Available online at www.pelagiaresearchlibrary.com

Pelagia Research Library

Der Chemica Sinica, 2013, 4(1):155-161

Pelagia Research Library
ISSN: 0976-8505
CODEN (USA) CSHIA5

Assessment of water quality parameters from Swamps around Kokori-Erhoike Petroleum Flow Station in Delta State, Nigeria

Arise R. O., *Osioma E. and Akanji M. A.

Department of Biochemistry, Faculty of Science, University of Ilorin, Nigeria

ABSTRACT

This study assessed the water quality from swamp around Kokori-Erhoike petroleum flow station of Delta State, Nigeria. Water samples were collected from Eku River (Site A, reference site), Erhoike swamp (Site B) and a natural fish pond located within Erhoike environment (Site C). Physico-chemical parameters and some selected heavy metals (Lead, cadmium, chromium, manganese, copper, zinc, iron and mercury) including total petroleum hydrocarbon were analysed. Results indicated that pH, electrical conductivity, total solids, biological oxygen demand, total hardness, phosphate and calcium were not comparable (p<0.05) in water samples from the three sites. Dissolved oxygen was significantly lower (p<0.05) in Sites B and C as compared with Site A while Site B recorded the highest biological oxygen demand concentration. Oil and grease was absent in Site A but comparable in Site B and C. Heavy metal results showed that all sites have comparable (p>0.05) heavy metal content. Total petroleum hydrocarbon was significantly elevated (p<0.05) in site B (Erhoike swamp) as compared with site A and C. Overall, the results obtained for the control Site (Eku River) indicated that the water is relatively not polluted. However, the presence of total petroleum hydrocarbon and oil and grease in water sample from Erhoike swamp confirm the over 30years of crude oil exploration in the area and the observed elevated levels of electrical conductivity, total solids, calcium, magnesium, phosphates and moderately low dissolved oxygen suggest that Erhoike fish pond (Site C) is polluted with organic or inorganic contaminants. In conclusion, pollutants present in Site B and C may affect aquatic lives especially fish. Therefore it is recommended that adequate measures should be put in place to reduce the introduction of petroleum products into the environment.

Keywords: Kokori-Erhoike, water quality, flow station, physico-chemical properties, heavy metals.

**Corresponding author:ejoviosioma@yahoo.com, +2348068562275*

INTRODUCTION

Petroleum exploration usually takes place in the marine ecological environment where geological conditions are most favourable for the accumulation of organic materials. Oil exploration activities have extended from the Niger Delta basin to the Lake Chad basin in the North Eastern part of Nigeria and the scope of oil exploration activities and its associated environmental consequences have been increasing over the years [1] and the contamination of streams and rivers is one of the environmental problems associated with oil exploration and production in the Niger Delta [2].

The aquatic environment with its water quality is considered the main factor controlling the state of health and disease in both man and animals and contamination of fresh water with a wide range of pollutants has become a subject of interest over the last few decades [3]. Among the different types of pollutants, petroleum products according to [4] are the most relevant to aquatic ecotoxicology. Exploration activities including production, transportation and storage of petroleum products have added to the devastating consequences of oil spill and this affects water quality of the environment.

Water quality assessment is of immense importance to practices involving the use of water bodies and its remains a useful tool for pollution control and assessment, development of fishery resources, planning of water resource control and management as well as disease vectors [5,6]. The status of water quality is based on the evaluation of its physico-chemical and metallic characteristics. This may help to determine the water ecosystem integrity and establish the levels of contamination in aquatic environment.

Few studies have been carried out in Erhoike petroleum flow station area addressing issues on radiation [7], quantification and distribution of polynuclear aromatic hydrocarbons [8], thermal gradient due to gas flare [9]. However, for over 30years of crude oil exploration in Erhoike [8], literature has not revealed the pyhsico-chemical and metallic characteristics of the area. This information paucity prompted this study. Therefore, the objective of this study is to determine the physico-chemical and heavy metal contents of water sample from swamp around Erhoike petroleum flow station of Delta State, Nigeria.

