

Health, Safety and Environmental Management in Petroleum and offshore Engineering

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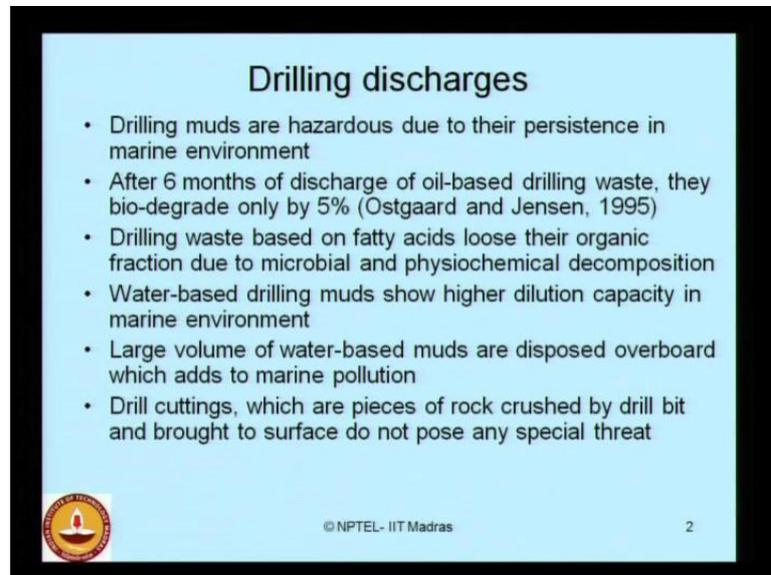
Module No. # 02

Lecture No. # 04

Chemicals and wastes from offshore oil industry and Environmental management

Ladies and gentlemen, we will continue with module two lecture number four on HSE in offshore and petroleum engineering management. In this lecture, we will discuss very briefly about the chemicals and wastes which are discharge from offshore and oil industry, and how are they complimenting to the environmental management problems.

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Drilling discharges

- Drilling muds are hazardous due to their persistence in marine environment
- After 6 months of discharge of oil-based drilling waste, they bio-degrade only by 5% (Ostgaard and Jensen, 1995)
- Drilling waste based on fatty acids loose their organic fraction due to microbial and physiochemical decomposition
- Water-based drilling muds show higher dilution capacity in marine environment
- Large volume of water-based muds are disposed overboard which adds to marine pollution
- Drill cuttings, which are pieces of rock crushed by drill bit and brought to surface do not pose any special threat

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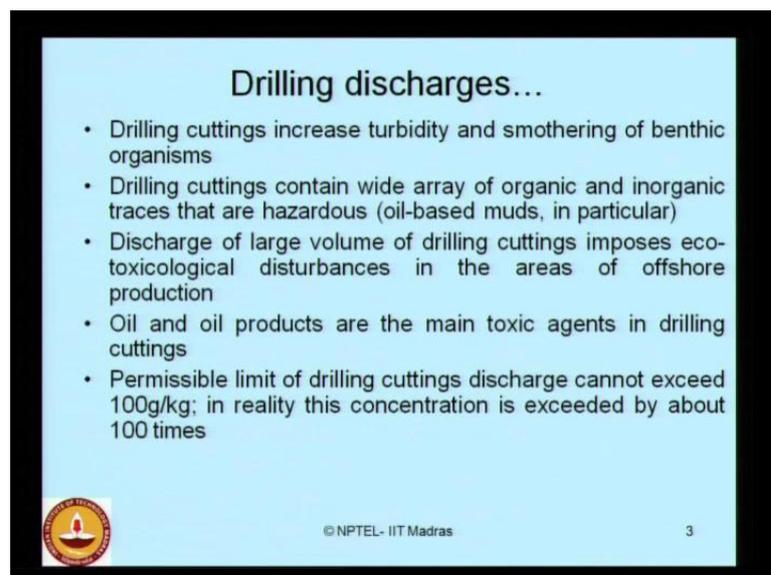
If we look at the primary resource of pollution in the marine environment which comes from oil and gas industry, one of the primary suspect is what we call as a drilling discharge. Drilling muds are hazardous due to the persistence in the marine environment. After six months of discharge of oil based drilling waste, they bio-degrade only by 5

percent. It means 95 percent of the content of the discharge, which is basically in the marine environment remains non bio-degradable which is very hazardous.

