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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 2: Oil spills

Welcome to the second lecture on module 3 where we are focusing on environmental issues and management under the course on HSE in offshore and petroleum engineering under the braces of NPTEL IIT Madras in the 2nd lecture in module 3 we will talk about the consequences and significance happening in the marine environment which essentially occurs from 1 important outcome of drilling which is oil spills.

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Let us look at some important facts related to hydrocarbons abundant evidence demonstrates global distribution of oil contamination when tests have been conducted to estimate the content of hydrocarbons in marine pollution. Therefore it is important friends to know that concerns about scale and consequences of oil pollution is increasing day by day over to the last leakages.

Oil spill therefore are oil content in the marine environment is one of the leading contributors of impact cost to the marine environment crude oil contains some hydrocarbons with hybrid composition.

For example paraffin- naphthenic, paraffin aromatic composition which are highbred in nature their behavior and biological impact in the ecosystems are essentially governed by the physical and physiochemical properties for example some of the properties which govern there impact on the ecosystem is essentially based on the specific gravity the volatility and water solubility we can see each one of them separately in detail and see what are the consequences occurring from water solubility and volatility of these physical and chemical properties of this system which cause serious effects on marine pollution.

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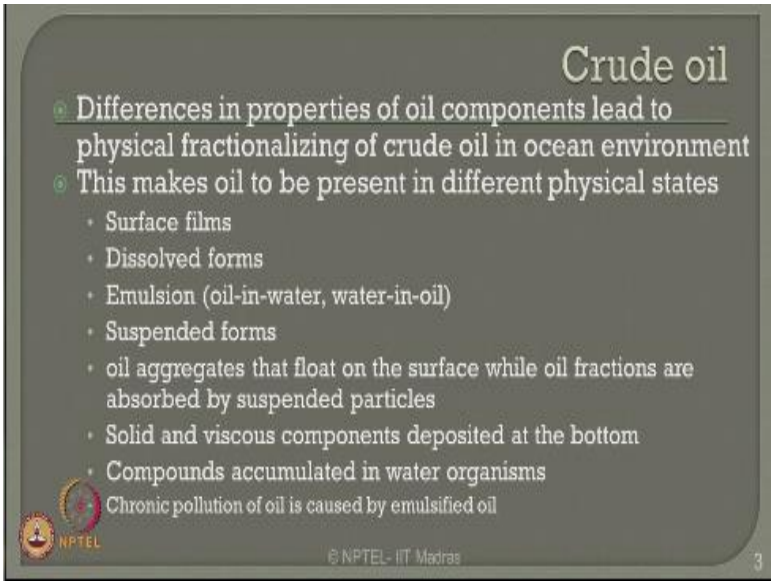

Let us quickly ask the composition of what a crude oil consists of differences in properties of oil components actually lead to physical fractionalizing of crude oil in ocean environment. This makes oil to be present in different physical states in the marine pollution they can occurs in the form of surface films, they can be also seen in dissolved forms can also see in some emulsions, oil in water, water in oil composition etc..

Can also see crude oil as suspended forms oil aggregates that float on the surface while oil fractions are observed by the suspended particles in the marine environment solid and viscous components are deposited usually at the sea bottom, compounds accumulated in the water organisms as well and chronic pollution of oil is essentially caused by the emulsifying oil content present in crude oil.

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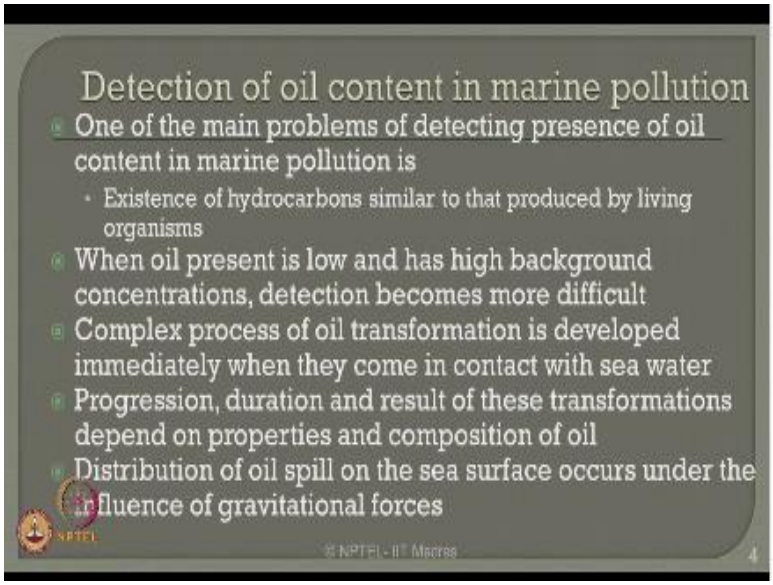

Now the question comes how do you detect the oil content in marine pollution? Rather it is very difficult and complex because of certain reasons, one of the main problems of detecting presence of oil content in marine pollution is that existent hydrocarbons are similar mostly to that of produced by living organisms and mammals in the sea environment, when oil presence is low and has high background concentration, detection becomes much more difficult.

The complex process of oil transformation is developed immediately when they come in contact with sea water and they disperse very fast. Progression, duration and result of these transformations essentially depend on the properties and composition of the oil, distribution of oil spill therefore on the sea surface occurs under the influence of gravitational forces.

