GLOBAL JOURNAL OF ENVIRONMENTAL SCIENCES, VOL.1, NO. 1 2002:59 - 63

QUANTAL RESPONSE OF *LUMBRICUS TERRESTIS* FROM TWO OIL SPILLAGE - PRONE SITES TO TOXICITY OF BONNY LIGHT CRUDE OIL

L. C. OSUJI, S. O. ADESIYAN and M. O. WEGWU

(Received 21 November 2001; Revision accepted 18 April 2002)

ABSTRACT

Test fauna, *Lumbricus terrestis*, were obtained from two oil spillage-prone sites in Rivers State, Nigeria and were treated with varying concentrations of Bonny Light crude oil with known physico-chemical properties to determine the "all or none" response of the *Lumbricus terrestis* to lethal doses of the test compound. Data based on quantal response (mortality) were subjected to probit analysis using the Standard Probability Scale of three-cycle logarithm (AP-0573-GT). Toxicity Index, LC_{50} (median lethal concentration) of 74.14ml/L and 17.82ml/L of Bonny Light were obtained after 48 and 96 hours respectively for animals from Ogbodo-Isiokpo while 70.79ml/L and 16.98ml/L of Bonny Light were obtained after 48 and 96 hours respectively for animals from Eneka. These results imply that such concentrations of Bonny Light crude oil would be lethal to 50% of the population density of *Lumbricus terrestis* within the fixed periods of 48 and 96 hours respectively. One of its major highlights is the decrease in the values of LC_{50} with time of exposure (24 hours – 96 hours). Expectedly, higher exposure periods to the crude oil might have induced more toxicity. LC_{50} after 24 hours was not possibly determined because no mortality was recorded for animals exposed to the test compound within the fixed period of 24 hours.

Key words: crude oil, test fauna, toxicity index, quantal response, oil spillage –prone sites.

INTRODUCTION

Eco-toxicology although relatively new is increasingly gaining relevance in the field of Chemical Ecology. For example, it has opened a new vistas in the impact assessment of environmentally hazardous substances by enabling empirical correlation to field survey (Imevbore *et al.*, 1984, Forbes and Forbes, 1994). An environmentally hazardous substance as defined by the United Nations Industrial Development (UNIDO, 1995) is "any waste or combination of wastes which pose a substantial hazard or potential hazard to the health of human or other living organisms because the wastes are lethal, non-degradable, persistent in nature and can be biologically magnified or otherwise cause detrimental cumulative effects".

Quantal response, such as mortality or paralysis is an "all or none" response of animals to lethal doses of toxicants. Such responses provide qualitative data which when correlated with results of field surveys, help to determine baseline or safe limits of exposure doses of project emissions, so that the extent of damage arising from ecological interactions with such project emissions or likely project emissions, can be predicted or detected and quantified by direct

L. C. OSUJI, Department of Pure and Industrial Chemistry, University of Port Harcourt, Choba, Port Harcourt
S. O. ADESIYAN, Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan
M. O. WEGWU, Department of Biochemistry, University of Port Harcourt, Choba, Port Harcourt

reference or comparison to subsequent monitoring programmes (Osuji, 1998, Don-Pedro, KNP, Personal Communication, 1998). Such project emissions include petroleum hydrocarbon from oil spills, dispersants intended to 'detoxify' a polluted environment, or discharged water and gaseous effluents from industries (Ayalogu, O.E. Personal Communication, 2000).

Lumbricus terrestis, a species of earthworm commonly found in southern Nigeria, is an important member of soil-fauna which contributes to earthworm casts, aggregate formation, drainage, aeration and soil structure. As adjunct to soil microflora, it participates in organic matter decomposition, an important process in the biogeochemical cycle of an ecosystem. (Alexander, 1961, Ewer and Hall, 1972, Forth and Turk, 1973, Benneth and Humphries, 1974). By burrowing of earthworms, the soil is made porous, enabling rainwater to penetrate within its subsurface.

Lumbricus terrestis, however, are continually threatened by incidental discharges of crude oil into the environment in the form of oil spills which are usually caused by equipment failure, operational mishaps, and/or intentional damage to facilities (Osuji, 1998). This paper is the report of an investigation on toxicity of Nigeria's Bonny Light crude oil on *Lumbricus terrestis*.

MATERIALS AND METHODS TEST COMPOUND

Bonny Light (BL) brand of Nigerian crude oil served as test compound. This was obtained from Shell Petroleum Development Company of Nigeria (SPDC). The Crude Oil was kept in a corked Winchester bottle to prevent escape of volatile components. Some physico-chemical properties of the crude oil as reported by Osuji (1998) are shown in Table 1.

Test Fauna

Lumbricus terrestis of average length (± S.E) of 9.6 ± 2.8cm collected from Ogbodo-Isiokpo and Eneka in Rivers State of Nigeria were used as test animals. The animals were collected by pouring 0.6% Formalin evenly over the surface of the soils from where the animals emerged within a time space of 10-15 minutes.

