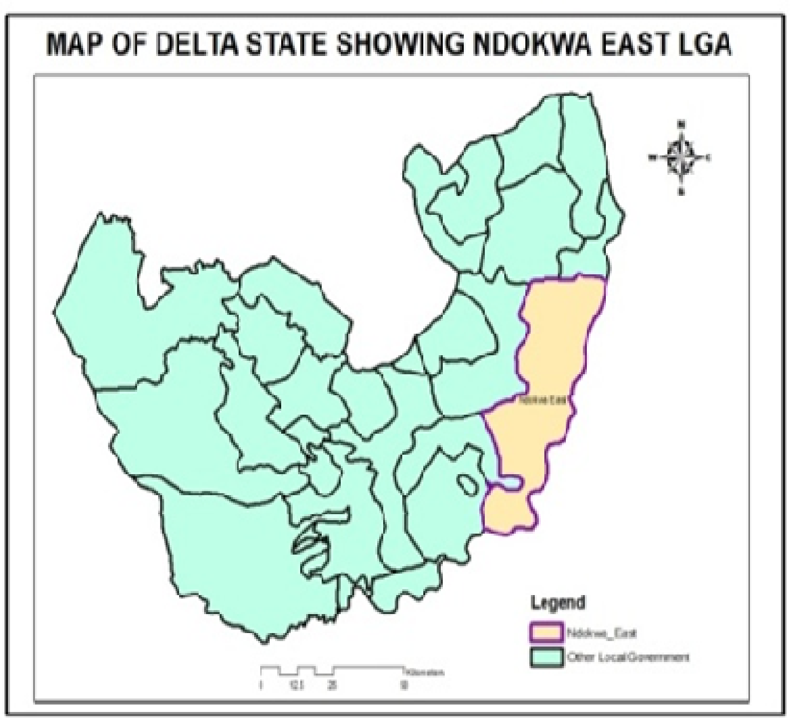

Figure 1: Map of Delta State showing Ndokwa East Local Government Area.

complete the digestion and after which it was brought down and another $5cm^3$ aqua regia added, with the beaker warmed slightly so as to dissolve the residue (Radojevic and Bashkin, 1976).

The brilliant green lactose bile broth medium was prepared by dissolving 40g of the BGLB powder in 1 litre of distilled water. The solution was then thoroughly mixed and put into test tubes fitted with Durham tubes and sterilized by autoclaving at 121ºC for 15 minutes. Parameters analyzed include pH, temperature, taste, colour, conductivity, alkalinity, turbidity, DO, BOD, COD, TDS, TSS, SO_4^{2-}, PO_4^{3-}, NO_3^-, Chlorides and fluorides. The Atomic Absorption Spectrometer (AAS) was used for the determination of all metals studied in this work. Examples of metals studied included calcium, magnesium, sodium, potassium, iron, copper, zinc, cadmium, lead, chromium, and aluminium. Coliform counts were then studied following the method adopted by Kolo (2007) Five tubes each of 50ml, 10ml and 1ml of single strength McConkey Broth Medium were inoculated with volumes of the water samples and incubated for 24 hours at 24ºC. Data collected from the experimental analyses were all subjected to analysis of variance using simple statistical models. One-way analysis of variance and t-test ($p<0.005$) were used to establish whether the parameters varied significantly among water samples and between sampling points at Okpai and Benekuku.

The Study Area

The Niger Delta is located within the southern part of Nigeria. It is home to numerous creeks, rivers and possesses the world's largest wetland with significant biological diversity (Twumasi, and Meren, 2006). Okpai/Aboh region are within Ndokwa East Local Government Area and are situated within the Sombriero Warri deltaic plain deposit invaded by mangroves.

The area is located within latitudes 5º40′N and 5º50′N and longitudes 6º15′E and 6º30′E (Figure 1). It falls within a low-lying height of not more there 3.0 meters above sea level and generally covered by fresh water, swamps, mangrove swamp, lagoonal marshes, tidal channels, beach ridges and sand bars along its aquatic fronts (Dublin-Green et al, 1999). The area has a characteristic tropical monsoon climate at the coast with rainfall peaks in June and September/October with prevailing tropical maritime air mass almost all year round with little seasonal changes in wind directions. Annual mean total rainfall has been put at between 1,500mm and 3,000 mm with a mean monthly temperature range of 24-25 ^oC during the rainy season in August and 27-29^0C during tail end of dry season in March/April. Leroux (2001) reported that maximum temperatures are recorded between January and March (33^0C) while minimum temperature are recorded in July and December (21^0C), respectively.

