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NPTEL ONLINE CERTIFICATION COURSE

Health, Safety & Environmental Management in Offshore and Petroleum engineering (HSE)

Module 3:
Environmental issues and Management
Lecture 3: Chemical waste from offshore industry

Friends we will talk about the third lecture in module 3, where we are focusing environmental issues and management, in this lecture we will talk about chemical waste from offshore industry under HSE course at NPTEL IIT Madras.

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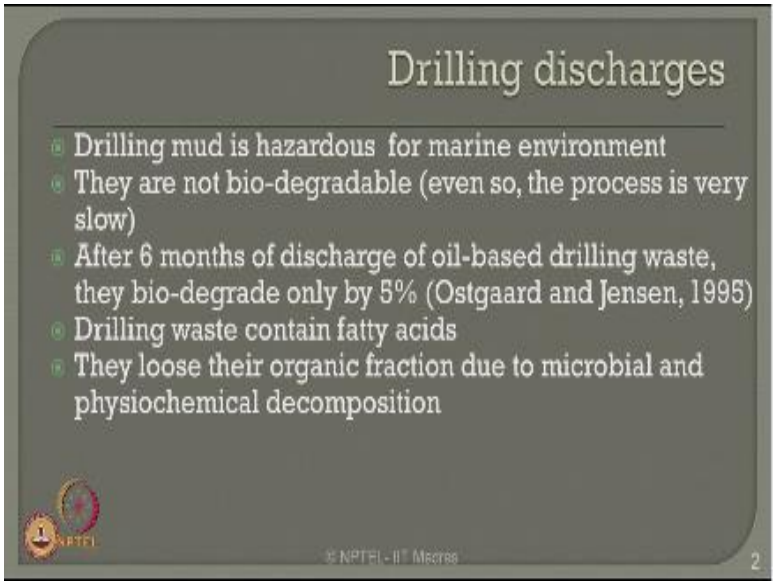

We already saw in the last lecture what are the consequences which arise from drilling which is one of the important consequence if the discharge which comes out during the drilling operations, drilling mud of course is hazardous for marine environment they are not

biodegradable even if they are so the process very slow, after six months of discharge of oil based drilling waste they bio-degrade only 5 %.

As told and as referred by Ostgaard and Jensen, 1995. Therefore drilling waste has been seen as containment of fatty acids, they lose their organic fraction due to microbial and physiochemical decomposition.

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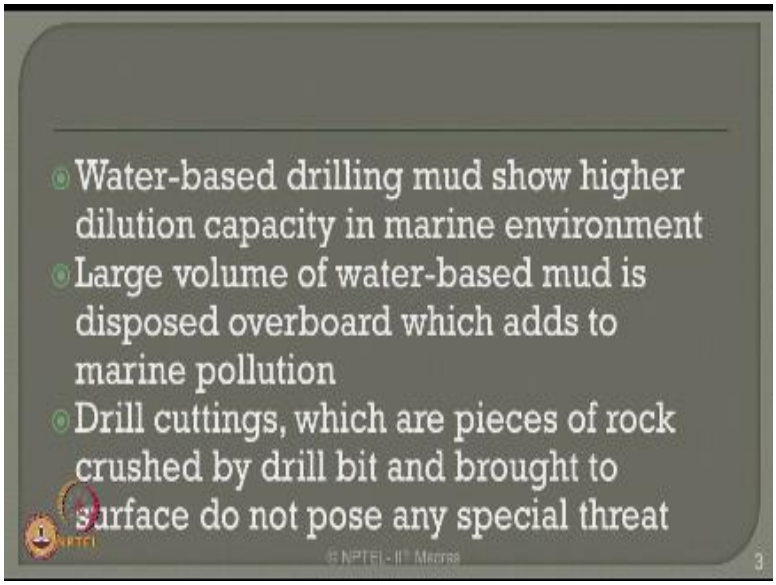

And there are some consequences which comes from water-based drilling mud, water based drilling mud show higher dilution capacity in the marine environment they disperse in large and quick contents, therefore larger volume of water bed must is disposed over go and this adds to quantifying marine pollution, in addition to the drill cuttings which are nothing with the piece of rock crushed by the drill bit and brought to the surface do not pose any special threat however.

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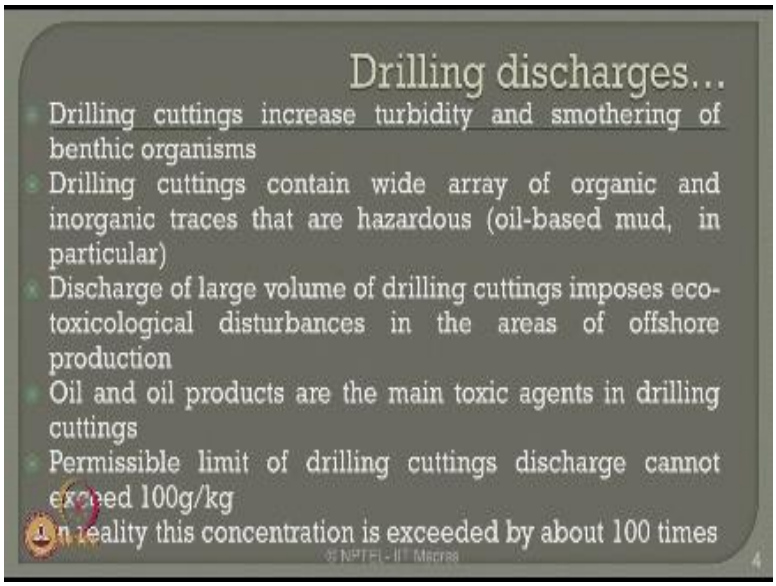

Drilling cuttings increase turbidity and smoldering of the benthic organisms, drilling cuttings contain wide array of organic and inorganic traces which are seems to be hazardous, in particular if you got an oil-based mud they are more hazardous compared to water based mud's that is why you see in the recent trend the drilling fluids has been changed and most particularly to water-based mud's.

Discharge of large volume of drilling cuttings impose eco- toxicological disturbances in the areas of offshore production, oil and oil products are of course the main toxic agents in drilling cuttings, if you look at the permissible limit of drilling cutting discharge as per the literature one can refer to a value of 100 grams per kg of the discharge which is the upper limit of drilling cutting discharge in the marine environment. But unfortunately in real since this concentration is exceeded for by closed over 100 times.

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Drilling waste therefore when discharged in the marine environment it is very clear that it disperses solid-phase this contains clay minerals, barite and crushed rock as a content of the discharge, large and heavy particles do undergo rapid sedimentation which settles on the seabed and causes lot of contamination to the seabed and the marine organisms, small fractions of course gradually spread over a very large distances around the concentration of drilling sites.

The produced waters which are byproducts during the drilling operation are another form of discharge which comes from the offshore platform which are quite high and vulnerable in its volumetric content, they of course include solutions of mineral salts, organic acids, heavy metals and suspended particles, when these contents combine themselves with injection water injection of course is the one which is used for enhancing the oil recovery from the well.

The deck drainage and the ballast water they induce more complications due to the mixed chemical composition of their content.

