Basic Environmental Engineering and Pollution Abatement

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Lecture 04

Ecosystem Services and its Risk 2

Hello everyone. Now, we will discuss on the topic Ecosystem Services and its Risk part 2. In the previous class, we have seen that ecosystem services are becoming riskier and are being associated with risks day by day because of the excessive pollution load, mostly manmade in some cases also naturally this is happening.

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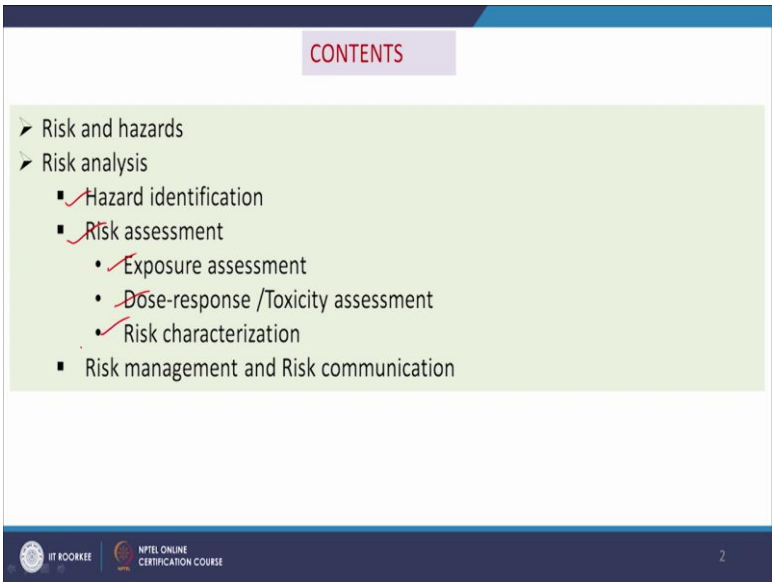

In this class, we will try to quantify or analyze these risks okay. So, the contents will be risk and hazards, risk analysis that is hazard identification, risk assessment, which includes exposure assessment, dose response and toxicity assessment, risk characterization and risk management and risk communication.

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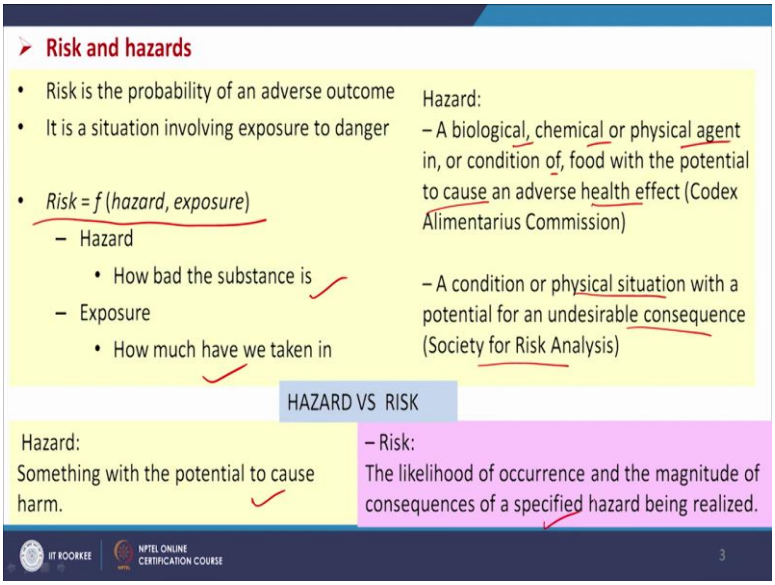

Now, we will see what is the risk and hazards. So, as per the definition of society for risk analysis, hazard is a condition or physical situation with a potential for an undesirable consequence. And hazard can be defined in other way also that is a biological, chemical or physical agent in, or condition of food with the potential to cause an adverse health effect. And the risk is the probability of an adverse outcome. It is a situation involving exposure to danger and risk is a function of hazard and exposure.

Hazard means, how bad the substance is? An exposure how much have we taken in? So, these two factors influences or decides the actual risk, one is hazard and the other is exposure. So, we see that hazard is something with the potential to cause harm and the risk, the likelihood of occurrence and the magnitude of consequences of a specified hazard being realized. So, this is the risk and hazard by definition.

Now, we will see hazard categories and examples of potential hazard manifestations. So, hazards may be related with human maybe related with environmental toxicity, it may be a physical hazards, it may be global hazards.

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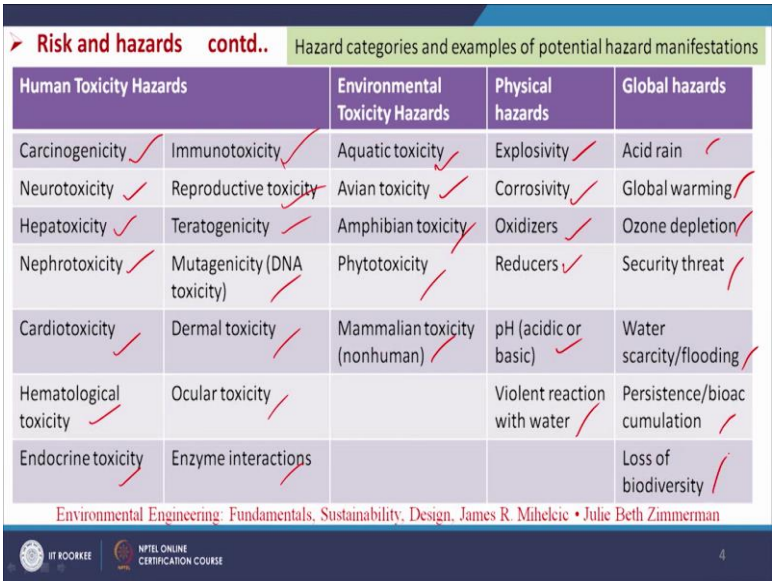

For example, see human toxicity hazards, carcinogenicity, neurotoxicity, hepatotoxicity, nephrotoxicity, cardiotoxicity, hematological toxicity, endocrine toxicity, immunotoxicity, reproductive toxicity, teratogenicity, mutagenicity, dermal toxicity, ocular toxicity, enzyme interactions and environmental toxicity hazards, maybe aquatic toxicity, avian toxicity, amphibian toxicity, phytotoxicity and mammalian toxicity that is non human.

And physical hazards we have already discussed in the introduction class that explosivity, corrosivity, oxidation or combustibility, okay the reducers, pH and violent reactions with water. So, those are the physical hazards and some global hazards some new hazards have been identified with respect to climate change. So, those are say global warming, Ozone depletion, acid rain, security threat, water scarcity, flooding, persistence and bioaccumulation loss of biodiversity. So, these are the different types of hazards have been classified or categorized into these.