Table 1: Physical Parameters of the Samples

Samples	Parameters Tempt (^oC)	Colour	Taste	Turbidity (NTU)
DRY.OK.GW	27.60	14.00	0.00	3.78
DRY.BN.GW	28.80	16.00	0.00	2.86
WET.OK.GW	27.20	13.33	0.00	2.93
WET.BN.GW	27.30	16.00	0.00	2.12
Max. Perm. Value	25 - 30^{0}C	15 TCU	0.00	5NTU

Table 2: Chemical/Biological parameters of the samples

Samples	Parameters Conductivity	Acidity	Alkalinity	Dissolved Oxygen	B O D	T D S	T S S	pH
DRY.OK.GW	44.28		12.63	4.67	1.24	23.76	8.70	6.81
DRY.BN.GW	131.183		4.14	3.96	0.92	72.88	8.98	6.81
WET.OK.GW	44.34		11.09	5.12	1.35	23.52	8.69	6.86
WET.BN.GW	131.18		3.78	4.04	1.26	65.24	9.10	6.85
Max. Perm. Value	1,000µ/cm		30 – 500mg/l	>4	0.1 - 1.9mg/l	1,000mg/l	20mg/l	6.5 - 8.5

Temperatures are seriously moderated by cloud cover and damp air. It experiences a tropical climate consisting of rainy season (April to November) and dry season (December to march). The average annual rainfall is about 2,500mm while the wind speed ranges between 2-5m/s in the dry season to up to 10m/s in the rainy season especially during heavy rainfall and thunderstorms. The region is criss-crossed with distributaries and creeks.

This area has been classified geomorphologically to consist of tidal flat and large flood plains lying between mean, low and high tides. Okpai and Beneku region is located at the north western parts of the Niger Delta complex. It is characterized by structures which resulted from listric growth faults and their associated roll-over anti clines (Ekine and Iyabe, 2009). They further reported those three different highs in Kwale region (which encompasses Okpai and Beneku); a central high where most of the wells have been drilled, an eastern high housing one well and a north western high whose extent has not been clearly defined. However, further detailed stratigraphic sequence studies of the Cenozoic Niger Delta complex have been reported in different authors such as Murat (1972), Avbovbo and Ogbe (1978), Allen (1972) as well as Merki (1972). Surface water bodies are generally located along valleyed – depressions and they receive lots of material discharges from exploration, exploitation, production and transport activities from the wells.

RESULTS AND DISCUSSION

The result of the physical parameters is shown in Table 1. The values revealed that although temperature was highest (with an average value of 28.8ºC) at Beneku during the dry season, generally, temperatures did not significantly change with the seasons. This suggests that gas flaring and oil spillage seem not to have influenced ground water temperatures with changing seasons. When compared with the maximum permissible range of 25 - 30ºC recommended by WHO, (1993) for drinking water, the temperature values all fall within the permissible range.

Pure water is colourless (Akan, 2006). Thus, any water with a characteristic colour insinuates contamination. From Table 1, both the values for Okpai during dry season Beneku during both wet season were 16TCU. This exceeded the maximum permissible value of 15 TCU recommended by the WHO. Colour at Beneku ground water could be attributed to dissolved salts and other materials from industrial or agricultural agents.

Ground water also revealed some level of turbidity with the highest value of 3.78 NTU for Okpai during the dry season. However, the turbidity values have not reached the maximum permissible limit of 5NTU for drinking water (NIS, 2007). Nevertheless, the medium range of turbidity consequent on oil related activities like gas flaring and oil spillage could have serious health implications for the residents within the studied areas. Table 2 shows the values for chemical parameters analyzed. These are conductivity, alkalinity/acidity, Dissolved oxygen (DO), Biochemical Oxygen Demand (BOD), Total Dissolved Solids (TDS), Total Suspended Solids (TSS) and pH. The results revealed that Conductivity was significantly higher at Beneku during dry and wet seasons compared with the values for Okpai ($p<0.05$). . This could be

