***Original Research Article***

# Assessment of Physicochemical Qualities of Oilfield Wastewater in Bayelsa State, Nigeria


## Abstract

Oilfield wastewater which is not properly treated before being discharged has great negative impacts on the environment and aquatic life and also affects humans. It is necessary to assess the physicochemical qualities of oilfield wastewater to reduce its environmental impact. Oilfield wastewater samples were collected from an onshore oil production platform for a period of eight months (March to October, 2018). These were analyzed for physicochemical parameters and heavy metals using standard methods. Oilfield wastewater gotten from EPU 05 had higher TDS 294.6 mg/l, conductivity 619.0 µS/cm, COD 6.44 mg/l, BOD 2.24, compared to that found from Kolo creek flow station and were significantly different (P>0.05). While, TSS 16.85 mg/l, salinity 175.0 mg/l, turbidity 4.8 (NTU), and THC 1.39 were higher in that of the Kolo creek flow station. There was no significant difference in pH and temperature in the Kolo creek flow station and EPU 05. Higher values of iron 0.46 mg/l, chromium 0.03mg/l, was observed in that of the Kolo creek flow station compared to that of the EPU 05 0.14mg/l. EPU 05 had higher values in zinc 0.09 mg/l, copper 0.12 mg/l, cadmium 0.18 mg/l, mercury 0.08 mg/l and arsenic 0.07 mg/l. All the physicochemical parameters were within the allowable limit recommended by regulatory bodies (eg. WHO, DPR, FMEnv etc.). Regulatory bodies should ensure that companies practice proper waste management and compliance.



**Keywords:** Oilfield wastewater, physicochemical parameters, heavy metals.


## Introduction

The oilfield wastewater is often generated during the production of oil and gas from onshore and offshore wells (Neff, 2002; Veil *et al*., 2004). It contains a complex mixture of dissolved and particulate organic and inorganic chemicals in water that can adversely affect the air, water, and soil environment if not properly discharged and controlled (DPR, 1991).

Oilfield wastewater is also known as wastewater produced which is usually very salty and may contain suspended and dissolved solids, residual hydrocarbons, numerous organic species, heavy metals, naturally occurring radioactive and chemicals used in hydrocarbon extraction. Several studies investigated the characteristics of produced water and its impact on the surrounding environment (Neff, 2002; Obire and Amusan, 2003; Aleruchi and Obire, 2018).

Oilfield wastewater represents the largest volume waste stream in oil and gas production operations on most oil production platforms (Stephenson, 1991; Krause, 1995). Produced water may account for 80% of the wastes and residues produced from natural gas production operations (McCormack *et al*., 2001). It has been observed that every aspect of oil operations, though in varying degrees, poses significant negative impacts on the environment and also the environmental consequences impose economic effects on the indigenes of that locality (Nwokoma and Anene, 2010; Joel *et al,* 2009; Ugochukwu and Leton, 2004; Orubu *et al.,* 2004;

Onosode, 2003; Onah, 2001), such as receiving water bodies and aquatic life (Obire and Amusan 2003; Sommerville *et al.,* 1987). The contents of the effluents have serious toxicological effects on aquatic environment and humans. It can lead to depletion of dissolved oxygen and eutrophication in the aquatic environment (Beeby, 1993).

The Niger Delta ecosystem has been subjected to pollution by petroleum industries and their operational activities. It is therefore necessary to assess or monitor the wastewater produced by oil producing company before its discharge to the environment. The objective of this study therefore was to assess the physicochemical parameters of the oilfield wastewater.

## Materials and Methods

### *Collection of Oilfield Wastewater Samples*

Oilfield wastewaters were collected from the point of discharge at Kolo creek flow station and EPU 05 an onshore oil production platform located in Bayelsa State, Nigeria. The oilfield wastewater samples were collected using 4 Litre capacity plastic bottles. Prior to the collection of the oilfield wastewater the interior of the nozzle of the outlet biofilter was flushed for few minutes before collecting directly into the 4 litre plastic bottles. The plastic bottles were appropriately labeled and stored in an ice packed cooler. The stored samples were immediately transported to the laboratory within 24 hours for processing and analyses. Samples were collected monthly for a period of eight months (March to October, 2018).

### *Physicochemical Analysis of Oilfield Wastewater Samples*

Physicochemical analyses of the oilfield wastewater samples were conducted according to standard procedures of APHA (1998) and ASTM (1999). The physicochemical parameters determined include pH, temperature, turbidity, total dissolved solids (TDS), total suspended solids (TSS), salinity, conductivity, biological oxygen demand ($BOD_5$), chemical oxygen demand (COD), total hydrocarbon content, odour and heavy metals such as lead, zinc, total iron, chromium, mercury, arsenic, copper, and cadmium.

