Basic Environmental Engineering and Pollution Abatement
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Lecture 03
Ecosystem Services and its Risk 1

Hello everyone, now, we will discuss on the topic ecosystem services and its risks. We have discussed in the previous class that in nature, the living and nonliving elements of the environment or biotic and abiotic components of environment co-exist and there are some interactions and we have also seen that the producers produce food and then this energy goes to the upper level that is consumer level and so, all the living organisms are connected by each other through the food chains.

And we have also seen that the ecosystem provides different services which are very essential for the existence of human society and for the well- being of the human societies and for also other living organisms. And we have also seen that due to increase in pollution load, this ecosystem is altered in many places and many risks are imposed on the existence of the living being or on the sustainability of our development.

In this class, we will discuss on ecosystem services and then risk due to inferior quality of resources and risk due to conservative nature of pollutants. That is, we will also discuss on bio concentration bioaccumulation bio magnification. And we will also discuss the risk due to transmission of diseases. Now, we see what are the ecosystem services as you already discussed in the previous class.

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That ecosystem services are the contributions that ecosystems make to human wellbeing including provision of food and fiber regulation of the biosphere and cultural services and you see this figure It shows the different services provided by the ecosystem for the human wellbeing.

So, these are categorized into supporting then provisioning and regulating and cultural So, you see we get food, we get clean water, we get fish, we get air everything from the environment and we also get the help for cool temperatures the natural system is there for cooling the temperature flooding control also naturally takes place water purification, nature has provided the systems that is filtrations infiltrations.

And then carbon storage due to the plants. So, these things these services are provided by the nature and it also provides us photosynthesis which is the source of all energy, then soil formation and biodiversity. It gives us the habitat for all living organisms. Apart from that, it provides education, we can learn maximum from the nature it gives us clean air, it gives us recreational facilities.

You see, during last two years, there were COVID-19 pandemic and we suffered a lot. There are no games, no sports, no outdoor activities, So, we had to suffer. So, these things we cannot realize the importance of nature or ecosystem in our life, but under this situation, or pandemic, we have realized the importance of the open and outdoor games, and sports.

Now these are the ecosystem services but these ecosystem services are becoming riskier day by day because of more pollution load and the contamination of the resources like, we need water, we need food, but water is being contaminated food is being contaminated.

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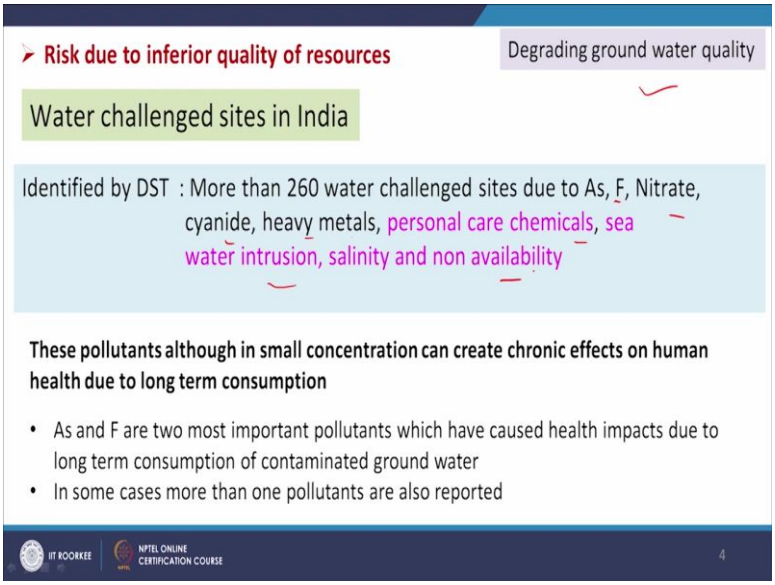

So, we will discuss how the risk we are going to face due to inferior quality of resources. This slide gives us some example of the risks related with degrading groundwater quality. And you see department of science and technology government of India, they have identified more than 260 Water Challenge sites in the country due to arsenic fluoride, nitrate, cyanide, heavy metals, personal care chemicals, sea water intrusion, salinity and non availability of the water as well show these are posing a threat all the water is available, some are not available, but some are is available but we are not able to consume it because it is riskier, it is giving us some health impacts, different types of cancer, different types of diseases etc. So, out of these are silicone fluoride, these are very - very important because these have carcinogenic effect.

