Effects of Gas Flaring and Oil Spillage on Rainwater Collected for Drinking in Okpai and Beneku, Delta State, Nigeria

Tony Dami [1], H. K. Ayuba[2] and O. Amukali[3]

[1] University of Maiduguri, Borno State, Nigeria.

Received: 13 June 2012 Accepted: 30 June 2012 Published: 15 July 2012

Abstract

This paper evaluates the effects of gas flaring and oil spillage on rainwater quality for domestic use in Okpai and Beneku areas of Delta State, Nigeria. Both field and laboratory techniques were employed in the analyses of rainwater quality. Rain water samples were collected in the dry (December, January and February) and wet (June, July and August) seasons from Okpai (experimental site) and Benekuku (controlled site). The water samples were analyzed for chemical, physical and biological parameters using the methods of Radojevic and Bashkin, 1976; USEPA ,2007; and Kolo, 2007.The results showed that gas flaring and oil spillage have significantly changed some physic-chemical and biological properties of drinking water in the study area. For instance, there were changes in the taste, color, temperature, conductivity, alkalinity and total dissolved salts. These could have serious health implications on the ihabitants of the area. Apart from these, other parameters analyzed corresponded to the approved maximum permissible limits for drinking water set by NAFDAC, USEPA and WHO.

Index terms— flaring, oil spillage, pollution, rain water quality.

1 Introduction

he coastal areas of the Niger Delta in Nigeria have experienced tremendous oil exploration and exploitations over the years (Nwilo and Badejo, 2005). This is largely due to the huge deposits of crude oil and natural gas deposits within the region. The World Bank report of 2002 succinctly stated that Rivers and Delta states alone produced about 75% of Nigeria's petroleum, which represents over 50% of national government's revenues. In the same year (2002), Nigeria was rated the fifth largest supplier of crude oil to the United States. Nigeria's proven oil reserves fuel the economy because it is almost exclusively dependent on earnings from the oil sector and this generates about 20% of GDP, 95% of foreign exchange and about 65% of budgeting revenues (CIA World fact Book, 2008).

However, human activities have impacted negatively on the delicate balance of nature and the fragile ecosystems of atmospheric, surface and ground water bodies (Nwankwo and Ogagarue, 2011). Domestic, agricultural and industrial wastes have over time been discharged into the environment (air, water and soil) and these end up accumulating within such entities and causing health and environmental problems. When pollutants are received by water, generally they are dispersed over water molecules immediately to nullify their attendant effects. But, if this continues over time uncontrollably, the carrying capacities of such water bodies could be exceeded and their resultant health and environmental impacts would be felt.

Generally, gaseous pollutants move into the atmosphere, displace and affect the quality of air. These could condense in the cloud and later fall back as rain. When they fall back as rain, they settle either directly on surface waters or on soils before been conveyed to surface water bodies where they accumulate. These pollutants could later sink into the underground aquifers to cause underground water pollution too. All these generally upset the water food web and affects health and environment of living organisms that depend on them.

The overall effect of water pollution is much easily noticeable in surface than atmospheric and underground water bodies. For instance, agricultural pollutants like pesticides, herbicides and fertilizers (Kolo, 2007) and industrial pollutants (Akan, 2006) have reportedly caused serious environmental problems to living organisms. The severity of the negative impact has been found to be more on stagnant waters than the moving ones **??**Bhutia, 2009). This is because, when pollutants are received, they accumulate and sediment beneath untransformed, and resultantly, they reach high concentrations that could induce health and environmental effects on dependent living organisms. This is unlike moving waters that carry pollutants and disperse them out, immediately. This study assesses the effects of gas flaring and oil spillage on atmospheric (rain) water collected for domestic use in the area.

2 Year

3 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 Merm, 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 $5^{o}40$ N and $5^{o}50$ N and longitudes $6^{o}15$ E and $6^{o}30$ E (Figure **??**) (Oseji and Ofomola, 2010).

The geographical Niger Delta has been said to cover an estimated area of between 19,100 km 2 to 30,000 km 2 based on hydrological, ecological as well as political boundaries **??**SPDC, 2006 and **??**NDP, 2006). Okpai/Aboh region is 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,

4 1997).

