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ANALYSIS OF PRODUCED WATER FROM FOUR COMMUNITIES IN DELTA STATE (NIGER DELTA), NIGERIA

Umudi, E. Q.
Department of Chemistry
College of Education, Agbor, Delta State, Nigeria
e-mail: ese.umudi@yahoo.com

ABSTRACT

Produced water from four Delta State Community flow-stations [Ogulaha (A), Sokobolor (B), Iyokiri (C) and Okirika (D)] 10 miles apart were analyzed. They contain 35.26ppm polycyclic aromatic hydrocarbon for A, 4.57ppm for B, 60.68 for (C) and 53.00 for (D). pH values were 8.10 for A, 8.20 for B, 8.10 for C and 8.10 for D, tuibidity values were 63NTU for A, 51 for B, 47 for C and 66 for D. BOD and COD were (310.00, 121.00, 201.31 and 231.21)ppm and (810.00, 710.00, 913.00 and 810.00) ppm respectively for samples A, B, C, and D. Total organic carbon (mg/l) was 30.00, 154.00, 23.00 and 240.00 for the samples A, B, C and D. The metal concentrations of iron, zinc, nickel, cadmium and lead were higher than accepted limits of World Health Organisation (WHO) and National Environmental Standard and Regulation Enforcement Agency (NESREA) while copper, chromium and manganese were within acceptable limits.

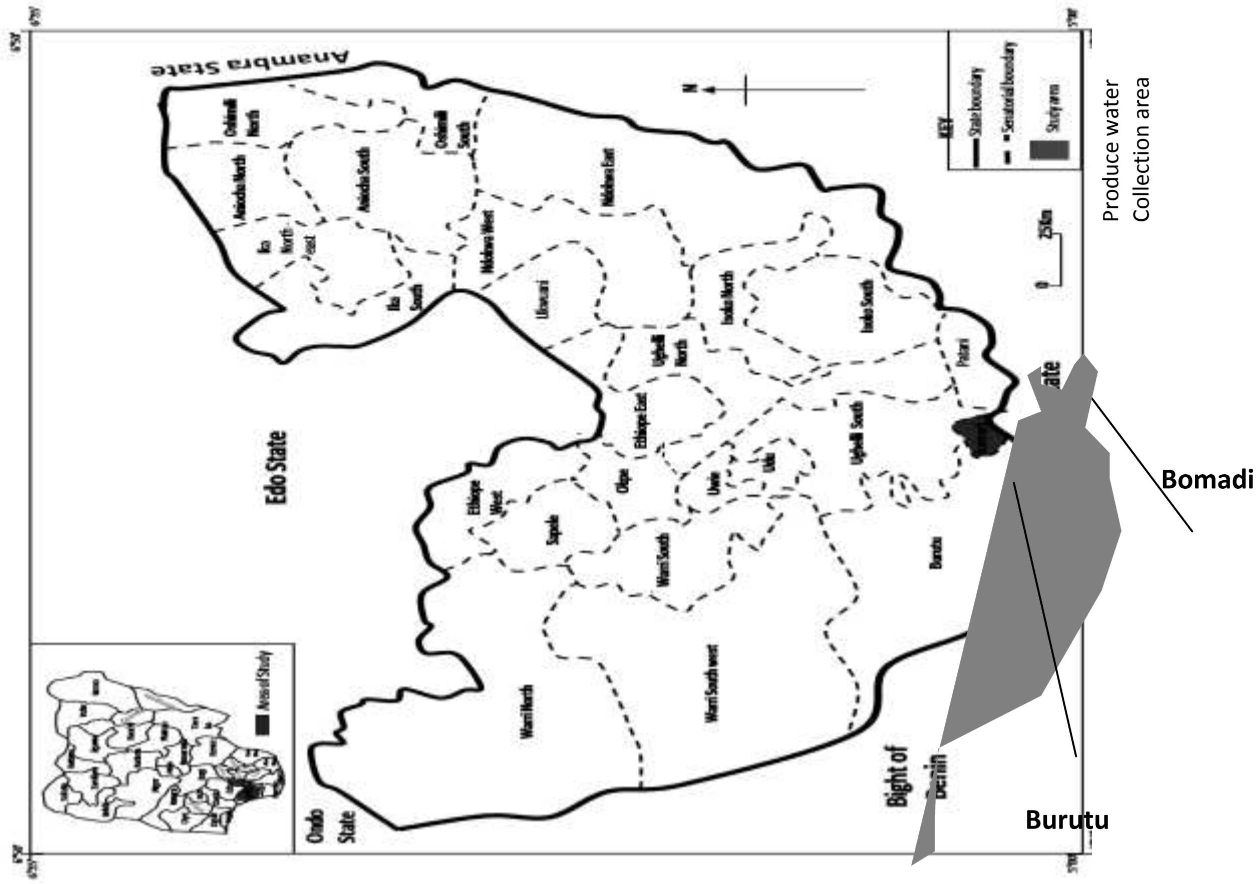
Keywords: Polycyclic aromatic hydrocarbons (PAHs), mutagenic, tetratogenic, NESREA and water.