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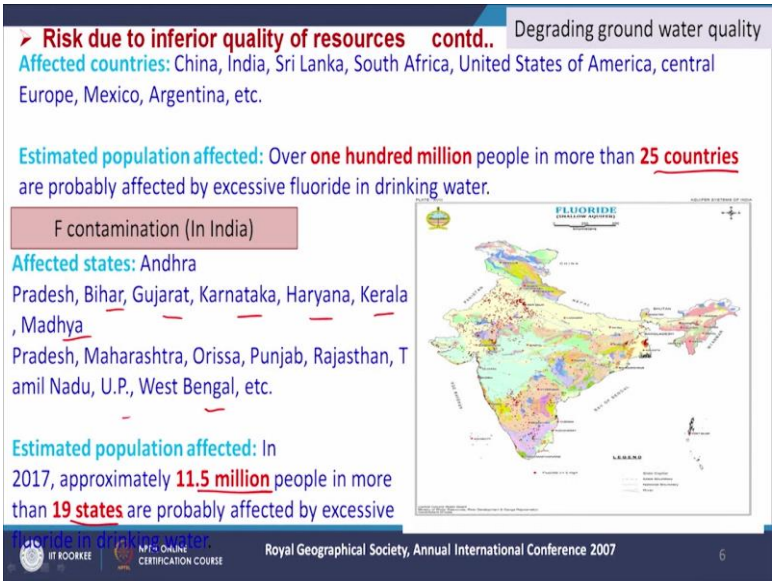

And I will show you some data here around the globe. Many countries are affected due to arsenic and 2014 study by W.H.O found that over 200 million people in more than 70 countries are probably affected by arsenic poisoning of drinking water. So, because long term consumption of arsenic contaminated water is causing these impacts that is different types of cancers. So, that is also a chronic effect we can say prolonged utilization of this contaminated water is giving us this risk to our health.

And in India, different states like West Bengal, U.P. Jharkhand, Bihar, Assam and Manipur, Chhattisgarh are having arsenic contaminated groundwater. And in 2017 Reports says that approximately 239 million people in more than 21 states are probably affected by arsenic poisoning of drinking water in the country.

Similarly, if we should have fluoride contamination, So, that is also many countries around the globe are having the fluoride contaminated groundwater. And it is estimated that over 100 million people in more than 25 countries are probably affected by excessive fluoride in drinking water.

And in India, Andhra Pradesh, Bihar, Gujarat, Karnataka, Haryana, Kerala, Madhya Pradesh, you see the map all red spots, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, U.P. West Bengal, all these states are having fluoride contaminated groundwater. And approximately 11.5 million people in more than 19 states are probably affected by the excessive fluoride fluoride contamination in the groundwater.

So, we see that the degradation in the quality of the services that is there as for example, in the previous example, the groundwater, it is posing a risk to our health or to our survival. Similarly, degrading fuel quality also another example, that is, you know, we use coal for the production of electricity in a thermal power plant.

And this coal contents sulfur nitrogen ash content, and it contains mercury, it contains arsenic, it contains selenium. So, all those things and those come out into the atmosphere and creates different types of health impacts. So, we should have some idea about these, So, that we should have some idea about the processes So, that we can take action and we can make more awareness to prevent the impact of these. And other is your heavy crude oil.

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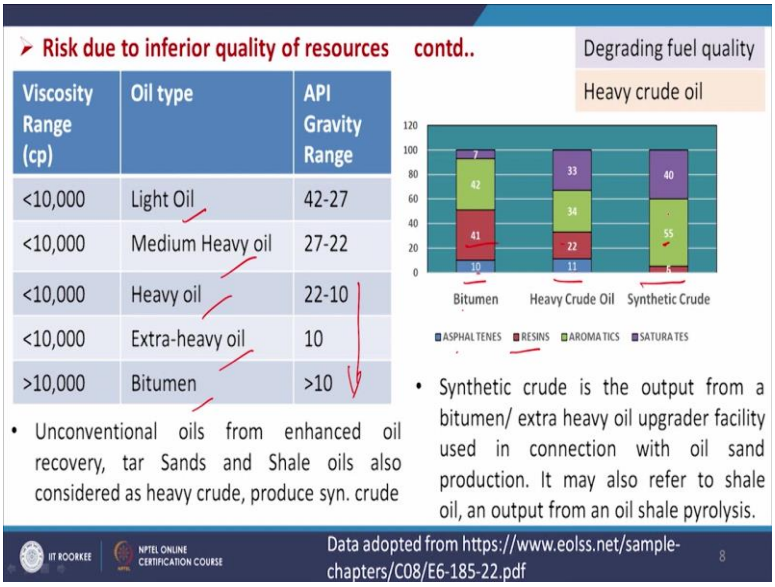

We know that crude oil quality is also being degraded, its viscosity is increasing its sulfur content, Ash content is increasing, asphalt content is increasing. As for example, it is shown here you see the different types of oil, that is crude oil, light oil, medium heavy oil, heavy oil, extra heavy oil and bitumen. We are having the API gravity range is decreasing.

So decreasing API gravity range when, its density is increasing its asphalting content is increasing show the quality is degraded. So, when you will process it in a refinery it will give more pollution and it will give some threat to the existence of the society if you do not take proper actions to control those pollutions.

And another issue here this graph shows that if use bitumen, heavy crude oil then this can be converted to synthetic crude. So, with synthetic crude contains aromatics 55% and only 5 to 6

% of resins, but in bitumen and heavy crude, you see the resins contents and asphalt in contents are very high. So, those are problematic.

