

**Transportation-Environmental Impacts and Remedies**  
**(Biodegradation by Oil-Eating Microbes)**



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**Abstract:**

Almost 90% of the world's entire transportation of goods is done by ships. But we face a few problems such as the environmental impacts that the shipping field has.

Shipping has several environmental impacts. Like pollution from [ships](#) which directly affect coastal areas. The pollution produced affects [biodiversity](#), climate, food, human health to name a few and not to forget the impact of ballast water that releases organisms which either are not used to the new habitat or invade the habitat of other organisms causing them harm thereby making them extinct, a good example would be the zooplankton in the Black sea. (Noise pollution and vibrations may also be included to the list of impacts).

A major hazard that has come from the shipping side is oil spills. Oil spills have played a major role in harming the marine ecosystem which are mainly caused by grounding of ships and collision. The paper emphasises on some organisms main microbes which would probably change the current unhealthy and non environmental friendly sphere that has been created worldwide due to several oil spills.

### **Keywords:**

- Oil Eating Microbes,
- Oil spills,
- Environmental impacts,
- Transportation,
- Generic details

### **INTRODUCTION TO TRANSPORTATION:**

Transport or transportation is the movement of people and **goods** from one location to another. **Modes of transport** include **air, rail, road, water, cable, pipeline, and space**. Although the needs of people stimulate the demand for transportation, environmental pollution and health care which are also very important for the people. The transportation systems should ensure efficient movements of passengers and freights but, such a system should not deplete the natural resources and badly affect the environment.

### **MODES OF TRANSPORTATION AND THEIR ENVIRONMENTAL IMPACTS**

Rail transport is the most commonly used mode of transport for heavy and bulky loads over long land routes (in general, greater than or equal to 200 km) without paying enormous charges. Trains can provide reasonably high speed and they are conveniently linked with other modes of transportation.

From the environmental aspect on railway, there are some damages caused from improper fuelling, maintenance and cleaning rail car, locomotives and parts; oil and coolant releases.

For door-to-door transportation, the most widely used mode is road transportation. Its main benefits are the flexibility and the ability to reach rugged terrains. Fuel combustion, motor oil, brake and transmission fluids, coolants, solvents, etc. pollute the air, soil and water.

Air transportation is the most convenient mode when slow speed is unacceptable. Loading and unloading operations can be carried out frequently and the flexibility level can be increased. However, aircraft operations create noise, engine emissions and waste disposal problems.

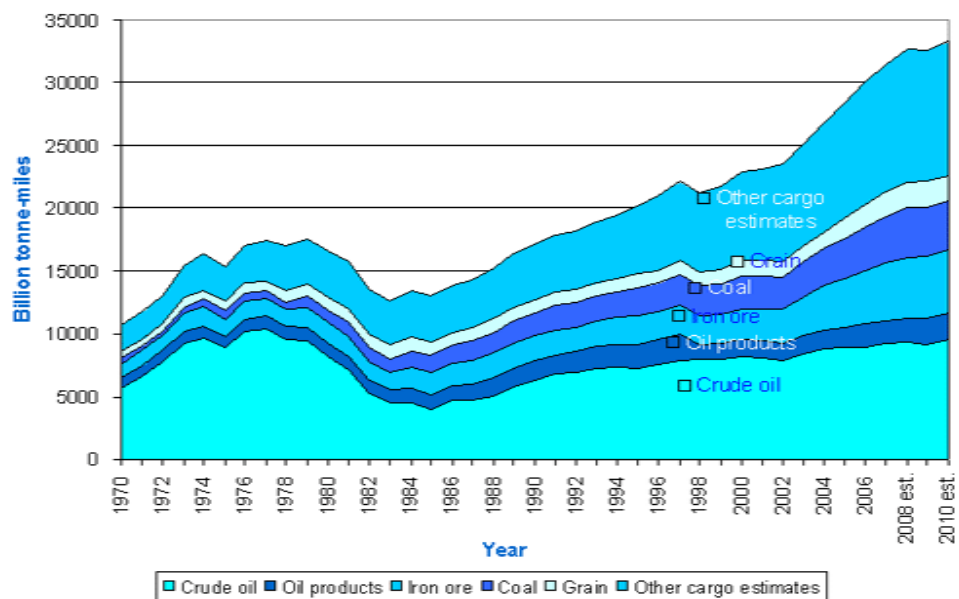
**Sea transportation** can be classified into three basic types:

- (i) river and canals,
- (ii) coastal shipping and
- (iii) Ocean transport.

