

**Ocean Structures and Materials**  
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**Module - 2**  
**Lecture - 10**  
**Ocean pollution**

Ladies and gentlemen,, welcome to the tenth lecture on ocean structures and materials on module 2. In this lecture, we will discuss about ocean pollution. Now interestingly there is a very common question asked by people - are ocean engineers responsible for series of ocean pollution, which being caused around the world? Is ocean pollution essentially caused only because of drilling operations or is it because of disposal of industrial waste in water body?

Now, as ocean engineers, as petroleum engineers we are responsible for causing ocean pollution. There is no doubt on that, but that is not the only element which responsible. So, in this lecture, let us quickly see what are those factors which are very alarming with respect to ocean pollution caused by petroleum engineers or offshore engineers, what are those facts which have been alarming and which should be under control and how can we apply (( )) measures to make them all right.

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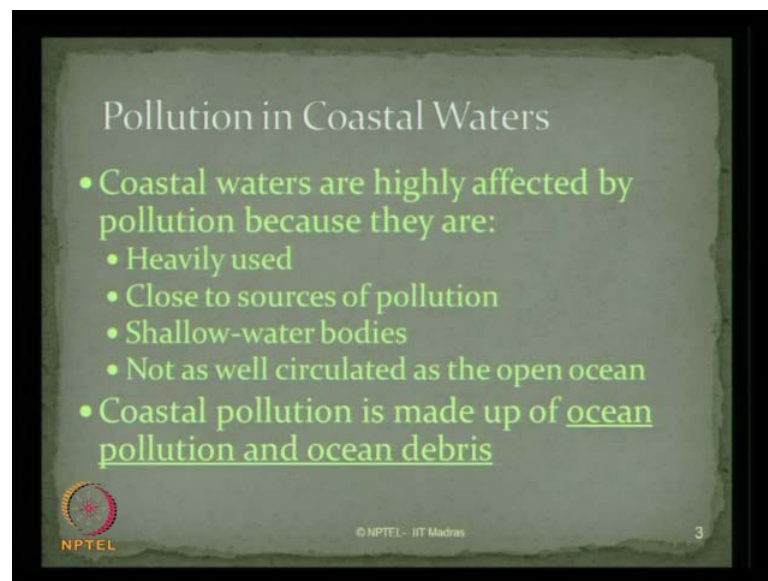
**Ocean Pollution- some facts**

- Coastal areas receive the maximum impact.
  - especially wetlands and estuaries, coral reefs, and mangrove swamps
- Half of world's population lives within 100 km of ocean
  - 14 of 15 largest cities in the world are coastal cities
- Even in many developed countries, about 35% of the municipal sewage is discharged virtually untreated in ocean waters
- many countries still dump large quantities of industrial waste containing toxic substances into ocean

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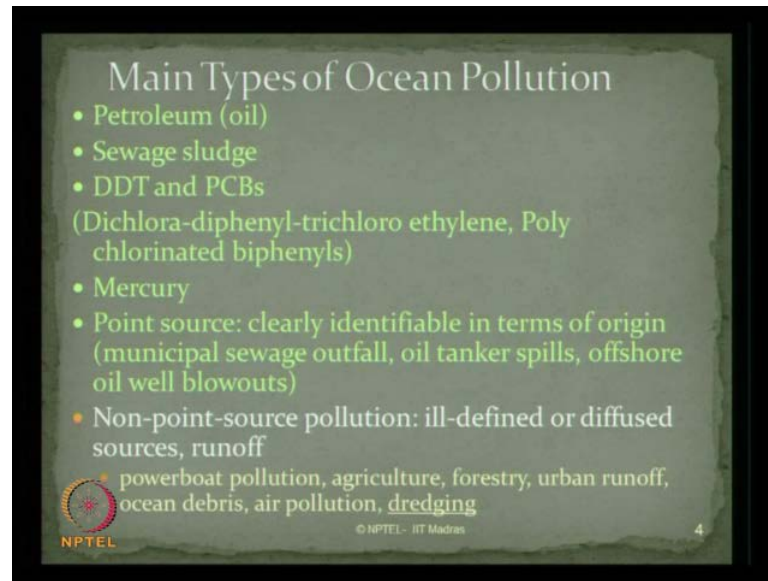
Let us quickly see some few facts related to ocean pollution. Coastal areas actually receive the maximum impact, especially wetlands and estuaries, coral reefs and mangrove swamps. Half of the world's population lives within 100 kilometre of ocean, 14 of the 15 largest cities in the world are coastal cities. Even in many developed countries about 35 percent of the municipal sewage is discharged virtually untreated in ocean waters. Many countries still dump large quantities of industrial waste containing toxic substances into ocean.

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Let us talk about the facts which are affecting pollution in coastal waters. Coastal waters are highly affected by pollution. There are many reasons for this. The top most reason is coastal waters are heavily used for discharge, they are very close to sources of pollution, they are shallow water bodies, they are not as well circulated as the open ocean, the coastal pollution is made up of ocean pollution and ocean debris put together.

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There are many types of ocean pollution which can be classified. This can be caused because of oil which is petroleum, it can be a sewage sludge, it can be DDT that is Dichloro-diphenyl-trichloro ethylene or it can be from PCBs which is Poly chlorinated biphenyls, it can be mercury concentration, familiar to a specific point source clearly identifiable in terms of origin that is discharge point of municipal sewage outfall, oil tanker spill points, an offshore oil well blowouts, these are all what we call point source responsible for ocean pollution. The non-point-source can also be identified as ill-defined or diffused sources for example, they can be runoffs. I can give classical examples: the powerboat pollution, agricultural dispersions, forestry, urban runoff, ocean debris, air pollution and most interestingly and importantly dredging. These are all what we call non-point-sources for ocean pollution and above are so point sources for ocean pollution.

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Ocean Pollution: Petroleum

- Oil spills can be caused by:
  - Tanker accidents
  - Intentional dumping
  - Drilling/pumping operations

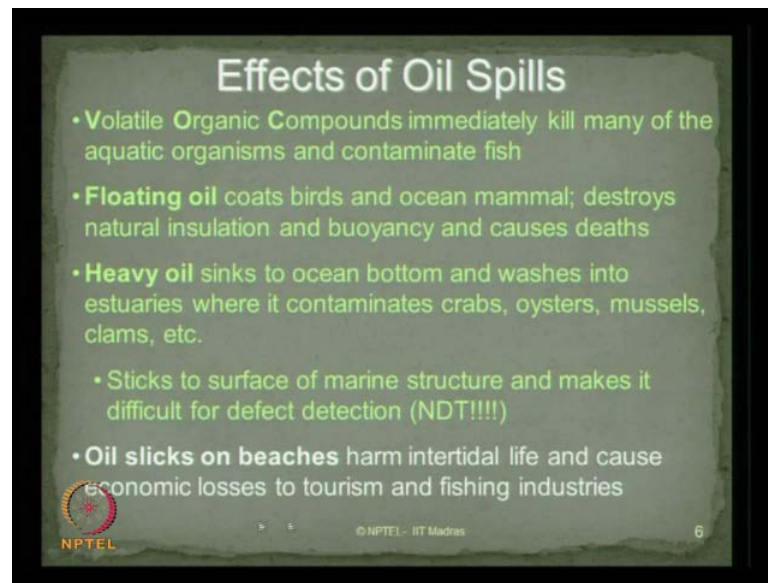


A GIFT from our modern oil-powered companies.

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Now interestingly petroleum or the pollution caused by gas or oil or petroleum is what we call as a gift from our modern oil-powered companies. This interesting photograph shows a specific location in Gulf of Mexico near Bay of Campeche where you got Ixtoc number 1 well will had a blow out or an oil spill. We can see this photograph showing a wide area of oil being spilled on the surface because of some accident caused in the plant. This is one of the interesting vital and very important sources of ocean pollution which essentially comes from petroleum or oil industries. Oil spills can be therefore, caused by variety of reasons, can be because of tanker accidents, can come from intentional dumping can also come from drilling or pumping operations.

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Once the oil spill occurs let us quickly see, what are the effects of oil spills on ocean environment? The volatile organic compounds briefly called as VOC in the literature. They immediately kill many of the aquatic organisms and contaminate fish in the water body. That is a foremost and dangerous effect caused by volatile organic compounds present in ocean which essentially comes from oil spill.

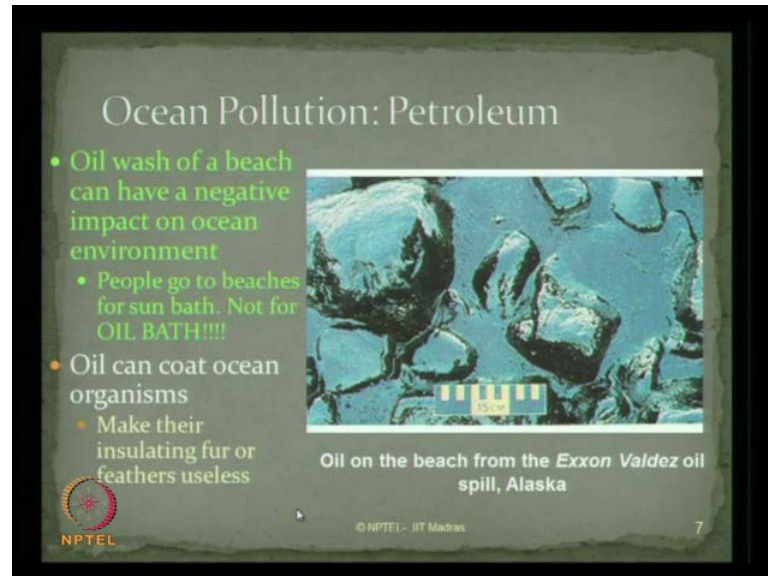
The floating oil, because oil spill also has the floating content of oil; the floating oil actually coats the birds and ocean mammals. They keep on coating the fins and feathers of the birds and ocean mammal. When they get coated it destroys the natural insulation property of the mammal and it causes affects buoyancy therefore, they sink and die. So, it affects buoyancy and causes fatal to the birds and ocean mammals.

Heavy oil, they sink to the ocean bottom and get washed into estuaries whereas it contaminates crabs, oysters, mussels and clams. It sticks to the surface of marine structures and makes it difficult for detection in terms of NDTs.

Oil slicks on beaches harm intertidal life and of course, cause economic losses to tourism and fishing industry. Ladies and gentlemen, oil spill has got many multi effects for example, the VOC compounds which kill immediately the aquatic organisms, the floating oil which kills the mammals by coating them on the fins and feathers, the heavy oil which gets stuck to the marine structure makes it impossible for non- destructive

testing and oil slicks on beaches loses the commercial value of tourism and affects fishing industry very seriously.

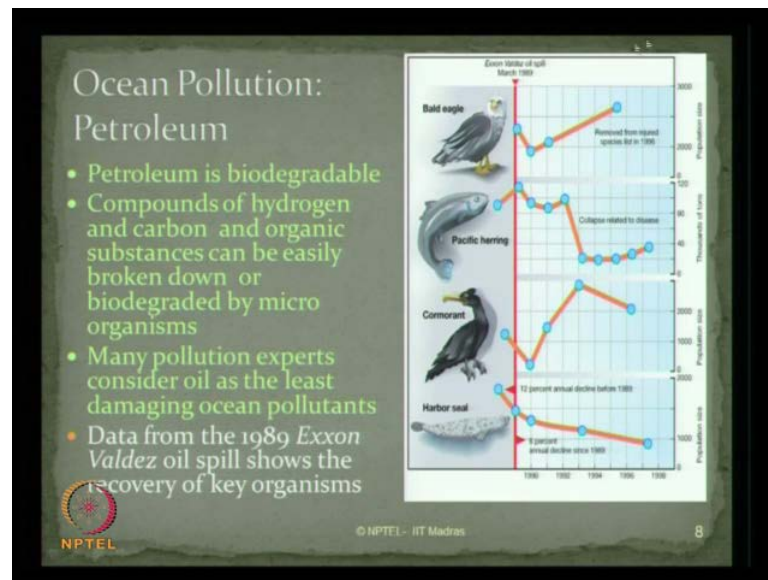
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This is the photograph what you see here which is an effect of an oil spill which occurred due to a petroleum leak industry in ocean pollution. The oil wash of a beach can have a negative impact on ocean environment. Ladies and gentlemen, people actually want to go to beaches for sun bath, but unfortunately if you go to beaches of this order we get an oil bath. Oil on the beach from Exxon Valdez oil spill, Alaska is the picture what you see here.

You can see even all the surface and rocks have been coated by the oil which has been settled, which are heavy particles of this oil, which has contaminated the sea bed as well as the whole area for a large volume. Oil can coat the ocean organisms, they can make their insulating fur or feathers completely useless as you understand ocean mammals breathe from the insulating fur and once this gets coated there is no insulation remaining in the fur therefore, they die because of this.

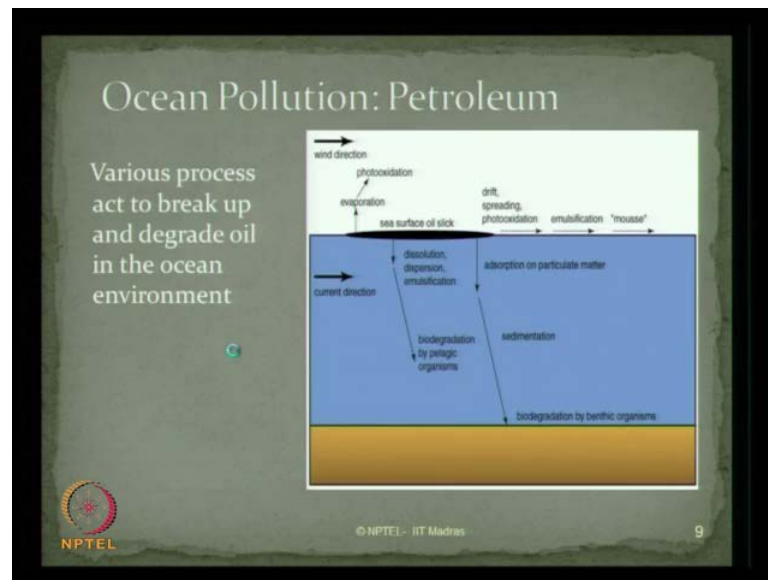
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If you look at some of the interesting statistics which occurred and caused as reasons for ocean pollution arising from petroleum; to look at example of Exxon Valdez oil spill which acquired in march 1989. There has been a deep and steep drop in the Bald eagle species, in the Pacific herring and in the Cormorant species and the Harbour seal after this oil spill is occurred. For example, this has been improved substantially after making some efforts in terms of its population size, which varies from 2000 to 3000 as far as the Bald eagle is concerned, as far as the Pacific herring is concerned varying from the scale of 0 to 120 and so on, there are thousands of tons.

So, the production of these kinds of mammal, the living life cycle are all seriously affected by ocean pollution. So, petroleum is a biodegradable product, the compounds of hydrogen and carbon and organic substances can be easily broken down or bio degraded by micro-organisms. Many pollution experts consider oil as one of the least damaging ocean pollutant that is the saving news and the grace effect for offshore and petroleum engineers. Data from 1989 Exxon Valdez oil spill shows there is a recovery of key organisms after a treat that area which proper scientific approach.

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Let us quickly see, how ocean pollution is caused from petroleum leak as a source. For example, if this is considered as wind direction, when the petroleum leak occurs because of an oil spill, the process first starts with evaporation, which results further in photo oxidation, if this becomes a current direction the surface oil slick gets dissolved, dispersed and emulsified and forms bio degradable products by pelagic organisms.

As the current direction takes it forward, it results in drift, spreading and photo oxidation, results further in emulsification what we call as lot of foams being formed on the surface and these foams are called as mousse. Once this photo oxidation emulsification occur the absorption on a particular matter occur sedimentation is resulted, this results in biodegradation of benthic organisms.


So, ocean pollution results from petroleum has got multilevel effects on the surface as well as in the sea bed and through and through the water depth as a sea depending upon what is the wave direction, wind direction and current direction. So, various processes act together to breakup and degrade oil in the ocean environment.



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### Case Study I: Exxon Valdez Oil Spill

- March 24, 1989, tanker in Prince William Sound, Alaska, spill oil in U.S. waters
- Coated 1,600 of shoreline, killed wildlife, and caused serious contamination
- Exxon spent \$2.2 billion on direct cleanup + \$1 billion fines and damages; another \$5 billion being appealed



The map shows the coastline of Alaska with Prince William Sound highlighted in blue. Labels include 'PRINCE WILLIAM SOUND', 'Valdez', 'Alaskan Pipeline', 'Tanker terminal', 'Accident site', 'Oil Slick', and 'Shipping lanes'. A scale bar shows 0 to 150 miles and 0 to 150 km.

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Interestingly, we look as Exxon Valdez oil spill as a case study which has occurred on a specific time of March 24 1989 a tanker in Prince William Sound, Alaska spilled oil in US waters. It coated about 1600 of shoreline, killed wildlife and caused serious contamination. Exxon actually spent from the statistic it says the 2, billion dollars on direct clean up and 1 billion fines and damages, another 5 million dollars is being appealed to make it rectify.

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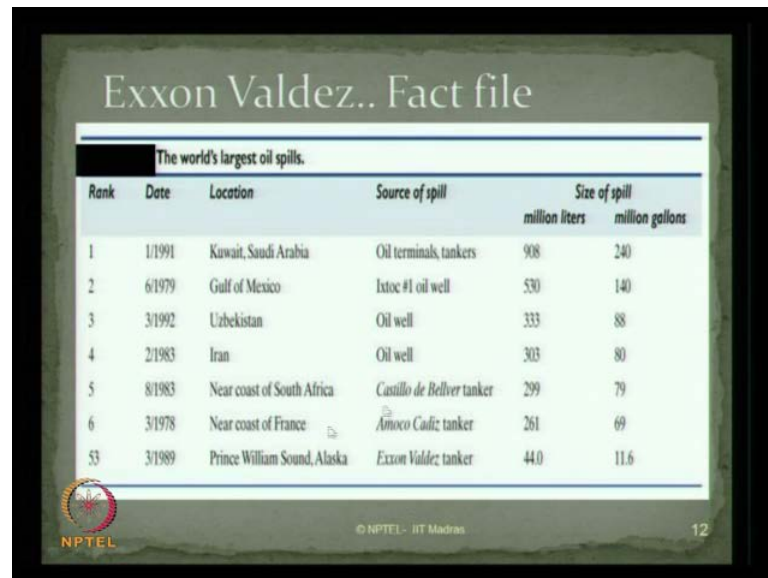


The map shows the state of Alaska with labels for 'ALASKA', 'Anchorage', 'Valdez', 'Bligh Reef', 'Prince William Sound', 'Kodiak Island', and 'Gulf of Alaska'. A legend indicates 'Areas where oil has been spotted since the spill'. A scale bar shows 0 to 200 miles and 0 to 200 Kilometers. An inset map shows 'RUSSIA', 'Pribilof Bay', 'Terra-Alaska Pipeline', and 'Valdez'. A photograph of three otters is shown on the right.

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Interestingly, you can see the photograph here, where, because of the oil spill even the mammals are completely coated and they die because of such effects of oil spill.

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The slide is titled "Exxon Valdez.. Fact file" and contains a table titled "The world's largest oil spills." The table lists the top 6 largest oil spills and the Exxon Valdez spill as rank 53. The columns are Rank, Date, Location, Source of spill, and Size of spill (in million liters and million gallons).

Rank	Date	Location	Source of spill	Size of spill	
				million liters	million gallons
1	1/1991	Kuwait, Saudi Arabia	Oil terminals, tankers	908	240
2	6/1979	Gulf of Mexico	Ixtoc #1 oil well	530	140
3	3/1992	Uzbekistan	Oil well	333	88
4	2/1983	Iran	Oil well	303	80
5	8/1983	Near coast of South Africa	Castillo de Bellver tanker	299	79
6	3/1978	Near coast of France	Amoco Cadiz tanker	261	69
53	3/1989	Prince William Sound, Alaska	Exxon Valdez tanker	44.0	11.6

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Now, look at the statistics which is a fact file created from Exxon Valdez oil spill case right from 1991 till 1993 and so on. The rank has being given depending upon the source of spill and the millions of tonnes and litres and gallons has been spilled off. Look at the size of oil spill according Saudi Arabia, Gulf of Mexico, Uzbekistan, Iran, near coast of South Africa, near coast of France and Prince Wiliam Sound, Alaska you will see that this specific oil spill according 1989 ranking 53 in terms of its excessive oil spill in about 12 million gallons which has been spilled in 1989.

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### Ocean Pollution: Sewage Sludge

- Sewage sludge is the semisolid material that remains after sewage treatment
- Much sewage sludge was dumped offshore until laws restrict sewage dumping

1 - New York Bight sludge site  
2 - New York Bight alternate sludge site  
3 - 106-mile site  
4 - Philadelphia sludge site

NEW JERSEY

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Now, the oil spill, is not the only reason for ocean pollution can also have sewage sludge which is coming from the industrial waste, the New York Bight sludge site and the New York Bight alternative sludge site and 106 mile site are all interesting examples where people have located sewage sludge happening in the ocean pollution. Sewage sludge is a semisolid material that remains after the sewage treatment. Much sewage sludge was dumped offshore until laws restrict sewage dumping because initially, there were no stringent regulations to stop sewage dumping in ocean environment. Subsequently, after the laws became stricter the much sewage sludge was dumped before to that.

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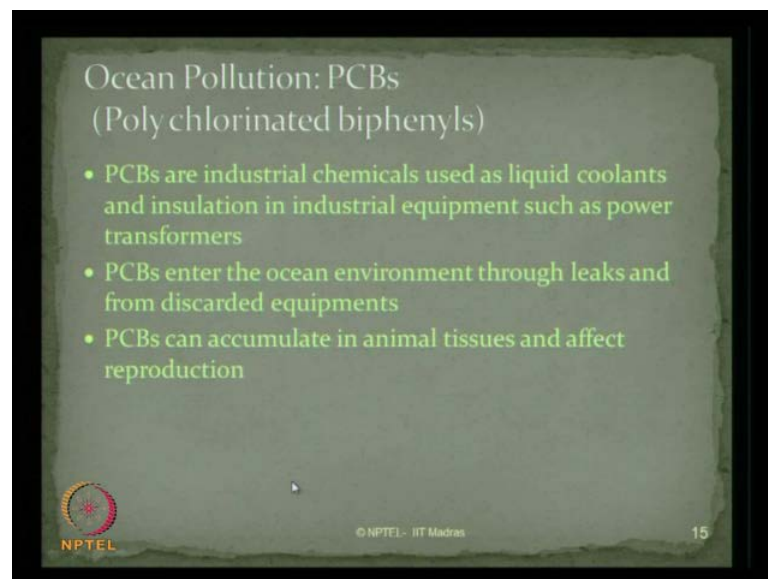
### Ocean Pollution: DDT (Dichloro-diphenyl-trichloro ethylene)

- DDT was a widely used pesticide that became concentrated in ocean fish
- DDT caused birds (like brown pelicans and ospreys) to produce thin egg shells
- Worldwide, DDT has been banned from agricultural use but is still found in developing countries...

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If you look at ocean pollution arising from chemicals like Dichloro-diphenyl-trichloro ethylene, which we briefly call as DDT; DDT was widely used as a pesticide that became concentrated in ocean fish. DDT caused birds to produce thin egg shells, for example, this problem was seen biologically with brown pelicans and ospreys. Their eggs being caused after this kind of spill happen in ocean pollution make their eggs very thin in shells. Worldwide DDT has been banned from agricultural use, but it is still found in some interesting developing countries.

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If you look at another source of pollution which comes from Poly chlorinated biphenyls which we called as PCBs. PCBs are industrial chemicals which are used as liquid coolants and insulation materials in industrial equipments such as power transformers. PCBs enter the ocean environment through leaks and from discarded equipments. PCBs can accumulate in animal tissues and affect reproduction very strongly.

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Ocean Pollution: Mercury and Minamata Disease (Case study II)

- Mercury has many industrial uses but is extremely toxic
- A chemical plant released large quantities of mercury into Minamata Bay, Japan.
- Minamata is a farming and fishing area on the west coast of southern island of Kyushu
- Residents who ate highly contaminated fish suffered neurological and birth disorders

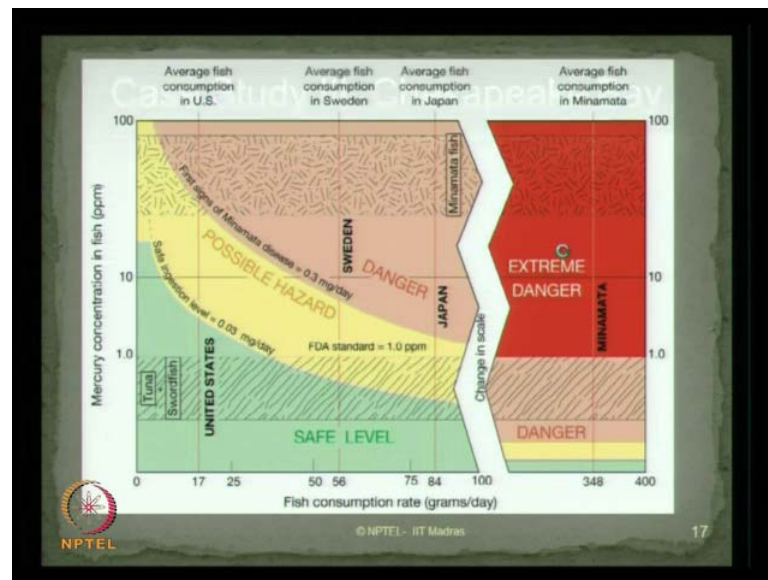
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The slide features a photograph of a person in a small boat, likely a fisherman, in a dark setting. The slide also includes the NPTEL logo and the text '© NPTEL - IIT Madras' and the number '16'.

There is another interesting case discussed in Japan which is caused Minamata disease. Minamata it is another case study which you want to throw light on this. Mercury has a very serious industrial application, but it is extremely toxic in nature. A chemical plant released large quantity of mercury into Minamata Bay in Japan. Minamata Bay, ladies and gentlemen, is a farming and fishing area on Japan which is located on the west coast of southern island of Kyushu. Resident who ate this highly contaminated fish coming from this Minamata basin suffered neurological disorders and birth disorders.

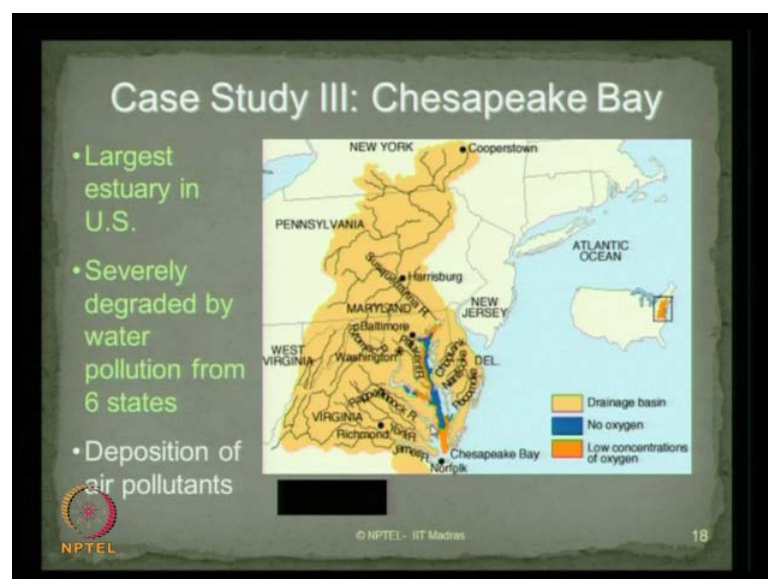
This photograph is dedicated to those people who were being suffering from neurological disorders and birth disorders. So, please think over as an ocean engineer and petroleum engineer, should we be responsible for causing neurological and birth disorders to our own human mankind? This has arised because of discharge of medical mercury contamination in a specific bay in Japan and still it is been told the fish which produced from Minamata Bay is not been consumed because of people developed fear of neurological disorders and birth disorders after eating this particular fish. This is called Minamata disease famously known in Japan.

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So, look at the fish consumption rate; this is what the safe level is, this is what the extreme danger. We can see very well here the Minamata Bay falls in the dangerous zone. The average fish consumption in Minamata has been about 100 to 400 large volume of people started consuming fish, the particular basin had a mercury concentration pollution which affected the neurological problems and that disorder in the human mankind.

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Case study 3 is a Chesapeake Bay, which is located the very interesting problem is the largest estuary in United States. It severely degraded by water pollution from 6 states of USA. The deposition of air pollution is found to be one the interesting reason why this specific bay is very seriously affected by air and water pollution.

