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EFFECT OF PETROLEUM WASTE WATER ON NEW CALABAR RIVER AND ITS SEDIMENT IN BUGUMA, RIVERS STATE OF NIGERIA

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ABSTRACT

Effect of petroleum waste water on New Calabar River and its sediments in Buguma, Rivers State of Nigeria, was investigated. Water and sediment samples were taken upstream; point of waste water discharge, and downstream 1 and 11. Some physico-chemical properties [pH, temperature, turbidity, conductivity, and salinity] were determined using standard methods, and results showed significant increase in these parameters at the petroleum waste water discharge point, compared to the upstream and downstream points. Water analysis results also showed that Biological Oxygen Demand (BOD), Total Dissolved Solid (TDS), Total Suspend Solid (TSS) was significantly increased. However cation and anion components Calcium, Sodium, Magnesium, Potassium and nitrate, sulphate and phosphate were not significantly ($p>0.05$) affected. Microbial load were also significantly reduced at the discharge point. The results indicate that the petroleum waste water adversely affected the water quality at the point of discharge into the river and by extension the aquatic organisms of the river. The probable effects of these findings on human life and the environment are discussed.

KEY WORDS: Petroleum, waste water, river sediment, environmental pollution, aquactic organisms

INTRODUCTION

Pollution in the crude oil producing areas has become a thing of concern. This is understandable because pollution directly affects the quality of life (Agwu, 1995). Pollutants in the oil producing areas could be classified into three: solid, liquid and gaseous pollutants. The solid pollutants include drilled cuttings (NaCl, KCl), and drilling mud ($BaSO_4$). The liquid pollutants comprise of location water (rain), brine, crude oil spill and sewage. Others are oily residues, tank bottom sludge and obsolete chemicals. If these are not properly treated before disposal, they constitute a health risk. The gaseous pollutants are the flared gases. Nigeria currently flares 25% of its associated gas due to inadequate infrastructure and technology to harness these gases (Waslen and Mclusky, 1982).

Petroleum waste water is the water produced from oil during or after drilling. During drilling the ensuing fluid is a water-oil-gas mixture since oil and gas reservoirs have a natural water layer which is petroleum waste water, which lies under the hydrocarbons. In some cases, additional water is usually injected into the reservoirs to help force the oil to the surface and ensure maximum oil recovery. Both waste water and injected water are eventually produced along with the hydrocarbon (Wills, 2000). Produced water is an inextricable part of the hydrocarbon recovery process. Water pollution according to Udosen (1992) is the disruption of a complex stability of surface water by gases, hydrocarbons, contaminants, agricultural wastes, sewage or other refuse and microorganisms. Buguma town in Rivers State of Nigeria is the host community for Shell Petroleum Development Company (SPDCC) which has oil drilling facilities in this area. The discharged petroleum waste water from the drilling activities of this company is discharged into the New Calabar River which serves as the major source of water and marine food for the community.

The agitations of oil producing communities of Niger Delta areas of Nigeria, about large scale pollution of agricultural farmlands, water bodies and the atmosphere, and the attack of militant groups on oil prospecting companies and the Federal government of Nigeria by the communities, has created public awareness. Hence we thought it necessary to investigate the likely effects of discharged petroleum waste water on the water body and its sediments of the river.

MATERIALS AND METHOD

***Sample Source**:*

The study site was the New Calabar River in Egbema of Rivers State of Nigeria. The petroleum waste water was produced by the Shell Petroleum Development Company (SPDC) Buguma flow station. Sampling of the river was carried out five times (between November and March), on the 13^{th} of every month; November and December 2010, through January, February and March 2011, which was the dry season period.

Sampling points:

Water samples were collected from four sampling points along the course of the river:

a. Upstream - 100m before the point of waste water discharge

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b. Point of waste water discharge
c. Downstream I - 300m from discharge point
d. Downstream II - 500m from discharge point

Sample collection:
Samples were aseptically collected using sterile screw-capped bottles (4-6mm below the water surface against the water flow).Sediment samples were also aseptically collected using a sterile spatula (about 2-4cm deep), in the direction of the water flow.