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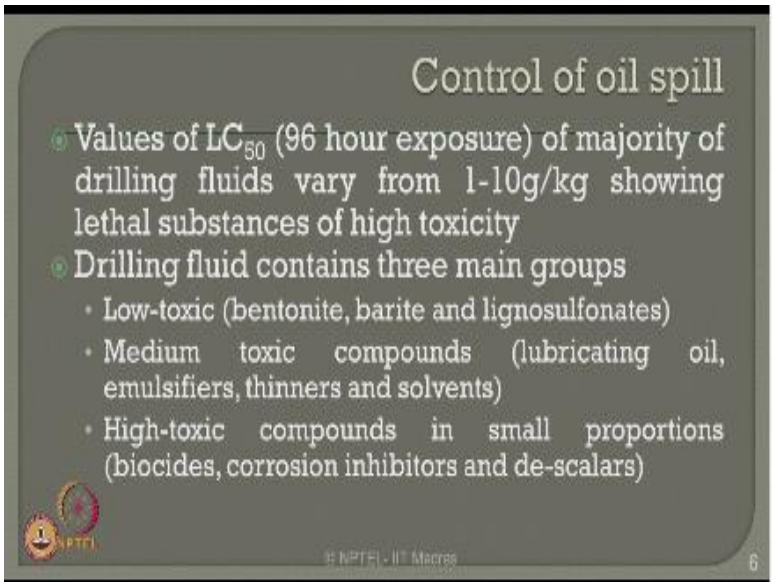

Now let us come to a point of how to control the oil spill if it occurs in offshore sites, values of lethal concentration 50 after 96 hour exposure of majority of drilling fluids essentially vary from 1 to 10 grams per kg which shows lethal substances of very high toxicity in the content of the oil spills, drilling fluid of course contain main three groups low toxic, medium toxic and high toxic compounds.

Low toxic compounds can have an example derived from bentonite, barite and lignosulfonates whereas a medium toxic compounds can have contents from lubricating oil, emulsifiers, thinners and solvents used for the process of drilling and production, high- toxic compounds of course represent in very small proportions but however examples can be biocides, corrosion inhibitors and de-scalars used for protecting the marine risers and the drilling risers from segmental corrosion in the inner lining of the risers.

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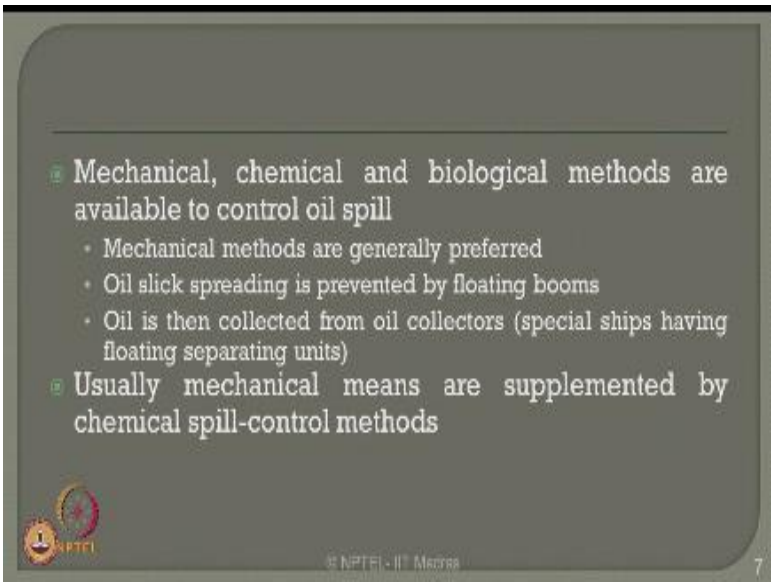

Now the mechanical, chemical and biological methods are available in the literature which can control the oil spill, mechanical methods are generally preferred over the remaining two, oil slick spreading can be prevented by what we call as floating booms once the floating booms are placed in position it contains a spread of oil spill, oil is then collected from the oil collectors special ships having floating separating units will be deployed for this purpose.

And oil from the surface will be collected in these spaceships and they are discharged back, usually mechanical means are generally supported by chemical spill control methods to enhance the effectiveness of the oil spill recovery or control mechanisms.

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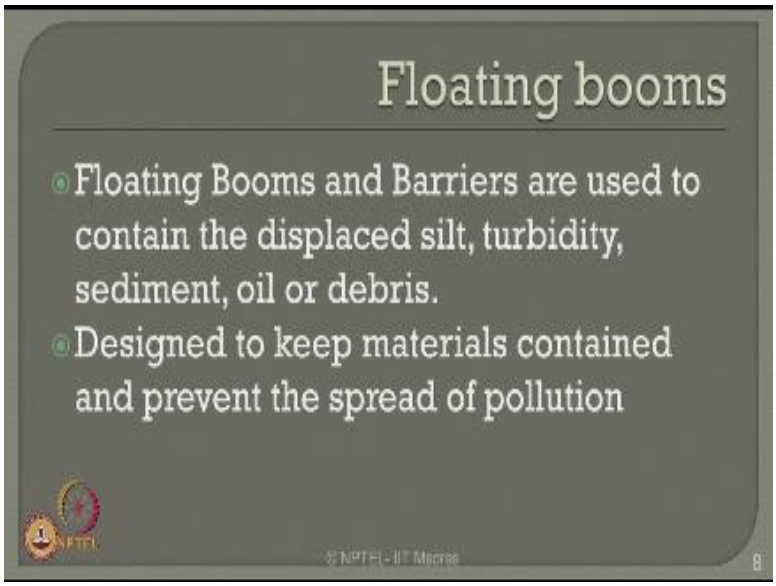

Let us talk about one important application in mechanical method of controlling oil spill which comes from floating booms, floating booms are other ways called as barriers essentially they are used to contain the displaced slit, turbidity, sediment, oil or debris. They are specially designed to keep materials contained in a closed environment and prevent the spread of pollution further in the larger area of contact.

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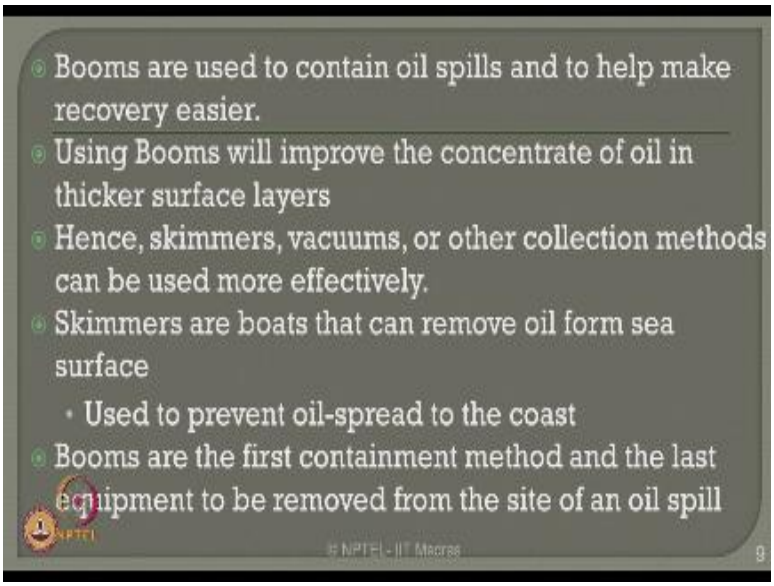

Booms are used to contain oil spills and to make help them make recovery easier, using booms will improve the concentrate of oil in thicker surface layers by which the secondary methods a recovery can be useful in cleaning on maintaining the enhancement of oil spill control in an efficient manner. So people use skimmers, vacuums or other collection methods more effectively once you contain the oil spill using boomers.

Skimmers are nothing boats that can remove oil from the sea surface where essentially used to prevent oil spread to the coastlines, booms are the first containment method and last equipment which are generally removed from the site of an oil spill.

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The picture we show you on the right is actually a boomer which is now containing the oil spill spreading from one contained area to the remaining area, they are effective of course in calm waters, however when the wave height increases it washes the contaminants over the top of the booms and make it ineffective, booms are used in series not in individual or isolation therefore the containment of oil spill can be made more effective.

