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SORBMOP
CLEAN-UP TECHNOLOGY FOR OIL SPILLS

by

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ABSTRACT

Fast and wide-ranging expansion of oil slicks, extensive and long-term pollution of coastal areas, sinking of oil clods covering sea bottom, and oil washing ashore even after years - these are effects which are commonly known. Through the food chain of marine creatures like plankton, mussels and fishes, eventually even people are affected by pollution. Different technical systems are on the market to control the pollution of oceans caused by oil spills, ship accidents or illegal draining of used oil.

Existing systems to clean up oil spills work unless there are no difficult meteorological and hydrological conditions at sea, i. e. the methods often fail during strong currents or rough seas combined with strong winds, and in shallow waters.

Considering the shortcomings of existing systems a new clean-up technology named SORBMOP has been developed by EKU Entwicklungen Calla Millor in cooperation with the Institute for Hydraulic and Coastal Engineering of Rostock University.

The SORBMOP technology consists of the following main components:

- Oil adsorbing elements – adsorbents
- Containers for storage, transport and placement of adsorbents
- Equipment for collection of used adsorbents based on a surface-controlled net and/or vacuum technique
- Recycling of adsorbents and oil

Compared to the limited applicability of existing systems the SORBMOP technology has various advantages:

- Rapid reaction - start of operation within few hours after detection of oil spill by using airplanes (avoiding oil pollution of plant, animal, and bird communities)
- Contamination of oceans can be efficiently controlled, cleared away and disposed, even during strong currents, rough seas, and strong wind forces
- Transport of adsorbents by plane guarantees short time interval between detection and cleaning of oil spills
- High transfer speed enables the system to keep longer distances between stationing places of clean-up equipment and possible locations of oil spills
- Technology can also be used in shallow waters with a sensitive environment, e. g. wadden areas or sandy beaches
- Cost saving

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1. INTRODUCTION

Oil spills in marine environment have different causes, which can be separated in intentional and accidental spills. The daily pollution by ships illegally giving their residual heavy oil to the sea instead of legal disposal in harbours belongs to the first group. Worldwide harbour regulations with flat rates not depending on the use or not use of waste management services can lower the number of this kind of oil spills significantly.

On the other hand, oil spills can be caused by accidents in shipping (see Figure 1) or offshore oil drilling. Improved safety regulations can lower the probability of these oil spills, but the risk of such accidents will remain.

Figure 1: Prestige accident off the Spanish coast in November 2002 (Photo: Netscape)

Oil is an complex mixture of different organic compounds: aromatics, alkene, alkane, paraffins, naphthenes and elements like nitrogen, oxygen, sulfur, sodium, nickel, iron, vanadium (US EPA). The main cargo of tankers is crude oil, but also refined products like diesel fuel, fuel oil and bunker-c-oil are being transported by ship. The main problems in controlling oil spills are based on the variability of oil characteristics of different oil-types and their weathering products. The ecological toxicity strongly depends on the chemical components and on the weathering processes after spill. Especially the persistent nonhygroscopic ingredients like polycyclic aromatic hydrocarbon are a big threat for marine life, because these cancerous and mutagen substances accumulate in the marine food chain (FENT 1998).

Viscous oil slicks are only slowly decomposed by natural biodegradation in water and sediments as well as on rocks (BRAGG ET AL. 1994). The damages due to oil spills are more serious onshore than offshore, as shown in the description of the Prestige accident off the Spanish coast in November 2002 of WHITFIELD (2003). Cleaning of sediments and rocks was difficult mechanical and chemical methods lead to serious damages of the ecosystem.

Worldwide, different attempts to control oil spills are in use (US EPA 1999):

- Mechanical containment using booms
- Recovery of oil by using pumps, skimmer systems, or adsorbents
- Chemical (dispersing agents) and biological (biostimulation and bioaugmentation) treatment of oil, often in conjunction with mechanical containment
- In-situ burning of oil spills in conjunction with mechanical containment
- Shoreline cleanup of oil spills using natural (evaporation, oxidation, biodegradation) and physical processes (wiping with adsorbent materials, pressure washing, raking or bulldozing)

The efficiency of these methods depends on a variety of factors such as characteristics of the oil itself and natural conditions like weather, water temperature, salinity, water depths, and bottom material. In addition, some of these methods are regarded to be damaging the environment and/or to be ineffective. For this reason in-situ-burning as well as chemical treatment of oil are e.g. not in use in Germany (SCHROH 1998).