***Determination of Physico-chemical parameters of water*:**
The methods of APHA/AWWA, (1985) and Ency, (1998) were used to determine the physico-chemical parameters of the water and sediment samples.

Determination of Heavy Metal Concentrations:
The method of APHA/AWWA, (1985) and Atomic Absorption Spectrophotometer (AAS) were used to determine heavy metal concentrations.

***Microbial Analysis*:**
The total viable count for bacteria was carried out using the membrane filtration technique. The bioload was estimated by the plating method of Chessbrough, (1987) as described by Davies *et al.,* (1996).

***Statistical Analysis*:**
Values are represented as Mean±SD. Data were analyzed using one-way analysis of variance (ANOVA) and values for $p<0.05$ were considered statistically significant.

RESULTS

Table 1: Physicochemical Parameters [water Sample]

Parameter	Upstream	Discharge Point	Downstream I	Downstream II
pH	7.20±0.02	7.80±0.04	7.50±0.01	7.30±0.06
Tempt (^oC)	28.40±0.01	30.30±0.02	29.80±0.06	29.10±0.01
Turbidity	16.20±0.06	21.00±0.01	19.20±0.03	17.30±0.03
Conductivity	26.31±0.03	31.30±0.03	28.50±0.04	27.20±0.02
Salinity	0.03±0.01	1.12±0.06	0.04±0.01	0.09±0.04

Mean values of five determinations, Mean ±SD

Table 2 Physicochemical parameters [Sediment Sample]

Parameter	Upstream	Discharge Point	Downstream I	Downstream II
pH	7.40±0.02	7.70±0.01	7.40±0.03	7.40±0.01
Tempt (^oC)	27.30±0.01	29.80±0.07	29.10±0.06	28.20±0.02
Turbidity	18.20±0.03	21.40±0.04	18.12±0.04	17.60±0.04
Conductivity	27.30±0.06	30.90±0.06	28.10±0.03	27.40±0.06
Salinity	0.03±0.02	1.10±0.01	0.51±0.01	0.08±0.01

Mean values of five determinations, Mean ±SD

Results for the physico-chemical parameters of the water and sediment samples (Table I and II), show that the upstream which is 100m from the discharge point has significantly lower values ($p<0.05$) for all the parameters measured compared to other sampling points. The Downstream I values (Table 1 and 2) were also significantly decreased ($p<0.05$) compared to values of the discharge point. For Downstream II values, there was a further significant reduction of the values ($p<0.05$) compared to those of Downstream I. The significantly higher value of the parameters at the discharge point seems to show that the petroleum discharged waste water may have impacted negatively to the river environment.

Table 3: Water Analysis [mg/l].

Parameter	Upstream	Discharge Point	Downstream I	Downstream II
DO	5.28±0.04	2.75±0.02	3.50±0.03	4.70±0.03
BOD	75.00±0.07	85.00±0.06	80.00±0.04	77.00±0.09
TDS	450.00±0.06	3110.00±0.08	2910.00±0.04	1920.00±0.06
TSS	21.40±0.03	51.20±0.04	42.10±0.03	32.30±0.09
SO_4	20.30±0.01	20.70±0.03	20.50±0.01	20.35±0.04
PO_4	0.07±0.03	0.08±0.01	0.70±0.04	0.07±0.01
NO_3	9.30±0.04	9.80±0.03	9.60±0.06	9.40±0.02
Na	0.81±0.05	1.78±0.03	1.12±0.01	0.97±0.07
Ca	21.30±0.04	21.70±0.06	21.50±0.03	21.40±0.03
Mg	1.28±0.01	1.30±0.03	1.28±0.04	1.28±0.03
K	1.10±0.04	1.13±0.02	1.11±0.03	1.09±0.03

