Sustainable Transportation Systems
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Lecture 09
Impacts of Transportation Systems - IV

Hello friends, so you might be remembering that we are these days discussing about impacts of transportation system on various aspects of the environment and society. So, in the series of that several kinds of impacts, today we will discuss about impact of transportation on soil and water, like earlier we have discussed impact on air and impact on human health etc., so especially today we will focus on in this lecture on soil and water.

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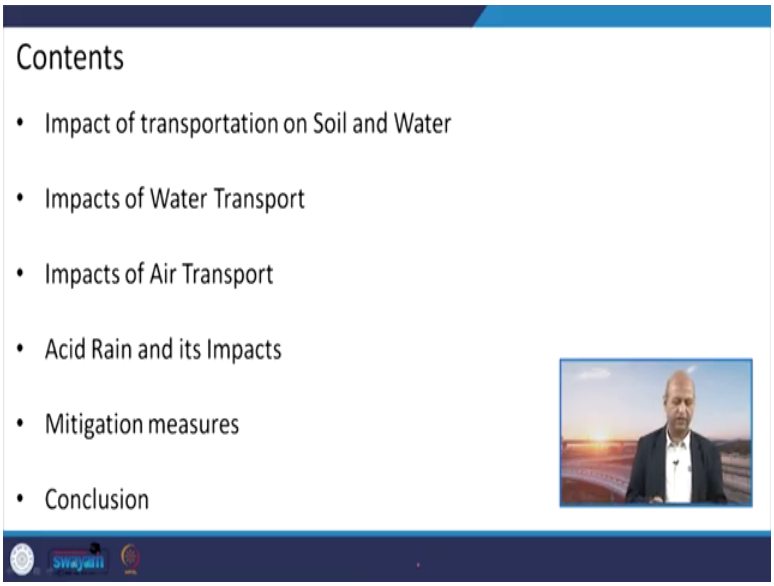

And also we will see like impact of water transport or impact of air transport because road transports impact we have seen or discussed in detail earlier also and then we will also see like acid rain and its impacts, so again this is because the acid rain is due to emissions of transportation sector means of course there are other emissions also they contribute into acid rain, but transportation sector emissions also greatly contribute in that, so we will discuss what is acid rain, acid rain we have already seen, but still we will again see its impacts in detail. And lastly we will go through mitigation measures and then conclusion of this talk.

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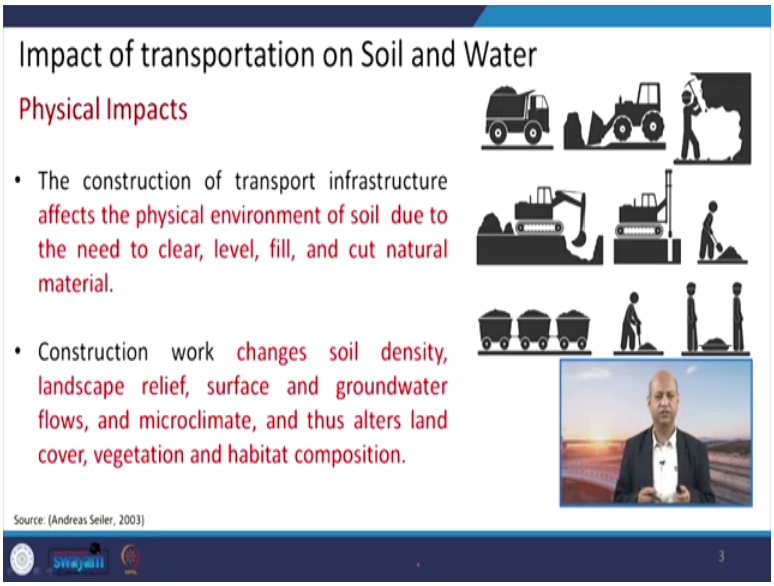

Well, so we can divide or classify these impacts on soil and water, in physical and chemical those kinds of things. So if you talk about physical impacts, then we see that physical environment like when we are digging soil, when we are cutting some hilly area, all these activities they influence this surface and groundwater flows and they can alter the land cover, the vegetation and habitat composition last time we in detail have seen those habitat related issues.

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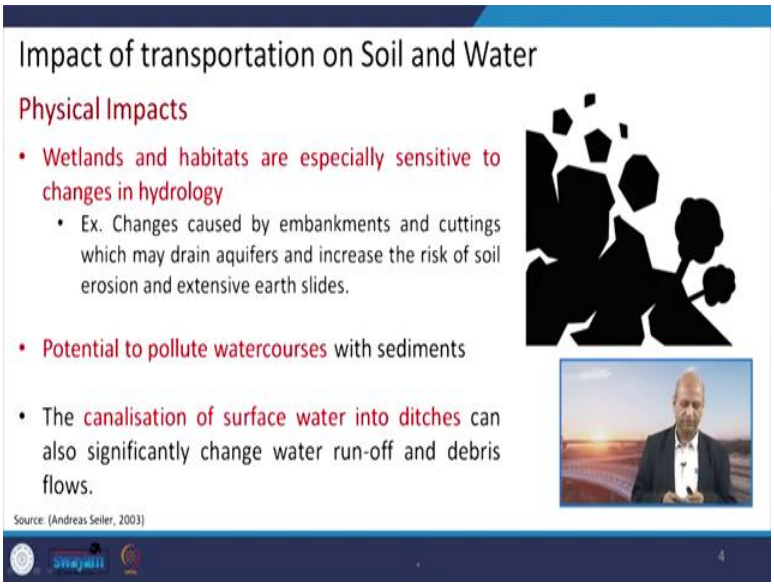

So, physical impacts again, if we talk about then this erosion of soil because of these transportation activities like we are cutting road, lands into a given terrain, so the soil erosion

may increase, because we have to cut the vegetation and lot of land use patterns are changed because of that, so this subsurface water flow also gets changed because of these activities.

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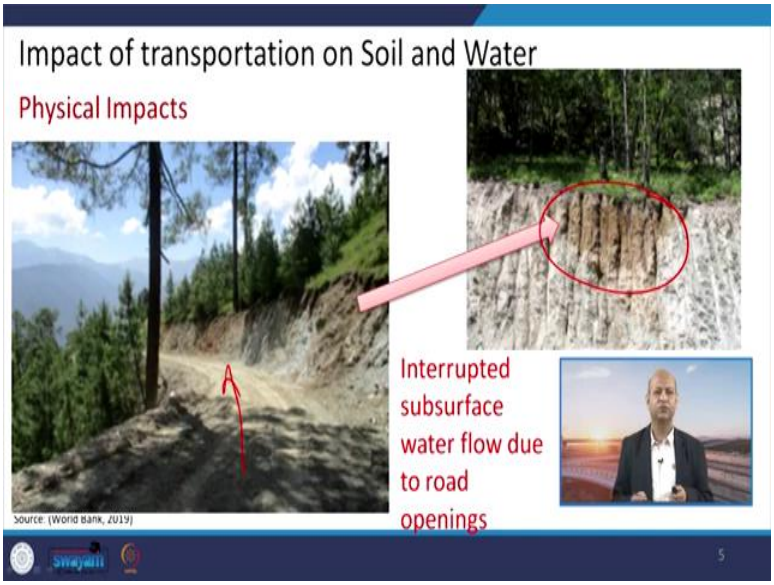

Like this pictorial representation can show you very nicely that if this subsurface water flow is influenced by road cutting, because we have to remove the topsoil and these kinds of issues may happen which can loosen the strength of the soil and later on it can also result into like landslides or soil erosion, those kinds of things.

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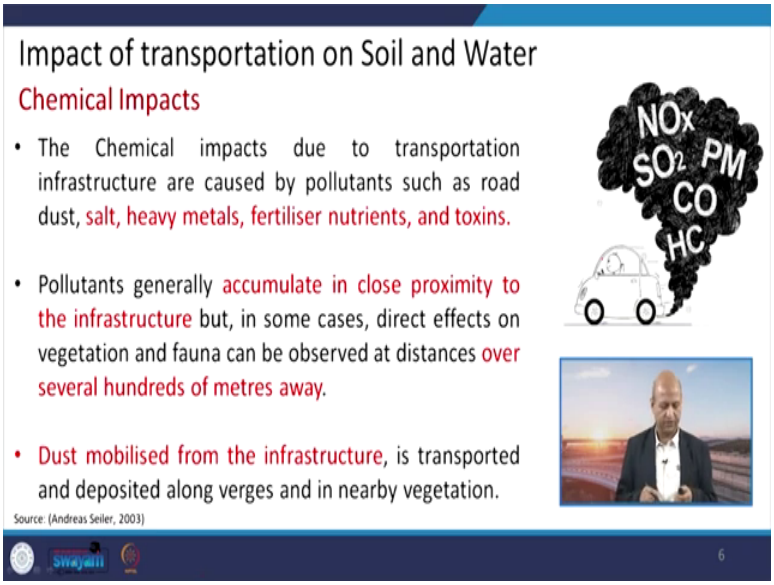

At the same time, if we go to chemical impacts, because emissions are nothing but chemical compounds of several sorts or kinds, like oxides of sulphur, oxides of nitrogen, particulate matter, particulate matter can have some heavy metals in it, or some toxins maybe there, so all these things are chemical emissions you can say, so these chemical compounds when they interact with environmental components whether air, water or landmass or flora and fauna, then they tend to change their characteristics.

Well, so they can percolate even these chemicals can percolate down up to aquifers, that is the thing although slowly but when this filters out from several strata of the soils, they can reach to the aquifers and aquifers may be contaminated and this topsoil of course that will be contaminated more.

