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Biodispersion, An Ultimate Solution For Treating Bilge Water

ABSTRACT

Discharge of Bilge Water generated on ships is a problem faced by all the maritime operators. According to MARPOL regulations all the ships may only discharge bilge water containing less than 15 ppm of oil at sea. Oil and oily residues exceeding the limit cannot be discharged at sea and hence, are retained on board and discharged in the port receiving facility for treatment and disposal.

There is a need for a technology that can remediate the bilge oil on the ship itself and reduce the volume of waste oil being discharged at the port facility. The paper presents data on the evaluation of SpillRemed and BilgeRemed developed on the basis of biodispersion technology for remediation of bilge water on vessels and ships. The study also focuses on the benefits of use of this alternative technology to smaller boats and fishing vessels for treating their bilge water without using expensive oil water separators.

Results on field trials carried out on fiberglass boats, wooden boats and in aluminum boats are discussed. In a fiberglass boat the bilge water was not only remediated in less than 15 days time but the water was also discharged in open water without leaving any sheen.

On ships, BilgeRemed can complement the existing systems in reducing the amount of waste oil.

INTRODUCTION

A ship is a city in itself producing its own source of energy for day-to-day operations. In the process it produces a very large amount of oily wastewater commonly known as bilge water. Bilge water on ships is a mixture of discharges and leakages from a wide variety of sources and directed to the bottom (lowest) compartment or bilge tank. The bilge tanks may be either non-oily bilge collecting tanks or oily bilge collecting tanks also known as Oily Waste Holding Tanks (OWHT).

All ships produce bilge water that needs to be discharged. Every ship is expected to have in place a treatment plant for separating water from oil prior to discharging over board. As per the international law no ship can discharge untreated oily wastewater in open waters and these laws are enforced strictly by most of the maritime countries. US Navy on the other hand is governed by OPNAVINST 5090.1B (Tompkins ***et al.,*** 1997)

Bilge water does not contribute to marine pollution directly since it cannot be discharged and hence it is an operational problem for boats and ships. In smaller boats, it is a normal practice to absorb oil on absorbent socks or pillows that are later deposited at the port or a marina for final disposal (Boat US, 2001). However, the liability of the waste generator does not end there. In fact in such hazardous wastes, the liability of the waste generator is in perpetuity. The oil is completely consumed

either by incineration or by employing bioremediation products described in this paper. In this case there is no need for further disposal of residual oil in a land fill. This is what we define as an ***"End of Chain solution***".

In the present paper, application of biodispersion products for treatment of residual oil in bilge water is described. Currently there is no ***"End of Chain Solution"*** for the bilge water treatment in the entire protocol. Biodispersion products contain oil-eating bacteria that consumes the waste oil, thus offer a much needed ***"End of Chain Solution"***. The liability of the generator of hazardous material can is reduced considerably.

THE PROBLEM

Untreated bilge water contains oil and grease (O&G) and an assortment of oxygen demanding substances both organic and inorganic materials. These materials include volatile and semi volatile organic compounds (VOCs), inorganic salts and metals. Oil Water Separators (OWS) on ships remove and separate only oil soluble components and discharge water containing water-soluble constituents in the open water. Most of the ships are equipped with OWS, Marine Pollution Control Devices (MPCD) and Oil Content Monitors (OCMs) to monitor the oil before discharge of water in the sea. In the event that the oil content of the discharge exceeds the international limit of 15 ppm, OCM sets out an alarm and diverts the effluent back to the OWHT. However, some of these systems are reported to function less efficiently resulting in an over board discharge of bilge water exceeding the international limits for oil content. Many of the ships had to pay heavy penalties for violating the international directives.

Volume Of Bilge Water

The amount of bilge water produced is directly proportional to the size and nature of operation of each ship. Thus an aircraft carrier produces on an average 3,000 gallons of bilge water a day during idle hours or 4.9 million gallons in one year with a maximum of 25,000 gallon per day. Other classes of ships of navy on the other hand generate an average of 2,000 gallons per day totaling to 84.9 million gallons per year. Adding the total volume of 4.9 million gallons of Aircraft carrier fleet, the total volume of bilge water produced by the US Navy alone is 89.8 million gallons per year for surface ships only (DOD Report, 2000).

