NPTEL

NPTEL ONLINE CERTIFICATION COURSE

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

Module 3:
Environmental issues and Management
Introduction

Friends we have successfully completed two modules, module 1 and module 2 now the lectures of module 3 are now open in module 3 lecture1 will be an introduction to the environmental issues and management which is one of the vital path in the HSE course at IIT Madras.

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Let us quickly see what would be covering in module 3 in this course we will look at various environmental issues and management aspects of these we look at atmospheric pollution, flaring and fugitive release models, water pollution which includes drilling waste, oil spills, oil sludge, drilling solid waste, and production waste we are also look at the features of environmental

monitoring and the impact assessment and decommissioning which is cost during the platform management. We will also look at the overall structure of environmental management which arise from the problems related to oil and gas industries alone.

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In today's lecture we will start introducing what are those environmental issues which are of primary concern to oil and gas industries. The primary concerns are many but few of them are listed here then environmental issues actually causes a seviour impact on the shelf eco systems and marine biological recourses it contributes to the life hierarchy at different levels and different stages it significantly influences fishing or aqua culture it results in biological consequences of accidental oil spills into the marine environment the oils spills which are result from the failure accidents happen in tops 8 of the platforms cause serious environmental concerns in the marine environment. They are very serious because the issues are highly irreversible.

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One can ask me a question is there any report of visible consequences which can arise from these kind of pollution arise from the oil and gas industries. The complexity urgency and variety of emerging problems in environmental management itself can be listed as one of the primary visible consequences that arise from oil and gas industries, uneven distribution of marine life is again an evidence because the concentration in the shelf and coastal zone very significantly they cause of the production units settle at these stages.

The coastal zones habited contain about 90% of marine commercial organisms which are shifted are which transposed because of the concentration of oil and gas industries in this vector. Most if the known oil gas fields are also located in this zone which therefore causes a serious ecological disturbances to a marine culture which are habited at this place it is very interesting friends to know there about 90% of the aqua culture is actually habited in the coastal zones there many of the oil and gas industries and fields are located to be in this area.

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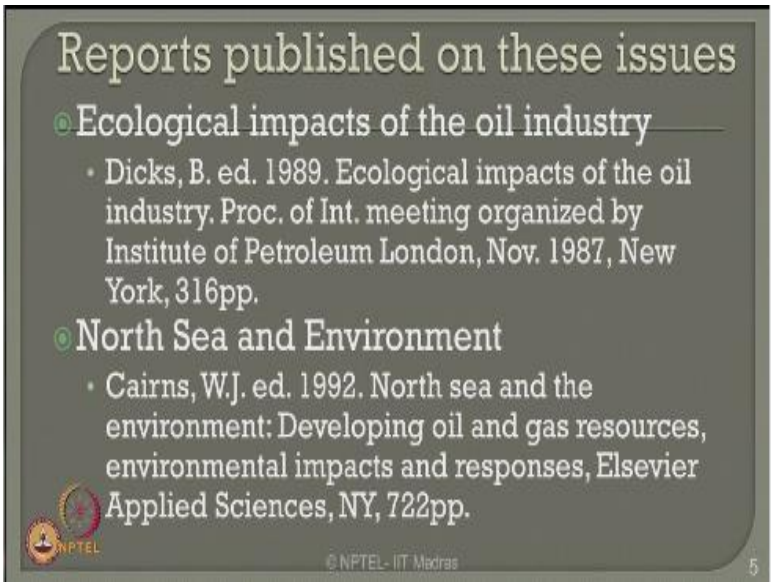

Now there are evidences in form of reports published on these issues which I will now highlight ecological impacts of oil industry can been seen from various published authentic reports Dicks, ed.1989 ecological impacts of oil industry which is a result of proceedings of interactional meeting organized by institute of petroleum London in November 1987 published in new York. North sea and environment as a special report dedicated by Carins ed. 1992 North Sea and environment developing oil and gas resources the environmental impacts results a causes published by Elsevier applied sciences new York in the year 1992.

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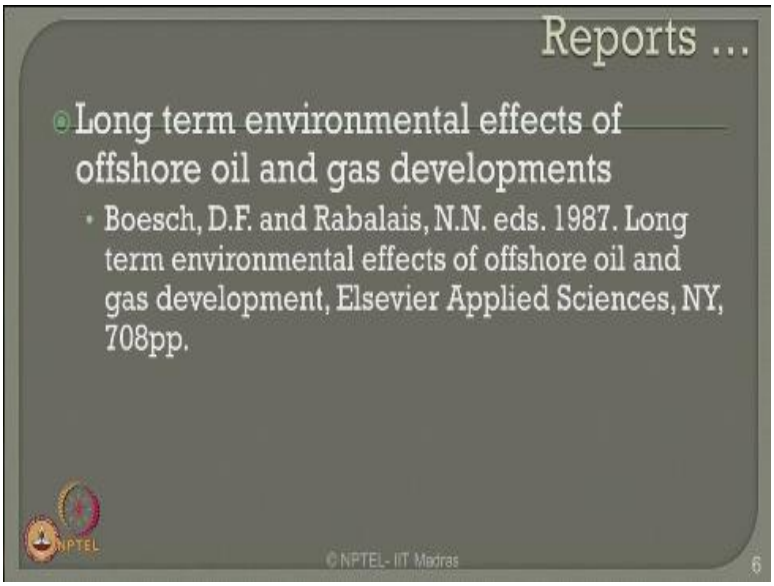

Subsequently if you look at the long term environmental effects of offshore and oil and gas developments Boesch and Rabalais n 1987 published a very interesting report indicating long term environmental effects of oil and gas industries in terms of development published by Elsevier applied sciences New York in the year 1987.

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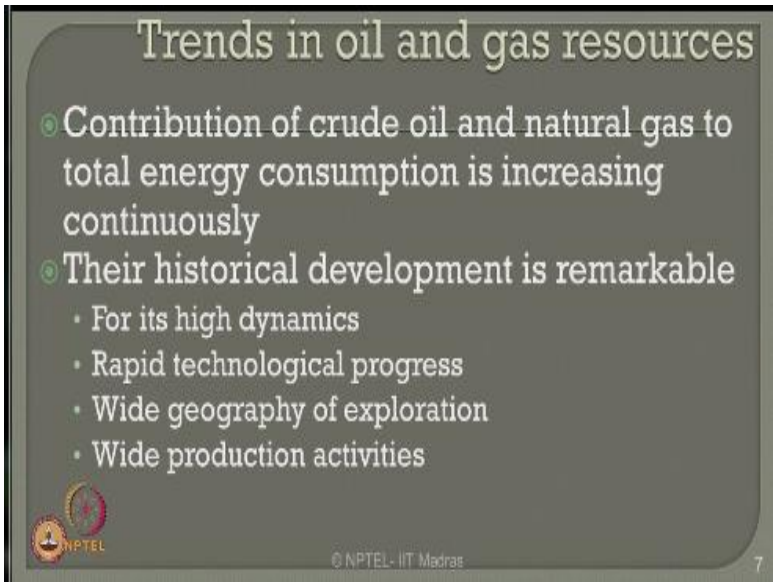

Now let us look at the responsible items which contribute this kind of oil and gas industry pollution to understand that we must know what are the different trends in oil and gas resources because we must address the problem from the fundamental region alone, if you look at the various trends involved in oil and gas resources contribution of crude oil and natural gas to the total energy conception is increasing continuously day by day which then own fact to all of us there historical development is remarkable which we know we appreciate because oil and gas industry is one of the industries which whose growth is promising and exponentially faster because of the reasons it has got very high dynamics in economics it as got very rapid technological progress wide geography of exploration is being covered and there is wide production activity happing all over the world.