The drilling waste based on fatty acids lose their organic fraction due to microbial and physiochemical decomposition. Water-based drilling muds show higher dilution capacity in the marine environment compare to that of oil-based drilling waste. Large volume of water-based muds are disposed overboard which adds to the marine pollution. Even though water-based drilling muds are common in these days and researchers claims that due to their high dilution capacity their contribution to marine environment is on the lowest scale. Now, one part is the concentration of pollution caused by the drilling mud. It is very obvious that water-based drilling muds cause low scale of marine pollution, because of the high dilution capacity.

On the other hand, the fact which is very alarming is the volume of this kind of drilling mud being disposed to over board in the marine pollution. These add to a large content of marine pollution, because very substantial high volume of water based drilling muds are discharged overboard from every offshore plant. The drill cuttings, which are extracted through the drill bit while drilling operation goes on, they consist actually pieces of rock which are crushed by the drilling bit and brought to the surface; they do not actually pose any special threat to the marine environment.

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Drilling discharges...

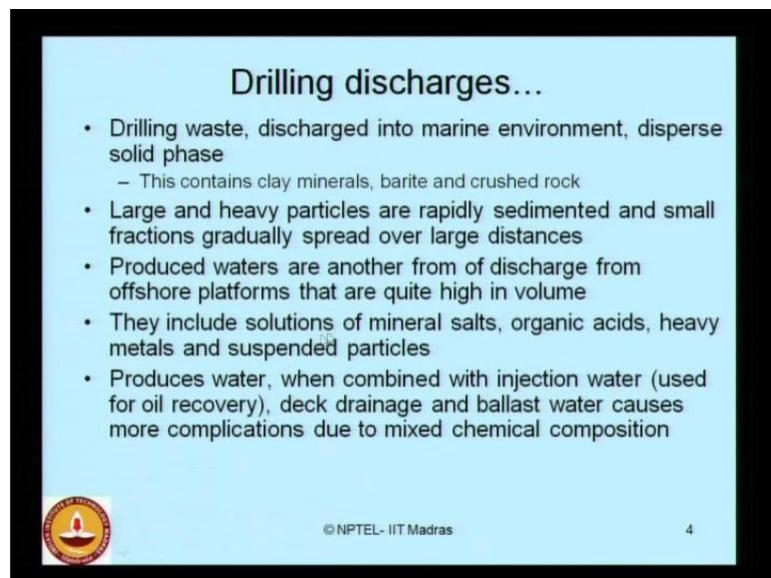
- Drilling cuttings increase turbidity and smothering of benthic organisms
- Drilling cuttings contain wide array of organic and inorganic traces that are hazardous (oil-based muds, in particular)
- Discharge of large volume of drilling cuttings imposes ecotoxicological disturbances in the areas of offshore production
- Oil and oil products are the main toxic agents in drilling cuttings
- Permissible limit of drilling cuttings discharge cannot exceed 100g/kg; in reality this concentration is exceeded by about 100 times

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However, drilling cuttings increase turbidity and smothering of benthic organisms. The drilling cuttings contain wide array of organic and inorganic traces that are hazardous. In particular, if you look at the oil-based muds, the organic and inorganic content present in oil-based muds are very hazardous for marine organism. As I told you earlier, large volume of drilling cuttings which is discharged in the marine environment imposes, ecotoxicological disturbances in the areas of offshore production.

Wherever, offshore platform are located wherever there are active drilling exploration as well as production drilling take place. Large volume of drilling cuttings basically a discharged, they cause what we call local turbidity in that area which affects basically the marine environment very significantly. Oil and oil products are the main toxic agents in the drilling cuttings. The permissible limit, if you look at the upper limit of the drilling cutting discharge, generally as per the literature the permissible value cannot exceed 100 grams per kilogram, but in reality this concentration is exceeded easily by about 100 times.

