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Influence of light, heavy and crude oil on the mortality of shrimps *Crangon crangon* L. under laboratory conditions

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Abstract

Shrimps (*Crangon crangon* L.) were exposed to 5, 7.5, 10, 25, or 50 ppm of light fuel oil, heavy fuel oil or crude oil at 15° C or 20° C with aeration. The mortality was recorded. It was found that light fuel oil was the most toxic and crude oil the least toxic.

Introduction

Crude oil and its products belong to the most dangerous pollutants for ecosystems. Estimates vary, but the total annual influx of oil into the oceans probably lies between 5 and 10 million tons (BLUMER et al. 1971). Crude oil in sea water undergoes dispersion, some of its components evaporate, others are biodegraded by bacteria. For these reasons, investigations on the influence of oil pollution are difficult to carry out *in situ*. It is also not easy to count the number of dead animals *in situ*, in order to establish LC_{50} for different species. Therefore, such investigations have been carried out under laboratory conditions, where it is easier to determine all the above-mentioned parameters of pollutant toxicity. At a time of increasing pollution of the seas in general, and of the Baltic Sea in particular, we have designed investigations on the influence of crude oil and light and heavy fuel oils on the mortality rate of shrimps *Crangon crangon*. This species was selected as a test animal on account of its wide occurrence in Gdańsk Bay and its role as food for fish.

Material and methods

Shrimps *Crangon crangon* were collected in summer in coastal waters of Gdańsk Bay. Groups of 30 shrimps were acclimated in plastic containers (26 x 20 x 30 cm, 10 l of water, depth of water 20 cm). Ramashkin crude oil and diesel fuel oils (light and heavy) were supplied by the Gdańsk Oil Refinery. The oils were added to brackish water from Gdańsk Bay (7 $^0/_{00}$ salinity) in amounts of 5, 7.5, 10, 25 and 50 ppm. Determination of shrimp mortality at each oil concentration with aeration (60 l of air/10 l of water/hour) were run in triplicate. Intensive aeration assured proper mixing of the pollutants with water. Because of evaporation and biodegradation of some oil hydrocarbons, the water as well as the bottom sand in the tanks, were exchanged once daily. Dead animals were counted and removed from the tanks every 4 hours round the clock.

The 96 h LC_{50} for *Crangon crangon* was read from the regression lines with the use of a graphic-logarithm-probit method.

The differences in the mean survival time between the control and the experimental shrimps were evaluated by Student's *t* test. A difference at the P = 0.05 level was regarded as significant.