Mean values of five determinations, Mean ±SD

Table 3 shows results for water analysis. Dissolved oxygen (DO) was significantly higher ($p<0.05$) at the upstream 5.28±0.04mg/L compared to all other sampled points. DO significantly decreased ($p<0.05$) from upstream to discharge point 2.75±0.02mg/L. There was also a significant increase ($p<0.05$) in dissolved oxygen (DO) from discharge point, through downstream I, 3.50±0.03mg/L to 4.70±0.03mg/L at downstream II. All other parameters measured showed significant increase ($p<0.05$) at the discharge point compared to the upstream, and also showed non – significant increase ($p<0.05$) as we sampled through to downstream I and II.

Table 4: Sediment Analysis [mg/l]

Parameter	Upstream	Discharge Point	Downstream I	Downstream II
DO	4.37±0.04	2.81±0.03	3.00±0.01	4.50±0.04
BOD	80.00±0.03	85.00±0.06	82.00±0.02	80.00±0.02
TDS	550.00±0.09	3110.00±0.08	2700.00±0.06	2000.00±0.03
TSS	22.30±0.02	51.00±0.04	45.10±0.03	35.00±0.04
SO_4	20.70±0.03	20.80±0.06	20.50±0.02	20.50±0.05
PO_4	0.08±0.01	0.09±0.01	0.70±0.01	0.07±0.01
NO_3	9.50±0.02	9.80±0.03	9.50±0.03	9.40±0.01
Na	0.83±0.01	1.80±0.02	1.08±0.02	0.89±0.01
Ca	22.40±0.03	21.70±0.06	21.60±0.05	21.60±0.03
Mg	1.30±0.02	1.30±0.02	1.29±0.02	1.29±0.02
K	1.14±0.03	1.13±0.03	1.10±0.03	1.10±0.03

Mean values of five determinations, Mean ±SD

Table 4 shows the results of sediment analysis. Dissolved oxygen (DO) at the discharge point was significantly lower ($p<0.05$), 2.81±0.03mg/L compared to 4.37±0.04mg/L at the upstream. DO gradually increased significantly ($p<0.05$) through to downstream I, 3.00±0.01mg/L to 4.50±0.04mg/L at the downstream II. The concentrations of the cations Ca, Mg, K and Na at the four sampling points were not different. But all other parameters measured showed significantly higher values ($p<0.05$) at the discharge point compared to the upstream. But as we sampled through to downstream I and downstream II, the measured parameters decreased non- significantly ($p<0.05$) compared to the discharge point values.

Table 5: Microbiological Analysis [Water Samples]

Parameters	Upstream	Discharge point	Downstream I	Downstream II
TVBC	$4.4x10^4±0.01$	$2.3x10^4±0.02$	$3.2x10^4±0.02$	$4.1x10^4±0.01$
ODBC	$2.8x10^3±0.03$	$2.0x10^3±0.03$	$2.6x10^3±0.01$	$2.9x10^3±0.02$

Table 6: Microbiological Analysis [Sediment Samples]

Parameters	Upstream	Discharge point	Downstream I	Downstream II
TVBC	$4.6x10^4±0.04$	$2.4x10^4±0.03$	$3.6x10^4±0.02$	$4.3x10^4±0.01$
ODBC	$2.9x10^3±0.02$	$2.1x10^3±0.01$	$3.7x10^3±0.02$	$3.1x10^3±0.02$

