Journal of Natural Sciences Research
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.3, No.15, 2013

Crude Oil Mediated Electrolytes Changes In Bay Scallops After Short Term Exposure

JOSHUA LELESI KONNE[1] and *ONISOGEN SIMEON EDORI[2]
1. Department of Chemistry, Rivers State University of Science of Science and Technology, P.M.B. 5080, Port Harcourt, Nigeria.
2. Department of Chemistry, Ignatius Ajuru University of Education, PMB 5047 Rumuolumeni, Port Harcourt, Nigeria.
*E-mail of the corresponding author: onisogen.edori@yahoo.com

ABSTRACT
Bay scallops (*Placopecten magellanicus*) of mean weight 20.79 ± 5.2 g that were handpicked from the Bonny River were bought from market women at the Kaa waterside and transported to the Chemistry Department of the Rivers State University of Science and Technology and were acclimated to laboratory conditions for 24 hours. They were then exposed to graded concentrations of crude oil (2.50, 5.00 and 10.00 ml/L) and a control. The scallops were drawn out of the toxicant (crude) media at intervals of 3, 6, and 24 hours to determine the levels of electrolytes such sodium (Na^+), potassim ($K^{+)}$ and chloride (Cl^-) in the muscle and digestive tissues of the scallops. Results obtained showed significant difference (P>0.05) in the levels of sodium in the control and the crude oil solution in the muscle and digestive tissues of the scallops. However, there was a general decline in the levels of sodium in the exposure concentrations except at 2.50 and 5.00 ml/L in 3 hours intervals in the muscle, while in the digestive tissues, increase was observed at 5.00ml/L in 3 hours and 10.00ml/L in 3 and 6 hours interval. Potassium levels were significantly lower in all the exposure concentrations in the various time intervals in both organs except at 10.00ml/L in the 6^{th} and 24^{th} hour. There was no significant difference (P>0.05) in the levels of chloride ion in the test solution at any time interval. The results obtained for this ion fluctuated with a difference of 1.00 mmol/L, between 23.50-24.50 mmol/L. The results indicated that crude oil caused negative consequences on the organ functions of the scallops. Therefore adequate measures should be put in place to check oil spill and remediation methods be applied immediately in the incidence of oil spill.
Keywords: Crude oil, Scallops, Electrolytes, Environment, Oil spill

1. INTRODUCTION

Crude oil or petroleum is a mixture of hydrocarbons which are complex in nature. The various fractions are separated only by fractional distillation at very high temperature of about 450 ^oC. They are constantly present in aquatic environment in different amounts or quantities depending on the prevailing environmental activity which may be anthropogenic or industrial (Al-Saad *et al*., 1997; Nasir and Hantoush, 2010). Crude oil spreads rapidly from entry points to other areas in the aquatic environment and is transmitted into tissues and organs of organisms through the food chain, absorption through the gills and other body parts in contact with water.

Since the discovery of crude oil in Oloibiri in the present day Bayelsa State, Nigeria in 1956, there has been steady rise in exploration and exploitation of crude oil and its allied products in the country, since it is the main stay of the nation's economy. However, this act has led to the attendant problem of oil spillage into the adjoining water bodies, which is the natural habitat of aquatic organisms and on the land (Akpofure *et al*., 2000; Sunmonu and Oloyede, 2007). According to USEPA (1999), the volume of crude oil spilled into the aquatic environment averages up to 14 million gallons per year from 10,000 accidental spills particularly through leakages of pipe carrying oil and underground reserves.

The adverse effects or consequences of oil spill in the Niger Delta region of Nigeria are enormous and manifest in irreversible chain effects on both the biodiversity and human safety. The occurrence of oil spill threatens surface water and a wide range of sediment organism which are directly linked to the food web and food chain (Katwijk Van *et al*., 1999). Environmental and physiological factors are known to affect many blood parameters and the organs responsible for the proper body maintenance and functions such as behaviour (Al-Kahem, 1995), mortality (Renner *et al*., 2008), biochemical changes (Sunmonu and Oloyede, 2007), changes in gill histopathology and morphology (Carls *et al*., 1999; Hesni *et al*., 2011), change in gonadal tissue and reproductive processes (Tintos *et al*., 2007) and brain neurotransmission (Gesto *et al*., 2006).

