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THE ENVIRONMENTAL IMPACTS OF INLAND WATER TRANSPORT AND POSSIBILITIES OF OIL SPILLS CLEANING

Abstract:
The inland water transport is of great importance in European economy. It is necessary to implement wide safety rules to achieve also environmental friendly kind of transportation – mainly occupational safety, fire protective and environmental measures, to avoid oil and oil-based products leakage into the water environment. If still, accident occurs, immediate action has to be done, to minimize the negative impacts of the oil spill on the environment.
Even all the safety measures are taken and implemented; the risk of accident is still present. Therefore, prompt action has to be taken to reduce negative environmental impacts, using the oil barriers, oil absorbers, chemical agents, oil collectors and other devices.

Keywords:
inland waterways, accident, oil barriers, oil absorbers

INTRODUCTION

Inland navigation can contribute to making transport more sustainable, particularly where it substitutes for road transport, but inland shipping and especially the development of waterways for navigation can have considerable environmental impacts. [1], [8]
Waterways for inland navigation can have significant impacts on the ecological value and water quality of water bodies. Water pollution or damage caused by the inland vessels, dredging pose a threat to aquatic environment. Another significant threat to the environment is caused by operational discharges of mineral oil and lubricants, as well as organic substances (mainly PAHs) due to shipping operations. [7]
The nature and extent of the impacts depends on the vessel types and on the characteristics of the water body itself. The kinds of mitigation techniques that can be employed can also differ markedly, for example between sections of river with rocky bed and banks, and reaches with sandy or muddy bottoms situated in flood plains. In some cases new works for navigation can be designed to improve water quality or biodiversity and create valuable habitats. [2], [10]
Altering the shape of river courses to improve navigation affects bottom and bank characteristics and the dynamics of sediment transportation. Effects can spread up- and downstream over many years. Without careful attention, alterations can interfere with communication between the main channel, side branches and backwaters. Permanent changes to water levels and flows affect the whole river valley bottom and notably the ecology of floodplains. This can affect the habitats and biodiversity. [10], [4], [5] The greatest attention in the paper is paid to the oil spills and oily-based liquid spills into the water environment and possibilities of negative effects mitigation.

CHARACTERISTICS OF OIL-BASED PRODUCTS

Proper classification and characterization of crude oils and oily products in a release situation is one of the most important and earliest response tasks that must be undertaken. Hazards to personnel and biotopes depend highly on the chemical and physical properties of these substances Non-petroleum-based oils also pose a potential threat to human health and the environment. Crude oils contain hundreds of different hydrocarbons, and other organic and inorganic substances including atoms of sulfur, nitrogen and oxygen, and metals such as iron, vanadium, nickel, and chromium. [20]

The distribution of oil spilled on the water surface occurs under the influence of gravitation forces. It is controlled by oil viscosity and the surface tension of water. Only ten minutes after a spill of 1 ton of oil, the oil can disperse over a radius of 50 m, forming a slick 10-mm thick. The slick gets thinner (less than 1 mm) as oil continues to spread, covering an area of up to 12 km^2 [6]. During the first several days after the spill, a considerable part of oil transforms into the gaseous phase. Besides volatile components, the slick rapidly loses water-soluble hydrocarbons. The rest - the more viscous fractions - slow down the slick spreading. [21]

Upon release, the hydrocarbons that are composed of fewer carbon and hydrogen atoms vaporize, leaving behind a heavier, less volatile fraction. Gasolines are comprised of relatively high proportions of toxic and volatile hydrocarbons, such as benzene, which is known to cause cancer in humans, and hexane, which can affect the nervous system. Gasoline and kerosene releases are exceptionally hazardous due to their high flammability. Crude oils and semi-refined products, such as diesel and bunkering oils, may contain cancer-causing polycyclic aromatic hydrocarbons and other toxic substances. [20], [3]

CRISIS MANAGEMENT AND PREPAREDNESS FOR OIL RELEASE

Oil release and spills occur despite efforts to prevent them. It is necessary to prepare a timely and coordinated response to the emergency of undefined magnitude, place, time, and other circumstances. The crisis management for emergency with oil release requires significant planning and personnel training. Well-designed facility, local, area, regional, and national contingency plans assist response personnel in their efforts to contain and clean up any size spill by providing information that the response teams will need before, during, and after an oil spill occurs. Training ensures that emergency responders know how to act with minimum impact to the environment. [14] [3]

