Physicochemical Characterization of a liquid Effluent from a Refinery

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ABSTRACT: The physicochemical profile of wastewater from a Refinery in the Niger Delta was evaluated to ascertain efficiency of wastewater treatment methods applied using standard analytical methods. In all samples, temperature ranged between 26.45 – 28.65 º C while the pH values of the untreated and treated wastewater samples were 8.39 ± 0.04 and 7. 82 ± 0.02 respectively. Total dissolved solids and observed total hydrocarbon levels gave maximum values of 172 mg/L and 11.35 mg/L respectively. The turbidity values for untreated and treated wastewater samples were 7.55 ± 0.08 and 3.49 ± 0.01 NTU respectively. The results revealed that the untreated wastewater sample had a higher concentration of phenol (28.46 ± 1.23) when compared to those (9.34 ± 0.89) of the treated wastewater sample while the cyanide content was relatively higher when compared to the limits set by World Health Organization for such effluents. Although substantial improvements were obvious in some water quality indices with treatment, high concentration of major effluent pollutants, phenol and total hydrocarbon content in the treated wastewater is indication of ineptitude in the effluent management system and calls for immediate intervention.

Even though citizens of Nigeria and other oil producing countries cherish the petrochemical and petroleum industries for improved quality of life and national development, the potential negative effects of pollution by effluents from these industries are serious reasons for concern (Nwaichi et al., 2013; Adeyemi, 2004). The effluent discharged from these industries are mostly characterized with heavy presence of sulphides, heavy metals, phenols, polycyclic aromatic hydrocarbons and other chemicals etc. (Suleimanov, 1995). Once in the environment, these hydrocarbons are easily absorbed by aquatic organisms via various mechanisms and are in turn transferred to humans when consumed (Oyibo *et al*., 2018). Following the ineptitude of the present purification systems, the effluents from these industries might become hazardous, which will result to the inadvertent accumulation of lethal products in the recipient environment with potential severe health and environmental implications in the ecosystem (Beg *et al*., 2003; Aghalino and Eyinla, 2009). The unrestrained discharge of refinery effluents into water bodies renders the water precarious for recreational and economic uses. It also poses severe threat to human life because it is in contradiction with the principle of sustainable development. When this happens, water related illnesses are bound to occur. Water-related health problems and diseases occurs as

a result of ineffectual management of water resources. Individuals can only be guaranteed of safe water when the access, availabilty and sustainability is assured (Atubi *et al*., 2009). The risks associated with contamination of the environment by volatile organic materials have motivated numerous research designed to remedy or eradicate its venomous effects. Some of these volatile compounds like benzene, toluene, ethyl benzene and the isomers of xylene (BTEX) and phenol that is reportedly abundant (Nwaichi and Warigbani, 2013) in wastewaters emanating from the petrochemical and petroleum industries, and they are significant contaminants because of their apparent high toxicity (Akhtar *et al*., 2007). Furthermore, effluents from the petroleum and petrochemical industries can cause depletion of dissolved oxygen when released into water bodies as a result of loss pf biodiversity via a decline in the population of "amphipod"- which is very vital in food chain, eutrophication and biotransformation of some organic constituents into inorganic constituents. Acute toxicity to aquatic faunas include: hemorrhagic septicaemia, epidermal hyperplasia and lymphocytosis etc. There are few refineries in Nigeria including the Niger Delta, the oil producing region. Numerous research investigations have established that effluents emanating from oil industries contain certain carcinogenic, mutagenic and growth inhibitory

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compounds which can drastically affect the ecology of terrestrial and aquatic environments. Hence, it is imperious to investigate the physicochemical characteristics of the wastewater from a refinery in the Niger Delta.

MATERIALS AND METHODS

Sample collection: Following approval by responsible authority, untreated and treated wastewater samples were collected in triplicates from a refinery in the Niger Delta using a sterile container. The temperature and pH of the wastewater sample were determined on site of collection using standard methods and portable meters. The samples were preserved in an ice box prior to transportation to the laboratory for analysis.