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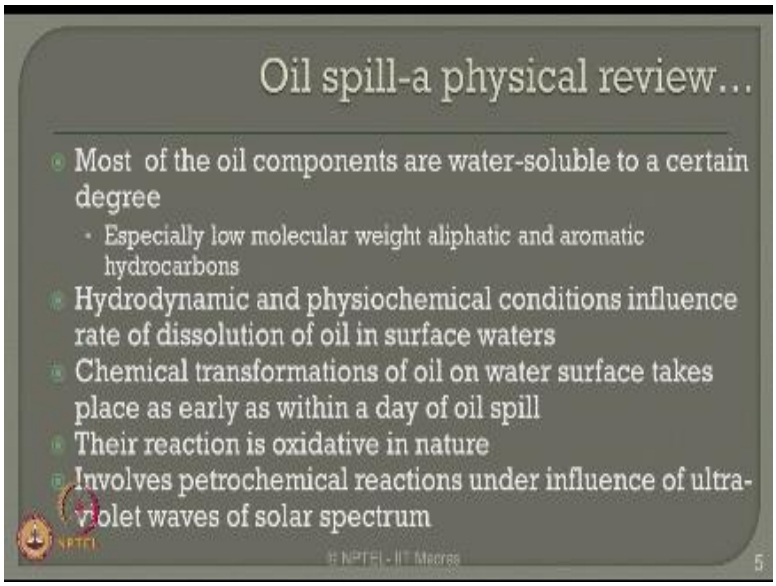

If you look at the physical review of how oil spill actually takes place, most of the oil components are essentially water soluble to a certain degree, especially low molecular weight aliphatic and aromatic hydrocarbons are water soluble, hydrodynamic and physical chemical conditions influence the rate of dissolution of oil in surface waters, chemical transformation of oil on water surface takes place as early as within a day of oil spill, the reaction is oxidative in nature, it involves petro chemical reactions under influence of ultra-violet waves of solar spectrum.

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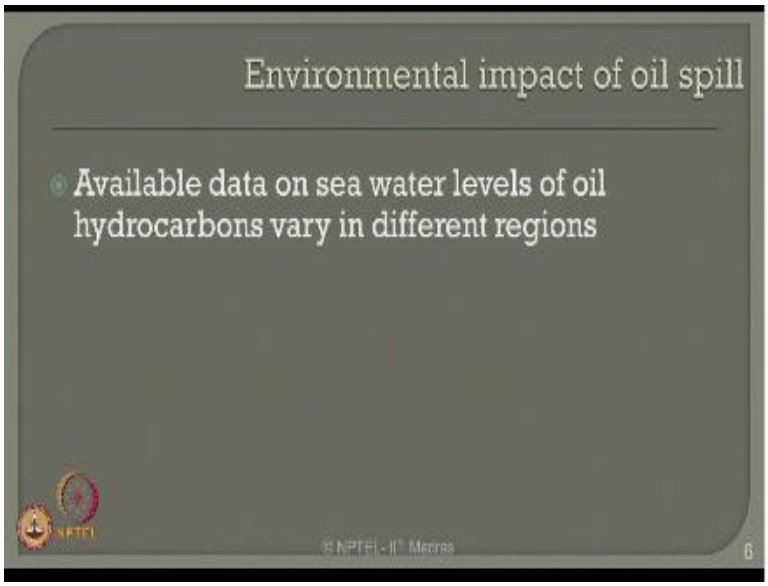

If you look at series of environmental impact cost by oil spill in marine environment the available data on the studies on sea water levels of hydrocarbons vary in different regions, friends it is important for us to know that if really wanted to measure the marine pollution which cost by oil spill you must always look at the contents present in the sea water and try to disintegrate them by some chemical reactions to know what are actually the contents contributed by hydrocarbons from the oil spill.

But unfortunately the available data on thus such test are showing different results of hydrocarbon content in different regions.

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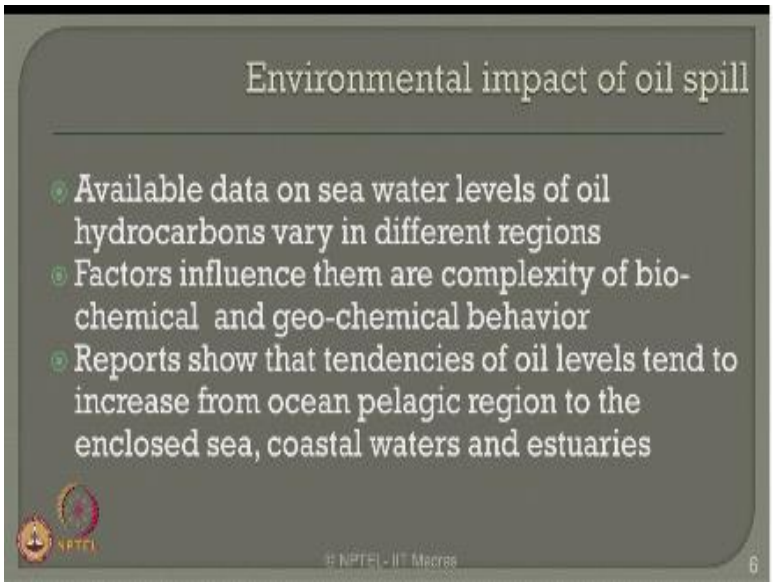

Now there are many factors this influence them essentially the primary factors or the complexity of bio-chemical and geo-chemical behavior of these hydrocarbons in water, therefore the report show the tendencies of oil level tend to increase from ocean pelagic region to the enclosed sea, coastal waters and estuaries which is very dangerous and very peccary situation which bothers the environmental list in the present state.

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Marine pollution is generally studied by identifying the following factors. Maximum contamination of euphotic layer. Patchy distribution of contaminants present term surface water. Localization in upper micro layer, deposition in bottom sediments at sea rate, increased levels in contact zones, overlapping fields of maximum pollution and of course one can also study the relative stability of oil flow in the given situation.