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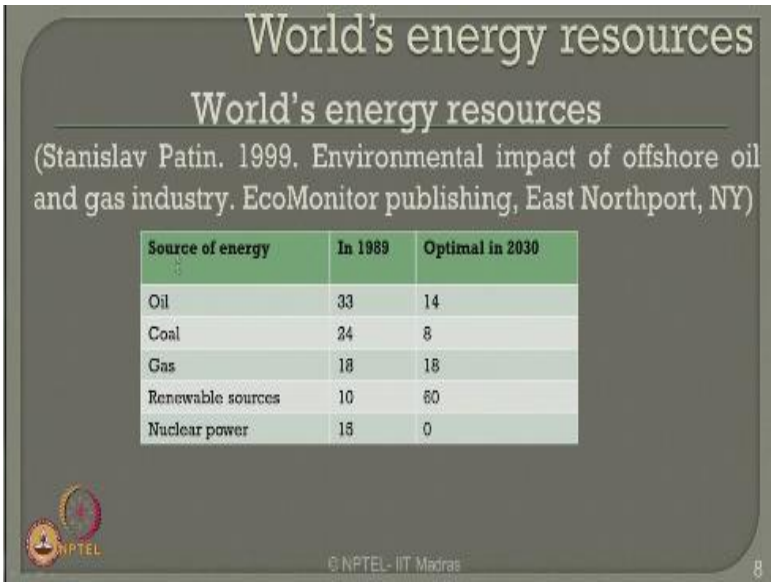

If you look at the worlds energy resources in general as given and pointed out by Stanislav Patin, 1999 there are various source of energy from which people depend on looking at the statistics about 30 back and above 20 ahead there are various resources being from oil, coal, gas, renewable sources and nuclear power, if you look at this table it is interesting that the dependency of oil as a source of energy in the coming further is departing where as the dependency of source of energy in renewable source have to is exponential a very significantly increasing.

However in the present scenario we are somewhere in-between saying that we have strong dependence on oil, coal and gas even today where as the nuclear power will start entering into this market very decently in the reason times so if you look at the source of energy as on today in the present trend oil and gas exploration becomes a very virtual sector for the economic growth of any country because the major contribution of the source of energy to any country essentially comes close to about 50% from oil and gas alone.

Now there is a always a possibility that this trend will marginally deceases but not expected to deceases beyond 30, 35% as you see in this picture as given by this Stanislav Patin, 1999 report

therefore oil and gas industry will still continue to remain as one of the dominant industry even after 20 years from this particular point of time of discussion.

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Therefore it is important that this industry has to face a significant growth which is always receive in the natural gas and relative stabilization industries, decrease in oil production I'm large regions is also significantly noticeable in the recent past studies reported by the researchers, therefore expansion of oil and gas industry has become significant in terms of inland hydrocarbon fields are depleted completely.

And therefore the attention of researchers is switched towards continental shelf in the world ocean region and that creates lot of disturbances in the ecology to the marine culture, this shift of course to continental shelf will affect certainly the growth of marine organisms in a very significant manner, recent exploration which is seen in polar region actually has become a focus of attention by various environmental list all over the world.

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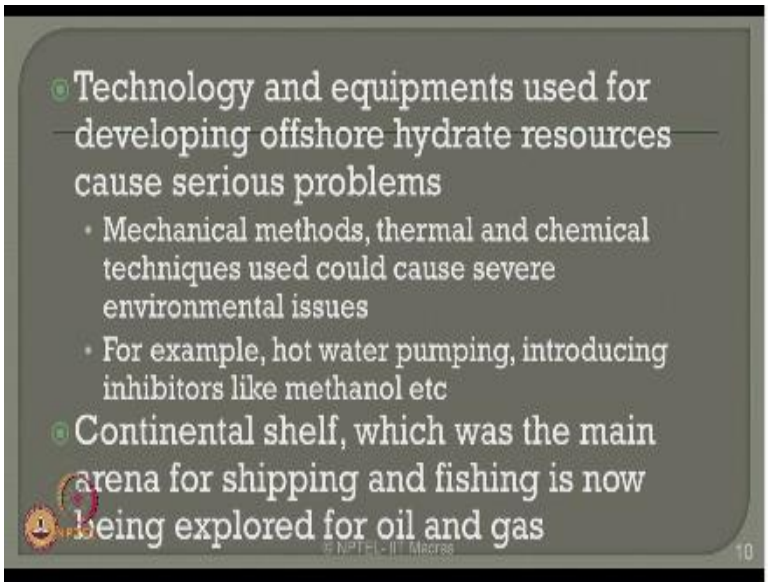

Technology and equipments used for developing offshore hydrate resources cause also serious parallel problems because the mechanical methods the thermal and chemical techniques that are used to oil exploration has caused severe environmental issues parallel to those sector, for example hot water pumping, introducing inhibitors like methanol for enhance oil recovery as created a very serious problem and resulted in ecological disturbances in a marine aqua culture in the sea sector.

Continental shelf, which once upon a time was a main arena for shipping and fishing is now being explored for oil and gas never the less we do not want the promotion of this industry all over the world however we should also understand water environmental issues faced by the production of this industry to a marine aqua culture which one of the vital and important natural resource available to the mankind.

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Prospective locations identify for oil and gas fields in the shelf zones often overlap with the region unfortunately with the high biological productivity of world ocean, the fish culture will be completely challenged if this kind of oil and gas fields are being explored for a larger form of production in the recent future, gas hydrates which are of course highly promising are found unfortunately in the marine regions.

Therefore the development of these filed of production will certainly lead to severe environmental problems there is no doubt about it, modern technologies being practiced for oil and gas exploration impose also serious threat to the environment I will show you some statistics and some examples in the coming slides.

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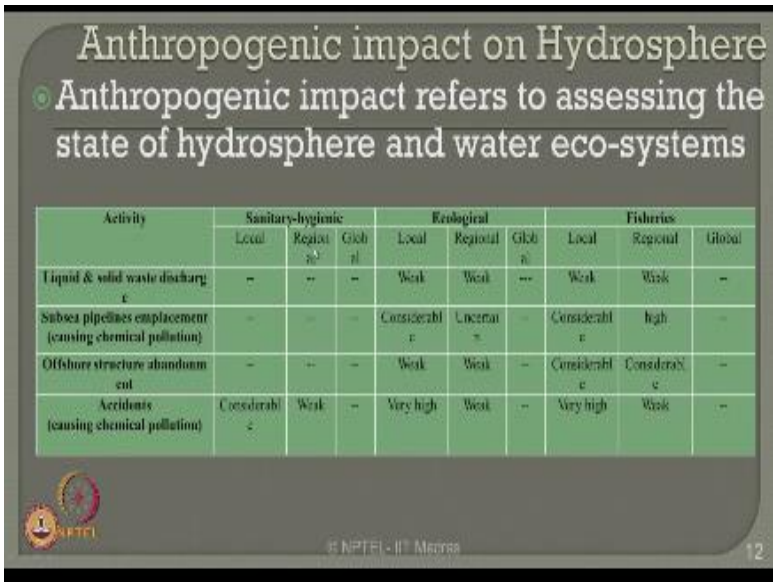

If you look at the anthropogenic impact on hydrosphere caused by various activities in oil and gas sector as given in the table is very interesting that anthropogenic impact actually refers to assessing the state of hydrosphere and water eco-systems, now let us look at the various activities in a given sector liquid and solid based discharge which comes from the oil sector into the sea the other activity can be subsea pipeline emplacements.

