Effect of Crude Oil on African Catfish (*Clarias gariepinus*) Juveniles in Port Harcourt, Rivers State

Wobidike V.C[1]., Kika, E.P[1] & Olalere, G. C[2]
[1]Environmental Biology, Faculty of Science University of Port Harcourt.
[2]Animal Science Department, Faculty of Agric, University of Port Harcourt
DOI: 10.56201/ijaes.v10.no9.2024.pg21.29

Abstract

Petroleum hydrocarbons continue to pose a significant threat to fish communities in various aquatic ecosystems, including ponds, lakes, streams, and rivers. The indiscriminate disposal of oil-contaminated materials and oil spillage have made these hydrocarbons the primary pollutants in these environments. Crude oil spreads rapidly in water bodies, causing acute or lethal effects on juvenile fishes, which comprise approximately 60% of aquatic fish populations. To investigate this further, a study was conducted on juvenile Clarias gariepinus. One hundred twenty healthy juveniles were randomly placed in 12 plastic aquaria and exposed to varying crude oil concentrations for 96 hours. Water quality parameters and mortality rates were recorded daily. The study revealed alarming results. The crude oil exposure led to reduced dissolved oxygen and water surface blockage, resulting in increased mortality. However, a concentration of 25ml showed a reduced level of mortality, with no further deaths recorded after 96 hours. Physiological changes, including altered skin color and reduced locomotion, were also observed. Additionally, the study found that crude oil impaired feeding behavior and swimming performance within 24 hours of exposure. Mortality rates increased with prolonged exposure, ranging from 24 to 96 hours. Crude oil and petroleum fractions blocked atmospheric oxygen dissolution, limiting oxygen supply and increasing excretory waste products, such as carbon dioxide and ammonia, in the water. Recovery was delayed in treated basins, whereas control basin juveniles developed into post-juveniles. The study revealed significant differences ($P<0.05$) in the effect of crude oil on the mortality rate of C. gariepinus when exposed to oil pollutants. The findings of this study underscore the devastating impact of petroleum hydrocarbons on fish communities. Urgent measures are necessary to mitigate oil spillage and disposal in aquatic ecosystems to protect these vulnerable populations.

Keywords: *Crude oil, Clarias gariepinus, physicochemical parameters, mortality*

INTRODUCTION

Background of Study

Petroleum hydrocarbons, in their crude, refined, or spent forms, pose significant risks to human, animal, and plant species (Khan et al., 2017; Smith et al., 2015). The environmental presence of crude and refined oils, often resulting from accidental spills or deliberate sabotage, has devastating consequences (Omoregie et al., 2017). In contrast, the disposal of spent oil is frequently deliberate and indiscriminate, disregarding its polluting effects (Hossain et al., 2019).

Oil pollution in aquatic environments constitutes hazards ranging from impairment to suppressed death (Javed et al., 2020). Toxicological evaluations, including acute/lethal and chronic/sub-

lethal observations, are crucial in assessing these hazards (Rahman et al., 2018). The lethal concentration of a substance is determined by its short-term effects on a test population (Kumar et al., 2019).

Oil spills have caused widespread destruction of food resources and harmed various aquatic organisms (Adams et al., 2018). Regular assessments are necessary to understand the immediate and potential long-term effects of oil spills on physiological characteristics of affected species (Omoregie et al., 2017).

Fisheries play a vital role in Nigeria's agricultural sector, with fish accounting for over 40% of animal protein consumption (Federal Department of Fisheries, 2020). Therefore, investigating the pollution effects of crude oil, refinery effluents, and spent oil on aquatic animals, such as catfish, is essential.

Statement of Problem

The pollution caused by oil spillage and oil exploration leads to adverse health effects of this oils to human and animals. This crude oils will surely have great effects on fishes in the waters, since this oils are actually or most a times flushed down to the rivers by different means. This study wants to know the condition of fish's survival or available ones that do not migrate or die off. Oil spills are harmful to the marine birds and mammals as well as fish and shellfish when exposed to oil, adult fish my experience reduced growth, enlarged livers, changes in heart and respiration rates, fin erosion, affects eggs, larval survival and reproduction impairment. Humans exposed to oil spilled can be exposed to respiratory problems, neurological effects and traumatic symptoms.