TVBC: Total Viable Bacteria Count, **ODBC**: Oil Degrading Bacteria Count

Table 5a and 5b show the results for microbial analysis of the water and sediment sample. Comparatively, the upstream has significantly higher ($p<0.05$) total viable bacteria count (TVBC) $4.4x10^4±0.01$ (table 5), $4.6x10^3±0.04$ (table 6) compared to those of the discharge point (2.3x104±0.03 table 5 and $2.4x10^4±0.03$ table 6). TVBC significantly increased ($p<0.05$) as we sampled through to downstream I and II for both the water and sediment samples. The oil degrading bacteria count (ODBC) were non-significantly higher ($p<0.05$) at downstream II 2.9x103±0.03 and $3.1x10^3±0.02$ for water and sediment samples respectively. The discharge point had comparatively significantly lower ($p<0.05$) ODBC values $2.0x10^3±0.03$ and $2.1x10^3±$ 0.01 for water and sediment samples respectively. The sediment sample showed non-significantly higher ($p<0.05$) bacteria count compared to that of the water sample (table 5a and 5b).

DISCUSSION

The pH of the water 7.20 ± 0.02 increased from slightly acidic to pH 7.80±0.04 slightly neutral at discharge point and then reduced to 7.50±0.01 and 7.30±0.06 which is slightly acidic at downstream I and II respectively. These findings agree with those of Sorkhorh *et al.,* (1993); Kimura *et al.,* (1989) and Betrand, (1986) who reported that petroleum waste water alters the pH of the water body from slightly acidic to neutral at the point of discharge. Amund *et al.,* (1993) also reported that engine oil polluted sediment sample had pH values that tend to change from neutral to alkaline. This also agrees with our findings (table 2), as the pH of the discharge point sediment showed 7.70 ± 0.01. A significant increase ($p<0.05$) of temperature was also observed at the discharge point 30.30±0.02^oC and 29.80±0.07^oC for water and sediment samples respectively compared to values for upstream, downstream I and II. The increase in temperature may be attributed to biochemical and chemical reactions caused by the discharged petroleum waste water at the point of discharge into the New Calabar River. Microorganisms, especially the hydrocarbon degrading microorganisms must have degraded the oil content of the petroleum waste water. This process could lead to increase in heat content and ultimately increased temperature. This observation agrees with those of Oudot and Dupont, (1993); Amund and Omole, (1993) and Jansen, (1997) who reported a similar temperature increase of about 2^oC from upstream or downstream to discharge point.

Turbidity, conductivity and salinity significantly increased ($p<0.05$) for water and sediment at the discharge point compared to the upstream (table 1 and

2), which also declined as we sampled to downstream I and II. The high concentrations of these parameters may be due to the content of the petroleum waste water, which contains NaCl, KCl, drilling mud ($BaSO_4$, NaCl, KCl) which are pollutants (Pelozar *et al.,* 1993; Ingle, 1988).

Petroleum waste water discharged into the New Calabar River may have created anaerobic conditions as typified by the values obtained for the BOD, DO, TDS and TSS (table 3 and 4). The degradation of the petroleum waste water may have reduced gaseous exchange, and may have made available trapped oxygen. DO was significantly lower ($p<0.05$) at discharge point 2.75±0.02 and 2.81±0.02mg/L for water and sediment sample respectively, while at the downstream I, significant increase ($p<0.05$) in DO content occurred 3.50±0.03 and 3.00± 0.01mg/L respectively. A similar increase followed at downstream II 4.70 ± 0.03 and 4.50± 0.04mg/L respectively. At the discharge point, a significantly higher ($p<0.05$) BOD was observed 85.00 ± 0.06mg/L for both water and sediment sample.

A significant decrease ($p<0.05$) in BOD was also observed at downstream I and II for both water and sediment samples. TSS is also significantly higher ($p<0.05$) at discharge point 51.20± 0.04mg/L for both water and sediment samples, and significantly decreased ($p<0.05$) at downstream I and II. TDS was also significantly higher ($p<0.05$) at discharge point 3110.00± 0.08 for both water and sediment sample. TDS showed significant decrease as water flowed through downstream I and II. DO, BOD, TDS and TSS showed significantly higher ($p<0.05$) values at upstream. The variations for DO, BOD TDS and TSS at discharge point, downstream I and II showed that the water may have been polluted. Petroleum waste water degradation may have given rise to death of aquatic organisms, which, in cause of decay may have needed more oxygen for biodegradation. The high BOD and low DO observed in this study is similar to the report of Odu, (1981); Odum, (1994); Gibson and Subramarian, (1997) who gave low values of oxygen tension in oil polluted environments 3.00 and 80.00mg/L for DO and BOD respectively.