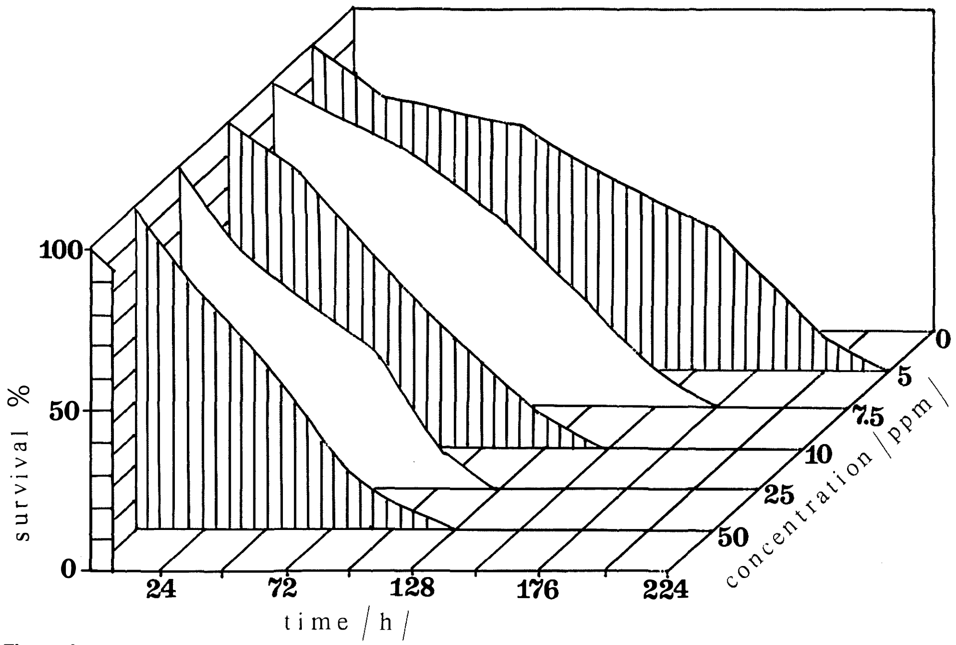


Figure 1

Mortality of *Crangon crangon* exposed to light fuel oil at 15° C with aeration (60 l of air/10 l of solution/h). Total initial number of shrimps at day 0 was 90. Mortality curves have been calculated from three replicates of 30 shrimps each. Z-axis is not to scale. 0 = controls

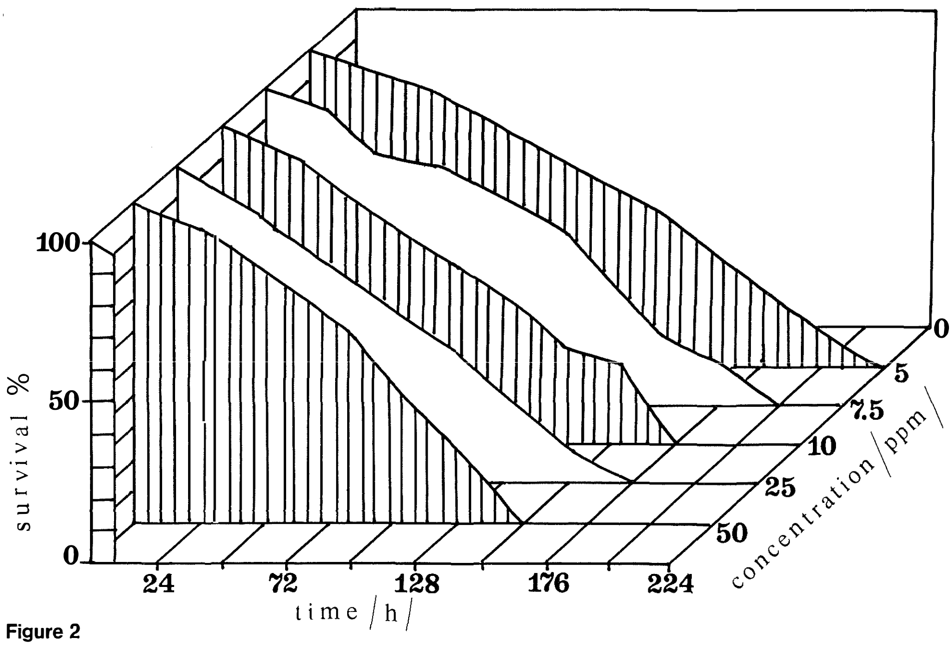
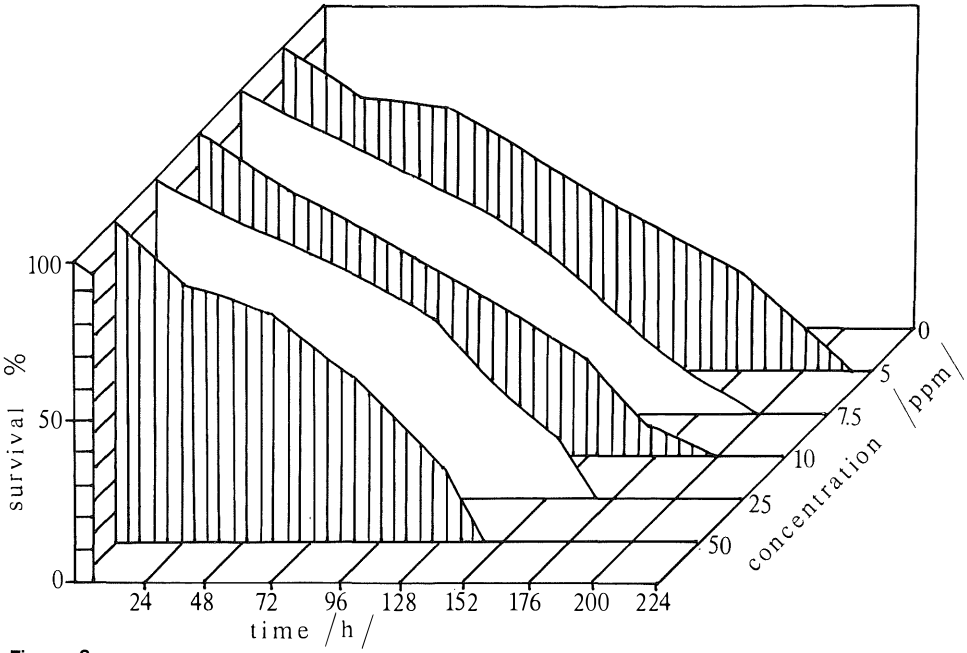