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 (Olaniran, 1986). Annual mean total rainfall has been put at between 1,500mm and 3,000 mm with a mean monthly temperature range of 24-25 o C during the rainy season in August and 27-29 0 C during tail end of dry season in March/April. Leroux (2001) reported that maximum temperatures are recorded between January and March (33 0 c) while minimum temperature are recorded in July and December (21 0 c), respectively. 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 distributories and creeks. This area has been classified geomorphologically to consist of tidal flat and large flood plains lying between mean, low and high tides. Three different highs exist within the Kwale block, namely; 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. The area lies within the freshwater forested region of the Niger Delta.

5 III.

6 Methodology

Rain 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 rainwater 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 rain water samples collected were analyzed. At every point, two sets of samples were collected: one for AAS 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 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 (2007) 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 of water samples were measured and put into a beaker. A 5cm aqua regia (HNO : 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 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 complete the digestion and after which it was brought down and another 5cm 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. 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 24 C. 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.

IV.

7 Results and Discussion

Table 1 shows the summary of the twenty nine (29) parameters analyzed both Okpai and Beneku. Sources : (Amukali, 2012)

Temperature was found to be highest with an average value of 30.4 C at Okpai during the dry season. The maximum permissible limit for temperature of between 25-30 C for drinking water (WHO, 1996) was only exceeded at Okpai during dry season. Bhatia (2010) stated that areas prone to discharge of industrial wastes usually have temperature ranges above those of their surrounding environments. Unarguably, the gas flare site at Okpai must have influenced an increase in air temperature, thus correspondingly increasing the temperature of rain water. This is indicative of rain water pollution since organisms that initially depended on such rain waters could find the temperature ranges no longer suitable for their continued stay and could migrate to areas with favourable temperature ranges. Increased temperature of rain water could cause corresponding increase in temperature of surface waters. High temperatures outside the optimum range for a prolonged period of time could cause organisms that depend on it to undergo stress and probably die (USEPA 1991).

Pure water is tasteless (Akan, 2006). Taste in rain water samples within Okpai in dry and wet seasons and that of Beneku in the dry season is indicative of possible contamination. This could be because of dissolved salts and other contaminants finding their ways into rain water sources through gas flaring for Okpai. Kolo (2007) suggested that taste could be an indication of the presence of iron, manganese and hydrogen sulphide in water; thus it could be deduced that objectionable taste in rain water waters for the present study except at Beneku during wet season could be due to the impact of gas flaring.

In terms of color, the maximum permissible value of 15 TCU (NIS, 2007) was exceeded by rain water samples from all studied sites during both seasons. Akan (2006) stated that pure water is colourless. Thus, any water with a characteristic colour insinuates contamination.

At $p<0.005$ level of significance, there were significant differences in colour between Okpai and Beneku and even between wet and dry seasons respectively. The more than 300% value recorded at Okpai with respect to the maximum permissible value could be attributable to gas flaring activities within the region while about 200% observed at Beneku could be due to translocation movements of precipitations through agents of weather. This shows a level of contamination in rain waters of both Okpai and Beneku respectively. Like taste, colour could be an indication of dissolved salts and suspended solids. It has no health or environmental effects though, but a major determinant of a consumer's choice of drinking water.

From table 1 the conductivity was highest at Okpai during wet season with an average value of 26.08?s/cm and closely followed by same Okpai during dry season with a value of 25.723?s/cm. At Beneku, dry and wet season average values were 17.927 and 17.643 respectively. The maximum permissible limit of 1,000?s/cm was not met by all values under study. Significant differences at $p<0.005$ existed between Okpai and Beneku but none were noticed between dry and wet seasons in both study areas. Higher conductivity values at Okpai rain waters as compared to Beneku during both seasons could be due to high amounts of dissolved salts and higher evapotranspiration of water.

The low values of conductivities in rain waters could be due to effects of excessive cloud cover, release of antagonistic substances and massive evapotranspiration within the region.

Alkalinity was highest at Okpai with an average value of 8.887mg/l and closely followed by same Okpai during dry season with an average value of 8.877mg/l as shown in table 1 at Beneku, the highest value of 7.187mg/l was observed during dry season but 6.693mg/l during the wet seasons respectively. All values were below the maximum permissible value range of between 30-500mg/l (NIS, 2007). At $p<0.005$ level of significance, no significant differences existed between seasons but there were significant differences between study areas. Generally, alkalinity tended to be comparatively higher in Okpai than in Beneku rain water. The higher rate could be attributed to continuous release of acidic substances into Okpai's adjoining environment. Low levels below the recommended maximum range is an indication that rain waters have high chances of acidifying lakes and other surface waters as well as ground water sources within the studied area. Consuming such waters could acidify the human bodies and predispose them to chances of reduction in immunity.