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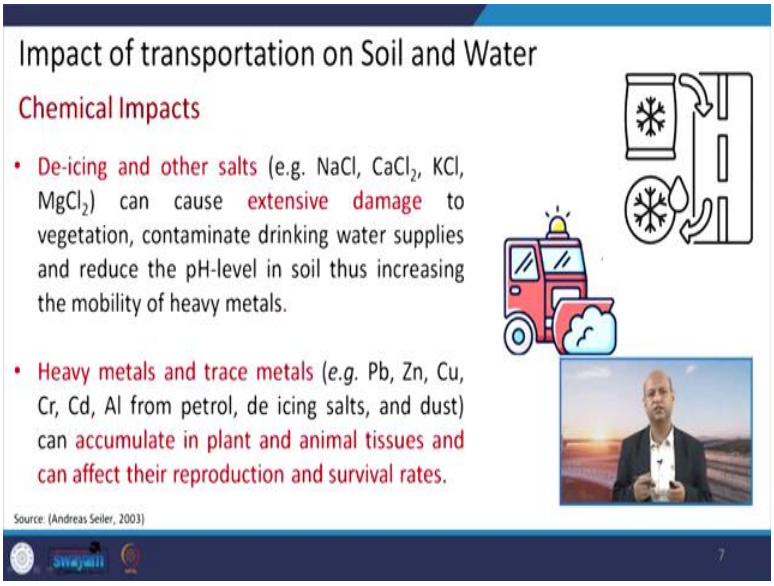

So, the chemical impacts means after physical impacts, we can also see the chemical impacts in which these compounds like chlorides which are used for de-icing etc., they also contribute into contamination of soil they can change the pH level of the soil and they can also go through different water bodies, because of water runoff and storm water and those.

And heavy metals, they get accumulated into plants and animal tissues and then they can transfer into even human beings because when we are eating something then bioaccumulation takes place, bioaccumulation means when from plant to animals from animals to human beings and in the food chain when some toxins or some toxic chemicals or heavy metals when they go up into

the ladder their accumulation occurs more and more and we are at the kind of top in the chain of food, so we get our system get high level of contamination or these pollutants enter into our body and then they triggers some kind of disease or some problems.

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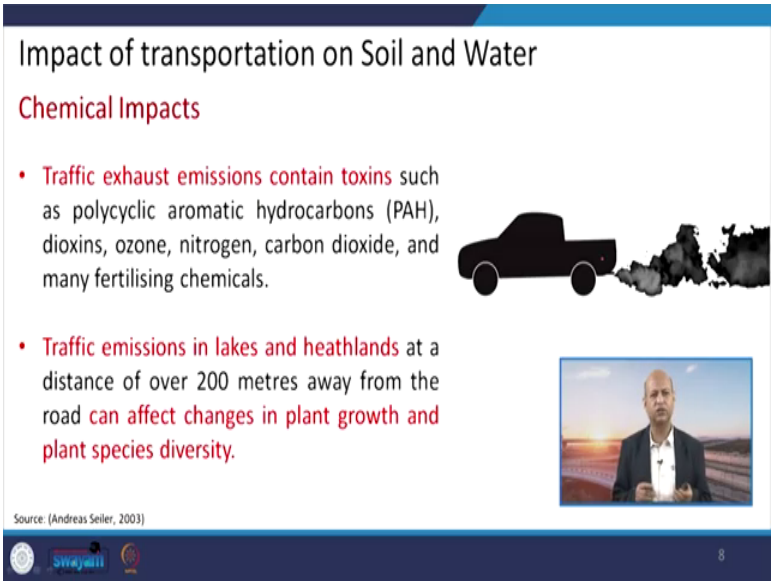

Well, again from chemical impacts point of view, there are other traffic emissions like polycyclic aromatic hydrocarbons (PAH) we call and then there are like PAN also and dioxins or ozone, nitrogen all these chemical compounds which are emitted in terms of gases whether primary pollutants or secondary pollutants they contribute into air pollution. And it has been seen that even up to 200 meters away from the road or that facility where transportation is there, there plant life can get affected because they get those contaminated you know, water or soil and ultimately their growth is reduced.

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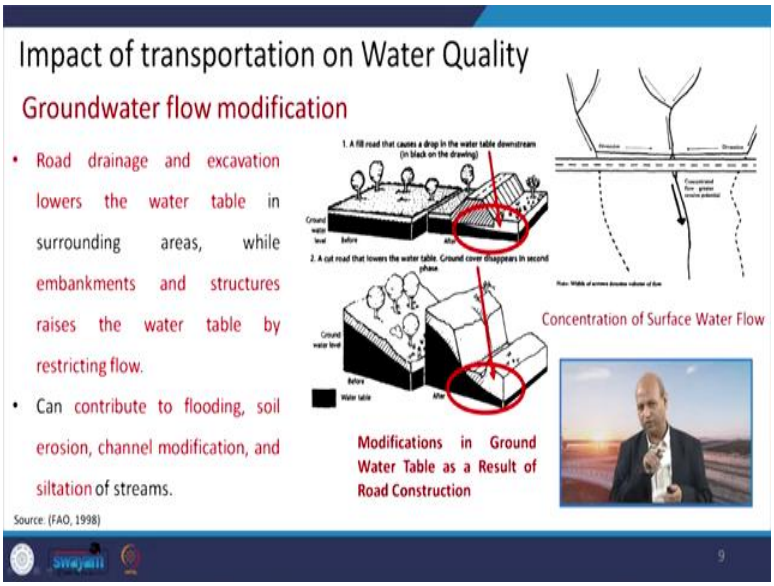

When we see the groundwater flow modification, because of different kinds of activities like road is there, so, subsurface water becomes very less and in next picture, we will see properly that how this water flow get influenced.

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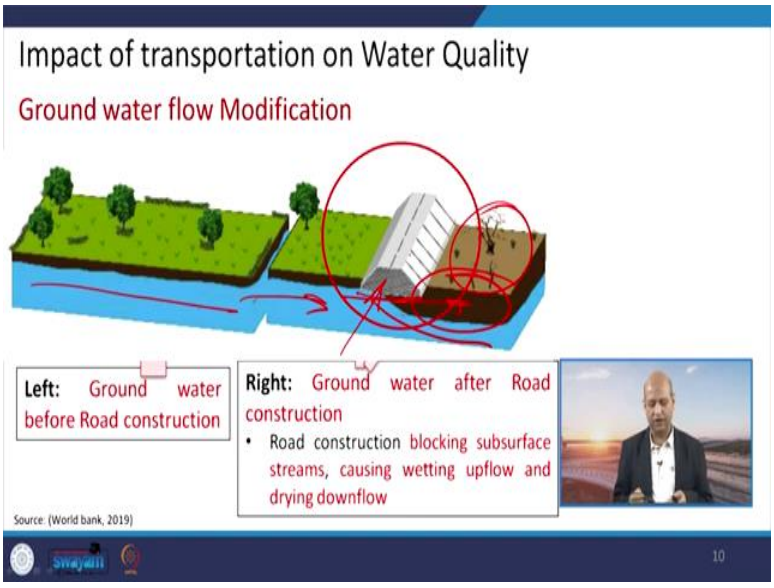

And like earlier this was the stretch and everywhere greenery was there and if some kind of road structure is there, so this water which was flowing without any barrier or without any check, it gets blocked by this structure and then water rather than flowing straight it goes down, so this much of part which loses this subsurface water content and that is why you can see and the

vegetation goes away and you can say, very localized desertification occurs or barren land starts to take place.

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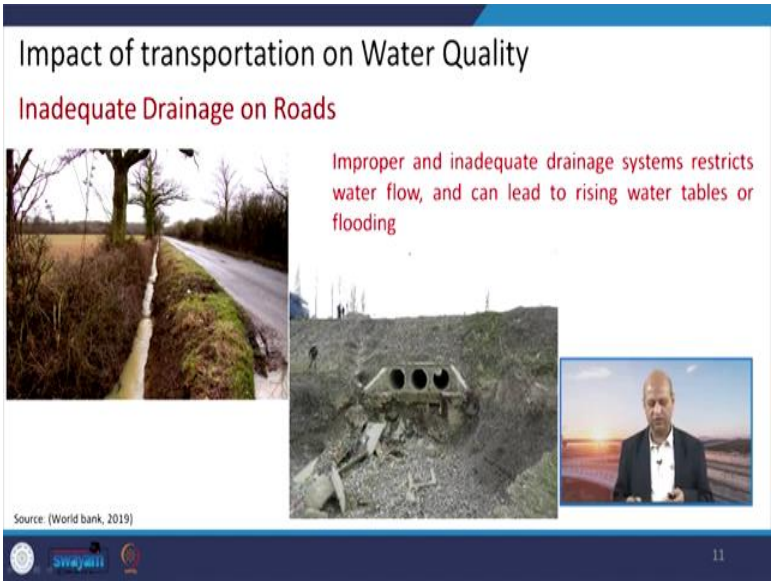

Similarly, if there are inadequate drainage facilities in and around road, then also there may be like accumulation of water and they can again change this topography, also sometimes flooding occurs at one side and on the other side different kinds of problems occur because of this water pressure difference and you can see the damages to these soil strata because of these activities of road construction and operation.

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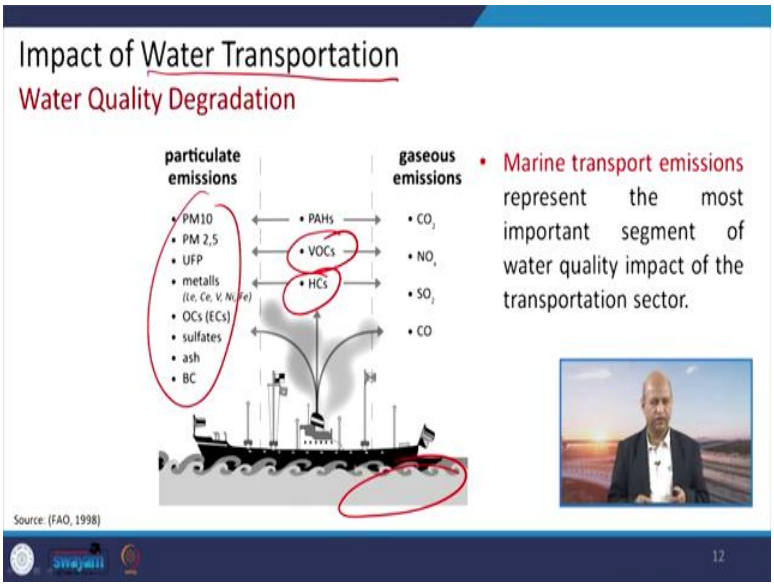

When we see like water quality, how does it get impacted by water transportation like vessels ships etc., so like there are various emissions again, because fossil fuel is used for energy purposes, so all hydrocarbons or volatile organic compounds and pH etc., and then there are several kinds of other air pollutants, they get emitted and they get dry deposited or wet deposited.