Environmental pollution can only be assessed through biomarkers which have been developed for environmental monitoring and are validated through the exposure of organisms to chronic, subchronic and acute levels of xenobiotics and contaminants (Gagnon and Holdway, 1998). This study would be carried out to investigate the effect of crude oil on the organs electrolytes of an important mollusk, scallops (*Placopecten magellanicus*) after short term exposure.

2.0 MATERIALS AND METHODS

2.1 Source and Acclimation of Scallops

Bay scallops (*Placopecten magellanicus*) of mean weight 20.79 ± 5.20 g were handpicked at low tide from the Kaa-Andoni axis of the Bonny river in Khana and Andoni Local Government areas of the Rivers State. They were transported in plastic buckets to the Chemistry Department Laboratory of the Rivers State University of Science and Technology Port Harcourt. One hundred apparently healthy scallops were acclimated to laboratory conditions in plastic tanks of thirty litres capacity. The tanks were half filled with brackish water and sediments collected from same source. The acclimation was done for 24 h. The substrate was prepared by air drying the sediment and then macerated in a mortar and sieved in 2 mm mesh.

2.2 Experimental Design and Exposure of Scallops to Crude Oil

About 250 g of finely prepared sediment were put into each of the plastic tanks to serve as the substrate base. Completely randomized design (CRD) was used for the experiment. The experiment was divided into three treatment levels and a control with three replicates. The test media were prepared in the following concentrations: 2.50 ml/L, 5.00 ml/L, 10.00 ml/L and a control of crude oil. Ten of the test animals were introduced into each of the toxicant media.

2.3 Sample Collection

Samples from the organs of the scallops were removed at the intervals of 3, 6 and 24 h by separating or opening the valve into two and the systems/organs of interest removed. Two major organs/systems chosen were the muscle and the digestive system. Approximately 0.5 g of each of the systems were finely ground and mixed with de-ionized water. The de-ionized water-organ mixture was then centrifuged at the rate of 3000 rpm and the supernatant decanted into plain bottles. The samples were then sent to the laboratory to determine the levels of the electrolytes namely: sodium, potassium and chloride through the method of Schales and Schales, (1941).

2.4 Statistical Analysis

The data obtained were subjected to analysis of variance (ANOVA) to determine if significant differences existed between the means of the electrolyte concentrations at different levels of contamination. Where differences existed, Duncan's multiple range test (DMRT) was used to compare the means (Zar, 1984).

3.0 RESULTS

The results of the electrolyte concentrations in the muscle of the bay scallops showed that the sodium levels of the exposed samples were slightly higher than the control value (45.67 ±4.25mmol/L) only at 2.5 ml/L (50.00 ± 3.01) and 5.00 ml/L (55.00 ± 4.15) after 3 h of exposure. However, after 6 h and 24 h of exposure in the various concentrations, there was generally slight decrease in sodium level as against the control value. In the digestive system, increase in value was observed at 5.00 ml/L, which was 50.00 ± 6.22 mmol/L at 3 h interval and 10.00 ml/L which were 55.00± 1.87 and 50.00 ± 3.61 mmol/L in the 3rd and 6th h of exposure as against the control value of 49.67±2.57mmol/L. Decrease in levels of sodium was again observed in the 24th h in the some toxicant concentration (**Table 1**).

Similarly, the levels of potassium in the muscle of the scallops were significantly lower than that of the control (33.67±1.36 mmol/L). Potassium levels in the digestive system also tend to follow the pattern of the muscle in all the exposure concentrations and time intervals except for the 10.00 ml/L and particularly in the 6th and 24th h which were 32.00 ± 5.03 and 35.00 ± 2.35 mmol/L respectively as against the control value of 31.33 ±2.55 mmol/L (**Table 2**).

However, a different trend was observed in chloride levels. There was no significant change in the levels of chlorides in all the exposure concentrations in the muscle at the various time intervals when compared to the control which was 24.00 ± 0.00 mmol/L. The digestive system also followed the same trend (**Table 3**).

Table 1: Sodium (Na^+) in muscle and digestive system in scallops exposed to different concentrations of crude oil at different time intervals.

