Health, Safety and Environmental Management in Offshore and Petroleum Engineering

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Module – 01
Lecture - 04
Oil Spills

Welcome friends to online course title Health, Safety and Environmental Management in Offshore and Petroleum Engineering.

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We are talking about the lectures, module 1 where we are focusing on the environmental issues, the impact on the environment caused by oil and gas industries during the production and processing stages, how they can be controlled? How they can be modeled, etcetera? Today in lecture 4, we are going to talk about exclusive characteristics of oil spills. In the last lecture, we briefed that what are the contents present in hydro carbon? How are they harmful to the marine flora and fauna? How they can cause contamination at different levels namely local regional and global level? What are the concentrations which are spread in the marine environment? And how they can be causing damage to the ecosystems? Today, we will discuss more in detail about one specific aspect which is of course, accidental in offshore and oil industries which is an oil spill.

Now, the special feature of an oil spill, the moment you talk about oil spill whether it is occurred because of accidents or because of leakage in the pipe line or whatever be the reason, the main demerit of an oil spill is within few minutes of its occurrence it disperses over a large area. It means the spread of oil spill on a free surface is very fast. Now, when it spreads it forms a thin oil slick; we call usually this slick is about 10 millimeter thick. Of course, as it spreads further and further in the larger area it becomes thinner and the concentration gets reduced.

During the first few days after the oil spill occur, considerable amount of the oil spill gets transformed. Let us say large quantity of the spill gets transformed into gaseous phase. Of course, oil spill slick becomes water soluble, the hydrocarbons the remaining fractions being viscous reduces the slick spreading most of the oil components which are actually aliphatic and aromatic hydrocarbons, which are most commonly present oil components.

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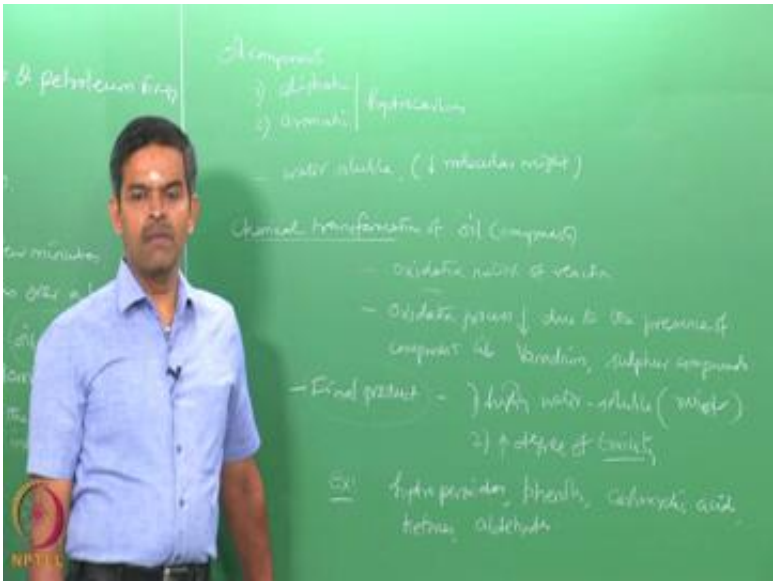

They are water soluble to a certain degree because they have a very low molecular weight. Because, they have a very low molecular weight they are water soluble. The hydrodynamic and physicochemical conditions influence the rate of dissolution of oil in surface waters. Talking about the next stage, this is a physical stage; the next stage could be a chemical transformation of oil. I should also say oil and oil components the

chemical transformation of oil on the water surface results in the oxidative nature of reaction.

So, this results in oxidative nature of reaction. This of course, involves petrochemical reactions under the influence of ultra violet waves of solar spectrum which is present in abundance. In open sea condition this oxidation process will be delayed due to the presence of certain components in the oil. So, the oxidation process will be delayed due to the presence of certain components, for example, presence of vanadium presence of sulphur compounds, etcetera creates retardation in the oxidation process.

The final product which comes from oxidation has a very high water solubility and toxicity. So, the final product which results from oxidation is highly water soluble. It can get mixed very well with the sea water, two; it has got a very high degree of toxicity. I can give certain examples on this hydro peroxides phenols, carbocyclic acids, ketones, aldehyds are certain examples which are the final products of the oxidation process which is a chemical transformation of the oil spill, which is highly water soluble. So, gets easily mixed with the sea water and most dangerously they are highly toxic in nature. Having said this, let us try to see, what are the environmental impacts of oil spill now?

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So, there are various factors which influence them and the complexity arise essentially due to the bio geo chemical behavior. There are tendencies of oil levels which tend to

increase from ocean region to enclose the sea and coastal waters, which has been seen and reported in the literature by resources and researchers. The marine pollution studies also identify the maximum contamination are seen in euphotic layer, I should say reported in various layers, let us say euphotic layer patchy distribution of contaminates seen in local.