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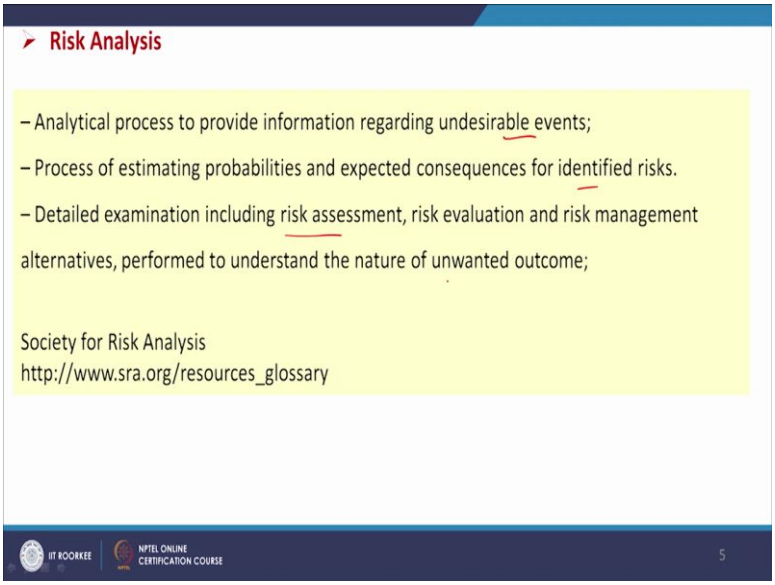

Now, we will see how we will do the risk analysis. So, analytical process it is an analytical process to provide information regarding undesirable events and process of estimating probabilities and expected consequences for identified risks, and detailed examination, including risk assessment, risk evaluation, and its management, which is performed to understand the nature of unwanted outcome.

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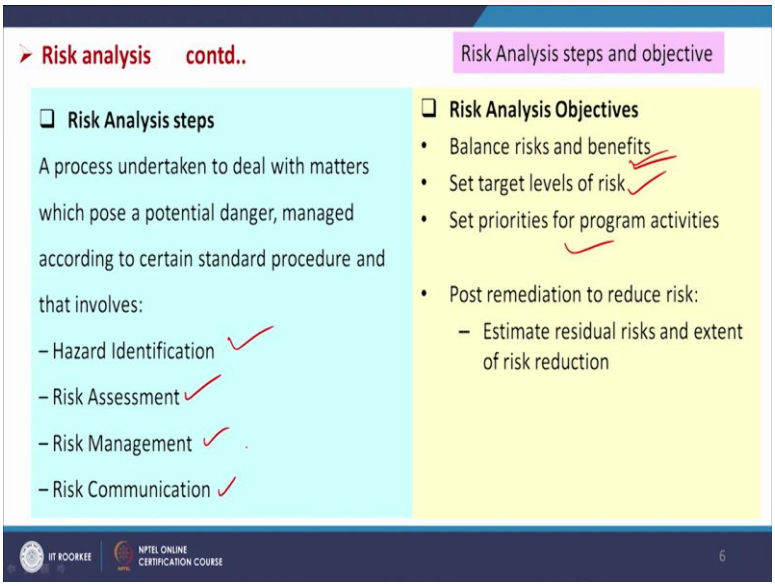

And we will see the objective of risk analysis and the steps. The main objective of the risk analysis is to balance risk and benefits. Certainly, when we are taking of new initiatives, we will be getting some benefits and there will be some risk also. So, we have to consider both and take an optimum situation. So, that balance risks and benefits that is the main objective to

the risk analysis, and then set target levels of risk and then set priorities for program activities. So, that means that I told you that if I want to take new initiatives, I have to optimize it, So, that the environmental impact will be under control. So, that way, the risk analysis is necessary.

And then post remediation to reduce risk, again, what remediation measures we can take to eliminate these risks that are also the objective of the risk analysis and how we can do it. So, first job is to identify the hazards or what are the risks basically, So, hazard identification, and then risk assessment, we have to assess the risk from the hazards and then we have to risk management and risk communication.

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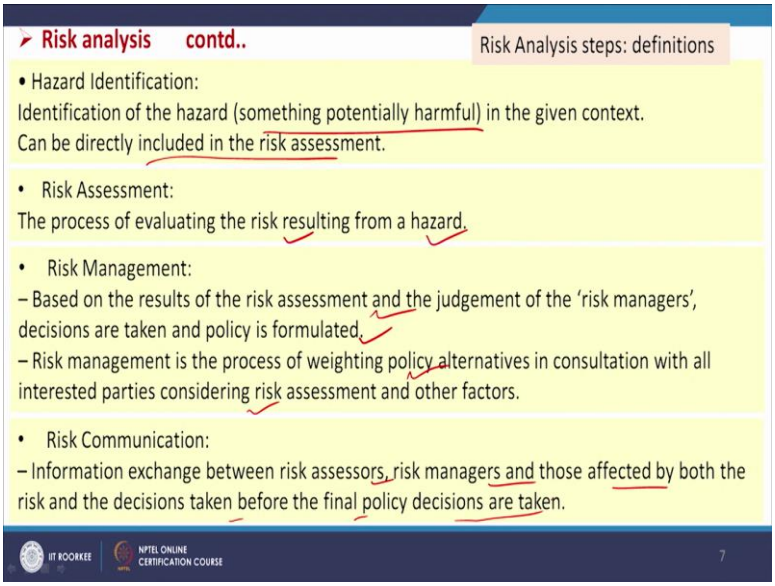

So now, one by one, we will see how this can be taking place. Hazard identification, So, the identification of the hazard that is something potentially harmful, that is hazard in the given context, this can be directly included in the risk assessment. So, we will be examining the hazards for example, shave there is some accident in the industry. So, there will be some chance of release of some poisonous gases.

So, that is one hazards identifying or say we are getting some smell in our room, then just like a melting of plastic. So, we will be taking care to find out where from it is coming? So, what is the source of it? So, that is identifications, then the first we will identify the hazards, what is the hazards?. So, that hazard identifications and then those points as those information will be used for the risk assessment and risk assessment is the process of evaluating the risk resulting from a hazard. Any sort of hazard whatever the risk of it that will be assessing.

And then risk management, the based on the results of the risk assessment and the judgment of the risk managers, those experienced persons who have knowledge on this subject, they will be assessing it and they will take a decision okay are taken and then the policy is formulated, and then the policy will be formulated. And risk management is the process of weighing policy alternatives in consultation with all interested parties considering risk assessment and other factors.