Dry deposited means, slowly they get deposited because of gravity, otherwise wet deposition, because some precipitation is there, then also they can get deposited on the surface of land or water. So, these marine transport emissions, they also change this water quality parameters, because of these pollutants, which get ultimately mixed with the water body.

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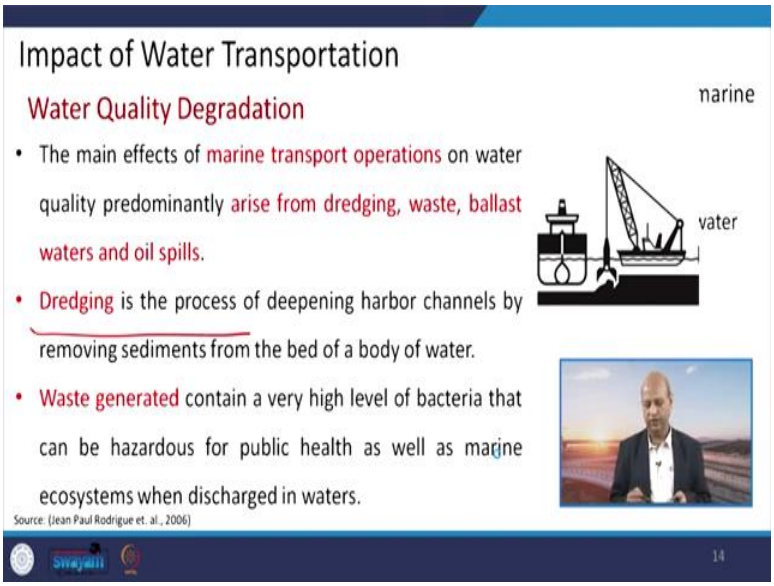

Also, we see like when we want to have these inland waterways, so to have minimum depth of water sometimes or many times dredging is needed, which is costly affair, and now new techniques are coming where dredging are not needed, but naturally rivers can take care of their depth of the water, there are new techniques, which is beyond the scope right now, we will maybe see in later on.

So, those kinds of activities they create a lot of sedimentation in downstream and again the erosion of banks or these surfaces takes place and they also degrade the water quality in and around those activities where these ships are going on or fossil fuel based energy driven, small boats are going on.

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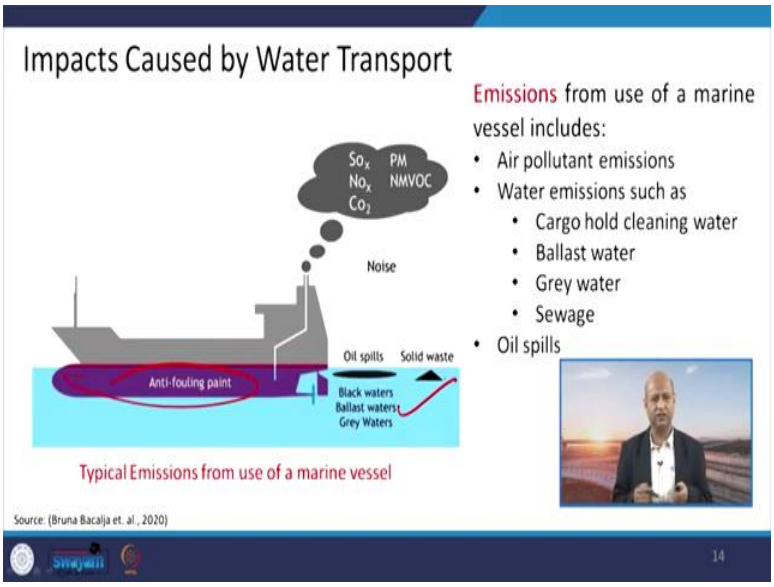

Then you can see like at the bottom antifungal paints are there. So, various kinds of chemicals are there in the vessels material. So, they also interact with the water ultimately, they go into water bodies plus like ballast water or grey water from toilets etc., and if they can get leaked then contamination is there.

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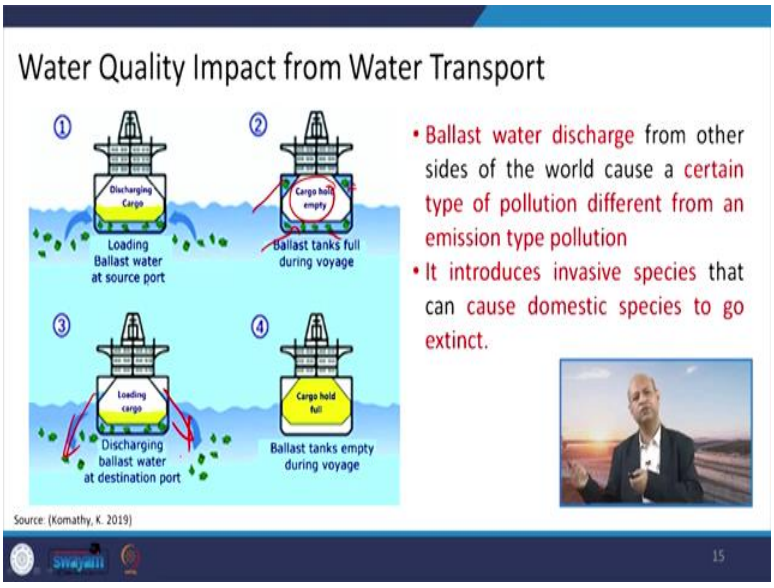

Ballast water you can see like when ships are going without cargo then they need this water for balancing purpose. So, when empty the ship is there like this is empty, so this ballast water is

needed for balancing purpose. When loading happens then you just empty this ballast water and you drain it out, so from one place you took this water and on other place you are discharging it, so sometimes the characteristics of water may be quite different and when we are discharging that water from farther away, so that can change the quality of water in those areas and ultimately aquatic life can get affected.

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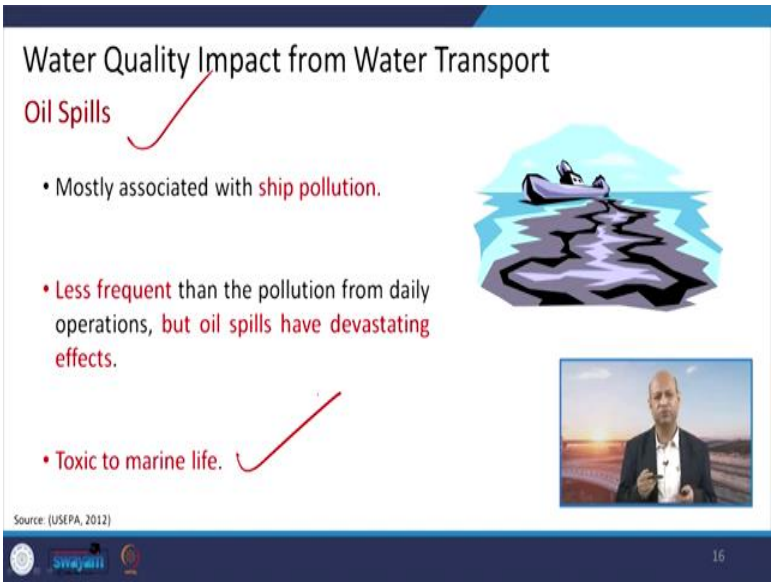

Also there are like accidents as we discussed in earlier lecture, so oil spills maybe there because of accidents and they again influence the water quality as well as aquatic life. Although less frequent, but they happen sometimes and then marine life affected because of toxins due to these oil and sometimes fire also occurs, so the temperature increases of the water and it is dangerous for aquatic life.

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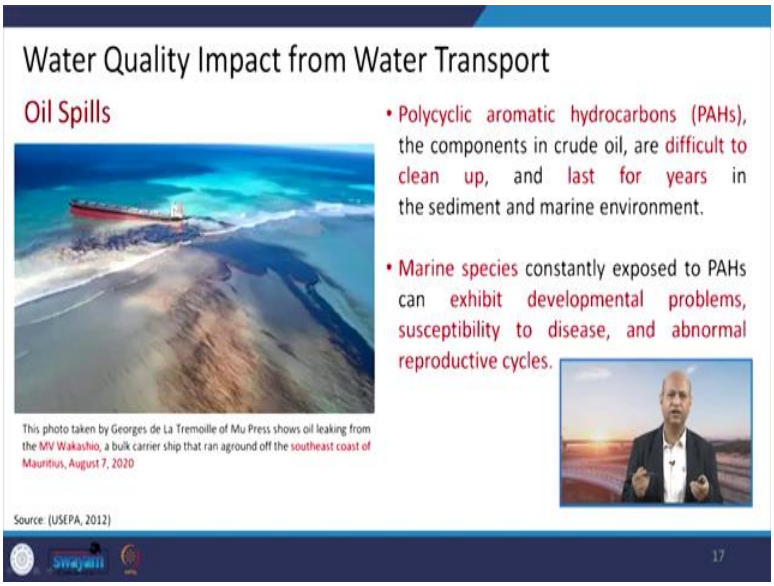

Here some examples are given for example, some species can get diseases because of these oil or some toxic material which has which are emitted by oil spillage and some other toxic material because of crude oil has lot of things in it and when it is spreading in the sea or water then various fish varieties or species they get into contact with this toxic and they get several ill effects on their health.

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Well, this one example of Italy HAVEN oil spill in 1991 and around this 144000 tonnes heavy crude oil was exploded because of some electric spark during cleaning and this fire broke and around 10,000 of tonnes of the oil that got spilled on the in the ocean and this was a big accident.