Bioassay Containers

Petri-dishes (diameter 10.8cm) were used as containers for the bioassay.

Toxicity Tests

Forty grams (40g) of soil sample was treated with a pre-determined concentration of Bonny Light crude-oil and thoroughly mixed together. The concentrations were 300, 220, 180, 150, 100, 50, 25, 15 and 5 milliliters per litre (ml/L) plus an untreated control. Fifteen (15) *Lumbricus terrestis* were put into each of the petri-dishes. Quantal response (mortality) was assessed every 24, 48 and 96 hours by examining the animals individually by probing with a glass-rod.

Statistics

Data based on quantal response (mortality) were expressed as probits using standard probability scale of 3-cycle logarithm (AP-0593-GT). Best-fit lines were drawn by IBM Computer based on maximum likelihood interactive regression. Index of toxicity was LC_{50} (median lethal concentration), that is, the concentration that will bring about 50% mortality of the exposed population of test organism (Finney, 1971, Beynon, and Cowell, 1974).

RESULTS AND DISCUSSION

The quantal response (mortality) of *Lumbricus terrestis* from Ogbodo- Isiokpo and Eneka are shown in figures 1 – 4. The median lethal concentration after 96 hours (96 hours LC_{50}) for test organisms from Ogbodo-Isiokpo and Eneka was found to be 17.82ml/L and 16.18ml/L respectively. The 48 hours LC_{50} for Ogbodo-Isiokpo and Eneka was extrapolated to be 74.14 ml/L and 70.79ml/L respectively. After twenty-four

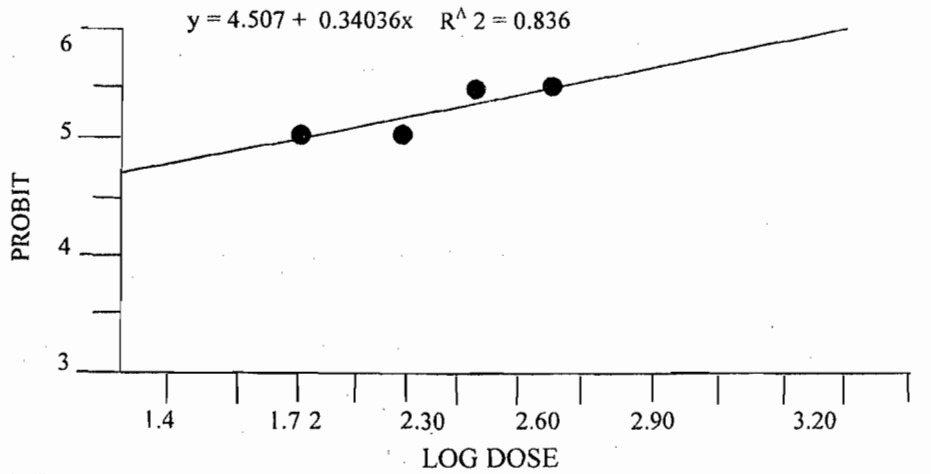

Fig. 1: Log Dose / Probit Transformation for Quantal Response of *Lumbricus terrestis* from Ogbodo – Isiokpo after 48 hours

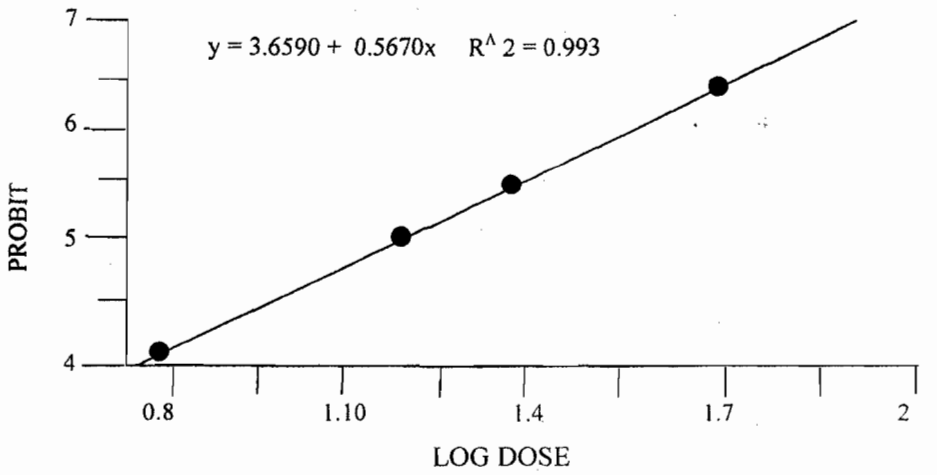

Fig. 2: Log Dose / Probit Transformation for Quantal Response of *Lumbricus terrestis* from Ogbodo – Isiokpo after 96 hours

hours, median lethal concentration (24 hours LC_{50}) was not possibly determined because no mortality was recorded for animals exposed to the test compound within the fixed period of 24 hours.