The report also details analysis of constituents of bilge water and that it contains over 25 priority pollutants. Inorganic metals like arsenic, copper, cadmium, chromium, lead, mercury, selenium and zinc were recorded. Organic constituents identified were benzene, Benzene Hexa Chloride (BHC) isomers, ethyl benzene, heptachlor, heptachlor epoxide, naphthalene, phenols, phthalate esters, toluene, trichlorobenzene and trichloroethane. These pollutants may be restricted to naval ships and may not be for commercial ships.

THE TREATMENT

The bilge water is treated on board primarily to remove only oil, greases and other hydrocarbon elements and water containing less than 15 ppm of oil is discharged over board. Oil free from water is then stored in a sludge holding tank for disposal in an on-board incinerator or at a port receiving facility.

The bilge water treatment system varies from ship to ship depending upon the size and the volume of bilge water produced. For example, cruise lines that may be described more as large floating cities,

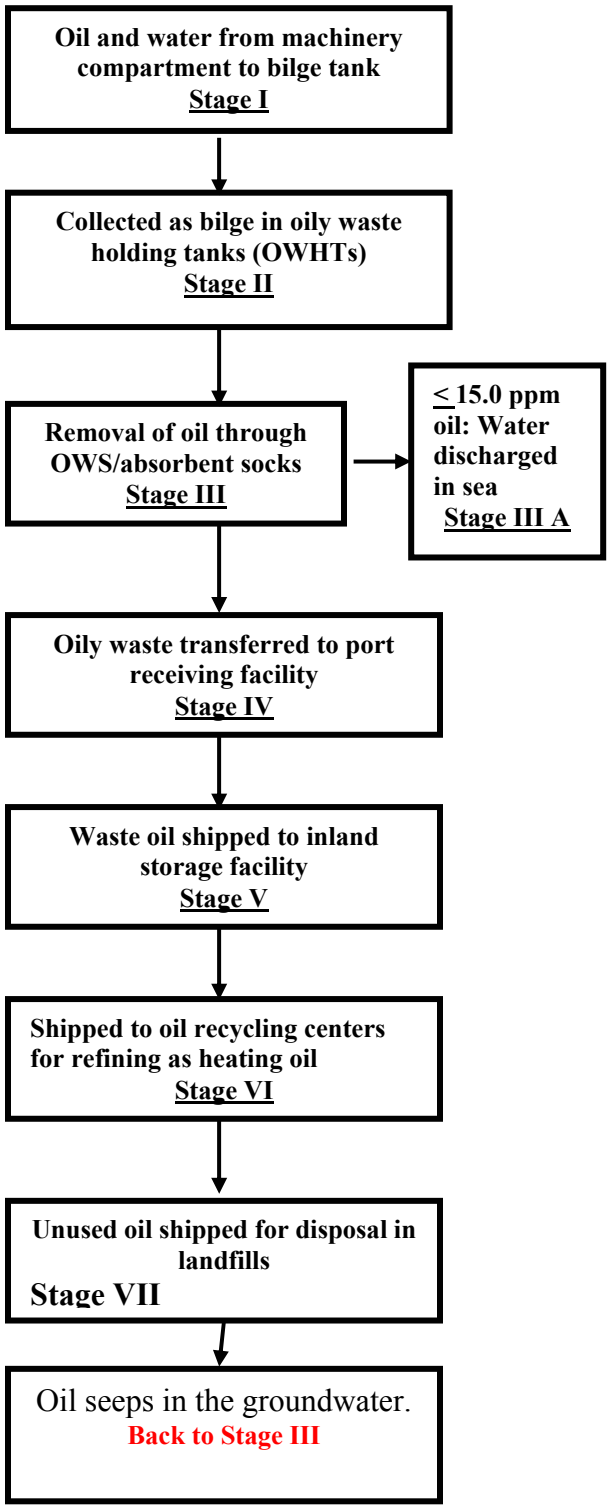
produce more bilge water than an aircraft carrier. Guidelines for bilge water treatment systems for cruise ships and other commercially operating ships have been well defined under MARPOL 73/78 and these guidelines are followed very strictly. A similar uniform standard for disposal of bilge water by war ships is also in progress under the National Defense Authorization Act of 1996 (DOD Report, 2000). The final phase of the project will determine the design, construction, installation and use of MPCDs suitable for war ships.