The TDS in the table 1 shows that the highest value at Okpai during dry season with an average value of 15.933mg/l. This was followed by same Okpai during wet season with an average value of 15.163mg/l. before 10.02mg/l and 8.933mg/l were then observed for Beneku dry and wet seasons respectively.). However, WHO (1996) recommended 1,000mg/l for the protection of fisheries and aquatic lives as well as for domestic water supply while less than 500mg/l (NIS, 2007) is the maximum permissible value for TDS in drinking water. All values were below the acceptable limit. There were significant differences at $p<0.05$ level of significance between Okpai and Beneku as well as between dry and wet seasons. Higher TDS values at Okpai during both seasons as compared to Beneku could be due to the release of hydrocarbons into the atmosphere through gas flaring. Based on TDS as a criterion, rain waters of both studied sites and during both seasons are safe for consumption.

V.

8 Conclusion

The results revealed that parameters such as temperature, taste, color, conductivity, total dissolved salts and alkalinity were significantly affected as their values were either less than or exceeded the maximum permissible limits. The chemical parameters however, did not show significant changes when compared with the permissible standards

Figure 1: Global

S/No.	Parameters	Okpai Rainwater (dry season) DRY.OK.RW	Beneku rainwater (dry season) DRY. BN. RW	Okpai Rainwater (wet season) WET. OK. RW	Beneku rainwater (wet season) BN. RW/ WET.	Max. Permissible Value	Polluted	Unpolluted	Health/ Environment Effects
1.	pH	5.083	6.527	5.973	6.483	6.0 - 8.5	DRY.OK.RW/WET.OK.RW	DRY.BN.RW/WET.BN.RW	Indicates acidification of rain/ corrosion of pipes
2.	Temperature	30.4	28.603	28.303	27.2	25 - 30 C	DRY.OK.RW	DRY.BN.RW/WET.OK.RW/WET.BN.RW	Drives organisms away / Aesthetics
3.	Taste	1	1	1	0	0	DRY.OK.RW/DRY.BN.RW/WET.OK.RW	WET.BN.RW	Aesthetics
4.	Colour	48	32	48.333	29	15 TCU	All	None	Aesthetic
5.	Conductivity	25.723	17.927	26.08	17.643	1,000 / cm	None	All	None
6.	Alkalinity	8.877	7.187	8.887	6.693	30 - 500mg/l	All	None	Lowers immunity
7.	Turbidity	2.423	1.723	1.747	1.19	5 NTU	None	All	None
8.	Dissolved Oxygen	6.277	5.803	6.483	6.157	>4	None	All	None
9.	B O D	2.443	2.14	2.71	2.58	0.1 - 1.9mg/l	All	None	Smelly waters
10.	C O D	0.08	0.127	0.15	0.18	200mg/l	None	All	None
11.	T D S	15.933	10.02	15.163	8.933	1,000mg/l	None	All	None
12.	T S S	10.473	8.67	6.84	5.473	20mg/l	None	All	None
13.	Sulphates	0.004	0.003	0.012	0.01	100mg/l	None	All	None
14.	Phosphates	0.0177	0.001	0.04	0.004	10 - 50mg/l	All	None	Hypophosphotaemia

Figure 2:

1

15.	Nitrates	<0.001	<0.001	<0.001	<0.001	50mg/l	None	All	None
16.	Chlorides	0.146	0.102	0.2	0.111	250mg/l	None	All	None
17.	Flourides	<0.001	<0.001	<0.001	<0.001	0.8 - 1.5mg/l	All	None	Easy bacterial contamination
18.	Calcium	1.933	1.327	1.84	1.217	50mg/l	None	All	None
19.	Magnessiu m	0.647	0.667	1.077	0.933	37 - 150mg/l	All	None	Hypermagnesa emia/Hard water
20.	Sodium	0.093	0.11	0.13	0.137	200mg/l	None	All	None
21.	Potassium	0.01	0.013	0.077	0.037	1 - 2mg/l	All	None	Hypopotasaem ia
22.	Iron	0.006	0.004	0.003	0.001	0.3mg/l	None	All	None

Figure 3: Table 1 :

[UNDP] , *UNDP* p. 48.