The main advantage of sea transportation is the ability to transport large amounts of bulk freights, liquids and containerized freights by ships and vessels. In addition, it is the cheapest transportation mode and there are no duty or transit-passing transactions between the starting and arrival points.

### ADVANTAGES OF SHIPPING AS A MEDIUM OF TRANSPORT

- Around 90% of world trade is carried by the international shipping industry.
- There are over 50,000 merchant ships trading internationally, transporting every kind of cargo.
- Over the last four decades total seaborne trade estimates have quadrupled, from just over 8 thousand billion tonne-miles in 1968 to over 32 thousand billion tonne-miles in 2008.
- The better means of transportation for bulk goods, heavy machinery and heavy load of raw materials etc. are cheaply transported from countries to countries easily through sea route..



*Fig:graph showing various cargoes carried by shipping by volume.*

# COMPARITIVE STUDY OF ENVIRONMENTAL IMPACTS SHOWING ADVANTAGES OF SHIPPING

## MARINE POLLUTION

Sea transport is one of the least environmentally damaging modes of transport and, when compared with land based industry, is a comparatively minor contributor to marine pollution from human activities.

In tonnage terms, the amount of oil transported by sea increased from 1,600 million tonnes in 1992 to over 2,400 million tonnes in 2008. Over 34,000 million tonnes was carried over the 16 year period. By contrast, the number of major oil spills during the same period shows a steady reduction. Although serious accidents occasionally occur -

the loss of the 'Erika' and 'Prestige' being recent high profile examples - the trend shows a continuing improvement, both in quantity and reduced frequency of oil spills each year

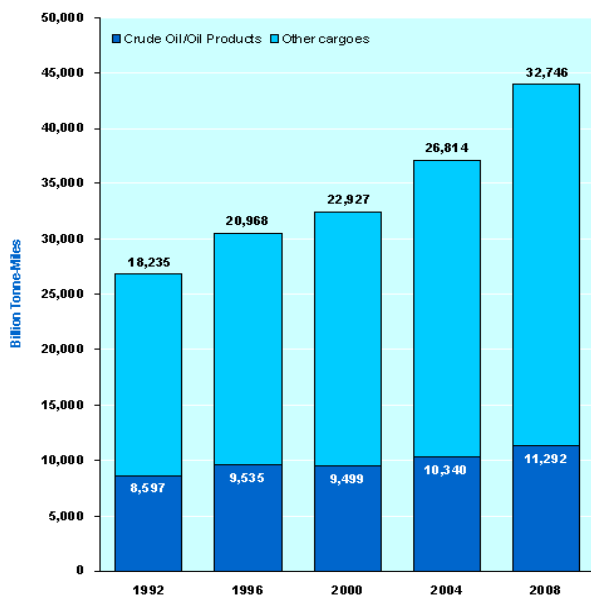
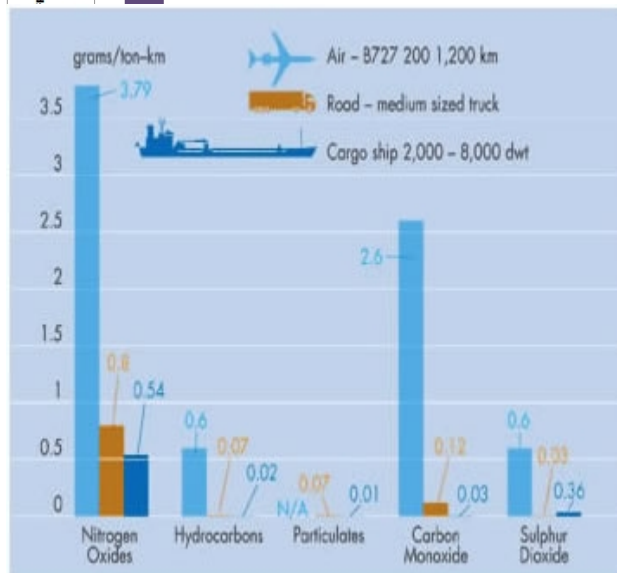


