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Full Length Research Paper

Pollution status and effect of crude oil spillage in Ughoton stream ecosystem in Niger Delta

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The present study evaluates the pollution status and the physico-chemical characteristics of Ughoton stream water as it affects the quality of water and its impact on Ughoton stream ecosystem. Surface water samples were collected at various distances, 50,100, 250, and 500 m downstream from an oil well. The potentially toxic elements, Fe, Mn, Zn, Ca, Cr, Cd, Ni, and Pb were analyzed. Other parameters including cations, hydrocarbonoclastic, heterotrophic bacteria and Total hydrocarbon were analyzed. The study reveals most of the parameters; pH, DO, BOD, and COD are within limits set by World Health Organization (WHO) for surface water. The heavy metal concentrations in the stream water are also below the threshold levels associated with the toxicological effects and the regulatory limits. However, the high concentration of nutrients, hydrocarbonoclastic and heterotrophic bacteria confirmed high pollution status. The hydrocarbonoclastic and heterotrophic bacteria count ranged from 96 to 520 and 48 to 284 per 100 ml respectively. Pollution nature of Ughoton stream water is further confirmed by its oil films coated environment; the pollution load exceeded tolerance limit of stream that empties into major river. Therefore, The Ughoton stream water is considered as a threat to Ughoton natural ecosystem.

Key words: Physico-chemical parameters, hydrocarbonoclastic and heterotrophic bacteria, freshwater stream.

INTRODUCTION

Coastal belts and in particular, Niger Delta of Nigeria are highly populated as a result of agricultural activities, mining, production and distribution of petroleum products (Eke 2002; Ijah 2003,Williams et al.,2010). Oil production has predominantly interfered with greater densities on recreational activities such as bathing, boating and fishing, often leading to public disquiet and disenchantment of the communities (Achudume, 2009). The normal everyday routine operations are adversely affected by petroleum spills. The threats to aquatic species are persistent with physical smothering of surface water (Brassard 1996; Achudume, 2009). Humans are exposed to petroleum compounds by inhalation, direct contact with the skin and /or ingestion. Heavy metal uptake occurs directly from the surrounding as a chemical compound in the atmosphere. The bioavailability of trace metals is a key factor in determining metal levels in fresh water biota. Information on the level of heavy metals pollution in freshwater environment is important as they cause serious environmental health hazard (Shukla et al. 2007; Achudume, 2009). In recent past, a study was conducted on the sediment samples after flooding in the Niger Delta (Achudume, 2007). The study showed that heavy metals toxicity in regular flooding of the coastal communities has similar disastrous consequences because of chemical pollution that may on the long run have adverse effects on soil and vegetations in Niger Delta. Besides, increase industrialization in the past four decade has resulted in increased effluents being discharged into the aquatic system (Ekpo and Ibok, 1999). These wastes are potential sources of trace elements in the surrounding environment (Malaviya et al., 2007). The industrial effluent

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Abbreviations: DO, Dissolved oxygen; **BOD,** biological oxygen demand; **COD,** chemically oxygen demand; **THC,** total hydrocarbon.