There were no significant difference ($p<0.05$) in SO_4, PO_4, and NO_3 concentration (table 3 and 4) in all the sampled points for both water and sediment sample. The non-significant increase in SO_4 and NO_3 20.70±0.03 and 9.80±0.03mg/L for water and 20.80 ± 0.06 and 9.80±0.03mg/L for sediment may have resulted from the decay of organic matter. Odu, (1987) reported similar conditions in Obagi, while Morgan and Natkinson, (1989) attributed the increase in SO_4 and NO_3 to reactions of oil fractions and some dissolved drilling chemicals.

For elemental content, Na showed a significant increase ($p<0.05$) at the discharge point 1.78± 0.03 and 1.80±0.02mg/l compared to the upstream for both water and sediment samples. As the water flowed through downstream I and 11, a gradual significant decrease ($p<0.05$) was observed. All other ions assayed for showed no significant change ($p<0.05$) in concentration at the discharge point.

Microbiological assay (table 5a and 5b) show there were significant reductions ($p<0.05$) in TVBC and ODBC values at the discharge point $2.3x10^4$±0.02; $2.0x10^3$±0.03 respectively for water sample compared to $4.4x10^4$ ± 0.03, $2.8x10^3$±0.03 for upstream. While for the sediment, a similar trend was observed $2.4x10^4$±0.03, $2.1x10^3$±0.01 at discharge point and $4.6x10^4$±0.04, $2.9x10^4$±0.02 at upstream. TVBC and ODBC significantly increased ($p<0.05$) as we sampled through downstream I and II. The petroleum waste water discharged into the river may have had effects on the bacteria population and spectrum. The total viable bacteria count at the discharge point decreased with prolonged waste water discharged into the river. The significantly higher ($p<0.05$) TVBC and ODBC values at the discharge point could be due to the facultative aerobes nature of most oil degrading bacteria, which could withstand and adapt to the environment of petroleum waste water. This observation was also reported by Odu, (1972; 1978); Amund *et al.,* (1987) and Amund and Omole, (1993). The results of this study therefore suggest that the petroleum waste water discharged into the New Calabar River impacted negatively to the water body, and therefore may constitute an environmental pollution.

CONCLUSION

The observations made from this study showed that the petroleum waste water must have polluted the river and its sediments. Physico-chemical parameters were significantly increased at the discharge point compared to downstream 1 and 11 for water and sediment. Microbial load was non-significantly decreased at the discharge point compared to downstream 1 and 11. These effects would by extension affect the aquatic organisms and the life of the people who depend on these for source of animal foods. There is need to encourage proper treatment of petroleum waste water before disposal, or better disposal methods should be encouraged and enforced.

REFERENCE

Agwu, E. I.C., 1995. Environmental Sciences: A planner's view. Mishbet Nigeria Ltd. Lagos. 43-53

Amund, O. O, Adebowale, A. A and Ugorji, E.O., 1987. Occurrence and characteristics of hydrocarbon utilizing bacteria in Nigerian Soils contaminated with spent motor oil. Indian J. of Soil Microbiology 27: 63-87

Amundu, O. O and Omole, J. C., 1993. Biological Aspects of Land rehabilitation following Hydrocarbon contamination. Environ. Pollute. 8: 107-112

Amund, O. O, Okpokwasil, G. C and Akujiobi, T. C., 1993. Bacteriological indicators of tropic water quality. J. Environ. Toxicol. and Water Quality. 11: 77-62

APHA/AWWA, 1985. Standard methods for the examination of water and waste water quality. J. Environ. Toxicol and water quality 11:72-82