Fig: oil carried by shipping

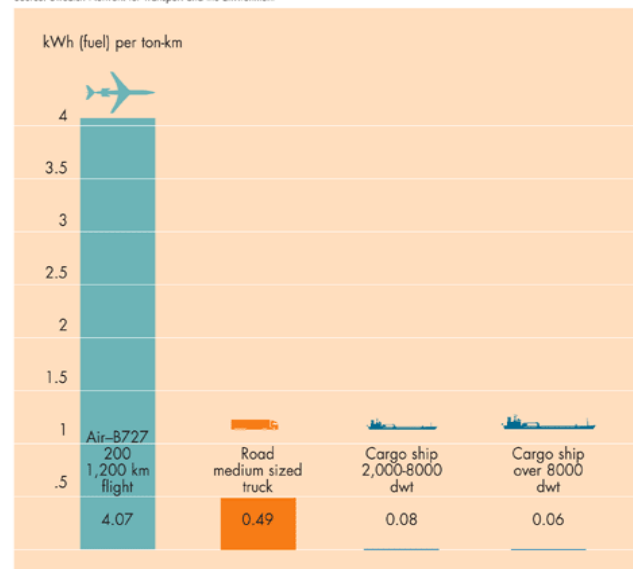
The introduction of industry practices such as crude oil washing for oil tankers, coupled with segregated ballast requirements for tankers, has contributed significantly towards reducing operational pollution.

Important advances have been in the design of OWS which doesn't allow more than 15 PPM of oil to throw over board.



### Comparative fuel consumption

Source: Swedish Network for Transport and the Environment



## **SHIPPING AND ENVIRONMENTAL IMPACTS:**

As mentioned earlier shipping contributes least to the environmental pollution. Some modes of pollution from ships include

- NO<sub>x</sub> and SO<sub>x</sub> and carbon dioxide that contributes to air pollution.
- Accidental and purposeful oil spill on the ocean's surface.
- Impact of ballast water due to change in habitat of micro organisms.
- Disposal of sewage.
- Disposal of garbage
- Pollution due to paints from the ship's hull
- Noise pollution caused by ships.

Since our paper is all about Oil Eating Microbes (OEM) we will be concentrating only on oil spills to emphasize to what extent they have affected the environment and also quickly seeing the behaviour of oil spills and mentioning the previous methods and then seeing in detail about the OEM.

## **OIL SPILLS**

- An oil spill is the release of a liquid petroleum hydrocarbon into the environment due to human activity, and is a form of pollution..
- Sudden, localised release of petroleum into the environment. In the case of major spillages, the quantities greatly exceed what the local environment is able to assimilate without resulting in damages.
- An accidental or intentional discharge of oil which reaches bodies of water. Can be controlled by chemical dispersion, combustion, mechanical containment, and/or adsorption.

Hence a marine engineer is to take utmost importance that such spills never occur especially during bunkering operation or even the purpose overboard discharge from sludge tank or untreated bilge from the bilge water lines. Oil spills may also occur when two ships collide or even when the underwater oil pipelines fail and crack or burst.

Now let us see a few noteworthy examples of oil spills made by vessels in the past.

Position	Shipname	Year	Location	Spill Size (tonnes)
1	<a href="#">Atlantic Empress</a>	1979	Off Tobago, West Indies	287,000
2	<a href="#">ABT Summer</a>	1991	700 nautical miles off Angola	260,000
3	<a href="#">Castillo de Bellver</a>	1983	Off Saldanha Bay, South Africa	252,000
4	<a href="#">Amoco Cadiz</a>	1978	Off Brittany, France	223,000
5	Haven	1991	Genoa, Italy	144,000
6	Exxon Valdez	1989	Prince William Sound, Alaska USA	37,000

### **OIL SPILL BEHAVIOR**

Initially the oil that spills, spreads over the water. This includes oil spill caused by collision or by grounding or failure of the hull due to corrosion or any other cause as. Due to the density difference the oil rises to the surface of the water. This oil now forms a kind of blanket layer over the water body by spreading evenly over the water layer or this layer may get broken up due to the rough weather conditions that may prevail and hence this is mostly dependent on the area of the oil spill.



