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INFLUENCE OF CRUDE OIL EXPOSURE AND RECOVERY ON GROWTH PERFORMANCE OF *Oreochromis niloticus*

Ochuko J. Eriegha*, Victor O. Eyo and Ibrahim A. Adeleke

Department of Fisheries and Aquaculture, Nigeria Maritime University, Okerenkoko, Nigeria.

Corresponding Author: Email: oj.eriegha@yahoo.com; Tel.: +234 703 213 2859.

ABSTRACT

Water-soluble fractions (WSF) play a crucial role in the toxicity of crude oil to aquatic organisms. In this study, the effects of water-soluble fractions of crude oil exposure and recovery on growth performance were evaluated in *Oreochromis niloticus*. Fish (8.6 ± 0.5 g) were exposed to 4 sublethal concentrations (30, 45, 60, and 75% of the LC_{50} corresponding to 28, 41, 55, and 69 mg/l respectively) of the oil and control. After 90 days of exposure, growth parameters were measured. Previously exposed fish were transferred into other aquaria containing dechlorinated water and left to recover for 90 days. After the recovery phase, growth parameters were also measured. The result showed that the mean weight gained in fish in the test solutions reduced significantly ($p < 0.05$) with increasing concentration. The condition factor of the fish reduced significantly from 1.30 ± 0.10 in control to 0.99 ± 0.18 in the highest concentration of the oil. During the post-exposure (recovery) phase, control groups performed better in terms of growth as the removal of the toxicant did not compensate for the disparity observed during the exposure phase. Thus, the suppression of growth observed in *O. niloticus* during crude oil exposure and recovery can be used as a biomarker for evaluating the long term impacts of crude oil spillage.

Keywords: Crude oil, pollution, LC_{50} , growth

INTRODUCTION

Aquatic pollution is a serious problem in Nigeria and it is majorly caused by a variety of sources such as industrial effluent, agricultural runoff, solid waste, and oil spills (Akankali and Elenwo, 2015; Olufunke, 2022). The latter is endemic to the Niger Delta region of the country where numerous oil exploration, exploitation, and transportation activities take place. The impact of oil spills on the environment has been reported by many investigators (Eriegha and Sam, 2020; Onyena and Sam, 2020). Oil spills like most other sources of pollutants have been shown to cause the death of organisms, disrupt biochemical pathways, metabolites, and enzyme systems in their cells and tissues, cause physical damage to their tissues and organs, and changes in chromosomes and genes in gametes, embryonic developments and growth (Nwabueze and Agbogidi, 2010; Olaifa, 2012; Eriegha *et al.*, 2017; Eriegha *et al.*, 2019; Eriegha and Sam, 2020; Eriegha, 2023; Eriegha *et al.*, 2023).

Crude oil contains polycyclic aromatic hydrocarbons (PAHs) that are capable of suppressing growth (Laurel *et al.*, 2019). Growth is an integrated physiological response encompassing external environmental conditions and internal physiological status. Growth in fishes has been recognized as a complex process by which ingested energy is converted to biomass. The efficiency of this conversion is regulated by the growth potential of the organism, its trophic status, and various abiotic factors such as food supply, temperature, and adverse environmental conditions (Soderberg, 2017). Therefore, the health and subsequent growth of fish are directly related to the quality of water in which the fish are raised (Viadero, 2005).



The Nile tilapia (*Oreochromis niloticus*) is one of the most widely cultured freshwater fish across the world (Munguti *et al.*, 2022), and the most extensively studied. It is popular because of its fast growth rate, easy management, omnivorous nature, hardiness, resistance to low dissolved oxygen, and enjoyable flavour. Nile tilapia is a common model organism in the field of ecotoxicology and is suitable for monitoring toxic-induced changes in fish health (Hasan *et al.*, 2022). Several studies have addressed the effect of crude oil on the growth performance of various fish species (Moles and Rice, 1983; Laurel *et al.*, 2019). However, in most previous research, very little information is provided on long-term exposure and the post-exposure (recovery) phase. Therefore, this study focused on the impact of crude oil exposure and recovery on growth performance in juveniles of *O. niloticus*.

MATERIALS AND METHODS

Experimental fish

Healthy Nile tilapia juveniles (average weight = 8.6 ± 0.5 g, $n = 300$) with a good physical appearance were purchased from a reputable fish farm and transported to the laboratory in an oxygenated bags. The average body weight of the tilapia was 8.6 g. The experimental fish were first kept in the laboratory for 2 weeks in natural photo-regime conditions in 30 L experimental tanks containing 20 fish each. The experimental tanks were filled with 20 L of the test solution and covered with a lid made of fine polyethylene gauze screen of 1mm mesh size to prevent the fish from jumping out of the containers. They were fed with commercial feed, 2mm Coppens® ad libitum two times a day (9:00 and 15:00 h) during the acclimatization period.

Exposure assessment

The juveniles of Nile tilapia were treated with four different sub-lethal doses (30, 45, 60, and 75% of the LC50 corresponding to 28, 41, 55, and 69 mg/l respectively) of WSF of crude oil and a control group without crude oil for 90 days. The selected concentrations were based on research on tilapia (Eriegha *et al.*, 2017). The test was performed using a semi-static renewal method in which the exposure medium was exchanged every 3 days to maintain the strength of the toxicant and minimize the level of ammonia. The experimental fish were fed 2 times a day (9:00 and 15:00 h). After 90 days of treatment, the length and weight of the fish were determined using a meter rule and a digital scale (OHAUS Corporation, Model SPX622, 600g Max, USA) respectively.

Recovery phase

Previously exposed fish were transferred into other aquaria containing dechlorinated water and left to recover for 90 days. Each treatment was replicated three times. During the recovery trial, fish were fed with commercial feed, 3mm Coppens® ad libitum twice daily at 9:00 and 15:00 h. Dead fish were also removed and recorded daily and water exchange was made every 3 days. At the end of the recovery phase, the length and weight of the fish were determined

Growth performance and survival

Growth parameters such as mean weight gained (g/fish), specific growth rate (%), condition factor (K), and survival rates were determined as described by Ricker, 1975, Eyo and Ekanem, 2011, Eriegha and Eyo, 2023;

Specific growth rate (SGR; %/day) = $100 (\ln W_2 - \ln W_1) / T$; where W_1 and W_2 are the initial and final weight, respectively, and T is the number of days in the feeding period;

Condition factor (k), $K = (W / L^3) \times 100$ Where W is the wet weight in g. and L is the total length in cm.



RESULTS

Information on the growth parameters of *O. niloticus* exposed to varying concentrations of WSFs of crude oil during the 90-day exposure period and the 90-day recovery period is presented in Table 1. Growth of *O. niloticus* was observed to reduce with increasing concentration of WSFs of crude oil when compared with control fish. The result showed that the mean weight gain in the test solutions reduced significantly ($p < 0.05$) with increasing concentration. Also, the fish in the control group were observed to be agile, free-swimming, and fed well in comparison to those exposed to the various concentrations of the oil. The condition factor of fish reduced significantly from 1.30 ± 0.10 in control to 0.99 ± 0.18 in the highest concentration of the oil. The survival rate in juveniles of *O. niloticus* exposed to sublethal concentrations of WSFs of crude oil is also shown in Table 1. The result revealed that 91.67% of the fish in the control group survived after 90 days of rearing and mortality rates continue to increase with increasing levels of crude oil. The number of fish survived in each concentration differs significantly ($P < 0.05$) among the exposed groups.

During the post-exposure (recovery) phase, control groups had better growth performance as the removal of the toxicant did not compensate for the disparity observed during the exposure phase. The mean weight gained (MWG) in control groups after the recovery period was 37.61 ± 5.77 g/fish. The MWG observed in control groups differ significantly ($p < 0.05$) from previously exposed fish. The fish that was exposed to 75% of LC_{50} had the least increase in weigh (16.47 ± 4.06). The fish in the control group were in better health condition (well – being) when compared to the other exposed groups. Although, there were no significant differences ($p > 0.05$) among the exposed groups. The frequent lethargic display observed in exposed fish during the exposure phase continued to the first few days of the recovery phase. By the end of the second week of the recovery phase, normal swimming behavior was observed in all groups of fish.

Table 1: Growth Parameters in juveniles of *O. niloticus* after 90 days of exposure to crude oil and 90 days of recovery.

Parameter			% Concentration of LC_{50}				
			0%	30%	45%	60%	75%
Exposure							
Mean initial Weight (g/fish)			8.61 ± 0.07^a	8.52 ± 0.37^a	8.61 ± 0.19^a	8.60 ± 0.81^a	8.92 ± 0.15^a
Mean final Weight (g/fish)			38.43 ± 5.15^c	25.61 ± 3.28^b	23.25 ± 2.42^b	17.63 ± 5.86^a	14.84 ± 2.18^a
Mean weight gained (g/fish)			29.83 ± 5.15^c	17.03 ± 3.30^b	14.66 ± 2.39^b	9.04 ± 5.89^a	5.85 ± 2.16^a
Specific Growth Rate (%)			0.77 ± 0.07^c	0.56 ± 0.06^b	0.51 ± 0.05^b	0.34 ± 0.17^a	0.26 ± 0.09^a
Condition Factor (K)			1.28 ± 0.08^b	1.21 ± 0.10^b	1.14 ± 0.11^b	1.16 ± 0.16^b	0.97 ± 0.17^a
Survival (%)			91.67 ± 2.89^d	71.67 ± 2.89^c	60.00 ± 5.00^b	53.33 ± 2.89^{ab}	46.67 ± 2.89^a
Recovery							
Mean initial Weight (g/fish)			38.43 ± 5.15^c	25.61 ± 3.28^b	23.25 ± 2.42^b	17.63 ± 5.86^a	14.84 ± 2.18^a
Mean final Weight (g/fish)			76.04 ± 7.14^e	62.90 ± 4.20^d	53.67 ± 4.38^c	40.86 ± 6.08^b	30.93 ± 5.21^a



Mean weight gained (g/fish)	37.61 ± 5.77 ^c	37.26 ± 4.70 ^c	30.42 ± 5.07 ^{bc}	23.22 ± 8.49 ^{ab}	16.47 ± 4.06 ^a
Specific Growth Rate (%)	0.36 ± 0.06 ^a	0.47 ± 0.07 ^a	0.43 ± 0.07 ^a	0.45 ± 0.18 ^a	0.39 ± 0.18 ^a
Condition Factor (K)	1.71 ± 0.31 ^a	1.58 ± 0.15 ^a	1.54 ± 0.20 ^a	1.56 ± 0.24 ^a	1.60 ± 0.16 ^a

Mean values with the same alphabet superscript among treatments are not significantly different ($P > 0.05$)

DISCUSSION

The significant decrease in growth indicators with increasing concentration observed in the present study can be attributed to stress induced by the WSFs of crude oil leading to loss of appetite, poor feeding and reallocation of energy to balancing of homeostatic mechanisms (Ugwu *et al.* 2006; Ofojekwu and Onah, 2002; Nwabueze and Agbogidi, 2005 and Obasohan *et al.* 2011). The reduction in growth can also be attributed to decreased food consumption or increased energy expenditure in exposed fish due to costs to avoid exposure, for detoxification, or repair tissue (Di Giulio and Hinton, 2008).

The negative effects of petroleum and its compounds on feeding and feed conversion to growth have been reported in a wide range of fish species. The result of the present study was in agreement with the report of Omoregie *et al.* (1995) and Omoregie and Ufodike (2000) that documented a drastic reduction of growth in *O. niloticus* exposed to WSFs of diesel fuel and crude oil respectively. Omoregie and Ufodike (2000) have also reported that juveniles of *O. niloticus* exposed to WSF of crude oil fed less aggressively and consumed less by 20% compared to control. Also, the reduced growth rate observed in the exposed fish may be attributed to the low dissolved oxygen content of the water after the introduction of WSF of the crude oil. Boyd and Lichthoppler (1979) reported that low dissolved oxygen content of water could have stressful effects on the growth and behavior of fish.

It is believed that fish exposed to WSF of crude oil used their energy for physiological compensation rather than growth. Adaptation to stressful environments such as crude oil-contaminated water might entail complex detrimental effects on the fish causing deviations from the typical expectations of local adaptation and leading to poor overall performance of affected populations (Rolshausen *et al.*, 2015). Exposure of fish to water-soluble fractions of crude oil has been shown to stimulate metabolism at the expense of tissue growth (Smith and Cameron, 1979). This is a result of the fact that fish increases their metabolic rates to metabolize and excrete aromatic hydrocarbons and consequently, allocate more energy to homeostatic maintenance rather than storage, ultimately leading to a reduction in growth rate (Omoregie and Ufodike, 2000). In a natural water body, the result implies that changes in somatic growth may have consequences on the population level, such as reduced growth or population decline (Elliott *et al.*, 2002). Also, recruitment and population dynamics may be affected by the reduction in growth (Heintz *et al.*, 2000).

The reduced condition factor (K) in proportion to the increased concentration of crude oil could be attributed to the influence of the oil on growth features. The present findings were in agreement with those of Omoregie *et al.* (1995) who reported a drastic reduction of growth in *Oreochromis niloticus* exposed to WSFs of diesel fuel. Furthermore, the mean condition factor in all experimental fish was below the observations of Omitoyin *et al.* (2013) who reported a condition factor of 2.14 in *O. niloticus* from Ona Lake, Asaba. The larger the condition factor, the better the condition of the fish (Nikosky 1963).



CONCLUSION

The results of this work showed that long-term exposure of fish to water-soluble fractions of crude oil has a deleterious impact on growth performance. Also, the withdrawal of the toxicant did not compensate for the disparity in growth performance observed during the exposure phase. Therefore, stringent measures to prevent new oil spills and immediate cleanup of contaminated sites to mitigate the impacts of such spills are strongly recommended.

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