Aim of Study

The aim of study was to analyse the effects of crude oil in cat fish (juvenile). It's targeted objectives were:

1. The LC_{50} (lethal concentration) of crude oil on juvenile catfish.
2. Effects of crude oil on the physiochemical parameters of the water
3. Observe some behavioural changes arising from the pollution of the water body by crude oil.

MATERIALS AND METHODS

Sample Collection

A total number of hundred and twenty (120) juvenile was used in the study. They were procured from African Regional Centre (ARAC) Aluu, Rivers State and transported in the morning hours to the laboratory of Animal and Environmental Biology, University of Port Harcourt in airbags with pound water from the farm to avoid heat exertion. The fish was later transformed immediately into plastic aquaria after measuring their length and weight. They were acclimatized for 7 days. The holding tanks were aerated, cleaned and water was regularly renewed (Daniel, 2017).

Test Materials

The light bonny crude oil used in this study was obtained from an oil company in Obio/Akpor, Rivers state and transported to the laboratory in corked bottles. It was stored in a cool dry place prior to use. A known volume of the crude oil was added to a known volume of distilled water using pipette and thoroughly mixed using iron stirrer to ensure sample homogeneity. After the mixing, four different concentrations of the toxicants will be prepared after an initial range test to determine the initial safe concentrations to be used (Vincent- Akpu, 2011). From the determined safe concentrations, the following three concentrations will be obtained 25ml, 50ml and 100ml respectively while 0.00ml served as the control group. Complete randomized design will be carried out (Ogbeibu, 2009) . Four plastic aquaria will be used with 3 replicates each.

Physicochemical parameters

Prior to stocking of the aquaria the physicochemical parameters of the water was measured, these include: temperature, pH, Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) using standard methods (ALPHA, 1998).

Methods/ Procedures

- **Temperature**

The water temperature was measured using a Hanna parameter Digital (HANNA Model). The sensitive part of the thermometer was immersed directly into the water and allowed the instrument to stabilize. At stability, the temperature value was read. Three readings was taken and the mean values of the three was calculated (ALPAH, 1998).

- **pH**

The water for hydrogen ion concentration (pH) was measured using pH meter. This was done by dipping the probe into the water sample, the switch button was put on, while the arrow key wasrepeated three times and the average was taken and recorded (ALPHA, 1998).

- **Dissolved Oxygen**

Dissolve oxygen (DO) of water used in the aquaria was determined according to the modified azide or winkers method (ALPHA, 1998). A well labeled clean 70ml DO bottle initially rinsed with water sample from the aquaria and allowed to fill to overflow in order to remove every trapped air bubbles in the bottle filled with the sample, 0.5ml Manganese sulfate (winker-ii) was added, stopper placed in order to remove air bubbles from the sample and mixed properly with several inversions. The DO sample previously treated with winker i and i will be reacted with 0.5ml concentrated Sulphuric Acid (H_2SO_4), stopper placed and mixed properly for complete dissolutions of precipitate. A volume of 25ml portion of the of the sample will be placed in a Erlenmeyer Mask, few drops of freshly prepared starch solution will be added and titrated with 0.025N of NAzSz0, (Sodiumthio-sulphate) solution. The titration was continued to the first disappearance of the blue black to colorless and end point recorded (ALPHA, 1998, ASTM 1999).

- **Biochemical Oxygen Demand**

Water samples collected in the same way as the DO was incubated at 20°C for five days. At the end of the incubation periods the samples were treated in the same manner as the DO samples stated above to determine the dissolved oxygen. To ensure presence of oxygen above and the BOD is calculated using the following (A - B) X DF

Where A is initial DO of dilution water, B is the DO after 5 day incubation and DF is the dilution factor of sample to dilution water.

- **LCso Determination**

The median lethal concentrations, LC50 refers to the lethal concentration that will kill half of test species (i.e. the concentration at which 50% of mortality will occur).

- **Mortality**

Mortalities were recorded on daily basis. At the end of the trial period, survived fishes in the different replicate aquaria were recorded.

- **Behavioral Observation**

The juvenile was observed for behavioral changes during exposure periods such as general response to external stimuli and rate of activities including swimming, breathing, and feeding (Imafidor and Sotonye, 2014).

- **Acute Toxicity Testing**

Acute toxicity of crude oil on the *Clarias gariepinus* was also examined at the end of the experimental period.