Figure 2

Mortality of *Crangon crangon* exposed to heavy fuel oil at 15° C with aeration (60 l of air/10 l of solution/h). (For further details see legend Fig. 1)



Firgure 3

Mortality of *Crangon crangon* exposed to crude oil at 15° C with aeration (60 l of air/10 l of solution/h). (For further details see legend Fig. 1)

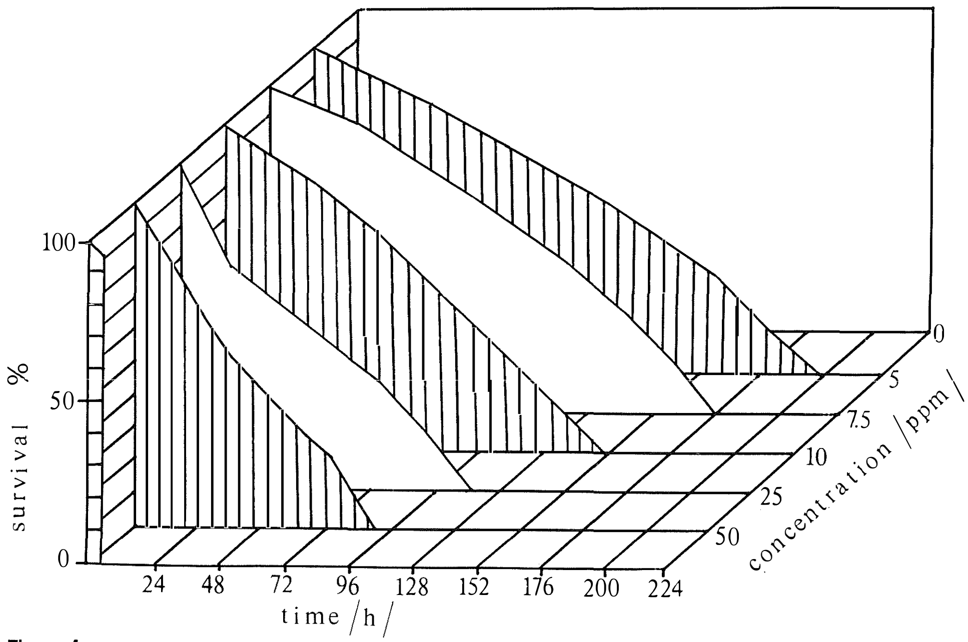


Figure 4

Mortality of *Crangon crangon* exposed to light fuel oil at 20° C with aeration (60 l of air/10 l of solution/h). (For further details see legend Fig. 1)