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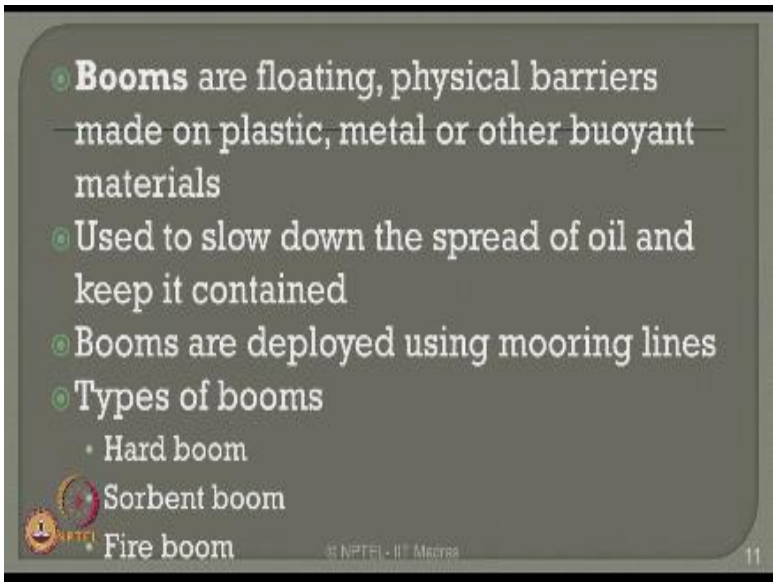

Booms are nothing but floating physical barriers which are either made of plastic, metal or other buoyant materials, they are used to slow down the spread of oil and keep it contained within a specific surface area, booms are of course deployed using mooring lines because they are stay in position, there are different types of booms which are mechanically deployed to control oil spill, hard boom, sorbent boom and Fire boom

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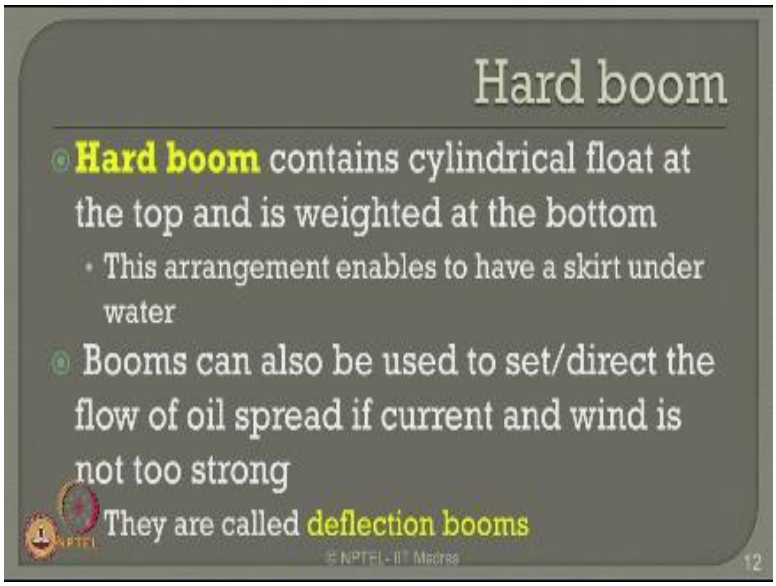

Hard boom actually contains cylindrical float at the top and it is weighted at the bottom this arrangement enables to have a skirt underwater which is useful and make the oil spill control more effective, booms can also be used to sit or direct the flow of oil spreading if current and wind is not too strong in the specific location therefore hard booms also have a subcategory called deflection booms.

Which are used to set or direct the flow of oil spit in the desired manner as decided by the local authority?

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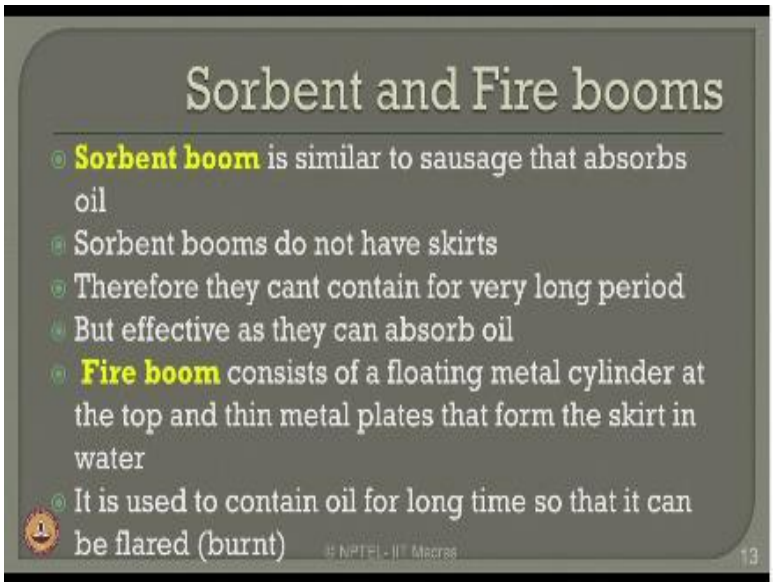

Sorbent and fire booms are another classical types of booms which are mechanical means of controlling oil spill, sorbent booms is similar to a sausage that absorbs oil, sorbent booms do not have skirts therefore they cannot contain oil for a very long period, however they are effective because they can absorb oil much faster, fire booms of course consists of floating metal cylinder at the top.

And I have thin metal plate that forms the skirt in the water, it is used to contain oil for a longer time. So that the oil can be flared up or burnt off in the position.

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The photograph as you see here in the slide now are very interesting this is one of the hard boom which is containing the oil in a specific location is as an example of an hard boom which is moved to the seabed which contains or prevented designed to prevent the oil spill further this is a skimmer which is nothing but a special boat which collects the contained or the controlled oil spill by a mechanical device.

And of course what you see here is a flare which has been set by the contained oil which is done by what is called as a fire boom, the fire boom actually contains a retain soil for a longer time then that is being set ablaze or set fire. So that viral contamination is controlled within a specific location.

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Let us try to now understand what are the environmental management issues related to oil spill alone or the chemical spill in general, environmental issues of oil and gas development is one of the current focus of scientific and public attention all over the world because the effects caused by this are highly irreversible in nature, environmental management policies therefore should and are accounting for the following factors.

What would be the balance of the current and future interest in terms of oil spill spread and control, what are the possibilities of alternate sources of energy can we get rid of really oil and gas production from the deep sea, what are those natural conditions which can be man over or altered or can be designed accordingly so that any catastrophic happening from the environmental issues can be contained or controlled to a larger extent.

There is also look into the policies related to ecological factors which either influence or promote the control of oil spill in a larger manner, we should also looked at the technical or economical factors by which a design can be suitably done so that if at all an accident occur the oil spill or the environmental issues are controlled to a very large manner, unfortunately friends many developing countries are involved in continuous exploitation of Natural resources.

To ensure environmental sustainability, therefore a very constant revisiting environmental management issues by these developing countries is on a very low scale.

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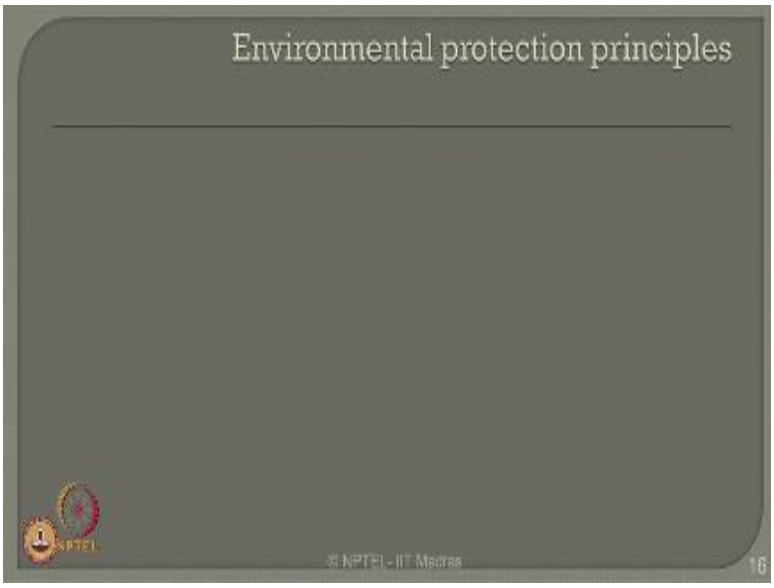

If you look at the environment production principles based on which the principal should be arrived at, one should always look at the acknowledgment of socio-economic stipulation.