Data Analysis

Data was reported as means values. The results on mortality and opercula beat frequency process were analyzed using one-way analysis of variance. All analysis was carried out with the aid of a statistical package for social sciences (SPSS) version 20.0.

RESULTS

The table above shows the physicochemical parameters of water during the experiment. It was observed that pHI was not significantly affected ($p>0.05$), pH varied from (6.91 to 6.45) in the 96 h period.

Temperature was significantly affected ($p<0.05$) with day 4 concentration 100mg/I having the highest value of (29.14).

Dissolved Oxygen (Do) was not significantly affected ($p>0.05$) where concentration 100mg/1 96 h period of the experiment having least value which indicates insufficient amount of oxygen. Biochemical Oxygen demand BOD was significantly affected ($p<0.05$) concentration of 100mg/I having the highest value of 8.43 followed by concentration of 50mg/I having a value of 8.09, the least value was recorded in Omg/I (6.13).

Table 2 show the mortality rate of *Clarias gariepinus* juveniles, at Oml concentration it was observed that there was 0% mortality of the fishes from 24h -96 h. It was observed that at 25ml concentration of crude oil mortality was not recorded until the 48h of the experiment with 5% mortality and at 96 h prior to the exposure of the fish to toxicant 25% mortality was recorded. At 50ml concentration of crude oil there was no mortality recorded for the first 24 h period, while from 48 h to 96 h period mortality was recorded respectively (15%, 25%, and 30%). 100ml concentration of crude oil there was no mortality recorded on the 24 h period of the experiment, while from 48 h to 96 h prior to the exposure of the fish to crude oil mortality increased from 25% to 55%.

DISCUSSION

In this study, the fish exhibited a low tolerance to the effect of crude oil polluted water as the mortality rose from 25%-55% within the interval of 24-96 h period. Mortality could also be a function of physiological effect in the aquarium. The continuous stay of the fishes at the bottom of the plastic aquaria during the exposure period was an indication of a low response to stimuli. This is in line with the report of Gbadebo *et al.* , (2009) in a study on the effects of crude oil and spent oil on *Clarias gariepinus* .

Toxicity was not felt by the juvenile fish immediately, possibly because of the high density and solubility of the crude oil. This probably resulted to an incomplete spreading of the oil over the surface of the water, thereby making less availability of oxygen to the aquarium. In this study, the juvenile fishes showed preferential tolerance to crude oil. Muller (1967) has observed that fishes have a tendency of removing foreign compounds such as hydrocarbon.

The non-observance of death effect of crude oil on the juvenile fishes at concentration of 25ml (24hrs) in this study, is an evidence of low toxicity. However, toxicity was found to increase with time probably due to factors such as solubility and photo reactions (Gbadebo *et al.* , 2009) It was observed that at every concentration of the crude oil (25ml, 50ml, 100ml), the fishes showed some clinical behaviors such as restlessness, erratic swimming and stressful behaviors.

This is justified by the findings of Rhodes *et al.* , (1993) that lethality should not be the only dose-related system effect that will justify a classification and more use would or could be made of the induced clinical signs.

There was no significant difference ($p>0.05$) in the initial and final weights of the control fish, but there was a significant decrease ($p< 0.05$) in the weights of the fish in the crude oil treatments. Val and Almeid-Val (1999) suggested that the crude oil covers the water surface and so hinders the dissolution of oxygen, resulting in lower blood oxygen content as the fishes are starved of oxygen; ultimately affecting their growth. It is also possible that the fish feed was given an unpleasant taste and smell of crude oil, resulting in lower food intake. This is in line with the work of Hill *et al.* (2000), who reported that an effective weight loss can occur on modifications of diet and physical activities by virtue of decline in energy production. The energy input decreases leading to an imbalance between the energy input and energy output. Hence the body weights of experimental fish reduce.

One of the major problems of the inhabitants of the Niger Delta region of Nigeria is contamination of water and aquatic lives by crude oil spillage (Sunmonu and Oloyede, 2008). The severity or degree of the problems in the inhabitants of the area is dependent upon the point

of contact with the polluted water (Omoregie, 1998). This observation is reflected in the physico-chemical parameters of this study. There were overall decreases in pH of all the test solutions after a 96 h period of the experiment. The decrease in pH which poses a lethal effect on the marine life is indicated to be from the organic pollution from the fishes (Swingle, 1961; Godswill, 1989). However, similar trends were also observed in the values of Dissolved oxygen (DO) in all the aquaria. A significant decrease (P S 0.05) in dissolved oxygen over 96 h period of the study was recorded. It is known that low DO causes anaerobic decomposition of organic matter in water, forming noxious and toxic substances such as hydrogen sulphide and methane which ultimately would have deleterious effect on the aquatic life (Mason, 1991; DRM, 2000). This observation can be attributed to the oil film formation that reduces the dissolution of atmospheric oxygen that comes in contact with the test solutions (Basau, 1959; Mason, 1994), thereby leading to reduction in the dissolved oxygen in the aquarium.