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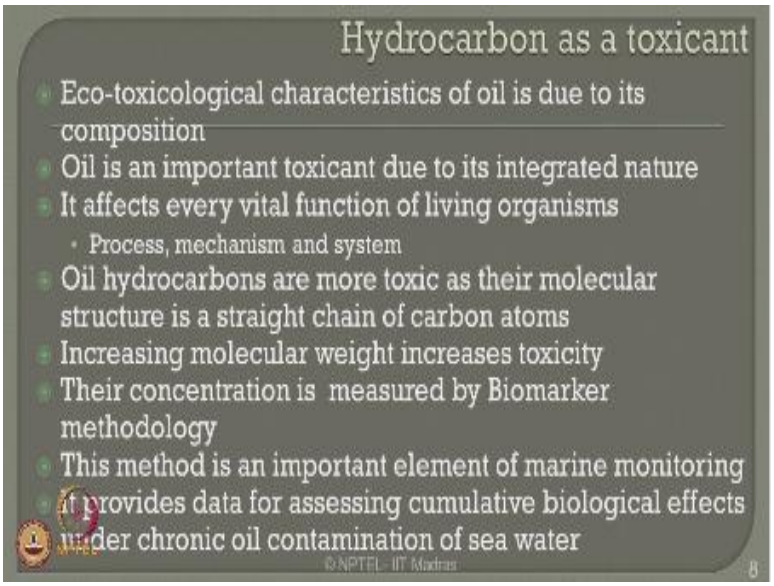

If you look at hydrocarbon as one of the important toxicants, let us see what are the contents present in hydrocarbon which classifies or qualifies this as a toxicant. The eco toxicological characteristics of oil is essentially arising from its composition. Oil is an important toxicant due to its integrated nature. It effects every vital function of living organisms for example, it seriously effects the process system, the mechanism and the reproductive system of a given living manners.

Oil hydrocarbons are more toxic as their molecules structure is actually a straight chain of carbon atoms. Increasing molecular weight increases toxicity. Their concentration is usually measures by a method call biomarker method. This method is an important element of marine monitoring system. It provides data for accessing cumulative biological effects under chronic oil contamination of sea water.

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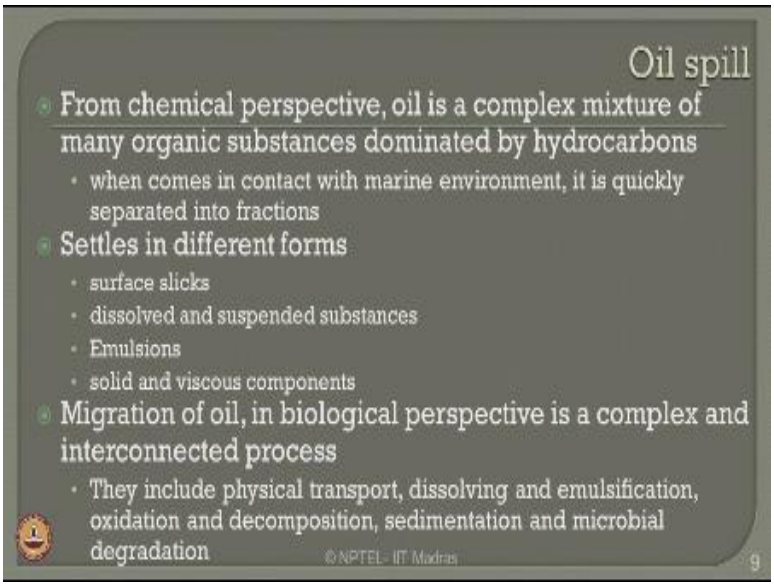

From chemical perspective friends oil is seen as a complex mixture of many organic substances which dominated essentially by hydrocarbons. When they come in contact with marine environment it is quickly separated into fractions. The settle and different forms in sea environment they can also form surface slicks, they can dissolve and also become a part of suspended substances, they also get disintegrated to form emulsions, some of them remain as solid and viscous components in the marine environment.

Therefore, friends migration of oil in a biological perspective is a very complex model because of its interconnection processes they include physical transport, dissolution and emulsification, oxidation, decomposition, sedimentation and of course ultimately the microbial degradation. Because of these interconnectivity between the processes biological perspective adds complexity to estimate oil spill or oil contamination mathematically in modeling sequences.

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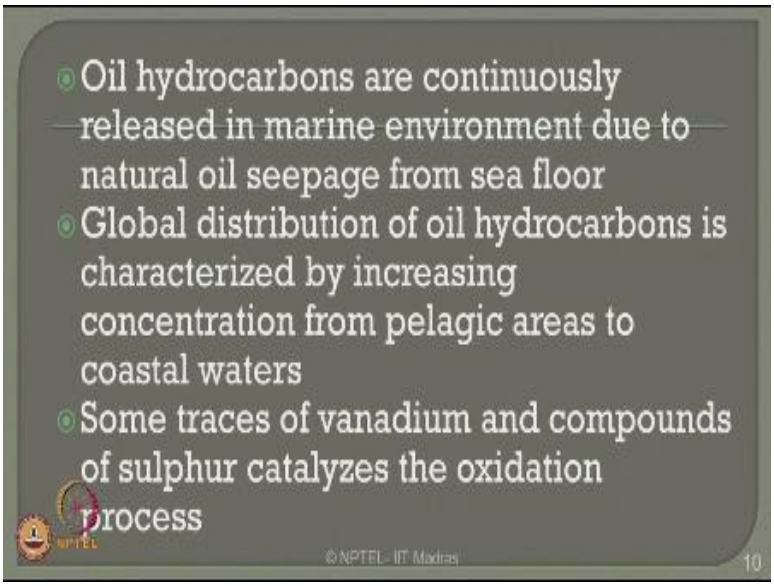

Oil hydrocarbons are therefore continuously released in marine environment not necessarily only during accidents but they also arise from natural oil seepage from the sea floor. Global distribution of oil hydrocarbons is characterized by increasing concentration from the pelagic areas to coastal waters which is one of the main concern to the environmentalist in the reason past. Some traces are vanadium and compounds of sulphur actually catalyzes even the oxidation process present in the environment which depletes the dissolve oxygen content in the sea water.

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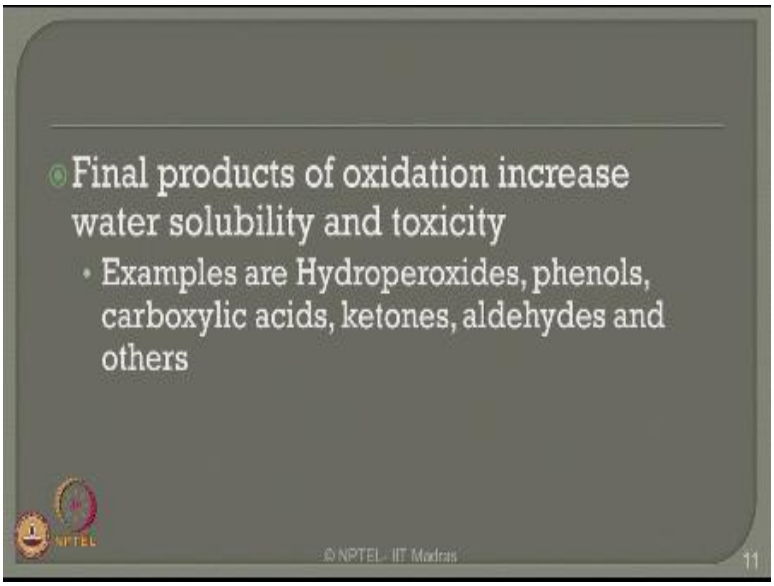

Final products of oxidation increase water solubility and toxicity examples are hyroperoxides, phenols, carboxylic acids, ketones, aldehydes and others.

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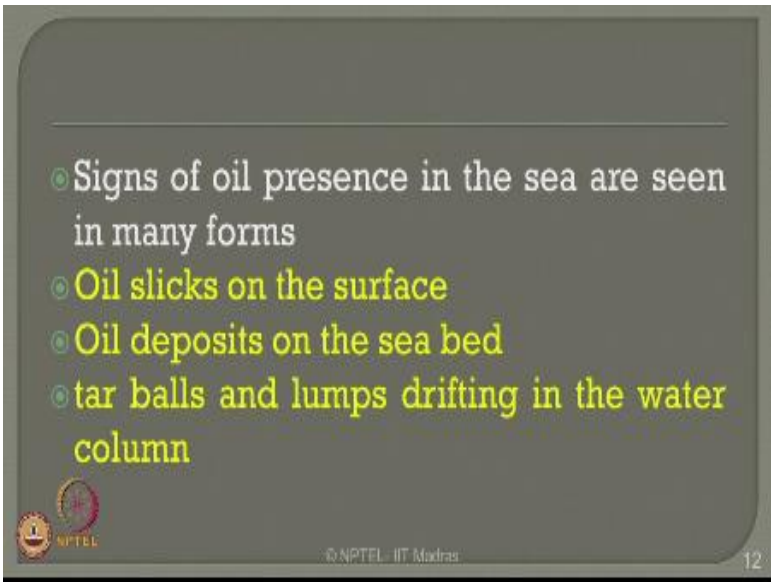

Signs of oil presence in the sea are seen in many forms ladies and gentleman oil sleeks or seen on the surface of our marine involvement oil deposited I mean noticed on the sea bed tar balls and lumps drifting the sea water column is also been seen.

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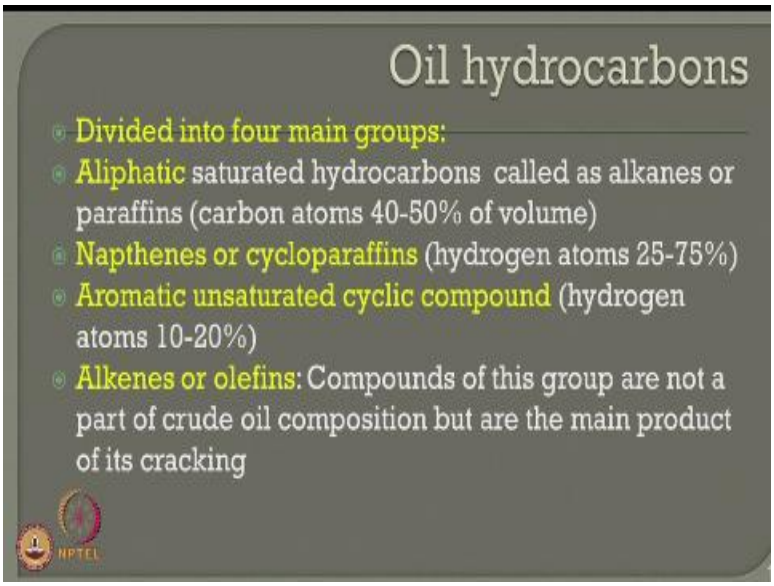

measures let us look at the contents if hydrocarbons and see what are the factors it influence the toxicity in given marine involvement if you look at oil hydrocarbons there are three divided into four main groups the first group is Aliphatic which is containing saturated hydrocarbons which otherwise called as alkanes or paraffins the carbon atoms present in this contain is about 40 to 50% of volume the second main group is Napthenes or cycloparaffins which contains hydrogen atoms is about 25 to 75% the third group is Aromatic unsaturated cylic compound.

Which of course contains hydrogen atoms in the range of 20, 20% and the last group of hydrocarbon is alkanes or olefins which are nothing but compounds which are a path of crude oil but the main product of it is cracking in terms of it is dissolution and decomposition.

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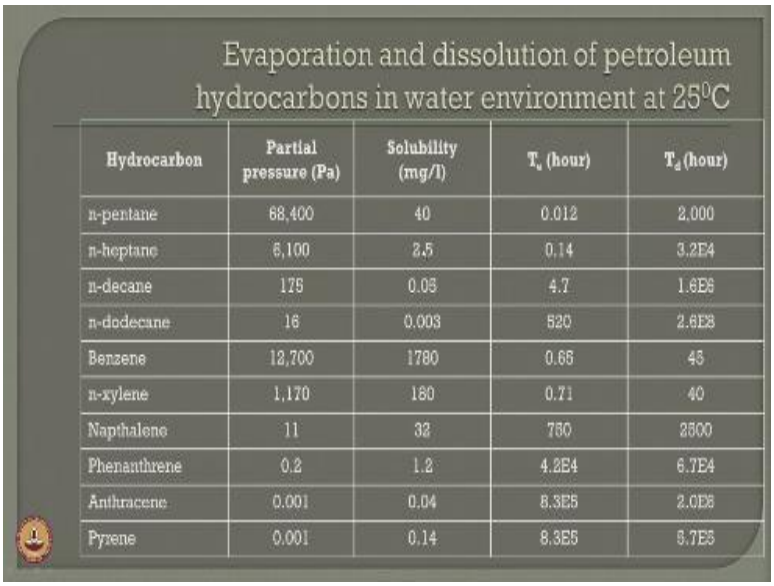

Hydrocarbon	Partial pressure (Pa)	Solubility (mg/l)	T_v (hour)	T_d (hour)
n-pentane	68,400	40	0.012	2,000
n-heptane	6,100	2.5	0.14	3.2E4
n-decane	175	0.05	4.7	1.6E6
n-dodecane	16	0.003	520	2.6E8
Benzene	12,700	1780	0.66	45
n-xylene	1,170	180	0.71	40
Napthalene	11	32	750	2500
Phenanthrene	0.2	1.2	4.2E4	6.7E4
Anthracene	0.001	0.04	8.3E5	2.0E6
Pyrene	0.001	0.14	8.3E5	3.7E5

This table gives a comprehensive layout of understanding in terms of evaporation and dissolution of petroleum hydrocarbons in the water environment as a simple at in temperature over 25^{0}C we can see the content of hydrocarbon varying from pentane to pyrene the partial pressure presents in terms of Pascal their solubility in terms of milligram per liter and the effective time saturation comes of hours and the TD in terms of hours there are different hydrocarbon components which are actually a path.

Of evaporation and dissolution process at a specific temperature this shown here now the content in terms of solubility or high as 40mg/l solubility and as minimum has very low value of 0.05 however the retention time varies as high as 200 hours environment very high value of 5.7 105 hours so the presents of this hydrocarbons during the process of evaporation and dissolution stays for a longer time and solubility is also very high.

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If you look at the fate and behavior of these hydrocarbon components in the marine environment their different stages at which they can be encounter in the marine pollution in the form of physical transport they can also appeal in the form of dissolution emulsification oxidation and destruction sedimentation microbial degradation and aggregation and lastly self-purification let us look at different forms of this quickly one by one and try to understand the significant contribution of these stages in the marine pollution.

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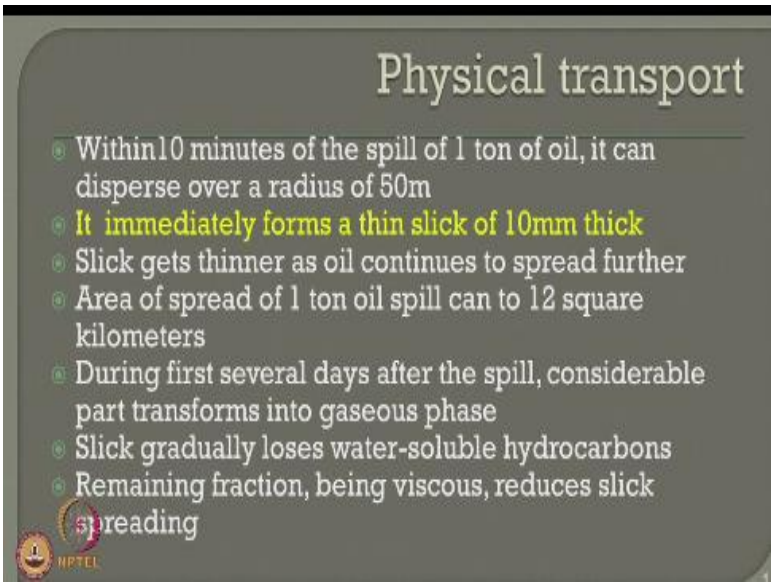

We look at the physical transport form it is evident from literature that within 10 minutes of the skill of let us say one ton of oil it can dispose over a radius about 50m so dispersion is very fast it immediately forms a thin slick of 10mm thick slick becomes thinner as oil continue to spread for the area spread of 1 ton oil spill can be as high as 12 square kilometers day in the first several days after the spill their considerable amount transforms into gaseous phase slick gradually loses water soluble hydrocarbons as a stays longer the reaming fraction bring discuss reduces the slick spreading automatically.

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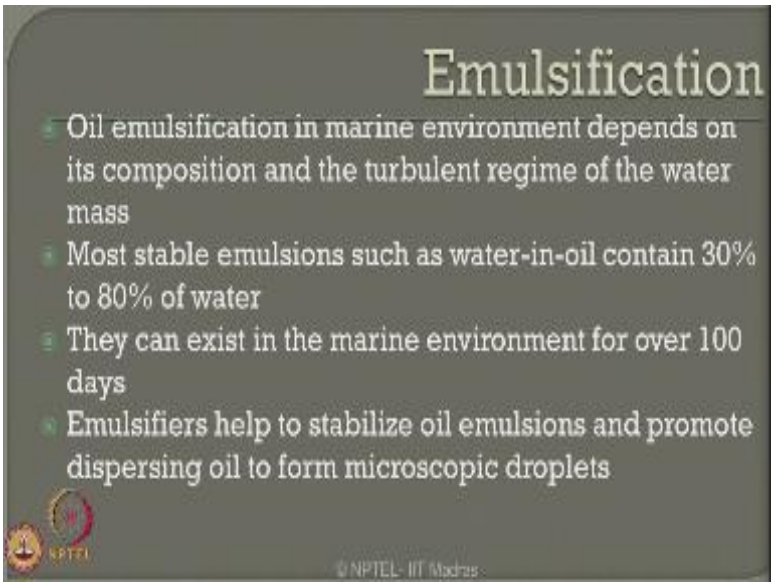

To talk about the next stage which is emulsification oil emulsification in marine environment depends on its composition and the turbulent regime of the water mass most stable emulsions such as water in oil contain about 30% to 80%of water, therefore they can exist unfortunately in the marine environment for more than over 100 days so the retention period in marine environment is very large and the spirit is very fast.

Emulsifiers help to stabilize oil emulsions and also promotes unfortunately the dispersing of oil perform microscopic droplets and they stay for a loner time this sea surface.

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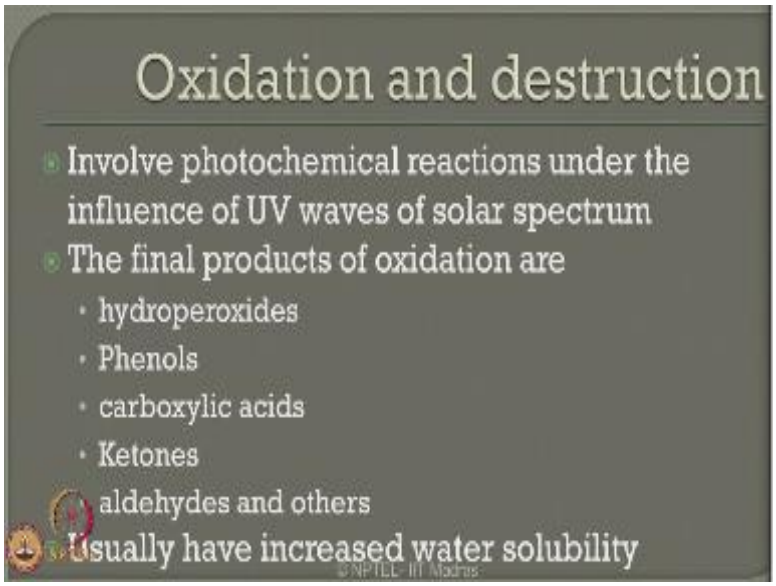

Now look this next state of oxidation and destruction it involves photochemical reactions under the influence of ultra avail at waves of the solar spectrum the final product s of oxidation are the following it can form hydro peroxides can form phenols carboxylic acids ketones aldehydes and others, it usually has increased water solubility.

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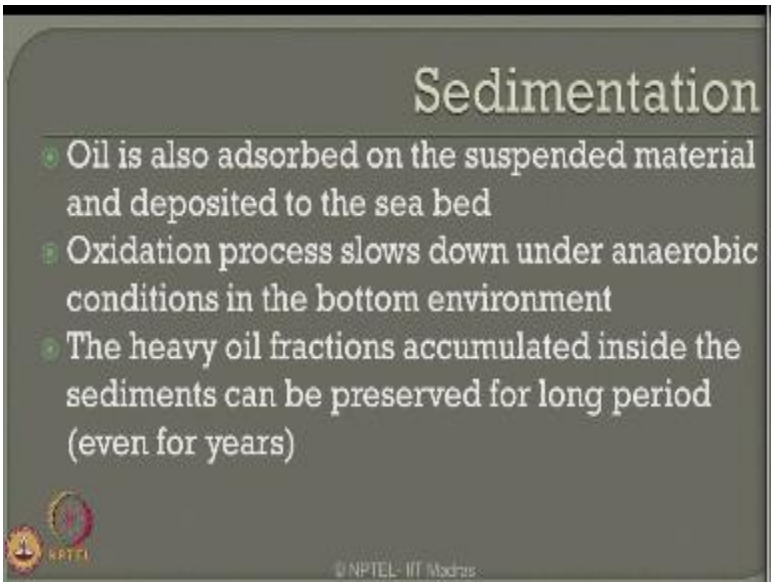

The next problem is from sedimentation oil is also adsorbed on the suspended material and deposited on the sea bed oxidation process slows down under anaerobic conditions in the bottom environment in the segment. Therefore the heavy oil fractions accumulated inside the sediments can be preserved for a very long period and that period can be as high as even many number of years.

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If we look at the next stage as microbial degradation it is known species and fungi uses oil components to sustain the growth and metabolism for a longer time, paraffin compounds biodegrade faster than aromatic and naphthenic substances.