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Drilling discharges...

- Drilling waste, discharged into marine environment, disperse solid phase
 - This contains clay minerals, barite and crushed rock
- Large and heavy particles are rapidly sedimented and small fractions gradually spread over large distances
- Produced waters are another form of discharge from offshore platforms that are quite high in volume
- They include solutions of mineral salts, organic acids, heavy metals and suspended particles
- Produced water, when combined with injection water (used for oil recovery), deck drainage and ballast water causes more complications due to mixed chemical composition

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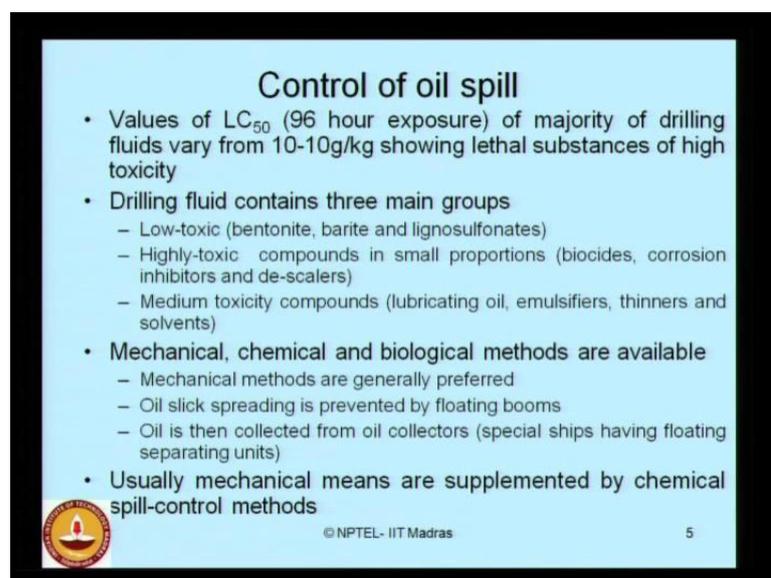
Drilling waste, when discharged into marine environment, disperse what we called as a solid phase. This solid phase contained clay minerals, barite and crushed rock. Large and heavy particles present in the drilling waste are rapidly sedimented and small fractions gradually spread over very large distances. The produced waters from the drilling operation are another form of discharge from offshore platforms, the most alarming fact

about the produced waters is the volume of discharge. Compare to the drilling discharges, produced waters are much more in volume and they are easily mixing with the water based compounds in the marine environment, and they spread for a large surface area in the sea. They include solutions of mineral salts, organic acids, heavy metals and suspended particles.

The produced water when combined with injection water. You may wonder what is an injection water, in many cases to enhance the recovery out to an enhanced production capacity of the yield of the well, people follow what we call enhanced oil recovery technique. One of the very common enhanced oil recovery technique is a water injection.

So, when the produced water when combined with injection water and the deck drainage water and ballast water causes more complications because their chemical composition is hybrid. You may wonder the generally for the people living on board and for other facilities, you need to have what we call as deck drainage facility. This will also collect an lot of waste water and of course, blast tanks or used in FBA source semi sub merge for maintaining the required bouncy during drilling operations. So, the blast water the depth drainage continent of waste water and the produced waters from the drilling operation put together when they get mixed up they form what we call a very hybrid chemical composition and when they are discharged in open sea the complications are increased manifold.