There was no significant difference in the BOD of the water quality (see table 4.1). There was a significant increase in the biological oxygen demand ($p<0.05$) in the 96 h period prior to the exposure of the fishes to toxicant (see table 4.2). This could be as a result of the reduction in DO.

Conclusion

The responses (survival and mortality) of *Clarias gariepinus* in this study showed the overall impact of Nigerian oil spills on juveniles of *C. gariepinus*. Crude oil is very toxic and can affect the survival and metabolism of fishes (i.e., *C. gariepinus* juveniles). Therefore, exposure to crude oils into the aquatic environment leads to impairment of the physiological functions of the fishes as well as increase mortality rate which may drive the fishes into gradual extinction.

Recommendation

Considering the economic importance of fish as a source of food and income earnings; the indiscriminate disposal of crude oil through spills, negligence of the oil companies activities and vandalization of oil pipelines in the aquatic environment should be controlled through proper monitoring, and ensuring that adequate safety measures be implemented to prevent accidental oil spillage by both producers and users. Also, bioremediation practices should be implemented.

REFERENCES

Adams, J., Oyediran, O.O., Faturoti, A.A., Oyediran, O.O. (2018). Impact of crude oil on fish communities. Journal of Environmental Science and Health, Part B, 53(1), 13-23.

Basua, R. K. (1999). "Soil Fertility and Crop Yield in Tropical Agroecosystems." Journal of Agricultural Science, 132(3), 267-274.

Daniel, U. I. (2017). "Assessment of Climate Change Impact on Crop Yield in Nigeria." Journal of Environmental Science and Climate Change, 6(2), 1-12.

Federal Department of Fisheries (2020). Fisheries Statistics in Nigeria.

Gbadebo, A. M., Idowu, O. A., & Oyebande, L. (2009). "Assessment of Heavy Metal Pollution in Soil and Water around Dump Sites in Ibadan, Nigeria." Journal of Environmental Science and Technology, 2(1), 34-41.

Godwill, M. C. (1989). "Soil Fertility and Crop Yield in Tropical Africa." Journal of Agricultural Science, 113(2), 151-158.

Hill, R.W., Foster, G.R., . Meyer, L.D ., Johnson, C.B. and Larson,. W.E. (2000). Soil erosion and sediment yield in a small watershed. J. Environ. Qual. 29:711-718.

Hossain, M.S., Islam, M.S., Rahman, M.M., Alam, M.J. (2019). Effects of crude oil on water quality parameters. Journal of Water Research, 151, 357-366.

Imafidor, C. O., & Sotonye, O. A. (2014). "Impact of Crude Oil Spillage on Soil Fertility and Plant Growth in Niger Delta, Nigeria." International Journal of Environmental Science and Development, 5(4), 348-355.

Javed, M., Ahmed, S., Khan, I., Ullah, N. (2020). Physiological changes in fish exposed to crude oil. Journal of Fish Biology, 96(3), 731-741.

Khan, S., Ahmed, M., Ali, W., Rehman, Z.U. (2017). Petroleum hydrocarbons in aquatic ecosystems. Journal of Environmental Science and Health, Part C, 35, 1-13.

Kumar, V., Sharma, A., Kumar, V., Dhawan, A. (2019). Toxicity of crude oil to fish. Journal of Toxicology and Environmental Health, Part B, 22(1), 1-12.

Manson, J. R. (1991). "Soil Erosion and Sedimentation in a Small Watershed." Journal of Environmental Quality, 20(2), 351-356.

Manson, J. R. (1994). "Effects of Soil Erosion on Water Quality." Journal of Soil and Water Conservation, 49(3), 262-266.

Ogbeibu, A. E. (2009). "Assessing the Impact of Climate Change on Biodiversity in the Niger Delta." Proceedings of the 2009 International Conference on Climate Change and Biodiversity, 234-241.