Which can result in chemical pollution, now other important activity as we all understand is offshore structure abandonment because there are many platforms which have been installed in shallow waters and medium water depths which cannot produce oil which has without no processing platforms need to be actually abundant at issue related to abundant this platforms you can also cause serious anthropogenic impact on hydrosphere.

And of course we all agree and understand at least in HSE course that accidents are unavoidable of course we realize that we take ultimate care to avoiding this accidents but because of various factors aligning in one shore accidents become generally unavoidable if they become then they result in serious chemical pollution. Well let us look at this activities in different segments where fisheries is also one of the important segment of marine aqua culture let us look at the

ecological problem and sanitary hygienic problem in different sectors namely local, regional and global level.

If you looked at essentially the accidents cussed they have impact caused in sanitary hygienic point of view in ecological point of view as well as in fishery point of view however in more the cases you will see that the impact caused by these accidents in the local sector in different regions is predominantly high, however in global sector the accidents caused causing chemical pollution in the fisheries is minimal.

Or insignificant but however in regional sector they been indicating as weak representation, so these activities which are very common in case of oil and gas exploration industries have significant impact in different regions as you see here in different sectors like Local, regional and global accordingly.

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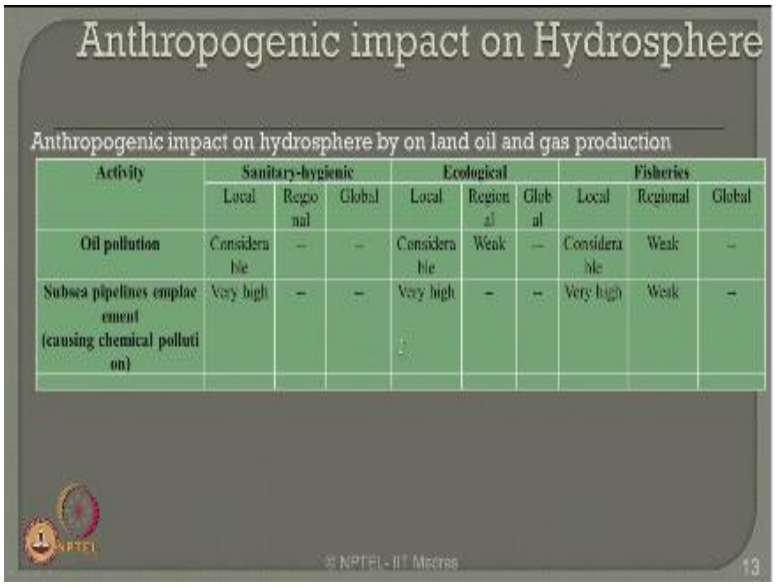

If you look at anthropogenic impact on hydrosphere which is caused by land, oil, gas production now let us look at the activities related to on shore which is oil pollution or subsea pipeline emplacement which can also cause serious chemical pollution again we can divide them into

local, regional and global in this three sectors and they also will see significantly influencing the local sector in all the three regions respectively.

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So friends anthropogenic impact on marine and fresh water systems actually cause hidden disturbances of natural structure and function of water communities, it drastically changes the composition and characteristics biotopes it alters hydraulic regime and geomorphology of water bodies, it results in diminishing fisheries event it also results unfortunately diminishing recreational values where you see lot of oil pollution, it also results in other ecological, economic and socio economic consequences which are very important for oil and gas industry engineer to understand.

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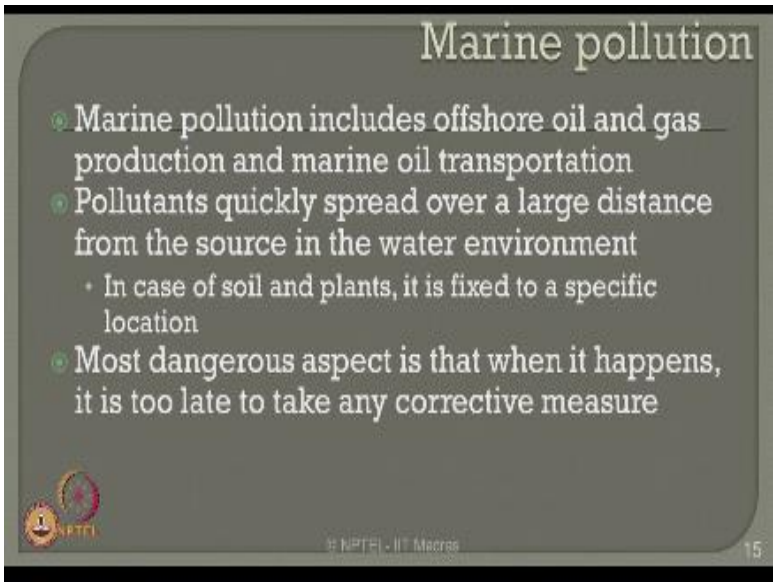

The most important derivative of any oil and gas industry consequence is what we identify as marine pollution, marine pollution actually includes off shore oil and gas production and marine oil transportation in a total sector, pollutants quickly spread over large distance from the source in the water environment in case of soil and plants it is actually fixed for specific location unlike in the case of water bodies so we are very serious concern here only have pollution occurring in see where oil and gas industries are located during production systems the spread of this particular pollutants or very large and very fast unlike land pollution cost in terms of specific location which can be resulted only in soil and plants.

So the volume and the dimension of pollution in terms of marine pollution is enormously high compared to other forms of pollution therefore the most dangerous aspect is that when it happens it is unfortunate for as very it is too late to take any corrective measure so always post accidents scenarios are only being acted upon in marine pollution private in the shows in marine pollution are very rare unfortunately friends in oil gas industries.

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Let us look at why did you have concern about marine pollution to understand that let us see what are the contents percent in marine pollution what the other is called marine pollutants marine pollutants can be grouped in increasing order of hazard group A has the lowest and subsequent groups in highest substances causing mechanical impacts the damage respiratory organs digestive systems etc. Format a group A there are examples liked it in the slide now suspensions films solid base etc.

Group B has an higher impact compared to group A in terms of hazard is nature substances provoking eutrophic effects that cause mass rapid growth of phytoplankton and disturbance of balance structure and functions of water eco systems for under group B examples could be the mineral compounds the organic substances present in the drilling outlets.