So, we can correlate with these with the, formation of the standards of different pollutants in our environment, find it say some waste stream is entering into the environments and what will be the limit of different contaminants in it. So, that particular value we need to decide. So, that will be based on our risk factors. And in that case, we need to involve all stakeholders, then decision is taken that decision is also open before taking a final decision, that interim decision is open for public comment and then it is finally accepted as a rule or regulation.

So that way, risk management and risk assessment and risk communication is also very important. So, risk communication is an information exchange between risk assessors, risk managers and those affected by both the risk and the decisions taken before the final policy decisions are taken. So, these are the process through which the risk analysis takes place.

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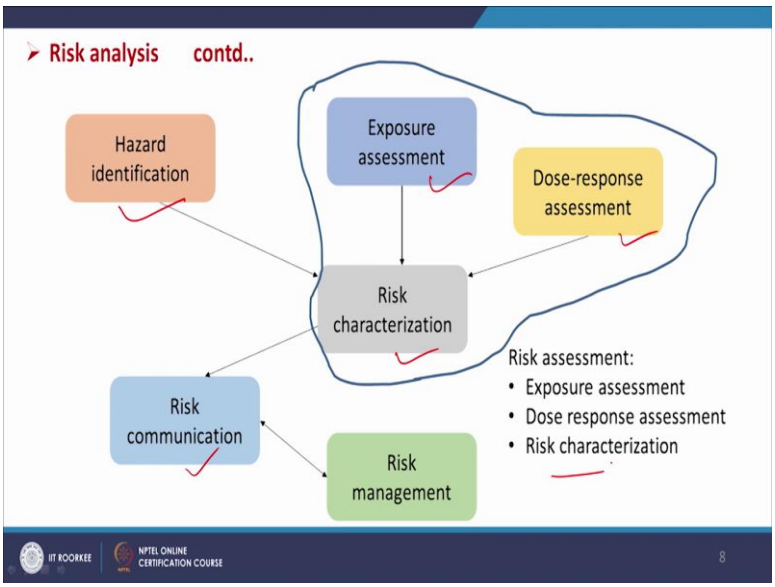

Now, this slide shows us the different steps which you have discussed the same in this diagram. So, hazard identification, then we will do the risk assessment which is composed of say exposure assessment, then dose response assessment and then risk characterization, and

then we will do risk communication and risk management both things take place simultaneously. Okay, and risk assessment is basically exposure assessment, dose response assessment and risk characterization.

Now we will see what are these? So, hazard identification, So, what is this? to identify chemicals of concern which chemicals is responsible for that, for example say we see that some time on river Yamuna the dead fishes bodies are floating on the water. So, what is the reason of it? We have to identify.

Say we have got a news that such and such village there are many people are affecting from cancers. So, what is the reason for it, so, we have to identify that hazard identifications.

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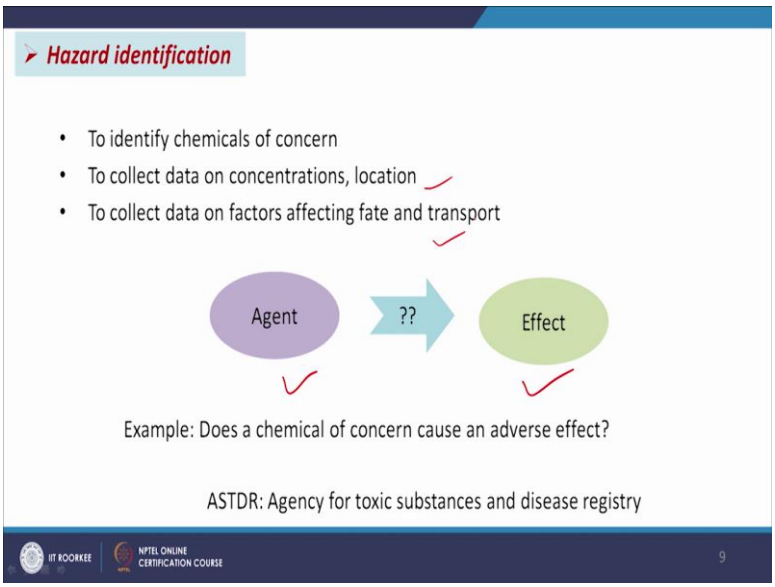

So, what is the agent and what are the effect? so, that first job and that can be done by field work and studying the scientific aspect of this phenomenon. To collect data on concentrations and location and then to collect data on factors affecting fate and transport. So, all those things are necessary. So, that way we can identify the hazards show example says some concerns are there in the village so, the groundwater is contaminated with heavy metals, so, arsenic or fluoride or many thing. So, we have to analyze all those water for the presence of these contaminants. So, that way we will do it. And then we will do the exposure assessment So, how we can do that exposure assessment.

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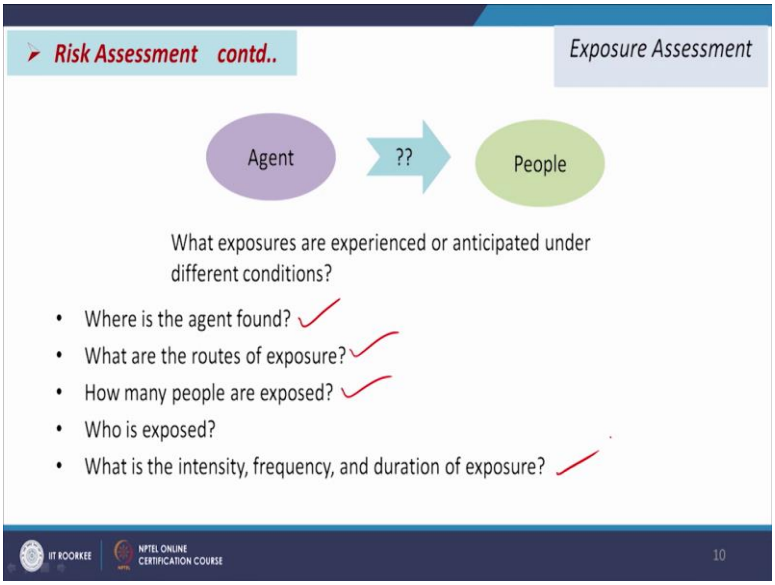

Now, we have identified what are the hazards what are the chemicals present in it, then we will decide what is the duration that people will be exposed to it or what is the agent found then what are the roots of exposure and how many people are exposed? So, who is exposed? What is the intensity frequency and duration of exposure? So, all those things we will be considering and we will collect data on these for exposure assessment.