One of the most important points in controlling oil spills in aquatic environments is the quickness of reaction to limit spreading due to currents, wind, and wave attack. Only a few hours after spill the oil can cover extensive areas and can move in direction of shallow water areas and shorelines where the

oil-pollution can result in disastrous damages to aquatic habitats and recreation areas. In addition, oil properties are changing rapidly after spilling. During the first 12 hours following a spill, up to 50 % of the light components evaporate (US EPA 1999), which decreases the toxicity of the spilled oil over time, but also thickens the residual oil. Consequently, the rate of natural biodegradation decreases, the oil forms dense, sticky black spheres like tar balls or emulsions which can linger in the environment for years, or which are heavier than water and sink to the sea floor. The effectiveness of recovery measures, like use of skimmers or adsorbents, chemical or biological treatment, and in-situ burning decreases significantly with time.

A rapid reaction on oil spills is difficult especially in rough seas, where accidental oil spills most often occur and spreading is fast. The polluted area can hardly be reached in time by ships for containment and recovery measures. In addition, containment by booms and recovery of oil by skimmers can easily fail in rough and choppy waters. Even under favourable conditions cleaning rates attain 15 % only, whereas cleaning rates below 10 % are the rule (STEEN ET AL. 2002).

Considering these shortcomings of conventional control measures for oil spills a new system named SORBMOP was developed by EKU Entwicklungen Calla Millor in cooperation with the Institute for Hydraulic and Coastal Engineering of Rostock University.

2. SYSTEM SORBMOP FOR USE IN OPEN MARINE AREAS

The oil containment and recovery system SORBMOP for use in open marine environments consists of four components:

- Oil adsorbing elements – adsorbents
- Containers for storage, transport and placement of adsorbents
- Surface-controlled net
- Conventional seagoing vessels and fishery equipment

Up to now, adsorbents are used as sole cleanup method only for small oil spills or for removal of residual traces of oil. The characteristic of the system SORBMOP is the use of adsorbent material as the basic method also for the cleanup of bigger oil spills. It consists of specially manufactured adsorbents as well as a storage, transportation, placement and collection system for the adsorbing material.

The oil adsorbents are foamed plastic elements with hydrophobic, oil adsorbing and floating characteristics and a pore size according to oil viscosity (Figure 2). The dimensions of prototype adsorbents are 5 x 2 x 1 cm. They are stored 1:3 compressed in special textile containers (Figure 3), which can be transported to polluted areas by airplanes or conventional seagoing vessels. Transportation by airplanes can not be hindered by heavy seas. Thus, the system SORBMOP enables a rapid action even under severe weather conditions.

After placement the containers sink into the water and open automatically. The released adsorbents rise to the water surface and the oleophilic elements adsorb the oil in the water column on their way to the water surface.

Figure 2: Oil adsorbents (prototypes) partly filled with extremely viscous oil (IFO 380)

Figure 3: Container (prototype) for storage and placement

Collection of the oil-filled adsorbents floating on deeper water is carried out by specially constructed enclosing nets (Figure 4). The arch-shaped upper edge of the net reaches above the surface of the water. Pulling the net by two ships at a distance of about 150 to 200 m a wedge is formed for collection of adsorbents. Conventional seagoing vessels fitted for lowering and pulling in the special net can be used (Figure 5). After hauling in the net, the adsorbents are picked up by special equipment to avoid losses of the adsorbed oil.

Figure 4: Field test with a prototype of a surface controlled net

Figure 5: Conventional seagoing vessel with equipment for lowering and pulling in the special net (prototype)

For waste management, adsorbents and oil can be separated by centrifuging for further treatment. Alternatively, both components can be burnt together in special plants.

3. SYSTEM SORBMOP FOR THE USE IN SHALLOW WATERS

Oil spills in shallow water areas can be caused directly in shallow water zones or by drift of spills from deep to shallow water. Shallow water areas, esp. tidal flats usually contain rich plant, animal, and bird communities. Deposited oil can cause enormous ecological damages, esp. if the oil is allowed to seep into the muddy bottoms of the flats. In addition, the oil-pollution of coastal stretches can cause huge economical damages esp. in tourist business and fishery.

The SORBMOP system can offer rapid remedy also for oil spills in shallow waters. The adsorbing material can be brought into the spoiled areas by airplane thus being independent of water depth and weather conditions. Pollution of the bottom material as well as harm to animals can be reduced significantly. The adsorbents can be collected in shallow water by special keel-less ships with surface controlled nets or at the shoreline by using vacuum technique.

The adsorbing material can keep oil over a long period of time, allowing longer intervals between containment of oil and collection of adsorbents. After impact on the beach, the adsorbents only loose a very small amount of oil and sediments as well as rocks are hardly affected by the spill.

