Journal of Basics and Applied Sciences Research (JOBASR)
ISSN (print): 3026-9091, ISSN (online): 1597-9962
Volume 2(2) June 2024
DOI: https://doi.org/10.33003/jobasr-2024-v2i2-51

Effects of Water-Soluble Fractions of Crude Oil on Physicochemical Quality and Heavy Metal Status of River Ethiope at Abraka, Nigeria

Agbogidi, O. M.[1*], Ogbemudia, C. O.[1] and Nwabueze, A. A.[3]
[1]Department of Botany, Delta State University, Abraka, Nigeria.
[2] Department of Fisheries and Aquaculture, Delta State University, Abraka, Nigeria.
*Corresponding Author Email: omagbogidi@yahoo.com

ABSTRACT
Crude oil exploration and exploitation has impacted the environment and humans negatively. The effects of Water Soluble Fractions (WSFs) of Universal Energy Akwa Ibom crude oil on River Ethiope, Abraka, Nigeria were assessed so as to ascertain its physiochemical qualities and the presence of heavy metals. Physicochemical qualities were determined following standard procedures of APHA and AOAC. The impacts of WSFs on the physicochemical parameters was significant when compared with water sample controls from River Ethiope but were still within the limits of WHO. Chemical Oxygen Demand (COD), turbidity, total alkalinity, calcium, nitrates and HCO_3 had levels higher than water samples controls. Other parameters were either lower in water sample control or did not differ significantly in values between the water samples and WSFs of crude oil.COD, DO, BOD, turbidity, conductivity, sulphate, calcium, magnesium, potassium and chloride ion had values lower than the WHO recommended range. Both water samples and WSFs contained traces of heavy metals. All trace heavy metals in water samples and WSFs were lower in levels when compared with WHO recommended levels except lead which had a higher levels in the WSFs. Although most of the parameters and heavy metals determined in this study were within the WHO permissible levels for drinking water, there is the need to exercise precaution because of the health risks associated with metal load and their non-degradable nature. Hence, regular monitoring by regulating bodies to avoid possible bioaccumulation and biomagnification along the food chain and webs is necessary.

Keywords:
Physicochemical quality,
crude oil,
heavy metals,
River Ethiope.

INTRODUCTION

The oil industry in Nigeria has no doubt significantly improved the country socioeconomically but with notable side effects (Agbogidi, 2003; Agbogidi, 2005). Oil exploration and exploitation has been reported to impact the environment negatively either directly or indirectly due to human error, overloading, transportation, leakages, sabotage among others (Agbogidi *et al*., 2006). Ahmad *et al.* (2010) and Ifelebuegu *et al.* (2017) reported that oil spill pollution affect physicochemical, microbial and hydrobiological properties of river water. Ecological impacts of oil spills are widespread with bioaccumulation of crude oil lipid-soluble fractions in aquatic organisms. Zhang (2020) reported that spilled oil is the common source of heavy metal contamination in aquatic ecosystem. Ogeleka *et al.* (2017) noted that oil spills affect and damage the water and sediment and therefore cause harm to aquatic organisms in the ecosystem. Many aquatic organisms have been found not suitable for human consumption due to heavy metal contamination (Nwabueze, 2011; Nwabueze and Emefe, 2012).

The water soluble fraction of crude oil are a mixture of hydrocarbons, volatile hydrocarbons, phenolic compounds and many heterocyclic molecules hence highly toxic to aquatic life forms (Bamidele and Agbogidi, 2000).Similarly, Nwachukwu and Osuagwu (2014) reported that oil spills had significant effect of reducing ground water quality in Nigeria. Imoobe and Aganmwonyi (2021) also noted that water quality of drinking water may be compromised and not fit for consumption. There is a dearth of information on the effects of water soluble fractions of crude oil on the physicochemical qualities of River Ethiope. It is against this background that this study was carried out. This study assessed the water physicochemical quality and heavy metal status of River Ethiope as influenced by universal energy Akwa Ibom crude oil in Abraka, Delta State.

MATERIALS AND METHODS

Study area

The research was done at the Screen House of the Department of Botany, Delta State University, Abraka. Abraka lies between latitude 05°47'N and longitude 06°06'E of the equator, with an annual rainfall, relative humidity and mean temperature of 3,097mm, 83% and 30.60°C, respectively (Efe and Aruegodor, 2003).