TECHNIQUES AND EQUIPMENT FOR CLEANING OIL AND OIL BASED SPILLS

A number of advanced response mechanisms are available for controlling oil spills and minimizing their impacts on human health and the environment. The key to effectively combating spills is careful selection and proper use of the equipment and materials most suited to the type of oil and the conditions at the spill site. Damage to spill-contaminated waters and dangers to other threatened areas can be reduced by timely and proper use of containment and recovery equipment. [3], [15]

Primary line of defense against oil spills is the mechanical containment or recovery. Containment and recovery equipment includes a variety of booms, barriers, and skimmers, as well as natural and synthetic sorbent materials, that are used to capture and store the spilled oil until it can be disposed of properly. [15], [5]

Skimmers are the devices for recovering spilled oil from the water's surface. The efficiency of skimmers depends highly upon waterway conditions. In moderately rough or choppy water, skimmers tend to recover more water than oil. Various types of skimmers (e.g. weir, oleophilic and suction) (Fig. 1, 2) are in use, and each type offers advantages and drawbacks depending on the type of oil being cleaned up, the weather conditions during cleanup efforts, and the presence of ice or debris in the water. [16]

Weir skimmers use a dam or enclosure positioned at the oil-to-water interface. Oil floating on top of the water will spill over the dam and be trapped in a well inside, bringing with it as little water as possible. The trapped oil and water mixture can then be pumped out through a pipe or hose to a storage tank (Fig. 3) for recycling or disposal. These skimmers are *prone to becoming jammed and clogged by floating debris.*

FIGURE 1. Mini skimmer [17]

FIGURE 2. Multiskimmer [18]

FIGURE 3. Floating tank for collected oils [13]

Oleophilic skimmers use belts, disks, or continuous mop chains of oleophilic materials to blot the oil from the water surface. The oil is then squeezed out or scraped off into a recovery tank. Oleophilic skimmers have the advantage of flexibility, allowing them to be used effectively on spills of any thickness. Some types, such as the chain or "rope-mop" skimmer, work well on water that is choked with debris or rough ice.

Suction skimmers operate similarly to a household vacuum cleaner. Oil is sucked up through wide floating heads and pumped into storage tanks. Although suction skimmers are generally very efficient, they are vulnerable to becoming clogged by debris and require constant skilled observation. Suction skimmers operate best on smooth water, where oil has collected against a boom or barrier. [16]

Sorbents can be used to recover oil through the mechanisms of absorption, adsorption, or both. Absorbents allow oil to penetrate into pore spaces in the material they are made of, while adsorbents attract oil to their surfaces but do not allow it to penetrate into the material. [4], [5]

Sorbents need to be both oleophilic and hydrophobic. Although they may be used as the sole cleanup method in small spills, sorbents are most often used to remove final traces of oil, or in areas that cannot be reached by skimmers. Sorbents must be removed from the water and properly disposed or cleaned for re-use. Any oil that is removed from sorbent materials must also be properly disposed or recycled.

Sorbents can be natural organic (peat moss, straw, hay, sawdust, ground corncobs, feathers, and other readily available carbon-based products), natural inorganic (clay, perlite, vermiculite, glass wool, sand, or volcanic ash), and synthetic (polyurethane, polyethylene, and nylon fibers). Organic sorbents can soak up between 3 and 15 times their weight in oil, but they do present some disadvantages. Some organic sorbents tend to soak up water as well as oil, causing them to sink. Many organic sorbents are loose particles such as sawdust, and are difficult to collect after they are spread on the water. Adding flotation devices, such as empty drums attached to sorbent bales of hay, can help to overcome the sinking problem, and wrapping loose particles in mesh will aid in collection. [4], [19]

Natural inorganic sorbents can absorb from 4 to 20 times their weight in oil. Most synthetic sorbents can absorb as much as 70 times their weight in oil, and some types can be cleaned and re-used several times. Synthetic sorbents that cannot be cleaned after they are used can present difficulties because arrangements must be made for their temporary storage prior to disposal.