So, degrading fuel quality for this threat to the environment as well this is an example now, we will see the other aspect in environment all living organisms are in direct contact with either air or water the living organisms living in aquatic environment are direct in contact with water and people who live in, in land and we are in direct contact with the air. So, if some pollutants are entering into the environment either in aquatic or in our air environment atmosphere, then we living organisms are in direct contact with it. and the pollutants which are available in ecosystems in terms of ecosystem services and available in the ecosystem.

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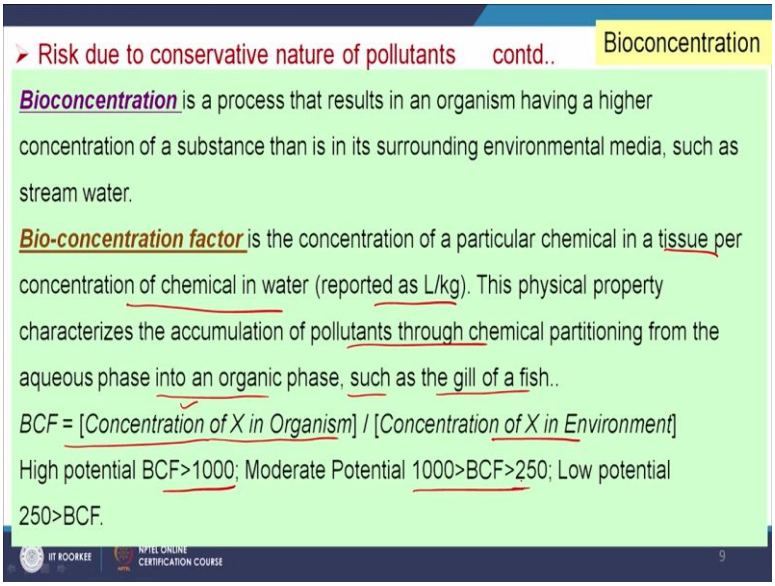

So, they are in equilibrium with the living organism body and the outside environment. So, there is some depending on the partition coefficient if we take an example of fish or zooplankton phytoplankton and any pollutants within the neck aquatic environment lacks any pesticides or heavy metals etc.

So, that there is less concentration of pesticides, which is available in the water that will be in equilibrium with the body mass of the living organism. And that is called bio-concentration and it is found that the concentration of that pollutant will be much more in the body mass of the living organism than the environment that is in case of water or air in this case of water. So, the concentration increases, so, that is this term is called Bio concentration, this is a natural phenomenon and that is also if any pollution comes into the water stream, so, then that will be stored in the living organism.

So, that is your bio-concentration and bio-concentration factor is there, you know, we want to quantify this phenomenon that how much pollutants will be stored in the living organism. So, the bio-concentration factor has been proposed and it is the concentration of a particular chemical in tissue per concentration of chemical in water that is reported as L/kg.

So, this physical property characterizes the accumulation of pollutants through chemical partitioning from the aqueous page into the organic page such as gills of a fish and this can be defined as

Bio-concentration factor (BFC) = [concentration of X in organism]/[concentration of X in environment]

X is the pollutant. Now, if the bio-concentration factor is high say greater than 1000 then it indicates that concentration of X in organism is also high. with respect to the concentration of X environment.

And moderate bio-concentration factor, we have 1000 less than BCF less than 250 and low potential that is bio-concentration factor less than 250. In that case, we can say that the pollutant has less potential to be bio concentrated. Now, how can we measure this bio concentration factor, it is not possible every time to collect sample or water sample and again the collection of fish and fish biomass and fish mass and then measure the concentration of pesticides in water and fish and get the ratio it is not very possible for every time.

So, people develop some alternate technique. So, they have taken two solvent systems one is water and another is your organic solvent and they add the respective pollutants and after sacking well so, they say what is the distributions of the particular pollutants in these two phases and take the ratio of that and that organic solvent is nothing but the octagonal

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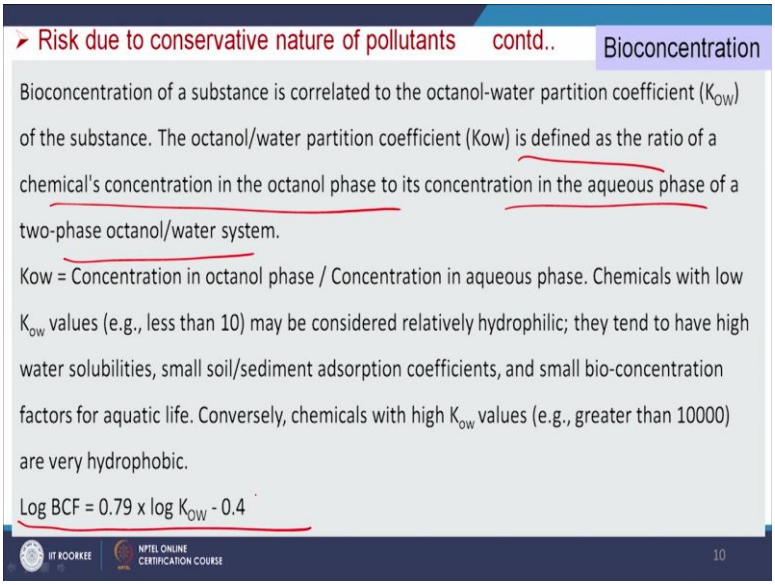

So, octanol water partition coefficient each call is also known as K_{OW} is defined as the ratio of the chemicals concentration in the octanol phase to its concentration in the aqueous phase of the two phase octanol water system. So, K_{OW} value is determined in a lab and with some correlation, the BCF is determined what is that correlation logBCF=0.79*logKow – 0.4 log this is an empirical relationship and this relationship is has been tested and it is found reasonably applicable for many cases in the environment.