Collection of samples

Water samples were collected from River Ethiope at Abraka between 7.00 and 9.00 hours using sterile 20 L plastic containers once a week for four weeks. Samples of water collected were taken to the laboratory, and allowed to settle overnight in a stock tank. The crude oil, Universal Energy Akwa Ibom crude oil was gotten from NNPC, Warri, Delta State.

Preparation of water soluble fraction of crude oil

The procedure of Afolabi *et al.* (1985) was employed in the preparation of WSFs. Distilled water was used to mix the crude oil and the mixture was agitated for 24 hours. WSFs was siphoned into a dark colored screw capped Winchester bottles to make a 100% stock. The stock was diluted to obtain 50% strength WSFs which was stored in screw capped bottles. Buffer solution was used to adjust the pH of the WSFs. Water from River Ethiope was used as control (0%). The set up was replicated three timesandwas monitored for four weeks.

Experimentation

Water samples from the stock was distributed into eight different aquaria tanks (30cm x 40cm x 60 cm) of one control and one treatment as well as the three replicates.To all treatments 50% of WSFs were added while the controls had 0% WSFs. The set up was a static non-renewal assay. Determination of physicochemical parameters and heavy metal loads were carried out and findings recorded.

Determination of physicochemical parameters

The standard procedure of APHA (2012) was used in determining the physicochemical parameters of the WSFs. Mercury-in-glass was used to determine the surface temperature, total dissolved solid (TDS) was quantified by gravimetric method, total suspended solids by oven drying method and pH determination carried out using an EIL model 720 pH meter while electrical conductivity (EC) was determined using the portable conductivity meter (Hanna) with values expressed in µs/cm. Dissolved oxygen was determined using Winkler's method and biochemical oxygen demand (BOD) using Azide modification method. Chemical oxygen demand (COD), total alkalinity, sulphate, nitrate, sodium, calcium, carbonate and magnesium were all also determine following the procedures of APHA (2012).

Determination of heavy/trace metals

Prior to analysis, nitric acid was used to digest the samples. Atomic Absorption Spectrophotometer (AAS, Unicam 969) was used to determine the contents of trace metals in WSFs, and their concentration was read in accordance to the procedure of AOAC (2010).

Quality Control Assurance

Each analysis was done in triplicates. All reagents were of ANPOLAR grade. Prior to the usage of apparatus and sampling containers, they were thoroughly washed with detergent and rinsed in distilled water so as to minimize or prevent experimental error due to instrumentation.

Statistical analysis

The data collected were subjected to Students' statistics at $P \leq 0.05$ using SAS (2010).

RESULTS AND DISCUSSIONS

Results

The results of the effects of water soluble fractions of Akwa Ibom oil in the physicochemical qualities of River Ethiope in relation to the controls are shown in table 1.

The results of the physicochemical quality of River Ethiope as affected by the water soluble fractions of crude oil relative to controls are presented in table 1. The WSFs significantly ($P<0.05$) impacted some of the physicochemical quality parameters. Chemical Oxygen Demand (COD), turbidity, total alkalinity, calcium, nitrates and HCO_3 had levels higher ($P<0.05$) than water samples controls. Dissolved oxygen (DO), pH and electrical conductivity, magnesium and potassium ions had lower values ($P>0.05$) in water samples from River Ethiope compared with the WSFs of crude oil. Temperature, dissolved oxygen, sulphate, potassium, phosphate and chloride ions did not differ significantly in values between the water samples and WSFs of crude oil. Most of the physicochemical parameters such as COD, DO, BOD, turbidity, conductivity, sulphate, calcium, magnesium, potassium and chloride ion had values lower than the WHO recommended range. The values obtained for HCO_3in WSFs was higher than the WHO limits while pH value was lower inWSFs as compared with recommended limit. For the WSFs, only phosphate and nitrate were within limit. HCO_3 and sodium were higher than the recommended range while the other parameters were lower than the limit. Comparing these values with WHO standard shows that both water samples and the WSFs had values of COD, DO, BOD, turbidity, conductivity, sulphate and chloride ions, lower than recommended limits.