*Fig: spreading of oil on water body forming thick layer*

**The volatile compounds in this spill start to evaporate on its own and we have a 20 to 40% reduction in the total mass.** Now this also is not very favourable when it comes to the clean up point of view because this makes the oil remaining highly viscous and very dense. The oil now becomes sticky tar balls and the following happens to it:

- Deteriorates(decomposition by sunlight)
- Gets biodegraded (by aerobic or non aerobic)

*It may be noted that the rate of biodegradation depends upon the availability of oxygen nitrogen and microorganisms and also on the temperature of the location.*

### **ENVIRONMENTAL IMPACTS:**

The oil spill contaminates beach sand, gravel, rocks and boulders, vegetation and terrestrial habitats of both wildlife and humans. It may also kill to a large extent the fish and other food species and this also affects the humans in case they consume these infected food stuffs. Long term ecological effects are still worse. Wildlife near the ocean are poisoned by the oil and this includes the reptiles mammals and amphibians in water bodies adjacent to the ocean. Research on the oil spill in Alaska states that the oil traces will remain for the next thirty years.



*Fig: Penguins drenched in oil being washed after an oil spill*

Birds die from oil spills if their feathers are covered in oil. The bird will then be poisoned because it will try to clean itself. Animals may die because they get hypothermia, causing their body temperature to be really low. Seabirds are strongly affected by oil spills. A seabird may get covered in the oil. The thick black oil is too heavy for the birds to fly, so they attempt to clean themselves. The bird then eats the oil to clean its feathers and poisons itself. Plankton, larval fish, and bottom dwelling organisms are strongly affected. Even seaweed, clams, oysters, and mussels can be affected by oil spills. This is what happens when a species from animal becomes extinct of a large oil spill. The oil spills can damage the entire food chain in the area.

#### **CLEAN UP AND RECOVERY:**

The method they use to clean the beaches or oceans depends on many things. They have to look at the weather, the type and amount of oil spilled, if people live in that area, what types of animals live in that area, and many more parameters. In some situations, they may not react to a spill.

It may not be helpful or it would just cause even more damage to that habitat. Depending on the respective areas following methods are employed:

- Skimming
- Filtering
- Above two in combination
- Dispersing (to avoid immediate environmental damage)

Other methods have been used for example usage of a large ring of floating absorbent pads as shown in the picture that follows.



*Fig: cleaning up a spill with oil absorbent pads*

## **INTRODUCTION TO OIL EATING BACTERIA**

*Alcanivorax*, first described in 1998, is a Gram-negative, halophilic, aerobic, rod-shaped, oil-degrading marine bacterium that is found in low abundances in unpolluted environments in the upper layers of the ocean, but quickly becomes the predominant microbe in oil-contaminated open oceans and coastal waters when nitrogen and phosphorus are not limiting. When conditions in these moderately halophilic environments are right, *Alcanivorax* may make up 80-90% of the oil-degrading microbes present in the area. It is described as a non-motile bacterium which is true for species such as *Alcanivorax borkumensis*, but other species such as *Alcanivorax venustensis* were described to be motile by polar flagella. The optimal conditions described for *A.borkumensis* growth include temperatures in the range of 20-30 degrees Celsius, and a NaCl concentration of 3-10%.

## **TECHNICAL DETAILS OF THE BACTERIA**

The genomic analysis of *A. borkumensis SK2* revealed several new insights into the bacterium's role for ;

(i) n-alkane degradation (which includes metabolism, biosurfactant production and biofilm production),

(ii) its system for capturing or scavenging the small amounts of nitrogen, phosphorous, sulfur, and other elements in a nutrient-poor marine environment which allows for more efficient alkane degradation due to their main limitation of nutrient availability,

(iii) as well as means for coping with stress factors such as high salt contents and high UV radiation since it thrives mostly in the upper layers in the ocean where UV light is encountered. The bacteria can be taxonomically classified as:

Kingdom: [Bacteria](#)