Table 3: Levels of some Anions in the samples

Samples	Anions (Mg/L)				
	SO_4^{2-}	PO_4^{3-}	NO^{3-}	Cl^-	F^-
DRY.OK.GW	1.10	0.05	0.02	0.01	0.001
DRY.BN.GW	1.43	0.20	0.13	0.16	<0.001
WET.OK.GW	1.13	0.09	0.02	0.18	<0.001
WET.BN.GW	1.54	0.24	0.12	0.12	<0.001
Max. Perm. Value	100mg/l	10 – 50mg/l	50mg/l	250mg/l	0.8 - 1.5mg/l

attributed to more accumulation of dissolved salts and other organic materials present at Beneku as natural resources.

The water samples were more alkaline than acidic Alkalinity was highest at Okpai during dry season with a value of 12.627. This was followed by same Okpai during wet season with an average value of 11.087. Beneku then had 4.143 during dry season and 3.777 during the wet season, respectively (table 2). The high rate alkalinity at Okpai could be attributed to continuous release of acidic substances into its adjoining environments which later percolate underground.. There were significant differences in the values for alkalinity ($p<0.05$) between Okpai and Beneku. Even though these values have not reached the maximum limit for drinking water as recommended by WHO an alkaline water could still pose health hazards for the inhabitants of the area. Values for Dissolved Oxygen (DO) were generally high in the study areas with values ranging from 3.96 to 5.12.. According to PESCORD (1977), ground waters could also be conveniently used to support fish pond activities since DO values were above the recommended value of greater than 2 as stream standard for fishing.

The values for BOD showed that they are approaching the maximum limit recommended WHO standard (WHO, 1993 and USEPA, 1999), with values ranging from 0.92 to 1.35 mg/l. .Thus, it could be deduced that oil-related activities could influence higher BOD. Based on Radojevic and Bashkin (1976) classification of water for purity on criterion of BOD, all ground waters of the studied area over seasons were found to be moderately clean. If the ground waters are to be used for fish pond purposes, organic matter would have to be added to encourage more biological activities since they fell short of the stream standard for fishing of between 3.0 – 6.0mg/l (PESCORD, 1977).

The values for Total Dissolved Solids (TDS) were significantly lower in the study areas compared with the maximum limit by NIS and WHO. Less than 500mg/l is the maximum permissible value for TDS in drinking water in Nigeria (NIS, 2007), whereas WHO (1993) recommended 250mg/l as maximum permissible limit for drinking water. However, should the waters be considered for use in fish ponds, it could be used without fear since WHO (1993) recommended 1,000mg/l for the protection of fisheries and aquatic lives as well as for domestic water supply. Since all values were below the acceptable limit, they are all safe for drinking on the basis of TDS as supported by Bruvold and Ongerth (1969) that waters within the limits obtained here are highly palatable.

From Table 2, the values for Total Suspended Solids (TSS) and pH fall within neutral limits and as such the water may be considered safe for drinking. Badmus et al (2001) stated that higher values of water pH for wells within vicinities of waste dumpsites relative to the residential areas was attributed to the release of carbon dioxide, ammonia and methane during decomposition of the waste materials, which percolate through the aquifer to the groundwater via leachates while a reduction in pH of water samples from wells located close to the defecation sites relative to residential areas was attributed to sulphur and amino acid compounds from human and animal excreta. This agrees with the reduced pH of groundwater samples within the gas flaring sites of Okpai.

Sulphate concentration in the ground water of Beneku in the wet season had the highest value of 1.544mg/l. An average value of 1.427mg/l was recorded for Beneku during dry season, 1.13mg/l and 1.097mg/l for Okpai during wet and dry seasons (table 3). All values recorded in this study were below the maximum permissible limit of 100mg/l for drinking water (NIS, 2007), hence, could be utilized in fisheries project and agricultural activities (USEPA, 1991). Levels of sulphate above 600 mg/L act as purgative in humans (Esry et al, 1991). Benekuku had higher values than Okpai during both seasons. Wet season influenced sulphate concentration in ground water more than dry season. High values of Sulphate in ground water at Beneku for wet and dry seasons could be attributed to agricultural contamination from fertilizers which later seeped underground to mix with ground water. Also, it could be stated that sulphate is very unstable in the atmosphere from where they are converted into forms suitable for their stay in surface and ground waters. Other possible sources could be due to natural oxidation of sulphides and elemental sulphur transported from igneous rocks upstream to form