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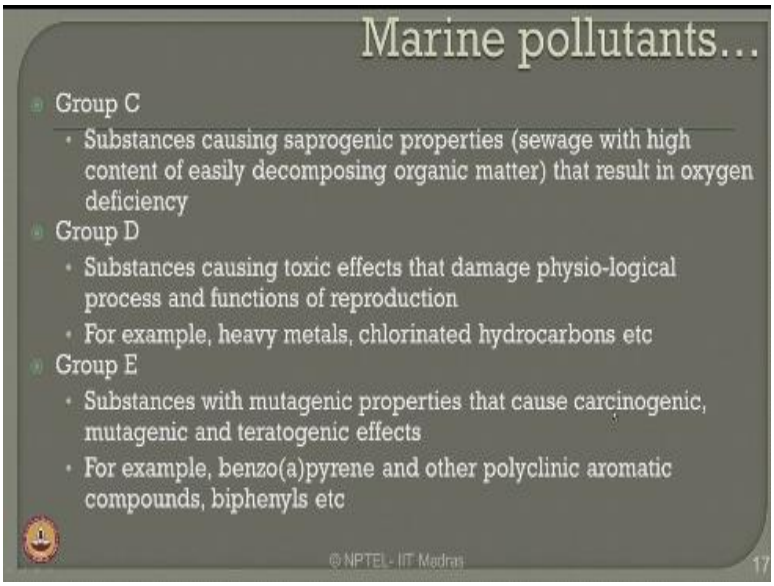

Subsequently group C includes substances that cause saprogenic properties that is sewage with high content of easily decomposing organic matter which result in oxygen deficiency group D includes substances causing toxic effects that damage physio-logical process and functions of reproduction organisms for example heavy metals percent in drilling fluid chlorinated hydrocarbons etc. Can be a classical examples which result in group D contamination of pollutants.

Which cause very serious effects on reproduction organisms on any biological manners group E which is more worst than compared to all the groups into substances with rotation of properties that cause carcinogenic effects mutagenic and teratogenic effects on human beings for example benzo(a) pyrene and other polyclinic aromatic compounds biphenyls etc. Can be classical examples format of this group E which we can cause carcinogenic effects on human beings which can result in fatal.

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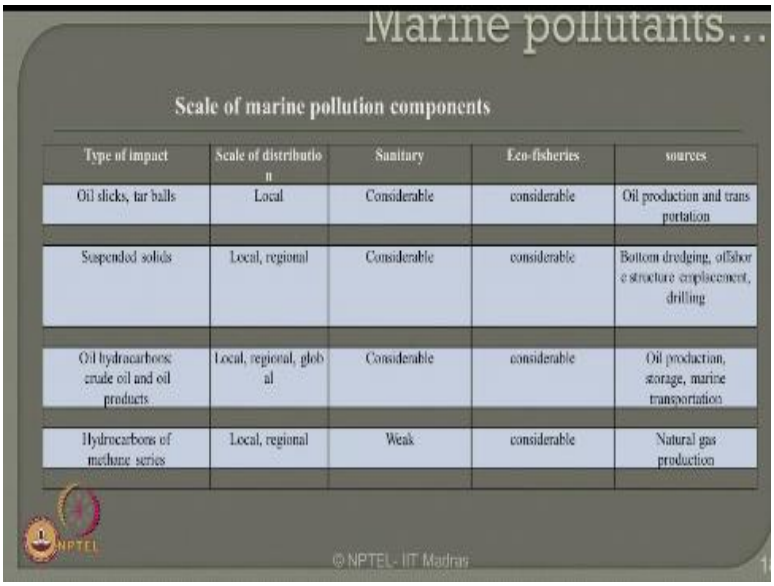

Let us quickly see after understanding what are the contents in the marine pollution of pollutants let us try to understand what the scale in which they are present let us look at the table now they shows the scale of.

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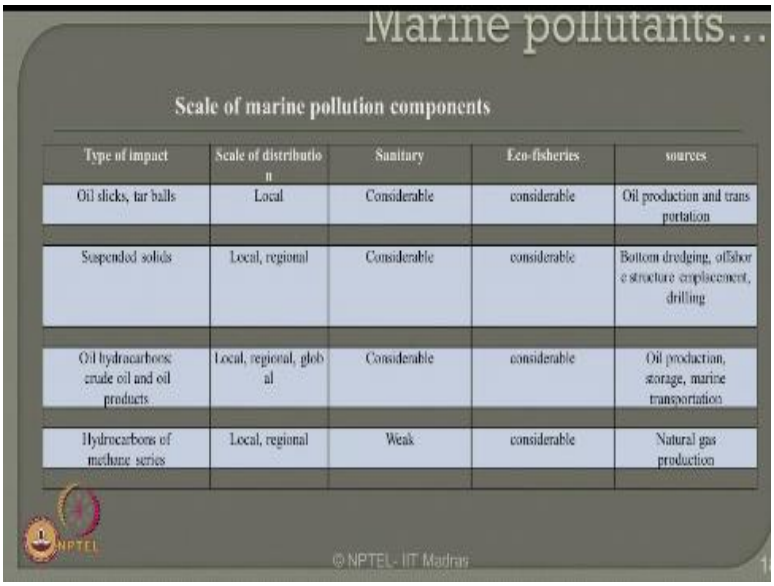

Marine pollution components that different types of impact let us say these are the very common impacts caused in oil gas pollutions oil sleeks tar balls suspended solids hydrocarbons which contains crude oil and other oil products hydrocarbons of methane series they where some of the byproducts which can cause very serious impacts let us quickly see what are the scale of distribution in terms of the marine from the pollution components where we can see the scale of pollution can be varying.

From local to global or regional let us see what are the sanitary the Echo-fishery effects which are caused by these pollutants you will see in all the cases mostly the types of impact cost the scale of distribution being local regional and global their impact caused by the sanitary issues and eco-fisheries are highly considerable nature which is very significant let us quickly see where are the sources from which these type of impacts come from if you look at oil six in thermal essential source is oil production in transportation.

Will you look at the suspended solids they essentially come from bottom ridging of a structure in placement and primarily from drilling activity you look at the crude oil, oil as hydrocarbons they come from of course oil production storage and most importantly from marine transportation

hydrocarbon of methane series essentially come from gas production platforms which are now come to the current active explosion stage in the entire world.

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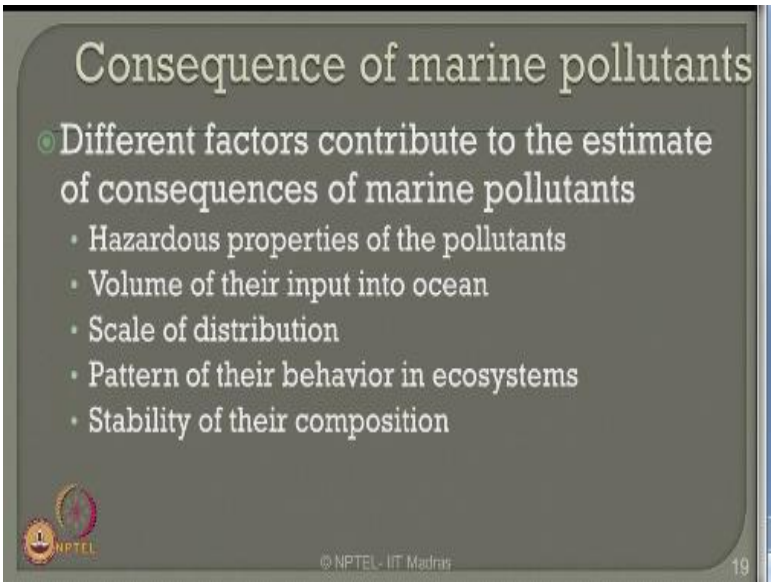

Having said what are the contents of what are the marine pollutants and what is k they do affect in the sanitary and ecological disturbances in terms of local regional and global sector let us quickly see and understand what are the consequences caused by this marine pollutants there are different factors that contribute to estimate the consequences of marine pollutants the hazard as properties of this pollutants form a very major factor in understand in the consequences of course the volume of the input into version involvement.