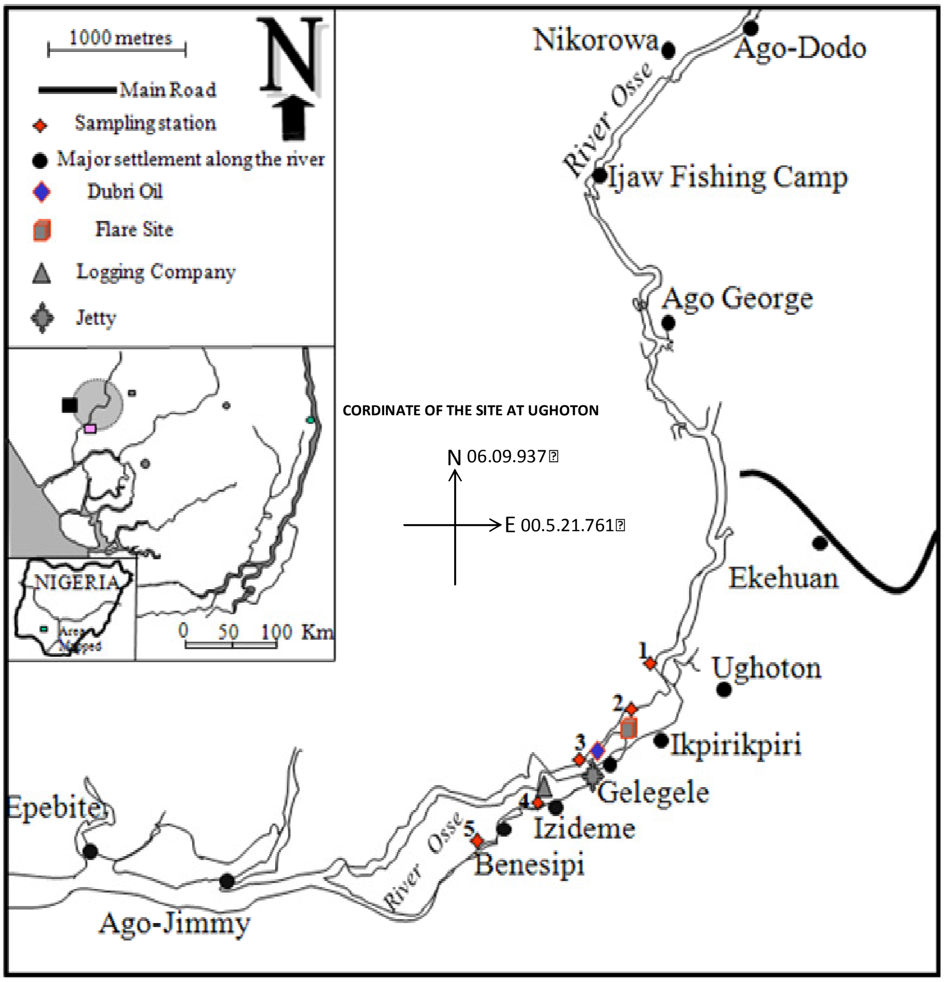

Figure 1. Detailed map of Study area showing sampling stations.

generally contains high quantities of dissolved and suspended particles including toxic trace elements which cause deleterious effects on the freshwater sediments and vegetations when discharged into water bodies (Muley et al., 2007). Additionally, concentration of trace elements in sediment may render soils non-productive because of phytotoxicity. In addition, impeded litter decomposition and soil respiration are common features of heavy metal polluted soils (Nwuche and Ugoji, 2008).

Achudume (2009), studied the impact of oil spill and concluded that Niger Delta are important breeding ground for marine organisms and continuous absence of fish and other aquatic organisms was a result of diminished levels of dissolved oxygen. In recent time, considerable studies have been carried out on heavy metal levels in various media and surface water; there is a paucity of information in the heavy metal concentrations in the ecosystem. The effect of various heavy metals entering the environment is still not well understood (Nduka and Orisakwe, 2011). Some of the important pollutants in the Niger Delta may not necessarily be on the oil spills, rather, on agricultural fields and gas flaring from flow stations. No investigation has taken cognizance on the status of the stream and its impact on Ughoton ecosystem. The present study evaluates the pollution status and shed light on potential toxic effluents in the stream water. The secondary objectives were to obtain the basic information permitting a better understanding of its impact on human health and ecosystem.

MATERIALS AND METHODS

The study area along the Ughoton stream encompasses the stretch between Benin River and Osse river transverses through Ekehuan and Ughoton village (Figure 1). The freshwater stream is a typical mangrove canopy with thick tropical vegetation cover along the bank. An oil well head situated 50 m adjacent to the stream bank spills oil on regular basis and empty itself into larger Benin River. Surface water samples were collected between 9 and 11 in the morning from the downstream of Ughoton stream near the mouth of

Table 1. Physico-chemical and microbiological characteristics of Ughoton stream between November 2007 and September 2009 **.

