Siphoning the spill

Deep into the sea, some 90 miles away from the Coast of Sunshine, a lone dolphin swims just below the water surface. For company, it has scores of 'chocolate coated' half-dead birds, dazed fish, soapy algal blooms and a thick layer of crude oil floating on the water. The playful animal that it is, the dolphin decides to examine the oil-coated birds from close quarters and raises its head out of the water. However, what confronts him is a layer of viscous, smelly oil, forcing him to rush underwater. Lucky to be blessed with fur-less skin, the oil doesn't coat the dolphin. But one wouldn't say the same about the luck factor of other marine animals and birds. For not only will the oil coat the feathery birds and the furry seals, penguins and sea otters, it will also sign a slow and torturous death warrant for them. While the dolphin evades the oil, it is more likely to perish in a few days time due to the toxins and Polycyclic Aromatic Hydrocarbons (PAH) contained in the oil. That's an oil spill for you; dark, slippery, smelly, destructive and a sight so ugly.

Oil, often addressed with tags such as 'liquid gold' and 'fuel elixir', is an organic paradox that humanity is so dependent on. One of the supporting stilts world economy progresses on, it is the backbone of the transport and aviation industries. Yet, oil has repeatedly found itself taking the blame for various man-induced environmental damages. It leaches from pipelines; blackens the atmosphere with smog, heating up the planet; and unleashes destruction on marine ecosystems when it spills in the seas. It heralds celebration when struck on ground or in water and triggers environmental aggression when spilled. It is one of the nature-gifted commodities that we wish we could do without, but cannot.

Crude oil in the form of marine spills has always given governments, environmentalists and oil companies more than a dozen reasons to worry.

Spilled on the ocean surface, it is known to cause immediate and long-term damage that is likely to continue for centuries to come. The Exxon Valdez oil tanker tragedy is one such event that continues to send reminders in the form of poisoned fish, blinded turtles, health problems for the fishing families residing around the Bligh Reef of Alaska and oily ducks and otters that dig into the ocean floor for food and eat settled crude oil, hastening their death every time they do so.

The oil tanker ran aground in the shallow waters of Bligh Reef, spilling 10.8 million gallons of oil into the sea demarcating Prince William Sound

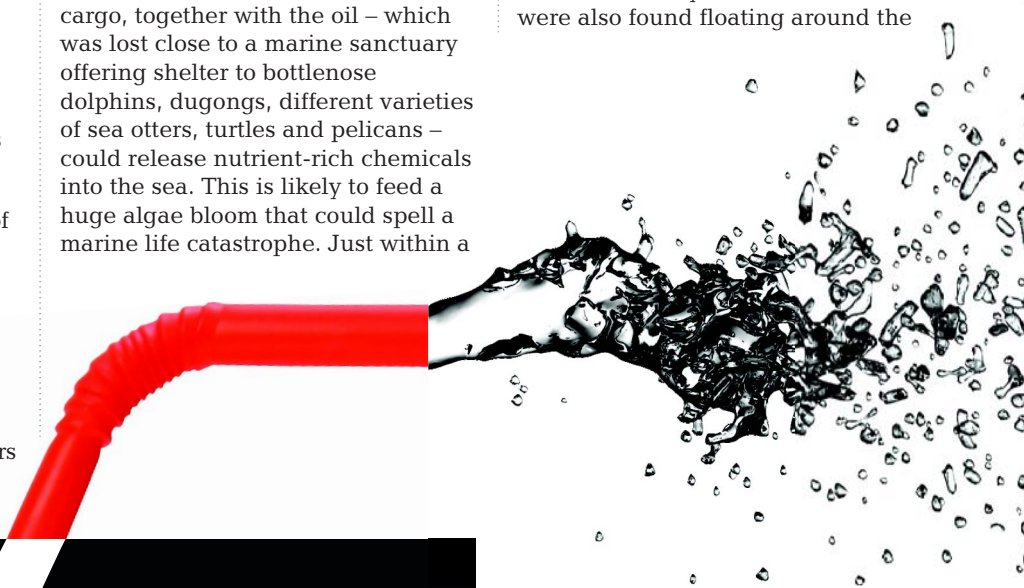
It took 10,000 workers, 1,000 boats, 100 airplanes, and the Navy, Army, and Air Force to clean up the Exxon Valdez spill. Exxon spent about $ 2.1 billion for the clean up.

on March 24, 1989. Some of the marine populations that were affected by the spill stretching across 11,000 miles are yet to recover from its devastating effects. Local human population constantly complain of breathlessness, food poisoning and heavy headedness, even 20 years after the incident. The worst hit was herring fishing, which was a major source of livelihood for the plaintiffs who reside in the region.