Determination of physicochemical properties of the sample: The physicochemical properties characterized were: temperature, turbidity, pH, dissolved oxygen (DO), chemical oxygen demand (COD), total dissolved solids (TDS), biochemical oxygen demand (BOD), total suspended solids (TSS), electrical conductivity and salinity. The APHA standard testing technique was used to determine the water quality indices except otherwise stated. The TSS was evaluated using weight loss technique, TDS was determined using TDS meter (MODEL C020: HATCH), conductivity was extrapolated using conductivity meter (SUNTEX), turbidity was determined using a spectrophotometer (MODEL DR2010: HATCH) and pH was determined using Hanna pH meter.

Determination of Phenol: The concentration of phenol in the water sample was estimated using 4-amino antipyrine method as reported by Nwaichi and Warigbani (2013). In this technique, phenol and other phenolic constituents react in the presence of K_3 Fe (CN)$_6$ with 4-amino antipyrine to produce a purple-red product. The reaction mixture containing 0.9 mL distilled water, 25μL of 2% 4-amino antipyrine, 50μL of 2M ammonium hydroxide, 8 % K_3 Fe (CN)$_6$, and 0.1mL sample was allowed to mix thoroughly. The resultant mixture was centrifuged for 2 min at 4,000 rpm. The absorbance of the supernatant was read at 510 nm using a spectrophotometer.

Data analysis: Means of triplicate determinations were subjected to test of significance using student's T-test.

RESULTS AND DISCUSSION

In this study, we investigated the qualities of physicochemical characteristics of wastewater produced by a refinery in the Niger Delta and estimated the concentration of pollutants therein. The results obtained are as shown in Table 1 and Figure 1. Our findings reveal that wastewater samples had a pH within alkaline range of 7.74 and 8.26 which fell within acceptable range given by WHO (Table 1). This may not be unconnected with the heavy presence of soluble inorganic and organic alkalis. Generally, the pH values recorded in this study fell within the limits (6.5 – 9.7) set by the World Health Organization standards for effluents prior to their disposal to the waterbodies (WHO, 2006). The pH level indicates that the wastewater will unlikely have a negative influence on the receiving environment based on the pH. These findings are in consonance with the work of Nwaichi *et al.* (2013), who reported analogous pH ranges for treated and untreated wastewater from Warri Refinery.

Table 1   Physicochemical constituents of study refinery wastewater

S/N	Parameters	Untreated wastewater	Treated wastewater	WHO Standard
1	Temperature (ºC)	28.65±0.79[a]	26.45±0.19[a]	30
2	pH	8.39 ± 0.04[m]	7. 82 ± 0.02[m]	6.5 – 9.6
3	Turbidity (NTU)	7.55 ± 0.08[x]	3.49 ± 0.01[y]	5.82
4	Total dissolved solids (mg/L)	172±2.14[e]	69±0.95[f]	500
5	Total suspended solids (mg/L)	41. 12± 0.78[j]	15.09±0.18[k]	30
6	Salinity (mg/L)	12.34±0.34[a]	29.36±0.87[b]	NA
7	Biochemical Oxygen Demand (mg/L)	1.53±0.23[x]	0.59±0.13[y]	1.0
8	Dissolved Oxygen (mg/L)	3.45±0.16[e]	4.27±0.18[f]	4-5
9	Conductivity(μS/cm)	212.00[a]	140[b]	500
10	Chemical Oxygen Demand (mg/L)	1.87±0.16[i]	1.87±0.13[i]	40
11	Cyanide (mg/L)	0.007±0.001[m]	0.12±0.001[n]	0.07

Data are presented as mean ± SE for n=3. Values in the same row with same superscripts are not significantly different at p<0.05. WHO (2006) standard was added for comparison.