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Control of oil spill

- Values of LC_{50} (96 hour exposure) of majority of drilling fluids vary from 10-10g/kg showing lethal substances of high toxicity
- Drilling fluid contains three main groups
 - Low-toxic (bentonite, barite and lignosulfonates)
 - Highly-toxic compounds in small proportions (biocides, corrosion inhibitors and de-scalers)
 - Medium toxicity compounds (lubricating oil, emulsifiers, thinners and solvents)
- Mechanical, chemical and biological methods are available
 - Mechanical methods are generally preferred
 - Oil slick spreading is prevented by floating booms
 - Oil is then collected from oil collectors (special ships having floating separating units)
- Usually mechanical means are supplemented by chemical spill-control methods

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Now, the question comes if at all we have an oil spill which may occur deliberately by an accident or by natural seepage of oil from the sea flow, how do you control an oil spill? The values of what we call LC 50, LC 50 is a mathematical count determined experimentally from the sample taken on the sea water after 96 hour of exposure of majority of drilling fluids. The LC 50 value of the majority of drilling fluids samples taken from the sea water generally vary from 10 grams per kg showing lethal substances of high toxicity.

Drilling fluid generally contain three main groups in its constituents - Low-toxic, medium toxic and high toxic. The low toxic one is combination of bentonite, barite and lignosulfonates. The medium toxic compounds are lubricating oil, emulsifiers, thinners and solvents used during the drilling process. The high toxic compounds they are very small in proportion, but they are very toxic in nature, for example, biocides, corrosion inhibitors and de-scalers compounds.

There are many methods which are available in the literature by which you can control the oil spill namely mechanical, chemicals and biological treatments. Mechanical methods are generally preferred for controlling oil spill for example, we can discuss very quickly how the oil spill can be controlled mechanically. Oil slick, ladies and gentlemen, you will remember it is the thin layer of oil film which is being formed on surface of sea water in case of oil spill occurrence. Oil spill spreading is prevented by what we call constructing floating booms.

Floating booms are floating structures which collects oil from the chambers called oil collectors and from the oil collectors a special ships having floating separating units will dispose of these oil from offshore to onshore. So, floating booms will form a temporary barrier which can prevent the spreading of oil slick from the local area towards regional or global segment. However, the effectiveness of the floating boom design depends on how faster and how viscous the oil slick is. Usually mechanical methods are supplemented by chemical spill-control techniques.

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Environmental management issues

- Environmental issues of oil and gas development is the current focus of scientific and public attention all over the world
- Environmental management policies takes into account the following factors
 - Balance of current and future interest
 - Possibilities of alternative sources of energy
 - Natural conditions
 - Ecological factors
 - Technical and economical factors
- Unfortunately, many developing countries are involved in continuous exploitation of natural resources to ensure environmental sustainability

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After understanding what are the problems associated with drilling discharges with the produced waters with the deck drainage wastewater and production waste. We will look into some of the environmental management issues related to these areas. Environmental issues of oil and gas development is; obviously, the current focus of scientific and public attention all over the world. In many recent conferences and symposiums, you will exclusively have certain sessions where people deliberate issues related to environmental management problems, which are specifically arising from oil and gas development sector.

Environmental management policies which are generally framed to governed these issues takes into account the following factors. It has to consider a perfect balance between the current and the future interest of the country, which make such policies. Generally these policies are not made by single company or a country; it is a concrete of different group of countries with jointly make such policies because ocean remains a common barrier between adjacent countries. So, a mutual benefit of interest is being seen based on the current and future policies of the countries participating in such management issues, and there has got to be a perfect balance maintained between there interesting areas of growth and development of each country.

Generally, the committee or the people who make such policies also look into seriously the possibilities of alternative source of energy. As we said oil and gas production is on

the depletion at least after 2030, so people are looking forward for a very strong contribution an alternate sources of energy what we call as renewable energy sources. One of the main renewable energy source, which is now being explode strongly is offshore wave energy; people also looking for offshore wind energy as well. In addition to these two important points which are considered in environmental management policies. People also look forward to understand the natural conditions prevailing in that sector where the oil and gas development takes place.

The ecological factors for example, the sea state it is a rough, calm, quite and turbid; the wind conditions - the wind speed the wind velocity what we call and other temperature on humid factors which we put together as ecological factors. They are also considered while drafting, management policies based on environmental issues pertaining to oil and gas development. In addition to this lastly, but not the least the technical in economic factors of the countries guiding or managing these environmental policies or stipulating this policies will also be taken cared of while such policies are being drafted. After, all the participating countries should gain a mutual benefit from imposing such management policies towards environmental protection.

