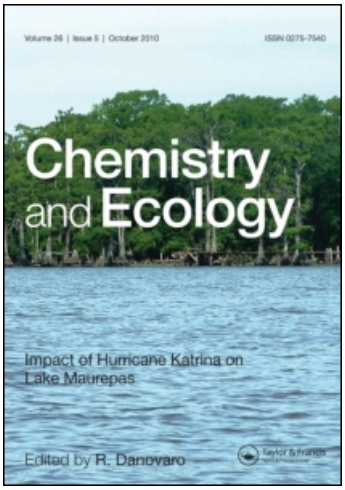

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VEGETABLE OIL SPILLS – POLLUTION OR OVER-CAUTIOUSNESS?

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Vegetable oil spills are relatively uncommon compared to those of mineral oil in the marine environment. Evidence from the spillages that have occurred indicate that they can cause the death of animals in the vicinity through suffocation, inhibition of feeding and other non-specific toxic effects. Smothering of the intertidal area may lead to the development of anoxic conditions with associated changes in species diversity. Polymerisation appears to be a key process in determining the persistence of these oils in the intertidal region. Experiments have indicated that indigenous bacteria are capable of degrading the oil until it polymerises and work is being directed towards determining mechanisms to aid in the degradation process. In conclusion, vegetable oils are pollutants although the risk to the marine environment is small but that does not mean we should not be prepared for such events.

Keywords: Vegetable oils; animal effects; polymerisation; degradation

DOCUMENTED SPILLS

There have been a small number of vegetable oil spills reported in the marine environment. The work in this laboratory was precipitated by the spillage of 1500 tonnes of sunflower oil from the M. V. "Kimya" in to the coastal water of Anglesey, North Wales. The oil was lost over a period of 6–9 months during 1991, although there were events where significant proportions were lost over a short period of time e.g., during autumnal storms. Analysis of mussels as bioindicators (Mudge *et al.*, 1993) indicated that the oil did not disperse very far along the

coast. The majority of the effects were seen within 3 km of the wreck site due to the local hydrography around the rocky shoreline (Salgado, 1992).

Examples of other spills in the recent past have included a small discharge of an unidentified vegetable oil into the River Tweed (The Times, 1996). This led to the fouling of a number of swans living on the river. Larger spills include the loss of palm oil and its products from the M. V. "Lindenbank" on Fanning Island, Pacific Ocean (Russell and Carlson, 1978), rapeseed and other oils into Vancouver Harbour (McKelvery *et al.*, 1980; Smith and Herunter, 1989), soybean oil into the Minnesota River (Gunstone, 1994), fish oil discharges from the coast of South Africa (Anon, 1974) and an unidentified oil along the coast of the Netherlands (Zoun *et al.*, 1991).

KNOWN EFFECTS

In most of the above spills, some fouling of birds was observed (e.g., Gunstone, 1994) and led to the death of significant numbers of them. In the Minnesota River case, this was 4000 killed and a further 1300 injured. Once the birds' feathers are covered with oil, it has the effect of reducing their insulation and ability to fly (Zoun *et al.*, 1991). In some cases, the degradation of the oil by micro-organisms can lead to regions of water oxygen depletion and a reduction in the water quality. This can alter the behaviour of some animals such as fish that were observed to abandon their breeding grounds (Gunstone, 1994).

The oil spill on Fanning Island led to the death of the fauna in the immediate vicinity and a subsequent increase in green algae due to reduced grazing pressure (Russell and Carlson, 1978). A similar growth of green alga (*Enteromorpha* sp.) was observed after the sunflower oil spill from the M. V. "Kimya" (Mudge, 1996).

The principal mechanisms in which the fauna die is likely to be asphyxiation, due to damage to the respiratory organs, and clogging of the digestive tract preventing feeding. In most cases however, there does not appear to be any direct toxicity with an easily definable dose-response curve describing the effects. However, in the case of the M. V. "Kimya", adult mussels were alive (and well ?) with 40% of their total body lipids comprised of linoleic acid derived from the sunflower oil.

