Trends in

Applied Sciences Research

ISSN 1819-3579

Academic
Journals Inc.

www.academicjournals.com

Trends in Applied Sciences Research 9 (9): 540-544, 2014
ISSN 1819-3579 / DOI: 10.3923/tasr.2014.540.544

Effects of Dispersed Bonny Light Crude Oil on Water Quality Parameters in Tanks Containing *Oreochromis niloticus* (Linneaus, 1757)

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ABSTRACT
The physico-chemical water variables of water samples contaminated with a mixture of the Water Accomodated Fractions (WAF) of dispersed and undispersed phases of Bonny Light crude oil at sub-lethal concentrations of 0.2, 0.4, 0.8 and 1.6 mL L^{-1} were analysed to assess the effects of these mixtures on the water quality of the test media containing a fish, *Oreochromis niloticus*. These were measured against a control. The temperature, pH, DO, TDS, conductivity and redox potential of the test media were significantly affected ($p<0.05$) by the presence of the mixture especially by the dispersed phase at the different concentrations and these were positively correlated.

Key words: Physico-chemical variables, water accommodated fractions

INTRODUCTION
Crude oil spills have both long and short-term effects on coastal habitats. Components of crude oil include the aliphatic and aromatic hydrocarbons. The aromatic hydrocarbons which are polycyclic can be classified as Persistent Organic Pollutants (POPs), bioaccumulative and toxic (PBTs-persistent, bioaccumulative and toxic chemicals) with time, making them compounds of great concern. Several of them are known to be carcinogenic, teratogenic and immunotoxic to exposed organisms (Adams, 2003; Traas and van Leeuwen, 2007; Malik *et al.*, 2008; Wills *et al.*, 2010). Their transformed products are among the most hazardous constituents of crude oil which have long-term effects (Reddy *et al.*, 2002; Peterson *et al.*, 2003; Short *et al.*, 2004; IDPH, 2009).

Consequently, several measures have been taken to reduce the spread and deleterious effects of the oil. One such approach is the use of Oil Spill Dispersants (OSDs) amongst which is Goldcrew SW. This chemical reduces the interfacial tension (adhesion) between the oil and water, oil and sediments and other surfaces, helps create small droplets that move into the water column facilitating quicker weathering, natural biological breakdown (biodegradation) and dispersion by decreasing the size of the oil droplets and dispersing the oil into the water column. The oil surface area exposed to the water increases, thereby, enhancing breakdown and thus reducing the resident time of the oil within the aquatic system (EHP, 2005; AMSA, 2006). OSDs are composed of surfactants, solvents (hydrocarbon and water-based) and stabilizing agents. OSDs are applied as quickly as possible after a spill has occurred since there is limited 'window of opportunity' to use

OSDs in an oil spill incident. This is primarily due to the changing properties of the oil due to weathering of the oil which may last for a few hours to a few days depending on the type/volume of spilled oil (ITOPF, 2005). However, the use of dispersants in spill situations may alter the components of the crude oil by increasing their functional water solubility; resulting in increased bioavailability and altered interactions between oil, dispersants and biological membranes (Pollino and Holdway, 2002; Barron *et al.*, 2003; Koyama and Kakuno, 2004; CouIllard *et al.*, 2005). This study was carried out to determine the effects of the Water Accommodated Fraction (WAF) of the mixture of Goldcrew SW dispersant and Bonny Light crude oil on the water quality on fish production using *Oreochromis niloticus*.

MATERIALS AND METHODS

Three hundred and fifty fry and fingerlings of *Oreochromis niloticus* (Nile tilapia) of different sizes of average weight of 8.8 cm were procured from the African Regional Aquaculture Centre (ARAC) Aluu. The test organisms were kept in holding in plastic tanks (36×39×53 cm) of 25 L for 14 days and allowed to acclimate in the test medium of acceptable quality before being used for the bioassay (Reish and Oshida, 1987). They were fed twice daily with Coppen feed of 0.8-1.2 mm pellet size ad libitum at 5% body weight.