Is enormously high as I said the spread of pollutants in the water body is much faster and rapid compared to earth forms of pollution in land most important difference the scale of distribution of this pollutants and water body is unimaginably high and it is very difficult to model this pollution phenomenon because the pattern of the behavior in ecosystems is highly complex to study, and most dangerously and more vital the stability of the composition plays a very important role because they get completely mixed up with marine environment which causes very serious effect to the marine organisms very easily.

Let us look at a statics quickly what are the different forms of marine pollutants and what are the world wide contaminants in terms of the levels of mixture in micro gram per liter in surface waters measure from statics. If you look at the different ecological zone varying from south zone, ocean, pelagic areas southern part the enclosed sea open waters and coastal zones.

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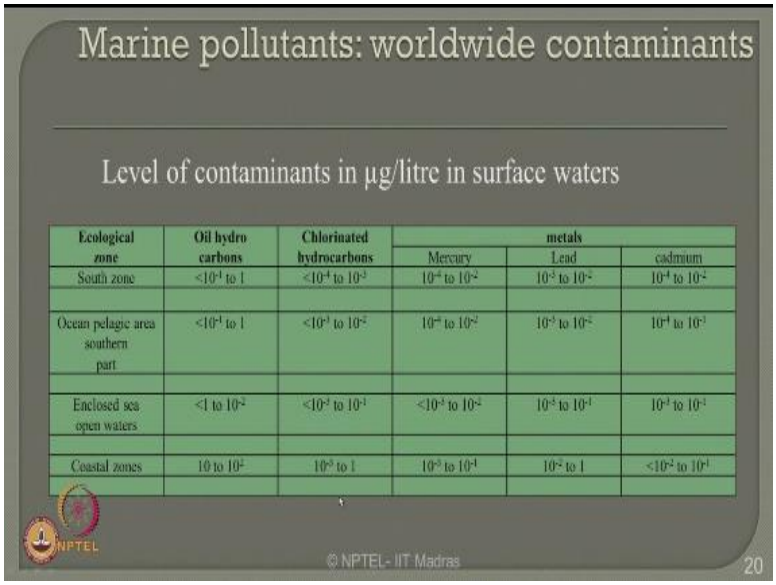

Looking at different forms of contaminants in terms of hydrocarbons, chlorinated hydrocarbons and metals presented in drilling fluid outcomes are discharges in terms of mercury, lead and cadmium. Look at the concentration you will see that the concentrations are higher and higher as they move towards the coastal zones, it means there is a very sea is impact caused the ecological zones various zones by these kinds of contaminants and the values you see they are significantly high because the values indicate are per liter in the surface water.

So there are been a very significant indication of the pollutants being present as contaminants around involved in different zones but different contaminants essentially arise from oil and gas industries alone.

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Therefore the anthropogenic impact on water environment is a very cumulative effect caused by the oil and gas production facilities install in sea. Sanitary and hygienic consequences of anthropogenic impact on marine environment is mostly focused by the local level however it is advantages that the global distribution of this has not yet occurred so far. Marine pollution therefore, is one of the leading factor for anthropogenic impact on marine ecosystems. Offshore activities it is been seen friends where they contribute to about 2 to 5% of the overall pollution in the ocean environment.

They the number may be very low but I am looking at the volume of the spread in a very rapid rate. Anthropogenic impact therefore increases the concentration on marine coastal areas and shelf zones where aquaculture was one of the important habitats above 90% do rest in these zones.

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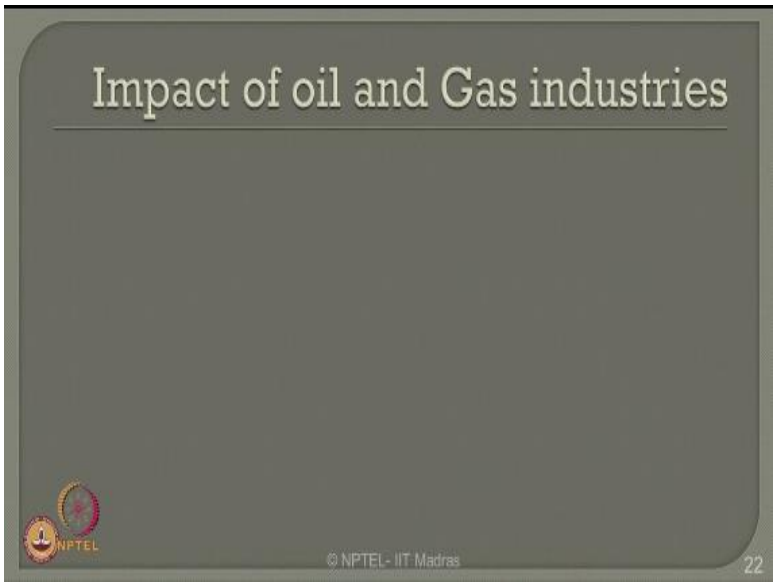

Now let us try to understand what would be the impact caused for the oil and gas industries in the marine aquaculture or in general the ocean environment.

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To understand this let us try to know what are the different stages of oil and gas development because at different stage there are different forms or sources of pollution caused in the marine environment.

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There are of course four stages which exist in oil and gas development. Stage 1 is a geological and geographical survey even doing a survey you can also result in pollution I will come to that later. Why these survey are conducted because it is very vital to know the potential of oil will present in a given sector. The second stage in development is exploration where we do rig placement, we do an exploratory drilling, we plug the well and we also do what we call well killing extra, what we all include in exploratory stage.

The next could be of course a production and development stage where the platform commissioning takes place, laying of pipeline takes place and production drilling happens in a very continuous scale and pipeline maintenance is also a very important factor which contributes to marine pollution which include in the dipper development and production stage, of course the most serious stage is the last one which decommissioning stage where we intend the remove the platform and do well plugging which can also cause pollution very seriously.

So friends there are four stages that exist in oil and gas field development in all these four stages independently and mutually they contribute significantly to the marine pollution which you will see now in the present slides.

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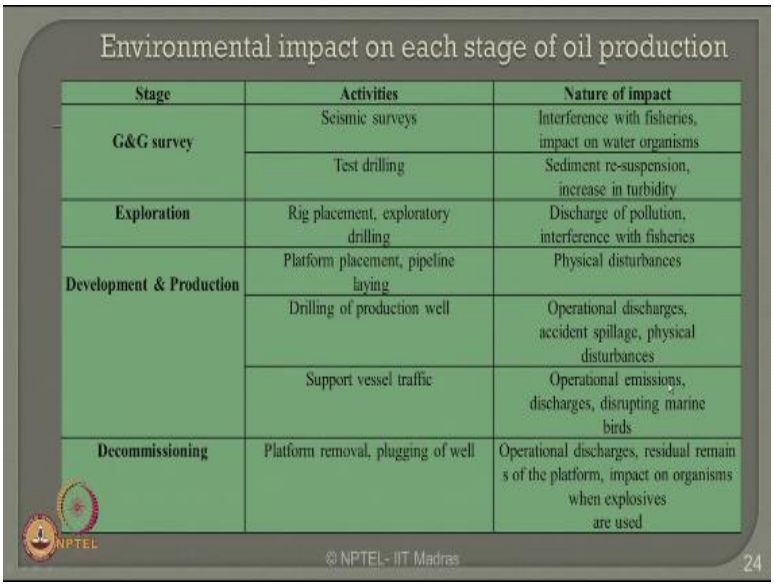

Now let us look at the four stages in this table the G and G survey stage, the exploratory drilling stage, the development and production stage and of course the final stage of decommissioning or the platform. Let us look at what are the general activities which generally happen most commonly during the stages. If you look at the survey stage it is very important and all of us to agree that we do lot of seismic surveys and we do test drilling during the stage.