INTRODUCTION

Water is produced from underground formation during the process of oil and gas production. This production water is of environmental and economic concern to regulator and operators of oil and gas industries worldwide (Veil, Pruder, Elcook and Redweik, 2004). This water-oil mixture is separated by floatation or gravity separation in tanks, heat separated, skimming pit and other methods. The remaining water or produced water can be deep-well injected or discharged to surface waters as permitted. This water contains contaminants such as crude oil, trace metals, dissolved gases, produce solids and other chemicals (Grigson, Cheong and Way, 2010).

Analysis of oil-produced water is important for regulatory bodies and process chemistry (control). It is source of information for stakeholders. Hydrocarbons, radionuclide, trace elements can bioaccumulate in sediments and persist in food chain even to aquatic birds (Ramirez, 1993). Some of the polycyclic aromatic hydrocarbons (PAHs) and Nephthalene, Phenanthrene, dibenzothiophene are present in water in dissolved form. PAHs were reported in the bile metabolites of waterfowls near wetland near cody, Wyoming, bone tissue from these birds contained radium – 226. This showed that aquatic birds ingesting sub-lethal doses of oil experience impaired reproduction, this could result from birds returning to their nest with oil may transfer the oil to eggs and cause embryo mortality (Grau, Roudybush, Dobbs and Wathen, 1997). PAHs generally have been a major health concern because they are toxic. These PAHs which occur with crude oil are four or more aromatic rings fused with no heteroatoms for substitution. They have been identified as carcenogenics, mutagenic and tetragenic (Luch, 2005). Benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, dibenzo[a,h]anthrcene, benzo[k]fluoranthene, chrysene and indeno(1,2,3-Cd) pyrene have been classified as probable human carcinogens by the United States Environmental protection Agency. High prenatal exposure to PAH is associated with lower intelligent quotient (IQ) (Lee, Liow, Tsai and Hsieh, 2002).

It is therefore necessary to know the quality of produce water and the composition to access the viability of reuse and appropriate treatment process for the water reuse eventually (Obuzor and Ejimozor, 2010). The aim of this study is to give an assessment of the physical and chemical characteristics of produce water of four Niger-Delta communities (Ogulahai and Sokobolor in Bomadi Local Environment Area and Iyokiri and Okiriko in Burutu Local Government Area of Delta State).



Map of Delta State showing study area
Source: Modified after Ministry of Lands and Survey, Asaba, 2008.

They are about 10 miles apart. The produced water was analysed to know if it meets National Environmental Standard and Regulation Enforcement Agency (NESEREA) set limit since this water is not usually treated before discharged to the environment. This was done by measuring some pollution characteristics using standard methods.

MATERIALS AND METHODS

The produced water used was obtained from Ogulaha and Sokobolor in Bomadi Local Government Area and Iyokiri and Okirika in Burutu Local Government Area, Delta State, Nigeria, lying between longitudes $05^0 45^1$ and 05^0 49^1 East of the Greenwich Meridian and latitudes 05^0 35^1 and 05^0 45^1 North of the equator. 5 litres sterile plastic container containing 1:1ml concentrated hydrochloric acid, produce water was collected from the well head. This was taken to the laboratory within 6hours for analysis.