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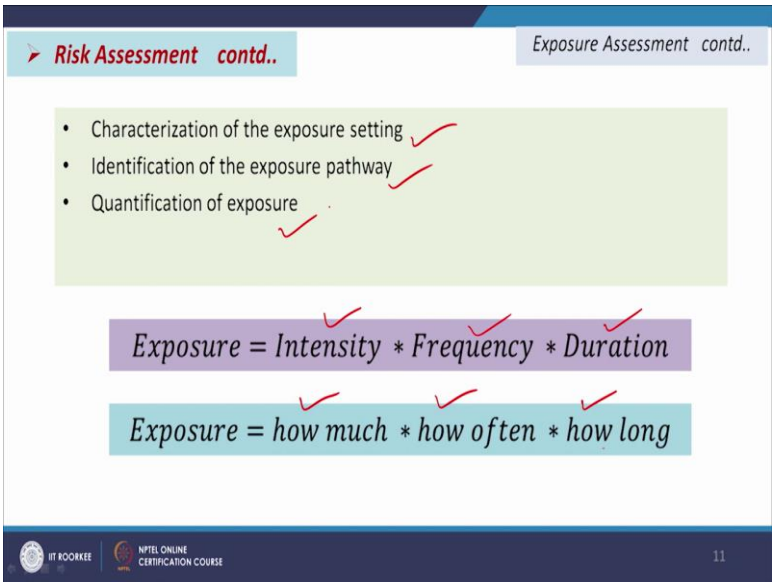

Then, we will define exposure what is that?

Exposure= intensity*frequency*duration

Exposure= how much*how often*how long

What is the intensity? What is the frequency and what is the duration, How much what is the concentration of the chemicals? How often I am in contact with? and how long I am considering that? Say I am living in a particular region for last 30 years. So, during last 30 years, what is the exposure so, that is an every day say I go to that particular area for two hours a day. So, 365*2 hours per year. So, that way, how open and how long So, that is into consideration and how much what is the condition present in that. So, that will be considered to get the to characterize or to quantify the exposure.

So, characterization of the exposure setting, then identification of the exposure pathway and quantification of the exposure. So, these are the main steps for exposure assessment.

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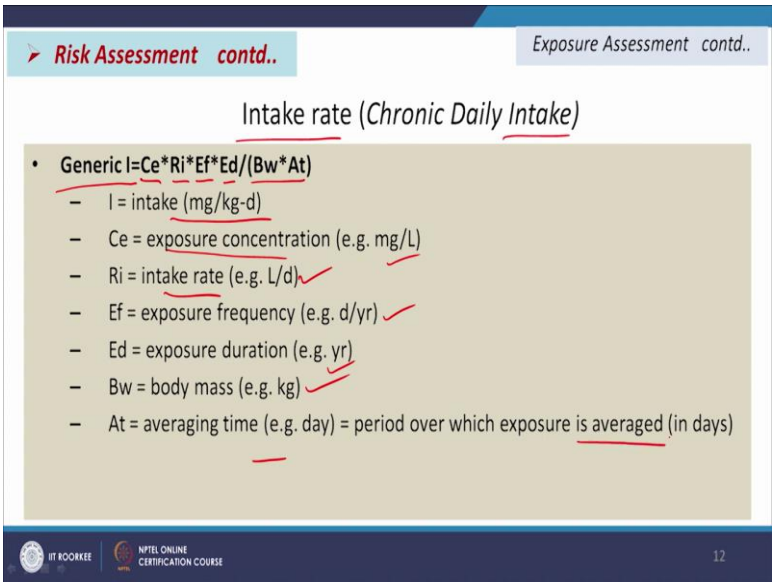

Then you know, here how we will quantify the intake rate? for mass of human body how much pollutants we are taking intake rate. So, that is 'I' generic term is 'I' intake that is equal to mg/kg-day. So, per day how much mg or pollutants I am taking per one kg of the body mass. So, that is called intake rate, this is chronic daily intake means that is very small concentration we will be taking this.

And there are two types of effects basically, one is chronic effect another is your acute effects. So, acute effect, the concentration of the pollutants will be more than immediate impact we will get but for chronic effect the concentration of the pollutant will be less but for long term conjunctions we will be getting the impact of it. So, that is called chronic daily intake that is intake mg/kg-day higher $I = C_e*R_i*E_f*E_d/(B_w*A_t)$.

So, Ce is equal to exposure concentration that is mg/liter. What is the concentration of the pollutants and then Ri is the intake rate that is how much water if we take say how much liter of water I am taking per day and then Ef is the exposure frequency, how many days in a year I am living in that area. And Ed is exposure duration, how many years I am there and Bw is the body mass what is the body mass my self or the living organism or the human and then At is averaging time. So, that is very important averaging them that is the period over which exposure is averaged in days. So these are the terms which are used to calculate the intake rate for a longer period or Chronic intake.

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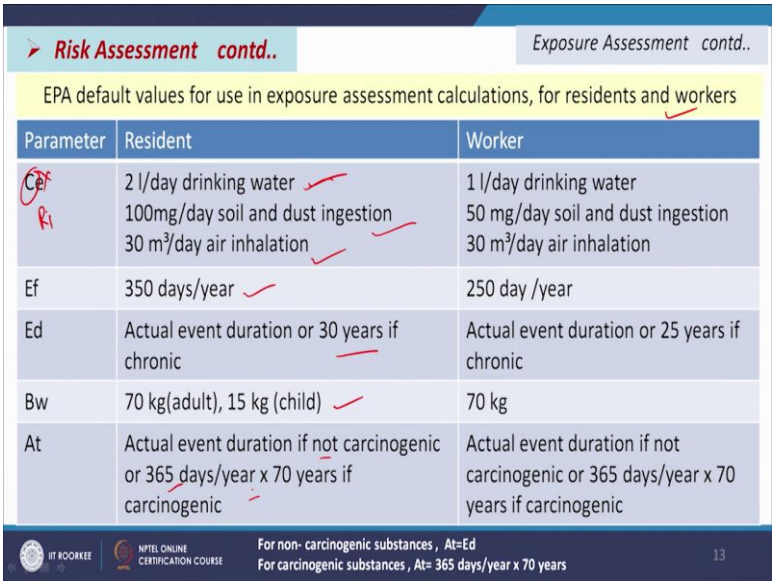

Then EPA, Environmental Protection Agency we say they have some default values for the use in exposure assessment calculations. And for residents and workers Ri that will be rate of intake that is 2 L/day for drinking water 100 mg/day soil and dust ingestion and 30 m^3/day air inhalation and for similarly, Ef which is exposure frequency, that is 350 days per year and for resident Ed value is actual event duration or 30 years if chronic if we want to consider for chronic intake. So, then there will be 30 years, but for actual event that means for your acute intake and Bw is 70 kg for adult and 50 kg for child and At is the actual event duration if not carcinogenic or 365 days/year*70 years.

