Impact Of The Dispersants On The Marine Environment

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Abstract: Use of oil spill dispersants is one of the possible oil spill response techniques that remove floating oil. Dispersants are an effective way of minimizing the overall ecological and socio-economic damage, by preventing oil from reaching coastal habitats and shorelines and meanwhile enhancing the natural biodegradation processes. Their use accelerates the rate and extent of natural dispersion and dilution of oil caused by wave action. The dispersants surface active agents transform by using the energy of the waves the most of the spilled oil into droplets. They are pushed into the upper column by wave action and kept there by turbulence. These oil droplets are much more available to naturally-occurring hydrocarbon-degrading microorganisms compared to floating or stranded oil. In comparison with other oil spill techniques it has some limitations related to oil viscosity and the time of applying after the oil spill.

Index Terms: Dispersant, Oil spill, Response technique, Marine environment, Ecological process, Surfactant, Environmental protection.

1. INTRODUCTION

The chemical combating of oil spills began in 1960's at the same time as oil spill response began. Although they can be highly effective and sometimes the only way of combatting oil spill, their practical use is limited in some countries due to environmental concerns. Over the years there has been a certain controversy related to the use of dispersants. It is therefore important to understand the conditions where their use will be most effective. It is important to be aware of the facts – as opposed to the myths-related to the use of dispersants. In the beginning the dispersants were first used on several high profile tanker spills. At that time they were not very effective, and turned out to be more toxic than the oil. Dispersants used today have lower toxicity and have been proved to be effective in a number of actual incidents.Dispersants break up the oil in small droplets reducing oil concentrations and enabling faster natural biodegradation. They contain surface action chemical agents and are less toxic than the oil but the toxicity must be considered. At the end they can be only used in salt water areas with a good water exchange in order to reduce the impact on the marine environment. [1]

2 PERFORMANCE OF THE DISPERSANTS

2.1 Composition of the dispersants

In general dispersants consist of two components:

- A blend of active chemicals which consists of emulsifiers and wetting agents;
- A solvent system which acts as a carrier but does not take an active part.

The active chemicals are called surfactants – surface active agents.

2.2 Effectiveness of the dispersants

The active chemicals in the dispersant prefer to sit at the interface between the oil and the water. This means that the surface tension between the oil and water is reduced and the oil breaks up into small droplets and emulsify with the water. The speed of the emulsification depends basically on the wave action. When the oil is in small droplets the dilution and natural bio-degradation accelerates. It means the oil concentrations reduce more rapidly. When the oil droplets are formed they appear as a light brown or white cloud in the water. If the cloud is black it is because the droplets are quite large and are liable to resurface.

2.3 Impact of the dispersants

The types of dispersants used today are not as harmful to the environment – aquaculture, marine culture, fish etc. as their predecessors. However, dispersants cause the oil to leave the sea surface and instead disperse in water column where the oil becomes more available to the marine environment. As other combatting techniques are available – especially mechanical, many national environmental protection agencies forbid the use of dispersants or, more frequently, impose strict conditions on their use.

2.4 Apply of the dispersants

Dispersants should be applied by spraying as soon as possible after the oil spill. They are not effective against all oil spills. The viscosity must not exceed 5 000 centistokes. If the water is calm the oil is often seen resurfacing as the energy in the water is not enough to maintain droplets below the water surface. When a dispersant has been applied it is normally not possible to recover the oil mechanically as the oil often transforms into tar balls. Also, dispersed treated oil does not adhere to some types of oleophilic skimmers. [2]

3 TYPES OF DISPERSANTS

In the UK, where the use of dispersants spraying has been adopted as the primary at-sea response to oil spills in UK waters, the British National Environmental Technology Centre of AEA Technology introduced the classification of dispersants which is used worldwide based on the dispersant's form application.

The three principal types of dispersants are:

- Type 1: Neat, non-concentrated;
- Type 2: Diluted, concentrated;

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- Type 3: Neat, concentrated.

Type 1: They are more toxic first generation dispersants which are no longer made. If they are still available, they should not be used because of their toxicity and potential harm the environment. Old stocks of this type should be destroyed in an environmentally safe manner.

Type 2: It is a diluted dispersant, normally diluted to 1:10 with sea water. This type is used to spray floating oil. It may also be used on beaches provided a source of clean seawater for dilution is available.

Type 3: It is a concentrated dispersant also used neat, which is applied at sea from aircraft or ships. May also be used on beaches where the oil is less than 6 mm.