Metal ion analysis

20ml produce water sample was used for the digestion using 20ml concentrated HCl and 6ml perchloric acid and 1ml HNO_3 and analysed for the metals by flame atomic spectrophotometer (Buck Scientific Model 200A), with high sensitive nebulizer while phosphorous was by ascorbic acid method (Lenore, Arnold and Andrew, 1999).

- The PAHs values were determined using gas chromatograph HP 5890 series II.
- HACH 2000N Turbidimeter was used for turbidity using formazin standards supplied with the instrument.
- Oil and grease values were determined using HACH DR2200.
- HACH digital pH was used for pH calibrating with buffers 4 and 7 and 9 buffers.
- Conductivity was carried out using Thermo Oriental.
- Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) by standard methods (Lenore, Arnold and Andrew, 1999).

Table 1: Metal contents of produce water from the four communities

Parameters (PPM)	Ogulaha (A)	Sokobolor (B)	Iyokiri (C)	Okirika (D)	WHO Standard Maximum Permissible	*Drinking water quality standard	*Effluent Discharges, irrigation & Reuse standard	*Fisheries & Recreation Quality Standards
Fe	0.531	0.600	0.160	0.210	0.3	0.3	0.5	0.05
Zn	0.121	0.300	0.310	0.021	3.0	3.0	0.2	0.02
Cd	0.001	0.001	0.001	0.002	0.003	0.003	0.001	0.005
Cr	0.010	0.010	0.05	0.010	0.005	0.5	0.5	0.5
Cu	0.010	0.010	0.010	0.04	1.0	1.0	0.01	0.001
Ni	0.020	0.020	0.020	0.02	0.01	0.1	0.01	0.01
Pb	2.040	0.020	0.010	0.02	0.01	0.20	40.0	40.0
Mn	0.010	0.010	0.010	0.20	0.4	0.20	40.0	40.0

*Values from National Environmental Standards and Regulations Enforcement Agency (NESREA, 2010).

Table 2: Results and Discussion

Polyaromatic hydrocarbons (PAHs) concentration of produce water of four communities in Delta State

PAHs (PPM)	Ogulaha (A)	Sokobolor (B)	Iyokiri (C)	Okirika (D)
Nephthalene	1.002	0.09131	1.391	2.0321
Acenaphthylene	3.201	0.02021	7.210	2.0312
Acenaphthlene	5.001	0.7312	10.231	1.0859
Fluorene	3.212	0.6123	7.183	10.3210
Phenanthrene	1.814	0.5121	6.1321	9.321
Anthracene	5.210	0.813	12.8132	4.2103
Fluoranthene	8.112	0.4123	3.4281	13.132
Benzo[a]anthracene	3.221	0.1002	2.1891	2.1320
Chrysene	1.124	0.0121	1.2182	1.3210
Benzo[b]fluoranthracene	0.101	0.0021	0.0521	0.5895
Benzo[a]pyrene	1.210	0.1234	0.6128	1.3210
Indeno[1,2,3]pyrene	0.131	0.4132	3.2101	1.201
Dibenz[a,h]anthracene	0.211	0.4136	3.001	4.293
Indenol[1,2,3,c,d]pyrene	1.713	0.2160	2.012	0.1201
Total	**35.26**	**4.57**	**60.68**	**53.00**

Table 3: Physiochemical concentrations of produced water from the four communities

Parameters (PPM)	Ogulaha (A)	Sokobolor (B)	Iyokiri (C)	Okirika (D)	WHO Standard Maximum Permissible	*Drinking water quality standard	*Effluent Discharges, irrigation & Reuse standard	*Fisheries & Recreation Quality Standards
pH	8.10	8.20	8.10	8.10	7.8-8.6	6.5-8.5	6.5-8.5	6.5-8.5
Turbidity (NTU)	63	51	47	66	5.0	10	10	10
Conductivity (µs/cm)	210.13	20.40	20.10	28.10	1200	NA	NA	NA
Oil and grease (ppm)	8,213	2,120	15,531	11,131	0.01	0.003	0.1	0.01
M-Alkalinity (ppm)	710.00	1,200.00	201.00	100	NA	NA	NA	NA
Chloride (ppm)	7,751.21	10,021,18	22,131.51	8,131.10	100	350	350	300
Ortho-phosphate (ppm)	0.18	0.06	0.51	3.3	3.5	3.5	3.5	3.5
Total Carbon (TC) (mg/l)	130.70	185.90	541.30	531.10	NA	NA	NA	NA
Inorganic Carbon (mg/l)	100.70	31.90	518.29	291.10	NA	NA	NA	NA
TOC = (TC-IC) mg/l	30.00	154.00	23.01	240.00	NA	NA	NA	NA
COD (ppm)	810.00	710.00	813.00	810.01	15	15.0	30.0	30.0
BOD (ppm)	131.00	121.00	201.31	231.21	15	5.0	6.0	5.0