Unfortunately, many developing countries are involved in continuous exploitation of natural resources this is to ensure their respective environmental sustainability. On one hand, ladies and gentlemen, people look forward for stringent environmental management policies, which will control the environmental issues towards oil and gas development. On the other hand, developing countries arguing there technological innovators to continuously exploit the natural resources for maintaining their environmental sustainability.

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Environmental protection: principles applied to oil and gas activity

- Acknowledgement of socio-economic stipulation
 - Many countries are framing policies in cooperation with oil producers, fisherman and environmentalists to achieve mutual understanding across their respective domains
- Expediency of developing offshore natural resources
- Using an eco-centric approach in contrast with anthropocentric approach
 - This alternative approach ensures stability of natural ecosystems
 - It supports conditions for self-renewal of biological resources
- Environmental protection policies are governed by regional aspects accounting for specific features of different marine basins
 - In terms of diverse climate, social, economic and other characteristics

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If you look at the environmental protection as a whole, what are the general principles applied to oil and gas activity? This is a very interesting question which one will like to know. Let see how this can be answered. The foremost principle applied in environment protection in particular to oil and gas activity is that acknowledging the socio-economic stipulation.

Ladies and gentlemen, as I told you it is very important for every country to understand what are the socio-economic commitments for future and the present growth. Many countries are framing policies in cooperation with participants of this kind of environmental protection namely oil producers, basically the companies which are involved in not only selling or marketing the oil products, but also involved in drilling, production, transportation process, both upstream and downstream segment as well. So, when the frame policies towards socio-economics stipulation, which governs environmental protection in the specific areas; they certainly have include the major operators from the oil producers.

Of course, to invent economical and ecological balance fisherman or large companies which are involved in fisheries are also involve in consultation. And of course, environmentalist to achieve mutual understanding across the respective domains. A large team with participation from the oil sector from fisheries and from environmentalist put together frame policies, while they do framing of such policies towards environmental

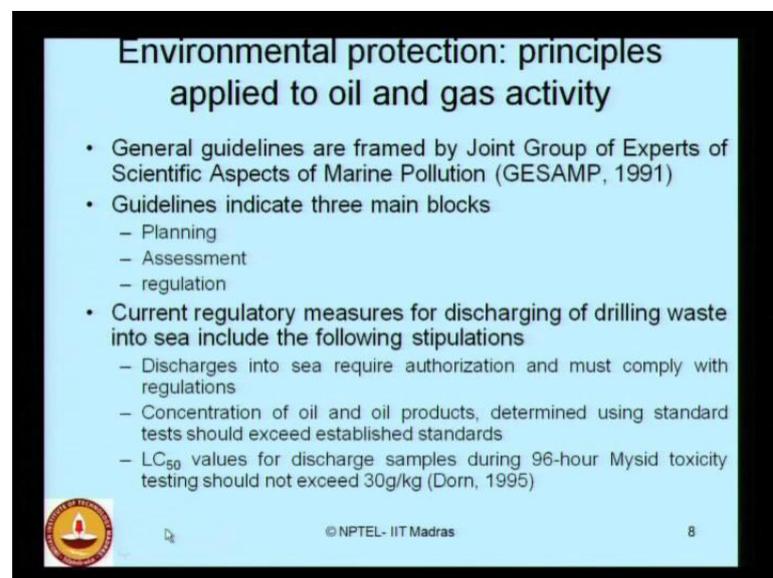
protection. They look forward very seriously for acknowledging the socio-economic commitment what the country has in the present and in the coming future.

The next point, which is generally applied as an important principle in oil and gas activity towards environmental protection is expediency of developing offshore natural resources. As I told you earlier, every developing country is looking forward for a faster growth rate in terms of its economic sustainability. So, oil source is one of the important segment where every developing country in specific looks forward for expediency in developing such offshore natural resources. So, these factors are also considered while framing the environmental protection policies.