You also notice locally an upper micro layer one can also notice deposition of bottom sediments, one can also see increased level of contact zones which is an indication that oil spill spreads very fast because the increase level of contact levels is an interesting area, and all these are actually seen in regions which are over lapping with the maximum pollution which are oil spills. So, oil now can be defined as a multi component toxicant. How one can say this the eco toxicological characteristics of oil is extremely complex to study, but people have realized that oil is an important toxicant, due to its integrated nature it affects every vital function such as process mechanism and system of living organisms.

Oil hydro carbons with complex and branches of molecules are very toxic than simpler molecules and straight chains of carbon atoms, the increasing molecular weight of the components increases their toxicity that is very important. Now, the question arises in mind is how to actually estimate this? How to quantify the oil spilled, oil pollution or the contamination which has come essentially from the oil spill? There is a method by name bio marker methodology, this is a method which an important tool in marine monitoring. The bio marker methodology provides data for assessing the cumulative biological effects under oil contamination of sea water. Let us discuss further in detail about the oil spill.

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Oil hydro carbons are continuously released in a marine environment due to natural oil, seepage from the sea floor, which is one of the unreported incidents which is very common in most of the offshore platforms. The global distribution of oil hydro carbons in the old version is characterized by increasing concentration from the pelagic areas to the coastal waters. From the chemical point of view, oil is a complex mixture of many organic substances. So, it is a complex mixture of many organic substances. Of course, they are dominated by hydro carbons there is no doubt on that. Now, when they become or when they come in contact with the marine environment, they are easily separated into fractions that are very important first stage, why oil spills are dangerously affecting the marine environment.

So, the first issue is when they come in contact with sea water or with marine environment in general, they get easily separated into fractions. Now, the separated fractions result in the formation of surface slicks, which is a physical appearance dissolved and suspended substances can also become as emulsions can also be seen as solids and other viscous compounds migration of oil in biological perspective is a complex again.

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Migration of oil is complex because of the inter connected process, since the process is inter connected process of what the transformation or oil spread is inter connected process. It is complex, what are the different stages when an oil spill migrates? Let us say, first stage is a physical transport. The second stage could be dissolving and emulsification; the third could be oxidation and decomposition because this takes more time relatively compared to that of dissolving and emulsification. Of course, it takes further more time to form sedimentation and the fifth stage could be very, very long time which is microbial degradation.

It is interesting fact, friends to know that oil spill also get self cleansing in the long duration because this gets bio microbial degradation happen. It can get self cleansed also, but that takes very long time to happen. So, when you talk about oil spill the essential source of oil spill also include the drilling discharges. The other major source of contaminating the marine environment is arising from the drilling discharges, let us say what are the chemicals and the ways which essentially form a component of drilling discharge, which essentially get released from the off shore oil industry.

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In the earlier lecture, we discussed about the components and the chemical substances present in a drilling mud. We will slightly elaborate this now and see, what are those exact difficulties which arise from the drilling discharge which are responsible for contaminating the marine environment? Drilling mud is hazardous when it is present in the marine environment because of one interesting reason, let us say after 6 months approximately of the discharge of the drilling mud, which essentially oil based it gets bio degraded only by 5 percent, remaining 95 percent remain as it is, you can see this specific statement from Ostguard and Jensen, 1995.

So, friends only 5 percent gets bio degraded. The majority volume of the discharge of the drilling mud remains in the same state even after 6 months. Therefore, drilling ways such as fatty acids lose their organic fraction due to microbial and physicochemical decomposition. Of course, in the case of water based drilling mud which is generally disposed over board adds more intensity to the marine pollution, people think that water based drilling muds are better. In fact, they had more complexity and more pollution to the marine environment. Drilling cuttings are pieces of rocks which are crushed by the drilling bit. They actually do not pose any serious threats to the marine environment at all.

So, the first component which essentially comes out on a drilling mud may be the rock cuts. They do not pose any special threat, but they increase turbidity and they increase

smothering effect of the benthic organisms. The discharge of drilling cuttings are present in larger volume creates eco toxicological disturbances, if present in large volume which essentially comes out from the off shore production. Oil and oil products that are present in the drilling cuttings are the main toxic agents because drilling cuttings will also include oil and oil products, these are the main toxic agents.

Oil based drilling mud contains an array of organic and inorganic traces which are hazardous in nature, if you look at the permissible limit of drilling cuttings discharged as advised by international regulations.