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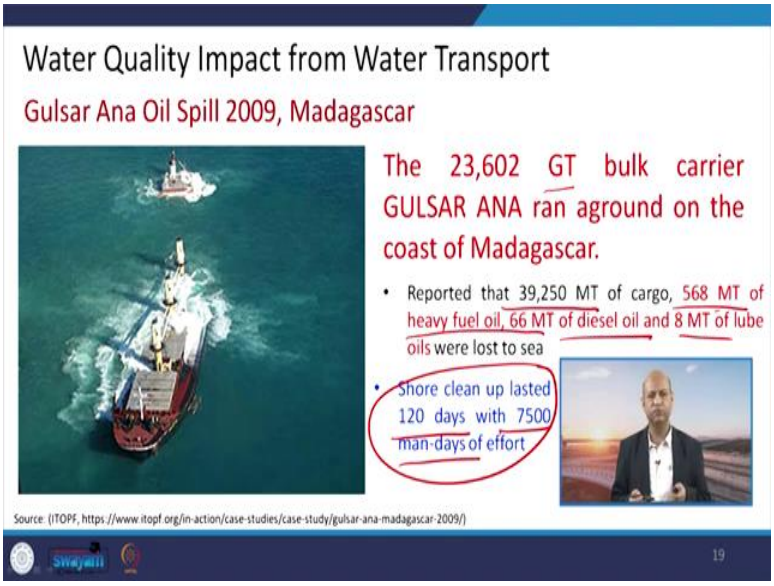

And so, this is another example of accident where oil spilled over the sea and around 39,000 mega tonne of cargo was there and this 568 mega tonne of heavy fuel oil and 66 mega tonne of diesel oil, 8 mega tonne of lube oils, they were lost to the sea, so not only financial losses are there but also problem to the aquatic life. So, around it took 120 days and 7500 man day's efforts to clean it. So, it is heavy loss in terms of time, in terms of resources, and in terms of negative environmental impacts.

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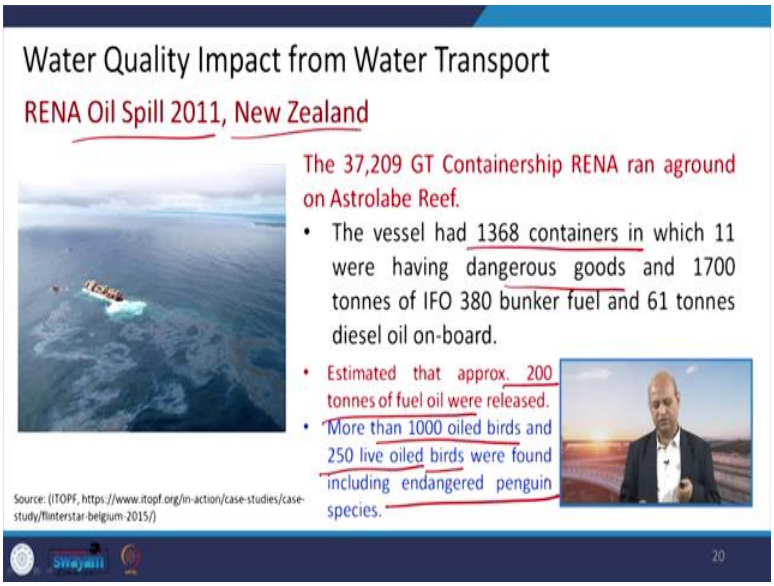

Another example is there of New Zealand this RENA oil spill in 2011, so there were around 1368 containers and 11 were having very dangerous goods, so some there may be some hazardous goods etc. So, again some accident happened and 200 tonnes of fuel oil was released, so you can see its size and then more than 1000 oiled birds means because when birds are floating around and they are streaming or they are taking their food nearer to the banks or in the water, when it is oil there so their wings get oiled and they cannot fly.

So, around 1000 these oil birds and 255 live oil birds were found, so means there were 1000's of birds which were not in position properly maybe they died and including some endangered penguin species in those birds. So, those were affected very negatively.

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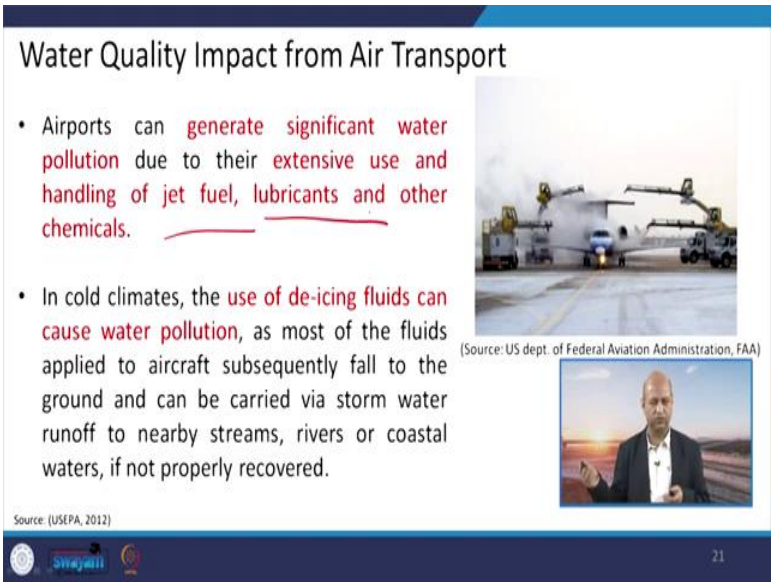

Water quality impact from air transport also happens, because when we are filling the air traffic, so jet fuels are there, lubricants when we are washing them into their hangars or doing some maintenance or operations, so all these oil and those kinds of things due to storm water they get into nearby water bodies or maybe some sewer line there, so ultimately they contaminate the whole system of water circulation.

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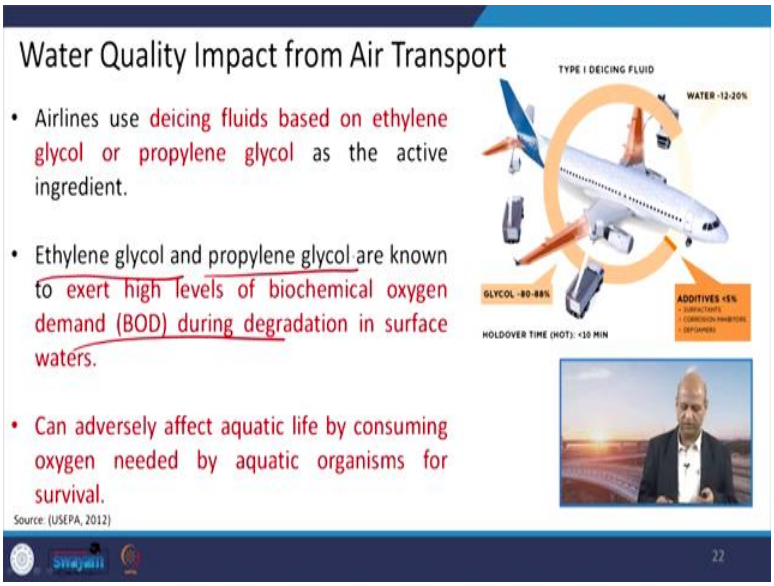

Well, they also have contribution to BOD etc., because of these like ethylene glycol or these propylene glycol, all these kind of chemicals they contribute a lot of BOD because of their

organic nature. So, again then high BOD is there that will affect the water and its DO level that is dissolved oxygen level and ultimately the aquatic life gets negatively impacted.

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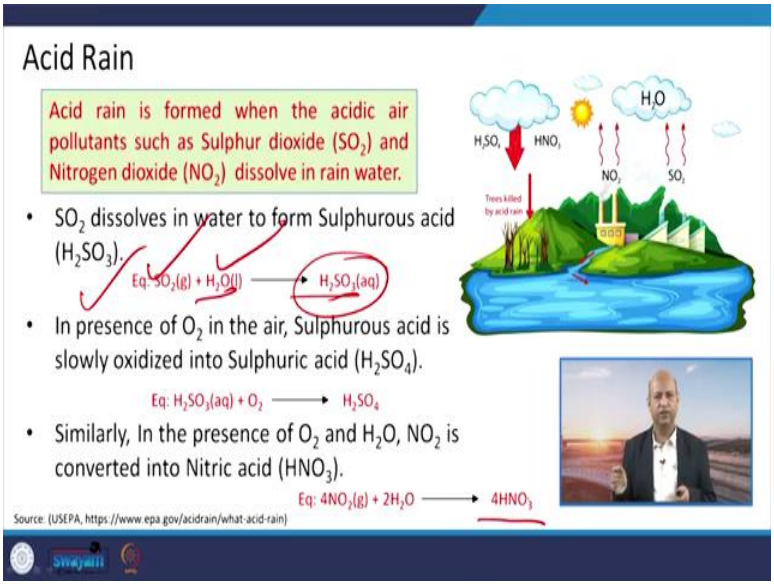

Acid rain we talked earlier also this is because of sulphur dioxide or nitrogen dioxide, so here are some equations are shown.

$SO2(g) + H2O(l) = H2SO3(aq)$

$H_2SO_3(aq) + O_2 = H_2SO_4$

$4NO_2(g) + 2H_2O = 4HNO_3$

Like first this sulphurous acid becomes because of moisture and this sulphur dioxide, so sulphurous acid is there then it gets again oxidized to sulphuric acid. Similarly, these nitric acid we have and they becomes part of the precipitation and that reduces the pH of the rain and we call it acid rain.