The third one is a very interesting and important approach what we call the approach should be generally egocentric, instead of anthropocentric approach; we have already discussed in detail. Ladies and gentlemen, what is anthropocentric approach related to environmental management in oil gas industry in the previous lectures. So, generally while framing policies and principle related to environmental protection to be specific with oil and gas sectors, policies are generally made egocentric instead of anthropocentric. This alternative approach ensures stability of natural ecosystems; it supports conditions for self-renewal of biological resources.

Therefore, in general, environmental protection policies are governed by regional aspects. They account for specific features of different marine basins; this is very important, because the features climatic physical oceanographic and other features for marine basins on the same segment are different. Therefore, your environmental protection policies should be governed by the regional aspects, which are predominantly present in a specific marine basin or a group of marine basins, where these policies will be applicable. In terms of diverse climate, in terms of social, economic and other characteristics these are looked forward to understand while framing the environmental protection policies as well.

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Environmental protection: principles applied to oil and gas activity

- General guidelines are framed by Joint Group of Experts of Scientific Aspects of Marine Pollution (GESAMP, 1991)
- Guidelines indicate three main blocks
 - Planning
 - Assessment
 - regulation
- Current regulatory measures for discharging of drilling waste into sea include the following stipulations
 - Discharges into sea require authorization and must comply with regulations
 - Concentration of oil and oil products, determined using standard tests should exceed established standards
 - LC₅₀ values for discharge samples during 96-hour Mysid toxicity testing should not exceed 30g/kg (Dorn, 1995)

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General guidelines are framed by joint group of experts of scientific aspects of marine pollution what we call as GESAMP. The latest version what we have as the general guideline is available at 1991, GESAMP. The guideline indicates three main blocks - one towards planning, next is on the assessment, third is on the regulatory measures. The current regulatory measures for discharging of drilling waste into open sea include the following stipulations, which are given as a guideline by GESAMP. Discharges into sea require certainly authorization and must comply with the local regulations. Concentration of oil and oil products should be determined using standard tests, and these concentrations should not exceed established standards. LC 50 values for discharge samples during 96-hour of Mysid toxicity test should not exceed 30 grams per kg.

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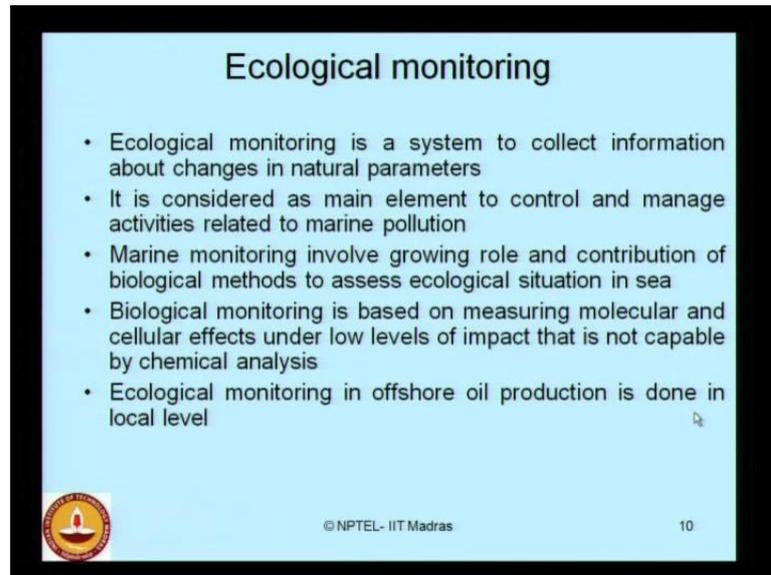
Environmental Management: standards and requirements

- Content of mercury and cadmium in barite base of drilling fluid is restricted
- No discharge of drilling waste allowed in waters within 3 miles from shore
- No discharge of diesel oil is allowed
- No discharge of free oil based on static sheen test is allowed
- Average limit of oil concentration should not be more than 7mg/litre for monthly oil content and 13mg/litre for average daily for average daily oil concentration
- Discharge is to be measured within 4 miles from the shore