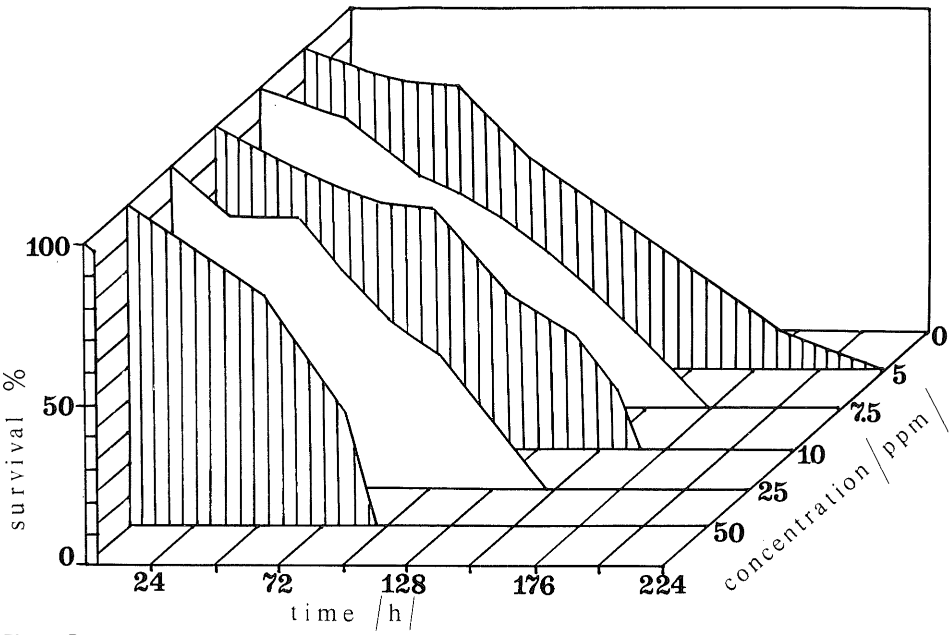


Figure 5

Mortality of *Crangon crangon* exposed to heavy fuel oil at 20° C with aeration (60 l of air/10 l of solution/h). (For further details see legend Fig. 1)

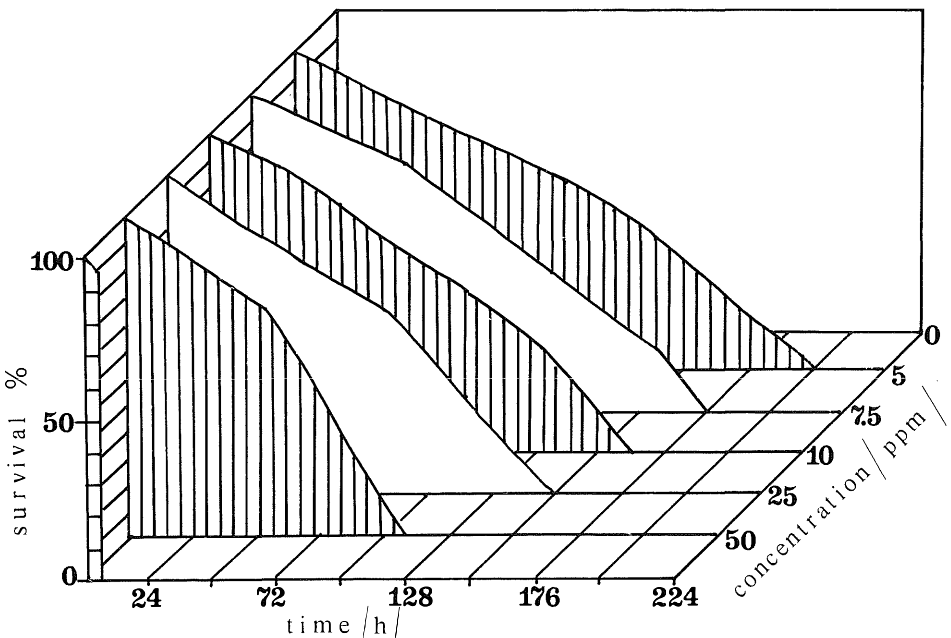


Figure 6

Mortality of *Crangon crangon* exposed to crude oil at 20° C with aeration (60 l of air/10 l of solution/h). (For further details see legend Fig. 1)

Results

The mortality curves of the shrimps are shown in Fig. 1 – 6. The most toxic pollutant was light fuel oil (Fig. 1). Total mortality of the shrimps after exposure to 50 ppm of this oil occurred after 120 h at 15° C. Heavy fuel oil and crude oil were less toxic. Total mortality of the shrimps exposed to 50 ppm of heavy fuel oil occurred after 144 h (Fig. 2), and those exposed to 50 ppm of crude oil died after 140 h (Fig. 3). Light fuel oil at a concentration of 50 ppm at 20° C with aeration caused 100 % mortality after 88 h (Fig. 4), whereas heavy fuel oil and crude oil under the same conditions after 90 h and 100 h, respectively (Fig. 5, 6).