aqueous sulphate ions in water (Waziri, 2006).
Phosphate had its highest value of 0.237mg/l at Beneku during wet season. This was followed by same Benekuku with an average value of 0.204mg/l during the dry season, 0.086mg/l and 0.053mg/l at Okpai during wet and dry season as shown in table 3. All values recorded in this study were below the maximum permissible limit of 10-50mg/l. Phosphate levels were observed to increase from dry to wet season. Beneku had higher phosphate values than Okpai over both seasons. Wet season influenced phosphate concentration more than dry season. The higher values in the wet season at the expense of dry season could be due to the fact that farmers in the study area usually do seasonal farming where rain is seasonally targeted before crops could be planted and the soil had to be nourished with fertilizers of which phosphate fertilizer is one. Traces of phosphates increase the tendency of troublesome algae to grow in the water and their presence in the study area may be traced to agricultural activities. Punmia and Jain, (1998) in humans, hypophosphotaemia results from having low levels of phosphorus in the blood, usually between 2.5 – 4.5mg/dl (Folkl, 2011) and consuming waters that are significantly very low in phosphorus content could be a cause. Beneku had considerably high values of 0.131mg/l and 0.115mg/l Nitrate during dry and wet seasons. Okpai had values of 0.019mg/l and 0.015mg/l during dry and wet seasons as contained in table 3. Dry season had higher values than the wet counterpart depicting significant differences at $p<0.005$ level of significance between Okpai and Beneku. Benekuku had very high values compared to Okpai. All values recorded in this study were below the maximum permissible limit of between 50 - 100mg/l by the WHO (1993) standard for drinking water.

Nitrate concentration above the recommended value of 10 mg/L is dangerous to pregnant women and poses a serious health threat to infants less than three to six months of age because of its ability to cause methaemoglobinaemia or blue baby syndrome in which blood loses its ability to carry sufficient oxygen (Groen et al, 1988). Malomo et al (1990) reported nitrate concentrations up to 124 mg/L and nitrite up to 1.2 mg/L in shallow groundwater near pollution source in southwest Nigeria. These concentrations were unusually high. Seasonal usage of nitrate fertilizers could also explain this trend. Since Beneku had higher values compared to Okpai, it could be said that availability of nitrogen fixing bacteria that penetrate atmospheric nitrogen into the soil could account for the very low levels of nitrates within ground water of the study area and this consequently resulted in higher amounts in ground waters through percolation. Low nitrogen concentration in ground waters of both Okpai and Beneku means that plants and animals that depend on nitrogen would be suffering from nitrogen-deficiency diseases. Vegetative growth of plants would be grossly affected if ground waters were to be used for watering plants within the studied area.
Chloride had its highest value at Okpai during wet season with 0.175mg/l. Then 0.158mg/l, 0.115mg/l and 0.013mg/l were accordingly recorded for Beneku during dry season (table 3). All values recorded in this study were below the maximum permissible limit of 250mg/l for drinking water (NIS, 2007). The very low value of chloride in ground water could be attributed to increased neutralization reactions by dissolved alkaline hydroxyl containing agents. Such waters could have a tendency of not being able to effectively prevent the proliferation of pathogens owing to the very low levels of chlorides in ground waters.

Values for fluoride were generally very low. Okpai during both dry and wet seasons recorded 0.001mg/l while Beneku during both seasons recorded slightly lower than 0.001mg/l (table 3). There was no significant variation between Okpai and Beneku and neither was there any between dry and wet seasons, respectively. This implies that activities that generate fluorides into the environment had no noticeable significant impact on ground waters within the studied areas. All values recorded in this study were below the maximum permissible range of between 0.8 - 1.5mg/l for drinking water (NIS, 2007 and WHO, 1993).