Concentration of crude oil (ml/L)	Muscle sodium (mmol/L) 3hrs	6hrs	24hrs	Digestive System sodium (mmol/L) 3hrs	6hrs	24hrs
Control (0.00)	45.67 ± 4.25^{b}			49.67 ± 2.57^{ab}		
2.50	50.00 ± 3.01^{ab}	43.00 ± 2.11^{b}	43.00 ± 1.22^{b}	44.00 ± 4.03^{b}	45.00 ± 3.55^{b}	43.50 ± 5.12^{b}
5.00	55.00 ± 4.15^{a}	43.50 ± 0.01^{b}	37.50 ± 2.03^{c}	50.00 ± 6.22^{ab}	45.00 ± 3.33^{b}	44.00 ± 4.02^{b}
10.00	44.00 ± 2.00^{b}	44.00 ± 1.02^{b}	44.00 ± 3.33^{b}	55.00 ± 1.87^{a}	50.00 ± 3.61^{ab}	37.00 ± 2.23^{c}

Figures with the same alphabet are not significantly different (P>0.005).

Table 2: Potassium (K^+) in muscle and digestive system in scallops exposed to different concentrations of crude oil at different time intervals.

Concentration of crude oil (ml/L)	Muscle potassium (mmol/L) 3hrs	6hrs	24hrs	Digestive System potassium (mmol/L) 3hrs	6hrs	24hrs
Control (0.00)	33.67 ± 1.36^{a}			31.33 ± 2.55		
2.50	14.00 ± 0.11^{c}	17.00 ± 2.13^{b}	17.50 ± 1.56^{b}	15.50 ± 4.02^{bc}	11.50 ± 1.98^{c}	18.00 ± 1.05^{b}
5.00	13.50 ± 3.32^{c}	18.50 ± 4.54^{b}	17.00 ± 2.93^{b}	14.00 ± 0.39^{bc}	17.00 ± 1.11^{b}	16.50 ± 2.96^{b}
10.00	15.50 ± 0.06^{c}	19.50 ± 2.85^{b}	18.00 ± 3.04^{b}	16.50 ± 0.78^{b}	32.00 ± 5.03^{a}	35.00 ± 2.35^{a}

Figures with the same alphabet are not significantly different (P>0.005).

Table 3: Chloride (Cl^-) in muscle and digestive system in scallops exposed to different concentrations of crude oil at different time intervals.

Concentration of crude oil (ml/L)	Muscle chloride (mmol/L) 3hrs	6hrs	24hrs	Digestive System chloride (mmol/L) 3hrs	6hrs	24hrs
Control (0.00)	24.00 ± 0.00^{a}			24.00 ± 0.00^{a}		
2.50	24.50 ± 0.99^{a}	24.00 ± 2.53^{a}	24.50 ± 0.14^{a}	24.00 ± 0.00^{a}	24.00 ± 0.13^{a}	24.50 ± 3.32^{a}
5.00	23.50 ± 3.33^{a}	23.50 ± 2.93^{a}	24.50 ± 2.34^{a}	24.00 ± 1.03^{a}	23.50 ± 4.01^{a}	24.00 ± 2.01^{a}
10.00	24.50 ± 2.22^{a}	24.00 ± 3.10^{a}	24.50 ± 1.17^{a}	24.00 ± 0.23^{a}	24.50 ± 2.44^{a}	24.00 ± 3.94^{a}

Figures with the same alphabet are not significantly different (P>0.005).

4.0 DISCUSSION

Apart from the death of organisms which results from oiling effects, some of the constituents or components of crude oil get incorporated in the water column which are taken up by aquatic organisms, the quantity taken, if it is small (chronic) though may not cause mortality but might cause serious disturbances in the basic functions in the organs of the organism. It was observed by Bradifield and Rees (1978) that toxicants generally disrupt cell membrane permeability through the replacement of structural and electrochemical important element in the cell which eventually lead to functional failure. The regulation of cations and anions such as Na^+, K^+, Ca^+, Mg^+, Cl, HCO_3^- are greatly affected and disturbed when aquatic animals are exposed to toxicants (Bruin, 1976).

The ions analyzed in this study (sodium, potassium and chloride) primarily functions in osmoregulation in aquatic animals and this role of the ions is achieved either by the exertion of osmotic effect or the effective uptake and excretion. These ions also, are very important factor in the electrochemical, enzymatic and structural functions of organisms.

The observed decrease in the sodium, potassium and the fluctuating levels of chloride in this study corroborates with the findings of others. Priya, *et al*., (1999) observed decrease in electrolytes when he exposed *Cyprinus carpio* to copper sulphate. Gabriel *et al*., (2009) observed decrease in sodium and potassium and fluctuation in chloride when they exposed *Heterobranchus bidorsalis* to cypermethrin a synthetic pyrethroid. Shahi *et al*., (2013) also observed decrease in these ions when they exposed *Channa Punctatus* to synthetic and plant origin pesticides.