Table 1: Physicochemical parameters of WSF of universal energy AkwaIbom crude oil

S/N	Parameters	WSF	River EthiopeWater (Control)	WHO/FAO
1	Temperature	25.96	25.96	
2	pH	4.86	6.8	6.5 – 8.8
3	COD	0.39	0.07	20.5
4	DO	0.89	1.08	20.0
5	BOD	0.06	0.8	3.5 – 5.0
6	Turbidity	4.57	0.01	500
7	Conductivity	17.74	26.31	200 – 1000
8	Total alkalinity	5.60	1.23	
9	Cl (mg/L)	2.45	2.13	200.400
10	Sulphate	2.01	1.09	200.00
11	Nitrate (NO_3)	3.07	0.90	0.6-5.0
12	Phosphate (PO_2)	4.40	4.36	0.05 – 5.0
13	Ca	1.58	0.42	2 – 5.0
14	Mg	0.54	1.53	2.0
16	K	1.06	1.90	5.0
17	HCO_3	6.76	0.80	0.6 – 2.0
18	Na	1.87	NA	0.5

NA- Not available

Both water samples and WSFs contained traces of heavy metals. The following heavy metals/trace metals were found: cadmium, chromium, cobalt, copper, iron and lead had higher values (P>0.05) in WSFs than in water sample controls. Zinc and Nickel had same values in the WSFs and water samples. All trace heavy metals in water samples and WSFs were lower in levels when compared with WHO recommended levels except Pb which had a higher (P>0.05) levels in the WSFs than the WHO limit (table 2).

Table 2: Heavy Metal Status of the WSF of Universal Energy AkwaIbom Crude Oil

S/N	Heavy Metal	WSF	River Ethiope Water	WHO level
1	Fe	0.002	0.001	0.01
2	Zn	0.88	0.88	200
3	Cu	0.002	0.001	0.05
4	Pb	0.002	0.001	0.001
5	Cd	0.002	0.001	0.05
6	Co	0.004	0.002	1.00
7	Cr	0.002	0.001	0.05
8	Ni	0.001	<0.001	0.05

Discussions

The water samples with WSFs of crude oil had different values of physicochemical compared with the water samples controls from River Ethiope. The WSFs may have caused changes in the values obtained. The observed alterations in the physicochemical qualities of the river water as affected by the WSFs of crude oil is in agreement with the studies of Kaizer and Osakwe (2010), Uhegbu *et al*. (2011) and Ikpeme *et al*. (2013) which reported the negative impacts of crude oil spills on life forms in the aquatic environment. Oti (2015) noted that WSFs altered the variability and had transformational effects on plants. Reduction in plant population and diversity has been reported due to crude oil pollution (Bamidele, 2006). Nwabueze and Agbogidi (2006) also reported reduced growth of fish resulting from WSFs of crude oil. Lower levels of some of the parameters such as pH, could lead to acidity. High acidity has negative effects on aquatic life forms by decimating their abundance and diversity (Adjarho *et al*., 2013; Nwabueze, 2015; Olele *et al.,* 2019).

The observed heavy metal contents of the WSFs of the crude oil is not unusual as there are several reports of heavy metal and trace metals in crude oil fractions. However, an understanding of the impact of WSFs in water bodies is important in preventing or mitigating its long term environmental effects. Kottuparambil *et al*. (2023) detected traces of oil hydrocarbons in plankton populations and observed that oil pollutants rapidly enter into the pelagic food web. Kim *et al.* (2019) opined that aromatic hydrocarbons and polar fractions from oil spills in water bodies will pose a major threat to aquatic ecosystem for a long time, and this is as a result of their long term persistency and toxicity to this environment.

Niches and ecosystems impacted with crude oil and its fractions and other industrial wastes accumulate heavy metals in aquatic systems where most spills occurposing risk and threat to the rural populace who depend on rivers, streams, ponds and wells as rural sources of water (Agbogidi *et al.,* 2016 and Agbogidi *et al.,* 2018).These heavy metals are not biodegrable as such bioaccumulates in tissues of life forms and man via food chains.