Now seismic surveys result in interference with fisheries, it has got a very serious impact on water organisms. Whereas test drilling leaves lot of sediment re-suspension which increases turbidity in the given zone. If you look at the exploration stage of oil and gas field development we do a rig placement, we do exploratory drilling at this stage which discharges lot of pollution and it has got a very serious interference with the aquaculture.

In terms of production and development we do platform placement, we do pipeline laying which has caused lot of physical disturbances in ecologic of the marine environment. When you talk about drilling of production wells there are many operational discharges which has a very serious effect in terms of marine pollution, they also result in what call accident spillage and which result in out of physical disturbances to the marine aquaculture.

During development and production we have got also transport oil therefore we have support vessel traffic which is very highly volumetric in a given production system which results in operational limitations because the production vessels are the supporting vessels do travel in the marine environment they also do lot of your machines they also do lot of discharges they disrupt with the marine birds which presents to the marine college for talk about decommission stage which is the final or a vital stage of course in all guess in production system.

Platform removal or plugging a veils takes place at this system or at this stage which also leaves lot of operation discharges the most important is the restively reline or the platform which causes a co legible disturbances very seriously they create lot of serious impact and organisms when exposes you use for decommissioning of platforms because it has been see in the literature that use of explosives as shifted a paradigm shift or cost a paradigm shift or marine aquaculture form the location where the platforms suggestion decommission.

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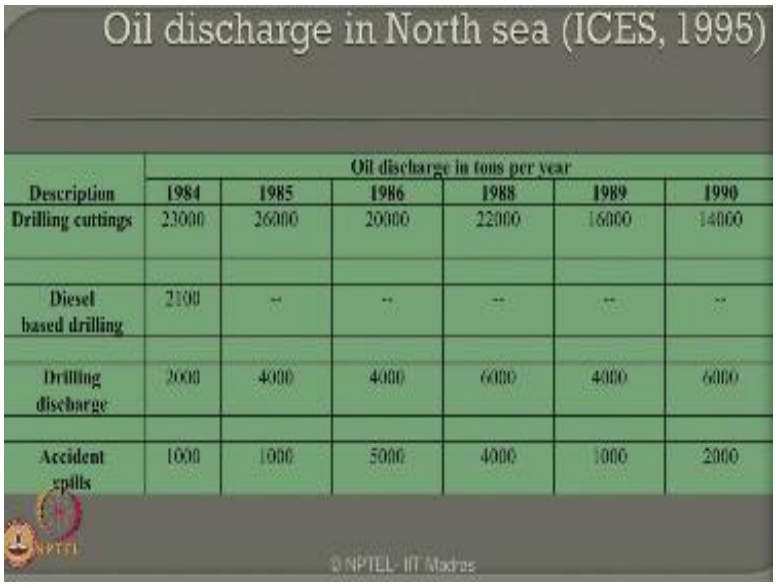

Now I did not said this let us look at the statistical report which is presented by ICES 1995 which indicates the amount or extent of oil discharge in north sea alone in terms of tons per year for

about a period of let say quickly 6 7 years gap there different mention about drilling cuttings diesel base drilling discharge and accident spills which is we reported in ICES 1995, I ask in oil discharge in tons per year you will say the drilling cuttings has been consistent and constant present or see in to be person or duration of about 56 years.

Whereas the accidents periods is sometimes increasing and sometimes decreasing however the presence of this oils accidents fields can be never been ignore from this statistics, but unfortunately friends please understand the drilling discharge pollution has been found to be an increase scale studiedly for a period even window of 6 years during this stage. One can ask me a question what is the fatality of this particular data in the present scenario.

Friends please understand the train still continues however the complicities are very highly very therefore the data presented here cannot be projected for future applications because the complexities involved in this kind of modeling is very high. However the factual demands that drilling discharge and accident spills continue to be a reprehensive value in marine pollution event today.

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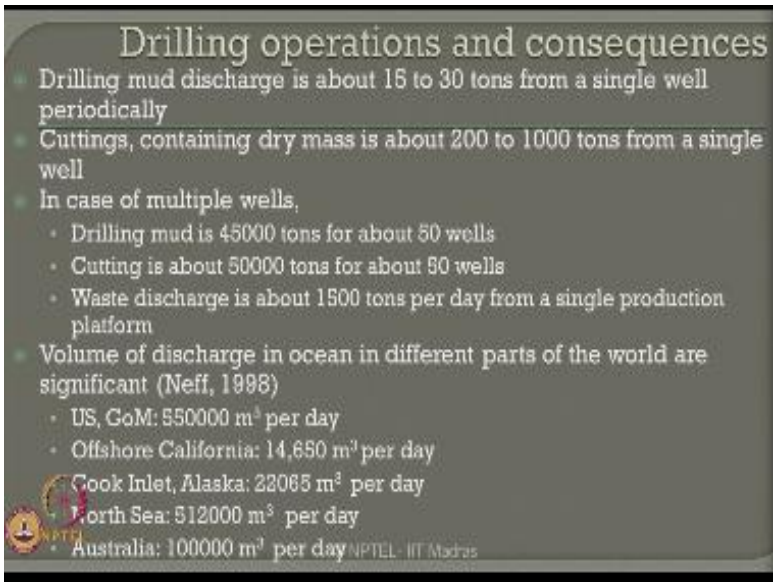

Let us focus on drilling operations and the consequences arraigns for the drilling operation alone as in part of marine pollution, drilling operation involves the drilling mud discharge or a fact to understand is about 15 to 30 tons from a single well which gets periodical discharge in the marine waters. Cuttings containing dry mass is about 200 to 1000 tons from a single well please understood the number is phenomenally high in case of course multiple wells.

The drilling mud is about 45000 tons for a about a range of 50 wells cutting is about 50000 500000 tons 50000 tons for about 50 wells water discharge is about 1500 tons per day even from a single production platform, the volume of discharge and ocean environment which is seen in the different part of the world as report is Neff 1998, as got a different sector as reported here in Gulfo Mexico 550000 m^3 a day friends in offshore California 14650 m^3 per day in Alaska 22065 m^3 per day in north sea alone is 512000m^3 per day in Australia is 100000 m^3 per day.

So one can see very clearly from this report are the statistic shown by Neff 1998 the volume of discharge per day is phenomenally high in terms of causing marine pollution which is of course the disturbing factor which disturbs physiology of the marine environment seriously.

