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Integrity testing and toxicity of three dispersants to *Chironomous transvaalensis Keiffer* (Diptera:Chironomidae)

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ABSTRACT: In-depth integrity testing of three dispersants: Corexit 9572, NalcoD4106 and Goldcrew was carried out to determine key physical characteristics of the dispersants and toxicity to the larvae of *Chironomous transvaalensis* Keiffer (Diptera:Chironomidae). The result revealed that Corexit 9527 and Goldcrew maintained their integrity while NalcoD4106 on the other hand deteriorated in storage. Static bioassay conducted to determine the 96hr $LC_{50}$for the dispersants against the insect species showed that Corexit 9572 was the least toxic followed by Goldcrew and Nalco D4106. Furthermore, mixtures of crude oil and either Corexit 9572 or Goldcrew were less toxic to the test animals than the crude oil alone whereas dispersant – crude oil mixtures containing NalcoD4106 were more toxic. Dispersants which would be effective for particular environmental conditions is discussed.

Key words: Bioassay, Dispersant, oil, integrity, LC_{50}, toxicity factor.

Introduction

The consequences of oil spills on the biological and physical processes in aquatic environment have been well established (Nelson-Smith, 1968; Baker and Crapp, 1974, Laws, 1981). The effect of marine oil pollution on aquatic organisms, mangrove and its community are very diverse and complex. To advert these deleterious effects of oil spills, pollution control measures have been taken internationally and nationally to protect the aquatic environment. Such measures include mechanical removal and recovery of spilled oil, use of chemical dispersants and micro-organisms (Engdahl, 1981).

Attention on oil spill chemicals focuses mainly on dispersants. This type of chemicals has been the subject of serious national and international controversy around the world (Kingham, 1981). Chemical dispersants are mixtures that contain “surface-active chemicals” (SURFACTANTS) and SOLVENTS. The surfactants actually cause the oil to “disperse” into tiny droplets that remain suspended in the water column. The objective of this investigation is to conduct in-depth tests on the integrity of dispersants: NalcoD4106, Corexit 9527 and Goldcrew currently being used to combat offshore oil spill and its degree of toxicity to the larvae of *Chironomous transvaalenses*.

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Materials and Methods

Three dispersants NalcoD4106, Corexit 9527 and Goldcrew and Forcados blend crude oil were used for these studies. Larvae of *Chironomus transvaalensis* (Diptera) were used as the test organism. These larvae occur naturally in large numbers in the waters of the Niger Delta areas of Nigeria. An Ekman dredge grab was used to collect this organism from stream substratum.

Semi-static bioassay as described in the Department of Petroleum Resources (DPR) (1989) guidelines for the determination of acute toxicity of dispersants was carried out. Two liters of filtered diluted water were poured into each test vessels which was made of glass with a working capacity of 2.5 litres. Twenty specimens of the test organism were placed in each vessel and the required amount of the test chemical added. The contents of the vessel were stirred to ensure adequate mixing. Test organisms were not fed during the experimental period but the system was aerated. Mortality was recorded at 3, 6, 9, 12, 15, 18 and 21 hours after commencement of the test and thereafter at 24, 48, 72 and 96 hours after exposures.

In addition to the semi static bioassays, the following properties of the dispersants were studied in order to access the integrity of the dispersants; viscosity, particulate formation, emulsification, conductivity, pH, opacity, specific gravity, water content and evaporation rate. These properties were determined employing methods described in the American Society of Testing Materials (ASTM, 1994). The data for survival in the bioassays were analyzed to obtain percentage mortality. These were plotted against concentration on probit graph paper (Finney, 1971; Reish and Oshida, 1986) and values of LC_{50} were determined from the line of best fit. The 95% confidence limits were computed to test for significant difference in the LC_{50} values obtained.

Results

A summary of the physical properties of the three dispersants are given in Table 1. Probit analyses for LC_{50} values obtained with dosage versus percentage mortality of *C. transvaalensis* are shown in Table 2. From the Table, we observe that the LC_{50} values for Corexit 9527 was 1.2mgl^{-1}, NalcoD4106 was 0.5mgl^{-1} and 0.8mgl^{-1} for Goldcrew.

On the basis of LC_{50} values obtained, the toxicity of the dispersants in a descending order was as follows: NalcoD4106 > Goldcrew > Corexit 9527 (Fig. 1a-b). With regard to relative potency of the dispersants based on 96hr LC_{50} values, it was observed that NaLcoD4106 was twice as potent as Corexit 9527 in water suspension and 1.3 times as toxic as Goldcrew when tested against *C. transvaalensis* (Table 2).