Statistical analysis was also conducted using Duncan Multiple Range test and Analysis of variance to determine whether there is significant difference between the physicochemical parameters of oilfield wastewater between the various samples collected during the various months.

## Results

The values represent the mean of the oilfield wastewater physicochemical parameters analyzed over a period of eight months from the Kolo creek flow station discharge point and EPU 05 discharge point. That of the EPU 05 had higher TDS 294.6 mg/l, conductivity 619.0 µS/cm, COD 6.44 mg/l, BOD 2.24, compared to that of Kolo creek flow station and were significantly different. While, TSS 16.85 mg/l, salinity 175.0 mg/l, turbidity 4.8 (NTU), and THC 1.39 were higher in the samples from the Kolo creek flow station. There was no significant difference in pH and temperature in the Kolo creek flow station and EPU 05 samples. All the physicochemical parameters analyzed were within the permissible limit set by Department of Petroleum Resources (DPR) and Federal Ministry of Environment (FMEnv).

Table 1: Physicochemical Parameters of Oilfield Wastewater from Kolo Creek Flow Station and EPU 05

| Parameter (Mg/L) | Kolo creek | EPU 05 | DPR Limits | FMEnv Limits |
|---|---|---|---|---|
| Temperature (°C) | 24.1 | 24.6 | 25 | 20-33 |
| pH unit | 7.12 | 7.19 | 6.5-8.5 | 6.0-9.0 |
| Salinity | 175.0 | 138.1 | 600 | - |
| Turbidity (NTU) | 4.8 | 3.1 | 10 | - |
| Conductivity (µS/cm) | 304.6 | 619.0 | - | - |
| TDS | 250.4 | 294.6 | 2000 | - |
| TSS | 16.85 | 15.5 | 30 | NS |
| THC | 1.39 | 1.29 | 10 | NS |
| BOD | 1.84 | 2.24 | 10 | 4 |
| COD | 5.19 | 6.44 | 10 | - |
| Odour | Unobjectionable | Unobjectionable | | |

Values represents means of the months analyzed.

Key: NTU: nephelometric turbidity unit, TDS: total dissolved solid, TSS: total suspended solid, THC: total hydrocarbon content, BOD: biological oxygen demand, COD: chemical oxygen demand, DPR: department of petroleum hydrocarbon, FMEnv: Federal Ministry of Environment, NS: not stated.

The result of the calculated average values of heavy metal content of oilfield wastewater in Kolo creek flow station and EPU 05 is as shown in Table 2 below. Higher values of iron 0.46 mg/l, chromium 0.03mg/l, was observed samples from Kolo creek flow station compared to that of the EPU 05 0.14 mg/l. EPU 05 samples had higher values in zinc 0.09 mg/l, copper 0.12 mg/l, cadmium 0.18 mg/l, mercury 0.08 mg/l and arsenic 0.07 mg/l. The heavy metals in the oilfield wastewaters analyzed from both sampling points were within the permissible limits for Department of Petroleum Resources (DPR). Heavy metals such as mercury and copper in both Kolo creek flow station and EPU 05 samples were slightly above the permissible limit for Federal ministry of environment (FMEnv).

Table 2: Heavy Metals Content of Oilfield Wastewater from Kolo Creek Flow Station and EPU 05

| Parameter (Mg/L) | Kolo Creek | EPU 05 | DPR Limits | FMEnv Limits |
|---|---|---|---|---|
| Lead | 0.02 | 0.02 | 0.05 | 0.01 |
| Zinc | 0.03 | 0.09 | 5.0 | 0.03 |
| Copper | 0.09 | 0.12 | 1.5 | 0.02-0.04 |

| | | | | |
|---|---|---|---|---|
| Iron | 0.46 | 0.14 | 1.0 | 1 |
| Chromium | 0.03 | 0.01 | 0.5 | 0.02-2.0 |
| Cadmium | 0.02 | 0.18 | - | - |
| Mercury | 0.06 | 0.08 | - | 0.01 |
| Arsenic | 0.05 | 0.07 | - | 0.5 |

Values represents means of the months analyzed.
Key: DPR: department of petroleum hydrocarbon, FMEnv: Federal Ministry of Environment.

