Original Research Article

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

Abstract

Oilfield wastewater which is not properly treated before being~~en~~ discharged have great negative ~~impacted~~ 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 ~~gotten~~ 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 0.009 mg/l, copper 0.12 mg/l, cadmium 0.18 mg/l, mercury 0.008 mg/l and arsenic 0.007 mg/l. All the physicochemical parameters were within the allowable limit recommended by regulatory bodies (e.g. WHO,DPR, etc). Regulatory bodies should ensure that companies practice proper waste management and compliance.

Keywords: Oilfield wastewater, bacteriological diversity, 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 ~~produced~~ 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 environmental (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 ~~residuals~~ residues produced from natural gas production

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operations (McCormack *et al*., 2001). In 2003, an estimated 667 million metric tons (about 800 million m^3) of produced water were discharged to the aquatic environment from offshore facilities throughout the world.

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Improper waste management and treatment of oilfield wastewater before discharge poses serious threats to 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.

Comment [a1]: The introduction is not supported by recent literature. It also requires a quality comparative perspective. Furthermore, composition of the wastewater elements and levels will need to be discussed. On the other hand standards on wastewater treatment are also essential to be mentioned at the onset to allow for comparisons.

Materials and Methods

Collection of ~~oilfield~~ Oilfield ~~wastewater~~ 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~~ Analysis of ~~oilfield~~ Oilfield ~~wastewater~~ 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 constituents 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

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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 w~~h~~ere within the permissible limit set by Department of Petroleum Resources (DPR) and Federal ~~ministry~~ Ministry of ~~environment~~ Environment (FMEnv).

Table 1: Average values of physicochemical constituents of oilfield wastewater samples

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		

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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 0.14mg/l. EPU 05 samples had higher values in zinc 0.009 mg/l, copper 0.12 mg/l, cadmium 0.18 mg/l, mercury 0.008 mg/l and arsenic 0.007. The heavy metals in the oilfield wastewaters analyzed from both sampling points were within the permissible limits for Department of Petroleum Resources (DPR).Some heavy metals in both Kolo creek flow station and EPU 05 samples w~~h~~ere ~~little~~ slightly above the permissible limit for Federal ministry of environment (FMEnv).

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Table 2: Average values of heavy metals in the oilfield wastewater samples

Parameter (Mg/L)	Kolo Creek	EPU 05	DPR Limits	FMEnv Limits
Lead	0.02	0.02	0.05	0.001
Zinc	0.03	0.09	1	0.03
Copper	0.09	0.12	1.5	0.002-0.004
Iron	0.46	0.14	1	1
Chromium	0.03	0.01	0.03	0.02-2.0
Cadmium	0.02	0.18	-	-
Mercury	0.06	0.08	-	0.001
Arsenic	0.05	0.07	-	0.5

Discussion

The mean value for ~~Total~~ total dissolved solids (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 w~~h~~ere still within the permissible limit (DPR, 2002) and there was a significant difference~~t~~. 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~~ total suspended solid (TSS), salinity, turbidity and ~~Total~~ total hydrocarbon content (THC) than that of the EPU 05 oilfield wastewater but are within the allowable limits set by regulatory bodies. 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 this study 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. Similarly, the temperatures recorded were also within the limit allowed by regulatory bodies. Temperature is

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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 but some values were slightly above the permissible limit for FMEnv(date). Continuous accumulation of heavy metals on receiving water bodies poses threat to aquatic life.

Conclusion and Recommendations

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.

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