Values for calcium in decreasing order were 3.08mg/l, 2.883mg/l, 2.387mg/l and 2.25mg/l for Beneku during dry season, Beneku during wet season, Okpai during dry season and Okpai during wet season (table 3). The maximum permissible limit for calcium in drinking water, of 50mg/l (NIS, 2007) or a range of between 75 – 270mg/l (WHO, 1993) was not exceeded by any of the studied sites over the seasons. At $p<0.005$ level of significance reveals that there were significant differences between mean variation values between Okpai and Beneku and even between seasons. Dry season tended to influence higher concentrations of calcium than during wet season. The reason for the trend could be partly due to the soils of Beneku and ground waters having deposits of calcium as natural resource and partly due to reduction in the quantity of ground water during season to effectively reduce calcium concentrations through dissolution unlike during wet season.

Table 4 shows that the highest value for magnesium was observed at Beneku during wet season with a value of 1.437mg/l while 1.277mg/l, 1.21mg/l and 1.173mg/l were recorded for Okpai during wet season, Beneku during dry season and Okpai during dry seasons. All values recorded in this study were below the maximum permissible range of between 37 - 150mg/l for drinking water (WHO, 1993). Beneku had higher values than Okpai during both seasons and it could also be stated that wet season influenced higher concentrations of magnesium than dry season. Higher values of

Table 4: Levels of some Elements in the samples

Samples	Elements (Mg/L)										
	Ca	Mg	Na	K	Fe	Cu	Cd	Zn	Pb	Cr	Al
DRY.OK.GW	2.39	1.17	0.25	0.03	0.04	0.01	<0.001	0.01	<0.001	<0.001	0.001
DRY.BN.GW	3.08	1.21	0.63	0.18	0.68	0.04	0.002	0.02	0.04	<0.001	<0.001
WET.OK.GW	2.25	1.28	0.33	0.06	0.02	0.01	0.001	0.01	<0.001	<0.001	<0.001
WET.BN.GW	2.89	1.44	0.87	0.29	1.06	0.01	0.01	0.02	0.01	<0.001	<0.001
Max. Perm. Value	50mg/l	37 - 150mg/l	200mg/l	1 – 2mg/l	0.3mg/l	1mg/l	0.003mg/l	3mg/l	0.01mg/l	0.05mg/l	0.2mg/l

Magnesium could be attributed to rock weathering which could disintegrate chemical substances like magnesium into surface water bodies from where they percolate into ground waters. Hypomagnesaemia could result from consistent dependence on usage of water sources as in this case where the magnesium levels were very low. Augmentation with magnesium salts would be necessary if the ground water sources have to be used for maintenance of fish ponds. The following values for sodium were recorded in decreasing order; 0.873mg/l at Beneku during wet season, 0.63mg/l at Beneku during dry season, 0.333mg/l at Okpai during wet season and 0.253mg/l at Okpai during dry season respectively (table 4). Beneku had higher values than Okpai over both seasons and wet season seemed to influence higher concentration of sodium in ground waters more than dry season. Highest calcium level at Beneku ground water could be an indication of natural resource deposit which later could disintegrate through chemical weathering. All values recorded in this study were below the maximum permissible limit of 200mg/l for drinking water (NIS, 2007).

Potassium had its highest value of 0.293mg/l for Beneku during wet season before being followed by same Beneku with an average value of 0.18mg/l during dry season. The least value for potassium was 0.027mg/l at Okpai during dry season and 0.063mg/l at same Okpai during wet season (table 4). Maximum permissible limit set by WHO (1993) ranged between 1 – 2mg/l for potassium, was not exceeded by any of the studied sites over the seasons. Comparatively, Beneku had higher values for potassium than Okpai during both seasons and wet season was found to influence the concentration of potassium more than dry season. Higher values of potassium at Beneku ground waters could be due to the use of potassium fertilizers by farmers and which later settle underground to percolate into ground waters. Also, potassium could be a natural resource within Beneku. Hypopotasaemia could result from consuming ground waters from the studied sites over the seasons (Folkl, 2011).

Iron had highest value of 1.062mg/l during wet season at Benekuku while 0.676mg/l was observed 0.676mg/l at same Beneku during season. Also, Okpai was observed to have 0.036mg/l and 0.021mg/l during dry and wet seasons (table 4). Beneku had higher values than Okpai during both seasons. While wet season influenced iron concentration more than dry season at Beneku, the reverse was the case at Okpai.