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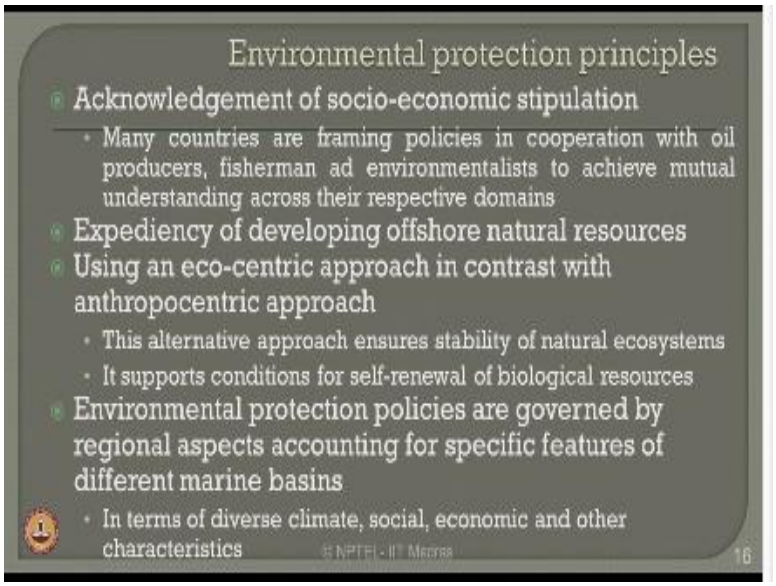

Many countries are actually framing policies in cooperation with oil producers, fishermen and environmentalist by which they can achieve mutual understanding across a respective domains so that the ecology is completely maintained and balanced, there should be an indication of expediency of developing offshore natural resources which are quite fast in nature and high economically supportive by the local governments.

Of course using an eco-centric approach in contrast with anthropocentric approach is what people generally follow in dividing or devising the environmental production principles, this alternative approach ensures stability of natural ecosystems and of course it supports conditions for self renewal of biological resources, environmental protection policies are therefore governed by the regional aspects.

Which accounts for specific features of different marine bases, therefore a general global guideline is very difficult to follow an implement because most of this protection policies should be based upon the local areas and the factors influencing the local government in terms of diverse climate, socioeconomic factors and of course other economic characteristics which govern such kind of protection principles in general.

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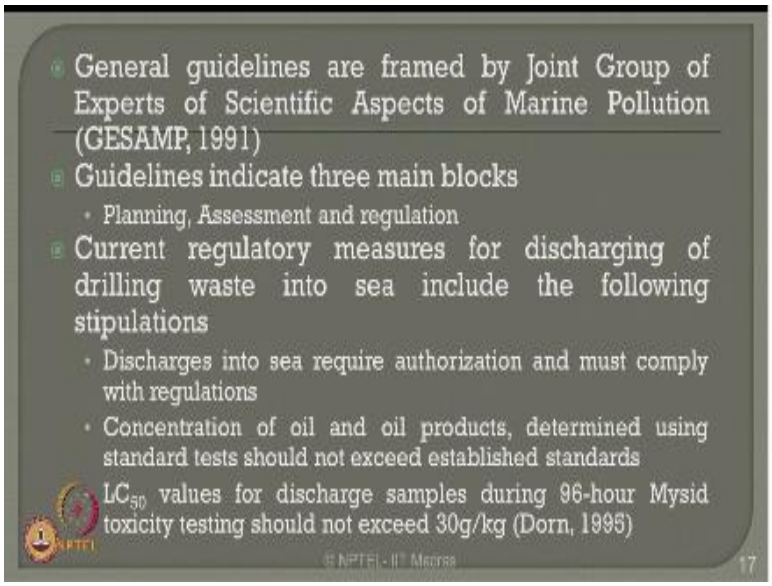

There are some general guidelines which are framed by join group of experts of scientific aspects of marine pollution which is GESAMP, 1991 which still forms now a general guideline for environment protection principles followed by oil and gas industries, these guidelines indicate three main blocks in the global perspective planning, assessment and regulation if any kind of extends do occur.

The current regulatory measures for discharging of drilling waste which is one of the important pollutant or contain contaminant in the sea water includes the following stipulations which are strictly implemented and being practiced in most of the developed and developing countries in the world, discharges into sea require authorization and must comply with certain regulations, free discharge of drilling waste is completely and totally abandoned and banned by most of the countries in the world.

Concentration of oil and oil products this should be determined using standard tests should not exceed acceptable results and standard values published in the general guidelines, for example the lethal concentration 50 values for discharge samples during 96 hour mysid toxicity tests should not exceed 30 grams per kg as referred by Dorn in 1995.

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There are few standards and requirements which must be implemented and practiced which is by enlarge practiced in almost all developed and developing countries.

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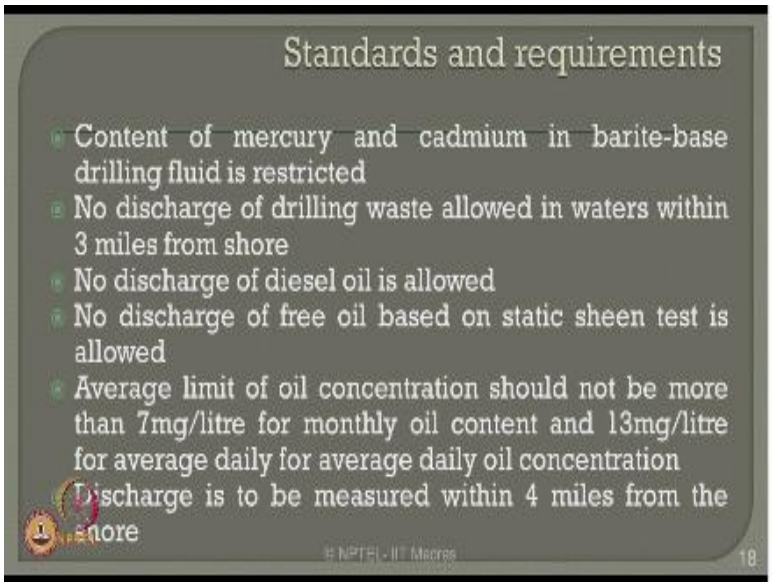

The content of mercury and cadmium in the barrage based drilling fluid is phenomenally restricted by its content and quantitative measure, friends please understand no discharge of drilling waste is allowed in waters within three miles from the show, no discharge of diesel oil is anything alone in the sea, no discharge of free oil based on static Sheen test is allowed to be discharged in the marine sea.

Average limit of oil concentration should not be more than seven milligram per liter for a monthly oil content and 13 milligram per liter or an average daily for average daily oil concentration, discharge is to be measured within four miles from the shore site.

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Let us look at few factors which are governing the ecological monitoring of environmental management, ecological monitoring of course the system which is in position to collect information about the changes in the natural parameters which are caused by the environmental pollution in the marine environment. So you measure the natural parameters and then monitor them continuously over a period of time using certain information which are collected from the sea site itself.

And this system or the scheme is called ecological monitoring, it is considered as one of the main element to control and manage activities.

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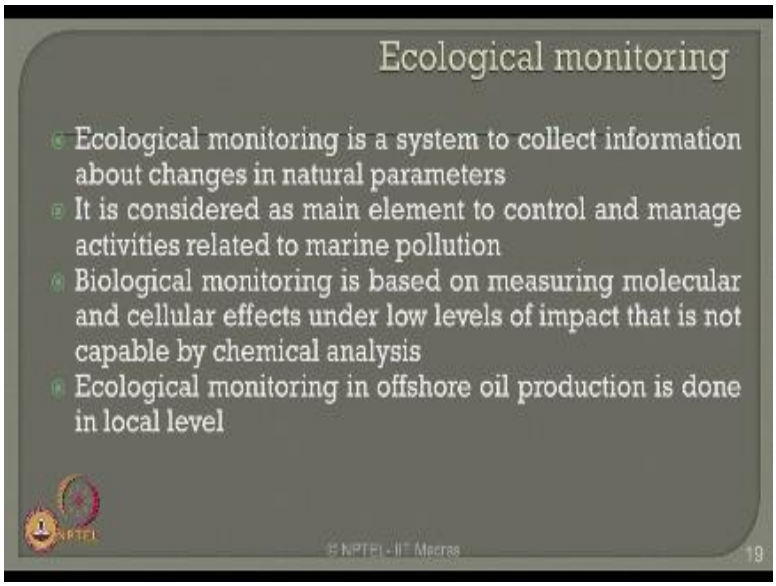

Related to marine pollution by enlarge in the world, biological monitoring is based on measuring molecular and cellular effects under lower levels of impact that is not capable by chemical analysis, ecological monitoring of course is very important in offshore oil production and it is to be done and generally carried out at local level itself.