The LC_{50} values of the crude oil (Forcados blend), which was used as the medium for the determination of the abilities of the dispersants to emulsify crude oil was 0.4mgl^{-1} when tested against *C. transvaalensis* (Table 2). The results of the determinations of LC_{50} values for the dispersants-Forcados blend mixtures against the specimens showed that Corexit 9527-Forcados blend mixture had value of 2.3mgl^{-1}when tested against *C. transvaalensis*, NalcoD4106-Forcados blend mixture against the specimen, LC_{50} value was 1.8mgl^{-1}, while Goldcrew-Forcados blend mixtures gave an LC_{50} value of 1.0mgl^{-1}.

Table 1: Relative potencies (toxicity factors**) of dispersants, crude oil, crude oil-dispersant mixtures tested on *C. transvaalensis* in 96hrs static bioassays.

TEST SOLUTION	TOXICITY FACTORS
(i) Dispersant – Crude oil	
Corexit 9527/Forcados blend	3
NalcoD4106/Forcados blend	1.5
Gold crew/Forcados blend	1.3
(ii) Crude oil – Dispersant mixtures	
Corexit – Forcados blend/Forcados blend	6.0
NalcoD4106 – Forcados blend/Forcados blend	4.5
Gold crew – Forcados blend/Forcados blend	2.5
(iii) Dispersant – Dispersant	
Corexit 9527/NalcoD4106	2.0
Corexit 9527/Gold crew	1.5
Gold crew/NalcoD4106	1.3

**Toxicity factor = A ratio depicting relative potency based on 96h LC_{50} values.

Table 2: Static-Bioassays showing 96h LC_{50} values (mg/l) of dispersant, crude oil and crude oil – dispersant mixtures tested against *Chironomus transvaalensis*.

Dispersant + Water	**Forcados blend + Water**	**Dispersant + Oil + Water**
Corexit 9527	Forcados blend	Corexit 9527 + Forcados blend
1.2	0.4	2.3
(0.6-1.5)	(0.2-0.5)	(1.6-2.8)
NalcoD4106		NalcoD4106 + Forcados blend
0.5		1.8
(0.3-0.6)		(1.5-2.2)
Gold crew		Gold crew + Forcados blend
0.8		1.0
(0.5-1.1)		(0.2-0.8)

Figures in parenthesis indicate range of 95% confidence limit.

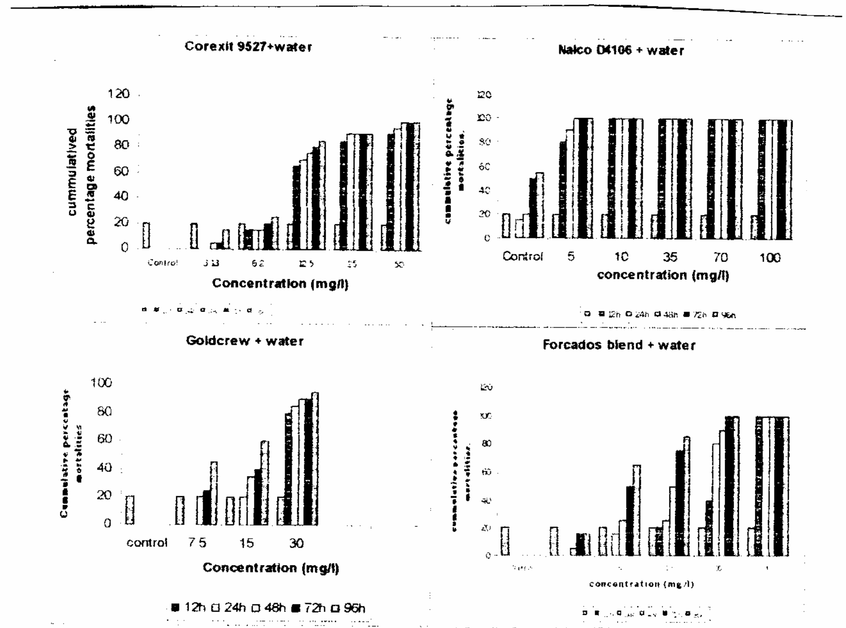

Fig. 1a: Cumulative (%) mortalities of *Sarotherodon melanotheron* exposed for 96 hours in Semi-static bioassays to varying concentration of test chemical in Brackish water