MATERIALS AND METHODS

Sampling Stations

The study was conducted in Kokori-Erhoike Petroleum flow station area and Ethiope River (Eku axis) in Ethiope Local govnerment Area of Delta State Nigeria. Three sampling sites (A, B, and C) were used and are depicted in Figure 1.

The main uses of water in the catchments include domestic, recreational (e.g. swimming) and fishing. Their major occupation includes farming of (cassava, yam, Okro etc.), fishing and petty trading on food stuff.

Water Sampling:

Collection of water samples from the sampling sites (A, B, &C) was carried out in October, 2011. Prior to sampling, all sampling containers were thoroughly cleaned. At each water sampling station, water samples were taken from the surface of the water body into appropriate sample containers, preserved accordingly [10] and taken to the laboratory (TUDAKA Environmental Consultants Limited, Ekpan, Warri, Delta State, Nigeria) for analysis. All analytical quality control requirements were strictly adhered to and carried out in triplicate. Physico-chemical parameters analysed included pH, Conductivity, Total solids, Dissolved oxygen, Biochemical oxygen demand, Total hardness, Sulphate, Phosphate, Oil and grease, Calcium, Magnesium and Potassium. Heavy metals include Lead, Cadmium, Chromium, Manganese, Copper, Zinc, Iron, and Mercury. Total Petroleum Hydrocarbon of water sample was also determined.

STATISTICS

The values for various physico-chemical parameters were expressed as mean±SD; data were analyzed using analysis of variance (ANOVA) and the group means compared by Duncan's Multiple Range Test (DMRT). Values were considered statistically different at $P < 0.05$. All statistical analysis was performed using SPSS version 16.

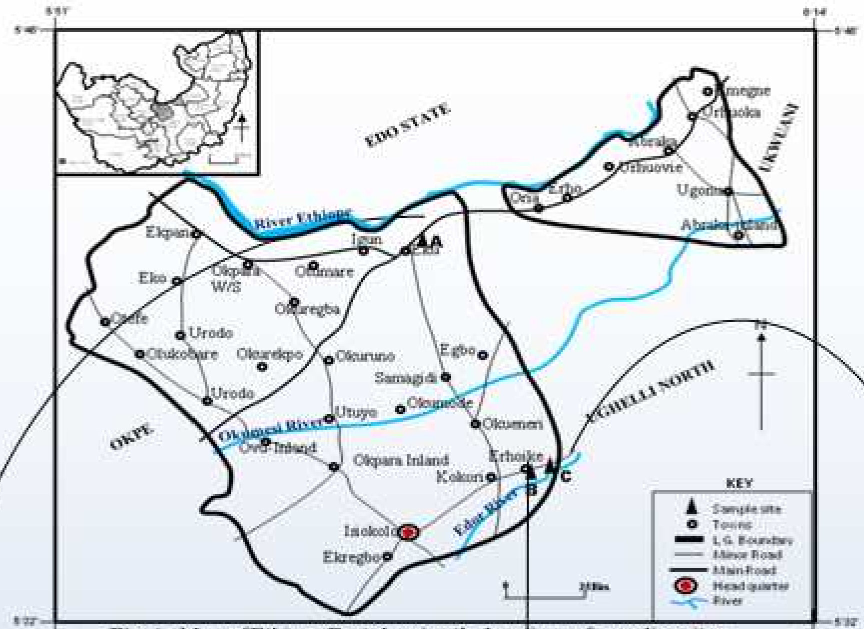

Fig. 1: Map of Ethiope East showing the locations of sampling sites
Source: *Ministry of Lands, Surveys & Urban Development, Asaba, (2008)*

Plate 1: Site A, Eku River

Plate 3: Site C, Erhoike Fish Pond

Plate 2: Site B, Erhoike Swamp

Site A *(reference site) is the Eku axis of the Ethiope River, Delta State. There is no presence of oil facilities/operations or any industry located along the Ethiope River from its source, Umuaja, about 22km away to the Eku axis. This qualifies the Eku axis of Ethiope River as a reference site for this study.*

Site B *is the swampy environment of Kokori-Erhoike petroleum flow station where oil exploration activities have been on for more than 35 years. This area has a number of oil wells and flow stations. The aquatic ecosystem in the area is constituted of nontidal freshwater swampy forest characteristics of those found within the freshwater survey zone of the Niger Delta.*

Site C *is a natural fish pond located within Kokori-Erhoike environment.*

RESULTS

Physico – chemical parameters and heavy metal content of water sample collected from the sampling sites (A, B and C) are shown in Tables I and II below.