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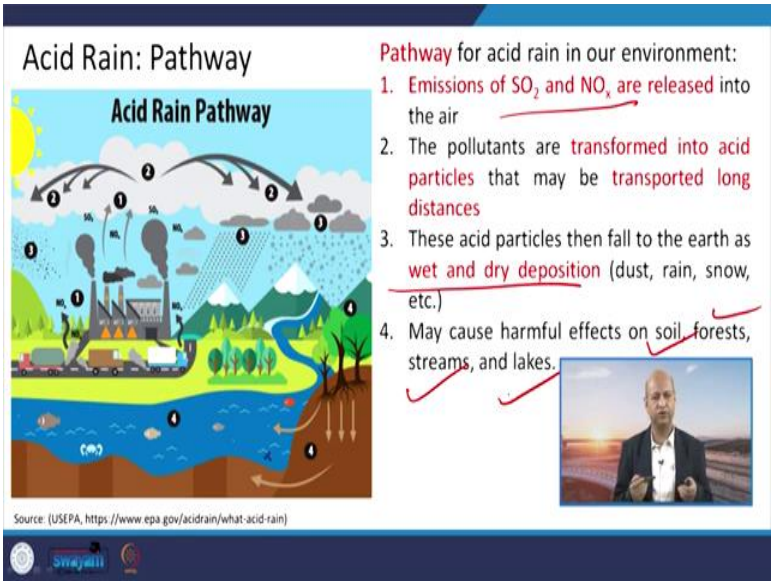

So, acid rain may occur and it can affect the ecosystem in the region wherever it is and it can be in hundreds of kilo-meters, because once it was identified like Black Forest of Germany were impacted because of acid rain that was linked to United Kingdom's thermal power plants emissions, lot of sulphur and those kind of later on some treaty happened and the problem was resolved.

So, means air pollution is not no more a localized phenomenon, it influences in downwind direction for several 100 or 1000's of kilometres. So, these emissions they can deposited by wet or dry deposition according to the phenomena and the influence the soil and forests, streams, lakes, there pH changes of these lakes and they may not be fit for not only drinking water or other purposes, but aquatic life also because we have seen that after certain pH, aquatic life becomes in a unsurvival mode.

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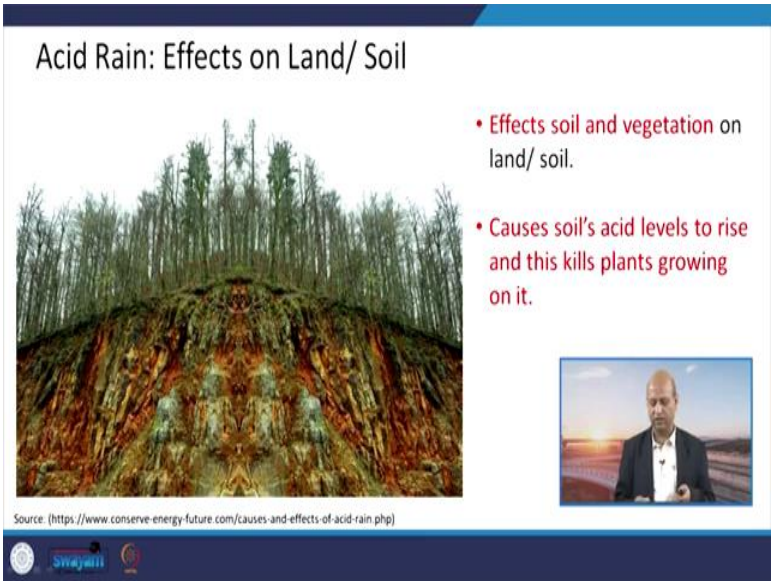

Here you can see like effects on the land and soil because of acid rain this damage is there to the plants and they can kill the plants and they do not grow properly.

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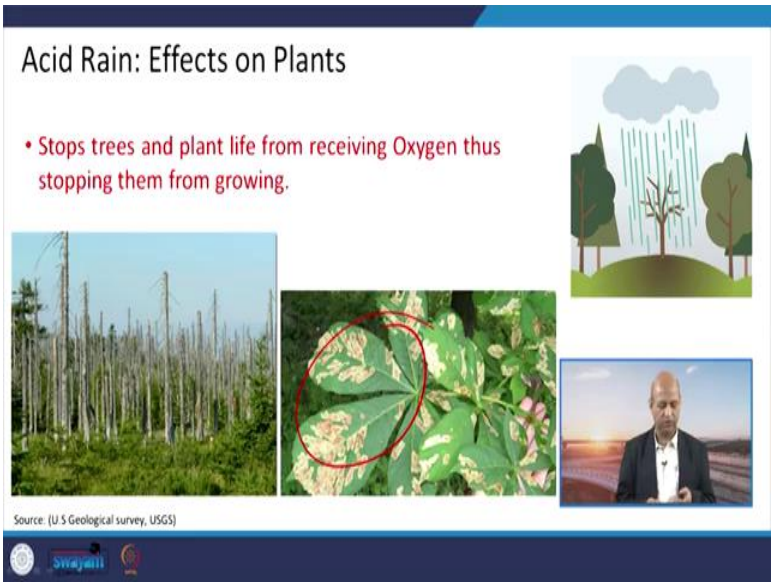

They are even leaves, this colour is there, so photosynthesis does not occur properly. Similarly, ozone pollution also causes these kind of things and you can see how these trees have been negatively influenced by acid rain.

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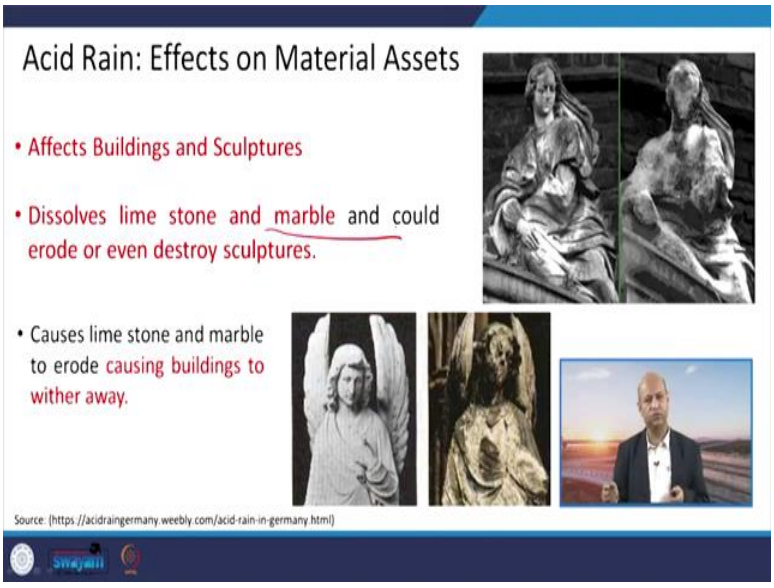

Also because limestone or sandstone and other particularly limestone and these marble etc., that they get damaged because of acid rain when chemical reactions occur, so these pictures before and after the acid rain phenomena you can see the impact, how severe it is.

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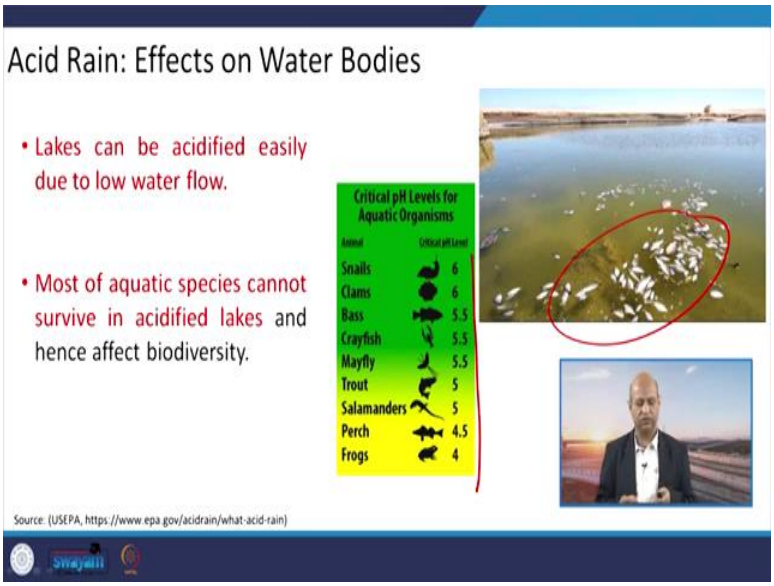

And also as we discussed that because of pH certain species are having some critical pH levels below that they will not be able to survive and these kinds of situations may occur if lot of acidic environment occurs in those water bodies.

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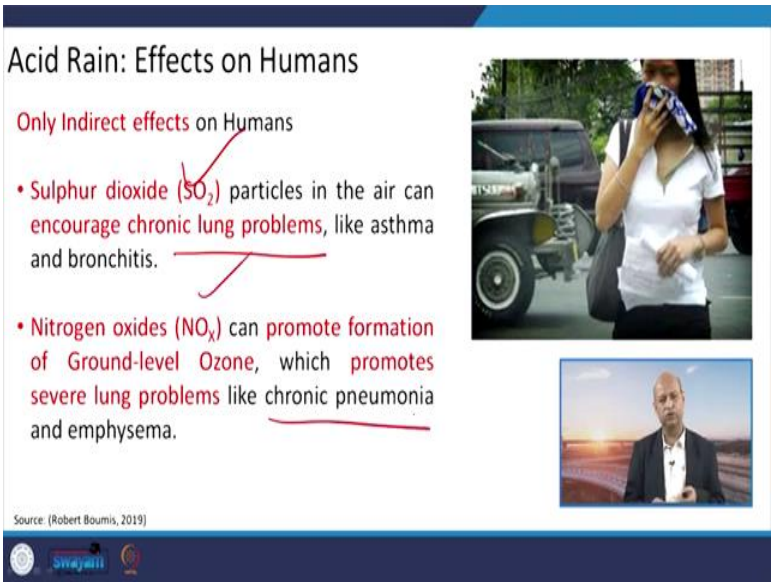

Also it influences the humans because it can encourage like lung problems or asthma because of these sulphur dioxides which are precursors of acid rain and NOx, they also influence our chronic pneumonia and these kinds of diseases.