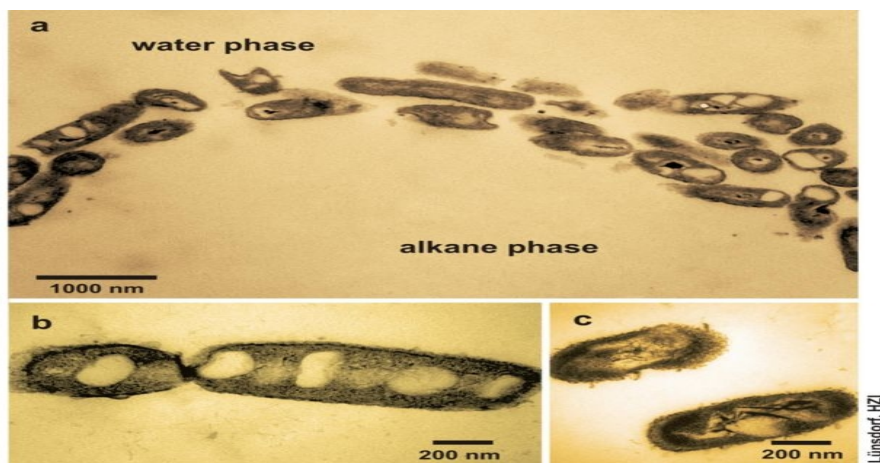
Phylum: [Proteobacteria](#)

Class: Gamma  
Proteobacteria

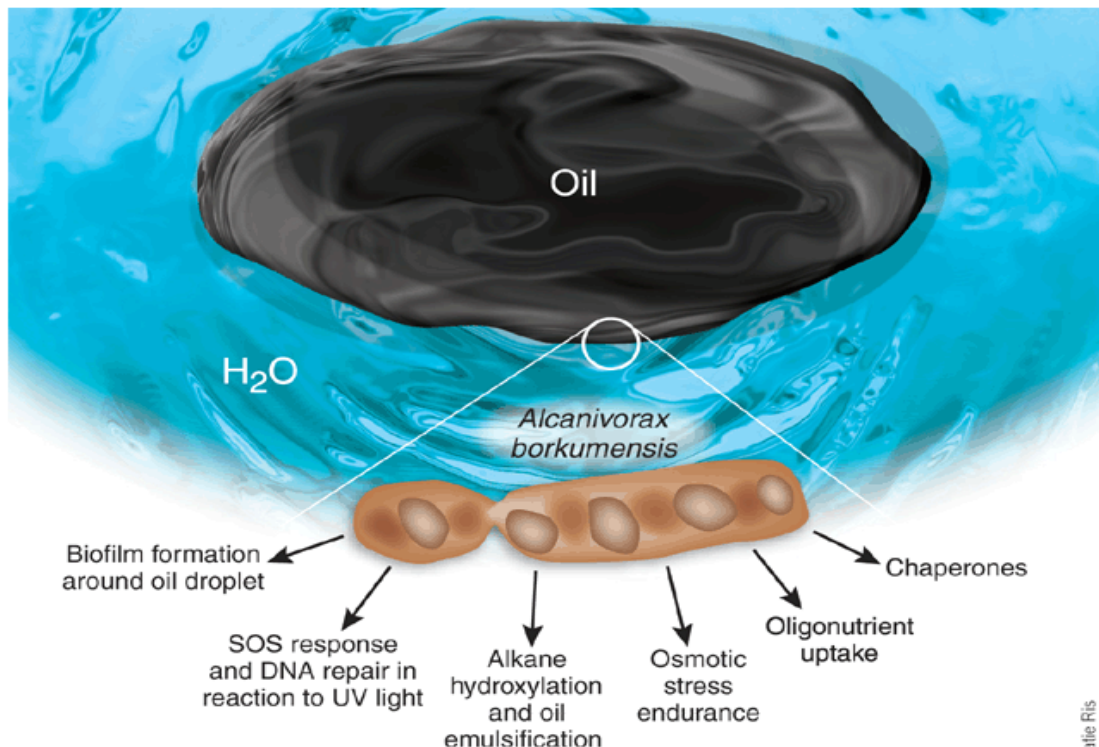
Order: [Oceanospirillales](#)