In general this type is considered to be the most effective.

4 ENVIRONMENTAL RISKS WHEN USING DISPERSANTS

When applied correctly, dispersants remove oil from the water surface and distribute it throughout the water column. The upper 3 meters of it will contain a high oil/dispersant concentration for a short period, since the water movement will ensure a continual and rapid dilution of the oil droplets. Significant dispersed oil concentrations are rarely seen below 3 to 5 m water depth. In countries permitting the use of dispersants, specific regulations normally have to be observed. Typically, the water depth must be at least 10 m before it is advisable to use dispersants. Some countries insist on 20 m. Dispersants may have to be tested and approved before they can be used. It is usually a condition that the combined toxicity of the dispersants and dispersed oil must not be more toxic than the oil alone. Even when approved, dispersants should not be used in stagnant water or where there are water intakes for industrial plants – desalination plants, power station cooling water, salt farms etc.

5 ENVIRONMENTALLY SENSITIVE AREAS FOR DISPERSANTS USE

The following list indicates areas where the application of dispersants would have considerable damaging environmental effects, bringing dispersed oil into contact with these sensitive environments. The use in or near such area is not recommended.

- Aquaculture;
- Birds;
- Coral reefs;
- Fish;
- Mangroves;
- Marine mammals and turtles;
- Salt marshes;
- Sea grass beds;
- Shellfish;
- Water intakes;
- Port and harbours.

The environmental effects of dispersed oil versus untreated oil for each area have been analyzed on the basis of actual spill experience and recorded international field experiments comparing chemically dispersed and untreated oil. [3]

Aquaculture: It is undesirable for either untreated oil or dispersed oil to enter aquaculture ponds because of the risk of tainting fish products which can result in serious economic consequences. Access can be temporarily shut off by closing pipes or sluice gates and the oil response should concentrate on removing oil from near the water intakes as quickly as possible. Birds: It is clear that the oiling of birds is disastrous for them, either because the oil destroys the insulating and water repelling properties of their plumage, or because of the toxic effects of the ingestion of oil, or because of the indirect effects of the destruction of habitats or food resources. However, the susceptibility of various groups of birds differs considerably. Dispersants are considered beneficial as it reduces the risk of fouling birds by oil on the water surface and ingestion. It also known that dispersants increase the “wet ability” of feathers which can lead to death by hypothermia. This suggests that direct accidental spraying of wildlife with undiluted dispersants will be harmful. Dispersants can be used off-shore to protect sensitive bird habitats but they should not be sprayed directly over rafting birds. Decisions need to be taken on a case by case basis taking into account all the relevant factors including the season of the year. Coral reefs: They are highly productive areas which support a diverse group of organisms, including many commercial fish species. Coral reefs are often associated with commercially important dive sites. They are easily damaged if oiled, nay take several decades to recover if killed, and are difficult or impossible to clean. The susceptibility of coral reefs to oil damage depends on a number of factors: size of spill, type of oil, type and depth of coral reef, the local wave energy, the existing stress of the corals, etc. In many cases oil slicks will float over reefs without causing damage to the submerged corals and associated organisms. The use of dispersants should not be allowed in shallow waters over and near coral reefs because this would increase the exposure of the corals to oil droplets. Fish: There is no evidence that oil slicks floating in the open sea above free-swimming fish have ever caused declines in fish populations. The net environmental benefit of using dispersants in open water conditions is neutral: dispersant spraying will not provide any advantages for the fish but neither is there likely to be deleterious effects if the dispersed oil is rapidly diluted in deep water. In shallow water, however, dispersed oil in the water column is more likely to reach concentrations where it may harm or taint fish, particularly eggs and larvae. Mangroves: Mangrove stands are highly productive areas and they provide habitats for a large variety of organisms as well as serving as a nursery ground for many fish and crustacean species. Mangrove trees commonly die when oiled thus resulting in loss of habitats for dependent species. Chemically dispersed oil has minor effects on mangroves compared with their sensitivity to more toxic undispersed crude oils. Damage is effected either through the coverage of breathing spores on the aerial root systems or through oil penetration of the sediments. Mangroves are often associated with coral reef ecosystems and these could be damaged by dispersed oil. Marine mammals and turtles: It is rare for free swimming whales, dolphins, seals and sea lions to be affected by oil at sea following a spill, however cetacean haul-outs can become oiled and, during the breeding season, these areas will be particularly important. Turtles are vulnerable to oil, eggs laid in sandy beaches and juveniles swimming in surface waters being their most sensitive stages. Sea grass beds: They are important nursery areas for reef fish and shrimps and are also feeding grounds for many fish and marine mammals. They occur both inter-tidally and in shallow sub-tidal areas. Sea grass beds should be mapped systematically and their occurrence noted and