In March 2009, more than 40 miles of Australian beaches were blackened and covered in slush resulting out of the oil that spilled from the Pacific Adventurer, which got caught in rough waters from typhoon Hamish. In addition to the oil from the tanker, some 600 tonnes of explosive ammonium nitrate fertiliser containers were also dumped into the sea.

The affected areas were declared a disaster zone as a navy mine-hunting ship searched for the lost chemical containers.

Scientists warned that the fertiliser cargo, together with the oil – which was lost close to a marine sanctuary offering shelter to bottlenose dolphins, dugongs, different varieties of sea otters, turtles and pelicans – could release nutrient-rich chemicals into the sea. This is likely to feed a huge algae bloom that could spell a marine life catastrophe. Just within a few days after the incident, residents of Sunshine Coast have intimated the authorities of a red algal bloom at the mouth of the Maroochy River. This, scientists believe, could be the first sign indicating the leaching of harmful chemicals from the containers. According to Cerran Fawns, who works with the Maroochy Waterwatch group, the large bloom of red algae had been identified close to a mangrove patch in the Maroochy River. Dead fish were also found floating around the bloom, which she reveals is growing at an alarming rate.



Oil from the spill, washed up to 16 beaches including Alexandra Headlands, Bulcock Beach, Coolum North, Dicky Beach, Mooloolaba Main Beach, Peregian, North Peregian, Sunrise, Sunshine and Noosa. However, after initial clean-up, they have been opened to the public.

Dr Dilsha Rajapan, scientist at the National Institute of Ocean Technology, Chennai believes that while the recent oil spills have caused quite a stir because of the media's reach in spreading the news, oil spills actually occur every day. "Every year tonnes of oil enters the seas through routine ship and car maintenance, oil drilling operations and ship spills. While every spill damages the environment to a certain extent, the size of a spill is

Whether spilled on water or on land, oil can wreak havoc as instances in the last decade have proved. What's heartening is the fact that their numbers have reduced and innovative, environment-friendly methods are emerging to combat the damage they unleash, writes **Sheetal Vyas**

obviously important. Damage is also assessed based on the kind of oil spilled and the location in addition to the temperature, wind and weather conditions," he points out. "Crude oil and aviation fuel, which also contain additives that make it stronger, are particularly damaging. And more often than not, these are transported through ship tankers," he adds.

Considering the kind of technology that's put in place to make oil tankers leak and spill-proof, it is rather surprising that marine oil spills continue to happen on such massive scales. Scientists believe that often, natural causes and unforeseen events lead to oil slick disasters. "There definitely have been a lot of technological changes, but one cannot predict the true mood of the sea. If caught in a storm or weakened by one, oil tankers can wreak havoc. They could enter shallow waters and get grounded, hit rock or even suffer technological damage. At times it has also been noticed that empty tankers fill sea water into the space to make up for the weight loss and then empty the same oily water while filling in the oil. A few dozen tanks doing the same will amount to an equally serious oil slick," says Dr R S Kankara, scientist at the Chennai-based Integrated Coastal and Marine Area Management centre.

Resting the blame on ships alone may not be appropriate because nations across the world have used the disaster weapon to intimidate other nations they share hostile relations with. The Gulf War in 1991 was one such case, when 1,500,000 tonnes of oil was flowed into the sea, the repercussions of which are still felt. Moreover, terrorists have used it time and again to terrorise nations and drive in their point. Or, the more recent case of the Pennsylvania man, who released thousand gallons of oil into two streams of the Allegheny National Forest because he was upset with his employer. This resulted in the death of an unknown number of birds, fish, reptiles and amphibians, in addition to polluting the drinking water sources for some tribal communities.