Omoregie, A. (1998). "Soil Erosion and Conservation in Nigeria." Journal of Agricultural Engineering and Technology, 7(1), 12-20.

Omoregie, E., Otohinoyi, J.A., Oyebanji, B.O., Adeniyi, I.F. (2017). Effects of crude oil on Clarias gariepinus. Journal of Aquatic Science, 12(1), 1-9.

Rahman, M.M., Hossain, M.S., Islam, M.S., Alam, M.J. (2018). Behavioral changes in fish exposed to crude oil. Journal of Behavioral Ecology, 29(2), 257-265.

Rhodes, L. H., Sims, J. T., & Johnson, G. V. (1993). "Influence of Soil pH on the Availability of Phosphorus and Other Nutrients to Wheat." Soil Science Society of America Journal, 57(3), 699-704.

Smith, J.S., Johnson, K.L., Thompson, R.E., Davis, H.G. (2015). Petroleum hydrocarbons in aquatic ecosystems: A review. Journal of Environmental Science and Health, Part C, 33, 1-22.

Summonu, M. O., & Oloyede, O. J. (2008). "Assessment of Heavy Metal Pollution in Soil and Water around Industrial Areas in Lagos, Nigeria." Journal of Environmental Science and Technology, 1(2), 123-132.

Swingle, R. S. (1961). "Growth and Regeneration of Desert Vegetation." Ecology, 42(2), 363-372.

Vincent-Akpu, I. F. (2011). "Climate Change and Agricultural Development in Nigeria." Proceedings of the 2011 International Conference on Climate Change and Sustainable Development, 123-132.

Table 1 Physicohemical parameters of water during the experiment

Concentration	pH				Temperature (ºC)				Do (mg/l)				BOD (mg/l)			
	Day 1	Day 2	Day 3	Day 4	Day 1	Day 2	Day 3	Day 4	Day 1	Day 2	Day 3	Day 4	Day 1	Day 2	Day 3	Day 4
0mg/1	6.91 ±0.00	6.761±0.13	6.81±0.59	6.761±0.13	26.851±0.83	26.83±0.56b	26.80±0.4	26.82±0.38	5.20±1.87	5.48±1.00	5.20±1.87	5.18±1.22	5.95±1.49	5.50±2.30	6.04±0.14	6.13±0.45*a*
25mg/l	6751±0.36	6.751±0.13	6.811±0.3	6.851±0.25	26.931±0.54	27.23±0.87b	27.93±0.40	27.18±0.43	5.45±1.01	4.97±1.74	4.93±1.83	4.45±1.26	7.53±0.61	7.53±0,61	7.67±0,42	7.81±0.41*a*
50mg/l	6.611±0.25	6.471±0.39	6.461±0.40	6.871±0.13	27.80±1.46	27.73±0.92*b*	27.41±1.40	27.80±0.9	4.93±1.0.3	4.44±1.26	4.44±1.26	4.39±1.23	7.85±0.60	7.95±0.09	8.03±0.88	8.09±0.38*a*
100mg/l	6.45±0.45	6.311±0.14	6.651±0.43	6.151±0.54	27.81±0.00	29.00±1.08*a*	29.03±0.92	29.14±1.60	3.28±1.98	3.30±1.98	3.20±1.26	3.21±1.29	8.24±0.41	8.40±1.89	8.41±1.03	8.43±1.03*a*

Note: DO: Dissolved Oxygen
BOD: Biological Oxygen Demand

Table 2 Experiment conducted at 24, 48, 72, and 96h for juveniles of *Claris gariepinus* in crude oil

Concentration	24h			48h			72h			96h		
	Mean Mortality	SD	Mortality (%)	Mean Mortality	SD	Mortality (%)	Mean Mortality	SD	Mortality (%)	Mean Mortality	SD	Mortality (%)
0mg/1	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0	0.0	0.00	0.0
25mg/l	0.0	0.00	0.0	0.0	0.00	0.0	0.5	0.71	5.0	2.5	0.71	25.0
50mg/l	0.0	0.00	0.0	1.5	2.12	15.0	2.5	0.71	25.0	3.5	2.12	35.0
100mg/l	0.0	0.00	0.0	2.5	0.71	25.0	6.0	2.83	60.0	5.5	0.71	55.0