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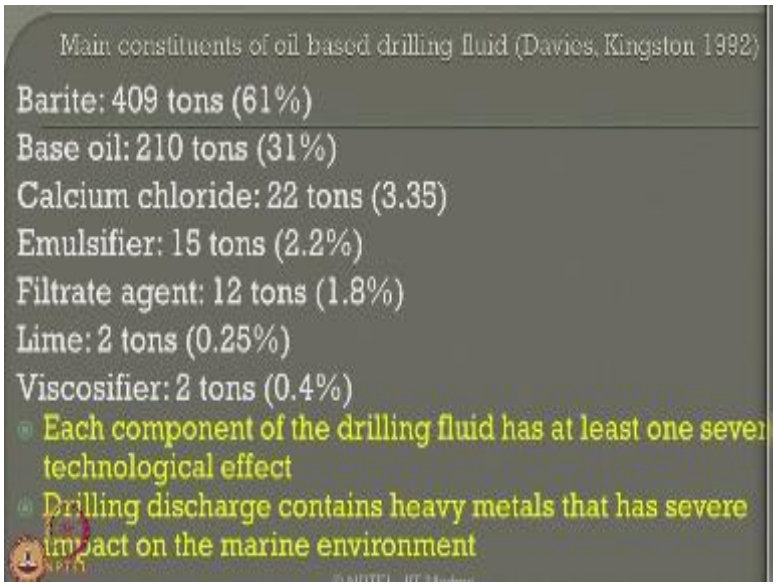

Now try to understand what are the main constituents present in oil based drilling fluid as indicated by Davics Kingston in 1992 there are different constituents present in oil based drilling fluid which causes a serious concern to the marine environment barite is about 61 %base oil is about 31 % and the remaining amounts to calcium chlorides various emulsifier various filtrate agents lime and viscosifier is used in the production systems.

Therefore the main constituent essentially come from the base oil and the barite which closes the about 92% each component friends of the drilling fluids has at least one savior technological effect which we call consequences in the marine environment. Therefore drilling discharge which contains very heavy metals has got serious and severe impact on the marine environment

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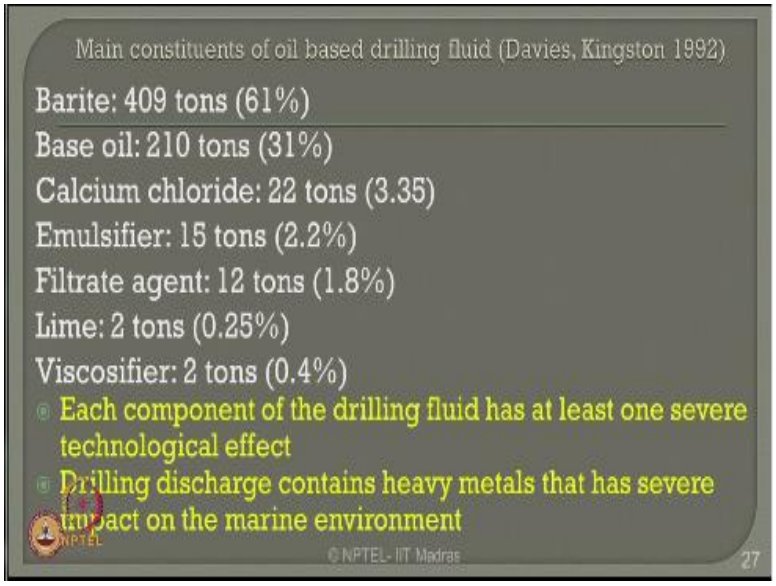

Pollution is also produced or cost by produce waters during drilling produce waters in drilling operation contain dissolved salts and organic compounds the oil hydro carbons traces a metals and suspensions are also see in the outcome of the drilling waters produce from the drilling platforms hence the compassion of produce water is very complex in nature however it generally contains benzene toluene and xylenes which about 30 mg per Kg of total of that about the discharge volume.

It also contains biocides organic molecules in heavy metals which cause serious concern of marine pollution the chromatographic analysis of discharge water in gulf of Mexico conducted a study showed very high and relatively stable level of phenol and its alkylate homologues in the discharge which is coming from the drilling fluid ,even radioactive elements like radium 226 and radium 228 are seen in the produced waters as we see from GESAMP report 1993

The radioactive elements are very dangerous because they cause catastrophic effects to any living mammals

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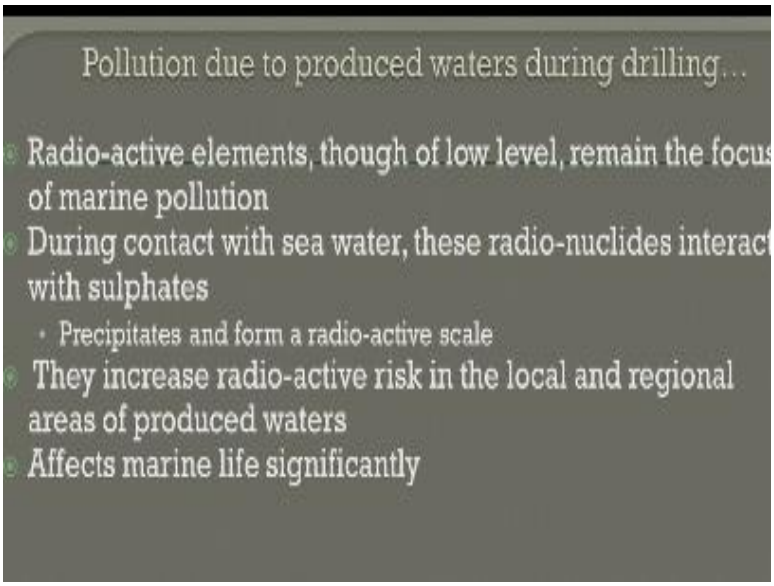

Radioactive elements though of the very low level in terms of its contribution remains the focus of marine pollution in the recent studies during contact with sea water these radio nuclides interact with sulphates precipitates and form what we called radioactive scale in the mammal surface they increase radioactive risk in the local and the regional areas of the produced waters it seriously affects the marine life very significantly.

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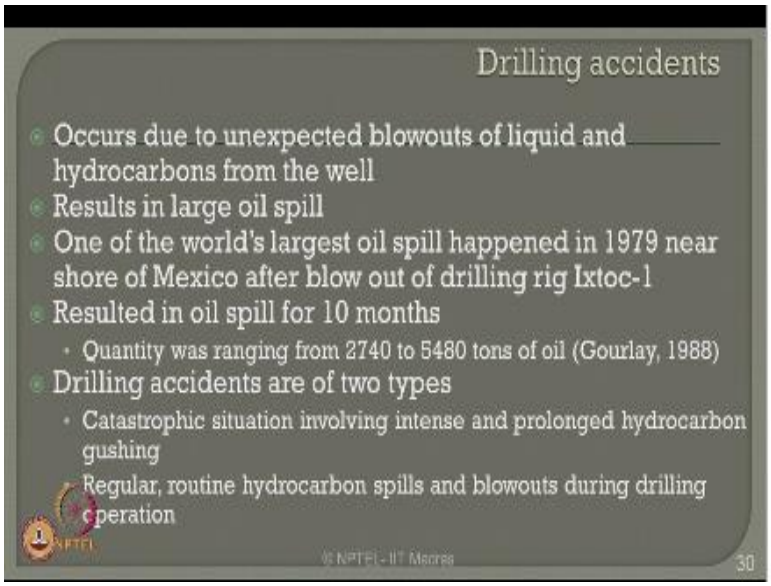

Adding to the complexity we all know and understood what are the forms of drilling accidents why they cannot be avoided we know about them so drilling accidents occur due to unexpected blow outs of liquid and hydrocarbons from a given production or expletory well, it of course results in large oil spill if the accidents occur one of the world's highest oil spill happen in 1979 near a shore of Mexico after a blow out of drilling rig ixtoc-1 resulted an oil spill close to 10 months dear friends.

