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Effects of Water Soluble Fractions of Crude Oil on Growth of the Nile Tilapia, *Oreochromis niloticus* (L.)

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Crude oil spillage during drilling operations, accidental spill during shipping of crude oil and leakages from under ground pipes are becoming a common phenomenon. These have over the years led to polluting the world aquatic ecosystem. The main objective of this research was to determine the effect of water soluble fractions of the Bonny light crude oil on the growth of the Nile tilapia, Oreochromis niloticus. This fish is a conspicuous member of the tropical freshwater system.

Several studies document that crude oil and its components inhibit growth of fish. Relatively short, static exposures to water soluble fractions of crude oil or refined oils inhibit growth of larval Baltic herring, Clupea harengus membras (Linden, 1978). Moles et al. (1981) reported that Juveniles coho salmon, Oncorhynchus kisutch had reduced growth after 40-day exposure to 0.67 mL/L naphthalene or 3.18 µL/L toluene (breakdown products of crude oil) in freshwater. Similarly, Woodward et al. (1981) reported that juvenile cut-throat trout, Salmo clarki had reduced growth after 60 days of exposure to 100 µL/L crude oil in freshwater. Ufodike and Omoregie (1991) reported that O. niloticus exposed to sublethal concentrations of lindane and pyrimiphos methyl (both active ingredients of insecticides and also breakdown products of crude oil) for 10 weeks had severe reductions in their growth.

MATERIALS AND METHODS

The soluble fractions of the crude oil was prepared in ten clean 50 L glass reservoir. Methods of the preparation of soluble water fractions for toxicological bioassays as described by Smith and Cameron (1979) were employed in this investigation. Each reservoir contained 45 L of clean tap water upon which was poured 500 mL of the crude oil to make a film about 0.5 cm thick. These solutions were mixed vigorously with stainless steel stirring rod for 24 hr and allowed to stand an additional 12 hr for the oil droplets to rise to the surface, which were eventually discarded. These reservoirs (and their contents which served as the stock solution) remained tightly capped during the entire experimental period to minimize evaporation.

Static bioassays were employed for this investigation during which periods the set-

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up were continuously aerated. For each batch of experiment (the experiment consisted of three replicates), 18 glass aquaria were used. Five different concentrations of the water soluble fractions were prepared. The last 2 glass aquaria served as the control. Preliminary experimental test were carried out to determine suitable sublethal concentrations of the water soluble fractions of the crude oil that will not result in outright mortality of fish. The various concentrations used were in the following order: 0.313, 0.156, 0.078, 0.039, 0.020 and 0.00 mL/L. Fresh preparations from the stock solution (diluted to appropriate concentrations) were introduced into the experimental media on a daily basis. The water physio-chemical parameters of the various experimental media were monitored at regular intervals. The parameters determined were: temperature, pH, free carbon-dioxide, dissolved oxygen and total alkalinity.

A total of 20 fingerlings of O. niloticus (mean weight 9.84 ± 0.67 g and mean length 7.56 ± 0.41 cm) were introduced into each of the aquaria. The fish were fed with 5% of their body weight with pelleted diets once daily (0800 hr). The growth of the fish were taken at every two week interval, exposure period lasted for 10 weeks. Mean and standard deviations of wet weights were calculated for the exposed fish. Analysis of Variance (ANOVA) and the Duncan multiple rage test was used in the determination of significance level at 0.05 level of probability.

RESULTS AND DISCUSSION

Control fish and fish exposed to the lowest concentrations (0.039 and 0.020 mL/L,) of the toxicant fed normally throughout the study. When food was introduced, these fish fed vigorously at the water surface and consumed all food supplied. Exposure to higher concentrations of the toxicant affected feeding behaviour. For example, fish exposed to 0.313 mL/L crude oil fed less aggressively and consumed only about 80% of the food supplied.

Table 1 shows the mean values of water quality parameters during the sublethal bioassays. The values show that dissolved oxygen and pH were significantly lower ($P < 0.05$) in the experimental media with 0.313 and 0.156 mL/L concentrations of the toxicant compared to those of the other media. Total alkalinity, free carbon dioxide and temperature values were significantly the same ($P > 0.05$) throughout the exposure period.

The growth rate of the exposed fish to the various concentrations of the water soluble fraction of the crude oil is graphically presented in Figure 1. Statistical analysis shows that the test fish exposed to the various sublethal concentrations of the pollutant had significantly ($P > 0.05$) lower weight gain compared to the groups of fish place in water devoid of the pollutant. The suppression in weight gain was observed to be directly proportional to the water soluble fractions concentrations. At the end of the exposure it was observed that the groups of fish exposed to 0.313 mL/L had a negative weight gain; the initial weight of the fish at the start of the exposure period was 12.45 g, while at the end of the exposure period the weight dropped to 9.26 g. The weight of these groups of fish increased initially for the first two weeks of exposure period and decreased thereafter.

Weight increases over the 10 week exposure period were 0.92, 3.03, 6.52, 12.82 and 19.68 g with concentrations of 0.156, 0.078, 0.039, 0.020 and 0.00 mL/L respectively.