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Now, if you want to see that what are the sources we have already discussed that on-road sources or non-road mobility maybe they are so different kinds of vehicles can contribute to the emissions.

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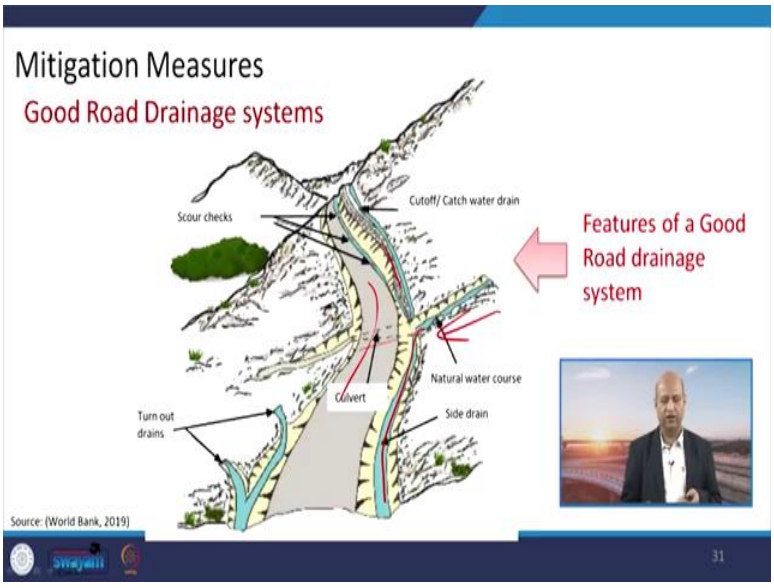

And when we talk about like these are the problems but there must be some mitigation measures also when problem is there, some solution can always be devised. So, good road drainage system must be there and you can see like, if it is nicely having some drains and also you cannot you do not see any water on the road etc., so they are properly directed in through drains and maybe

under path and so the roads life becomes quite long and it is not impacted by this water. So, drainage system must be very good especially like bituminous roads as you know, because of water they get damaged very quickly, so for that we should not be having accumulation of water in and around the road.

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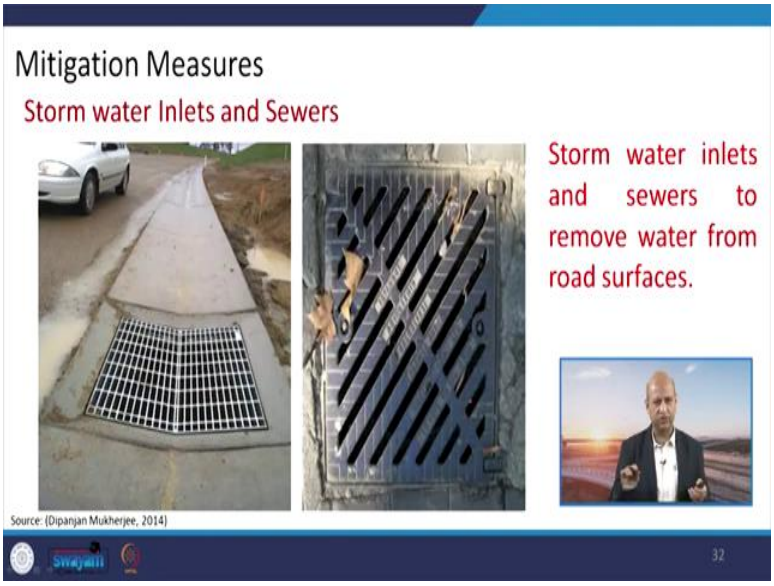

Well to drain the water of rain quickly these kinds of structures may be there, so wherever like at the horizontal level at the side level also you will see like at the side here and then horizontal.

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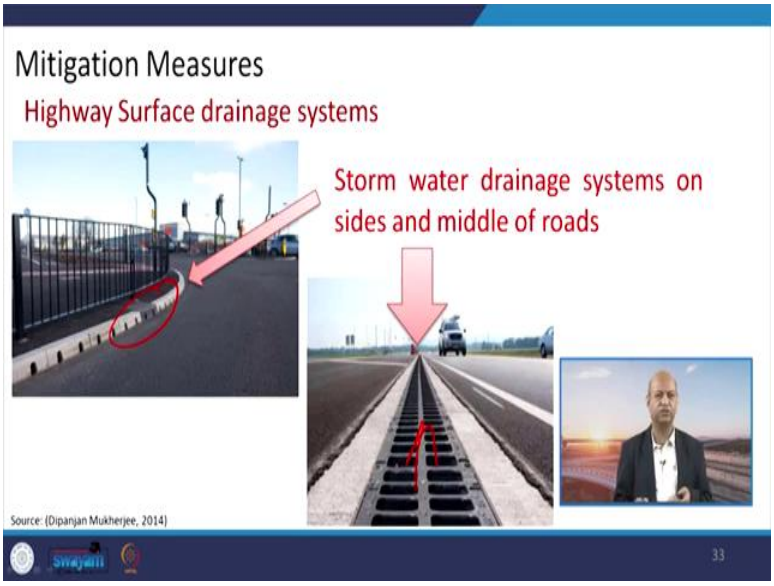

So, these kind of drainage systems may be there and of course cleaning is needed because sometimes silt will go and I small pebbles or leaves etc., so regular cleaning is also required about these kind of structures they help in draining water very quickly.

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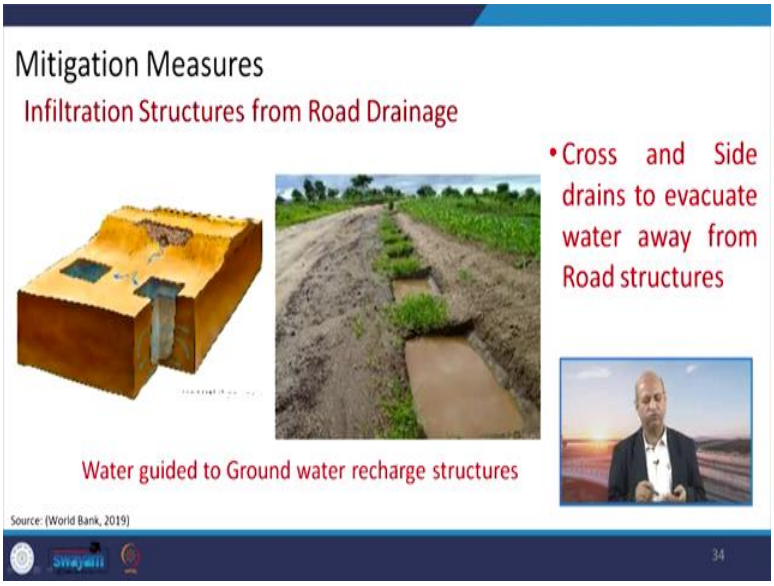

Some infiltration structures maybe there in and around the road, so these kinds of structures may guide the water to go from one end to another one.

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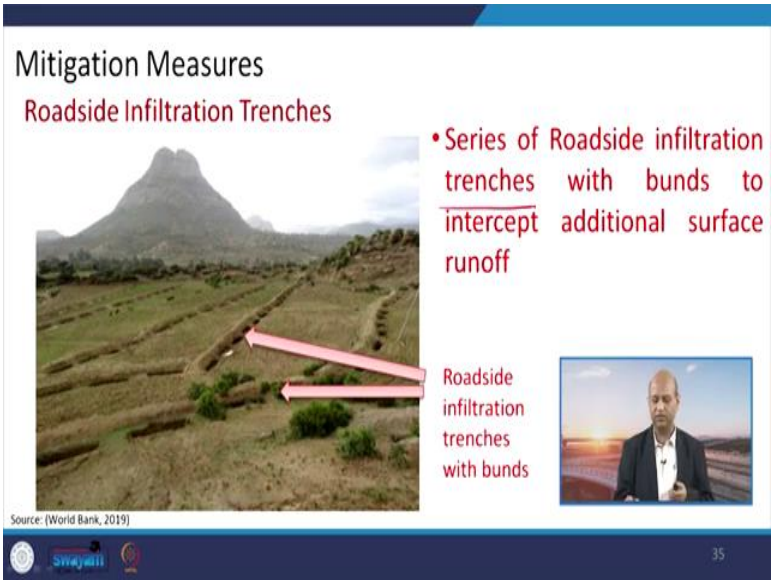

And also some series of roadside these trenches maybe there or bunds and they intercept additional surface runoff and they direct towards where we want to take them away from that particular site. So, these structures are needed.

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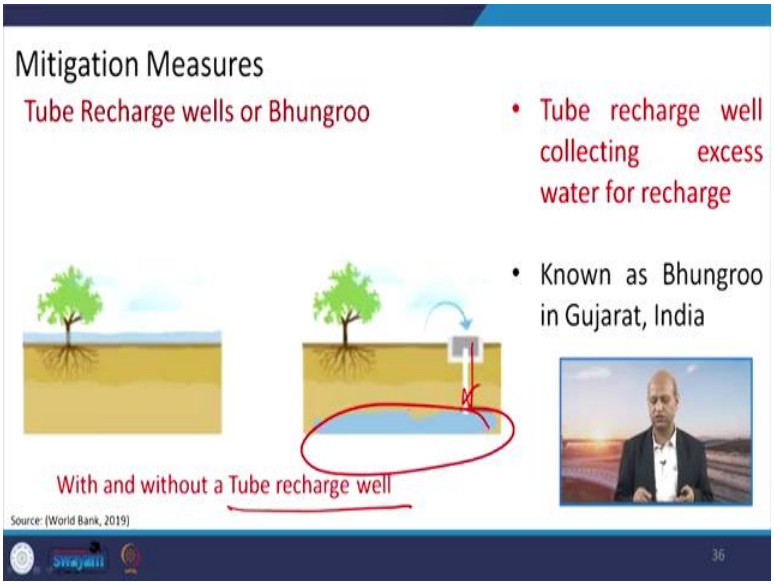

Also sometimes we use water harvesting kind of structures or like tube recharge wells, so like tube well we have to extract water similarly, those tubes may be there to recharge the water also. So, that goes down and it recharges groundwater. So, those kinds of structures should be used in Gujarat it is being used.