***Values from National Environmental Standards and Regulations Enforcement Agency (NESREA, 2010).**

Table I showed the metal contents of iron, zinc, nickel, cadmium and lead to be higher than NESEREA and WHO acceptable limits for water utilizations. The high concentration of lead is of concern because of its health effect on human and the environment (Benko and Drewes, 2008). Table 2 shows PAH distribution for the fourteen PAHs that were detected at the gas-phase for 2-6 rings PAHs. The total PAH concentration for A is 35.26ppm with the range of 0.101 – 8.112ppm, B's total is 4.57ppm, C has total PAH of 60.68 and range 0.0521 – 12.8132 and D total PAH is 53.00ppm with range 0.1201 – 13.132ppm C > D > A > B from table 2. For sample A, Fluoranthene, Anthracene and Acenaphthene were the most abundant. For sample B, Anthracene, Acenaphthene and Anthracene were most abundant, for sample C, Anthracene and Acenaphthene were most abundant, while sample D has fluocene and fluoranthene as most abundant. Those with two to three rings (naphthalene, acenaphtylene, acenaphtene, fluorine, phenanthrene, anthracene, fluoranthene and high molecular weight (HM-PAHs) benzo[a]anthracene, chrysene, benzo[b] fluoranthracene, benzo[a]pyrene, indenol[1,2,3]pyrene, dibenz[a,h]anthracene and indenol[1,2,3-c,d]pyrene) containing four to six rings. The low molecular weight PAHs 92-3 rings) were the dominant species, corresponding to (27.55ppm) 84.51% for sample A, (3.29ppm)72.04% for B, (48.39ppm(79.74%) and 42.13ppm (79.50%) for D. while the high molecular weight (4-6 rings PAHs) represent the other fractions of PAHs. Low molecular weight have weaker carcinogenic properties and are the most abundant in urban atmosphere ad react with other pollutants to form toxic derivatives. All the samples are above NESEREA permissible limit of 0.01ppm with five of the HM-PAHs benzo[b]fluoraanthraee, benzo[a]pyrene, indo[1,2,3-]pyrene, dibenz[a,h]anthracene and indenol [1,2,3-c,d] pyrene) identified in the sample are known mutagenic and tetragenic species.

The physicochemical data of the produce water is shown in table 3. The pH was within the range of 8.10 – 8.20. Turbidity were higher than WHO and NESREA limits. Oil and grease were higher than the set limits for various purposes. Chloride was also higher, concentration of orthophosphate were below NESREA set limits of 3.5 for the four communities. Organic matters dissolved in water were determined by measuring Total organic carbon (TOC) comprising sugars, vitamins, bacteria components and organic acids. TOC provides a broad measure of water quality. Chemical Oxygen Demand (COD) is a measure of the oxygen demand of biodegradable organic pollutants plus the oxygen demand of non-biodegradable oxidizable pollutant (inorganics) and were higher than NESREA set limits of 15.00ppm for drinking water. Also, the Biological Oxygen Demand values were higher than WHO and NESREA values for drinking water, fisheries and recreations for effluent discharges and irrigation.

CONCLUSION

Physical and chemical properties of produce water vary depending on reservoir geology, hydrocarbon composition, geographical location and water injection history therefore it is not consistent. Produced water should be monitored regularly. From this analysis, the produce water from the four communities' flow stations were highly contaminated with PAHs, organic and inorganic matters, oil and grease. It should be properly treated before it is discharged to the water bodies, environment or injected into the soil.

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