One of the major highlights of the results of the toxicity tests with Bonny Light crude oil on *Lumbricus terrestis* (figures 1 – 4) is the decrease in the values of LC_{50} with time of exposure (24 hours – 96 hours). Expectedly, higher exposure periods to the crude oil might have induced more

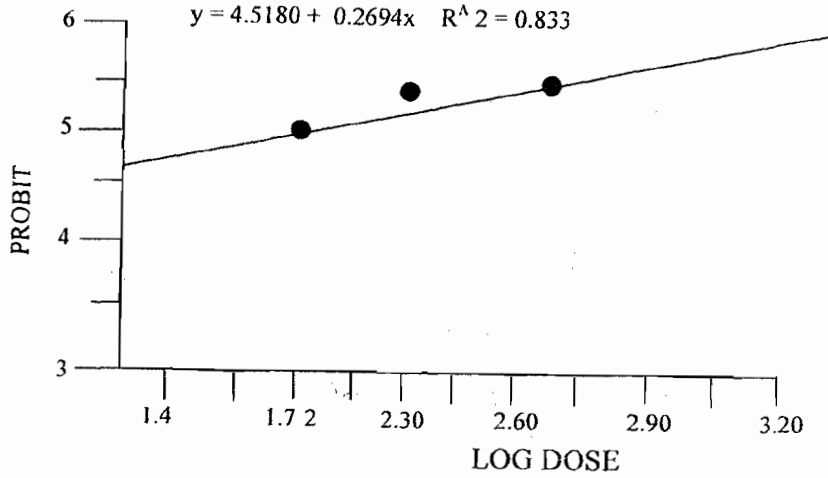

Fig. 3: Log Dose / Probit Transformation for Quantal Response of *Lumbricus terrestis* from Eneka after 48 hours

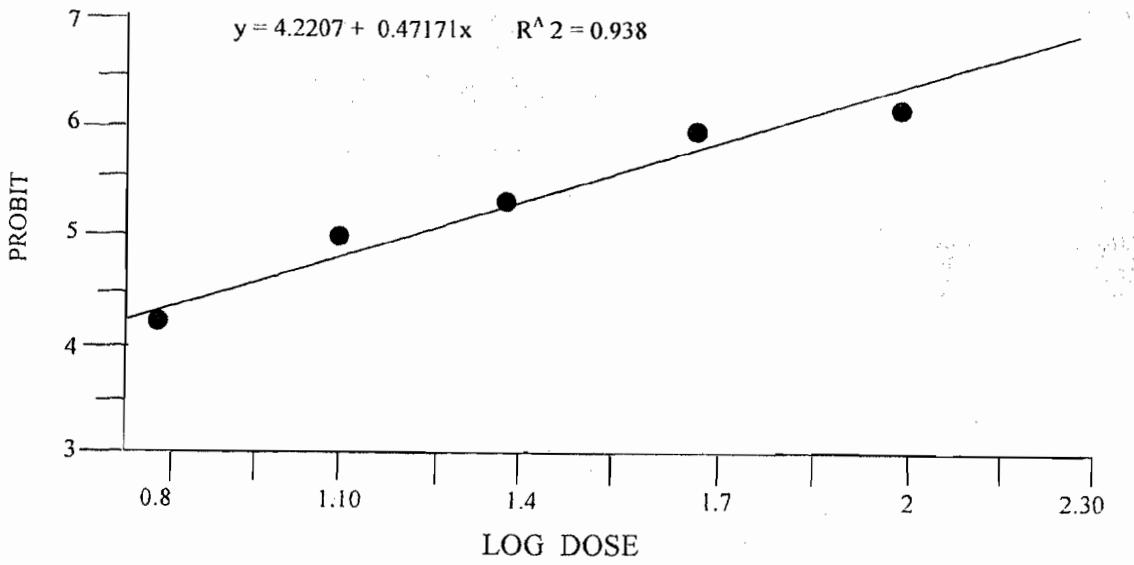

Fig. 4: Log Dose / Probit Transformation for Quantal Response of *Lumbricus terrestis* from Eneka after 96 hours

toxicity. In a similar test with *Tympanotonus fuscatus*, Asota (1990) reported that the more pronounced the effect of crude oil with time of exposure, the less the LC_{50} values.

CONCLUSION

Bonny Light crude oil, if spilled on soils of Eneka and Ogbodo-Isiokpo in Rivers State, Nigeria, can cause 50% reduction in the population density of earthworms found in these areas since the % mortality rates recorded in this study point to its high toxic potency on *Lumbricus terrestis*. Reduction in the population density of the animals can affect soil structure, aggregate formation, aeration, drainage, organic matter decomposition and thus, the agricultural potential

of the areas. Therefore, there is need for effective pollution management strategies to reduce the risks of oil spillage in the study areas.