## Discussion

The mean value for total dissolved solid (TDS), conductivity, chemical oxygen demand (COD), biological oxygen demand ($BOD_5$) were higher in the EPU 05 oilfield wastewater than that of the Kolo creek flow station oilfield wastewater but were still within the permissible limit (DPR, 2002) and there was a significant difference. The higher values in EPU 05 oilfield wastewater could be attributed to the treatment methods used and probably the monitoring processes. The TDS observed in both samples (250.4 and 294.9 mg/l) were low compared to 2440 mg/l reported by Neff *et al*., (2011). High TDS can result in low oxygen levels and be toxic to freshwater biota in receiving waters (Boelter *et al*., 1992) which poses a threat to aquatic life. Conductivity gives an indication of the amount of total dissolved solids in water (Yilmaz and Koc, 2014). The higher level of COD (6.44 mg/l) in the EPU 05 oilfield wastewater indicates that it contains higher oxygen demanding material than that of the Kolo creek flow station. Higher level of COD causes depletion of dissolved oxygen in water thereby limiting its use for other purposes such as irrigation and recreational purposes. $BOD_5$ in both samples were relatively low compared to the value obtained by Eunice *et al*., (2017).

Kolo creek flow station oilfield wastewater had higher values in total suspended solid (TSS), salinity, turbidity and total hydrocarbon content (THC) than that of the EPU 05 oilfield wastewater but are within the allowable limits set by regulatory bodies. The higher values could be due to treatment process and improper monitoring before discharge. Uzoekwe and Oghosanine (2011) reported lower TSS (10.60mg/l) and salinity (47.43 mg/l) but recorded higher turbidity (50.17 NTU), and THC (8.81mg/l) compared to the results of the Kolo creek flow station oilfield wastewater.

The pH values recorded in Kolo creek flow station and EPU 05 were alkaline, but slightly higher in that of EPU 05, which is tolerable for the proliferation of bacteria. Also, the pH of water is important because many biological activities can occur only within a narrow range, thus any variations beyond an acceptable limit could be fatal to a particular organism. Aleruchi and Obire (2018) also recorded alkaline pH ranging from 7.485 - 7.82. Similarly, the temperatures recorded in EPU 05 and that of Kolo creek flow station were slightly the same but were all within the limit allowed by regulatory bodies. Similar temperatures were also observed by Nwokoma and Dagbe (2012) ranging from 25.4 to 27.1 $^{o}$ C. The similarity in temperature could be attributed to the

sampling seasons. Temperature is one of the most important ecological and physical factors which has a profound influence on both the living and non-living components of the environment, thereby affecting organisms and the functioning of an ecosystem.

Similarly, the result for the heavy metal analysis showed that they were all within the permissible limits. Aleruchi and Obire (2018) also recorded similar values in heavy metals. Some values such as the mercury and copper in both Kolo creek flow station and EPU 05 were slightly above the permissible limit for FMEnv (1991). This could be as a result of inadequate treatment from stations. Continuous accumulation of heavy metals on receiving water bodies poses threat to aquatic life.

**Conclusion and Recommendations**

Conclusively, the values of most physicochemical parameters and heavy metals obtained in the Kolo creek flow station and EPU 05 were within the permissible limits but recorded slightly higher values in mercury and copper in both sampling stations. This study revealed that there have been improvements in the treatment of Kolo creek flow station and EPU 05 oilfield wastewater before it is been discharged compared to other studies (Aleruchi and Obire, 2018; Achudume, 2009, Nduka and Orisakwe, 2009; Ogunlaja and Ogunlaja, 2007). There is need for continuous monitoring of oilfield wastewater before it is discharged into receiving water bodies.

## References


Achudume, A.C. (2009). The effect of pertocemical effluent on the water quality of Ubeji creek in Niger Delta Region. Bull Environ. Toxicol. 83:410-415.

Aleruchi Owhonka and Obire Omokaro. (2018). Quality characteristics of an oilfield produced water and its recipient discharge pond. E-journal of science and technology. 13(4):1-10.

American Public Health Association APHA (1998).Standard Methods for Examination of Water and Waste Water. American Public Health Association, 20th Edition, Pp 113.

American Society for Testing and Materials (1999).Standard Practice, ASTM D., 11(3) 3370-3376.

Beeby, A. (1993). Measuring the effect of pollution. In: Applying Ecology. Chapman and Hall, London, New York.

Boelter, A.M., Lamming, F.N., Farag, A.M., Bergman, H.L. (1992). Environmental effects of saline oil-field discharges on surface waters. *Environmental toxicology and chemistry 11: 1187-1195*. Doi:10.1002/etc.5620110815.

Department of Petroleum Resources (DPR) (1991). Environmental Guidelines and Standards for the Petroleum Industry in Nigeria, Ministry of Petroleum Resources, Lagos, 30-37.

DPR, Department of petroleum resources. (2002). *Environmental Guidelines and Standards for Petroleum industry in Nigeria*. Department of petroleum resources, Victoria Island, Lagos Nigeria, 80-81.

Eunice, O,E., Frank, O., Voke, U., and Godwin, A. (2017). Assessment of the impacts of refinery effluent on the physicochemical properties of Ubeji Creek, Delta State, Nigeria. *J Environ Anal Toxicol. 7: 428*. dol:10.4172/2161-0525.1000428.