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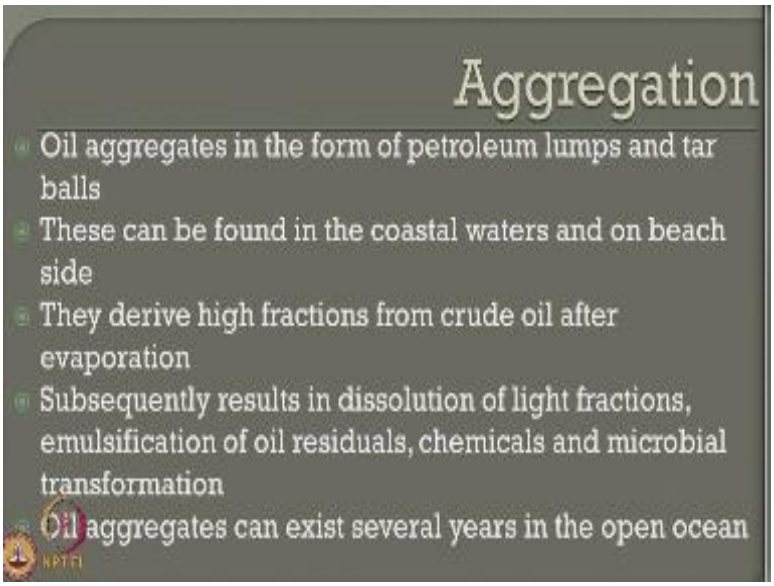

The aggregation process results in oil aggregates in the form of petroleum lumps and tar balls they can be found in coastal waters and on beach side they derive high fractions from crude oil after evaporation subsequently they result in dissolution of light a fraction emulsification of oil residuals chemicals and microbial transformation oil aggregates can exist several years in the open ocean.

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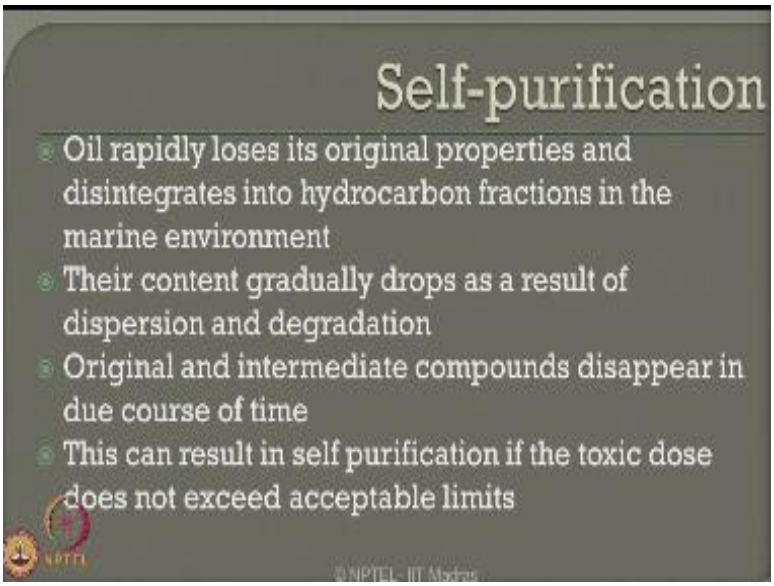

If we talk about self purification oil rapidly loses its original property and disintegrates into hydrocarbon fractions in the marine environment their content gradually drops as a result of dispersion and degradation original and intermediate compounds disappear in due course of time, this can result in self purification of course if the toxic dose arrays from the process does not exceed the acceptable limits.

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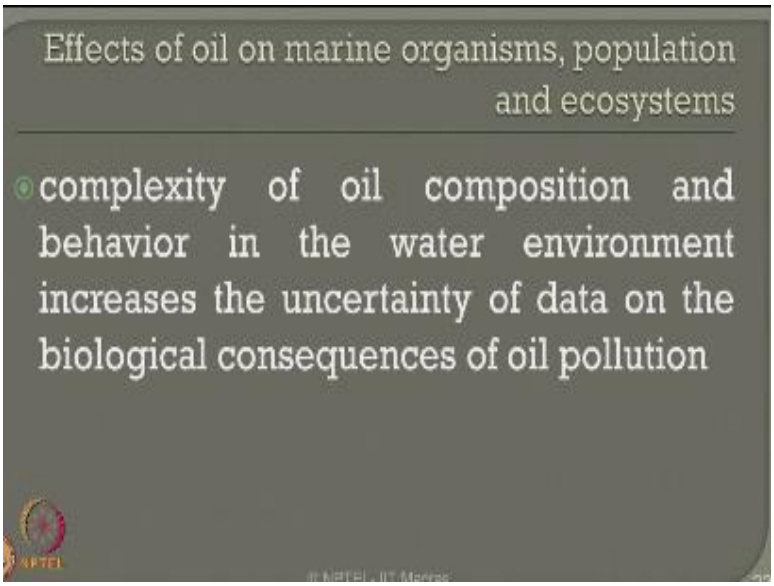

If you look at the effects of oil on marine organism's population and eco systems complexity oil composition and its behaviour in water environment increases uncertainty of data on the biological consequences of oil pollution.