The quantity was ranging from 2740 to 5480 tons of oil as reported in gourlay in 1988 drilling accidents as we are understands essential of two types one is catastrophic situation which involves intense and prolonged hydro carbon gushing the other can be a regular routine hydrocarbon spill and which results in blow outs during drilling operations friends both kinds of accidents discharge high quantum of volume in terms of contaminants in the marine pollution which is very serious concern which causes eco legible disturbances to the mammal life in ocean environment .

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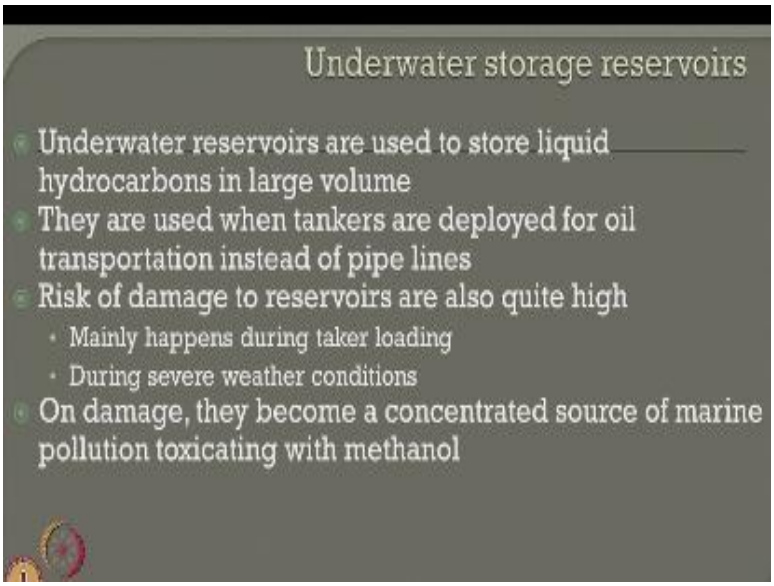

We also have a under water reservoirs because storage is a major concern in the production units when you talk about underwater storage reservoirs they are used store liquid hydrocarbons in large volume they are used when the tankers are deployed for oil transportation of pipe lines because you need a space to store oil the risk of damage to reservoirs is also quiet high it mainly happens during tanker loading or during severe weather conditions on damage they become a concentrated resource of marine environment or marine pollution which can toxicate with methanol very seriously .

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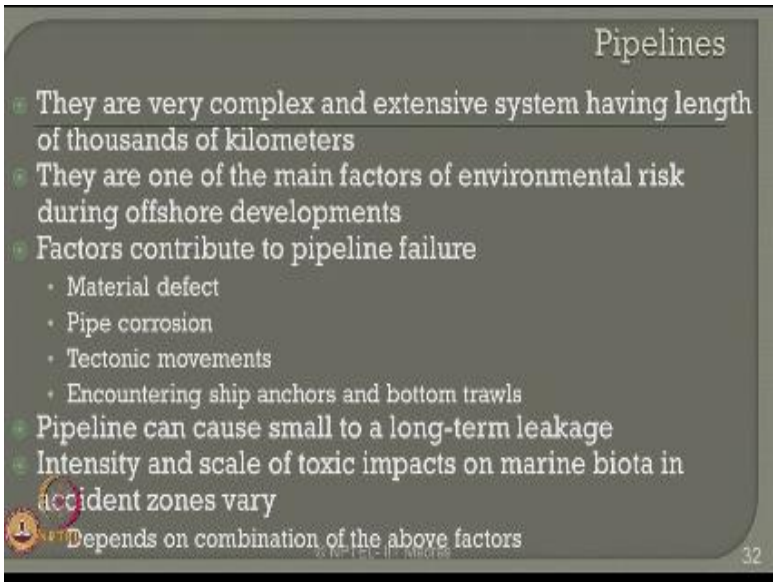

Of course pipeline are used for transporting hydrocarbon from the production source to the shore for further refinement they are very complex and extensive system having large links embedded in sea bed in thousands of kilometres they are one of the main factors of environmental risk during offshore developments the factors contribute the pipeline failure of the following it can arise from the material defect can cause pipeline corrosion can result from tectonic movements of the seabed can also be encountered from the ship anchors.

And bottom trawls failure pipeline can cause small term to a long term leakage to the marine environment intensity and scale of toxic impacts that arise from pipeline failure when on the marine biota in the accident zones varies significantly ,they depend on the combinational of the above factors like material defection pipeline corrosion tectonic movements and because of the damage caused by the ship anchors on the pipelines.

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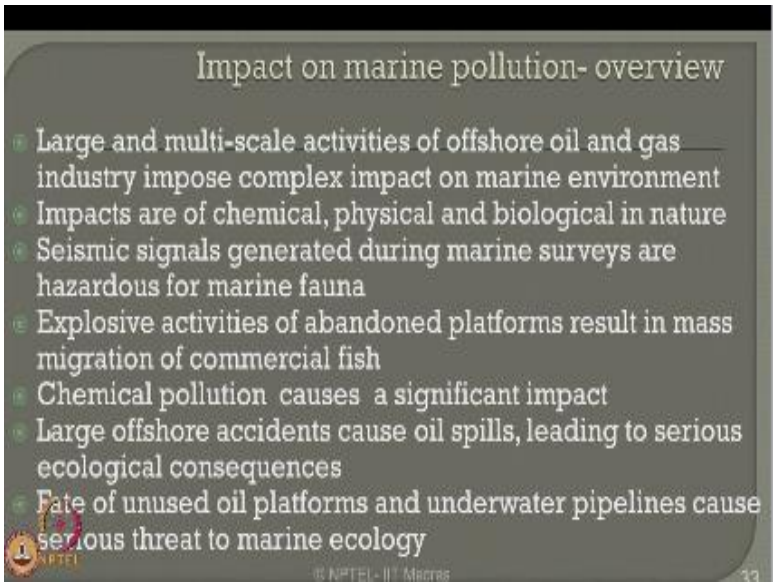

We look at the overview of the impact caused on marine pollution by offshore drilling operations there are large and multi scale activities of offshore and drilling happens which imposes complex impact on the marine environment, impacts of chemical physical and biological in nature seismic signals generated during surveys or even hazardous to the marine fauna and flora explosive activities of abandoned.

Platforms result in mass migration of commercial fish chemical pollution also causes a significant impact on the marine environment large offshore accidents cause oil spills leading to serious ecological consequences Friends fate of unused oil platforms and underwater pipe lines cause serious threat to the marine ecology in general. So in this lecture we try to introduce what are the different factors scenario an regions involved and affected by marine pollution caused essentially by the products operational features and different stages of oil and gas production in the marine environment thank you very much.

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