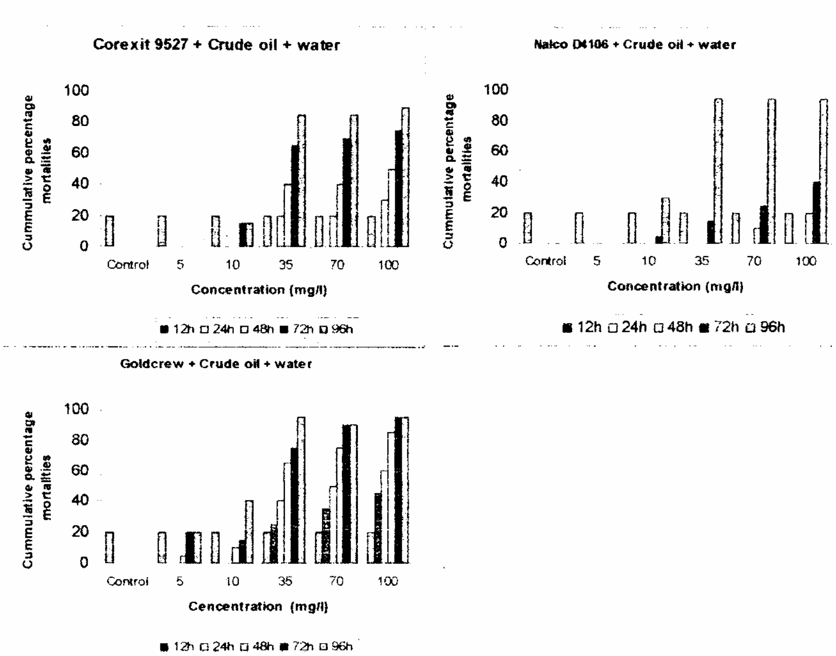

Fig. 1b: Cumulative (%) mortalities of *Sarotherodon melanotheron* exposed for 96 hours in Semi-static bioassays to varying concentrations of test chemicals and forcados blend crude oil in brackish water.

Discussion

The type of dispersants used in combating oil spills has been the subject of serious national and international controversy around the world. Chemical dispersants increase the rate at which an oil slicl would normally disperse into the marine environment. The basic argument against dispersant use is that it does not remove the pollutant from the marine environment but rather disperses it throughout that environment in such a way that it can never be recovered, but may cause serious harm to underwater organisms (Blackhall et al., 1981). However, the basic argument in favour of the use of dispersants is that they increase the rate of oxidation, biodegradation and other weathering process and thus reduce immediate damage to aquatic flora and fauna which would be adversely affected by a surface slick.

In this study, the evaluation of the physical properties of the dispersants showed that Corexit 9527 and to a large extent Goldcrew were in conformity with those given by the manufacturers, thus establishing their stability and integrity. On the other hand, NalcoD4106 appears to have deteriorated in storage. This could be attributed to the storage containers, while Corexit 9527 and Goldcrew were stored in plastic drums, NalcoD4106 was store in metal containers. The reaction between the metal and the dispersants could have resulted in the deterioration of the dispersants. It is known that the integrity of a dispersant is determined by the stability of its physical properties while in storage (NRC, 1989).

The studies also showed that there was differential toxicity of the dispersants to the test specimen. This is in conformity with the observations of Beynon (1970) and Laws (1981). They found that the surface-active molecules of dispersants (surfactants) due to the differences in their physical and chemical nature have characteristics resulting in differential toxicities to organisms. Cairns (1974) also noted that there are considerable differences from one species to another in response to toxic materials, and some species are more sensitive than others to a particular toxicant. One might reasonably assume that there are many extremely sensitive species, which could be eliminated by concentrations of toxicants that would not kill fish or other higher organisms. Thus a community imbalance might be created within a community at concentrations presumably safe for higher organisms. The higher organism might be indirectly affected by these presumably safe concentrations.

The LC_{50} values showed that the crude oil was 2 to 3 times as potent as Coexit 9527, 0.67 to 1.5 times as NalcoD4106 and 1.3 times as Goldcrew. These higher toxicities of crude oil over dispersants are similar to the findings of nelson-Smith (1968), Baker and crapp (1974) and Laws (1981). Earlier, Cairns (1974) observed that certain oils contain toxic substances (i.e. naphthenic acid, phenol e.t.c.) that intensify the danger of these types of pollutant to aquatic ecosystem. The fact that emerges from the dispersant-crude oil mixtures tests is that dispersant-crude oil was less toxic than the crude oil alone when tested against the test organisms. For instance, Corexit 9527-Forcados blend mixture was 6.0 times less potent as forcados blend alone. Similarly, NalcoD41060Forcados blend was 4.5 times less potent when tested against *C. transvaalenses*. Also, Goldcrew was 2.5 times less potent. It therefore follows that when a dispersant is applied to an oil spill, aquatic organisms become exposed to a suspension of crude oil and dispersant mixtures which is less harmful to the organisms thereby giving them an added survival advantage than when they are exposed to crude oil or dispersant alone. The basic policy with respect to oil spill chemicals should always be that chemical dispersants should be used only when they will minimize the overall damage to the aquatic environment.

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