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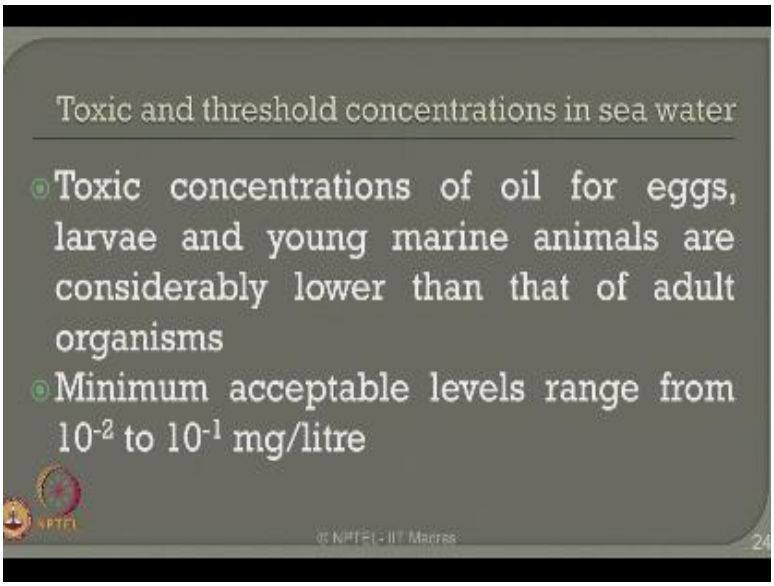

You look at the toxic and threshold concentration of this in sea water the toxic concentration of oil for eggs lava and young marine animals are consider lower than that of adult organisms the minimum acceptable level ranges from 10^{-2} to 10^{-1} mille gram per litre any toxic level more than this will not allow the lava to mature in to mammal or a egg.

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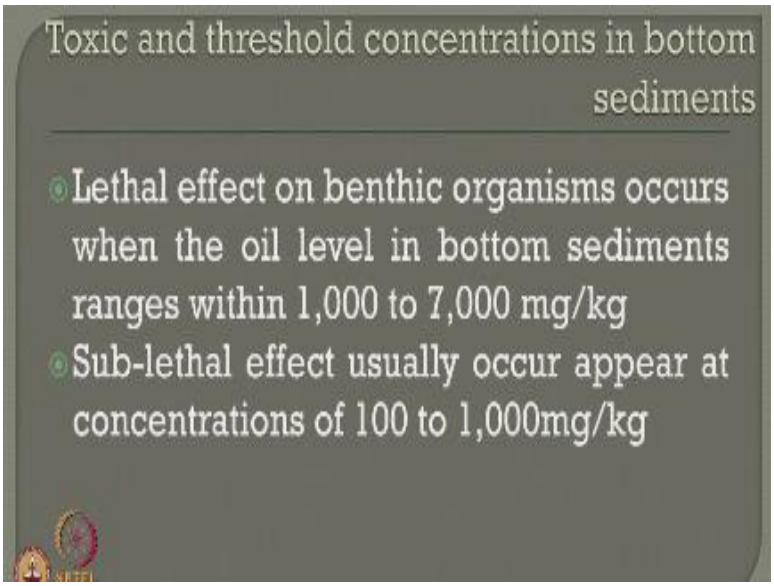

The toxic and threshold concentration in bottom sediments at sea bottom or sea bed can be seen like this the lethal effects on benthic organisms occur when the oil level in the bottom sediments are in the range of 1000to 7000 mille gram per kg the sub lethal effects will be caused when they are seen in concentration varying from 100 to 1000mille gram per kg so friends any lethal effect will be resulting from a concentration of sediments seen at sea bottom as minimum as 100 mille gram per kg to as high as 7000 milligram per kg which are generally seen but unfortunately friends the strategic show and the literature study show that the sediment concentration on the sea bed is much higher than these numbers shown in the slide.

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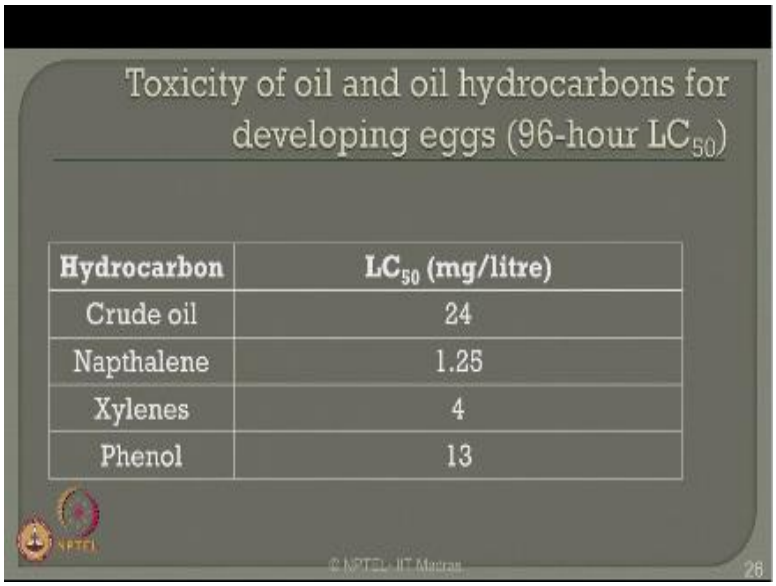

We look at toxicity of oil and hydro carbons for developing eggs as a result of 96 hour lethal concentration 50 ,we already know how to find out the lethal concentration 50 in the last module we are explained you a logarithmic curve depending upon how one can estimate lethal concentration if we look at the hydrocarbon contents like crude oil, naphthalene, xylenes and phenol the lethal concentration in mille gram per litre is seen in the screen now crude oil is seen to be very high as 24mille gram per litre whereas the naphthalene concentration in hydro carbon are seen as well as 1.25 mille gram per litre.

So friends in this lecture we have tried to understand what are the chemical composition the biological content and the physical separation and different processes involved in hydrocarbon how they can be separated and what are the different constants present in hydrocarbons and what are the individual influences on oil spill as well as marine pollution ,how do they effect physically biologically the organisms present in sea water we I will talk about in detail about this in the next lecture thank you.

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