So, that way we can determine the bio-concentration factor with some laboratory experiment. Now, then bio accumulation, so, this is the fact that pollutants are getting entered into the living organism mass or body mass and then it can be either converted to less toxic elements or can be destroyed otherwise, it can be stored also in the body it will never be rejected or excreted from the mass or from the body of the living organism, such type of situations,

We say the pollutants are conservation and this is accumulated and for a long term consumption the concentration of pollutants in the living organism body mass increases gradually. So, this phenomenon is called bio accumulation and more the concentration more the chance of risk and more the impact or effects on the health. So, this bio accumulation that will depend upon many factors.

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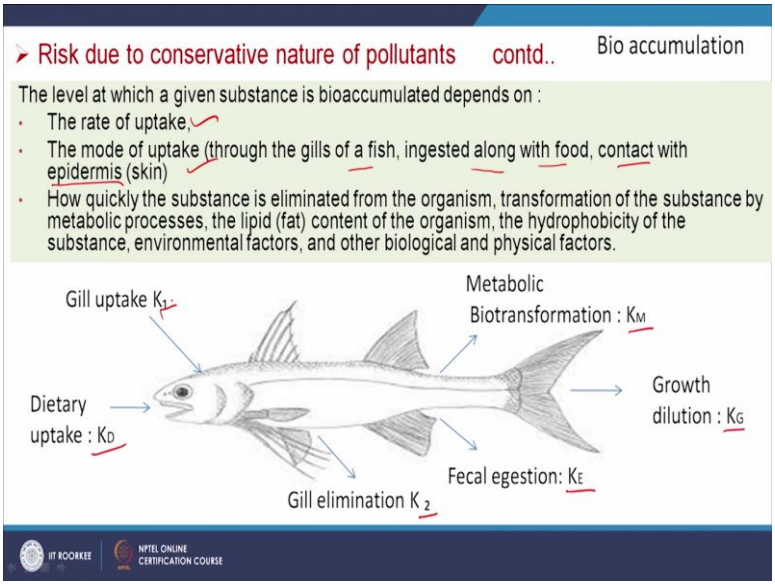

So, like say the rate of uptake, the mode of uptake for example, this fish through which part it is getting into the body mass actually to the gills of a fish ingested along with food or contact with epidermis skin. So, these are the different you see the different values Km somewhere Kg, Ke, K_2, K_d and K_1. So, all these coefficients are different values.

So, through which the pollutants are getting entered into the body mass that will define the bioaccumulation and also how quickly the substance is eliminated from the organism transformation of the substance by metabolic processes, the lipid content of the organism the hydrophobicity of the substance environmental factors and other biological and physical factors. So, lipid your hydrophobic show more than lipid that there may be more accumulation, so, that way many factors are there, which influences the bio accumulation.

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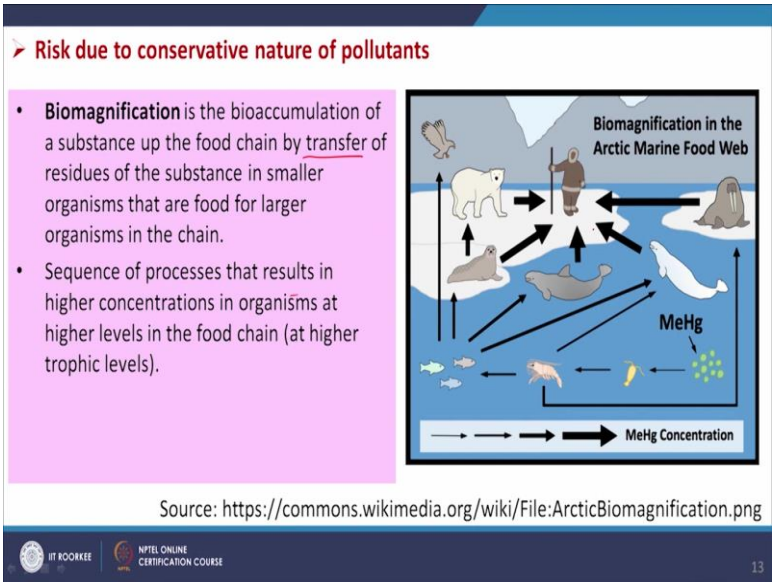

And other phenomena which happens in the ecosystem or in the environment that is your bio magnifications. So, the pollutants which are coming into the lower level of the living organisms, that is the producers and then producer to first consumer, second consumer like this at a lower level, the biomass is taken up by the upper level and then gradually the concentration of the pollutants increases when we go up from the bottom to top of the, of the ecological pyramid.