mapped during the course of any sensitivity analysis survey. Shellfish: Oil slicks floating above shellfish areas are unlikely to harm them but exposure to oil – and possible tainting – are likely to increase if dispersed oil enters the water column. Water intakes: Water intakes for desalination or cooling systems for power stations or refineries may be damaged by the intake of oil-contaminated water. The use of dispersants close to water intakes of industrial facilities will increase the risk of oil passing under protective booms and entering the water intakes. It should not be allowed within the vicinity of water intakes. Ports and harbors: Sea conditions in ports, harbors and docks in industrial areas are generally too calm to provide efficient dispersion. Furthermore, dilution of the dispersed oil plume may be restricted. Some oils commonly split in port areas are not amenable to dispersion, such as marine diesel and heavy fuel oils. However, conditions are often good for containment and physical removal of the oil. Dispersants should not usually be allowed within the confines of port areas. They should only be used in port areas subject to government approval, either on a standing approval or on a case by case basis. Consideration should be given also in anchorage areas.

6 SUMMARY OF THE ADVANTAGES AND DISADVANTAGES OF USING DISPERSANTS

A summary of the advantages and disadvantages of using dispersants in oil spill response are listed bellow. (see Table 1)

Table 1 *Advantages and disadvantages of using dispersants*

Advantages	Disadvantages
In contrast to containment and mechanical recovery, dispersants can be used in stronger currents and greater sea states.	By introducing the oil into water column, the process may adversely affect some marine organisms which would not otherwise be reached by oil.
Dispersants are often the quickest response method.	Surfactants may reduce the efficiency of oleophilic disc skimmers by reducing the attraction between the discs and the oil.
By removing the oil from the surface, dispersants help to stop the wind effect on the oil slick's movement that may otherwise push the surface slick towards the shoreline.	Dispersants are not effective on all types of oil under all conditions.
Use of dispersants reduces the possibility of contamination of sea birds and mammals.	There is a limited time window when dispersants can be used effectively.
Dispersants inhibit the formation of water-in-oil emulsions.	If used on shore, dispersants may increase the penetration of oil into the sediments.
Dispersants increase the surface area of oil that is available for natural degradation.	Use of dispersants introduces an additional quantity of extraneous substances into the marine environment.

Requirements for successful dispersant use:

Dispersant effectiveness on viscous oils and stable emulsions is low. Effectiveness reduces when the viscosity increases as dispersion relies on the ability of the surfactant to penetrate the oil. The point at which dispersants become ineffective depends on the pour point of 10 000 centistokes would not be dispersible and effectiveness reduces for some weathered oils above 2 000 centistokes. Most crude oils can be dispersed at the early stages of a spill, but the amenability of the oil to dispersants is reduced with time as the oil properties changes as it weathers. The rate of these changes varies with different crude oils and different prevailing conditions. Some crude oils remain dispersible for days, but others will become essentially non-dispersible sifter a few hours. Modern dispersants have a greater capability than older dispersants, but the threshold is not a fixed value because it depends on sea-state as well as the viscosity of the oil: higher viscosity oils can be dispersed in rougher seas than in calmer seas. Dispersants are generally ineffective above 5 000 centistokes which means that a timely response is essential. It has to be noted that the crude oils are more viscous when cold.

7 CONCLUSION

When considering the use of dispersant, the first task is to assess whether dispersant use would be effective on the spilled oil under the prevailing conditions. If dispersant use would be effective, the next task is to consider the consequences, the benefits and the potential risks. The benefits of dispersant use is to minimize the ecological and socio-economic damage by removing oil from the sea surface, preventing it from reaching sensitive coastal nad shoreline habitats and enhancing the natural biodegradation processes. The potential disadvantage of dispersant use is that marine organisms inhabiting the upper column will be briefly exposed to diffuse clouds of dispersed oil droplets and water-soluble oil compounds in the water column, compared to the situation if dispersants were not used. Past experience at several major oil spill incidents has shown that negative effects on marine organisms caused by elevated concentrations of dispersed oil in water greater than 10 meters depth due to dispersant use were localized and of short duration.[4]

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