The Bonny Light crude oil and Goldcrew SW were procured from the Nigerian Agip Oil Company in 1.5 L air tight plastic bottles and stored at 28°C until use for the preparation of the test solution. The Water Accommodated Fraction (WAF) of the mixture of Bonny Light crude oil and Goldcrew (SW) dispersant which contained the Polycyclic Aromatic Hydrocarbons (PAHs) in solution ($DCO_{WAF\text{-}PAH}$) and that without Goldcrew ($CO_{WAF\text{-}PAH}$) was prepared under laboratory conditions (Reish and Oshida, 1987; Khan and Payne, 2005). The application ratio of crude oil to Goldcrew (SW) was determined to be 1:30 with a 1:30 dilution ratio of dispersant to distilled water. Range finding tests were done to determine the threshold concentrations based on previous findings of Lelei (2007).

A static renewal bioassay of the two test exposure regimes ($DCO_{WAF\text{-}PAH}$ and $CO_{WAF\text{-}PAH}$) for 50 days with four concentrations, each and three replicates with a factor of 0.2 that gave 0.2, 0.4, 0.8 and 1.6 mL L^{-1} which were made up to 12 L, was done. Each container had 10 test organisms for the tests. There was 12 h light and dark time, respectively during exposures with a 48 h renewal of test media and test mixtures to prevent sequestration (aging) by which chemicals tend to become less available with time for uptake by organisms for partitioning into the aqueous phase or for extraction. The test organisms were regularly observed for any disease condition or abnormalities. The physico-chemical variables, Dissolved Oxygen (DO), Temperature, Total Dissolved Solids (TDS), redox potential, pH, conductivity and salinity were measured using Hanna HI 9828 pH/ORP/EC/DO water analyzing device after calibrations had been made. Readings were taken and recorded *in-situ*.

RESULTS

The data on water quality variables obtained from the test concentrations of $DCO_{WAF\text{-}PAH}$ and $CO_{WAF\text{-}PAH}$ showed that there was proxy in the values between the lower and upper ranges of concentrations and were different from the control (Table 1 and 2). The results from the concentrations of the $DCO_{WAF\text{-}PAH}$, presented in Table 1, showed temperature values ranged from 25.69-25.85°C which was narrow for the concentrations. The DO values ranged from 2.65-2.87°C. The pH, TDS, conductance and DO values showed slight reduction with increase in concentration

Table 1: Mean and standard error of physico-chemical parameters of $DCO_{WAF\text{-}PAH}$ treated water at sub-lethal concentrations

Concentrations (mL L^{-1})	Temperature (°C)	pH	TDS (ppm)	Conductivity (µs cm^{-1})	Salinity (ppt)	DO (mg L^{-1})	Redox potential (eV)
0	26.16±0.14	5.80±0.30	63±3.15	126±6.20	0.06±0.003	3.87±0.27	38.6±3.40
0.2	25.58±0.14	6.38±0.30	54±3.15	108±6.20	0.05±0.003	2.87±0.27	28.7±3.40
0.4	25.69±0.14	6.35±0.30	53±3.15	107±6.20	0.05±0.003	2.84±0.27	29.5±3.40
0.8	25.65±0.14	5.70±0.30	44±3.15	87±6.20	0.04±0.003	2.65±0.27	33.3±3.40
1.6	25.85±0.14	6.14±0.30	48±3.15	97±6.20	0.05±0.003	2.70±0.27	31.3±3.40

Table 2: Mean and standard error of physico-chemical parameters of $CO_{WAF\text{-}PAH}$ treated water at sub-lethal concentrations

Concentrations (mL L^{-1})	Temperature (°C)	pH	TDS (ppm)	Conductivity (µs cm^{-1})	Salinity (ppt)	DO (mg L^{-1})	Redox potential (eV)
0	26.16±0.13	5.80±0.30	63±2.03	126±4.94	0.06±0.003	3.87±0.21	38.6±4.06
0.2	26.16±0.13	6.24±0.30	64±2.03	129±4.94	0.06±0.003	2.43±0.21	28.3±4.06
0.4	26.01±0.13	6.21±0.30	55±2.03	130±4.94	0.06±0.003	2.45±0.21	25.2±4.06
0.8	26.01±0.13	6.21±0.30	59±2.03	118±4.94	0.06±0.003	2.53±0.21	21.7±4.06
1.6	25.85±0.13	5.95±0.30	60±2.03	120±4.94	0.06±0.003	2.48±0.21	22.0±4.06

except for slight fluctuations between the 0.8 and 1.6 mL L^{-1} concentrations. Conversely, the values of the redox potential increased with increase in concentration. For the salinity, the change was not significant ($p<0.05$).