So, bio-magnification says the bio accumulation of a substance of the food chain by transfer of residues of the substance in smaller organisms that are food for larger organisms in the chain. So, this is the sequence of processes that results in higher concentrations in organisms at higher levels in the food chain at higher trophic levels that. So, this is one example from smallest fish to bigger one then ultimately go up So, we will get more concentration.

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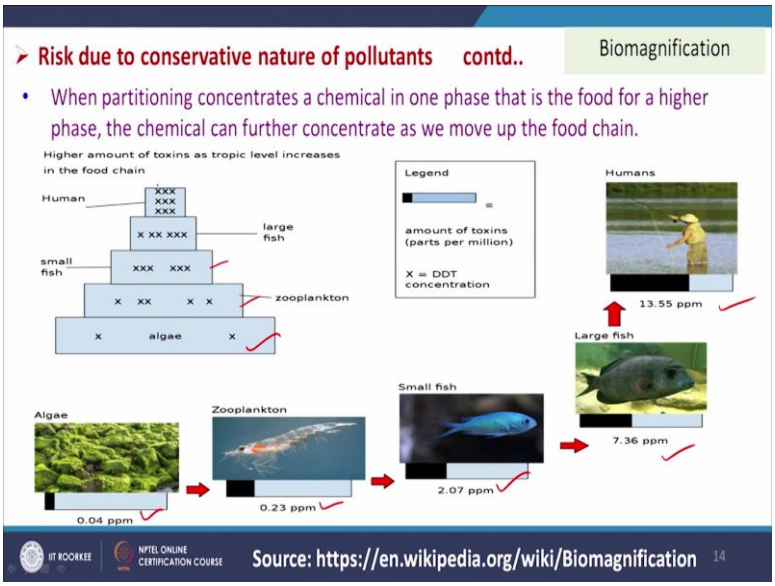

And another example we will see here you see Algae is having 0.04 ppm, then Zooplankton is 0.23 ppm, and small fish 2.07 ppm and large fish 7.36 ppm and human 13.55 ppm. So, what we see here, that concentration of pollutants it is magnified. Per body mass, when you go from lower to upper level in the ecological pyramid or in the food chain.

So, here also the same thing has been shown in other way. So, this is algae, more number of algae and then less number of zooplankton, but concentration of pollutants is higher. So, smallest fish, gradually number energy reduces, but concentration of the pollutants increases. So, we are at the top. So, human society is mostly at risk.

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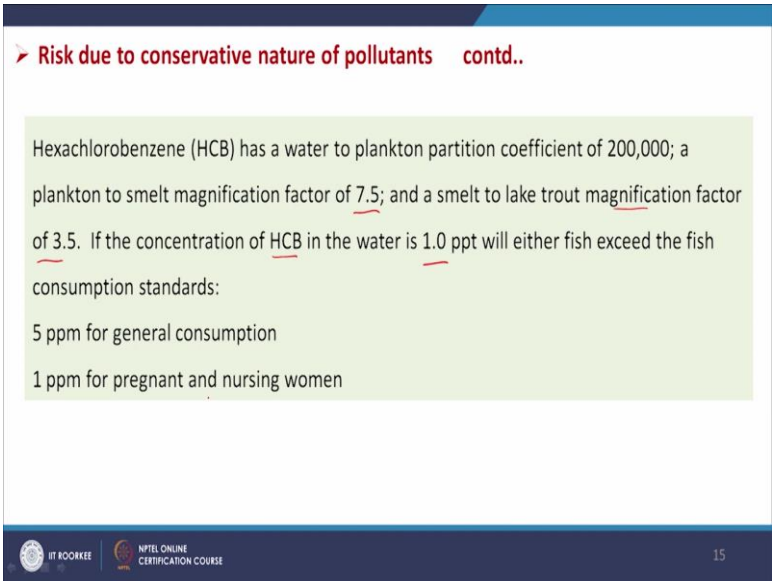

Now, we will give some example. So, hexachlorobenzene has a water to plankton partition coefficient of 200,000, a plankton to smelt magnification factor of 7.5 and a smell to lake trout magnification factor of 3.5 if the concentration of HCB that is hexachlorobenzene in the water is 1.0 ppt will either fish exceed the fish consumption standards for say 5 ppm for general consumption and 1 ppm for pregnant and nursing women.

So, we have to calculate whether this situation is posing any risk to these two scenarios that is for general consumption purpose or for this pregnant and nursing women. So, the data are given what type of data are given the water to plankton partition coefficient is given. And magnification factor is given plantain to smelt and then smelt to lake trout. These are also given an initial concentration present in the water is also given that is 1 ppt. So, this is our scenario we have to assess whether this will be the fish which is available for us is safe or unsafe or it is having some risk factor.