One physicochemical parameter used to ascertain if any water sample is free from impurities, ion and salt is electrical conductivity. It is very significant and used to control the level of pollution of effluents. The lower the conductivity, the purer the water. The high conductivity value observed in the untreated wastewater sample (Table 1) might not be unconnected to release of chemicals utilized during crude oil refining. The value recorded for the treated effluent was significantly lower. A marked difference

was observed in the values recorded for turbidity of the untreated effluent sample in comparison to the treated effluent sample and is attributable to accumulated debris. In relation to the standards stipulated by world health organization, the values recorded for temperature were below the tolerable limit of 30 ºC. with regard to biological oxygen demand, BOD, microorganisms utilize some part of the product from decomposition of organic matter within 48 hours while the other counterpart complex portion commonly referred to as chemical oxygen demand, COD, gets decomposed slowly.
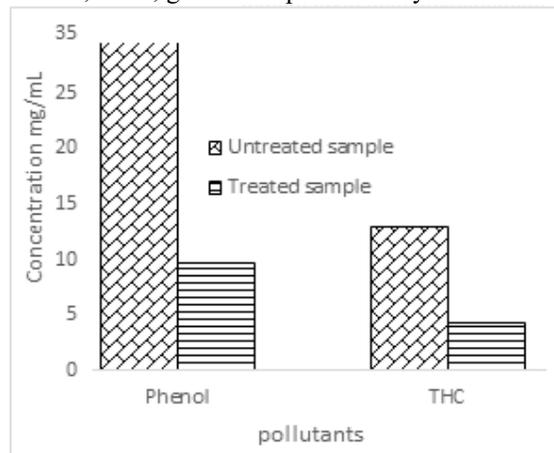
Fig 1 Phenol and Total hydrocarbon concentration in refinery wastewater

These markers are very vital in the determination of the quality of wastewater because they provide useful information about the total organic load of the sample. The BOD and COD levels of the treated wastewater samples were well within the limits stipulated by the WHO (Table 1). The amount of oxygen utilized during the oxidation of organic matter under aerobic conditions is referred to as dissolved oxygen. The study recorded 3.21 mg/L and 4.23 mg/L levels of dissolved oxygen for untreated and treated wastewater sample respectively. That of the untreated wastewater fell below WHO recommended range and is indicative of organic pollution. The results obtained for total dissolved solids are acceptable in relation to the tolerable range (500 mg/L) by WHO. There was a significant decrease in the treated sample. More so, the concentration for total hydrocarbon as demonstrated in Figure 1 was high in the untreated wastewater sample but saw a marked reduction with treatment. High concentration of total suspended solids observed in the untreated wastewater sample is higher than the tolerable limits (30 mg/L) reported by WHO for effluents but was more than halved with treatment. Phenol is one of the major pollutants found in refinery effluents (World bank, 1998). According to Nwaichi *et al*. (2013), phenol is among the major contaminants

present in petroleum refinery wastewater. It was observed in high concentrations in the untreated and the treated wastewater sample evaluated. Up to 28.76 mg/L of phenol (Figure 1) was recorded in the untreated wastewater sample and 9.32 mg/L in the treated wastewater sample and were significantly higher than 0.2 mg/L tolerable limit recommended by WHO (Nwaichi *et al*., 2013). The turbidity values recorded at the point of discharge (15.56 NTU) was not in conformity to permissible limit (5.81 NTU) for effluents as given by the WHO (WHO, 2006). These extremely high values may portend serious damage to the environment (Nwaichi and Wegwu, 2010).

Conclusion: Data obtained from this research reveal high presence of total hydrocarbon and phenol contaminants in the wastewater emanating from an oil refinery in the Niger Delta. Given vast patronage of recipient medium during discharges of generated effluent from study refinery and the quick turn over of processes generating these effluents, more efforts including informed wastewater monitoring and adoption of more appropriate treatment technologies are needed to make for sustainable release of compliant effluent into the water bodies. Also, stakeholders' engagement and remedial protocols are required for synergistic management approach.

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