The deleterious impact of the test compound on *Lumbricus terrestis* was probably due to toxicity of the light molecular weight (low boiling point) hydrocarbon fractions (at least to C_{10}) while aromatics (such as benzene, toluene, napthalene and phenanthrene) might have been even more toxic (Okonya *et al,* 1988). Benzene characteristically inhibits blood cell formation in bone marrow, and in combination with other hydrocarbon fractions, may cause local irritation of the respiratory system and excitation or depression of the central nervous system (Duffus, 1980, Afolabi *et al,* 1985, Okonya *et al,* 1988).

From the physico-chemical characteristics of the Bonny Light (as seen in Table 1), there are some attributes of the test compound which may have enhanced its toxic impact on *Lumbricus terrestis*. For instance, the refractive index of 1.472 and viscosity of 4.09 cSt (at 25°C) may have reduced the penetration of light. As the test organism is treated with the Bonny Light crude oil emulsion, it may have depleted available oxygen thereby creating an anoxic situation that may have caused the extinction of the organisms trapped beneath the oil coat by asphyxiation. In a field survey of oil polluted sites in the areas from where the test animal (*Lumbricus terrestis*) were collected, Osuji (1998) reported 4 and 5 times decrease in population density of earthworms fifteen months after recorded incidence of oil spillage in these areas. From results of the present study, the test fauna, *Lumbricus terrestis*, which are known to be usually present in the population density of over 100,000 per hectare, may have suffered 50% reduction in population within the fixed periods of 48 and 96 hours respectively, as reported here.

REFERENCES

Afolabi, O.A., Adeyemi, S.A., Imevbore A.M.A., 1985. Studies on toxicity of some Nigerian crude oils to some aquatic organisms. Proceedings of the International Seminar on Petroleum Industry and Nigerian Environment NNPC pp.269 – 272.

Alexander, M., 1961. *Introduction to Soil Microbiology*, John Wiley and Sons Inc., New York p. 114.

Asota, S.U., 1990. Effects of weathering on the toxicity of Forcados crude oil against *Tympanotonus fuscatus* Var radula (L) Unpubl. Thesis. University of Lagos, Nigeria.

Table 1: Physico-chemical characteristics of Spilled Bonny Light crude oil (Osuji, 1998).

Sulfur content (%)	0.14
Specific gravity	0.8398
API gravity 60/60°F	37
Viscosity in cSt at 25°C	4.09
Wax content (%)	3.8
Pour point (°F)	23
Surface tension (NM^{-1})	0.02041
Refractive index	1.472

API = American Petroleum Institute

cSt = Centistokes

Benneth, D.P. Humphries, D.A., 1974. Introduction of Field Biology. Edward Arnold (Publishing) Limited, London. pp.112 – 116.

Beynon, L.R. and Cowell, E.B., 1974. (Eds). Ecological Aspect of Toxicity Test of Oils and Dispersants. Applied Science Publishers Limited. Essex 149pp.

Duffus, J.H., 1980. Environmental Toxicology. Edward Arnold Publishers Limited. London. pp.21 – 103.

Ewer, D.W., Hall, J.B., Ecological Biology 1: Organisms and their Environment. Longman Group Limited. London pp.201 – 203.

Finney, D.G., 1971. Probit Analysis. 3rd Edition. Cambridge University Press London. pp. 5 – 20.

Forbes, V.E., Forbes, T.L., 1994. Ecotoxicology in Theory and Practice. Chapman and Hall, London pp. 35 – 42.

Forth, H.D., Turk, L.M., 1973. Fundamentals of Soil Science. 5th Edition Wiley. Eastern Private Limited. New Delhi. pp.176 – 220.

Imevbore, A.M.A., Adeyemi. S.A., Afolabi, O.A., 1984. Progress report on the study of the toxicity of Nigerian crude oil. A technical report submitted to the Nigerian National Petroleum Corporation, Lagos, by Eco-development Consultancy Group, Institute of Ecology, University of Ife, Ile-Ife Nigeria.

Okonya, E. C., Ajao, E. A., 1988. Case studies of pollution in the brackish and marine ecosystem in Nigeria. In: Sada, P. O. and Odemerho, F. O. (Eds). Environmental Issues and Management in Nigeria. Evans Brothers Nigeria Ltd., Ibadan. pp. 265 – 269.

Osuji, L. C., 1998. Some environmental effects of crude oil spillage in two sites in Rivers State, Nigeria. Ph.D Thesis University of Ibadan, Nigeria.

UNIDO, 1995. Annual Report Bulletin Volumes 1 and 2. Oxford University Press. pp. 16 – 18.