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There are different stages when you talk about ecological monitoring.

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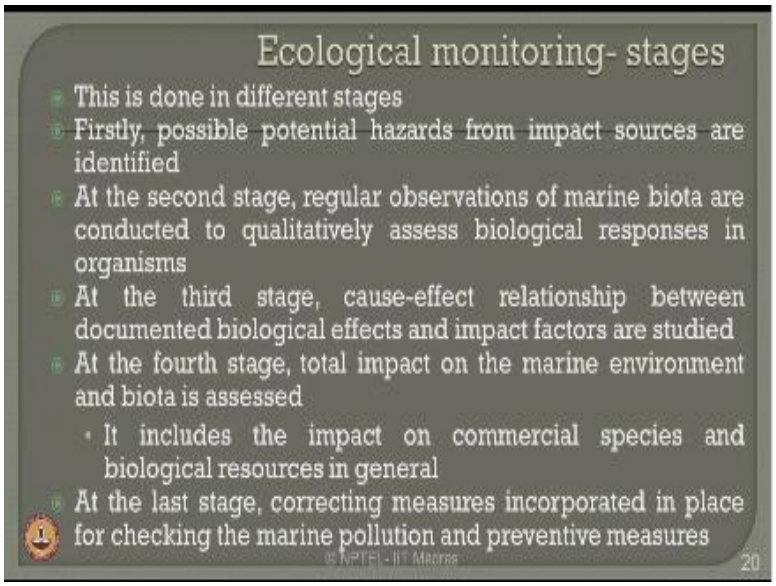

Firstly the possible potential hazards which arise from Impact sources are to be identified, followed by which in the second stage one has to do regular observations of marine biota which are conducted to quantitatively assess the biological responses in organisms whichis caused because of the drilling discharge in the marine environment and the next stage is the third stage people do conduct cost effect relationship.

Between the documented biological effects and impact factors which are studied in the first stage, at the fourth stage people arrive at what is called total impact on marine environment and the biota which is assessed at this stage it includes the impact on commercial species and biological resources by enlarge, in the last stage if at all any such unresponsive issues are seen and noted then corrective measures ought to be guided.

And incorporated in place for checking the marine pollution and implementing very seriously the preventive measures when such issues occur the site is revisited again all stages of economical monitoring is carried out to assess and ensure that at the last stage correcting measures are implemented and of course the marine pollution caused by the drilling discharges and chemical

waste in the marine environment is very much less than the threshold value accepted and given as guidelines by the international regulatory bodies.

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When you talk about chemical waste in general which comes from the oil and gas industry there are different types of chemicals and waste that actually enter the marine environment which extremely wide in nature they contribute overall about eighty percent of the marine pollution produced waters, ballast and injection waters, drilling cuttings and fluid are the main sources of pollution which comes from the marine environment.

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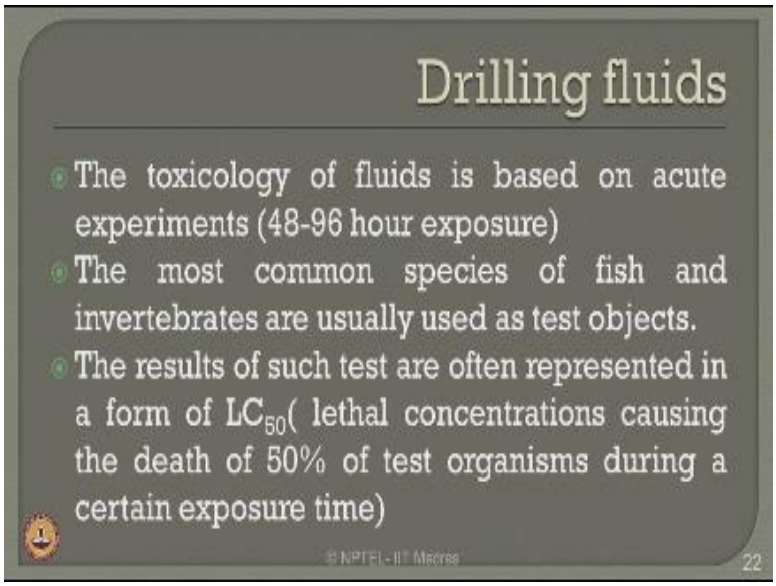

Out of which drilling fluids plays a very important role, the toxicology of fluids is based on acute experiments we conduct experiments the range of 48 – 96 hours exposure and try to measure the parameters on the organisms based on the effect cost by the drilling fluid discharge on the marine environment, the most common species of fish and invertebrates are usually used as test objects in this case.

The results of such tests are often represented in the form of lethal concentration 50, it means the lethal concentration causing death of fifty percent of test organisms during a certain exposure of time which is 40- 96 hours is a test period. So you pick up certain sample which is a special or species of fish in the specific location if fifty percent of that sample selected is ending it fertile then that concentration is called as LC_{50}. Which should not be allowed to be continued in the marine environment.

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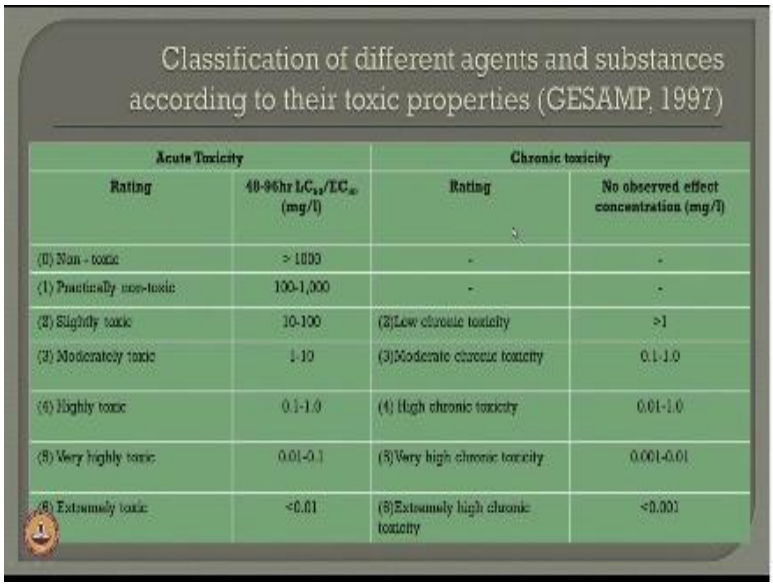

If you look at the classification of different agents and substances according to the toxic properties as given by GESAMP in 1997 we can rate the acute toxicity and chronic toxicity in the order of non-toxic, practically non toxic to the top very extremely toxic the moment we say toxicity to be classified and arranged then we must look at the lethal concentration 50 at the period of exposure of 40-96 hours as a standard test procedure.

And the value is given here are actually in milligram per liter and based on this we are going to rate them as non toxic or extremely toxic which gives on a value of 0 to 6 on a six-point scale for example if the value exceeds thousand then I call them as non-toxic and so on so forth, if you not extremely I-chronic toxicity then the toxicity which is allowed as per the GESAMP regulation should be as low as 0.001 milligram per liter where there should be no observed effect concentration available on the marine environment.