Oil spills of over 100,000 tonnes

Spill / Tanker	Location	Date	Tons of crude oil
Gulf War oil spill	Persian Gulf	January 23, 1991	780,000–1,500,000
Ixtoc I oil well	Gulf of Mexico	June 3, 1979 - March 23, 1980	454,000–480,000
Atlantic Empress / Aegean Captain	Trinidad and Tobago	July 19, 1979	287,000
Nowruz Field Platform	Persian Gulf	February 4, 1983	260,000
Prestige	Galicia, Spain	November 13, 2002	63,000
Sea Empress	Wales, UK	February 15, 1996	40,000–72,000
Exxon Valdez	Prince William Sound, Alaska, USA	March 24, 1989	37,000
Nakhodka	Sea of Japan	December, 1997	19,000
Hebei Spirit oil spill	Yellow Sea, South Korea	7 December 2007	10,800
Amorgos Oil Spill	Southern coast of Taiwan	January 14, 2001	1,150
Kerch Strait Oil Spill	Strait of Kerch,	November 11, 2007	1,000
Jessica	Galapagos Islands	January, 2001	568
West Cork oil spill	Southern coast of Ireland	February 2009	300
Queensland oil spill	Queensland, Australia	March 10, 2009	230+
Guimaras oil spill	Philippines	August 11, 2006	172–1,540

Whether spilled accidentally or intentionally, oil can never blend with water. It can have a smothering effect on marine life, birds and furry animals. A toxic poison, when ingested by birds and mammals while cleaning themselves, oil even when it does not kill, can cause genetic disruptions and affect embryos of marine animals, wiping out generations. The fumes and contact with oil can also cause nausea and health problems for people in affected areas. It can bio-accumulate through the food chain as fish form a source of basic food for numerous predators.

What exactly is it about crude oil that has had environmentalists crying hoarse every time it spills? According to scientific experts, crude oil contains hydrocarbons and their derivatives, which are mostly compounds containing sulphur and nitrogen. In addition to these, crude oil also contains nickel, vanadium, iron and other metals. Oil that flows, leaks or spills into the sea sprawls mainly horizontally and stays on the surface of water as a thin layer. The most prominent changes in the composition of the spilled oil happen in the first two days of the spill. It is observed that almost 50 per cent of the oil evaporates and what get left behind are the heavier and obstinate contents. Sunlight works at this level and dissolves these components in the sea water through photo-oxidation. This causes the toxicity of sea water to increase, exposing marine animals to a larger threat.

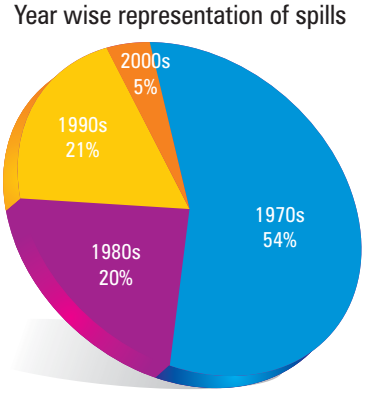
Throwing light on the consequences of oil slick on marine wildlife, Dr Rajapan explains that it is not necessary for the oil to stick to the fur, feathers or scales of wildlife to affect them. "All kinds of oil, whether it's the sticky crude oil or the non-sticky refined petroleum products, imperil wildlife. While the sticky ones smother them and cause prolonged damage settled at the sea bed, the non-sticky ones are more poisonous because of the refinement process," he adds.