The differences in the oils' toxicity are expressed not only by the means of the survival time in different concentrations of these pollutants, but also by the 96 h LC_{50} (Table 1). LC_{50} for light fuel oil is lower (10 ppm) than for the heavy and crude oil (20 and 25 ppm, respectively).

Table 1

96 h LC_{50} for shrimps *Crangon crangon* at 20° C in brackish water (7 $^0/_{00}$ salinity) with aeration

Pollutant	96 h LC_{50} (ppm)
Light fuel oil	10
Heavy fuel oil	20
Crude oil	25

The differences in the mean survival time between the controls and the experimental shrimps in all concentrations of all three oils are statistically significant ($p < 0.005$).

Discussion

Oil hydrocarbons penetrate into the aquatic animals through the digestive tract, respiratory system and through the integument. Their toxic action on marine organisms is chemical, as well as physical. Oil hydrocarbons interact with the lipid bilayer components of biological membranes (ZUBRZYCKA 1975). Physical effects are the agglutination of gill lamellae and disturbance of gas exchange through the gills. Impairment of gills has been observed by VERNBERG et al. (1977) and MOORE (1979). The influx of plant sewages containing oil products into Santa Monica Bay led to a significant decrease in the number of flat-fishes caught in this area. The decrease in catch resulted from high mortality and migration of the fishes from the oil-contaminated waters (SHELTON 1971). COWELL (1971) observed a high mortality rate of *Patella vulgata, Balanus balanoides* and *Littorina littorea* in ecosystems polluted with crude oil. Petrochemical sewages in Los Angeles were toxic for *Patella vulgata*. The mean number of living subjects was 3 per m^2. Beyond the polluted area the number of *Patella vulgata* individuals reached 450 per m^2 (BAKER 1976).

Oil can destroy or damage living organisms in numerous ways: it can smother animals resulting in their death by asphyxiation or starvation. It can damage plants by disrupting oxygen transfer (BAKER 1976). It can also kill by intercalation (GOLDRACE 1968). Octane and decane are very toxic, while dodecane and higher paraffins are nearly non-toxic. In general, the smaller the hydrocarbon molecule, the more toxic is the oil. The light fuel oil contains more smaller molecules and therefore it is more toxic than heavy and crude oil.

Oxygenation and temperature of the water are very important factors influencing the mortality of the shrimps. An increase of water temperature by 5° C, and a decrease of oxygen concentration accelerate shrimp mortality by about 25 %. At lower temperatures, the solubility of the oils is lower. Therefore, survival of the shrimps in oil-polluted waters is longer in lower temperatures (DREWA 1981). This phenomenon has also been observed by CRAPP (1971). CRAPP (1971) and LEVELL (1976) reported that some light fractions of crude oil are more toxic than crude oil alone.

Toxic effects of oil may lead to disturbances of metabolic chain and influence the trophic chains. Therefore, oils are harmful not only for a single species, but for ecosystems as a whole.

It has been suggested that oil pollutants are more toxic in marine ecosystems than under laboratory conditions, particularly since in natural conditions there are hydrocarbons produced by plants, many of which are also toxic to animals, and these may act synergistically with oil hydrocarbons from pollution. It has also been observed that oil hydrocarbon toxicity is much greater when it acts together with certain detergents. It is thought that the mixture of these substances is more active in penetrating through biological membranes into the blood and inner organs of aquatic animals.

In conclusion it may be assumed that:
1. light fuel oil is more toxic for *Crangon crangon* than heavy and crude oil,
2. the toxicity of oils increases with water temperature,
3. the oil toxicity increases with decreasing oxygenation of the water.

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