

Application of the multiuse encapsulator agent F-500 for environmental remediation

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Abstract

In the framework of the *Risk Assessment* procedure for the ecotoxicological evaluation of compounds used in the aquatic environment, tests with target species must be carried out. This paper reports the results concerning the evaluation of the acute toxicity of F-500 micelle encapsulator (Hazard Control Technologies Inc., Fayetteville, GA, USA) on cladocerans *Daphnia magna*, with the purpose to verify its compatibility for the aquatic environment and its adequacy for the remediation of soils polluted with hydrocarbons. The obtained results show that by adding F-500 to diesel-polluted soils, the toxicity on *Daphnia magna* decreases remarkably, indicating the usefulness of this compound to fight the environmental pollution consequent to hydrocarbon dumping.

Introduction

The surfactants are synthetic organic chemicals used in industrial employments, in the formulation of detergents, household and personal care cleaning products, as well as dispersants and emulsifiers.^{1,2} Due to their wide use, they can be an important source of pollution needing to be carefully controlled³ because their occurrence in untreated effluents and in soils can induce remarkable toxicity to organisms.⁴⁻⁶

According to US Environmental Protection Agency (EPA), the micelle encapsulator F-500 (Hazard Control Technologies Inc., Fayetteville, GA, USA) is a surfactant included into the surface washing agent (SWA) category (<http://www.epa.gov/oem/content/ncp/products/f500.htm>) and is employed as extinguishing agent as well as dis-

persant to fight hydrocarbon dumping waters.⁷ Structure activity relationships studies showed that the active-principle of F-500 – 2-Ethylhexanoic acid – has a mild toxicity against aquatic organisms.⁸

Considering that the risk assessment procedure for the ecotoxicological evaluation of compounds requires tests with representative and properly chosen target species, in this research the toxicity of eluates and elutriates from soils polluted with diesel and treated with F-500 was evaluated on the freshwater cladoceran *Daphnia magna*, a widely used organism in ecotoxicological testings, in order to verify the compatibility of F-500 for the aquatic environment and its potential usefulness for the remediation of hydrocarbon-polluted soils.

Materials and Methods

Daphnia magna (Crustacea, Cladocera) specimens have been obtained from commercial ephippia (Daphtoxokit, batch DM281009; Microtox, Milan, Italy), maintained at 20±2°C in aerated and properly screened mineral water supplemented with 0.45 mm-filtered 1:100 CaCl₂ solution and 0.45 mm-filtered 1:100 NaHCO₃ solution, and fed with algae (*Pseudokirchneriella subcapitata*). Before the test, 30 females were isolated and overfed for 24 h; the offsprings born during this period were used in the test and exposed for 24 h, at 20±2°C and 16:8 light:dark period, to soil eluates and elutriates in multiwell plates with polyethylene inserts provided with 74 mm porosity basal membrane (Netwell™; Corning Inc., Corning, NY, USA). Five organisms per test in quadruplicate against control test were utilized. The tested F-500 concentrations were chosen considering the results of preliminary assays. The acute toxicity was evaluated estimating the percent immobilization of treated newborn specimens after 10 sec according to the Organisation for Economic Co-operation and Development (OECD).⁹

The artificial soil was prepared according to standardized procedures.¹⁰ Soil constituents were previously dried and subsequently dampened with deionized water in order to obtain 40-60% of the maximum water retention. The artificial soil was treated with commercial diesel and with F-500 at the concentration (1.5%) known to be non-toxic for the organisms,¹¹ packed up in 5 cm diameter glass columns and subsequently eluted with deionized water to obtain the eluate, according to the EPA method.¹² The elutriate was obtained placing soil aliquots and deionized water (1:4) in glass beakers and stirring them for 1 h.^{12,13} For both eluate and elutriate testings the following four samples were prepared and subsequently tested: i) control (only soil), ii) soil+diesel, iii) soil+1.5% F-500, iv) soil+diesel+1.5% F-500. Two different tests were carried out with the eluate using two different amounts of both compounds (test A: Diesel 10 mL, F-500 5 mL; test B: Diesel 20 mL, F-500 10 mL), thus maintaining unchanged the Diesel:F-500 rate (2:1). Four different tests were carried out with the elutriate maintaining unchanged the diesel amount and varying the diesel:F-500 rate, namely 2:1 (C), 1:1 (D), 1:2 (E), 1:4(F).

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Results

The results of tests are shown in Table 1. The data confirm that F-500 is not toxic to daphnids and clearly show that by mixing F-500 to a soil pollutant (commercial diesel) the acute toxicity induced by eluates and elutriates on cladocerans decreases remarkably. This allows to confirm the eco-compatibility of F-500 and its suitability for soil remediation.

Discussion

F-500 micelle encapsulator (Hazard Control Technologies Inc.) is a mixture of ionic and non-ionic surfactants based on fatty acid esters with aliphatic polyalcohols in watery solution used as fire fighter agent as well as dispersant against hydrocarbon pollution; it is an easy-to-use compound effective mainly under aerobic conditions, useful for the remediation of soils and able to improve the biological degradation of contaminants carried out by natural microbial populations as well as to stimulate the biodegradation reducing the toxicity of environmental pollutants or making them innocuous. F-500 allows to restore the usage of the treated areas hastening the self-regeneration of contaminated soils and restoring rapidly the ecological equilibrium (<http://www.fct-services.co.uk/F-500-land-application/>).

As a matter of fact, F-500 has been indicated to be able to reduce hydrocarbon concentrations within the soil environment and therefore to be active for soil remediation.¹⁴ F-500 has high affinity for soil particles and it has been demonstrated that 0.1% F-500 solutions are adsorbed almost completely (>99%) in soils; furthermore, after elution of soil with water <1% of F-500 was found into the eluate.¹⁵ Furthermore, the overall eco-compatibility^{11,16} and the low toxicity against marine crustaceans and fish^{11,17,18} of F-500, evaluated through standardized parameters,¹⁹ are known.

Conclusions

The tests carried out in this study have shown an evident decrease of the toxicity in soils treated with diesel+F-500 in comparison with those treated with only diesel. As verified in other laboratory testings,²⁰ this result is supposed to be due to the power of the compound to encapsulate the hydrocarbon molecules present in the soil, extracting and maintaining them in watery solution, thus reducing their toxicity and availability and consequently making them more accessible to the remediation processes. The hydrocarbons could be made less available to the organisms thus resulting less toxic. Therefore, our results show a potential protective effect of F-500 against the damage exerted by pol-

lution on aquatic organisms and, as recently reported,¹⁴ the suitability of this compound to counteract the hydrocarbon contamination of soil.

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Table 1. Percent immobilization of *Daphnia magna* exposed to different amounts of contaminated soil eluates and elutriates.

	Test	Control	F-500 1.5%	Diesel	Diesel+F-500 1.5%
Contaminated soil eluates	A	6.0±8.9	0	31.8±24.4	12.7±20.0
	B	0	5.0±0.0	46.7±17.5	16.7±12.5
Contaminated soil elutriates	C	0	0	70.0±14.1	70.0±14.1
	D	0	0	30.0±14.1	40.0±28.2
	E	2.0±4.5	0	70.0±7.0	31.8±23.5
	F	2.0±4.5	0	70.0±7.0	16.0±14.0

Values are expressed as means±standard deviation.

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