Parameter	Range	Mean± SD
Water temperature	17.5℃	22.88℃
pH	6.14	7.63
Dissolved oxygen	3.8	6.2
Total dissolved solids	0.40	0.60
Chloride	5.40	8.5
Calcium	2.0	4.8
Magnesium	0.4	1.8
Sodium	0.2	4.5
Potassium	1.8	6.0
Nitrite-nitrogen	0.38	0.68
Nitrate-nitrogen	1.104	2.894
Total nitrogen	1.460	4.264
Inorganic phosphorus	0.068	0.152
Organic phosphorus	0.186	0.624
Total phosphorus	0.027	0.712
Hdrocarbonoclastic bacteria/100 ml	96	520
Heterotrophic bacteria/100 ml	48	284

All values are expressed as mg/l, except pH, temperature (℃),hydrocarbonoclastic/heterotrophic bacteria (cfu/g). ** Mean of two replicates.

the oil well, 50,100, 250, and 500 m. Five replicates of water samples were collected and their physico-chemical and microbiological parameters were analyzed following standard methods (APHA et al., 1989). Water samples were filtered through a 0.45 mm whatman No. 1 filter paper. Water samples (100ml) were acidified to a final concentration of 2% with nitric acid. Two samples were divided into two and portion of each half was spiked with known concentrations (0, 2.5, 5.0. and 10.0 ppm) of the eight analytes in order to determine percent recovery.

The potentially toxic elements- iron (Fe), manganese (Mn), Zinc (Zn), calcium (Ca), chromium (Cr), cadmium (Cd), nickel(Ni), lead (Pb) and Total hydrocarbon (THC) composition were determined at various distances along the stream. Water samples were analyzed twice daily for pH, electrical conductivity, turbidity, salinity, Total suspended solids (TSS), Dissolved oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrite, Nitrate, inorganic phosphate, and Total Hydrocarbon (THC). Unspiked samples, blanks and spiked samples were analyzed by atomic absorption spectrophotometer (Perkin Elmer 5000).The instrument was standardized frequently (every five samples with matrix-matched standards (inorganic ventures, Lakewood, NS). Standardization was verified with appropriate external standards (Spex Industries, Inc, Edison, NJ). Analyte recovery in spike samples ranged from 92 to 100% USEPA 1996). The average of five samples for each parameter studied was considered as one reading. The water temperature, pH, dissolved oxygen (DO) were determined in the field and other parameters were analyzed in the laboratory within 48hr. Water temperature was measured using a mercury thermometer and pH by digital pH meter. DO was estimated by the azide modification of Winkler's method. Total dissolved solid (TDS) was determined as the residue left after evaporation of filtered sample. (Trivedy et al., 1986).

Chloride, calcium, and magnesium were determined by titration methods. Sodium and potassium were estimated by flame photometer. Nitrite and nitrate were measured calorimetrically. The total nitrogen was estimated by micro-kjeldahl distillation method. Organic phosphorus was calculated as the difference between the total phosphorus and inorganic phosphorus. Hydrocarbonoclastic counts were made using membrane filter (MF) technique. To confirm the variability of data and variability or results, data were subjected to Barlett's test for homogeneity, followed by analysis of variance (ANOVA). For post hoc comparison Student Newman Keul.s test was employed.

RESULTS AND DISCUSSION

The results of physico-chemical characteristics of the Ughoton stream are summarized in Table 1. The Table indicates that surface water temperature fluctuates from7.5 to 22.8℃ with an average value of 20.1℃. The pH range showed normal daily fluctuations with average of 6.9. Electrical conductivity (EC) of 92 and 140 µΩ/cm is normal and suitable to support plants and aquatic fauna. The mean sodium, potassium, magnesium, chloride and calcium contents of stream samples were observed within the tolerance limits of Federal Environmental Protection Agency (FEPA), 1996 and Regulation Enforcement Agency (NESREA), 2007.