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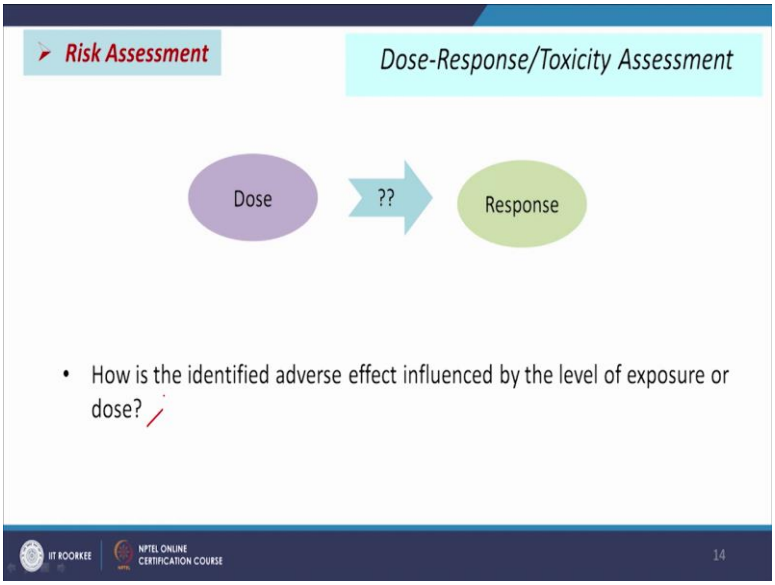

Now, we are going to see what is the dose response and what is the toxicity assessment. So, dose and response how is the identified adverse effect influenced by the level of exposure or dose that is the concern. So, if we take more dose, more impact we will get we will get less dose or less concentration, there will be less chance of contamination.

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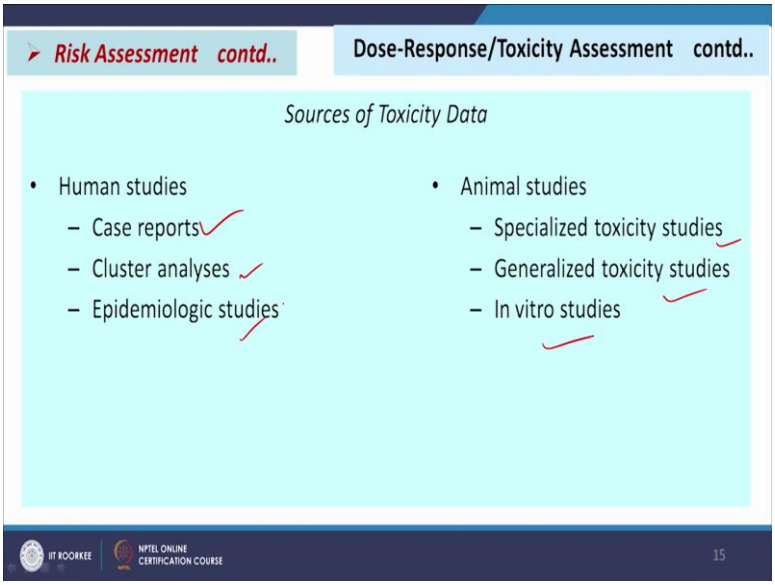

So, that way dose response assessment is needed. And for that, what do you do this can be done using different animals to animal studies, that is specialized toxicity studies, generalized toxicity studies and In vitro studies are done. And then for human studies, we case reports then cluster analysis, epidemiological studies, just like say vaccine production for COVID-19.

Initially it was tested from animals, then when it got success, then selected people are identified and then that was administered on that group of and then case reports and cluster analysis like this. So, that way the toxicity is assessed or the dose response, whatever the dose that is determined.

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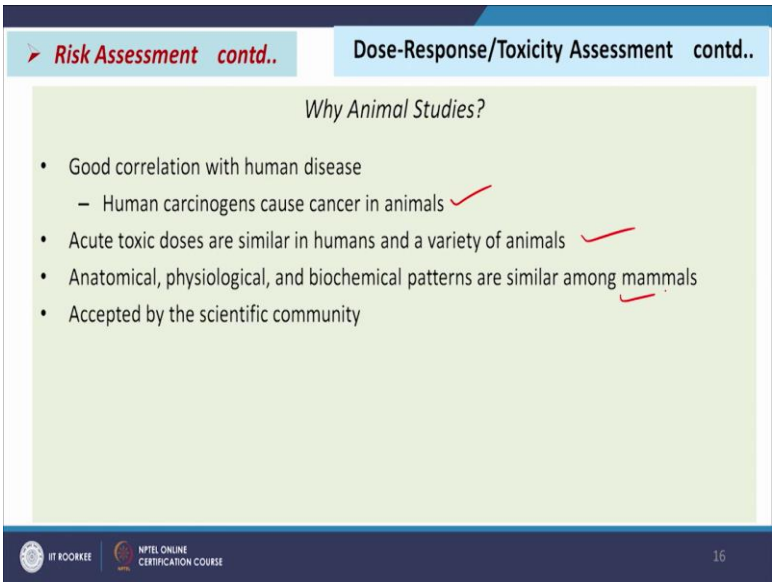

Now, why the animal studies is considered before administering the drug or the toxic element into the human body, because there is good correlation with human disease, human carcinogens cause cancers in animals as well. And acute toxic doses are similar in humans and a variety of animals and anatomical, physiological and biochemical patterns are similar among animals accepted by the scientific community. So, that is why the animal studies are taken first.