Ion imbalance in the organs of scallops may be a reaction to environmental stress caused by the crude oil. The decrease in sodium levels suggested a change in the diffusion properties of the different organs of the organism

(Karthikeyan *et al*., 2006) which in this case, crude oil was responsible for such change. Decrease in sodium, chloride and potassium is a condition displayed by the scallops to maintain iso-osmotic condition in the internal cells. This condition is achieved through the loss of water to the environment and the pumping out of these ions and the enhancement of amino acid pool during induced stress (Karthikeyan *et al*., 2006).

When there is a decrease in these ions, many essential enzymatic activities are affected. For example ionic imbalance and regulation was due to the inhibition of ATPase in the gill of fish (William and Eddy, 1988). ATP which is a high energy compound participates in several metabolic processes such as Na^+ and K^+ ATPase which are located in the cell membrane (Rajanna *et al*., 1981). Decrease in chloride in fish or organisms might be due to reduced activity of carbonic anhydrase (Thomas and Murthy, 1976) or steroidongenesis (Hart et al., 1973) or the interference of cortisol (Srivastava and Sriwastawa, 1980). Decrease in these ions implies organ injury resulting from stress (Gabriel *et al*., 2009) which might have caused them to leak out to the environment. It also implies that the rate at which these ions are absorbed by the organism (scallops) is less than the rate at which they are lost to the surrounding environment.

The electrolytes, sodium and chlorides are often used as index of osmoregulation and in most cases are found to take the same pattern of reaction in the event of contact with toxicant (Gabriel *et al*., 2009). The observed depreciation in concentration of potassium was in response to stress in the mollusk (scallop). Potassium is essential in the transmission of nerve impulse and also related to carbohydrate metabolism in animals (Shaanmugan, 1993; Gabriel *et al*., 2009). Therefore the decrease in this ion, potassium will have negative implication on carbohydrate synthesis in scallops and on the relay of information within the organism and also with the external environment. Increased induction in the extracellular space may also be responsible for the decrease in the ion.

5.0 CONCLUSION

Exposure of scallops to different concentrations of crude oil caused changes in the electrolytes content in the organisms. The changes in these electrolytes posed a great danger to the scallops due to changes in the internal biochemistry of the organism which is an indication of crude oil toxicity in the environment. If this condition is allowed to persist in the aquatic environment, it can lead to mass mortality or migration of this important commercial mollusk thereby affecting the fisheries quality and quantity in the Niger Delta area. Therefore adequate legislation should be put in place to check incidences of oil spill in the region. Also in the event of oil spill, proper clean-up or remediation exercise should be performed immediately so that the effect of crude oil spill on scallops and other aquatic organism could be minimized.

REFERENCES

Akpofure, E. A., Efere, M. L. and Ayawei, P. (2000). Integrated grassroot post impact assessment of acute damaging effects of continuous oil spills in the Niger Delta. A paper Reporton oil spillage in the Niger Delta.

Al-Kahem, H. F. (1995). Effect of Arabian Gulf crude on the freshwater fish *Oreochromis niloticus.* Bioassay, behavioural and biochemical response. Arabian Gulf Journal of Scientific Research, 13(1): 173-186.

Al-Saad, H. T., Shamshoom, S. M. and Abaychi, J. K. (1997). Hydrocarbons in fish from Shatt Al-Arab and North-West Arabian Gulf following the Gulf oil spill of 1991. *Marina Mesopotamica*, 12(2): 213-231.

Bradifield, R. E. and Rees, C. E. (1978). The impact of toxic pollutants. *Effluents and Water Treatment Journal*, 18: 61-81.

Carls, M. G., Rice, S. D. and Hose, J. E. (1999). Sensitivity of fish embryos to weathered crude oil. *Environmental Toxicology and Chemistry*, 28: 481-493.

Gabriel, U. U., Jack I. R., Edori, O. S. and Egobueze, E. (2009). Electrolytes in selected tissues of *Heterobranchus bidorsalis* treated with sublethal levels of Cypermethrin. *Ethiopian Journal of Environmental Studies and Management*. 2(3):83-87.