The maximum permissible limit of iron is 0.3mg/l (NIS, 2007 and USEPA, 1991). The very high value of iron at Beneku compared to Okpai could be as a result of iron being a natural resource. Iron exceeded the maximum permissible limit at Beneku during both seasons. Hence, iron indicates pollution at Beneku ground waters while Okpai is safe. Although, iron in drinking water is not a major health concern (Waziri, 2006 and Kolo, 2007), concentrations above 0.3mg/l can cause food and water to become discoloured and taste metallic. Iron deficiency in the human blood could lead to anaemia while excess of it could generate free radicals into the system which could speed up the aging process.

Values for copper contained in table 4 confirm that copper had its highest value at Beneku during dry season with a value of 0.035mg/l. During wet season, Beneku had 0.014mg/l. Okpai had 0.012mg/l and 0.005mg/l during dry and wet seasons. Beneku had higher values than Okpai during both seasons while dry season influenced the concentration of copper than wet season. All values recorded in this study were below the maximum permissible limit of 1mg/l for copper (NIS, 2007). Copper could be a natural resource in Beneku owing to its concentrations as shown in this study.

The highest value for zinc was observed at Beneku simultaneously during both dry and wet seasons while Okpai had values of 0.01mg/l and 0.009mg/l during dry and wet seasons (table 4). Although, Beneku had higher values than Okpai during both seasons, there was no significant seasonal variation within study sites. The maximum permissible limit of 3mg/l for zinc (NIS, 2007 and WHO, 1993) was not exceeded by any of the values. Zinc at these limits does not pose serious health and environmental effects.

Highest value of cadmium was observed Beneku during wet season with a value of 0.005mg/l. During dry season, 0.002mg/l was noticed at same Beneku while less than 0.001mg/l was observed at Okpai during both dry and wet season. All values recorded in this study were below the maximum permissible limit of 0.003 mg/l for cadmium (NIS, 2007 and WHO, 1993) except Beneku during the wet season. Cadmium could be a natural resource in Beneku ground waters. Cadmium elevation has been attributed to anthropogenic influence such as small-scale entrepreneur activities, which include open-air solid waste combustion, sawmills, wood works, quarrying, gas stations and autorepair workshops (Adepelumi, 2001). Long term exposure to cadmium could lead to carcinogenic occurrences in humans, kidney and lung damage, fragility of bones, stomach irritation, vomiting as well as diarrhea (Folkl, 2011). Over dependence on Beneku ground waters could over time initiate these disease situations in humans depending on the waters.

Chromium had insignificant values as both Okpai and Beneku during both seasons had values that were less than 0.001mg/ (table 4). The values recorded in this study for chromium were below the maximum permissible limit of 0.05mg/l (NIS, 2007 and WHO, 1993) for drinking water. Chromium does not pose a serious health or environmental threat to ground water sources within this study. Chromium does not pose any health or environmental threat at both studied sites over the seasons.

Aluminium had 0.001mg/l recorded for Okpai during dry and wet season while less than 0.001mg/l was observed at Beneku during both dry and wet season as in table 4. All values recorded in this study were below the maximum permissible limit of 0.2mg/l (NIS, 2007; WHO, 1993 and USEPA, 1991). Aluminium at the values observed for this study shows that it does not pose any health and environmental threat to consumption of ground water sources.

The highest value of 0.04mg/l of Lead was observed at Beneku during wet season, 0.005mg/l for Beneku during wet season while less than 0.001mg/l was recorded for Okpai during both dry and wet seasons (table 4). Dryness affected the concentration of lead more than wetness in season at Beneku. Values recorded in this study at Okpai were below the maximum permissible limit of 0.01mg/l (NIS, 2007 and WHO, 1993) but Beneku during wet and dry seasons were above the acceptable limit, thus could be said to be of health concern. Lead could be a natural resource at Beneku. Long term exposure to lead as in over dependence on water sources from Beneku during both seasons could lead to decreased performance in some tests that measure functions of the nervous system, weakness in fingers and wrists, emergence of wrinkles, small increases in blood pressure and anaemia while exposure to high levels of could instantaneously lead to severe damages to the brain and kidneys, miscarriage as well as outright death (Folkl, 2011).

