Oil Pollution

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Sources

In 2004, 30 billion barrels (4.8 km³) of oil were consumed worldwide, while only eight billion barrels (1.3 km³) of new oil reserves were discovered.

We may think that most incidents occur in the marine environment but in fact 30% of the world input of petrochemical hydrocarbons enter the sea from rivers and 45% from vessel operations and accidents.

In the UK about 75% of oil usage is in transport. Both mineral and vegetable oils are also used in industry.

Oil-related water pollution incidents in England accounted for 17% of all water pollution incidents in 1999, mainly due to leaks from unbunded oil storage tanks. Regulations have reduced the number of such oil-related incidents by setting design standards for all above ground oil stores and requiring that secondary containment, such as a "bund" (a surrounding wall) or "drip tray" is in place to prevent oil escaping into controlled waters.

Freshwater sources of pollution from oil

Industrial discharges
Fuels washed off roads and garage forecourts
Road accidents
Boats
Accidental spillages
Pipeline problems such as leaks and spills
Deliberate acts of vandalism.
Acts of war and sabotage
Natural disasters such as Tsunami and earthquakes
People changing their engine oil near a drain

Sea

Collisions
Leaks and spills
Running aground
Deliberate e.g. discharge of ballast water

Oil spills at Sea

It is notable that a few very large spills are responsible for most oil spilt at sea.

- most spills from tankers result from routine operations such as loading, discharging and bunkering which normally occur in ports or at oil terminals;

- the majority of these operational spills are small, with some 91% involving quantities of less than 7 tonnes;

- accidental causes such as collisions and groundings generally give rise to much larger spills, with at least 84% of incidents involving quantities in excess of 700 tonnes being attributed to such factors.

Tanker Accidents

Tanker accidents are widely reported as they attract the media and a major incident is recorded in world headlines. Typically only account for 12% of all oil pollution.

One of the first major world incident was the **Torrey Canyon**, which ran aground off the coast of Cornwall in 1967 after the captain ignored charts showing submerged rocks. The tanker lost half it's cargo of oil and a spill of 120,000 tonnes of crude oil covered the beaches of the south coast and France and killed over 100,000 birds, particularly Guillemots. Aircraft tried to set fire to the slick by bombing it but failed.

In 1989 the **Exxon Valdez** incident released 40,000 tonnes of oil and caused an oil slick that covered two thousand six hundred square miles. Over eight hundred miles of beach were spoiled and 3000 birds were killed as well as other animals. The clean up costs were over £118 million pounds.

When the tanker the **Braer** ran aground off the Shetland islands in 1993 winter 85 000 tonnes of oil were spilt killing 700 sea birdsHowever 500,000 farmed Salmon were killed and it cost £10 million pounds to clean up. The fishing industry in Shetland is worth £75 million so the potential impact on the economy was enormous.

In Feb 1996 the **Sea Empress** ran aground off the Welsh coast sea near Milford haven, a port that handles1/4 of all UK oil, and lost 130,000 tonnes. It's radar had broken so it hit rocks. The coast is an SSSI. Some of the coast was badly affected, the rest less so. Oil affected the Bristol channel and was found on the South coast of Ireland. The area is important for seals, dolphins, porpoises, and commercial shellfish and sea fishing. Fortunately it occurred at a time when the seals weren't breeding. Only 3000 tonnes was recovered. Killed directly 25,000 birds. Used little detergent on coast but some at sea. Used water jets on coast and rocks.

PRESTIGE (Spain, 2002)
Off Spanish coast 63,000 tonnes were lost from the PRESTIGE.

Oil first came ashore in Galicia, where the predominantly rocky coastline was heavily contaminated. A major offshore cleanup operation was carried out using vessels from Spain and nine other European countriesThe work commenced in May 2004 and was finalised in September 2004 at an estimated cost of some €100 million.

Freshwater accidents

Recently (Oct 2006) Petroplus were fined £30,000 for a kerosene leak from a tanker which spilt 40,000 tonnes of oil in Mildford Haven and cased significant groundwater contamination. The clean up costs amounted to £3 million.

Hurricane Katrina

In New Orleans the hurricane caused major environmental damage including oil spills, chemical releases, fires and other accidents. Tanks capable of holding two million barrels of oil were seen to be leaking into the Mississippi River near the Louisiana town of Venice, 70 percent of normal oil production and half of natural gas output shut down. Twenty oil platforms were reported missing.

Pipeline incidents

The trans- Alaska pipeline travels 800 miles, 410 miles are above ground. In Oct 2001 it was shot by a drunk and 6,800 barrels were spilt.

Trans Siberian leaking Russian oil pipe lines causes pollution in the tundra Oil from one pipeline which had been leaking for some time in 1994 was contained in a dyke but this collapsed and caused the third largest major oil pollution incident in history releasing 102,000 tonnes, 8 times larger than the Exxon Valdez spill. 72 miles of fragile Tundra ecosystem was affected.

In October 2004 at least 700 people were killed in Nigeria when massive explosions ripped through fuel pipes after thieves used welding tools they used to break into the pipe.

The composition of oil

HCs,
sulphur
metals
aliphatics
aromatics
PAHs
PCBs

Crude oil consists of thousands of different organic molecules, the majority of them hydrocarbons. There are also some sulphur and nitrogen compounds and metals such as vanadium. Crude oil is refined by a process of distillation with the products used in the production of petrol coming of at the lowest temperatures. At high temperatures naphtha, which forms the basis of the petrochemical industry separates and yet higher temperatures boil off diesel, bunker oil used to fuel ships and power generation stations and tars. Oil products may also contain compounds such as PCBs and PAHs (polynuclear aromatic hydrocarbons) and metals such as lead all of which may be both toxic and able to biomagnify or bioaccumulate.