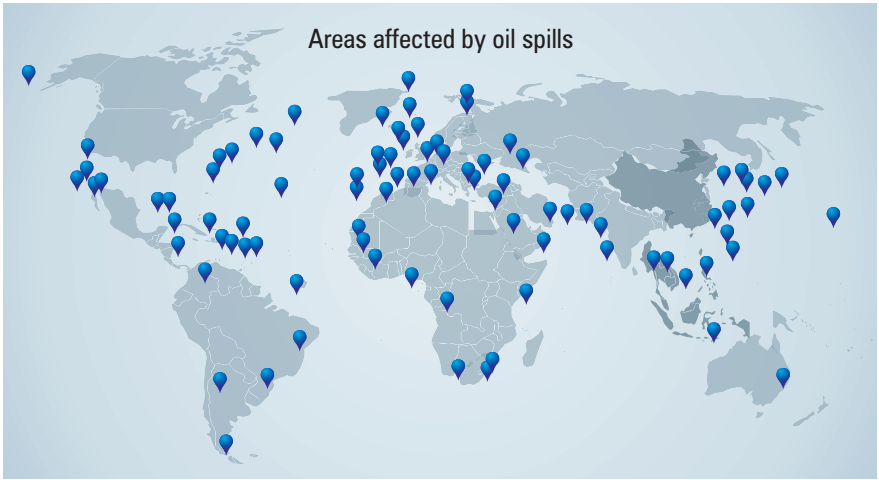
If the statistics offered by the International Tanker Owners Pollution Federation (ITOPF) are anything to go by, the number of oil spill incidents in recent years has clearly decreased. While the incidents have reduced in other parts, seas surrounding the continent of Asia have witnessed an increase in the number of oil spills. The transport of oils across these areas has picked up in the last two decades as a result of the demand to fulfill the energy requirements of the Asian countries that are getting economically active now. Therefore, there is an increased risk of ship accidents and thus spills.

Trailing hope

Extensive research has been put underway to ensure that the damage done by oil slicks is minimised and a healthy living environment restored to the exotic and amazing animal and plant life that inhabits the world's oceans. Since they can be drastically damaging to the environment, and may in the long run affect the climate of a particular area, oil spills require a quick response. It is all the more important that oil spills be cleaned to the last drop. Having tried for decades to soak up that last drop of oil from an oil spill, scientists have concluded that it is not possible to render an area oil-less after spillage, for it is likely to take decades to degenerate and may also settle at the bottom of the ocean. But success rate and the type of method adopted will depend on the area, location, extent of the spill apart from the geology of the ocean bed, coastline and the marine life contained in the ocean where spillage has occurred.

Containing the spread of oil forms an important aspect of clean-up, for which floating booms are used. These are inflatable foam and plastic tubes that can pull oil from one area to a nearby shoreline where it can be mechanically skimmed, using skimmers and separated from the water. Innovations continue to be made in enhancing the mechanical devices like the improvised version of the skimmer developed by Victoria Broje and Arturo Keller of the University of California-Santa Barbara. A typical skimmer has a revolving steamroller-like drum that picks up a film of oil on the drum's surface. The oil is collected by scrapers and dropped into a collector. The one developed by Broje and Keller has a grooved surface. The grooves scoop up more oil than the smooth-surfaced traditional skimmer. The scraper has been enhanced to work with the groove geometry, removing maximum oil with every rotation. Moreover the grooves have been coated with oil-adhering polymer to add to its efficiency. While booming and skimming are the two techniques that are applied as first measures to recover oil, it is possible that they may be rendered useless due to the nature of the sea, which could be rough or calm.





If the area in question experiences rough waters, then absorbent materials such as talc, sawdust, straw and synthetic sorbents are added to the surface. These are removed when they have soaked up oil. One of the most commonly used remediation methods for oil spills is dispersants. These are chemicals that promote the formation of tiny oil droplets, and delay the reformation of slicks. They contain surfactants and solvent compounds. "Sometimes, oil droplets break down because of the high waves and ocean currents during the dispersion process. In such an event, water and oil droplets combine to form an emulsion, which is highly viscose. It is necessary to ensure that there is a balance between natural dispersion and emulsification," marine environmental scientist Dr Reva Solanki informs. However, she is of the opinion that dispersants work best in warm water and are relatively less effective in case of highly viscous and floating oils because the weathering of oils causes their properties to change and they become less dispersible. "While they can speedily treat large spills, one should also be warned that certain dispersants can be damaging to the environment owing to their chemical properties," she adds.