Treatment of bilge water and residual oil is carried out on ships in the following manner.

- Separation of oil on-board using oil water separators
- Use of absorbent material like pillows or socks in smaller vessels.
- Disposal at an on-shore treatment facility
- Shore based reception facilities for transport, storage and disposal (T.S&D) of the oily waste

In all these operations, oil is collected either in holding tanks or in absorbent material that is disposed of routinely at port facilities at the cost of the ship/vessel. The liability of the ships (generator of waste), however, remains in perpetuity or 'from cradle to grave'. The flow diagram of the bilge oil transport and disposal is shown in Figure 1. All these solutions do not remove oil but leave an oily residue for dispossal. ***There is no end of chain solution for these vast amounts of waste oil generated by ships, vessels and fishing trawlers***.

Figure (1): Flow chart of on board oily bilge water and shore disposal process for ships



Biodispersion: "An End Of Chain Solution"

Bioremediation products developed on the basis of biodispersion provide the much-needed ***"End of Chain Solution"*** for on-site consumption of oil through the activities of oil-eating bacteria. Products evaluated here are added directly to the bilge water to remediate residual oil either after initial separation through OWS in the sludge tank or directly before passing through OWS. Four commercially available products developed on the basis of patented biodispersion technology have been examined for various field evaluations.

One such product BilgeRemed (manufactured & marketed by Sarva Bio Remed, USA) is used for bilges of ships and is prepared in a seawater medium. These products are oleophilic and hence the bacteria remain in the oil layer and are not lost in the large amounts of water in the bilge. Figure 2 shows the biodispersion of waste oil and breakdown of oil into smaller oil droplets and each of these is surrounded by a dense population of bacteria. Once the oil is consumed there is a progressive decrease in their population since many die a natural death due to the absence of food, the oil (Fig 3).

Figure (2). Microphotograph showing bacteria surrounding small oil droplets (TPH 286 ppm).

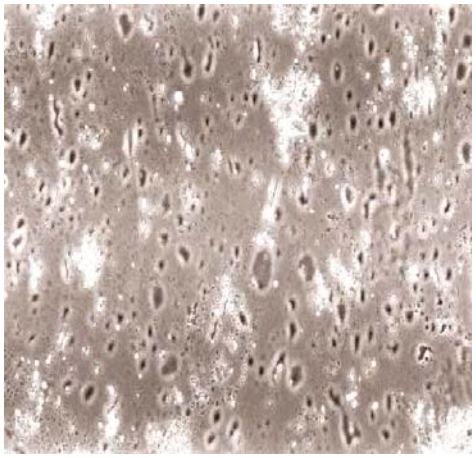


Figure (3): Microphotograph showing reduced bacterial population after consumption of oil (TPH 25.8 ppm).

Biodispersion products are effective against a wide range of oils and mixtures of oils as seen from various case histories described below. These products have been designed to provide following properties:

- Available in a ready to use (RTU) liquid form
- Non-corrosive to metal parts of OWS
- Not toxic to aquatic life and not harmful to ship's staff
- Do not require addition of supplementary nutrition
- Effective in a short time
- No residue after remediation of bilge oil
- Require little or no human intervention
- Do not contain genetically modified bacteria
- Environmentally safe