[United Nations Development Programme ()] , *United Nations Development Programme* 2006. Niger Delta Human Development Report. (UNDP)

[CIA ()] , `http://www.cia.gov/library/publications/the-world-factbook/print/uk.litml` *CIA* 2008. CIA-World fact Book

[Amukali ()] *Assessment of water pollution in Ndokwa-East Local Government area*, O Amukali . 2012. Delta State, Nigeria: An M. Sc. Dissertation. University of Maiduguri

[Oseji and Ofomola ()] 'Determination of groundwater Flow direction in Utagba Ogbe Kingdom, Ndokwa Land area of delta State'. J O Oseji , M O Ofomola . *Nigeria. Archives of applied Science Research* 2010. 2 (4) p. .

[Akan ()] 'Determination of pollutant levels in some surface and water wastes samples from Kano metropolis'. J C Akan . *Nigeria. An M.Sc. Dissertation. University of Maiduguri* 2006. p. 88.

[Nwankwo and Ogagarue ()] 'Effects of gas flaring on surface and ground waters in Delta State'. C N Nwankwo , D O Ogagarue . *Journal of Geology and Mining Research* 2011. 3 (5) p. .

[Twumasi and Meren ()] 'GIS and remote sensing application in the assessment of change within a coastal environment in the Niger Delta region of Nigeria'. Y A Twumasi , E C Meren . *Int. Journal Environ. Res. Public Health* 2006. 3 (1) p. .

[Dublin-Green et al. ()] *Large marine ecosystem project for the Gulf of Guinea*, C O Dublin-Green , A Awobamise , E A Ajao . 1997. p. 36. Coastal profile of Nigeria. Nigerian Institute of Oceanography

[Nwilo and Badejo ()] 'Management of Oil spill dispersal along the Nigerian Coastal Areas'. P C Nwilo , O T Badejo . *J. Envtal Mgt* 2005. (4) p. .

[Methods of chemical Analysis of water and waste water. Office of water Washington DC USEPA ()] 'Methods of chemical Analysis of water and waste water. Office of water Washington DC'. *USEPA* 1991. p. .

[Olaniran ()] 'On the classification of tropical climates for this study of regional climatology: Nigeria as a case study'. O J Olaniran . *Geography Annaler. Series A. Physical geography* 1986. 68 (4) p. .

[People and Environment Report Shell Nigeria Annual report ()] 'People and Environment Report'. *Shell Nigeria Annual report* 2006. 2006. p. 18. (Shell visual media services)

[Physicochemical and bacteriological investigation of surface and ground water of the Kumadugu-Yobe Basin of Nigeria Method 7 'Physicochemical and bacteriological investigation of surface and ground water of the Kumadugu-Yobe Basin of Nigeria'. GEMS/WATER. `http://www.epa.gov/osw/hazard/testmethods/sw846/pdfs/7000b.pdf19` *Method 7000B: Flame Atomic Absorption Spectrophotometry*, (Maiduguri, Nigeria; Geneva) 2007. 2006. 1991. 1999-2000. 20 p. . University of Maiduguri Postgraduate School (A Ph.D Thesis) (The challenge ahead)

[Radojevic and Bashkin ()] M Radojevic , V N Bashkin . *Practical Environmental Analysis*, (Cambridge) 1976. The Royal Society of Chemistry. p. 466.

[Standards Organisation of Nigeria] *Standards Organisation of Nigeria*, Lagos, Nigeria. p. .

[Kolo ()] *Study on the chemical, Physical and biological pollutants in water and aqueous sediments of Lake Chad area*, B Kolo . 2007. Borno State, Nigeria; Maiduguri, Borno State,Nigeria. p. 12. Submitted to The University of Maiduguri (A Ph.D Thesis)

[Leroux ()] *The Meteorology and climate of tropical Africa. Praxis publishing limited*, M Leroux
NIS . 2001. 2007. 8. Nigeria Standard for drinking Water Quality. Nigerian Industrial Standard under

[Bhatia ()] *Water Pollution in Chemical Industries*, Bhatia . 2009. India: John Welsh Publications. p. 658.

[World Health Organisation's guidelines for drinking water WHO ()] 'World Health Organisation's guidelines for drinking water'. *WHO* 1996. p. . (3 rd edition. Geners)