Microbial helpers

There have been incidents when in-situ burning of oils has also been practiced to eliminate oil spills. But this again adds to environmental pollution. Its far-reaching consequences and frequency has

encouraged scientists to look for effective, environment-friendly methods to clean up oil spills.
The most widely discussed being bioremediation using microorganism that are present in soil and marine environments. Research by Dr Efe Aganbi and colleagues at the University of Essex has suggested that microorganisms that are found on mudflats around the coastlines can be heroes of oil spill clean-up missions because of their ability to break down and degenerate petrochemical residues.
The researchers also state that there are likely to be noticeable differences in the speed of degradation of the chemicals on oil spills depending on the presence of oxygen. The microbes' versatility enables them to survive on most chemical types.

Explaining the process, Dr Aganbi says, "Microorganisms residing in mudflats and various other habitats use hydrocarbons as their source of carbon and energy. Not all microorganisms however can degrade hydrocarbons and the microbial species differ depending on the environment whether marine or fresh water. The processes involved could be either aerobic or anaerobic. Alcanivorax spp, Cycloclasticus spp and Thalassolituus spp, are some of the important microbial genera known to degrade hydrocarbons in marine environments such as mudflats include." Under aerobic conditions, benzene, toluene and naphthalene, which are found to occur in petroleum, were quickly broken down by the microbes. However, when studies were carried out on spills in the absence of oxygen, the process slowed down significantly and it was only toluene that broke down.

The study also revealed that over a period of time, the types of oil munching microorganisms also changed according to the compounds that were being degraded. Napthalene was observed to promote the growth of Cycloclasticus spp, a bacterium which is known for its ability to break down oil residues. These are likely to help eliminate oil in the most natural ways and are ideal for estuarine locations. "Estuaries are ideal locations for refineries and petrochemical facilities – it is essential that mudflats are preserved to provide a natural clean-up area for pollution," says Dr Aganbi.

Mudflats are increasingly being considered by the scientific world to lap up oil spills and attempts are also being made to grow the microbes in labs and use them. However, the cost-effectiveness, availability and practicality of the method is also being questioned because mudflats do not run through every coastline and are practically non-existent in the Arctic and Antarctic oceans, where even a small oil spill can cause greater damage. "This is simply because of the fact that cold conditions do not harbour the growth of oil-munching bacteria. These are very delicate oceans and are home to a variety of marine animals such as the harp seal, hermit crab, whales, penguins and exotic fish. The microbes are likely to work only in the warmer oceans," opines Dr Rasik Ravindra, director, National Centre for Antarctic and Ocean Research.

Warming temperatures have indeed put the Antarctic and Arctic oceans at an increased risk of oil pollution and spill damage because of the easy navigability offered by the melting ice, which earlier covered vast stretches of the two oceans. "With the clearing of the waterways, it is likely that more number of ships will ply in the area and this is bound to heighten the risk of oil tanker accidents because we are not used to these seas and are less informed about the types of coastlines they have and the ocean terrain they hide deep below," cautions Dr Ravindra.

'Smoke' it up

In fact, several other scientists have sought answers to the growing problem of oil spills in oceans around the world. Answer in the form of hydrophobic aerogels has been suggested by scientists in Arizona and New Jersey, who say that aerogels, which are super-lightweight solid matter, commonly referred to as "frozen smoke," could prove to be the tool for soaking up oil from wastewater and effectively siphoning environmental oil spills.

The team which includes, Dr Robert Pfeffer from the Department of Chemical Engineering, Arizona State University, Tempe states that the environmental challenges posed by oil contamination in water bodies and oceans is more than what has been revealed over the years.

Impact on marine life

- Oil coating an animal can cause hypothermia and limit its ability to swim or fly, and to maintain its body temperature, feed properly, and even reproduce
- Harms habitats, rendering them unsuitable for feeding and nesting
- Spills are damaging to intertidal areas where several species reproduce, as well as to wetlands, coral reefs and mangroves, which nurture fish
- Oil can affect the eyes, mouth, and nasal tissue, as well as the immune system and red blood cells
- Disrupts sensory organs of marine animals, affecting their skills to navigate to feed and breed
- Oil is composed of many toxic compounds which are carcinogenic
- Tourism gets directly affected
- Birds sink or drown because oiled feathers weigh more and cannot keep them buoyant
- Seal pups and mothers use scents to identify each other. Oil disguises the scent, leading to rejection, abandonment and starvation of pups
- Decrease in the thickness of egg shells and changes the cell structure of lesser animals
- Poisoning of young through mother's milk.