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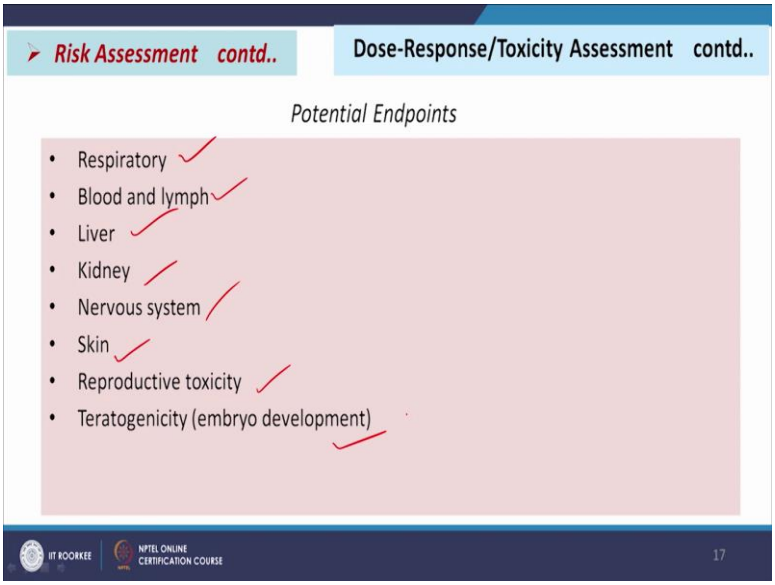

When you do this toxicity assessment test So, normally we try to understand the impact of the risk on respiratory system blood and lymph, liver, kidney, neuro system, nervous system, skin, reproductive toxicity, and teratogenicity. So, these are the different endpoints basically, or target which you want to know the impacts on these.

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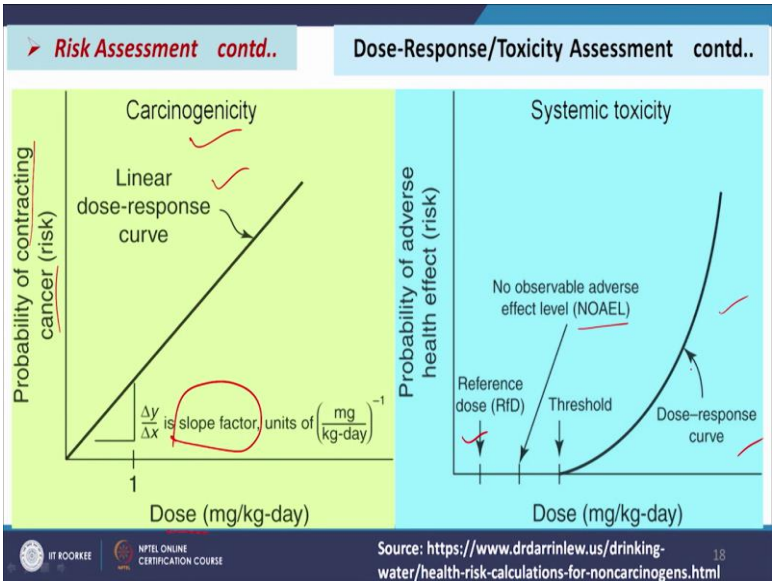

Now, dose response curve are also there graphs are also there. So, here you see the first one, it is a straight line that is linear dose response curve, but this is not a straight line, it is dose response curve, this is not linear one, nonlinear you can say. So, here, this curve is basically applicable for carcinogenicity the cases where the material is carcinogenic in nature and here, this $\Delta y/\Delta x$ if this is y and this is x. So, probability of contracting cancer that is risk and x is

your dose. So, the Δy/Δx is giving up slope factor. So, this slope factor value determines the risk actually, more the slope factor value more is at risk. So, that will shift it that way more risk and it will shift it this way less risk.

Similarly, when we think about the systemic toxicity, that means in this case, the impact is not carcinogenic in nature. And as for EPA, some reference dose is considered as for EPA. So, in case of systemic toxicity, higher the risk is not carcinogenic in nature. In that case, reference dose is considered as per EPA, and then one in NOAEL is considered, no observable adverse effect level dose this level and up to this we see there is no the probability of adverse health impact is very less zero.

So at RfD normally it is zero. So, below the RfD value, there will be no risk basically mostly and this RfD will be lower than NOAEL sometimes okay it may be say 10 times lower than that and there are some threshold value like this. So, this way this is for non carcinogenic effects these are the dose response study and this is dose response for carcinogenic elements.

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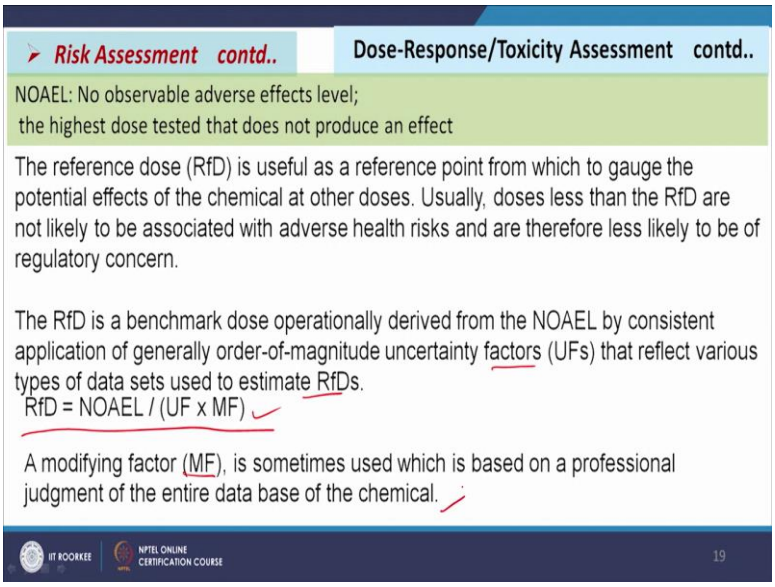

Now, the RfD, the reference dose is useful as a reference point from which to gauge the potential effects of the chemical at other doses. Usually doses less than the RfD are not likely to be associated with adverse health risks and therefore, less likely to be a regulatory concern. So, RfD is a benchmark dose operationally derived from the NOAEL by consistent application of generally order of magnitude uncertainty factors that reflect various types of datasets used to estimate RfD so, the relationship

RfD = NOAEL/(UF*MF).

So, MF is a modifying factor somewhere you may get this relationship

RfD = NOAEL/UF. and somewhere you may get this relationship as mentioned here, so, that MF is a modifying factor is sometimes used which is based on a professional judgment of the entire database of the chemical which is used.