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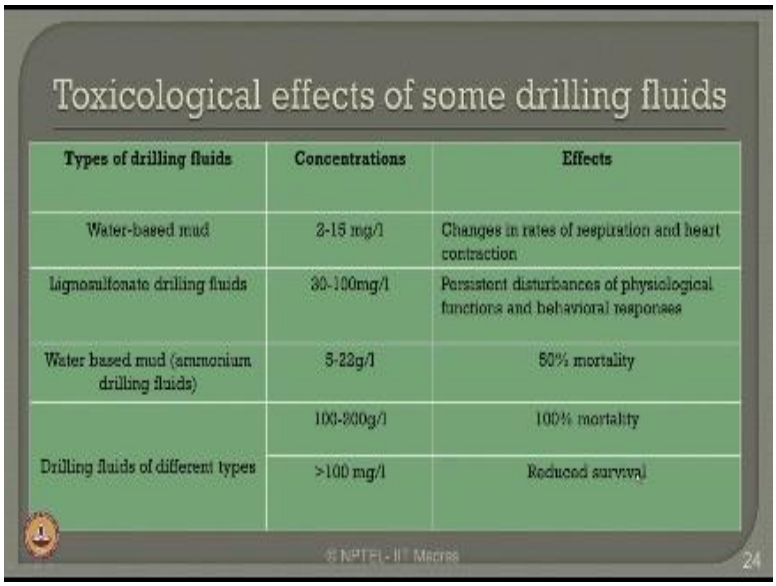

Similarly in parallel if you look at the toxicological effects of some drilling fluids which are water-based mud's, lignosulfonate drilling fluids, water-based ammonia drilling fluids and there are drilling fluids of other different types look at the concentrations in terms of milligram per liter and also let us look at the effects caused by these kind of drilling fluids in the toxicological effects.

You see that the water based drilling mud's is a concentration upto 15 milligram per liter changes the rates of respiration and not contraction of the sea mammals, whereas the drilling fluids of different types whose concentration exceeds 100milligram per liter even reduce the survival of these kinds of mammals.

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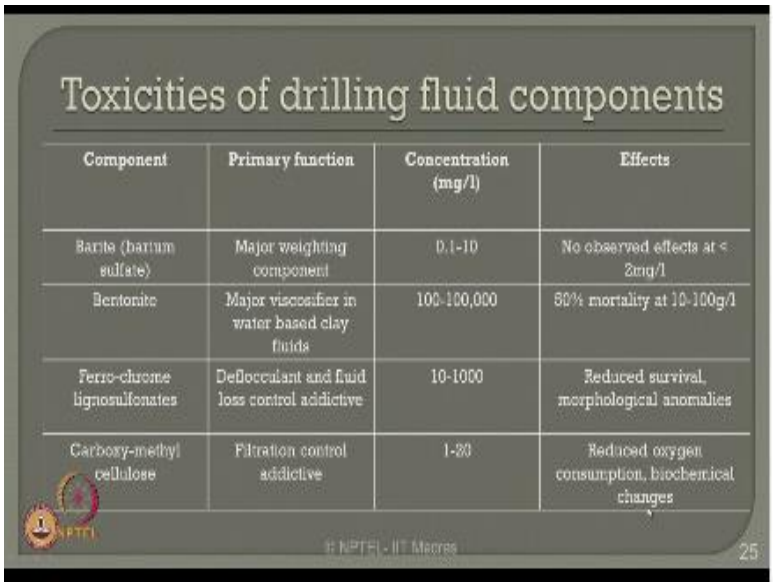

If you also look at toxicities of drilling fluid components which are present, looking at barite, bentonite, ferrochrome lignosulfonates and carboxylmethyl cellulose the primary function of these kind of components is also listed in the table along with the concentration sea in general milligram per liter, if you look at the effects of these components of drilling fluid on the toxic effect on the mammals living in sea it is seen that the carboxymethyl cellulose with the concentration 1 to 20 milligram per liter.

It results in reduced oxygen consumption and it results in serious biochemical changes in the marine environment.

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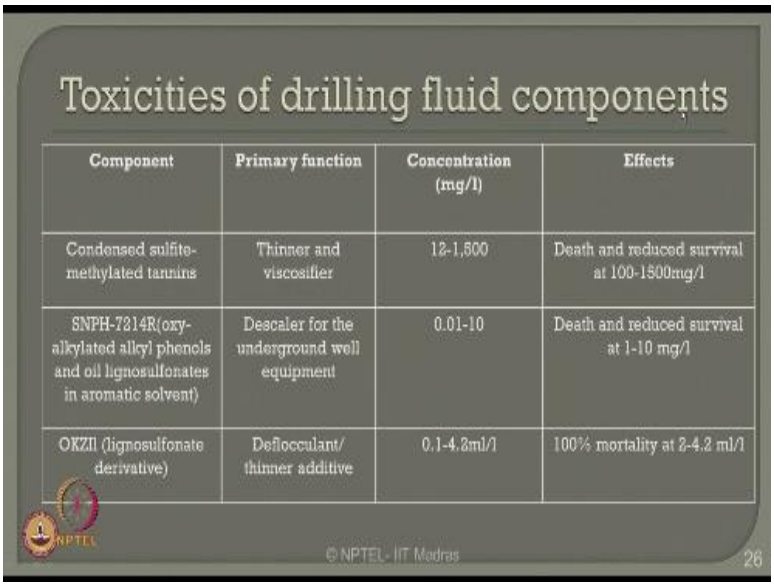

If you look at the drilling fluid components in general which contains condensed sulfide methylated tons oxy- alkylate alkyl fennels or lignosulfonate derivatives then in that case the primary function of this is used as a thinner of viscosifier, descaling agent or Deflocculant agent in the drilling operation and the permissible concentration varies somewhere from 12 to as high as thousand 500 milligram per liter in case of sulphate methylate tannins.

And if you see this kind of high concentration in general the toxic robot costs by this fluid components may result in death and reduced survival even at a concentration of about 100 milligram per liter, therefore it is important that every fluid component which is arising from drilling fluid or a drilling waste.

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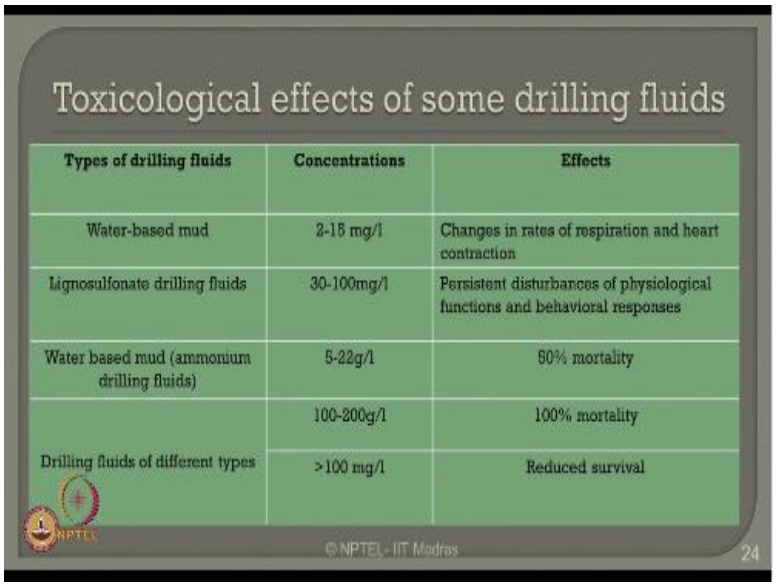

Has very specific toxicological effects.