4. FIELD AND LABORATORY TESTING

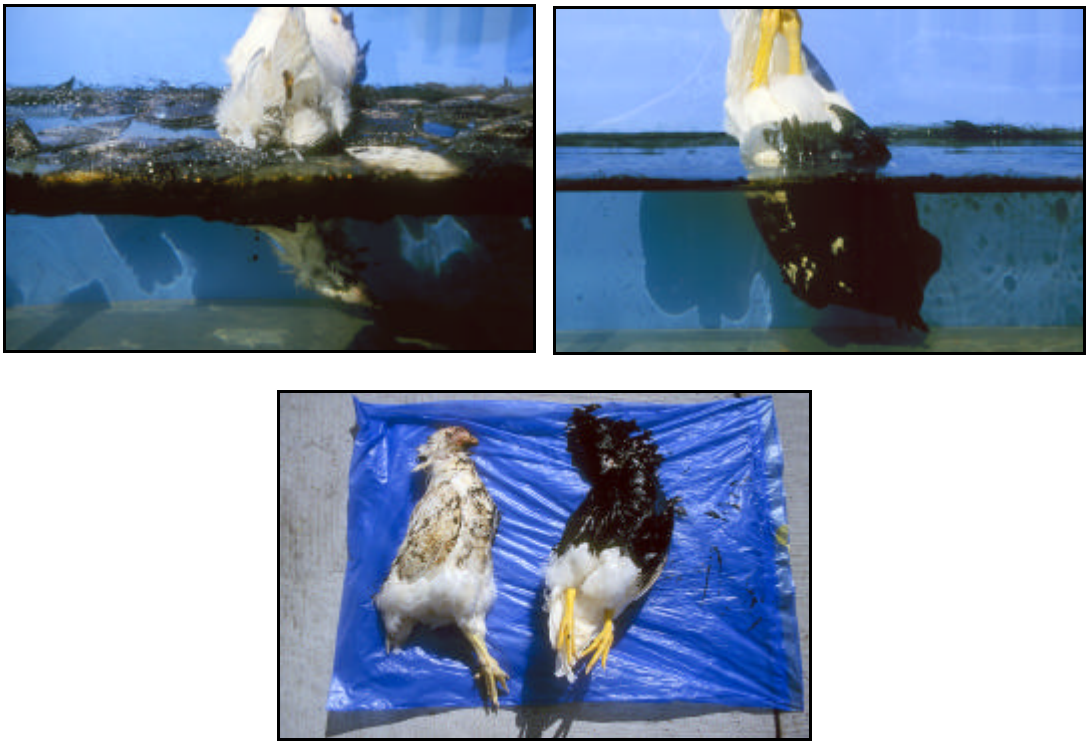

Figure 6: Impact of oil (IFO 380) contaminated seawater on the life of birds a) with and b) without use of adsorbents

First field and laboratory testing of suitability and handling of the system SORBMOP was carried out.

Laboratory tests show promising results in the rate of adsorption using different kinds of oil (light and heavy oil) and in the rate of oil retention. In addition, the small floating hydrophobic and oleophilic adsorbents are tracking oil spills for containment.

The oil-contaminated adsorbents can keep adsorbed oil over a period of several days. According to first tests, they are loosing only 3%vol. oil after impact on a concrete basis from a height of 1 m. Therefore, wash up of used adsorbents does not bring significant harm to the shoreline.

Laboratory investigations with dead birds show that only a very small amount of oil will soil feathers after cleaning an oil spill with adsorbents (Figure 6).

Field tests with a prototype of a surface controlled net for collecting adsorbents have been carried out successfully on the Baltic Sea near Thiessow / Island of Rügen (Germany) in 2002. A width of 150 - 200 m can be covered by the prototype net dragged by two vessels (see Figure 4). The weather conditions were rough with wind-force up to 9 Beaufort (45 knots of wind).

5. CONCLUSIONS AND PROSPECTS

Compared to the limited applicability of existing systems the SORBMOP system offers a number of advantages in the clean-up of oil spills in open marine areas as well as in shallow marine and inland waters:

- Rapid reaction - start of operation within few hours after detection of oil spill by using airplanes (avoiding oil pollution of plant, animal, and bird communities)
- Contamination of oceans can be efficiently controlled, cleaned and disposed, even during strong currents, rough seas, and strong wind forces
- Transport of adsorbents by plane guarantees short time interval between detection and cleaning of oil spills
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For the practical use of the SORBMOP system further investigations have to be carried out with special respect to the following questions:

- Improvement of adsorbing material focussed on optimization of adsorbing and desorbing rates, production costs and possibilities for recycling and disposal
- Optimization of containers for storage, transport and placement of adsorbents
- Optimization of surface-controlled net and vacuum technique for collection of adsorbents
- Investigations on temporary storage, recycling and disposal of oil-filled adsorbents
- Investigations on the technical and economical feasibility of the system SORBMOP

The research will be carried out by the Baltic Sea Research Institute Warnemünde and the Institute for Hydraulic and Coastal Engineering of Rostock University.

6. ACKNOWLEDGEMENT

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