The aliphatic compounds in oil are relatively innocuous but the monohydric aromatic compounds are generally toxic.

What are the effects of oil on the environment

The prediction of the effects of oil pollution is difficult, as it's chemical nature is very complex and there are many different grades and types. The effects of oil spills on the environment depend on the type of oil and the amount of time it has been in the water and the nature of the oil changes with time and the effects of animals depend on the exposure time. Generally a little oil goes a long way.

What governs the fate of hydrocarbons in the environment?

Spreading
Drift
Evaporation
Dissolution
Dispersion
Emulsification
Sedimention

Biodegradation
Photo oxidation

Effects

short term and catastrophic
respiration, photosynthesis or feeding buoyancy and insulation, (hypothermia)
ingestion of oil if they try to clean themselves, may prove toxic.

The most toxic components in oil tend to be those lost rapidly through evaporation when oil is spilt. Because of this, lethal concentrations of toxic components leading to large scale mortalities of marine life are relatively rare, localised and short-lived. Sub-lethal effects that impair the ability of individual marine organisms to reproduce, grow, feed or perform other functions can be caused by prolonged exposure to a concentration of oil or oil components far lower than will cause death. Worse for Sedentary animals in shallow waters such as oysters, mussels and clams that routinely filter large volumes of seawater to extract food are especially likely to accumulate oil components.
In coastal areas some marine mammals like Seals and Dolphins and reptiles, such as turtles, may be particularly vulnerable to adverse effects from oil contamination because of their need to surface to breathe and to leave the water to breed.

Many water soluble components of both crude oil and refined products are toxic to organisms, their eggs and young stages being especially vulnerable. There are also a whole range of sublethal effects. PCBs in particular are known to be both mutogenic and carcinogenic in some organisms. Because oil can effect each stage in the food chain from freshwater algae and seaweeds, through snails and crustaceans, to fish and mammals the whole balance of the ecosystem is upset. Toxicity varies with species . In a test of the effects of different single hydrocarbon compounds to freshwater organisms snails were less sensitive than arthropods and fish less sensitive than invertebrates. The toxicity increased with increasing ring number of the molecule, for example naphthol with two rings was 45 times more toxic to Gammarus than phenol with one ring.

Tainting
Other problems occur if oil gets into water or sewage treatment works, and obviously the loss of amenity value, when a water body is covered in oil can be enormous, and have huge repercussion on the tourist industry.

Contamination of groundwater can be a serious issue.

Recovery and Clean Up Techniques

1. Natural processes

After an oil spill 30% of the oil is usually lost be evaporation within the first 30 days. After this there are no volatiles left so no more evaporation takes place. The surface oil is thus dispersed by a series of chemical and physical processes , some components are lost by photochemical oxidation. Most of the remaining compounds are broken down by microrganisms on the sea or river bed. In fact a mixed population of bacteria, fungi and yeasts can degrade up to 97% of crude oil. Oil companies are now taking advantage of this and have developed "seeds" of these micro-organisms that can be introduced to oil polluted areas.

2. Enhanced Biodegradation

A large number of bacteria and fungi can break down HCs. The rate of bio-degradation is affected by oxygen availability, temperature, the type of oil, amount of emulsification, and availability of nutrients. Either Phosphorous and Nitrogen may be limiting, if these nutrients are added the process can be speeded up. “Seeds” of micro organisms can be introduced, (although this techniques has some critics who say the rate is not limited by availability of micro organisms but by factors such as N and P). Oxygen availability can be enhanced by direct injection or addition of hydrogen peroxide or chlorate, (latter method used to treat contaminated groundwater) Contaminated soil and groundwater can be treated either in situ or removed and treated elsewhere.

3. Chemical Dispersants

Another very contentious subject is that of the dispersants used in clean up operations, The problem with emulsifiers and dispersants is that their surface active agents make the cell membranes of the organisms more permeable and therefore this increases the penetration of toxic compounds. Experiments in the 70's found that whilst Bunker oil was virtually non-toxic to Atlantic salmon, (Salmo salar), when it was mixed with the dispersant COREXIT 8666, (also non-toxic by itself) increased considerably.

A further nine dispersants were found to be toxic alone but even more toxic when mixed with oil and this is generally the case with most dispersants.

4. Physical Methods

These obviously have to happen pretty quickly after the incidents and they are difficult in rough seas although easy in river. In rough water at sea the tides will disperse and break up the oil. In calmer waters booms are used to stop the slick spreading further, it may be sucked up or skimmed up by a pump, or in the case or rivers it is sometimes possible to flush the river out, if there are reservoirs or locks upstream. In places such as chemical works or garage forecourts surface drainage can be diverted through interceptor sewers and taken for treatment elsewhere. Oil contained by booms may be burned but this must be done quickly before the volatile component is lost by evaporation.

Another method for cleaning up polluted beaches is to use some absorbent material to soak up the tarry residues. Nowadays synthetic felted organic fibres, which can hold 150 times their weight of thick fuel oil, are available in the form of cushions, blankets, or loose chips. Chemical dispersants are now generally considered an undesirable option.

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Legislation

Marpol

International agreement from 1973 relating to pollution from shipping. Set up to prevent discharges deliberate of oil from ships. Also concerns issues like plastic refuse.

Prevention of Oil Pollution Act 1971

It is an offence to discharge oil in UK territorial waters unless is was due to damage to the vessel which reasonable steps were taken to prevent or to prevent accident or damage to ship or personnel.

Control of Pollution (Oil Storage) (England) Regulations SI 2001

Requires everybody in custody or control of oil to carry out certain works and take necessary precautions which will prevent the pollution of any controlled waters or the water environment: