Health, Safety and Environmental Management in Petroleum and offshore Engineering

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Module No. # 02
Lecture No. # 02
Impact of oil and gas industry on marine environment

Ladies and gentleman, in this lecture we will discuss about the impact of oil and gas industry on marine environment. This is lecture 2 on module 2 of HSE course.

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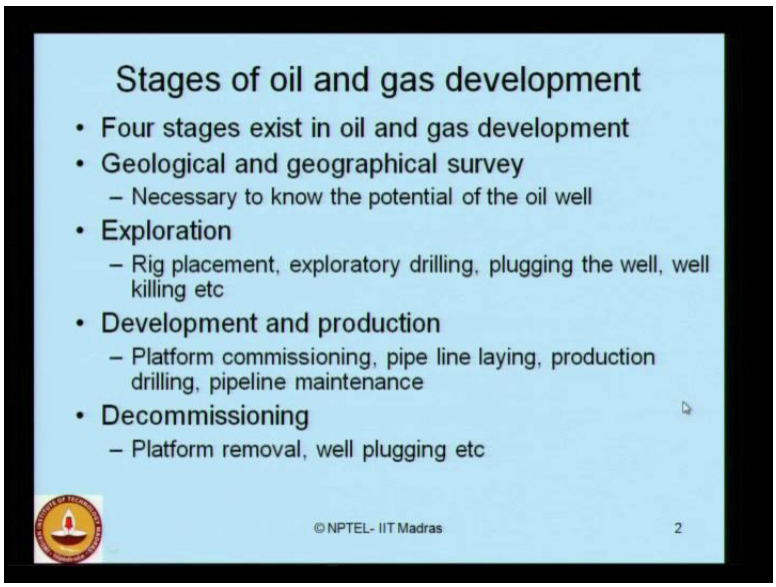

Let us look at the different stages of oil and gas development as an overall summary, because, it is easy for us to understand how they can be different consequences arising at different stages of oil and gas development, if you know different stages of this process. Actually there exist four stages in oil and gas development as a brief summary. In stage one: People generally do geological and geographical survey; this is essentially done to know the potential of any oil well. There are different kinds of surveys being carried out during this process which are catastrophic and very harmful to the marine environment. Let us see them in detail in the next slides.

The second stage could be an exploration stage, where people do exploratory drilling to really understand the capacity, the production and capability of different wells before they construct a platform at that location. During this process or stage of oil and gas development, people use to locate different rigs at different location. They perform what we called exploratory drilling, sometimes if the well is not have a good yield value they may plug the well, they may sometimes do well killing etcetera.

The third stage is actually the development and production stages, where platform are actually commissioned in location pipe line are lay to transport the oil from the location of offshore to onshore. They do extensive production drilling in 24 into 7 scale, and there will be long sequential pipelines being laid under water where as they do lot of maintenance activities for these pipelines.

The fourth one is the abandon the stage or decommissioning stage, where unused platforms are generally removed from the location and the wells are generally plugged etcetera. Ladies and gentlemen if you understand the sequence of these stages of operation in the oil and gas development it will be interesting for you to know there are serious threats caused to the marine environment at every stage of this development in detail. Every stage of the development posts a serious threat to the marine environment as we see them in further slides.

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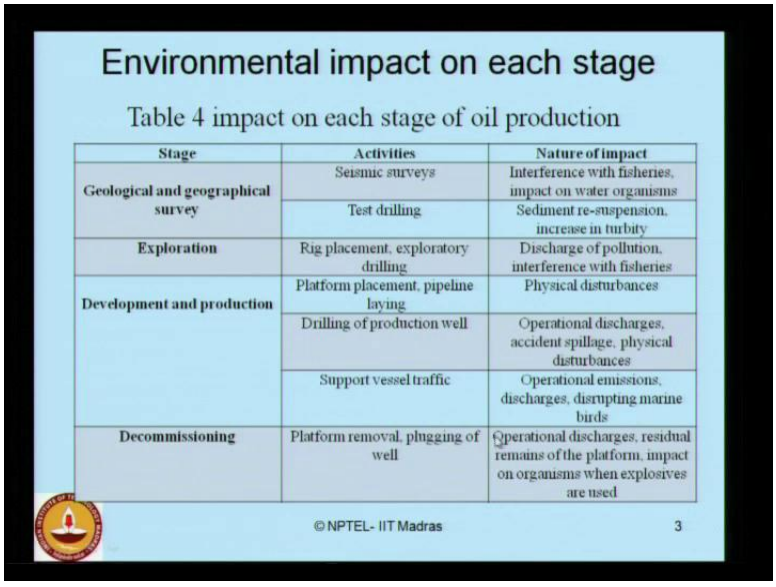

Let us look at the impact of each stage of oil production from this table. So, the stages what I list here are exactly the one which is showed in the previous slide. Geological and geographical survey stage; exploration stage; development production stage; and decommissioning stage. The activities generally being carried out under the different stages are listed here. For example, in the geological and geographical stage generally there are different kinds of surveys being carried out; they also do what is called test drilling at this stage. The seismic surveys carried out under water generally interfere with the fisheries life; they have a very serious impact on water organisms.

When we do what we called as test drilling in the geological stage itself, in the survey stage, the resultant lot of sediment re-suspension which increases turbidity in the water. If you look at the successive stage of oil production, which an exploratory stage we keep on doing lot of rig being placed during this stage of oil production. People do exploratory drilling to really estimate the yield of the well etcetera. During this process they discharge lot of pollution which interfaces also with fisheries live as well during this stage.

Once the exploration stage is completed and the oil well are established then platforms are actually put in position, pipelines are laid under water and production start and the drilling of production wells happens which we called as development and the production stage. There will be lot of support vessel happening during the stage; they cost lot of physical disturbances; they do lot of operational discharges in ocean environment. They also do unfortunately lot of accidental spillage and they do really physical disturbances during the production stage. During the support vessel traffic, they do lot of operational emissions; they also do lot of discharges; they disrupt marine, birds' etcetera extensively

When we look at the last stage of oil production, where platforms are decommissioning that is removal of the platform from the side location and plugging of well happens at this stage. They also do lot of operational discharges, the residual remains of the platform are left there which causes ecological disturbances, there is a series impact on organisms when explosives are used for decommissioning these platforms. This one of the very serious threat being post to the marine organism which will enable these organisms to relocate from location a where decommission is happening to a new location. There is an extensive shift of marine organism from the decommissioning location to the new location which causes lot of threat to the marine environment

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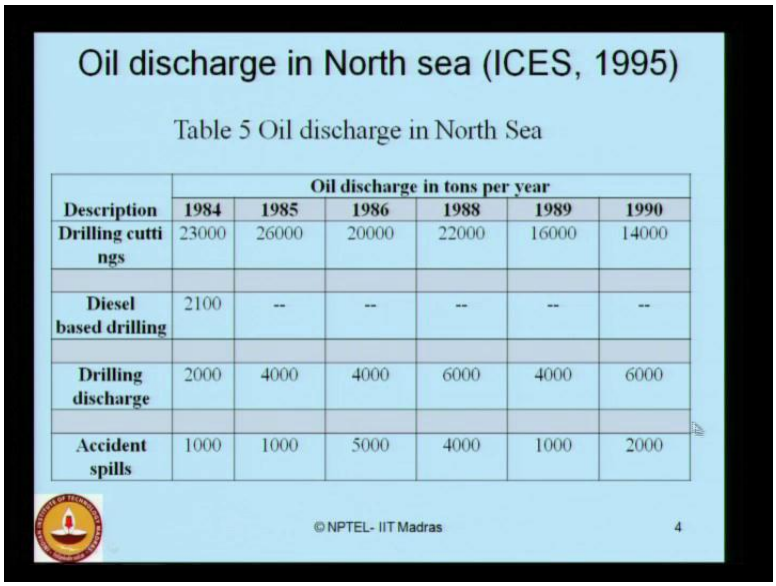

Ladies and gentleman, if we look at the oil discharge as one of the important pollutant which is response in a marine pollution, looking at the source in North Sea is ICES, 1995, the table discloses the oil discharge in North Sea in an approximate figure. If we look at the oil discharge in tons per year happening from 1984 till 1990, for a tune about six years in example survey reported in the report here. Look at the different levels of discharges. The discharge happens form drilling and cuttings, diesel based drilling, drilling discharges and accidental oil spills.

In 1984, the drilling cuttings had an oil discharge of about 23,000 tons which has been substantially reduced to about 14,000 tons in a year in 1990. However, if you look at the diesel based drilling discharges happening in North Sea specifically, they were happening in the tune of about 2100 tons in 1984, subsequently there has been insignificant reporting of this discharge in the North Sea.

If you look at the drilling discharge, which started off with 2000 tons per year in 1984, gradually raised the tune about 6000 tons in 1990. However, unfortunately, if we look at the accident spills in 1984, there were limited to only about 1000 tons in year which raised as an alarming situation to about 5000 tons in year in 1986. However there has been some control measures taking place to control the oil accident spills and now this has been substantially reduced 2000 tons, but ladies and gentlemen, please remember that accidents occurring from oil spills are inevitable and they are irreversible as well. So

therefore, even in 1990, you have a report stating 2000 tons of oil discharge happening in that year.

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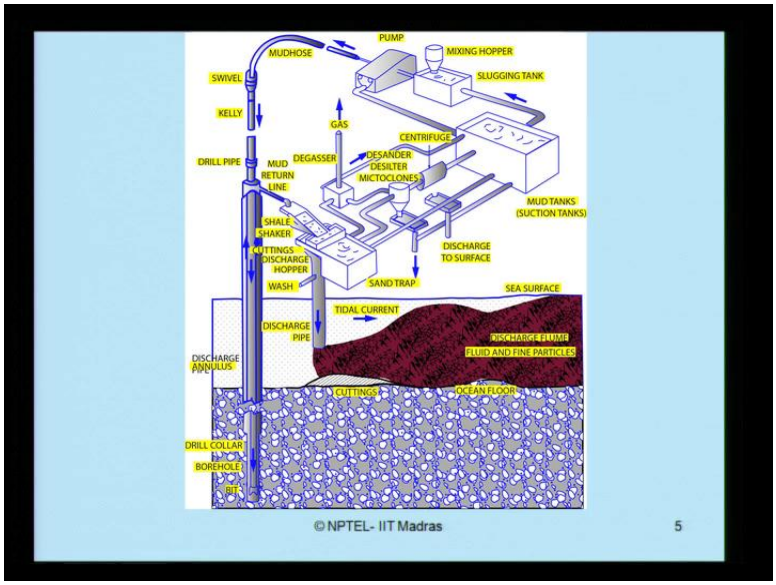

This is a very interesting conceptual figure, which explains the drilling fluid handling system. If you look at this conceptual figure in a simple format the drilling fluid is pumped inside and it pumps out lot of residuals as a reverse process. These residuals are processed and then discharged at different stages here. So, drilling as such is a process which discharges lot of pollutants in the marine environment.

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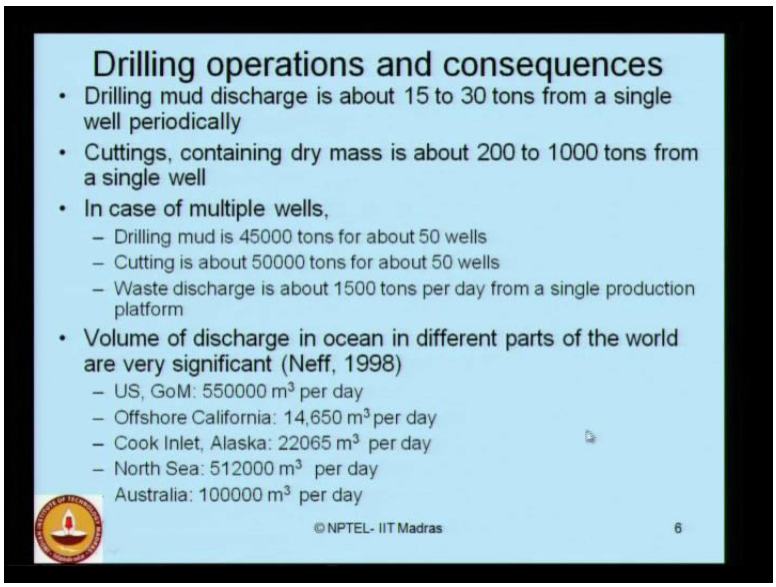

Now let us look at the drilling operation and the consequences of this as marine pollution. The drilling mud discharge is about 15 to 30 tons from a single well which happens periodically every year. Basically it arises from the cuttings, containing the dry mass which is being re-circulated back to the ocean environment which is to a tune of about 200 to 1000 tons from every single well which is being used for drilling operation.

This figure is very alarming when you use multiple wells. I have a statistics here which is being done for about 50 wells. The drilling mud happening from multiple wells the tune about 50 wells together is about 45 tones which is happening from all the wells put together. The cutting waste which is being discharged from the drilling operation is about 50000 tons from about these 50 wells. In addition to the drilling mud and cutting discharges, there is also a water discharge happening which about 1500 tons per day from a single production platform. All these put together add to a large volume of pollution to the marine environment.

The volume of discharge in ocean in different parts of the world is also being discussed here very briefly. If we look at the Gulf of Mexico, in United States it is about 550000 cubic meters a day. If we look at offshore California, it is about 14650 cubic meters per day. Whereas Cook Inlet, Alaska discharges about 22065 cubic meters per day. In North Sea, the values substantially high closed about 512000 cubic meters a day. Whereas in Australia it is about 100000 cubic meters a day. So, if you look at different parts of the world where oil production systems are concentrated. You will see the volume of discharge arising from oil and offshore facility or substantially high varying from about 550000 cubic meter a day to about 14000 cubic meter per day.

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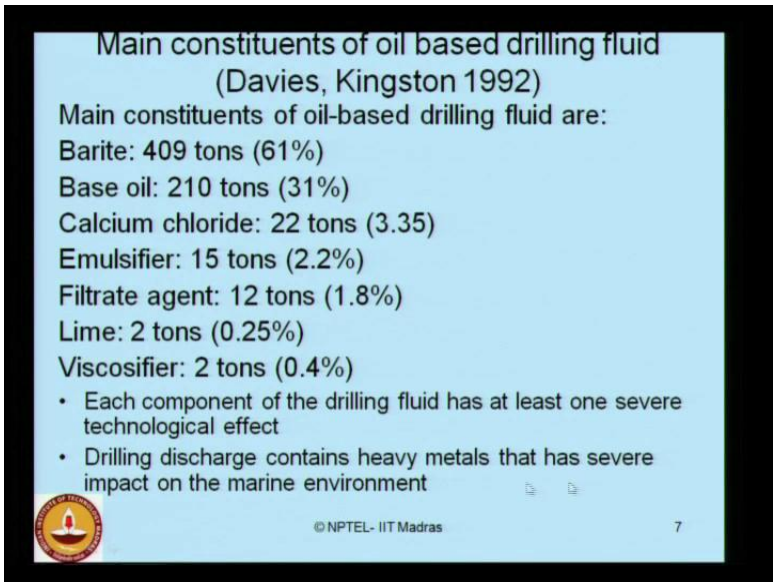

Now, let us look at the main constituents of the oil based drilling fluid and let us see why are they dangerous in terms of its pollution scenario. If we look at the main constituents of on oil based drilling fluid, they contain different constituents namely barite, base oil, calcium chloride, different emulsifiers, filtrate agents, lime and viscosifiers. The barite is about 409 tons which is about majority of the major constituent constituting about 61 percent of the total. The base oil which is about 210 tons contributes to about 31 percent. Calcium chloride constitutes about 3.35 percent. Emulsifier contributes about 2.2 percent. Filtrate agents contribute about 1.8 percent. Lime contributes to about 2 tones amounting 0.25 percent. And viscosifier contributes about 2 tons in the total of the drilling fluid.

Each component of the drilling fluid namely barite, base oil, calcium chloride, emulsifiers, lime, and viscosifiers have at least one severe technological effect on the marine pollution. Drilling discharge contains heavy metal that has severe impact on a marine environment.

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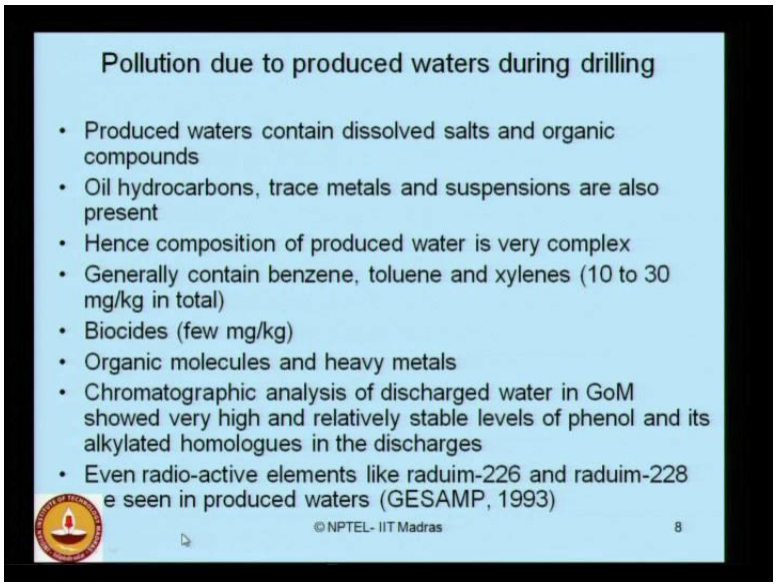

If you look at the pollution occurring due to the produced waters during drilling, this figure is also very alarming ladies and gentlemen. The produced waters contain lot of dissolved salts and organic compounds. Oil hydrocarbons, trace metals and suspensions are also present in the produced waters during drilling operation. Hence the composition of this produced water is very complex to analyze. Generally the produced waters during drilling operation contain benzene, toluene and xylenes which amounting about 10 to 30 milligrams per kilogram in total of the drilling compounds.

They also contain biocides, which are about few milligrams per kilogram of the total solids. The organic molecules and heavy metals are also present in the produced waters arising from the drilling process. The chromatographic analysis of discharged water in Gulf of Mexico showed very high and relatively stable levels of phenol contents and its alkylated homologues in the discharges. These are very dangerous source for marine pollution. Even amazingly radio-active elements like radium-226 and radium-228 are also seen in produced waters

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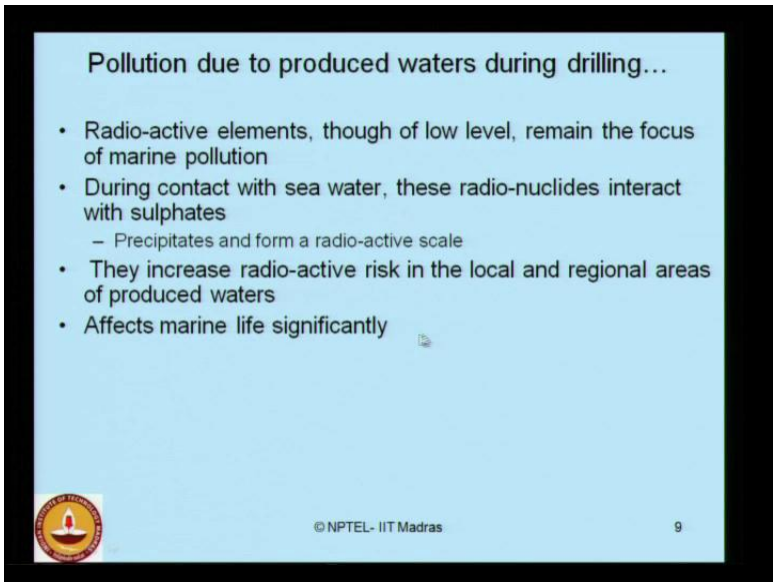

Let us quickly see, what would be the effect of pollution due to produced water during drilling with a focus to radio-active elements. The radio-active elements, though of very low level, remain the focus of marine pollution in the recent research. During contact with the sea water these radio-nuclides interact with sulphates. They form precipitates and also form what we call radio-active scale. They increase radio-active risk in the local and regional areas of these produced waters. They affect the marine life significantly.

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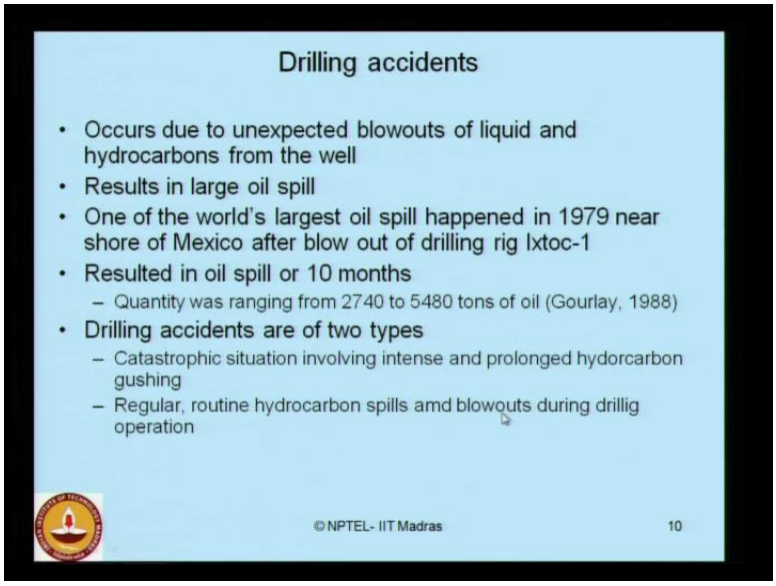

If you look at the drilling accidents, they are also one of the major contributors for marine pollution. The drilling accidents occur due to of course, unexpected blowouts of liquid and hydro carbons from the well. As offshore oil and gas engineers, we understand that drilling accidents are inevitable, of course, there are methods to prevent them, but there are no methods to completely avoid them. The unfortunate part as a result of drilling accident is a result in a large quantity of oil spill; that is one of the negative consequences what we have in the drilling accidents.

If you look at one of the world's largest oil spill that occurred in 1979 near shore of Mexico after blow out of drilling rig lxtoc-1. It resulted in oil spill for about 10 months. The quantity of oil spilled on the ocean surface was ranging from 2740 to 5480 tons of oil. It is a very large volume and the process becomes irreversible. Drilling accidents generally can be categorized in literatures which are of two types. One is catastrophic situation involving intense and prolonged hydro carbon gushing. The other one is a regular routine hydro carbon spill and blowouts during drilling operation.

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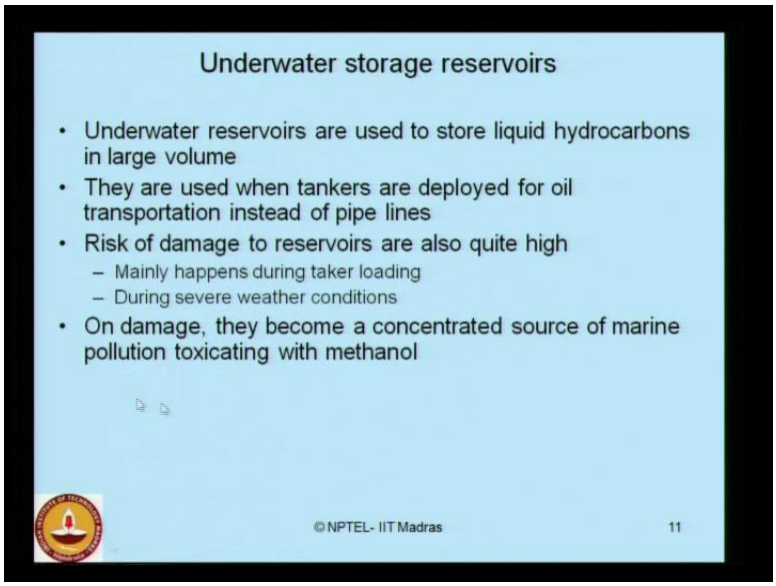

The other major source of marine pollution which arises from offshore gas and oil production platform is underwater storage reservoirs. You may wonder why we need under water storage reservoirs after all in the original source? The under water reservoirs are used to store liquid hydrocarbons in a very large volume. They are essentially used when the transportation occurs through containers and not through the pipe lines. If you

do not use the pipe line for the transport, you generally use tankers for deploying the oil transportation, then you require large under water storage reservoirs to store these hydro carbons.

Later on they subsequently transported to the field are to onshore of process using tankers. Now, the risks of damage to reservoirs are also very high. They mainly happen during tanker loading because of collision of the tanker with a reservoir and due to severe weather conditions. On damage they become unfortunately a concentrated source of marine pollution toxicating with methanol.