SUMMARY AND CONCLUSION

The result of the physical and chemical analyses of water samples taken at Okpai and Beneku areas of Niger Delta region of Nigeria revealed that gas flaring and oil spillage seem not to have influenced ground water temperatures, pH and Total Suspended Solids. However, the water had color suggesting contamination. Conductivity was high at Beneku. This was attributed to more accumulation of dissolved salts and other organic materials. The high rate alkalinity at Okpai was attributed to continuous release of acidic substances into its adjoining environments which later percolated underground.. Even though these values have not reached the maximum limit for drinking water as recommended by WHO, an alkaline water could still pose health hazards for the inhabitants of the area.

It can therefore be concluded that drastic efforts must be made to reduce the oil spillage and gas flaring as these affect drinking water, fishing activities and farmlands where the inhabitants depend on for their livelihood. We therefore recommend a complete stoppage of oil spilling activities and gas flaring in the region to avert the dangers and hazards associated with them. We also recommend a comprehensive Environmental Impact Assessment of the area in terms of water physico-Chemical assessment to be extended to other regions not covered by this study, within the Niger-Delta region of Nigeria.

REFERENCES

Adekunle IM, Adetunji MT, Gbadebo AM and Banjoko OB (2007). Assessment of Groundwater Quality in a Typical Rural Settlement in Southwest Nigeria.

Adepelumi A, Ako B and Ajayi IT (2001). Groundwater contamination in basement –complex area of Ile-Ife, southwestern Nigeria: A case study using the electrical-resistivity of geographical method. Hydrogeology Journal. 9(6): Pp. 611 -622.

Akan JC (2006). Determination of pollutant levels in some surface and water wastes samples from Kano metropolis, Nigeria. M.Sc. thesis. Department of Chemistry, University of Maiduguri. 88p.

Allen JR (1972). Late Quarternary of the Niger Delta and Adjacent Areas. Sedimentary Environments and Lithofacies. 49: Pp. 547-600.

Amukali O (2012). Effects of gas flaring and oil spillage on water quality for domestic use in Okpai and Beneku, Delta State, Nigeria. Unpublished M. Sc. Thesis, Department of Geography, University of Maiduguri

Avbovbo AA and Ogbe FG (1978). Tertiary Lithostratigraphy of the Niger Delta. A.A. PG. Bull. 62: Pp. 285-300.

Badmus BS, Odewande AA, Ojelabi EA and Oyedele T (2001). Leachate contamination effect on groundwater exploration. African Journal of Environmental Studies, 2(1), Pp. 38 – 41.

Bhatia (2010). Water Pollution in the Chemical Industries. John Welsh Publications, India. Pp. 35-658.

Bruvold WH, Ongerth HJ (1969). Taste Quality of Mineralized Water. Journal of The American Water works Association Vol. 61:170.

Dami A, Ayuba HK and Amukali O (2012). Effects of gas flaring and oil spillage on rainwater collected for drinking in Okpai and Beneku, Delta State, Nigeria. Global Journal of Human Social Sciences Volume 12 Issue 13 Version 1.0 November 2012 USA

Deborah C (1996). “Water Quality Assessment” UNESCO/WHO/UNEP.

Dublin-Green CO, Awobamise A and Ajao EA (1999). Large Marine Ecosystem Project for the Gulf of Guinea: Coastal profile of Nigeria. Nigerian Institute of Oceanography. Pp. 24-36.

Egila JN, Terhemen A (2004). A preliminary investigation into the quality of surface water in the environment of Benue Cement Company Plc. Gboko, Benue State. Nigeria. Int. J. Sci. Tech., 3(1), 12-17.

Ekine AS and Iyabe P (2009). Petrophysical Characteristic of the Kwale Reservoir Sands (Oml 60) from Wire-logs, Niger Delta, Nigeria. J. Appl. Sci. Environ, Mgt. 13 (4) Pp. 81-85.

El-Deeb MKZ, Emara HI (2005). Polycyclic aromatic hydrocarbons and aromatic plasticizer materials in the seawater of Alexandria Coastal area. Egyptian Jr. of Aquat. Res., 31, 15-24.

Enger ED and Smith BF (2010). Environmental Science: A Study of Interrelationships. (11th Edition). McGraw-Hill International, Boston. 488p.

Esry SA, Potash JB and Shiff C (1991). Effects of improved water supply and sanitation on ascariasis, diarrhea, Drancunculiasis, hookworm infection,

schistosomiasis and trachoma. Bulletin of the World Health Organization, 6 (5), Pp. 609 – 621.

Freeze RA and Cherry JA (2007). Groundwater. Prentice-Hall, Englewood cliffs, New Jersey. p604.

Folkl A (2011). Iron Levels in Drinking Water. Available at http://www.livestrong.com/article/91411-iron. Pp. 1 - 3.

Groen J, Schumann JB and Gernaer TW (1988). The occurrence of high nitrate concentration in groundwater in villages in Northwestern burkinafaso. J. Afri. Earth Sci., 7(7/8), 999 – 1009.

Kolo B (2007). Study on the Chemical, Physical and Biological Pollutants in Water and Aqueous Sediments of Lake Chad Area, Borno State, Nigeria. Unpublished Ph.D Thesis. Chemistry Department. University of Maiduguri, Nigeria. Pp. 12-56.

Malomo S, Okufarasin VA and Olorunnio MA (1990). Omode, A. A.: Groundwater chemistry of weathered zone aquifers of an area underlain by basement complex rocks. J. of African earth Sciences, (11), 357 -371.

Murat RC (1972). Stratigraphy and Paleogeography of the Bcretaceous

Merki P (1972). Structural Geology of the Cenozinc Niger Delta. In African Geology eds. and Lower Tertiary Southern Nigeria.

In: African Geology. Ed. T.J.F.

Dessanvagie ie and A.J. Whiteman, University of Ibadan Press, Ibadan. Pp. 635-648.

Neilson DM (1991). Ground water Monitoring. Lewis Publishers, Chelsea, Michigan. p717.

NIS (2007). Nigerian Standard for drinking Water Quality. Nigerian Industrial Standard under Standards Organisation of Nigeria. Lagos, Nigeria. Pp. 15-19.

Nwankwo CN and Ogagarue DO (2011). Effects of Gas Glaring on Surface and Ground Waters in Delta State, Nigeria. In: Journal of Geology and Mining Research. 3(5) Pp. 131-136.

Nwilo PC and Badejo OT (1995). Management of Oil Spill Dispersal Along the Nigerian Coastal Areas. J. Envtal Mgt. 4 Pp. 42-51.

Odukoya OO, Arowolo TA, Bamgbose O (2002). Effect of Solid Waste. Landfill on underground and surface water quality at Ring Road, Ibadan. Global J. Environ. Sci., 2(2), 235–242.

Otutu JO (2011). Groundwater flow direction in Ndokwa-East local government area of delta state, Nigeria. Journal of Geology and Mining Research Vol. 3(2). Pp. 21-24.

PESCORD MB (1977). Surface Water Quality Criteria for Developing Countries in Water, wastes and Health in Hot Climate. Faechem. R., McGorng, M. and Maro, D. (eds). John Wiley, London. Pp. 52 – 77.

Punmia BC and Jain AK (1998) Wastewater Engineering. Laxmi Publications (P) Ltd, New Delhi.

Radojevic M and Bashkin VN (1976). Practical Environmental Analysis. The Royal Society of Chemistry, Cambridge. 466p.

Speak Out (2010). The BP Oil Spill-Corporate Profits More Poisonous Than Oil. June 21, 2010 Edition. www.speakout.org. Pp. 1-2

Twumasi YA. and Meren EC (2006). GIS and remote sensing application in the assessment of change within a coastal environment in the Niger Delta region of Nigeria. Int. Journal Environ. Res. Public Health. 3 (1) 98-106.

Underwood EJ (1977). Trace Elements in Human Nutrition. 4th Edn., Academic Press, New York, pp: 545.

USEPA (1991). Volunteer Lake Monitoring:A Manual Method. Office of Water Monitoring. Washington DC. Pp. 44-62.

USEPA (1999). Cummulative Risk Assessment. Available at http://www.epa.gov Pp. 1 – 4

Waziri M (2006). Physicochemical and Bacteriological Investigation of Surface and Ground Water of the Kumadugu-Yobe Basin of Nigeria. Unpublished Ph.D Thesis. Department of Chemistry. University of Maiduguri. Pp. 24-186.

WHO (1993). World Health Organisation’s Guidelines for Drinking Water. (3rd edition). Geneva, Switzerland. Pp. 41-62.