Frozen-smoke

Mudflats

Hair mats

Hydrophobic silica aerogels are highly porous and absorbent material, and can soak up oil like sponges. It is believed that the aerogel absorbs up to seven times their weight in oil.

"We use hydrophobic aerogels to remove organic contaminants such as oil, toluene, ethanol and chlorinated hydrocarbons from wastewater. We accomplish this by configuring the aerogels as a sorbent in an inverse fluidised bed. Since the aerogel granules are much lighter than water, fluidisation needs to be carried out inversely, i.e. the oil contaminated-water mixture flows downward into a column filled with aerogel granules about 1 mm in diameter at a velocity sufficiently high to fluidise the granules.
The fluidised bed process allows for good mixing of the aerogels with the oil contaminated water and is also more energy efficient (because of the much lower pressure drop required as compared, for example, of using a packed bed of activated carbon to absorb the oil). Furthermore the fluidised bed can be run continuously by feeding in fresh aerogels to replace oil saturated aerogels leaving from the bottom of the column," explains Dr Pfeffer.

Though the method is presently being considered to clean oil from contaminated oil streams and wastewater, Dr Pfeffer is of the opinion that the frozen smoke blocks can as well be used to soak up and clean oil spills from oceans. "While the objective of our research is to use hydrophobic aerogels to remove oil and other organic compounds from wastewater, aerogels can certainly be used to clean-up oil spills," he says.

In addition to microbes in mudflats and frozen smoke, several innovative and eco-friendly options have been developed to remove oil that has spilled on the ocean surface, including milled sugar-based baggasse and human hair. Yes, it turns out that human hair is adept at playing the 'here now gone the next moment' tricks with oil. The OttiMat, serendipitously invented by Phil McCory, an Alabama based hair stylist, uses recycled human hair to repair and prevent the environmental damage caused by oil spills.
It comprises almost 99 per cent recycled human hair collected from salons and 1 per cent Polypropylene Skrim. A patented technology, the OttiMat is believed to absorb and hold oil in the mat till the time it is squeezed out into a reclaiming tank. Similarly, ammonia treated, milled bagasse was used by Dr Gary Breitenbeck to clean spilled oil from Louisiana marshlands. The process produces nitrogen compounds within the bagasse that the microbes present in water use to convert hydrocarbons into humic material. This has been proved as an excellent way of cleaning oil where it could not be recovered.

While it is true that oil spills will continue to occur as long as ships ferry across the seas and the currents continue to toss them around, preparing for an oil spill and timely response, however, are very essential. Software that helps track oil spills once they have hit water are available everywhere. There are certain very effective means that have been employed by the scientific community and ocean observers for damage control. Clearing oil spills is a herculean task. Managing them is equally difficult.

Scientists at the Directorate of Integrated Coastal Marine Area Management Project, Chennai, have developed a mathematical model, called the Oil Spill Trajectory Model, based on satellite monitoring that would enable it to detect and monitor offshore oil spills accurately.

"Managing oil spills greatly depends on the site conditions, the type of beach it harbours, depth of the water and currents. Based on information like the type of oil spilled, location, bathymetry (depth of water), live data of wind speed, wind direction, sea current and tide condition, the calculations-based model is applied to predict the path a spill is likely to take. The amount of time it would take to hit the shore and the kind of marine life it is likely to affect," informs Dr Kankara, who is involved in the model. According to him, this model enables the response agencies to mobilise resources and implement a clean-up plan accordingly.

Ever wondered why oil is found deep beneath the earth's surface? Perhaps earth realises that it's presence on the surface can damage the environment and smother life sprouting on it. While it's true that we cannot stop using oil, it only makes sense to fortify technology so that spillage is minimised in future.