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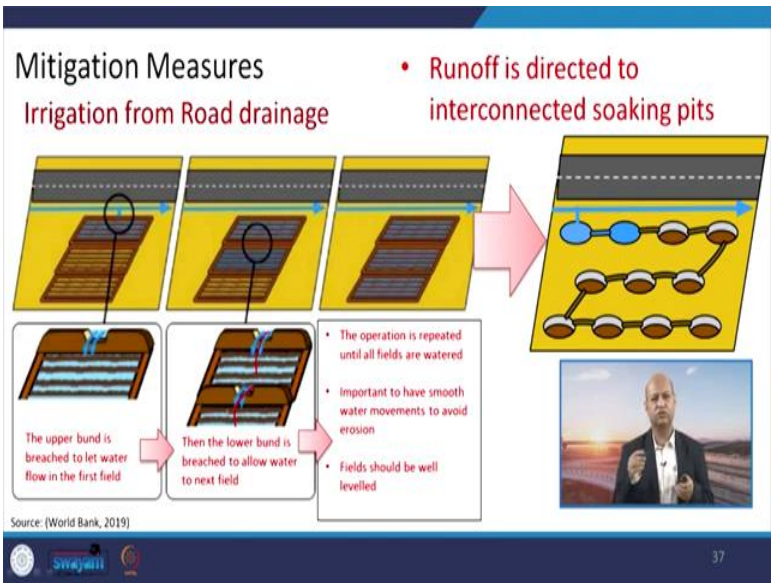

Again these road drainage structure in the on the sides of the road they are in a step formation, so that otherwise erosion may take place, so if these are the structures the water will come here first then it will go there, so its velocity becomes less and erosion does not happen much. So, those kind of structure help.

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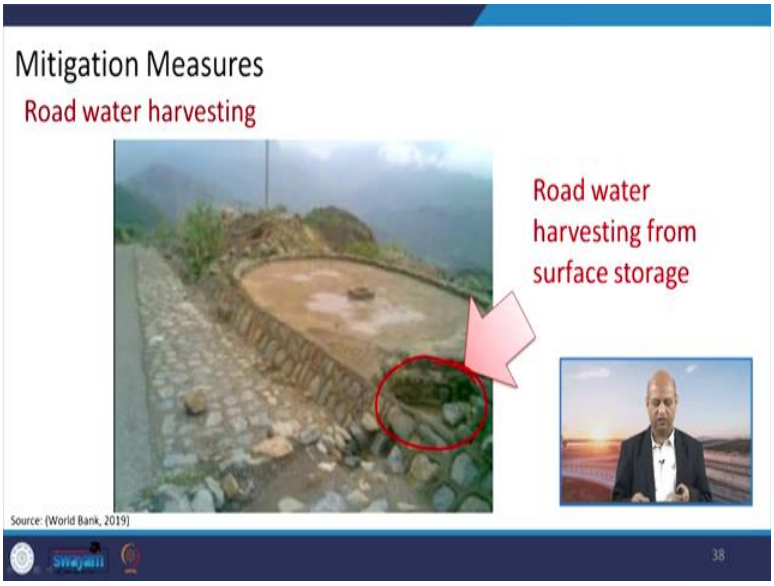

Similarly, on the roadside some water harvesting structures may be constructed and it takes place, I mean it helps to percolate water to downside.

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Also some kind of uses of this water or the roadside like in Bangladesh they are using for rice drainages and all kinds of things, so water can be taken place from one place to another.

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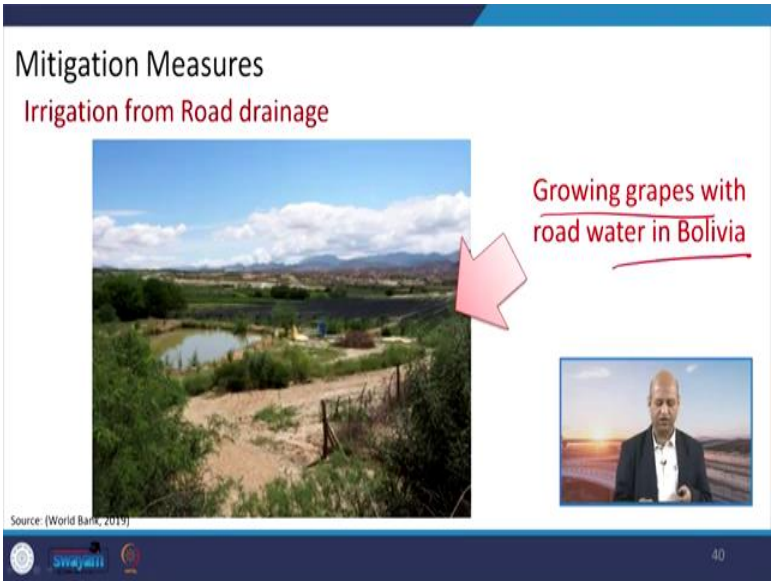

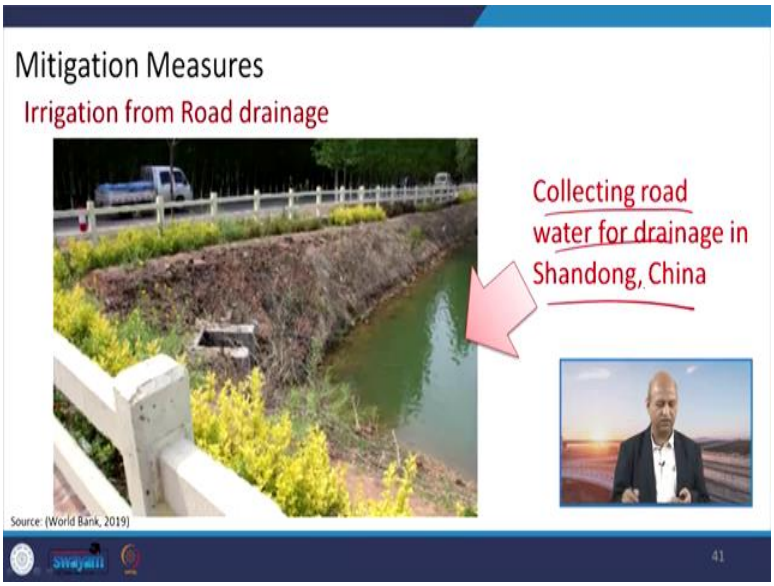

For growing grapes in Bolivia they are using these kind of water accumulation around the roads. So, means if you are creative or innovative enough you can use these structures for various purposes in they are collecting road water and drainage in China then they are taking to other places.

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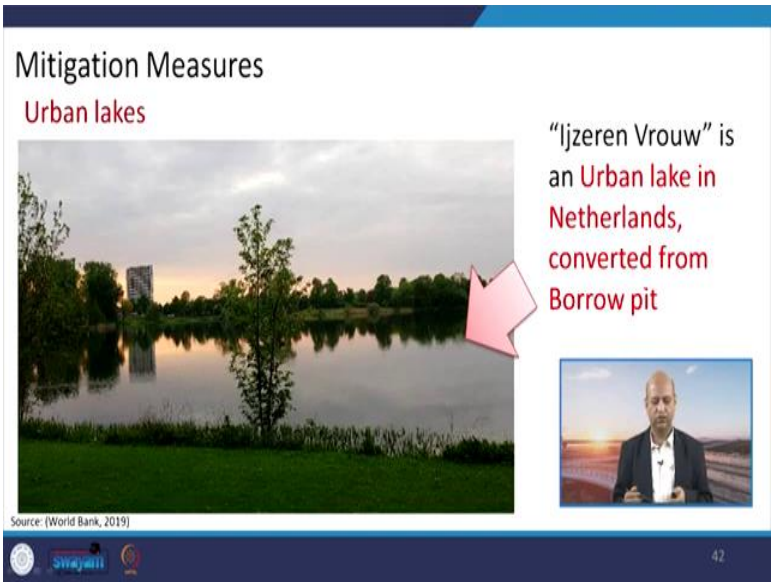

In like big kind of lakes maybe there even small lakes or some water bodies or reservoirs or talab and those kinds of structure can be constructed by directing those rain water around the roads.

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Well, for oil displays mitigations may be in the sense that you use these kinds of structures floating barriers they are called temporary floating barriers, they because of some weight they go underwater also and they does not allow oil to cross these are the barriers like these are floating, so oil will not go away from this particular location. So, now here you can treat it, there are many

ways to treat the oil like chemical, biochemical, some bacteria also and sometimes just use fire, if it is advisable if there are no much aquatic life there and within few hours or days it is burnt.

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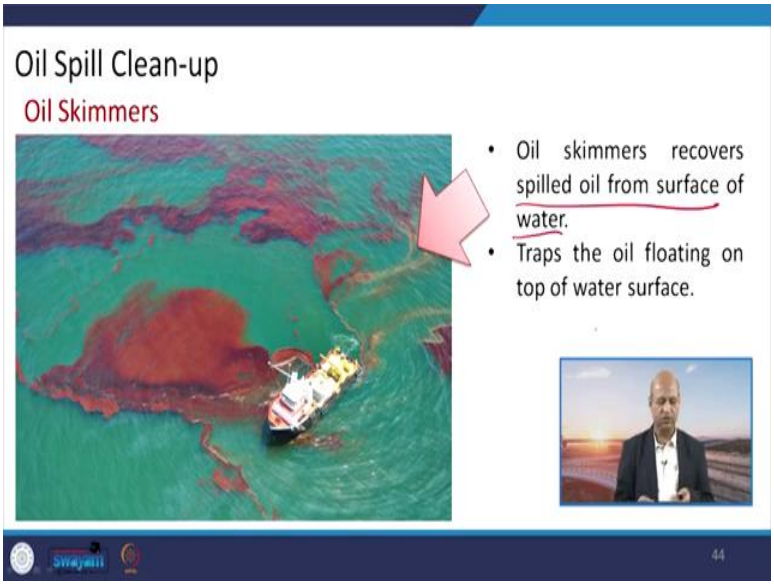

So, these examples maybe shown here also, so these are like spilled oil and on the surface and then that floating kind of structure using and taking them at one place and then treating them.