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The environmental management look forward for certain standards and requirements. Let us look into them, what are they. The content of mercury and cadmium in barite base of drilling fluid is completely and strongly restricted. There should be absolutely no discharge of drilling waste allowed in waters within three miles from the shore activity. No discharge of diesel oil is allowed; no discharge of free oil based on static sheen test is allowed on the open sea. Average limit of oil concentration should not be more than seven milligram per liter. If you look for a monthly oil content or 13 milligram per liter, If you look for a average daily oil concentration. The discharge should be measured within four miles from the shore.

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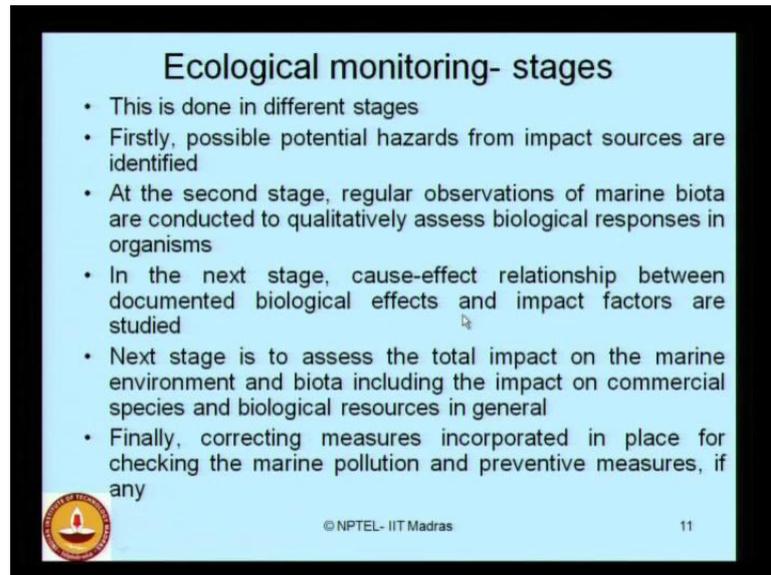
Ecological monitoring

- Ecological monitoring is a system to collect information about changes in natural parameters
- It is considered as main element to control and manage activities related to marine pollution
- Marine monitoring involve growing role and contribution of biological methods to assess ecological situation in sea
- Biological monitoring is based on measuring molecular and cellular effects under low levels of impact that is not capable by chemical analysis
- Ecological monitoring in offshore oil production is done in local level

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If you look at an important aspect of implementing this environmental management policies, then you look into the framework of what we call ecological monitoring. Ecological monitoring is actually a monitoring system which collects information about changes in natural parameters on open sea. It is considered as the main element to control and manage activities related to marine pollution. Marine monitoring involve growing role and contribution of biological methods to assess ecological situation in the sea. Biological monitoring is based on measuring molecular and cellular effects under lower levels of impact and that is not capable by chemical analysis. Ecological monitoring in offshore oil production is done in local level only.

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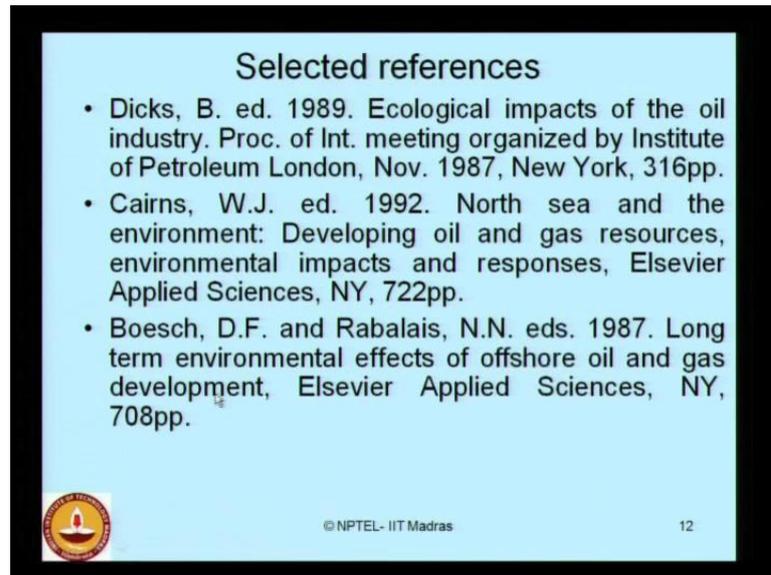
Ecological monitoring- stages