Federal Ministry of Environment (FMENV) (1991). National Environmental Protection (Effluent Limitation) Regulations, S.I.8 published by the Federal Government Press, Lagos, Nigeria and FGPL. 211/991/12000.

Joel, O. F., Akinde, B. S., and Nwokoye, C. U. (2009). Determination of some physicochemical and microbial characteristics of sewage samples from domestic, house-boat and offshore facilities discharge points. Journal of Applied Science & Environmental Management, Vol. 13, No. 3 pp.49-52.

Krause, P.R. (1995)." Spatial and temporal variability in receiving water toxicity near an oil effluent discharge site." *Archives of environmental contamination and toxicology. 29*: 523-529.

McCormack, P., Jones, P., Hetheridge, M.J., and Rowland, S.J. (2001). Analysis of oilfield produced water and production chemicals by electrospray ionization multistage mass spectrometry. "*Water research. 35(15)*:3567-3578.

Nduka, K., and Orisakwe, E. (2007). Heavy metals levels and physicochemical quality of portable water supply in Warri Nigeria. Annalt. Di. Chem. 97:86-87.

Neff, J.M. (2002). *Bioaccumulation in marine organisms. Effects of contaminants from oil well produced water.* Elsevier Science Publishers, Amsterdam. Pp 452.

Neff, J.M., Sauer, T.C., and Hart, A. (2011). Bioaccumulation of hydrocarbon from produced water discharged to offshore waters of the U.S. Gulf of Mexico. *In: produced water: Environmental Risks and Mitigation Technologies. Lee, K. and Neff, J. (eds.),* Springer Publishing.

Nwokoma, D. B. and Anene, U. (2010). Adsorption of Crude Oil using meshed groundnut husks, Chemical Product and Process Modeling, Vol. 5, Iss. 1, Art 9, pp. 1-23.

Nwokoma, D.B.M and Dagbe, K.K. (2012). Performance evaluation of produced water quality from a nearshore oil treatment facility. J. App. Sc. Env. Manage. Vol. 16 (1) 27-33.

Obire, O. and Amusan, F.O. (2003). The Environmental impact of oilfield formation water on a freshwater stream in Nigeria. *J. Appl. Sci. Environ. Mgt. 7(1)*: 61-66.

Ogunlaja, A. and Ogunlaja, O.O. (2007). Physicochemical analysis of water sources inUbeji communities and Histological impact on organs of albino mice. J.Appl.Sci. Environ. Manag., 11(4):91-94.

Onah, R. O., (2001). A Review of the Nigerian Petroleum Industry and the Associated Environmental Problems. The Environmentalist, 21, pp11-21.

Onosode, G. (2003). Environmental Issues and the Challenges of the Niger Delta: Perspectives for the Niger Delta Environmental Survey Process. CIBN Press, Lagos.

Orubu, C. O., Odusola, A., Ehwarieme, W., (2004). The Nigerian Oil Industry: Environmental Diseconomies, Management Strategies and the Need for Community Involvement. J. Hum. Ecol., 16(3), pp203-214.

Sommerville, H., Benneth, J.D., Davenport, J. N., Holt., M.S., Lynes, A., Mahieu, A., McCourt, B., Parker, J.G., Stephenson., R.R., Watkinson, R.J. and Wilkinson, T. G. (1987). Environmental Effects of Produced Water from North Sea Oil Operations. Mar. *Pollut. Bull*., 18(10): 549-558.

Stephenson, M.T. (1991). Components of produced water: A compilation of results from several industry studies. *Proceedings International conference on health, safety and environment, Hague, Netherlands, November 10-14, 1991.* Soc. Petrol. Eng., pap. No.23313, pp.25-38.

Ugochukwu, C. N. C. and Leton, T. G., (2004). Effluent Monitoring of an Oil Servicing Company and its impact on the environment, AJEAM-RAGEE, Vol. 8, pp27-30.

Uzoekwe, S.A. and Oghosanine, F.A. (2011). The effect of refinery and petrochemical effluent on water quality of Ubeji creek Warri, Southern Nigeria. *Ethiopian Journal of Environmental studies and management. 4(2)*: 107-116.

Veil, J.A., Puder, M.G., Elock, D., and Redweik, R.J. (2004). A white paper describing produced water from production of crude oil, natural gas and coal bed methane. *Report to the U.S. Dept. of Energy, National energy technology laboratory. Argonne national laboratory, Washington, DC*. Pp 79.

Yilmaz, E. and Koc, C. (2014). Physically and chemistry evaluation for the water quality criteria in a farm on Akcay. *J. water resour. Prot.* 6: 63-67.