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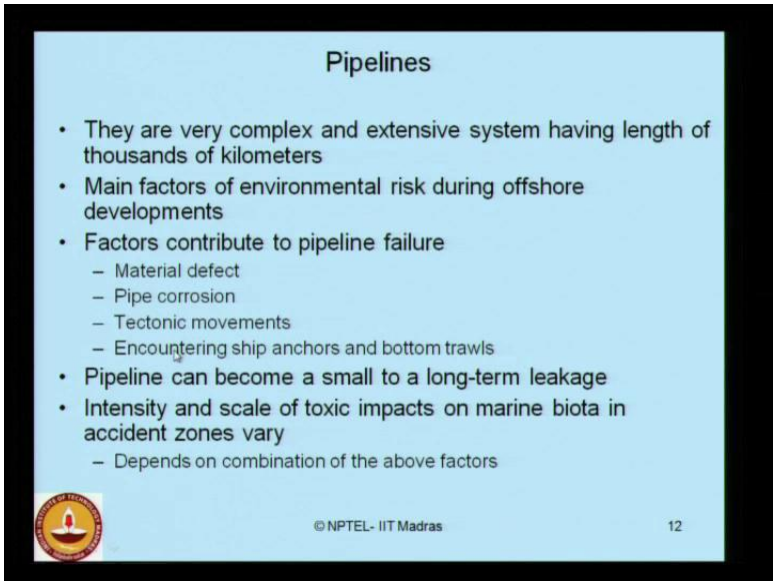

The other major source of oil and gas production platform systems to marine pollution is the pipe lines. Pipe lines are very complex an extensive system of network having lengths of thousands of kilometers. Main factors of environmental risk during offshore developments arise mainly from the pipelines. Factors contribute in general to the pipe line failure can be listed as below. There can be a serious material effect which punctures the pipe line results in failure of a pipe line. There can be serious pipe corrosion, because of the pure quality of material. Tectonic movements will also affect the pipe line network because they spread in extensive link along the sea bed. The encountering ship anchors and bottom trawls sometimes damage the pipe line which are laid under water.

Pipe line, therefore can become a small to a long-term leakage source which causes a permanent point of pollution for marine environment. The intensity and scale of toxic

impacts on the marine biota arising from the pipe line accident zones actually vary. They basically depend on combination of the above factors as discussed here.

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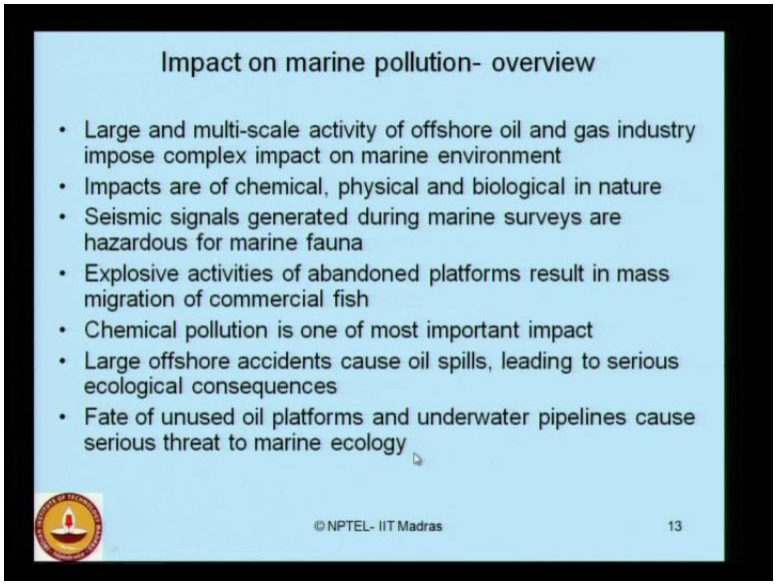

Ladies and gentlemen, lastly let us quickly look at an overview of impact on marine pollution. Large and multi-scale activity of offshore oil and gas industry impose complex impact on the marine environment. Impacts are of different types and nature, chemical, physical and biological in nature. Seismic signals generated during marine surveys are hazardous for marine fauna.

Explosive activities of abandoned platforms result in mass migration of commercial fish from one segment to another segment regionally, locally and even sometimes globally as well. Chemical pollution is found to be one of the most important impacts of marine pollution. Large offshore accidents cause oil spills which lasts month together, which leads to serious ecological consequences. Fate of the unused oil platforms and under water pipelines causes serious threat to marine ecology.

Thank you.