The results from the concentrations of the $CO_{WAF\text{-}PAH}$, presented in Table 2, showed that the values for salinity were the same. The temperature values ranged from 25.85-26.16°C which was wide with slight difference between the 0.8 and 1.6 mL L^{-1} concentrations. The DO values ranged from 2.65-2.87°C with slight difference between the 0.8 and 1.6 mL L^{-1}. The values of the temperature, pH, conductivity, DO and redox potential were affected with increase in concentration of dispersed phase in general. DO and redox potential values showed fluctuations in their values in the 0.8 and 1.6 mL L^{-1} concentrations.

The results from the ANOVA showed that the physico-chemical variables under the various concentrations of the $DCO_{WAF\text{-}PAH}$ showed significant differences ($p<0.05$) in their values with time and concentrations for temperature, TDS, conductivity, salinity, redox potential but that of DO was slight and not significant for the pH.

The $CO_{WAF\text{-}PAH}$ at sub-lethal concentrations also showed significant differences ($p<0.05$) in the values of the physico-chemical parameters with time and concentrations for the temperature, TDS, conductivity, salinity, redox potential but that of DO was slight and not significant for the pH. There was a positive correlation between the physico-chemical parameters and the concentrations of the mixtures. These values implied that except for salinity, the physico-chemical parameters were affected by the different exposures.

DISCUSSION

The values of the physico-chemical parameters varied with concentrations for the two exposure regimes with the lower values observed from the $DCO_{WAF\text{-}PAH}$ than the $CO_{WAF\text{-}PAH}$. Temperature and pH were slightly affected but this was not very obvious for the salinity.

The DO values reduced with increase in concentration, the DO values were higher in the test media of the $CO_{WAF\text{-}PAH}$, than the $DCO_{WAF\text{-}PAH}$ This may be due to better general physiological activities and respiration in fish exposed to the former than those in the $DCO_{WAF\text{-}PAH}$. TDS reduced with increase in concentration under the two exposure regimes and were lower for the $DCO_{WAF-PAH}$ but higher for $CO_{WAF-PAH}$ as against the control. The TDS reflected the presence of organic matter as a result of the activities (physiological processes) of the fish. The TDS values implied that the fish from the $CO_{WAF-PAH}$ showed better physiological processes than fish from the $DCO_{WAF-PAH}$.

Conductivity values increased with the TDS values, these showed a direct proportional relationship between the two parameters. These parameters can be indicted to have been influenced by the physiological activities of the test organisms which were in turn influenced by the contents and concentrations of the exposure regimes. These indicated that the values of the parameters- temperature, pH, TDS, conductivity, DO, salinity and redox potential were affected more by the $DCO_{WAF-PAH}$ hence reduced physiological activities of the fish since there is interrelationship between these parameters and fish physiology.

CONCLUSION

The use of dispersant on crude oil have impacts on the abiotic components of ecosystems, resulting in a cascade of events that begin with their introduction into the environment, their assimilation or uptake by exposed organisms and their interactions with the biological components. The physiological responses to these interactions and the climax of these interactions (mortality) may ultimately compromise the integrity of the ecosystem.

ACKNOWLEDGMENT

We are grateful to Mr. Okpara and Mr. Charles of African Regional Aquaculture Center, Aluu, Rivers State and Mr. Boma Ariweriokuma of Creative Resources Management Consultancy (Port Harcourt) for their assistance in sample collection, preparation and analysis. We also appreciate Dr. A.N. Okaeme and Dr. S.I. Ovie of National Institute for Freshwater Fisheries Research for providing this opportunity.

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