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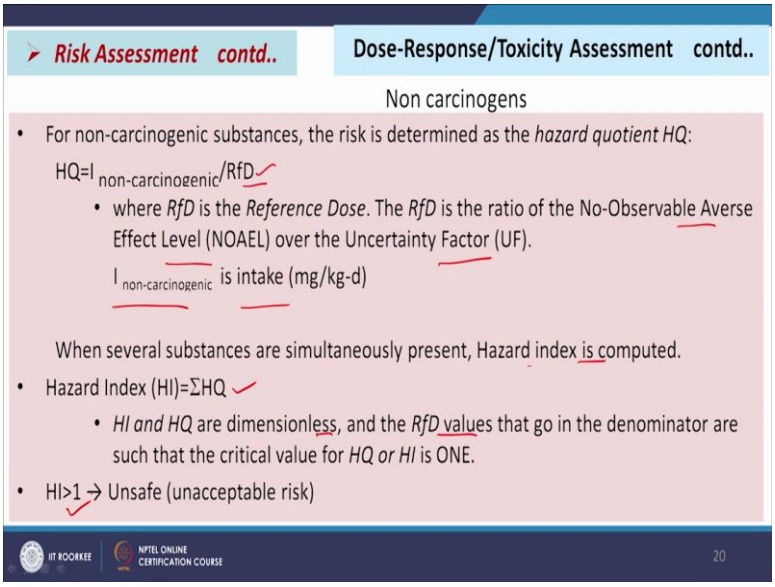

And then for non carcinogens you know, the risk is determined as the hazard quotient (HQ), so, one needs hazard quotient another is hazard index (HI) so, what is hazard quotient? hazard quotient is

$HQ = I_{non\ carcinogenic}/RfD$, what is this is $I_{non\ carcinogenic}$, it is intake. RfD is the ratio of the no observable adverse effect level over the uncertainty factor. So, that we have already discussed and when several substances are present not only one substance, more substances are within then simultaneously we will be taking the hazard index for that case.

So, hazard index HQ = ΣHQ that is the sum of the hazard quotient. So, now HI and HQ are dimensionless and the RfD values that go in the denominator in these expressions are such that the critical value of HQ or HI is 1. So, more than HI means it is unsafe. So, that will be not be safe, and there will be some risk with that, under that conditions.

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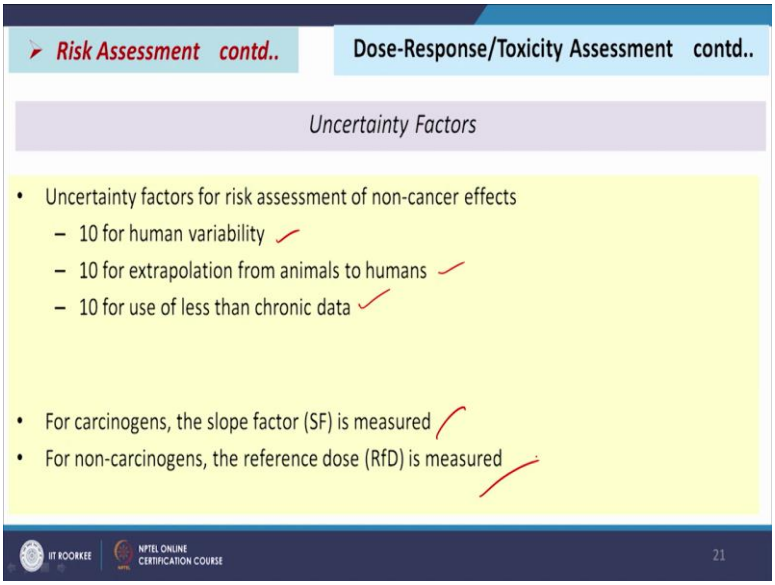

And uncertainty factors which we have seen UF that is basically 10 for human variability, 10 for extrapolation from animals to humans, and 10 for those of less than chronic data that means 10 times, that is RfD will be 10 times less than the NOAEL and then for carcinogens, the slope factor is measured and for non carcinogens the reference dose is measures will be below that RfD dose, it is safe.

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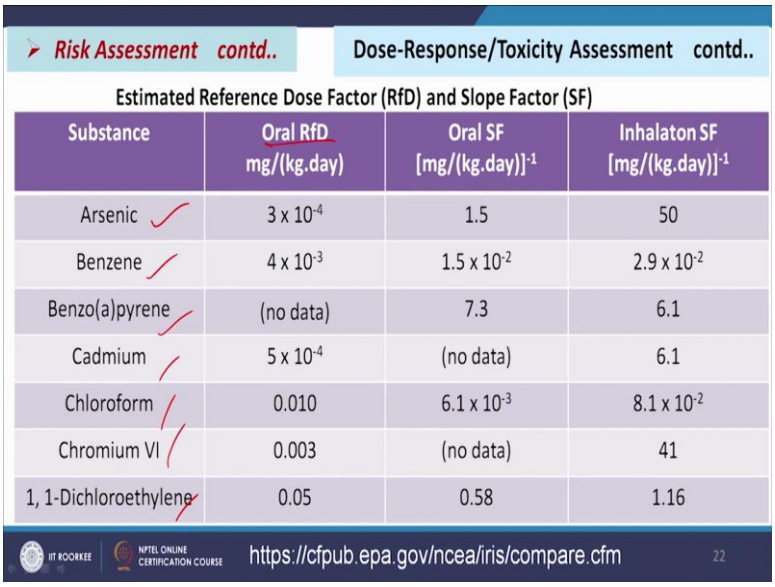

Now these are some example for arsenic, benzene, benzo(a)pyrene, cadmium, chloroform, chromium VI, 1, 1 – Dichloroethylene. We see oral RfD that means when we will take orally these pollutants then RfD is, this mg/kg-day and when SF will be these and when we will take inhalation through the inhalation from the air. So, the SF value are given here.

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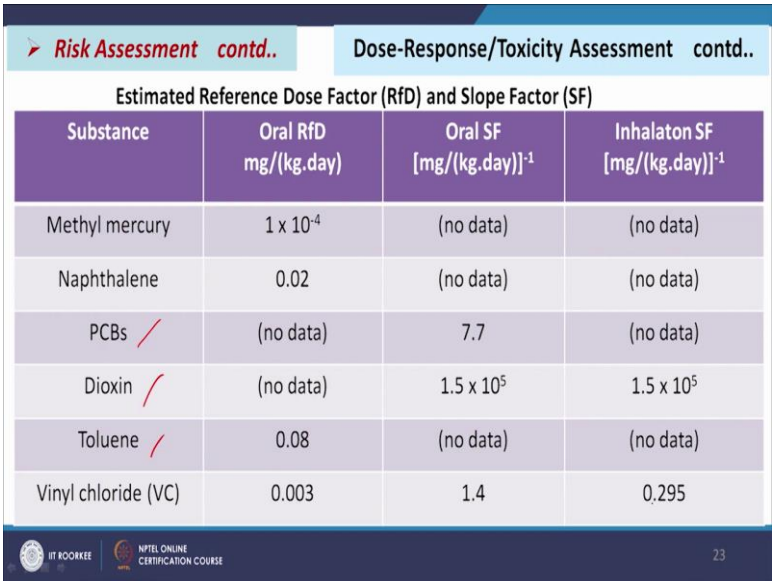

So, the values are different and for other like say Methyl mercury, Naphthalene, PCBs, Dioxin, Toluene and Vinyl chloride the other values are given here.