Table 1. Values of water quality parameters (mean ± SE) during the exposure of the Nile Tilapia to various sublethal concentrations of the Bonny light crude oil.

Parameters	Concentrations (mL/L)					
	0.313	0.156	0.078	0.039	0.020	Control
*DO (mL/L)	4.74 ± 0.02	4.93 ± 0.05	5.57 ± 0.01	6.25 ± 0.10	6.55 ± 0.03	6.98 ± 0.01
CO_2 (mL/L)	4.03 ± 0.01	4.28 ± 0.01	4.52 ± 0.04	4.81 ± 0.05	4.73 ± 0.04	4.79 ± 0.03
**TA (mL/L)	22.34 ± 0.06	22.96 ± 0.02	23.43 ± 0.01	23.29 ± 0.02	23.41 ± 0.01	23.63 ± 0.01
Temp (^{O}C)	16.33 ± 0.01	16.59 ± 0.01	16.35 ± 0.02	16.03 ± 0.02	16.10 ± 0.06	16.21 ± 0.01
pH	6.00 ± 0.00	6.09 ± 0.02	6.57 ± 0.01	6.68 ± 0.01	6.87 ± 0.01	6.94 ± 0.01

(DO = Dissolved oxygen, TA = Total alkalinity)

Contamination of aquatic environment by petroleum effluent, whether as a consequence of acute or chronic events, constitutes an additional source of stress for aquatic organisms as reported by Omoregie (1998). Results from this investigation revealed that O. niloticus exposed for 10 weeks to various sublethal concentrations of water soluble fractions of crude oil grew significantly less than unexposed fish. In a similar study, pink salmon exposed to sublethal concentrations of water soluble fractions of crude oil for 40 days were significantly smaller that the control (Moles and Rice, 1983). Smith and Cameron (1979) noted that exposure of fish to water soluble fractions of crude oil stimulate metabolism at the expense of tissue growth. The inhibition of growth reported in this study may therefore be due to a disturbance of the normal metabolism by the toxic components of the crude oil. Fish increased their metabolic rates to metabolise and excrete aromatic hydrocarbons and consequently, allocate more energy to homeostatic maintenance than storage, hence reduction in reduction in growth rate. Increase in metabolic rate in response to hydrocarbon pollution has been demonstrated by Brocksen and Bailey (1973) in the striped bass, Morone saxatilis and in the sheepshead minnow , Cyprinodon variegatus. Omoregie et al. (1995) had earlier noted the impairment of carbohydrate metabolism in the Nile tilapia exposed to petroleum refinery effluent. However, the suppressive effect on food consumption caused by stress due to the toxicant may not be ruled out as earlier reported by Ufodike and Omoregie (1991).

Long-term exposure to the water soluble fractions of crude oil as low as 0.078

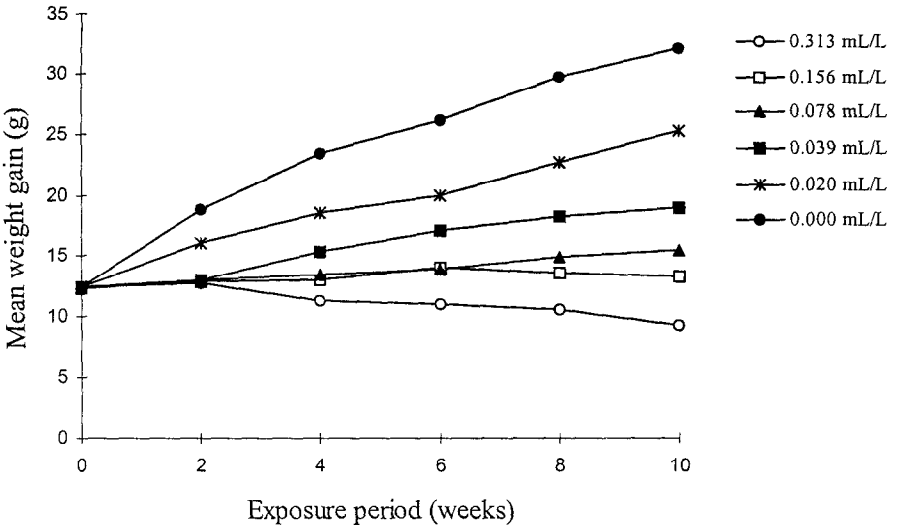

Figure 1. Effects of various sublethal concentrations of water soluble fractions of crude oil on mean weight gain of the Nile tilapia.

mL/L concentration is likely to inhibit growth of the Nile tilapia. Concentrations of crude oil in the environment after long-term, chronic oil pollution are undocumented; however, the concentrations of aromatic hydrocarbons present in the water column after short-term oil spills have been reported to be 0.002 - 0.8 mg/L (Grahl-Nielsen 1978), and most concentrations of total aromatic hydrocarbons that reduces growth of the Nile tilapia are within the upper limits of this range.

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