Table 1: Physico – chemical parameters of water samples.

PARAMETERS	SITE A	SITE B	SITE C
P^H	6.94±0.04[a]	7.05±0.06[b]	6.74±0.08[c]
Conductivity (us/cm)	18.37±0.47[a]	12.34±0.17[b]	440.33±5.03[c]
Total solids (mg/l)	18.83±0.31[a]	16.00±0.10[b]	232.93±0.30[c]
Dissolved oxygen (mg/l)	5.13±0.15[a]	4.53±0.12[b]	4.75±0.05[b]
Biological oxygen demand (mg/l)	1.20±0.10[a]	2.20±0.03[b]	1.45±0.05[c]
Total hardness (mg/l)	8.89±0.03[a]	4.88±0.03[b]	80.36±0.23[c]
Sulphate (mg/l)	0.23±0.001[a]	0.26±0.002[a]	0.56±0.003[b]
Phosphate (mg/l)	0.41±0.02[a]	0.77±0.05[b]	1.11±0.10[c]
Oil and grease (mg/l)	<0.001 (BDL)	0.0017±0.001[a]	0.0013±0.00[a]
Calcium (mg/l)	0.78±0.03[a]	0.48±0.01[b]	7.32±0.03[c]
Magnesium (mg/l)	0.022±0.017[a]	0.20±0.01[a]	2.02±0.02[b]
Potassium (mg/l)	1.89±0.05[a]	1.77±0.10[a]	2.11±1.10[b]

Values are expressed as mean±SD of triplicate determinations. Means not sharing the same superscript letter on same row differ significantly at p<0.05. A= Eku River; B= Erhoike swamp; C= Erhoike fish pond. BDL= Below detection limit.

Results in Table 1 indicate that pH, conductivity, total solids, biological oxygen demand, total hardness, phosphate and calcium were not comparable ($p < 0.05$) in water samples from the three sites.

Water sample from site B recorded the highest pH level, while site C showed an elevated conductivity, total solids, total hardness, calcium, magnesium and potassium levels.

A significant ($p<0.05$) high concentration of dissolved oxygen was observed in water sample from site A as compared with that of site B and C which have comparable ($p>0.05$) dissolved oxygen concentration. The biological oxygen demand (BOD) recorded for water sample from the three sites (A, B & C) were significantly different ($p<0.05$), with site B (Erhoike swamp) having the highest BOD value followed by site C (Erhoike fish pond) and site A (Eku River) respectively. Oil and grease level in site A was below detection limit while that of site B and C were comparable ($p>0.05$).

Table II: Levels of selected heavy metals and total petroleum hydrocarbon content of water samples from sampling site A, B and C.

PARAMETERS (mg/L)	SITE A	SITE B	SITE C
Lead (Pb)	0.001±0.001[a]	0.001±0.00[a]	0.003±0.001[a]
Cadmium (Cd)	<0.001 (BDL)[a]	<0.001 (BDL)[a]	<0.001(BDL)[a]
Chromium (Cr)	0.0013±0.001[a]	0.0013±0.003[a]	0.004±0.002[b]
Manganese (Mn)	0.013±0.001[a]	0.014±0.003[a]	0.014±0.003[a]
Copper (Cu)	0.33±0.005[a]	0.031±0.003[a]	0.035±0.006[a]
Zinc (Zn)	0.041±0.003[a]	0.041±0.04[a]	0.045±0.004[a]
Iron (Fe)	0.071±0.005[a]	0.066±0.004[a]	0.078±0.004[a]
Mercury (Hg)	<0.001 (BDL)[a]	<0.001 (BDL)[a]	<0.001(BDL)[a]
Total Petroleum Hydrocarbon (TPH)	0.001±0.000[a]	0.003±0.000[b]	0.001±0.001[a]

Values are expressed as mean±SD of triplicate determinations. Means not sharing the same superscript letter on same row differ significantly at p<0.05. A= Eku River; B= Erhoike swamp; C= Erhoike fish pond. BDL= below detection limit.