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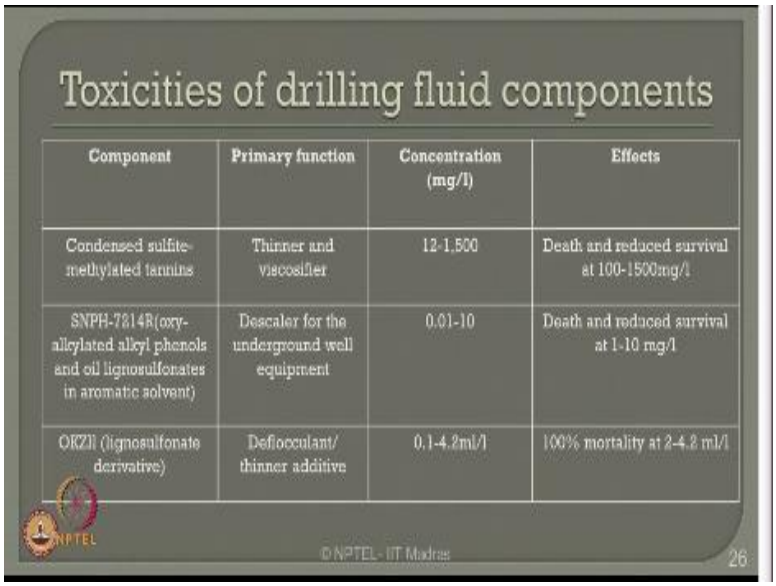

In the living mammals as you see here.

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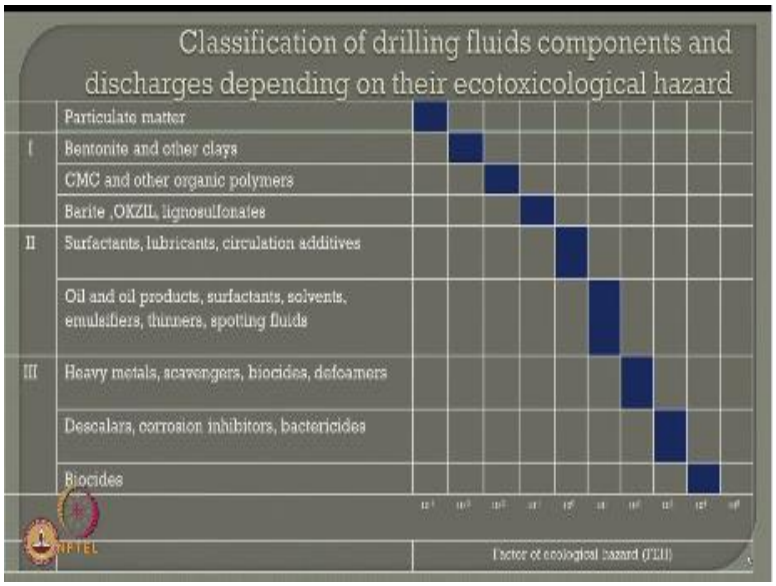

If you try to classify them in terms of drilling fluid components and the discharges depending on their eco-toxicological hazards which comes in a factor called factor of ecological hazard which is called FEH which is plotted in an x- axis here and the classification is done at three groups of 1,2 and 3 which is bentonite and other case surfactants and heavy metals in that case you will see the classification of these drilling fluid components have been also arranged interms of the FEH number. As you see in the table matrix as shown in the slide now.

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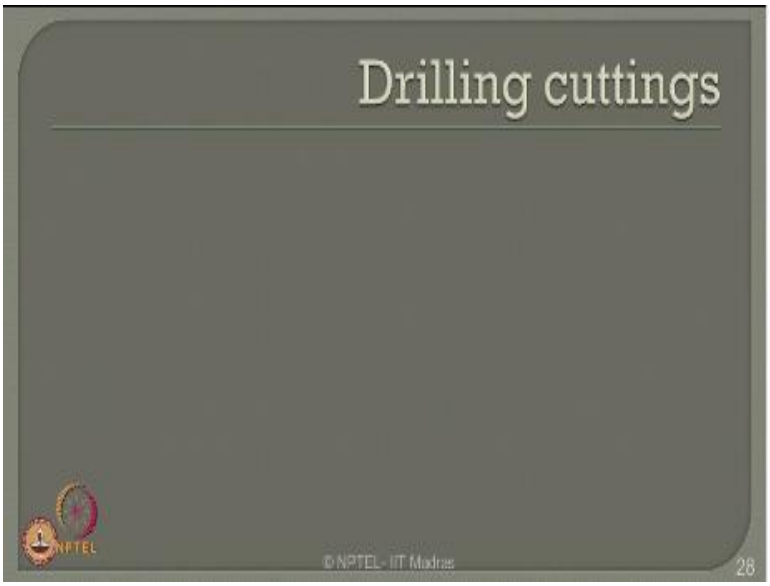

Therefore friends it is very clear that we understand drilling cuttings also contain undesirable.

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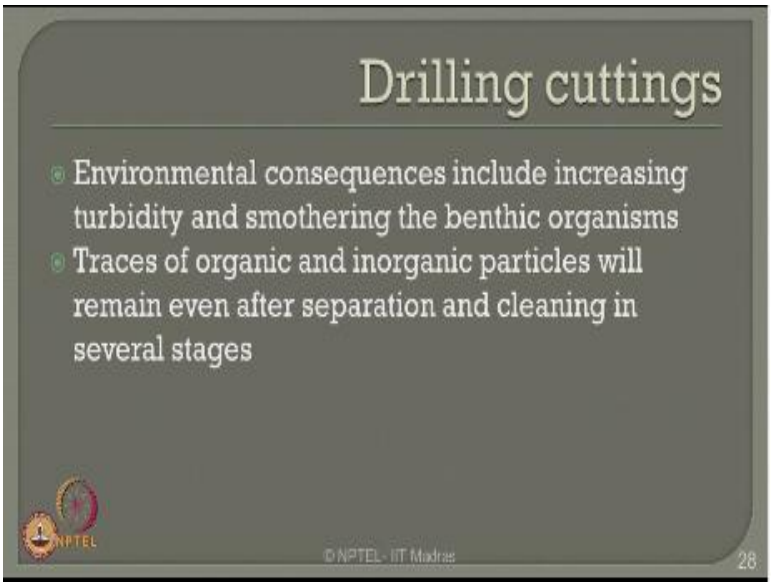

Contaminants which can result in marine pollution the environmental consequences which arise from drilling cutting include increasing turbidity and smothering effect on the benthic organisms, traces of organic and inorganic particles will remain even after separation for a longer time because the cleaning of this require several stages of operation which is generally not done with the seriousness.

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Also we have seen the tables before the slides there are many toxic contents present in water-based and drilling mud's etc the toxic agents which are main in nature arise essentially from drilling cuttings are from oil and oil products, the accumulate and solid phase of drilling cuttings when crude oil and drilling fluids contact these cuttings during oil extraction, the permissible content of oil in discharge drilling cutting should not exceed 100 grams per kg as per the guidelines given by GASAMP in 1993.

But the concentration during industrial operation is observed practically in the literature is about 100 to 1000 times higher than the threshold value therefore the toxicity cost by this kind of chemicals of drilling waste is phenomenally high they not only cause effect on the surface but also cause sedimental effect on the sea bottom which is a permanent problem related to seabed toxicology.

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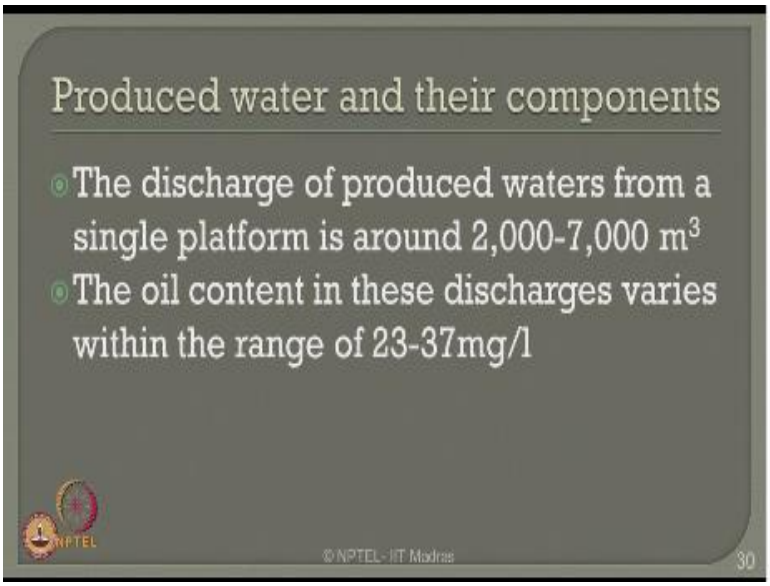

If you look at the contaminants arise from produced water and their components the discharge of produced water from a single platform alone can be as high as 7000 cubic meters, the oil content is discharges varies within a range from 23 to 37 milligram per liter.