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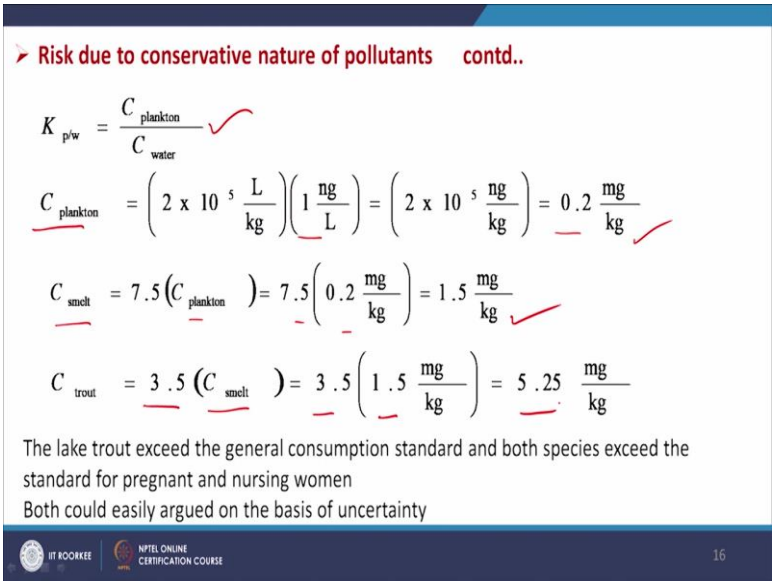

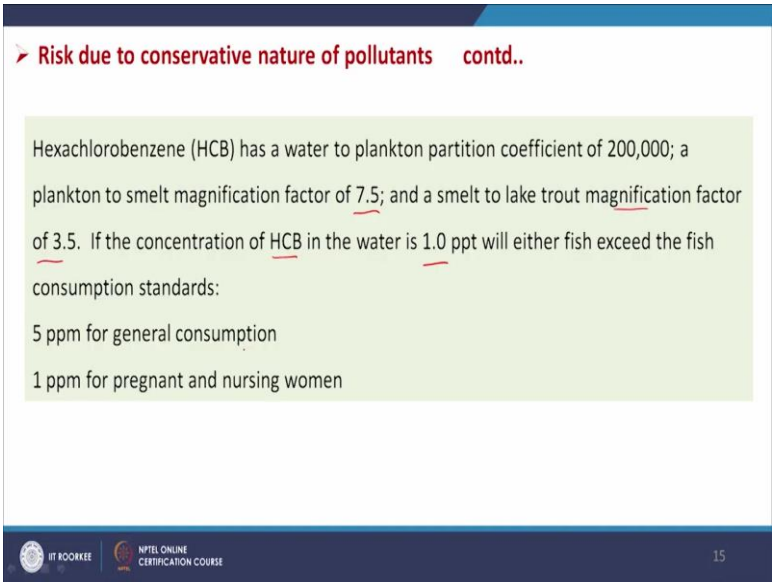

So, now you see we have

$K_{p/w} = C_{plankton} / C_{water}$

$C_{plankton}$ = Kp/w*C_{water}. So, in the consent water in the concentration is 1 ppt. So, 1 ng/liter and this plankton is 200,000.

$C_{plankton} = (2*10^5$ L/kg) (1ng/L) = 0.2 mg/kg

This is $C_{plankton}$ the concentration of the pesticide in the plankton cell biomass we can say this mg per kg then what will be the concentration in this smelt then the magnification concept will be applied.

$C_{smelt} = 7.5 (C_{plankton}) =7.5*2$ mg/kg =1.5 mg/kg

And what will be the concentration in the C_{trout} again some magnification will be there because one trophic level high were coming.

C_{trout}= 3.5 (C_{smelt}) =3.5*1.5 mg/kg =5.25 mg/kg

So, what is our standard the standard was in case of trout the standard was given that is 5 ppm for general consumption and 1 ppm for pregnant and nursing women. But here in case of trout we are getting the concentration is more than 5. So, this is not safe for both the categories. So, that we can predict that no this trout is not safe for consumption, there may be some risk or for the health impact.

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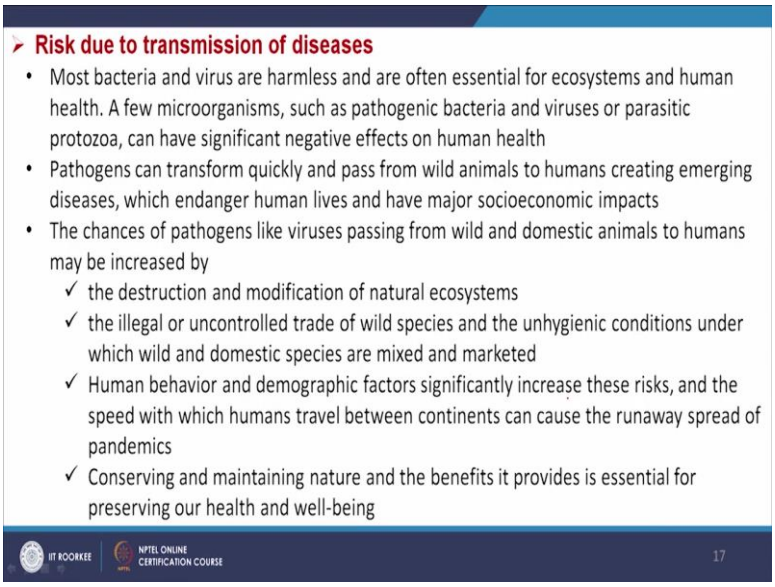