Family: [Alcanivoracaceae](#)

Genus: *Alcanivorax*



*Fig: showing the microscopic view of Alcanivorax borkumensis in its alkane phase.*



*Fig: showing mechanisms for oil degradation and survival encoded by the A.borkumensis.*

#### **METHOD OF USAGE:**

- We initially have to understand the basic concept that these microbes are already available in the ocean in low abundances.
- When there is an oil spill the microbes start to exponentially multiply.
- The oil serves as nutrients on which these microbes feast on.
- The first step would be to apply dispersants.
- Dispersants stimulate bacterial multiplication and it reduces the oil water interfacial tension so that the oils are effectively dispersed as fine droplets.
- It is of minimal toxicity and will not add to the environmental damage caused by the oil spills. These would be forms of carboxylic acids.
- These make it easier for the microbes to chew on the oil.

- There are three basic types of hydrocarbons, straight chain, branched chain and 6-member rings.
- The OEM breaks all the three types of hydrocarbons into basic non toxic elements such as carbon dioxide and water.
- Temperature should be maintained between -2° to 60° Celsius and pH of 5.5 to 10 for the microbes to work effectively.
- Metabolism slows down by a factor of 2 or 3 for every 10° Celsius drop in temperature.
- If oxygen is deficient anaerobic microbes work on the oil but they take 365 days to complete the work done by aerobic OEM in 10 days.
- In order to survive OEM require air, water, nitrogen and phosphorus and oil.
- Sediments that settle down deep inside say at a depth of 1400 meters can only be handled by OEM.
- Oil seep inch the ocean bed is taken care by these microbes.

#### **EFFECTIVE USAGE OF OEM:**

The oil eating microbes are being used successfully at several spots of oil spill. Let's see a few places and the related details with pastings from news reports.

#### ***Oil-Eating Microbes Successfully Clean Up Mumbai Oil Spill***



*Fig: oil spill affected parts in the shore lines of MUMBAI*

Look no further than Mumbai, where scientists recently used the Oilzapper (a mixture of five bacterial strains and corn cobs) to munch on oil spilled on a kilometer-long stretch of beach. So far the technology has been successfully used to treat over **130,000 tons** of contaminated soil.

Oilzapper, developed by The Energy and Resources Institute (TERI), eats hydrocarbon compounds found in crude oil and sludge and turns them into CO<sub>2</sub> and water. According to TERI, the Oilzapper is incredibly effective. In an interview, TERI scientist Banwari Lal explained, “In Awas village (Alibaug area) we first collected the oil in a pit and applied oil-zapper (the bacterial concoction). The entire area was cleaned in one day. Nothing remains except pure sand.”

Unfortunately, the Oilzapper hasn't been used outside of India. But it's certainly something we should keep in mind for future spills.

#### **Oil eating Bacteria clean up China Oil Spill:**

Beijing: Over 23 tonnes of oil-eating bacteria are being used to clean up an oil spill off the coast of northeast China's Dalian City, four days after pipelines exploded near one of China's largest oil reserve bases.

This is the first time China has made major use of bio-technology to solve an environment pollution problem. Although oil fences are being used to prevent the spill from spreading, workers are concerned the situation may worsen if winds blow or rain falls. "If the crude-oil slick is too thick, the chemical oil-dispersant may not work.

**London, (IANS) Scientists claim to have solved the mystery of the disappearing oil from the BP spill in the Gulf of Mexico.**

They believe that billions of oil-eating bugs have already done the most challenging part of BP's clean-up job. The bacteria, called oceanospirillales, munched through massive oil plumes in the Gulf of Mexico following the world's worst-ever spill, reports the Daily Mail.

It was caused by nearly five million barrels of oil gushing into the ocean over 87 days before it was capped.

The experts examined a 35-km, 3,600-foot-deep plume in May and June and found a growing population of carbon-eating bacteria about 10 km from the leak.

The bacteria worked so fast that each time the scientists could get back to the lab to test seawater samples, the bugs had already eaten all the oil in them.

Earlier this month, when the team returned to where the plumes had been, the bugs were still there but the oil was gone.

