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Biotechnology provides solutions to a wide range of marine pollutants

The ferry Peter Wessel, which operates between Norway and Denmark, uses a PetroLimiter 630M treatment system.

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Protecting the marine environment from oil spills, discharges of oily bilge water and contamination by nonnative organisms carried in ballast water represents three distinct problems, but steady advances in bioremediation and related biotechnologies may provide a common solution.

Bioremediation is defined by the IMO's Marine Environment Protection Committee as "the use of biological processes to accelerate the removal of contaminants from the environment." Bioremediation is seen, the committee says, "as the environmentally friendly response to an oil spill since it converts oil into harmless products such as carbon dioxide and water."

According to the U.S. Geological Survey, microorganisms can consume fuel-derived toxic compounds and transform them into harmless carbon dioxide, and the rate of these biotransformations can be greatly increased by

the addition of nutrients.

In a presentation at the 2004 annual meeting of the Society of Naval Architects and Marine Engineers, Hal Alper, president of Mycelx Technologies Corp. in Gainesville, Ga., outlined the state of bioremediation technology. "Of the oil released by vessels, 25 percent is reported to come from spills and 75 percent from operational discharges," he said. "Oily bilge discharge is second only to oily ballast tank discharge in its contribution. There has been much work conducted to determine the discharge standards for oily bilge water and how best to detect and monitor the discharge. The result appears to be that 15 ppm (parts per million) will be the standard of discharge for oily bilge water, although, within localities, more stringent limits often exist."

To reduce the possibilities of oil-contaminated discharges of bilge and ballast water, manufacturers of oil water separators continually improve equipment designs. Biotechnology offers great promise to not only remove the oil but also to reduce or eliminate the need for any landside disposal of residues.

One bilge water bioremediation technology approach for ship wastewater cleanup was outlined in a U.S. patent assigned to EnSolve Biosystems Inc. in Raleigh, N.C.

The EnSolve concept involves a piping and pumping system for removing bilge water containing oily biodegradable material, a bioreactor for treating the bilge water and a piping and pumping system for handling the treated bilge water.

The treated bilge water contains dissolved gases, nutrients and the microorganisms sloughed off the support media. This treated water can then be discharged into open waters if regulatory standards are achieved, or recirculated into the bilge. If recirculated, the water acts as a seed culture for regeneration of the microorganisms that will continue to decontaminate the bilge water. However, if discharged overboard, the microbe-rich effluent has the potential to help clean up any petroleum slicks surrounding the ship.

EnSolve Biosystems' patented bioreactors contain the viable cultures of microorganisms for the oil removal process and are maintained by gas and nutrient injection systems. The culture of microorganisms slough off and disperse into the recirculating or discharged bilge water. However, this bioreactor is designed to maintain a constant microbial biomass with nutrient concentrations to produce optimal microbial growth and metabolism of petroleum hydrocarbons.

Marine Environmental Management, of Warrington, Pa., has found that, under optimal conditions, a single microbe can divide every 20 to 30 minutes



Above, the PetroLimiter system aboard Peter Wessel is capable of

and will live as long as (optimal) conditions exist within a range of 30 to 90 days.

Cleaning up spilled fuels, lubricants or other petroleum products in the machinery spaces of vessels is a regularly occurring challenge. One solution is Navalkleen, a microbial-action product produced by Marine Environmental Management. Navalkleen contains no surfactants, solvents or chemicals and has proven effective to meet IMO guidelines of 15 ppm in treated water.

treating 5,400 gallons of oily bilge water per day. The biological agents effectively remove emulsified oil that cannot be easily separated from water by mechanical means.

Oily bilge water cleanups

Bilge water containing oily wastes is normally treated by regular operation of oily water separators, filtration and other related shipboard systems. Proper treatment-system maintenance is important, including ensuring the discharge piping for ballast and bilge systems is not internally coated with oily residues that could contribute to an overboard discharge of contaminated water. Still, accidental and intentional bilge water spills continually occur worldwide.

EnSolve said designing the PetroLimiter equipment for low maintenance was an important factor for its bioremediation oily water separators that have been in use aboard vessels since 2000. The systems have U.S. Coast Guard approvals and meet IMO discharge standards. The PetroLimiter treatment can reduce the total petroleum hydrocarbons to less than 15 ppm. In operation, suction is directly from the ship's bilges or oily water collection tank. The oily water goes directly from the bilge to the PetroLimiter for treatment and then discharge. The simplicity of this design reduces the need for piping, storage tanks and other equipment, thereby helping to keep maintenance requirements low.

"Unlike conventional oil water separators, the PetroLimiter actually destroys oil and grease using naturally occurring bacteria," according to EnSolve.

The PetroLimiter bioremediation technology systems were initially installed on Interlake Steamship Co.'s 1,000-foot bulk Great Lakes carrier MV James R. Barker in 2000. After the system proved successful, EnSolve equipment was later installed on Interlake's MV Mesabi Miner and the MV Paul R. Tregurtha.

"The system contains safe, non-pathogenic, hydrocarbon-ingesting bacteria that converts oils, greases, detergents and other hydrocarbons into harmless end products. The automated system works 24 hours per day processing up to 37,800 gallons of bilge water per week. It is equipped with a fail-safe oil content monitor that continuously tests the clean effluent prior to discharge," EnSolve said.

Bioreactor technologies

A key element of bioremediation systems is the bioreactor. The EnSolve bioreactor converts organic compounds into harmless end products such as carbon dioxide and water.

One feature creates in the support media a strong electrostatic charge opposite that of the bacteria, thereby attracting the bacteria like a magnet. Once attached to the support media, the bacteria secrete a biological glue called polysaccharide that further binds the bacteria to the support media. This strong binding minimizes bacterial washout, creating a denser population of bacteria and thereby increasing efficiency.

EnSolve said the bioreactor's configuration allows the use of lighter, less costly materials and provides a proprietary means of delivering nutrients and pH adjustment chemicals without costly pumps and tanks.

Another important feature of the PetroLimiter design utilizes bacteria specific for the target contaminants. Even though two different bacteria may degrade the same contaminant, one bacteria may do this quicker and more effectively than the other.

Ballast water

Similar approaches can be used to treat ballast water contaminated with oil. However, from the point of view of regulators, the greater concern with ballast water is the possibility it might be carrying invasive species from other parts of the world. Adherence by ships to regulations for total exchanges of ballast water at sea is problematic for many reasons. Moreover, the internal structures of ballast tanks can make it unlikely that even total ballast water exchanges will eliminate all invasive species.

The newly patented BalPure ballast water treatment system by Severn Trent De Nora in Fort Washington, Pa., is a high-capacity treatment system designed to eliminate harmful species in ballast water with no adverse environmental side effects.

The company describes the operation this way: "Through the oxidation of the halide ions in seawater, the proprietary BalPure electrolyzer generates oxidants that are injected into the ballast stream where they react with both inorganic and organic matter, as well as bacteria, to provide effective disinfection. As the harmful organisms are inactivated or destroyed, the oxidant concentration in the ballast water is reduced. The BalPure system then introduces a neutralizing agent to the ballast water

where it reacts with residual oxidant rendering the water safe to discharge into waterways."

Biotechnology advances, including bioremediation, increasingly provide ship owners with the tools they need to efficiently reduce environmental damage to the seas their ships travel on.

Photos courtesy EnSolve Biosystems Inc.