Now, we are coming to discussing the risk due to transmission of diseases. So, we have given some example of the risk associated with the consumption of contaminated resources or contaminated services provided by the ecosystem and through the food chain, how it magnifies and how it imposes risk in our health, now we will be discussing the risk due to transmission of diseases.

We know that many bacteria, virus, protozoa are responsible for the creation of different types of health impacts or diseases on our body, and we also know that there are many useful microorganisms for our health, but few are not that useful they create problems and these can be transmitted through the ecosystem services like what are your etc.

Apart from these, some roots are also there, that comes from microbes, that is bacteria and virus and protozoa also directly from lower species to upper species, that transmission species

transmission also takes place. And one big example is your COVID-19 We know, that is fruit bat from fruit bat the, virus has been transmitted to human.

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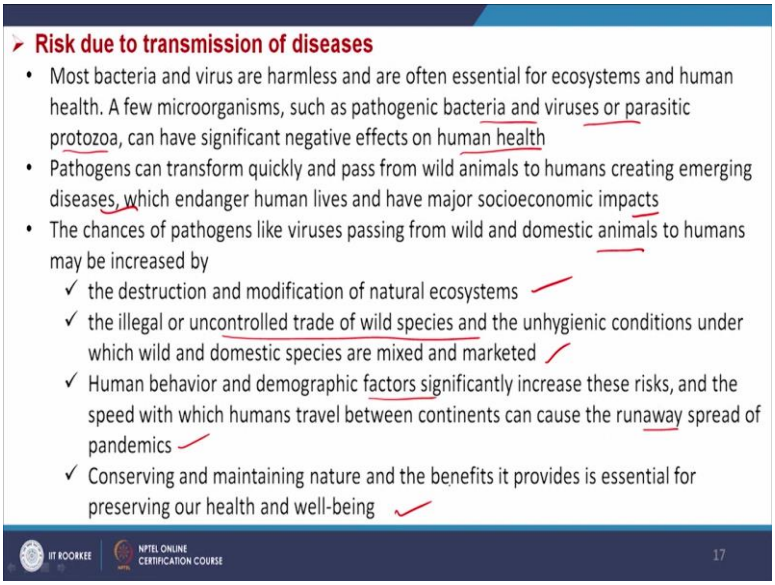

Now, you see, the most bacteria and virus are harmless and are open essential for ecosystem and human health. If you make organisms such as pathogenic bacteria and viruses are parasitic protozoa can have significant negative effects on human health. And pathogens can transform quickly and pass from wild animals to humans creating emerging diseases that we are talking about now, which endanger human lives and have major socio economic impacts.

And the chances of pathogens like viruses passing from wild and domestic animals to humans may be increased by the destructions and modifications of natural ecosystem or the illegal or uncontrolled trade of wild species and the unhygienic conditions under which wild and domestic species are mixed and marketed.

And then human behavior and demographic factors significantly increase these risks and the speed with which humans travel between continents can cause the runaway spread of the pandemics. COVID-19 is a big example of it, and conserving and maintaining nature and the benefits it provides is essential for preserving our health and well- being.

So, from this, we are, this is our understanding, that we should maintain the nature and the benefits provided by the essential for preserving our health and well- being.

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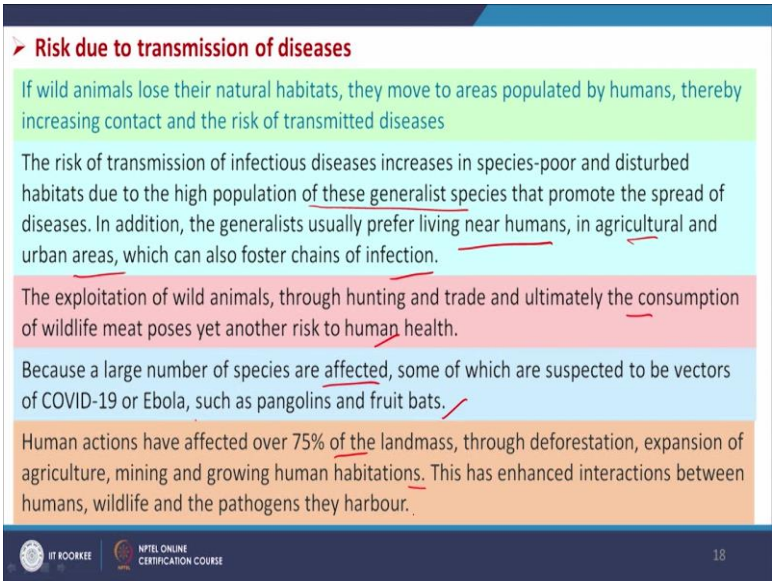

And here we see you know, if wild animals lost their natural habitats, certainly they will move to areas populated by the humans and thereby increasing contact and the risk of transmitted diseases. And that means we can say that if there is a loss of biodiversity, then these transmissions will be more.