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The slide is titled "Ocean Pollution: Point Source" and features a list of four bullet points on the left side. To the right of the text is a photograph showing a large, dark pipe discharging into a body of water. The water appears slightly turbid. The slide also includes the NPTEL logo in the bottom left corner, the text "© NPTEL - IIT Madras" in the bottom center, and the number "19" in the bottom right corner.

- Are clearly identifiable in terms of origin
- Originate from municipal and industrial facilities
- Bypasses and overflows from municipal sewage systems
- Oil tanker spills and offshore oil well blowouts

There are some point sources you can see here. This is discharge pipe coming from a specific source which discharges sewage and industrial waste in water body. These point sources are clearly identifiable in terms of its origin. They originate essentially from municipal and industrial facilities. These are very common features in many of the developing countries.. They bypass and overflow from the municipal sewage systems and they come and get mixed with the water body which is then contaminating the ocean environment totally. Oil tanker spills and offshore oil well blowouts are also very important point sources for ocean pollution.

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### Ocean Pollution: Non-Point Source

- Non-point-source pollution comes from material washed down by storm drains as "poison runoff"
- Includes fertilizers, pesticides, road oil, and trash
- In the US, amount of road oil discharged regularly each year is as much as 26 times of Exxon Valdez oil spill!!



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If we look at the non- point source as we see here, non-point-source essentially comes from the material washed down by storm water drains which we call as poisonous runoff. This includes fertilizers, pesticides, road oil and trash what we throw to the environment. In the US amount of road oil discharged regularly every year is as much as 26 times of the Exxon oil well. Remember this, this is a very amazing figure, people have identified that the oil spill or oil discharge coming from the road actually is about 26 times of that of the oil spill occur in a single accident which created havoc in US.

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### Plastic in the Ocean Environment

- Plastic:
  - Either does not biodegrade
  - Floats
  - Has high strength
  - Strangles ocean organisms to death
  - Is ingested by ocean animals

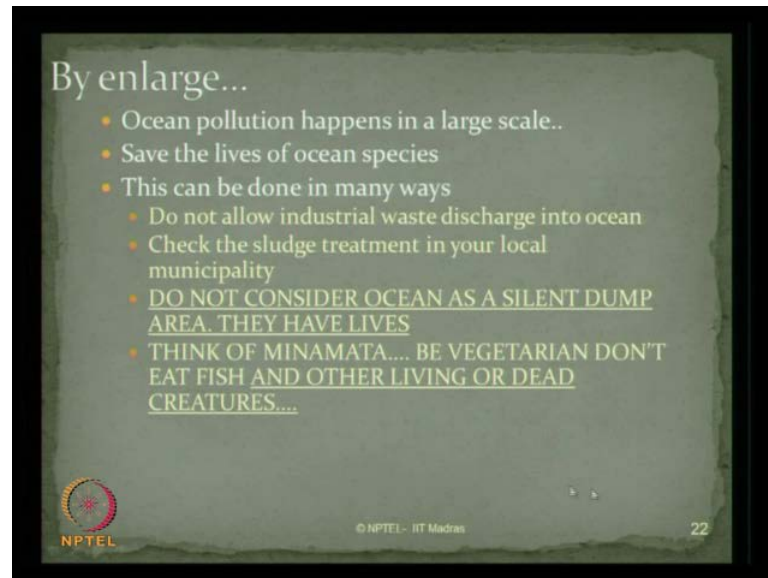


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Plastic is another source, where causes very serious pollution to ocean environment. Plastic does not biodegrade, it floats, it has high strength, it strangles the ocean organism to death, is ingested by ocean mammals or animals.

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By and large ocean pollution happens in a very large scale. Save the lives of ocean species, very important. This can be done in many ways, do not allow industrial waste discharge into ocean, check the sludge treatment in your local municipality, do not consider ocean anymore as a silent dump area, they have lives. Think of Minamata, be vegetarian, do not eat fish otherwise all living or dead creatures will create problems for you.

So, in this lecture we had a very brief discussion about what could be the effects of pollution caused because of different sources of course, oil spills, accidents of oil tankers are one among the source not only the only one. So, we as offshore and petroleum engineers should have this in mind that we will not contribute to the ocean pollution anymore. We will take all positive remedial measures to curtail them in a scientific manner.

Thank you very much.