According to Table II above, no statistical significant difference ($p>0.05$) was observed in the concentrations of Lead, Manganese, Copper, Zinc and Iron in water samples from sites (A, B and C). Cadmium and mercury levels were below detection limit (i.e. <0.001) in all the sampling sites under investigation.

Total petroleum hydrocarbon was significantly elevated ($p<0.05$) in site B as compared to site A and C which recorded comparable ($p>0.05$) total petroleum hydrocarbon level. Table II also showed that chromium is significantly ($p<0.05$) higher in site C as compared to site A and B.

DISCUSSION

Physico-chemical properties of water samples
Water is essential to all forms of life and makes up 50-90% of the weight of all plants and animals and about 70% of human body [11]. Water is also a vital resource for agriculture, manufacturing, transportation and many other human activities. Despite its importance, water is the most poorly manage resource in the world [12]. Water quality assessment is of immense importance to practices involving the use of water bodies and its remains a useful tool for pollution control and assessment which are usually expressed as biological and physico-chemical parameters.

Results from this study showed that the pH level of water sample from the three sampling sites is between the ranges of 6.94-7.05, with Erhoike swamp having the highest pH of 7.05. The pH of 6.09-8.45 is reported to be ideal for supporting aquatic life including fish [13] and unpolluted lakes according to [14] normally show a near central or lightly alkaline pH.

High conductance was recorded for water sample from Erhoike fish pond as compared with Erhoike swamp and Eku River. Conductivity is a measure of the ability of an aqueous solution to carry an electric current and can be indicative of excessive mineralization from either natural or industrial sources. The presence of elevated total dissolved solids in the Erhoike fish pond coupled with high levels of potassium, magnesium and calcium ions could have resulted for the high electrical conductivity recorded at this site. Fish feeds could also be source of additional minerals in the fish pond.
Dissolved oxygen (DO) measures the concentration of free molecular oxygen dissolved in water and is an important element for water quality assessment. The results obtained from the study showed that DO concentrations from Erhoike swamp and fish pond were significantly lower (4.53±0.12mg/L and 4.75±0.05mg/L; $p<0.05$) when compared with water sample from Eku River (5.13±0.15mg/L).

According to [15, 16, 17], when environmental conditions are favorable, a maximum constant level of 5.0mg/L of dissolved oxygen is satisfactory for aquatic life and domestic purposes. Although, DO recorded for Erhoike swamp and fish pond were below the acceptable limits, it may not adversely affects aquatic biological life because, [18] stated that DO concentration below 2mg/L may lead to death for most fishes. Organic waste in the fish pond could have resulted in the low level of DO and the utilization of oxygen by the aquatic life present in the pond.

The presence of oil and grease in water samples of Erhoike swamp and fish pond is indicative of the oil exploration activities in the area and this could account for the low level of DO in water samples from these areas because oil and grease inhibit the transfer of oxygen form the atmosphere to the water body. At low concentrations, oil and grease may be toxic to aquatic life, alter the usuability and aesthetics of water body [19].

The concentration of organic matter expressed as biological oxygen demand (BOD) is higher in Erhoike swamp. [20], reported that the addition of significant quantities of crude oil to any water body causes an immediate rise in BOD due to the activities of hydrocarbon degraders and blockade of oxygen dissolution. Total petroleum hydrocarbon (TPH) was significantly higher in Erhoike swamp. This result validates the findings of [8], who reported high percentage of polynuclear aromatic hydrocarbon in surface waters in the vicinity of Kokori oil field in Delta State, Nigeria. The high TPH will increase oxygen demand for aerobic micro-organisms present in the water body to oxidize the organic matter to a stable inorganic form. According to the classification of aquatic pollution with respect to BOD values by [21, 22. 23], Erhoike swamp is moderately polluted as compared with Erhoike fish pond and Eku River. Although, all sites have BOD Level below the maximum permissible limit of 5.0mg/L [24].

Hardness of water is due to the presence of multivalent metal ions which are principally calcium and magnesium ions. The study revealed that water sample from Erhoike fish pond recorded the highest level of total hardness. According to the water hardness classification of [24] Eku River and Erhoike swamp water are fresh and soft (0-50mg/L $CaCO_3$) and could be employed for domestic purpose, while Erhoike fish pond is moderately soft (50-100mg/L $CaCO_3$). The high content of calcium and magnesium in Erhoike fish pond could have accounted for the elevated total hardness.

Phosphate stimulates the growth of plankton aquatic plants which provide food for fish. Water sample form Erhoike fish pond recorded the highest phosphate level as compared with the other two sites (A=Eku River and B=Erhoike Swamp). High concentration of phosphate in the Erhoike fish pond may not be unconnected with the introduction of fish feeds into the pond which contains nutrients such as phosphorus. Low concentration of phosphate in Eku River and Erhoike swamp could mean that addition of nutrient from anthropogenic sources to the water is minimal.

Heavy Metal Content in Water Samples

Heavy metals are generally toxic to animal life and human health especially if their naturally occurring concentrations are exceeded. Petroleum contamination has been implicated as a major source of heavy metal introduction into the aquatic environment [25]. The determination of heavy metal concentration in water sediment and living organisms can be used to assess its pollution level in the marine environment [26].

Cadmium and mercury were below detection limit in the water samples from the three sites under investigation. Oil exploration activities in Erhoike environment may not have contributed significant amount of these heavy metals to the environment.

Lead is considered potentially hazardous and toxic to most forms of life. It induces lipid peroxidation in tissues and causes irreversible damage to the respiratory organs in fish [27]. The concentration of lead (Pb) recorded in the three study sites (A,B and C) were not significantly different and also below the criterion (0.025mg/L) for protection of aquatic life [24].

Chromium (Cr), manganese (Mn) and copper (Cu) levels in the sampling sites were below the maximum limit as specified by [24, 28] for drinking water.

Zinc (Zn) in high concentration can be toxic. It enters the aquatic ecosystem through natural processes such as weathering, erosion and human activities e.g. metal galvanizing, dye manufacture and processing, pigment, pharmaceuticals, fertilizers and insecticides. The Zn (II) ion is toxic to fish and aquatic organisms even at low concentration. Level of Zn recorded in water samples at sites A, B and C were comparable ($p>0.05$) and below the maximum desirable limit of Zn in drinking water, 3mg/L [24, 28].

Iron (Fe) is the fourth most abundant element in the earth's crust and is an essential micronutrient for all organisms. Iron concentrations is comparable in the three sites under investigation and lower than the median concentration of 0.7mg/L reported for Nigerian water bodies by [29]. The permissible limit of iron (Fe^{2+}) concentration is 0.3mg/L [24, 28].

CONCLUSION

Overall, the physico-chemical results obtained for the control site A (Eku River) corroborate the findings of [30] who reported that the River Ethiope water in Abraka axis, about 10km up course from the Eku axis of Ethiope River is not polluted based on some of the physico-chemical parameters measures(pH, temperature, conductivity, TDS, TSS, DO and BOD).

The presence of total petroleum hydrocarbon (TPH), oil and grease in Erhoike swamp is evidence from the physico-chemical investigations. This confirms the over 30years of crude oil exploration taking place in that area. Crude oil may have entered the environment through operational, accidental or transportation process.

The elevated levels of electrical conductivity, total solids, calcium, magnesium, phosphates and moderately low DO suggest that the Erhoike fish pond is polluted and could affect fish health. The heavy metal characteristics of the sampling sites (A, B and C) were below permissible limit and comparable in some cases, therefore observed changes in water bodies may not be attributed to the effect of heavy metal contamination.

REFERENCES

[1] A.O. Tolulope, *Environ. Inform Arch*, **2004**, 2, 387.
[2] J.N. Nwankwo, C.N. Ifeadi, Proceeding of an International Seminar, Port Harcourt, **1993**, pp 93.
[3] S. Vutkure, *Int. J. Environ Res Pub Health*, **2005**, 2, 456.
[4] M. Pacheco, M.A. Santos, *Ecotoxicol Environ. Saf.* **2001**, 49, 64.
[5] B.A. Abdullahi, A.H. Kawo, J. Na'aliya, *Nig. Biosci Res Comm.* **2008**, 20(3), 121.
[6] J.A. Adakole, D.S. Abulode, M.L. Balarabe, The 12th World Lake conference. Sengupta, M and Dalwani, R. (Eds). **2008**, Pp 1373.
[7] G.O. Avwiri, P.I. Enyinna, E.O. Agbalagba, *J. Appl Sci*. **2007**, 7 (11), 1543.
[8] O.O. Emoyan, 2009. *J Appl Sci Environ Manage*. **2009**, 13 (4), 39.
[9] J.O. Oseji, *Pacific J. Sci Technol*. **2010**, 11(2), 118.
[10] Standard Methods for the Examination of Water and Wastewater. 20th Ed, APHA, AWWA and WPCF, Inc., New York, **1998**

[11] R.A. Buchholz, Principle of environmental management. The Greening of Business; 2nd Prentice- Hall; London, UK. **1998**
[12] S.O. Fakayode, *Ajeam-Ragee,* **2005**, 10, 1.
[13] C.E. Boyd, F.R. Lichtkoppler, *Res. Dev. Ser*, **1979**, 22, 30.
[14] J.A. Adakole, C.F. Mbah, M.A. Dalla, Proceedings of the 29th Water, Engineering and Development Centre-UK. (WEDC) International Conference, held in Abuja-Nigeria. WEDC, London. **2003**, Pp: 165.
[15] J.S. Alabaster, R. Lloyd, Water quality criteria for fresh water fish. 2nd Ed. **1980**, pp: 325.
[16] B. Moss, Ecology of Freshwater. Blackwell Scientific Publications Ltd: UK.**1980**, pp :332.
[17] FEPA, Guidelines for the National water quality standard for human consumption. Federal Republic of Nigeria, **1991**.
[18] D. Chapman, Water Quality Assessment. A guide to the use of biota, sediments and water in environmental monitoring. 2nd Ed. E and FN spon, London. File: A//: Hydrology and water quality of Lake Merced, **1997**.
[19] S. Khan, S. Lau, M. Kayhanian, M.K. Stenstrom, *J Environ Eng*, **2006**, 132, 415.
[20] V.N. Enujiugha, L.C. Nwanna, *J. Appl. Sci. Environ. Manage.* **2004**, 8(2), 71.
[21] P.D. Vowels, D.W. Connel, Experiments in environmental chemistry. Pergamon Press. New York, **1980**.
[22] D. Mara, Sewage treatment in hot climates. John Wily and Sons. Toronto,**1983**.
[23] J.A. Adakole, J.K. Balogun, F.A. Lawal, *Nig. J Chem Res.* **1998**, 3, 13.
[24] WHO, Guidelines for drinking water quality. 3rd ed. Vol 1-Geneva, Switerland, **2004**.
[25] I.R. Santos, E.V. Silva- Filho, C.E. Schaefer, M.R. Albuquerque-Filho, L.S. Campos, *Mar. Poll Bull*. **2005**, 50, 85.
[26] B. Muhammet, A. IIhan, *Turkish J Fisheries Aqua Sci*, **2010**, 10, 565.
[27] T.K. Banerjee, R. Devi, *Iran J. Environ Health Sci Eng,* **2007**, 4, 249.
[28] Nigerian Industrial Standard, Nigerian Standard for Drinking Water Quality SON (Standard Organization of Nigeria) **2007**, pp 16.
[29] C.C. Asonye, N.P. Okolie, E.E. Okenwa, U.G. Iwuanyanwu, *Afr J Biotechnol.* **2007**, 6(5), 617.
[30] P.O. Agbaire, G.G. Obi, *J Appl Sci. Environ. Manage,* **2009**, 13 (1), 55.