The concentration of nitrogen and phosphorus in the stream water were high. The average concentration of inorganic phosphorus (0.11 mg/l) in the present investigation was found to be higher than the standard permissible limit (50 µg/l) recommended by USEPA (1976), World Health Organization (WHO) (2008), and Waziri and Ogugbuaja (2010). Both nitrite and inorganic phosphorus concentrations averaged 0.53 and 0.11 mg/l respectively. The high concentration of nutrients in the

Table 2. Heavy metal and Total hydrocarbon of the analyzed water in four locations **.

Sample	Fe (µg/g)	Mn (µg/g)	Zn (µg/g)	Cu (µg/g)	Cr (µg/g)	Cd (µg/g)	Ni (µg/g)	Pb (µg/g)	THC
Control	0.22±0.01	0.10±0.01	0.02±00	0.04±00	0.01±00	0.00	0.01±00	0.008±00	ND
50	0.34±0.05	0.14±0.01	0.03±00	0.05±00	0.03±00	0.08±00	0.08±0	0.01±00	5.6±0.01
100	0.36±0.01	0.17±0.01	0.04±00	0.05±00	0.08±00	0.01±00	0.01±00	ND	6.20±0.01
250	0.29±0.01	0.12±0.00	0.02±00	0.04±00	0.05±00	ND	ND	0.01±00	4.50±0.01
500	0.25±0.02	0.12±0.01	0.02±00	0.04±00	ND	ND	ND	ND	3.40±0.01

** Mean of two replicates.

stream water may be attributed to the fact that the stream receives large amount of domestic sewage and solid wastes from the village including the surface runoff, and the effluent from oil spill and surrounding agricultural fields. Though, the stream water may be considered suitable for aquatic and wild life propagation as the pH and DO, BOD and COD values are within the set limits for water (NESREA 2007 and WHO 2008). In contrast, the microbial analysis of probable number (MPN) of hydrocarbonoclastic and heterotrophic bacteria counts ranged from 96 to 520 and 48 to 284 (100 ml/l) respectively. These concentrations were high due to effluent discharge from the catchment area. The present findings indicate microbial contamination in the stream water and therefore not suitable for drinking.

Data on heavy metal and Total hydrocarbon of the analyzed water from five different locations is shown in Table 2. Heavy metal characteristics revealed that in most cases, the values were lower than recommended standard permissible limit (NESREA, 2007) for stream. These values are accompanied by low levels of DO, BOD, COD and effluent temperatures. Thus it may be concluded that the low values, for these pollution parameters reflect the reduced activity of indigenous micro flora present in the effluent, responsible for natural bioremediation. These changes with increasing distance suggest that the stream undergoes the process of self purification, which may be due to synergistic action of indigenous microorganisms, aeration, pH changes, photochemical effects and dilution. Not all sequences considered in this study are independent. In a recent study, sequences were considered as approximately independent factors (Zhang et al., 2011). Accordingly, water temperature is considered as the largest factors followed by pH value and DO using gray relational analysis (GRA). The COD indirectly impedes the growth of nitriifying bacteria because the DO is consumed in the decomposition of organic matter by heterotrophic bacteria. Though, the alkalinity can meet the requirement of nitrification, it is not restrictive factor.

However, it is clear that downstream of Ughoton stream water is polluted as it has high concentration of nutrients, hydrocarbonoclastic and heterotrophic organisms. Polluted nature of the stream water is further confirmed by oil films (from the oil spillage, overtime) in the polluted environment. The stream may be considered as a threat to the Ughoton stream ecosystem as its nutrient concentration exceeded the tolerance limit of any stream water discharging into a major river. In addition, the effects of heavy metal contamination are viewed as an international problem because of the effects on human health and ecosystem (Ayes et al. 2007; USEPA, 1977). Proper conservation measures should be taken up to protect the stream water and the ecosystem from further deteration.

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