CONCLUSION

The study established that the water soluble fractions of crude oil have significant effects of altering the physicochemical quality of River Ethiope in Delta State, Nigeria and hence its socioeconomic importance and other ecosystem services it renders. The operations of crude oil should be monitored regularly, likewise polluted water bodies, so as to avoid pollution and its attendant risks on the environment and rural populace.

REFERENCES

Adjarho, O.B. Esenowo, I.K. and Uhwunba, A. A. A. (2013).Physicochemical parameters andmacroinvertebrate fauna of Ona River at Oloyele Estate, Ibadan, *Nigeria Journal of Environmental and earth Sciences*. 5(1): 671-676. DOI: 10.19026/rjees.5.5722.

Afolabi, O. A., Adeyemi, S. A. and Imebore, M. A. (1985). Study on toxicity of some Nigerian crude oils on some aquatic organisms. In: Proceedings of 1985 International Seminar on Petroleum Industry and the Nigerian environment, Lagos. Pp 269-273.

Agbogidi, O. M. (2003). Response of *Azolla africana* Desv.and*Salvinianymphellula*Desv.tothe water soluble fractions of Odidi well crude oil. *Journal of Science and Technology Research, 2:* 276-80.

Agbogidi, O. M. (2005). The role of macrophytes in aquatic systems: a botanical review.*Nigerian Journal of Science and Environment, 4:* 1-9.

Agbogidi, O. M., Nwake, F. U. and Okechukwu, E. M. (2006). Yield performances of fivecultivars of soys bean (Glycin max L.) as influenced by soil contaminated with crude oil. *Nigerian Journal of Tropical Agriculture, 8:* 303-309.

Agbogidi, O. M., Adim, N. A. and Akintunde, J. (2016). (2006). Effect of kerosene contaminated soil on growth of maize (Zea Mays, L.) *Journal of Agriculture and Food Environment, 3(2):* 84 - 91.

Ahmad, H., Tsafe, A. I., Zuru, A., Shehu, R. A., Atiku., P. A. and Itodo, A. U. (2010). Physicochemical and heavy metal values of Nigerian crude oil samples.*International Journal of Natural and Applied Science, 6(1):* 10-15. eISSN: 0794-4713.

AOAC (2010). Official methods of Analysis Association of Official Analytical Chemist. 18th Edition, Washington, DC.

APHA (2012), *Standard methods for the examination of water and waste water.* 22nd Edition, American Public Health Association. Water works.

Bamidele, J. and Agbogidi, O. M (2000). Toxicity of Odidi petroleum oil and it's water solublefractions on three aquatic macrophytes. *Nigerian Journal of Science and Environment, 2:* 113 - 121.

Bamidele, J. and Agbogidi, O. M (2006). The effect of soil pollution by crude oil on seedlinggrowth of *Machaerium lunatus (L.)* GFW. Meg. *Discovery and Innovation, 18:* 104 – 108. DOI: 10.4314/daiv18i2.15712

Efe, S.I, and Aruegodor, P. (2003). Aspect of microclimates in Nigerian rural environment: TheAbraka experience. *Nigerian Journal of Research and Production, 2(3):* 48-51.

FAO (Food and Agricultural Organization, 2013). Permissible limits of drinking water. 4p.

Ifelebuegu, A. O, Ukpebor, J. E., Ahukannah, A. U, Nnadi, E. O. and Theophilus, S. S. (2017). Environmental effects of crude oil spills on the physicochemical and hydrobiological characteristics of the Nun River, Niger Delta. *Environmental Monitoring and Assessment*, DOI: 10.1007/s.10661-017-5882-x.

Ikpeme, E. M., Uttah, C. and Uttah, E. C. (2013). The effect of crude oil spill of Izombe, ImoState, Nigeria on plankton diversity and abundance. Australian Journal of Basic and Applied Sciences, 7(6): 178 - 183. Corpus ID: 20992566.

Imoobe, T. O. T., and Aganmwonyi, I. (2021). Impact of oil pollution on the water quality of Ekehuan River, Edo State, Nigeria. *Research Journal of Biotechnology and Life Sciences, 1(1):* 1-17. DOI: 10.52589/rjbls

Kaizer, A.N. and Osakwe, S.A. (2010). Physicochemical characteristics and heavy metal levels inwater samples from five River systems in Delta State, Nigeria.*Journal of Applied Science and Environmental Management*. 14(1): 83-87. DOI: 10.4314/jasem.vi1.56501.