Betrand, I. C., 1986. Controlled Marine Ecosystems. In: Investigation of Biodegradation of sea J. Microbial. Sci. (3): 7-9

Chessbrough, M. M., 1987. Medical laboratory Manual for tropical countries. 3rd edition (elbs). Tropical Health Technology and Butler Worth, London. 126-127

Crafts, T. T and Reiber, E. F., 1988. Bacteriological monitoring of Hongkong Marine Water Quality. Environ. International (14):496-499

Davies, T. M, Magnatus, C and Saurha, U. T., 1996. Isolation of Petroleum Degrading bacteria from various soil samples. Petroleum Microbiol. (21): 17-20

Ency, A. N., 1998. Effect of oil exploration and petroleum hydrocarbons utilization on water quality and fauna of Qua Boa river estuary. J. Aquatic Sci. (10): 43-5

Gibson, U. A and Subramarian, V. M. M., 1997. Relationship between water qualities and bacteria associated with tropical fresh water ponds. J. Aquactic Culture. Tropical (6):157-162

Ingel, J.D., 1988. Spectrochemical Analysis. New Jersey. Practice Hall Inc. 273-274

Jansen, J. D., 1997. Block mouldings – A solid solution for drilling. In: Environmental Affairs Newsletter. Warri- Nigeria

Kimura B, Murakamin M and Fujisaw H., 1989. Characteristics and oil degrading Activities of oil degrading bacteria isolated from the sea water of oil polluted Bisan Seto and oil polluted Hibiki Nada. Bulletin of Japanese Society of Scientific Fishers. (58): 1081-1095.

Morgan, C.U and Natkinson, J.C., 1989. Controlled Marine ecosystem in the investigation of biodegradation at sea. J. Microbiol. Sciences (8): 17-19

Nwankwo, J.N and Irechukwu, D.O., 1981. Problems of environmental pollution Control in the Nigerian Petroleum industry. In: The petroleum industry and the Nigerian environment. Proceedings of 1981 International Seminar (NNPC), 102-107.

Odu, C.T.I., 1972. Microbiology of soils contaminated with petroleum hydrocarbon. Extent of contamination on some soil and microbial properties after contamination. J. Instructional Petrochemical. (58):201-208

Odu, C.T. I., 1978. Fermentation characteristics and biochemical reactions of some organisms isolated from oil polluted soils. Environ. Pollut. (15):235-240.

Odu, C.T.I., 1981. The effects of nutrient application and aeration on oil degradation in soil. Environ. Pollut. (25):226-234

Odu, C.T.I., 1987. Degradation and weathering of crude oil under tropic conditions. The petroleum industry and Nigerian environment. Proceedings of 1987 International Seminar (NNPC). 16-20

Odum, P.D., 1994. Contamination of soils by petroleum hydrocarbons. Advances in Agronomy (32):197-216

Oudot, I. I. and Dupont, K.C., 1993. Soil and environment: An introduction. Oxford Press. London 256-280

Pelozar, M, Chan, (jnr) E.C.S and Kreig, N,R., 1993. Microbiology: Concepts and Applications. Magsaw-Hill Incoporated. New York. 772-779

Sorkhorh, N.A., Ibrahim, A.A., Ghannoils, M. A and Radidad, M. S., 1993. High temperature Hydrocarbon degradation of Bacillus stereothermophillus from oil polluted water in Kuwait estuary. Applications in Microbiol and Biotechnol. 39:123-126

Udosen, O.A., 1992. Indiscriminate disposal of effluents from industries. J. Environ. Quality (48): 69-72

Waslenk, K. and Mclusky, Y.P., 1982. Contamination of waters by petroleum hydrocarbons. Advances in Agronomy (13): 219-226

Wills, J., 2000. A survey of offshore oil field drilling wastes and disposal techniques to reduce the ecological impact of sea dumping. Sakhalin' Environmental Watch. (13):23-29