The risk of transmissions of infectious diseases incursions, species-poor and disturbed habitat due to high populations of these generalist species that promote the spread of disease. In addition, the generalists usually prefer living near humans in agricultural and urban areas, which can also foster chains of infection, the exploitation of wild animals through hunting and trade and ultimately the consumption of wild life meat poses yet another risk to human health.

And because of large number of species are affected, some of which are suspected to be vectors of COVID-19, or Ebola such as pangolins, and fruit bats. And human actions have affected over 75% of landmass, through deforestation, expansion of agriculture, mining and growing human habitations. So, these are geneticist interactions between the human's wildlife and the pathogens they harbor. Now these tables show just some diseases due to ecological changes. So, a COVID-19 this is one disease.

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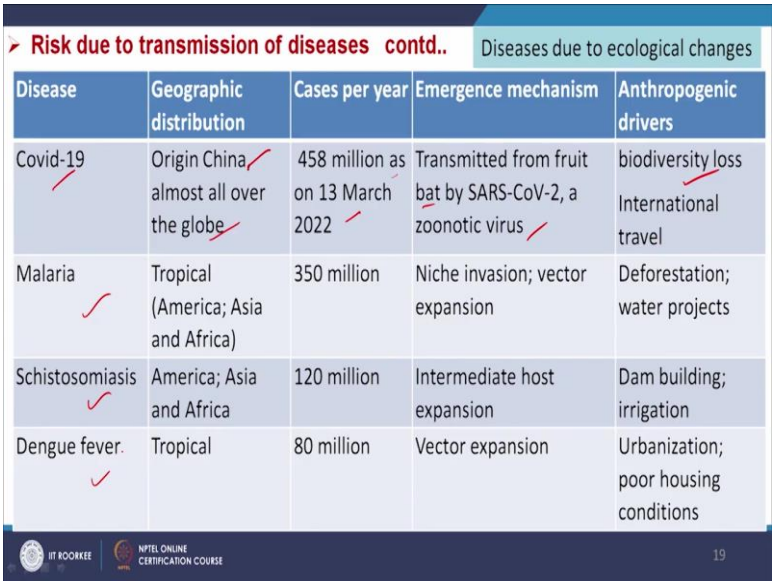

So we know it very well that originated from China and spread all over the globe. And 458 million people are affected as on 13 March 2022. And it is transmitted from fruit bats by SARS – Cov-2, to zoonotic virus, it is a zoonotic genetic virus and the anthropogenic drivers is biodiversity loss and international travel.

Similarly, malaria and other diseases are mentioned in this table. You will see that it is originated from different parts of the globe and transmitted to other areas as well and many people have been affected and the emergence mechanism is also provided in this table. And we see that there are many anthropogenic drivers like the deforestation, water projects, dam building irrigation, urbanization, poor housing conditions,

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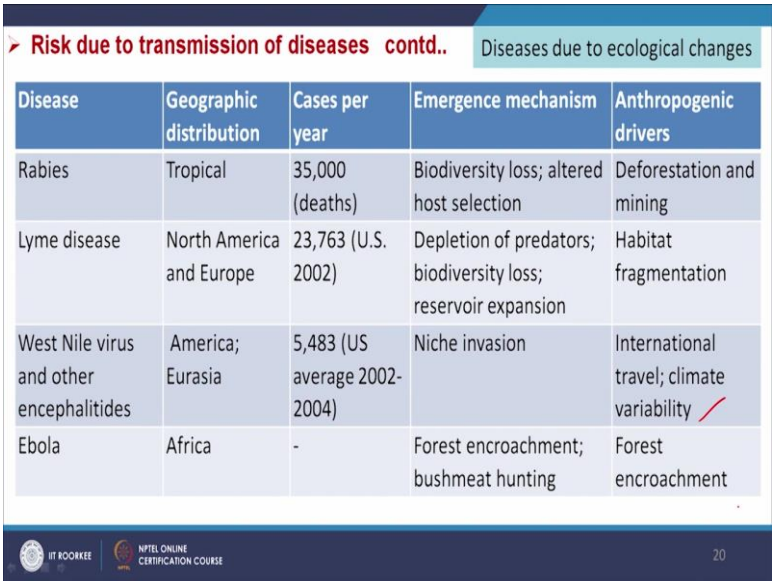

And deforestation, and mining, habitat fragmentations, international travel, climate variability, forest encroachment, etc. And you see different and types of diseases that spreads due to the ecological changes. So, what we see here in this class that due to many reasons, the ecosystem is getting disturbed. And because of ecosystem services are also becoming more risky day by day. So, we need to ensure the quality of the ecosystem services. For that we need proper attention. Thank you very much for your patience.