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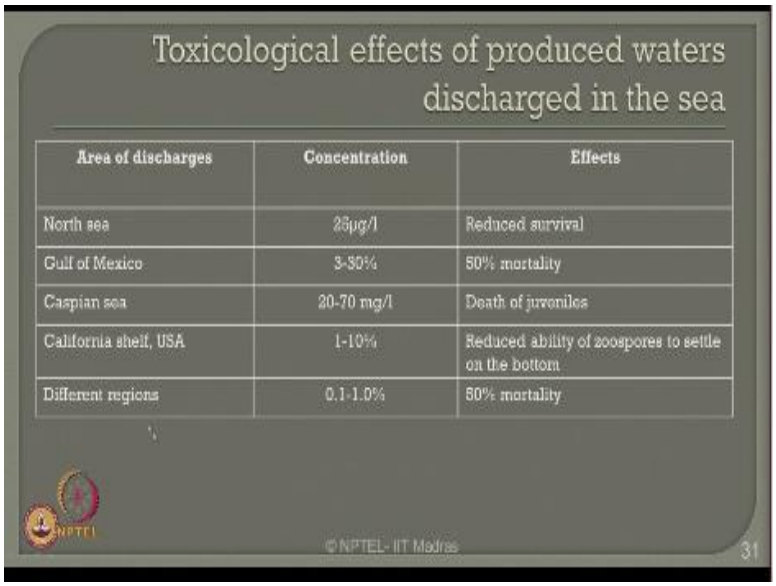

If you look at the toxicological effects are produced waters that is discharged in sea then one can look at them in different ranges of area north sea, gulf of Mexico, Caspian Sea, California shelf and other different regions the concentration varies as you see in the table, let us look at the consequences of this toxicological effects on the living organisms in not see a concentration of even this value is resulting in reduced survival.

However in Caspian Sea when the concentration has been seen as high as 20 to 70 milligram per liter this has resulted in depth of juveniles, in other different reasons by enlarge you will see there is fifty percent mortality rate in most of the areas which is essentially caused by the produced waters which are highly toxic in nature which are generally discharged in sea is not only true in only one segment. But of course in all parts of the world as see from this table here.

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Therefore Philippine the oil spill control agents which are one of the important remedial measures you can use mechanical, chemical and biological means from the ecological safety perspective the most preferable method is mechanical means we have seen usage of floating booms to control oil spill in the earlier slides.

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You can also use other spill control methods you can use dispersants which are used for reducing oil water tension the stabilizers oil droplets dispersed in the water, one can use De-emulsifiers which are used for breaking water in oil emulsions and preventing their formation, one can also use recovery enhancers which are generally used to enhance Visco-elastic properties of volume, the recovery enhancers generally reduces the spreading of oil slicks.

By enlarge they also improve the performance of oil skimmers, oil skimmers are nothing but tankers which collect oil from the spilled surface on the top.

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One can use herders which are used for decreasing the pressure of oil and collecting it into smaller area before mechanical removal methods are deployed for such causes, one can use gelling agents which are used essentially for creating gelly like structure on the oil spill, this occurs expedites the mechanical removal and repress the volatilization of the light fuel, one can use pyrotechnic materials.

Which are essentially used to ignite an oil slick on the icy surface they got a fire boom one can use this kind of material the ignite oil slick on the contain area given a fire boom, it improves flame propagation and increases combustion efficiency very highly.

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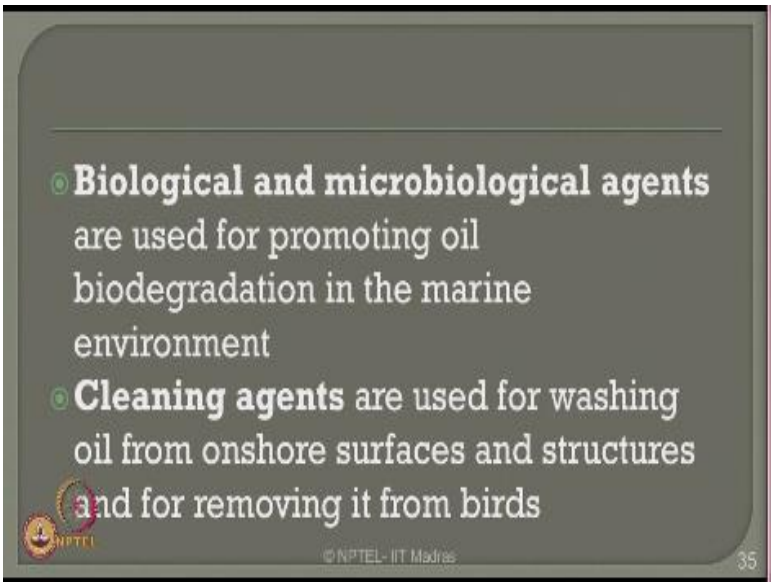

Therefore biological and microbiological agents as we saw in the last slide are essentially used for promoting oil biodegradation in the marine environment, cleaning agents are also used for washing oil from onshore surfaces and structures and then removing them from the birds skin layer as well.

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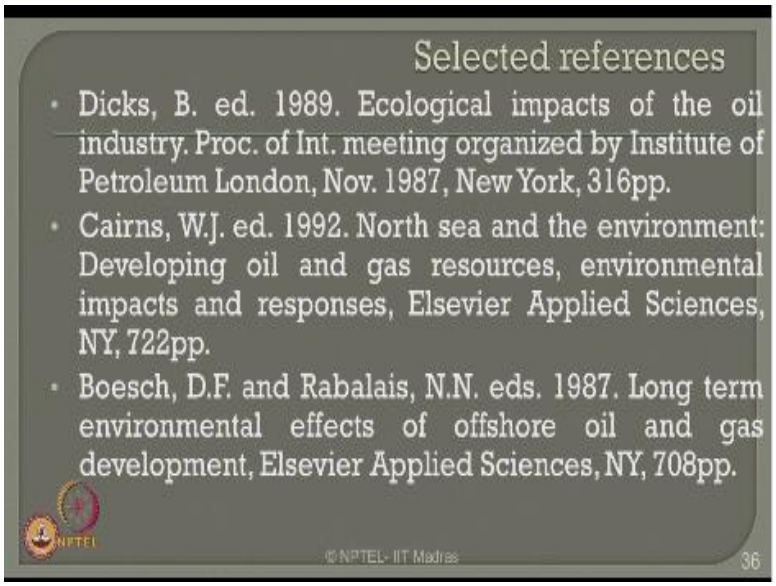

There are some selected differences which I would to mark in this particular lecture, Dicks 1989 ecological impacts of oil industry, Cairns 1992 North sea and the environment developing oil and gas resources Boesch and Rabalais 1987 long-term environmental effects of offshore oil and gas development.

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Stanislav Patin 1999 environmental impact of offshore oil gas industries, Neff 1998, fate an effects of drilling mud and produced water discharge in environment, Neff , Rabalais, and Boesch 1987 offshore oil and gas development activities potentially causing long-term environmental effects, Davies and Kingston 1992 sources of environmental disturbances associated with offshore oil and gas developments and so.

Friends in this lecture we understood what are the different components present in drilling fluid and the chemical wastes which are responsible for causing marine pollution there are some methods by which they can be contained which we saw as mechanical and chemical agents which can be used to contain oil spill and removal of oil spill once they occur in the marine environment, thank you very much.

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Funded by

Department of Higher Education

Ministry of Human Resource Development

Government of India

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