- This is done in different stages
- Firstly, possible potential hazards from impact sources are identified
- At the second stage, regular observations of marine biota are conducted to qualitatively assess biological responses in organisms
- In the next stage, cause-effect relationship between documented biological effects and impact factors are studied
- Next stage is to assess the total impact on the marine environment and biota including the impact on commercial species and biological resources in general
- Finally, corrective measures incorporated in place for checking the marine pollution and preventive measures, if any

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There are different stages by which you can do ecological monitoring. Firstly, possible potential hazards from impact sources are identified. At the second stage, regular observations of marine biota are conducted to qualitatively assess the biological responses in the organisms, because of the potential hazards. In the following stage, cause-effect relationship is established between the documented biological effects and the impact factors on these biological effects are thoroughly investigated. In the next stage, assessment on the total impact on the marine environment is done; including the impact on commercial species and biological resources in general. In the final stage, corrective measures are suggested and incorporated in place for checking the marine pollution, and if at all any preventive measures is to be ensured they are also suggested as a final stage in the ecological monitoring.

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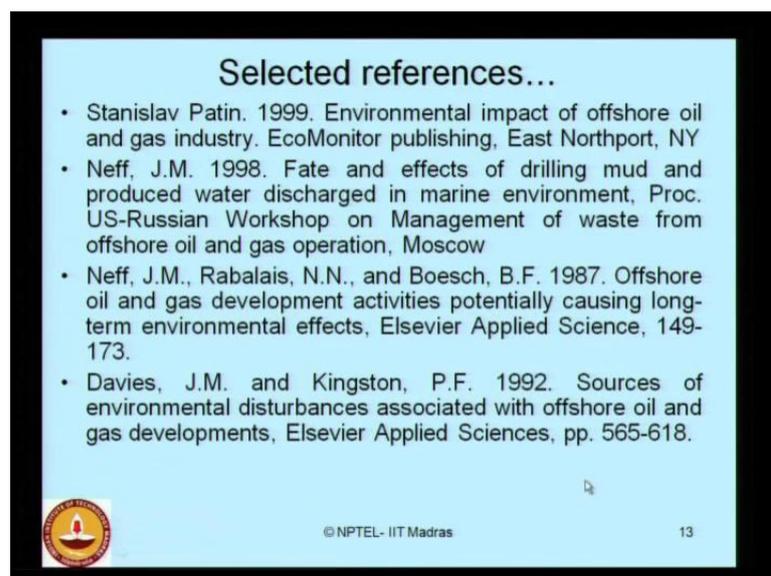
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Ladies and gentlemen, there are interesting selected references which I would like to cite for this specific lecture which will give an insight reading for you to understand more on marine pollution. Dicks speaks about ecological impacts of oil industry Cairns speaks on North sea and the environment developing oil and gas resources environmental impacts and responses. Boesch, Rabalais speaks on long term environmental effects of offshore oil and gas development Elsevier applied sciences New York.

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Stanislav Patin talks about environmental impact of offshore oil and gas industry. EcoMonitor publishing, New York. Neff talks about the fate and effects of drilling mud and produced water discharged in marine environment. Neff and Rabalais and Boesch talks about offshore oil and gas development activities potentially causing long term environmental effects, Elsevier applied science. Davies and Kingston talks about sources of environmental disturbances associated with offshore oil and gas developments.

I hope with these selected references, you will be able to understand more inside on marine pollution.

Thank you.