The characteristics of both sorbents and oil types must be considered when choosing sorbents for cleaning up spills:

- *Rate of absorption - The rate of absorption varies with the thickness of the oil. Light oils are soaked up more quickly than heavy ones.*
- *Oil retention - The weight of recovered oil can cause a sorbent structure to sag and deform, and when it is lifted out of the water, it can release oil that is trapped in its pores. Lighter, less viscous oil is lost through the pores more easily than are heavier, more viscous oils during recovery of absorbent materials.*
- *Ease of application - Sorbents may be applied to spills manually or mechanically, using blowers or fans. Many natural organic sorbents that exist as loose materials, such as clay and vermiculite, are dusty, difficult to apply in windy conditions, and potentially hazardous if inhaled. [19], [5]*

Chemical and biological methods can be used in conjunction with mechanical means for containing and cleaning up oil spills. Dispersants and gelling agents are most useful in helping to keep oil from reaching shorelines and other sensitive habitats. Biological agents have the potential to assist recovery in sensitive areas such as shorelines, marshes, and wetlands. [15]

Dispersing agents (dispersants) are chemicals that contain surfactants, or compounds that act to break liquid substances such as oil into small droplets. In an oil spill, these droplets disperse into the water column where they are subjected to natural processes - such as wind, waves, and currents - that help to break them down further. This helps to clear oil from the water surface, making it less likely that the oil slick will reach the shoreline. Heavy crude oils do not disperse as well as light- to medium-weight oils. Dispersants are most effective when applied immediately following a spill, before the lightest materials in the oil have evaporated. The effectiveness of dispersants is being tested in laboratories and in actual spill situations, and the information collected is being used to help design more effective dispersants. Dispersants used today are much less toxic than those used in the past. [11], [5]

Gelling agents (solidifiers) are chemicals that react with oil to form rubber-like solids. The gelled oil is removed from the water by nets, suction equipment, or skimmers, and is sometimes recovered and reused after being mixed with fuel oil. The drawback of gelling agents use is that the large quantities of the material must often be applied, as much as three times the volume of the spill. [12]

Physical methods are used to clean up shores. Natural processes such as evaporation, oxidation, and biodegradation can start the cleanup process, but are generally too slow to provide adequate environmental recovery. Physical methods, such as wiping with sorbent materials, pressure washing, and raking and bulldozing can be used to assist these natural processes.

Scare tactics are used to protect birds and animals by keeping them away from oil spill areas. Such devices as propane scare-cans, floating dummies, and helium-filled balloons are often used, particularly to keep away birds. [15]

Biological agents are chemicals or organisms that increase the rate at which natural biodegradation occurs. Biodegradation of oil is a natural process that slowly - sometimes over the course of several years - removes oil from the aquatic environment. However, rapid removal of spilled oil from shorelines and wetlands is necessary in order to minimize potential environmental damage to these sensitive habitats. [4], [9]

Bioremediation technologies can help biodegradation processes work faster. Bioremediation refers to the act of adding materials to the environment, such as fertilizers or microorganisms, that will increase the rate at which natural biodegradation occurs.

Fertilization (nutrient enrichment) is the method of adding nutrients such as phosphorus and nitrogen to a contaminated environment to stimulate the growth of the microorganisms capable of biodegradation. Limited supplies of these necessary nutrients in nature usually control the growth of native microorganism populations. When more nutrients are added, the native microorganism population can grow rapidly, potentially increasing the rate of biodegradation. Seeding is the addition of microorganisms to the existing native oil-degrading population. Sometimes species of bacteria that do not naturally exist in an area will be added to the native population. As with fertilization, the purpose of seeding is to increase the population of microorganisms that can biodegrade the spilled oil. [9]

CONCLUSION

IWT is, in comparison to air and road transport, seen as more environmentally friendly and energy efficient, and can therefore contribute to sustainable socio-economic development of the region. A multimodal use of available transport possibilities (road, rail and IWT) has to be ensured. To achieve highest possible safety and environmental protection in IWT, it is necessary to foster the co-operation between national agencies responsible for water and transport and navigation purposes to ensure integrative policy planning, to monitor the transportation and handling of dangerous goods; and plan, control and manage the emergency preparedness for crisis situations with the consequence of oil spilling into the water, thus minimizing the negative effects of water transport on the river environment.

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