Kaizer, A.N and Osakwe, S.A. (2007) water chemistry in the upper and middle Ethiope River,South Western Nigeria. *Journal of Science and Environment*. 6: 147-159.

Kim, D., Jung, J. H., Ha, S. N., An, J. G., Shankar, R., Kwon, J. H., Tim, U. H. and Kim, S. H.(2019). Molecular level determination of water contaminated fractions with embryonic developmental toxicity generated by photooxidation of spilled oil. *Chemosphere, 237:* 123346. DOI: 10.1016/j.chemosphere.2019.124346.

Kottuparambil, S., Ashok, A., Barozzi, A., Michoud, G., Cai, C., Daffonchio, D., Duarte, C. M.and Agusti, S. (2023). Tracking the early signals of crude oil in seawater and plankton after a major oil spill in the Red Sea. Environmental Science and Pollution Research, 30: 69150-69164. DOI: 10.1007/s11356-023-2711-0.

Nwabueze, A. A. (2015). Plankton abundance and diversity in relation to seasonal variations in physicochemical parameters of River Ethiope, Nigeria. *Journal of Agriculture and Food Environment, 2(3):* 89-101. https://www.jafedelsu.com/archive/2015no3.html

Nwabueze, A.A. and Emefe O. (2012).Heavy metal concentrations in the West African Clam,*Egeria radiate* (Lamark, 1804) from McIver Market, Warri, Nigeria. *International Journal of Science and Nature, I.J.S.N.* Vol. 3(2): 309-315. https://www.scienceandnature.org/IJSN_vol3(2)2012.php

Nwabueze, A.A. (2011). Levels of some heavy metals in tissues of Bonga Fish, *Ethmallosafimbriata* (Bowdich, 1825) from Forcados River. *Journal of Applied Environmental and Biological Sciences, Vol. 1(3-February): 44-47.*

Nwabueze, A. A. and Agbogidi, O. M. (2006). Impact of water soluble fraction of crude oil of growth performance of the catfish *Heterobranchus bidorsalis* (Geoffrey St. Hilaire, 1809). *European Journal of Scientific Research*, *Vol. 13 No 3 (2006):*369-373

Nwachukwu, A. N. and Osuagwu, J. E. (2014). Effects of oil spillage on ground water quality inNigeria, *American Journal of Engineering Research, 3(6):* 271-274. www.ajer.org

Ogeleke, D. F., Tudararo-Aherobo, L. E. and Okieimen, F. E. (2017). Ecological effects of oilspill on water and sediment from two riverine communities in Warri, Nigeria. *International Journal of Biological and Chemical Sciences, 11(1):* 453-461. DOI: 10.4314/ijbcs.v11i1.36

Olele, N. F. Jessa, Q. A., Garba, A.A and ikenga, F.E. (2019). Determination of somephysicochemical parameters of River Ethiope, Delta State Nigeria.*Journal of Agriculture and Food Environment* 6(3): 15 – 20.

Oti, W. J. (2016). Phytoremediation study on oil spill site using common Nigerian vegetables.*International Journal of Research in Science, 1(3):* 12 - 16. DOI: 10.5829/idosi.mejsr.2016.24.03.22976.

Uhegbu, F. U., Elekwa, I., Iweala, E. E. J., Kanu, I. and Uhegbu, O. C. (2011). Effect ofpetroleum waste water on new Calabar River and it's sediments in Buguma, Rivers State of Nigeria. *Global Journal of Pure and Applied Sciences,17(4)*: 481- 485. ajol-file-journal..0120712

World Health Organization, WHO (2010). Hardness in drinking water. Background documentfor development of WHO Guidelines for drinking water quality. Fourth edition, Incorporating the first and second addenda. Geneva. WHO/HSE/WSH/10.01/10/Rev/1.Pg 1-19.

Zhang, S., Guo, H., Zhang, S., Fan, H., Shi, J. (2020). Are oil spills an important source of heavymetal contamination in the Bohai Sea, China? *Environmental Science Pollution Research, 27(3):* 3459-3461. DOI: 10.1007/s11356-019-06913-1