At other nearby sites, mussels with smaller amounts of sunflower oil components in them were dead (Mudge *et al.*, 1993) although the cause is still unknown.

LABORATORY EXPERIMENTS

As a direct consequence of these observations, laboratory experiments were conducted into the effect of these vegetable oils on mussels (Salgado, 1995). The results using representative oils (olive oil as a non-drying oil, sunflower oil as a semi-drying oil and linseed as a drying oil) can be summarised as follows:

1. The growth rate (change in shell area) for all vegetable oils was approximately one fifth of the control mussels growth rate even at low exposure rates (1 part of oil in 1000 in a flow through sea water system).
2. In the laboratory, some of those mussels exposed to vegetable oils died although no mortalities were observed for the control animals given distilled water in sea water in the same ratio as above. The mussels exposed to linseed oil fared worse than those in other oils with an 80% mortality rate over 4 weeks.
3. Some behavioural differences were also noted with altered gaping patterns and, surprisingly, an increased tendency to gape at lower salinities possibly a response to obtain more oxygen.

EFFECTS ON THE SEDIMENTS

The oil from the M. V. "Kimya" was seen to polymerise both in the sea water and on the intertidal sediments. In the case of the oil in sea water, it formed lumps that resembled used chewing gum (Mudge *et al.*, 1993). The oil that entered the sediments, and then polymerised, formed hard dry lumps using the local sand as an aggregate. Surprisingly, this oil is still in the intertidal sediments 6 years after the loss of the ship and its cargo (Mudge, 1997). Analysis of the oil in these sands (Dunn, in preparation) shows that there has been a change in the fatty acid composition with geometric and structural isomers of

the original linoleic acid present, as well as more reduced octadecenoic acids. The exact mechanism of polymerisation is still under investigation.

Experiments on intertidal sediments (Mudge *et al.*, 1995) demonstrated the difference between sunflower oil which polymerised, and linseed oil which did not. These experiments have been repeated and the microbiological organisms responsible for the degradation investigated (Pereira *et al.*, this volume). The results from these two experiments indicate as follows:

1. Rapid penetration of the sediment by both oils although linseed oil was more mobile.
2. Increased bacterial numbers as the microorganisms utilise the oil as a carbon source.
3. Regions and periods of anoxia due to utilisation of oxygen during the degradation proesses.
4. Polymerisation of the sunflower oil leading to anoxia just below the surface cap. This has a reduced permeability for both air and water.
5. A change in species from an oxic community to an anoxic community.
6. Persistence in the Ecosystem.

Some of the interesting by-products of these studies has been the identification of a series of isomers of the octadecetrienoic and octadecadienoic acids. This has enabled us (Pereira *et al.*, this volume) to propose a degradation scheme for these two oils. This scheme contains previously unidentified isomers of these principal fatty acids with novel *cis*, *trans* configurations and bond positions in the marine environment. Results suggest that it is mainly the aerobic bacteria that are responsible for these changes.

RECOMMENDATIONS

The conclusions from earlier work (Mudge *et al.*, 1995) were that if linseed oil was spilled on to an intertidal sediment, it could probably be left for the natural bacteria populations to degrade. For sunflower oil, the reverse was true since it polymerised and effectively rendered the sediments beneath anoxic or cemented them together (also see

Mudge, 1997). These recommendations still hold true after further investigations. It appears as if these oils do have a deleterious effect notably on the fauna (fish and bird kills) and also may lead to sub-lethal changes (reduced growth rate). Therefore, they can be classified as pollutants, and as such there should be strategies in place to enable the containment and clean up of a spill. This may be hampered by the polymerisation process that alters their physical properties of the oil including allowing it to sink in the water column, thus exposing benthic communities of organisms.

In order to assist in this, further work is needed to identify "clean" technologies that may allow easy removal of spilled oil; Such work is being investigated at these laboratories. In the meantime, the general conclusion must be that these oils are pollutants in the marine system, although spills are fortunately uncommon and usually only of small volumes. Be prepared.

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