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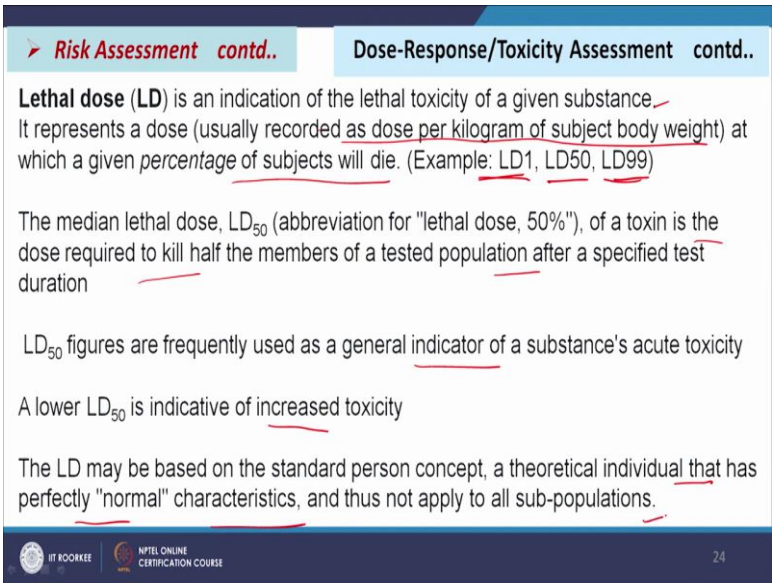

Now, another is your lethal dose. So, when we want to quantify the dose response, response on the dose with acute impact at that time, we get lethal dose. So, lethal dose is an indication of the lethal toxicity of a given substance. And it represents a dose usually recorded as dose per kilogram of subject body weight, at which a given percentage of subjects will die. For example say, LD1, LD50, LD99. LD50 means 50% of the subjects will be dead at that dose, if we if it is exposed for certain time.

Similarly, LD1 means 1% will die, LD99 maens 99% of the subject will be dead. So, the median lethal dose LD50 abbreviation for lethal dose 50% of a toxin is the dose required to kill half the members of a tested population after a specified test duration and LD50 figures are frequently used as a general indicator of a substances acute toxicity and a lower LD50 is indicative of increased toxicity. The LD may be based on the standard person's concept.a theoretical individual that has perfectly normal characteristics that is used and thus not be applicable to all sub population that means, this is for a perfectly normal adult persons can be considered for this investigation, not children or etc. and risk characterization report.

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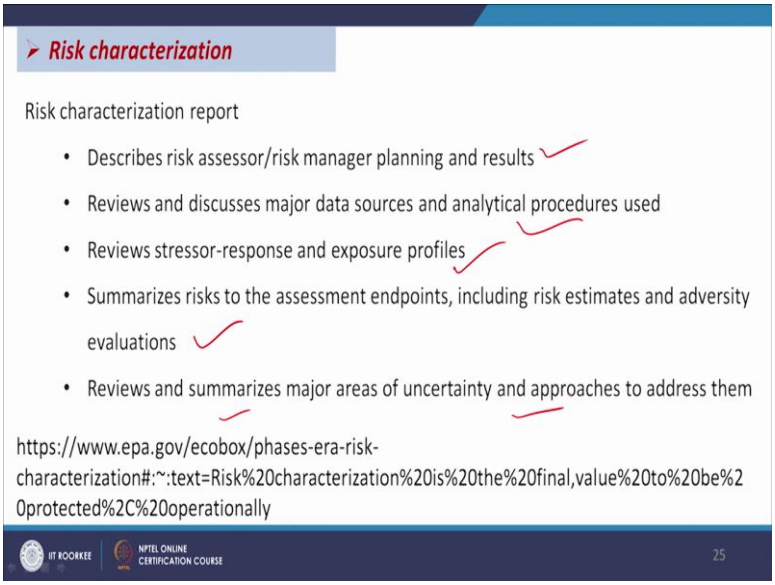

Next is your risk characterization. So, after assessment we will be characterizing it that means we will be maintaining a report we will be preparing a report basically from the start of it. So, describe risk assessor or risk manager planning and results and then reviews and discusses major data sources and analytical procedures used just like report writing, and reviews stressor-response and exposure profiles, that will give you give data.

Then what type of trained we are getting and then summarizes risk to the assessment endpoints including risk estimates and, adversity evolutions and reviews and summarizes major areas of uncertainty and approaches to address them. So, this is a risk characterization, then risk management and risk communication.

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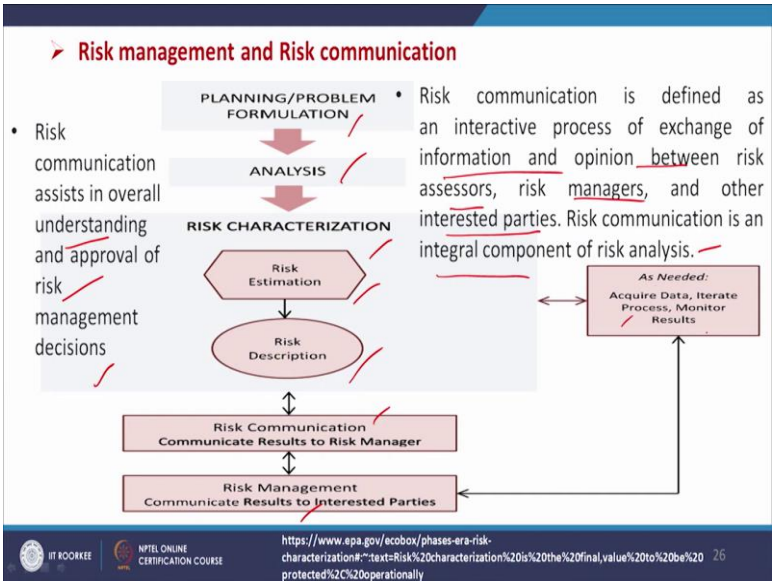

So, what risks characterization is made on the basis of decision is taken and that decision is communicated. So, that risk communication is defined as an interactive process of exchange of information and opinion between risk assessor, risk managers and other interested parties. Risk communication is an integral component of risk analysis and we also see that risk communication assist in overall understanding and approval of risk management decisions.

So, this is a total flow diagram we see. So, planning, problem formulation analysis, risk characterization, so, risk estimation, risk descriptions and risk communication and then risk management. So, for this we need acquired data, iterate processes and monitor results. So, these are the process for risk management. So, up to this in this class thank you very much for your patience.