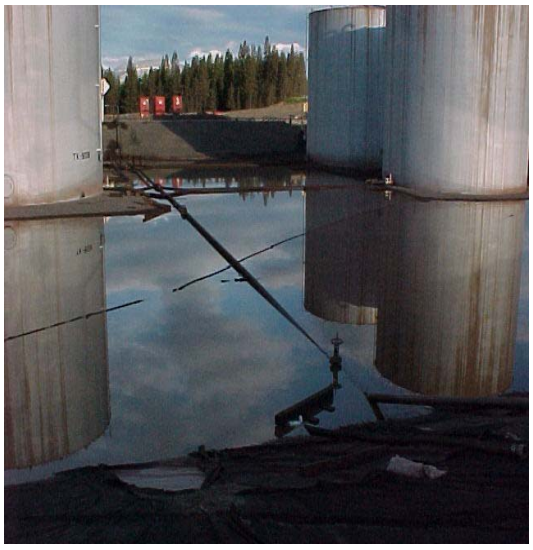
Field studies on utilization of waste oil by oil-eating bacteria in these products are described below to demonstrate a variety of oils remediated.

Case History 1:

Remediation Of Contained Open Water Spill

SpillRemed (Fresh Water) was employed for treating an oil spill contained in a lined and bermed storage area in a mine in Canada. The Kemess Mines located in the remote region of Rocky Mountains, British Columbia is involved in extracting noble metals. The mine employed the standard procedure of deploying oil absorbent booms in the berm for clean up. However, the booms absorbed water and they sank to the bottom of the berm releasing the absorbed oil (Fig 4).

Fig. (4): Untreated oil spill treated with SpillRemed under temperatures below 0° C.



Less than 2 gallons of SpillRemed (Fresh Water) was sprayed over the spilled oil. The atmospheric temperature was less than 0° C and the conditions did not look promising for any type of bioremediation. Nevertheless, next day a noticeable reduction or thinning of the oil film was detected. There were two more applications of SpillRemed. After 6 weeks the water became completely clear and was safely discharged into the waste stream (Fig 5).

Fig. (5): After remediation with SpillRemed. Clean water was discharged in waste stream.

Case History 2:

Remediation Of Mixtures Of Oils & Greases

A Louisiana based manufacturing company fabricating over-sized pipes and other parts generated a mixture of oils and grease that was collected in their storage or retention pond. About 2 gallons of SpillRemed (Fresh Water) was employed to completely remediate the mixture in 4 weeks time. The situation is similar to the one in bilge tanks in ships. The remediation was completed at the site itself without resorting to transport and disposal of the hazardous waste.

Case History 3:

Remediation Of Bitumen Waste Water

A New Zealand based company wanted a simple and fast acting solution for remediation of bitumen waste from tankers. 40 liters of the waste was stored in a tank and SpillRemed (Fresh Water) was added to

the tank in five installments. At the end of 3 weeks the original 1-inch layer of bitumen waste was reduced to a thin film. The temperatures were less than 5°C thus indicating effectiveness on one more component of hydrocarbons.

Case History 4:

Bilge Water In Fiber Glass Boat

Studies on bioremediation of bilge water were carried out on a fiberglass vessel undergoing refit along dockside in a marina in West Palm Beach, Florida. The fiberglass composite vessel had a high solid epoxy finish applied to the bilge space in the engine room. The bilge slop was a mixture of salt and fresh water contaminated with diesel "blow-by", lubricating oil and hydraulic oils. Some of the lubricant had globulized and a heavy sheen was evident.

One gallon of BilgeRemed was added to the standing bilge water in the ratio of 1:10 of BilgeRemed to bilge water and the mixture underwent bio-remediation. Periodic observations indicated an advancing form of remedial activity and at the end of 14 days the water was completely clear of any waste oil. There was no sheen and the water was in a state for release in the open water.

Results in boats with aluminum hull and wooden hull showed no effect of BilgeRemed since the bilge water contained amounts of copper toxic to the bacterial population. The results indicate that BilgeRemed is effective for on-site remediation of complex mixture of oils and greases in the bilge if there is no toxicity in the bilge water. There is no need for aeration or addition of supplementary nutrients for small boats studied above.