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The permissible limit of drilling discharges as recommended or admitted by international agency cannot exceed 100 grams per kg, but in reality they are exceeded at least by 100 times that is discharged in the marine environment will disperse in the solid phase actually. So, the dispersion takes place in solid phase. Now, the interesting part is this phase contains clay, minerals, and barite, crushed to rock pieces the larger and heavy particles will rapidly sediment, while the small fractions gradually spread over large distances on the surface of sea water. The second source apart from the drilling discharge is what we call produced waters.

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Produced waters actually are one of the forms of discharge that are evacuated from the offshore platform whose volume is significantly high. So, the produced waters include or contain solution of mineral salts, organic acids, heavy metals and of course, suspended particles. Now, what is the very big issue about the produced waters? The very big issue about the produced waters is they are discharged in very large volume that is a problem the quantity is difficult.

Now, the question comes oil spill drilling discharges produced waters are unavoidable. They have to be dispersed in the environment of course, there are regulations based on which they can be controlled. Now, the question is if the oil spill occurs we already said because of the physical process the spread of oil spill is more or less local, but once they get disintegrated decomposed then they gets mixed of with the lower intensity. So, one can always control oil spill. Let us see how an oil spill can be controlled and what is the regulation?

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Let us try to understand what is the toxicity level in an oil spill? Let us talk about lethal concentration 50; it is one of the terms or the method of the parameter to be evaluated for a toxicant which is declared as a toxicant, which is dangerous and harmful for environment. So, we workout LC 50, we look into how to evaluate LC 50 for given toxicant may be single phase, multi phase in the later lectures in different modules. However, let us believe that we know, what is LC 50 and LC 50 after 96 hours of exposure has variations present in form of 10 to 15 grams per kg in the oil spill. So, what does this mean, concentration relatively very, very high? This indicates that oil spill are highly toxic due to the presence of lethal substances, drilling fluid actually contains three main groups of toxicity, if we talk about toxicity of drilling fluid.

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It has got three groups. Group 1 actually refers to low toxic substances, example bentonite, barite, lignosulfonate. Group 2 refers to high toxic compounds, example biocides, corrosion inhibitors, de-scalers of course, is advantages from the researchers results. They are of course, seen in very small proportions. The third group refers to medium toxic compounds, example lubricating oil emulsifiers', thinners, solvents. The main comment of this specific compound is they are present in very large volume though they are medium toxic, but they are seen in very large percentage in a drilling discharge.

Now, the question comes back is how an oil spill which is containing or which is including heavy metals suspended particles. The organic acid low, medium and high toxic compound can be controlled. So, oil spill can be controlled by 3 methods mechanical, chemical and biological.

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Usually mechanical methods are more successful. They are most preferred, the reason being oil spill takes a longer time for biodegraded and spread, initially they remain in a physical state and therefore, floating booms are the mechanical devices or instruments or equipments which are generally deployed for controlling the oil spill from spreading over a large distance. It is being seen that floating booms are highly efficient in controlling the oil spill physically for a larger area. So, oil spread or the oil slicks spread can be controlled using the floating booms the oil, which is controlled by this booms will be then collected from the oil collectors and special ships having this floating booms separate them and transform it back to the shore, usually mechanical means are also supplemented and supported by the chemicals spill control method as well.

If you look at the environment management policies related to control of oil spill or imposing limitations on oil concentration in a marine pollution, the environment management policies essential framed with a local and global regulatory authorities. Let us quickly as a question, what should be rather the factors which govern these kind of regulations. So, we will try to find out.

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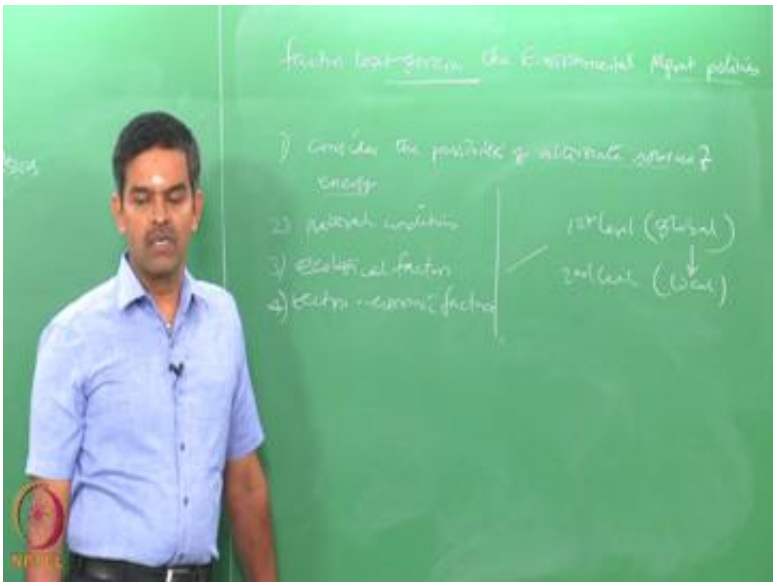

What are the factors that govern the environmental management policies? Before knowing the factors, one is interested to know why we should know the factors that influence the policy management issues. It is important to know this factor because then only you will really know whether they can uniformly applied globally or controlled by the local agencies or can these policies vary from country to country depending upon their specific economical situations.

So, let us say, first factor should be you must consider the possibilities of alternate source of energy, if a country or a region has possibilities of exploring alternate source of energy then one can impose a very strict and stringent regulation about environmental management policies. If you do not have successful alternate source which are commercially viable to meet the energy demand of a specific country or the local region then imposing stringent rules as environmental management policies will not really help the economic growth of a country.

The second could be what are the natural conditions, we have also taken to account the natural conditions prevailing in that particular region based on which you must reasonably frame the policies governing the environmental control. Third, could be the ecological factors and forth could be of course, the techno economic factors. Based on these factors usually the management policies are framed at two levels; the first level is actually the global level, the second could be the local level which actually follow by

enlarge the principles or the policies framed and the global level, then try to modify them as far as possible without altering the content or the original idea of implementing of this policy, but to suit to the local conditions prevailing in that particular situations.

However, all of us do know that these local bodies are also members of the global bodies, which actually dominate in framing the environmental management policies. Of course, when the policies are framed, they will consider all possible factors without having any bias on a specific group of countries or group of regions where this polices can create hazards for the economic growth of the specific regions or the nations. So, the question comes here, why do we actually frame policies? Why do we want to frame polices? We have to frame policies because we want to ensure environmental protection.

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So, polices are framed to ensure environmental protection. If we talk about environmental protection, let us orient our discussion only to oil and gas activities. The various factors which contribute to the implementation of the policies and the regulations that is regulatory to control environmental pollution, which essentially arises from oil and gas exploration. So, what are those factors? Now, foremost factor could be acknowledgment of socio economic stipulation. So, one should strongly consider the socio economic conditions on specific region before you start implementing those policies as a game play of environmental protection.

Many countries frame policies in co operation with oil produces. So, policies of frame by a team the team includes oil producers, fisher man and environmentalists. So, the socio techno economic and client or the user conditions are satisfied or considered, while framing the policies because this will have a mutual benefit and to implement that is very, very important. Policies frame, if not implemented or if not implementable are of no use, penalty or causing violating regulations is a very simple task that cannot achieve an economic growth of any country. You must always frame policies and ensure protection or following of the policy where the people of the stake holders are mutually benefited and of course, environment is also protected.

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Second important factor could be expediency of developing offshore natural resources. So, while framing the policies which ensure environmental protections, one should use eco centric approach. It should not be anthropocentric approach is not good eco centric approach is an alternative method which ensures stability of natural eco systems. It supports conditions for self renewal of biological resources environment protection policies are generally governed and nominated by regional aspects. They account for specific features or different marine basins in terms of diverse climate social economic and other characteristics.

There are different guide lines framed by the different agencies in the world. Let us try to understand who actually does this the frame, the guidelines of frame by joint group of

experts of scientific aspects of marine pollution, what we call GESAMP; Group of Experts of Scientific Aspects of Marine Pollution. The recent report has been released in 2004 by the GESAMP. These guidelines indicate three main blocks such as planning, assessment and regulation. They include regulatory measures for discharging drilling waste into sea. The most important guideline which is suggested in the GESAMP report in 1991, let us say as earlier as 1991, it says that the discharges into sea requires proper authorization discharges into sea requires proper authorization is the first and foremost rule which has been framed, and which to be strictly implemented and followed by oil and oil gas industries wherever they are producing oil globally.

Concentration of oil and products determine using standard test should not exceed the established standards. So, the second condition impost by the GESAMP that you must follow standard test and your results should not exceed the permissible values and most importantly, the LC 50 value which is lethal concentration after 96 hour of exposure which can be estimated using a test called mysid toxicity test.

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It should not exceed 30 grams per kg, which is referred by the researcher in 1995. So, ladies and gentleman, in this lecture we discussed about the characteristics of oil spill. The important components present in oil in various stages, how oil gets dispersed in open sea surface? How they can be controlled? What are the marine management policies? What are the regulations in local and global who actually formed these policies and

framed these guidelines? What are the difficulties in implementing these guidelines towards environmental protection? If you want to really implement them successfully the stake holder should be accounted for even in the formation of the policies. These are basic guidelines generally followed when such policies are made. We will continue in the next lecture.

Thank you very much. Bye.