Gagnon, M. M. and Holdway, D. A. (1998). MFO induction in Atlantic salmon (*Salmo salar*) during and after exposure to Bass strait Crude oil. *Australasian Journal of Ecotoxiclogy*, 4: 29-35.

Gesto, M., Tintos, A., Soengas, J. L. and Maguez, J. M. (2006). Effects of acute and prolonged naphthalene exposure on brain monoaminergic neurotransmitters in rainbow trout (*Oncorhynchus mykiss*). *Comparative Biochemistry and Physiology C* 144:173-183.

Hart, M. M., R. L. Reagen and R. H. Anderson 1973. The effect of isomers of DDD on the ACTH induced steroid output, histology and ultrastructure of the dog adrenal cortex. *Toxicol. Pharmacol,* 24 : 101-113.

Hesni, M. A., Savari, A., Sohrab, A. D. and Mortazavi, M. S. (2011). Gill histopathological changes in milkfish (*Chanos chanos*) exposed to acute toxicity of diesel oil. *World Applied Sciences Journal*, 14(10): 1487- 1492.

Katwijk Van, M. M., Schmitz, G. H. N., Gasseling, A. P. and Avesaath Van, P. H. (1999). Effects of salinity and nutrient load and their interaction on *Zostera marina*. *Mar. Ecol. Prog. Ser*. 190:155-165.

Nasir, A. M. and Hantoush, A. A. (2010). Effect of water soluble fraction (WSF) of crude oil on some biochemical characters of juveniles of common carp, *Cyprinus carpio* L. *Bas. J. Vet. Res*. 9(10): 122-129.

Priya, K., Dinesh, K P. B., Ramesh, M. and Manavalaramanujam, R. (1999). Impact of copper sulphate toxicity on plasma electrolytes of a freshwater teleost fish, *Cyprinus carpio* var. *communis*. *Indian J. Fish., 46(2) : 173-177.*

Rajanna, B., Chapatwala, K. D., Vaishnav, D. D. and Desaiah, D. (1981). Changes in ATPase activity in tissues of rat fed on cadmium. *Journal of Environmental Biology*, 2(1): 1-9.

Renner, K. O., Don-Pedro, K. N. and Nubi, O. A. (2008). Oil spillage and its impact on the edible mangrove periwinkle, *Tympanotonus fuscatus* Var *Radula* (L). *Science World Journal*, 3(3): 13-16.

Schales, O. and Schales, S. S. (1941). A simple and accurate method for the determination of chloride ion in biological fluid. *J. Biol. Chem*. 140:879-884. *Indian J. Exptl. Biol*. 33: 284-286.

Shaanmugan, A. (1993). Enzymes and carbohydrate metabolism in " Fundamentals of biochemistry for medical students" 7th edition (Ed). Karthik Printers. Madras India, 358; 145-146.

Shahi, J. Chauhan, S. and Singh, A. (2013). Comparative study on the heamatological effect of synthetic and plant origin pesticides on fish *Channa punctatus*. *Indian Journal of Natural Products and Resources*, 4(1): 48-53.

Srivastava, D. K. and V. M. S. Sriwastawa (1980). Erythrocytic abnormalities due to urea stress in *Cirrhina mrigala* fingerlings. *Curr. Set,* 49 : 799-800.

Sunmonu, T. O. and Oloyede, O. B. (2007). Biochmicl assessment of the effects of crude oil contaminated catfish (*Clarias gariepinus*) on the hepatocytes and performance of rat. *African Journal of Biochemistry Research*, 1(5): 83-89.

Thomas, P. C. and T. L. Murthy 1976. Studies on the impact of a few organic pesticides on certain fish enzymes. *Indian J. Anim. Sci.,* 46 : 619-624.

Tintos, A., Gesto, M., Maguez, J. M. and Soengas, J. L. (2007). Naphthalene treatment alters liver intermediary metabolism and levels of steroid hormones in plasma of rainbow trout (*Oncorhynchus mykiss*). *Ecotoxiclogy and Environmental Safety*, 69: 180-186.

USEPA (1999). United States Environmental Protection Agency, National health and Environmental Effect Research Laboratory, Ecology Division.

Williams, E. M. and F. B. Eddy 1988. Regulation of blood haemoglobin and electrolytes in rainbow trout, *Salmogairdneri* (Richardson) exposed to nitrite, *Aquat. Toxicol,* 13 : 13-28.

Zar, H. K. (1984). Statistical tools for scientific analysis. Oxford Publishers, London, 319pp.