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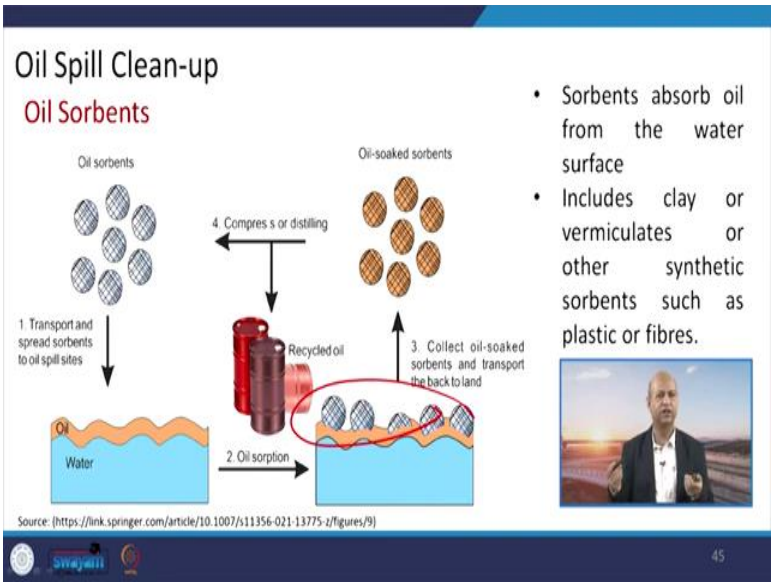

There are certain you know, like balls kind of structures, they are used for absorption. So, those means adsorption as well as absorption those kind of things can be used and then again collected

and taken away, so the oil can be that way you can collect oil from water body and take away and then treat and dispose it off properly.

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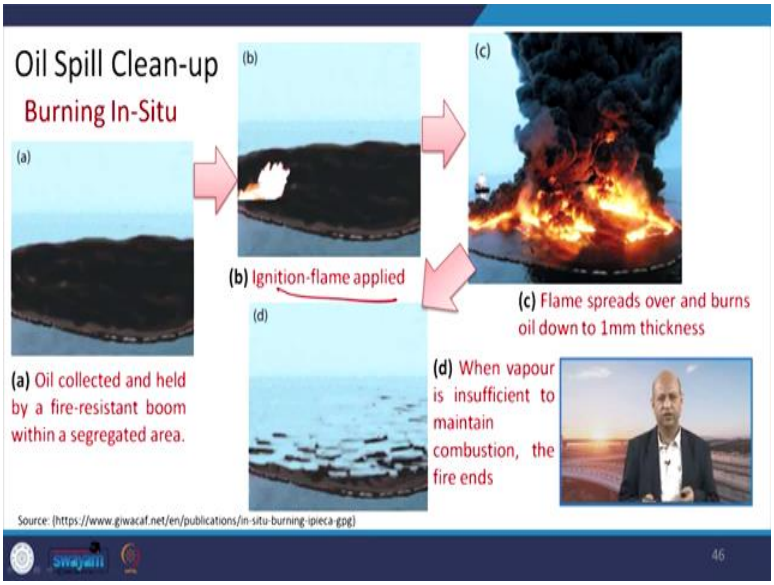

As I said earlier like in a localized phenomena you can collect the oil and then you ignite your ignition flame applied and then this is burnt and when very thin layer of oil is there then this fire douses and there is no issues after some days it becomes part.

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Another way is like you use some kind of dispersants which are one kind of detergents, they break this oily sink into small particles or small droplets and that way the dilution happens. So,

once it dilution happens then again there is no problem because in sea or ocean when it is diluted then there is no problem, it is a problem when it remains as a layer, because of layer then they will not be air exchange and aquatic life will be harmed because they will not be much oxygen.

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Manual cleaning can also be there, but at the same time there are other ways.

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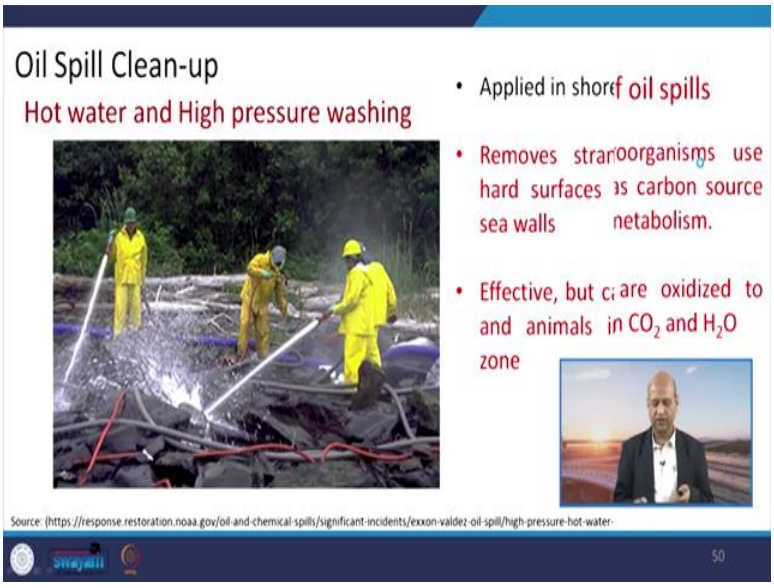

For example, you can use steam and hot water etc., to clean it properly, from the stone surfaces.

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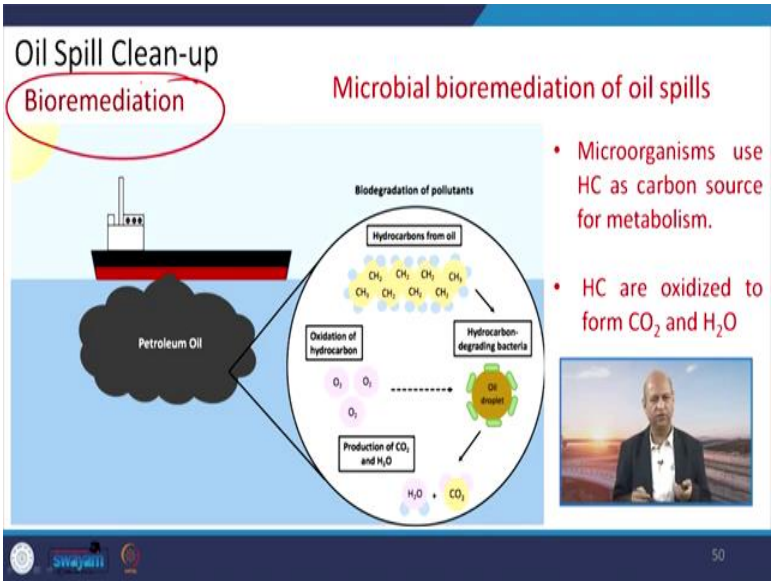

And as we can see like bioremediation, as I said there may be bioremediation like soil contamination is there then you can use phytoremediation means some plants are there which takes nutrients from the oil, these kinds of species are there. Similarly, bioremediation means some bacteria may be there which thrive on the oil, they derive the nutrients from the oil and they decompose it into harmless kinds of products and ultimately they oxidize because they use the carbon oil is nothing but carbon and nitrogen, so they take energy from that carbon, they use it for their energy needs and ultimately CO2 and H2O is there and it is done after some time. So, bioremediation may be there.

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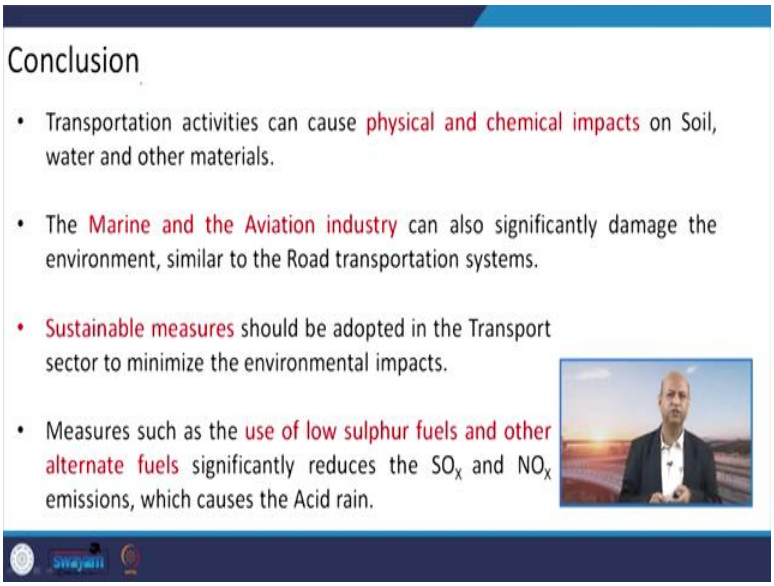

So, ultimately we can see that time in conclusion we can say that there may be physical and chemical impacts of these transportation activities on soil and water and other materials like artefacts or buildings or historical places and also there may be because of oil spillage etc., some marine accidents happens then oil spillage happens and there may be damage to the aquatic environment, so those kinds of things may be there.

So, means there are mitigation measures, which we should use for cleaning those sites and ultimately we should move towards the sustainable transportation system because sustainable will be only those kinds of systems which has minimum damage to other things like environment and human beings or property. Zero impact is means almost impossible or very, very difficult because there will be some sort of good or bad impact. So we have to see that how we minimize those negative impacts and make the transportation system as sustainable as it can be.

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Again, these are the references if any of you want to know more about some particular topics or particular issues in detail then you can refer these references and thank you again for your kind attention for this lecture and next we will see in the next lecture like impact of the noise. Noise we have studied very little but in detail we will study it in next lecture. Thank you very much.