**AFTERMATH OF ENGULFING BACTERIA**

The oil eating bacteria no matter of which family they belong to are basically working on the same mechanism. Once they chew up on the oil the only after effects is that they leave an increasing trail of depleting oxygen. The bacterial plume breaks up the ring structure of the hydrocarbons by the action of enzymes and by consuming oxygen. In the gulf of Mexico we have seen a 30% depletion in oxygen and this clearly indicates that these microbes are working hard to chew up errors we made.

The other major concern is the large amount of dispersants that have been dumped into the ocean. The quantity may have any adverse effects on the marine environment says the marine biologists but at such desperate times we need to take desperate measures. But after various tests in laboratory where the microbes were tested to see if they can chew up the subjected heavy fuel oil the scientists say that the microbes were successful and clean water was got after the experiment which could be released back into the sea.

It may be also noted that these bacteria give out carbon dioxide after they degrade the oil and this is just adding up to the green house effect.

## **MARKET POTENTIAL**

Ever since the scientists discovered these microbes, not only has it been used as a means to clean up the oil spills but also has started to launch itself as a commercial product in the market to clean up any small oil spill may it be in your garage or inside your car or even in your water tank. This product has been launched majorly in two forms. The product comes in a powdery form and also in a liquid form and the powdery form needs to be moistened for the bacteria to start acting and in case of the liquid product we have to just spray this over the contaminated area.

The microbes available commercially can chew on both crude oil and modified petroleum products and paraffin wax. They are also effective on animal vegetable oils and fats and they are environmentally friendly as the properties as mentioned on sale are non toxic, non – caustic, non – corrosive, non pathogenic and it is bio degradable. But since this is an emerging technology we cannot completely vouch on the statement of those interested in only making profit by the sales of these microbes. The ph value of these microbes vary from 7.0 to 8.0. and these are to be stored in temperature ranges of 10 to 40 degrees Celsius. The manufacturers also warn the users that it is advisable to avoid freezing of these microbes. It may be worth mentioning that the microbes that are commercially available are genetically engineered. Hence our motive is achieved that is, all the oil is eaten up by the bacteria.

## **FUTURE SCOPE**



The latest technology engineers are using to cope up with the oil spill is the gigantic dome placed over the oil spilled in the ocean. So, by capillary action the oil gets

collected inside the dome structure. On top of the dome a pump is fitted which pumps out the usable dense oil but the contaminated oil in lower layers are left for natural decomposition. Here we can inject the bacteria after pumping out the good oil so that the contaminated oil can be decomposed as quickly as possible so that the dome can be removed quickly from the place. These pictures show two types of dome used these days for oil spill control, one is rectangular shaped and another is the gigantic dome which was made to control the BP oil spill. On the top a pump is fitted to pump out the heavy oil and once the oil is pumped out the bacteriae are to be injected to remove the contaminated oil.

## CONCLUSION

Marine bacteria could be the key to cleaning oil spills in the sea, without further damaging the environment. In the future, we could be harnessing naturally occurring microbes and fertilizing them to increase their capacity to digest oil. These microbes are found in seawater all over the planet. They naturally occur on microscopic algae. Their numbers are regulated by the amount of their food source and certain nutrients that they need to thrive. The microbiologists at Bangor University are the first to trial this theory in a systematic experiment, using seawater collected from the North Sea, the Irish Sea and the Mediterranean. Their early results are strikingly similar- suggesting that the system could be effective in a wide range of locations. "The oil spill is an alternative digestible 'food source' for these microbes. Although probably present in the Gulf of Mexico, for example, a shortage of other essential nutrients limits their growth in numbers.

"The potential for 'bioremediation' as this technique is called is huge. It is the only technique that would effectively remove oil that is distributed over such large distances as are being seen in the current Gulf of Mexico oil spill. Generally speaking, only collecting ("skimming") the oil from the water surface, in-situ burning or biodegradation removes the oil from the ecosystem. Dispersants only distribute it nicely.

*Alcanivorax borkumensis* - is extremely well adapted to oil degradation. **It lives solely on oil and dies after consuming all oil in its surrounding.** Although it is effectively able to survive and function in a range of temperatures above 5° C, there are bacteria which perform this job in the Polar Zones, to

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