COST OF BILGE WATER TREATMENT SYSTEMS

Treatment of bilge water on board ships is a very expensive process and requires installation of Oil Water Separators to remove oil from the bilge before releasing water in the open sea. The limit of discharge is set at 15 ppm in the coastal regions and 100 ppm in the open sea. A large number of companies manufacture OWS and the cost of each unit may range from $ 50,000.00 to more than $ 100,000.00 depending on the sophistication of the system. In a recent report from Canada (Brewster, 2002)**,** the Canadian Navy will be spending $ 750,000.00 for installation of Oil Water Separators for each of the seven submarines.

Smaller vessels and ships not equipped with OWS employ oil absorbent socks or pillows each costing anywhere between $10.00 to $30.00 to absorb the bilge oil and discharge clean water over board and the oily absorbent is disposed of in the port. Oily wastewater in the bilge is often transferred in the port receiving facility at a cost of $1.00 a gallon. Larger ships discharge their bilge oil wastewater reportedly at the rate of 24 cents a gallon. The cost of disposal of bilge water at the port is in addition to other overheads for the ships.

In many Naval stations, Bilge and Oily Wastewater Treatment System (BOWTS) are installed on the shore for pretreatment of oily waste to meet the discharge limits of the effluents as per 40 CFR 122 **(**NFESC, 2002**)**. A cost comparison given by BOWTS for treatment of 15 million gallons of wastewater annually is detailed in the Table 1 (see Annexure I). Without employing any BOWTS, the cost for each port is $ 3.6 million whereas using BOWTS it costs almost $ 2.0 million including the cost of capital equipment of $1.4 million. The system is not considered economical for volumes of bilge water less than 1.0 million gallons annually. BOWTS, however,

produce as much as 1.5 million gallons of residual oil that may be used for recycling or for landfill disposal. None of this waste has been shown to produce any income.

Cost of treatment of oil with BilgeRemed is US $40.00 for 100 gallons of bilge water or 40 cents a gallon and does not need any installation of expensive capital equipments (Table 1).

CONCLUSIONS

The cost of treating bilge water by physical processes or by transportation to inland storage and disposal stations is very high. Sometimes the complex mixture of recycled bilge oil cannot be incinerated due to the absence of low boiling point fractions. This type of residual oil is then shipped to a landfill site for final disposal resulting in ground water pollution (Fig 1). Treatment of oil in bilge water is thus a cyclic process and after all the processes, the oil returns to the water unless the waste oil is consumed.

Oil eating bacteria in BilgeRemed effectively transform the hydrocarbon into food for their growth and survival. It is cost effective for any type of ship and vessel. The hydrocarbon or the oil is transformed in harmless by-products by the bacteria and once the oil is consumed the bacteria die a natural death as seen from the microphotograph (Fig 3). This benevolent population of microbes does not leave any residue nor do they cause any form of imbalance in the ecosystem after consuming the waste oil. They provide an ideal ***"End of Chain solution"*** to the complex problem of disposal of waste oil in the bilge water either on board ship or on shore. Further these products unlike other OSD's do not cause corrosion and are not toxic to marine life.

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ANNEXURE I.

Table (1). Cost comparison of BilgeRemed with other solutions

Sl. No.	Expense head	BilgeRemed	OWS	BOWTs	Traditional system
1.	Capital cost	0.0	>$ 50,000.00 to $750,000.00	$1,400,000.00	0.0
2.	Operations & Maintenance Costs	0.0	Power and replacement of filters	$ 300,000 + cost of replacement chemicals	0.0
3.	Transportation cost	On site	On site	On site	Transportation $1.0/gallon
4.	Waste Storage Costs	No waste and no residue	Residue transferred to shore based system	10% collected as oily waste residue	No waste at the port
5.	Liability	None since no waste generated	Storage & Disposal	Storage & Disposal	Transportation & insurance
6.	Total Cost of treatment (based on the current prices)	$ 40.00 for 100 gallons of bilge water	$ 100.00 per 100 gallons + cost for Transport Storage & Disposal	$ 750.00 per 100 gallons + re-cycling or disposal costs	$ 100.00 per 100 gallons + cost for Transport Storage & Disposal