Life Cycle Assessment
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Lecture – 07
Risk Assessment – Toxicology

Hello and welcome back to the second week of this course and we are on the second module now, we had the first module prior to this for the second week where we looked at the risk assessment, the basics of risk assessment, we also I give you some examples of how the risk assessment take is done.

So, today we will look at; see if you remember from yesterday, we were talking about things being toxic, things being harmful to the environment, harmful to the human beings. So, today we will be looking at the basics of what is the toxicity, what is the as you probably know this toxicity aspect is covered in a course called toxicology. So, I will give you a very brief overview of toxicology so that you are on the same page of what we have been talking about risk assessment and how that relates to the overall lifecycle analysis. So, let us look at the basics of toxicology.

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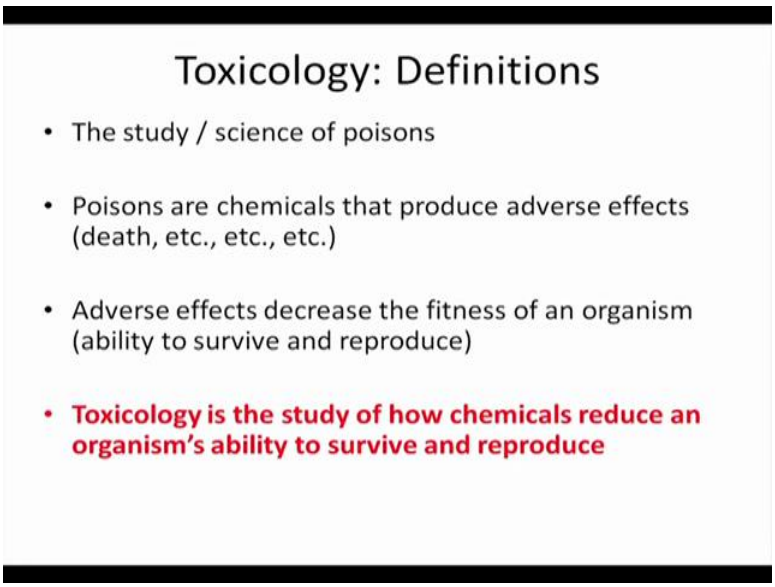

So, when we say toxicology, there are of course, certain definitions they it is a study and science of poisons. So, it is a study and you may heard in the past that even Hitler was poisoned by arsenic and you here from time to time certain people was poison and I will

give you some examples of that as well. So, it is a study and science of poison what are poisons? Poisons are chemical that has adverse health effect. So, when we have when we talk about adverse effect means it is something the effect is harmful it is a something which is going to do bad to us as human being it could do bad to the water do the bad to the soil. So, those are the term the essentially chemicals and they will have some adverse effect one of the common adverse effect we will talk about death and there could be other effect as well it could be just your impairment of eye, impairment of one particular organ or somebody getting some sort of damage to certain parts of the body not able to perform their function up to their 100 percent potential.

So, it is an adverse effect it decreases the fitness of an organism and it also can have ability to it how it effects it? It fitness it can affect the ability to survive some cases even to reproduce these days as you here may many places like if you follow newspaper you may have seen that we talk about the people are having the productive problems say in many many couples they want to have child, but they not able to have child and even then when they have child because of certain environmental impact certain of the environmental contamination especially with very unknown chemicals when I say unknown chemicals means the chemicals for which the impact is not known we had the issues of during the Iraq war as the war is still rapping up there are places in Iraq, Lucia and other places where the kids are born with lots of deformities. In few years back we heard that in even in parts of Bihar in the state of Bihar is state of India where we had several children born with like blindness. So, it is of course, there is something which is causing this kind of impacts. So, those are the poisons sometimes we know that chemicals sometimes we do not know the chemical.

So, toxicology as you can see on the last bullet of this of this slide toxicology is the study of the red colour bullet that you see on the slide is the study of how a chemical reduces an organisms ability to survive and reproduce. So, that is the big picture toxicology and we will be in this particular segment of the video this in this particular module we will give you a very brief overview of what toxicology is, especially those of you who are from the biology background have taken biology courses for you most of these material may you already may have covered in some other class, but those of you especially the engineers may be do not read that much biology. So, for us this will be kind of a; for the

students of engineering background or its non biological science background this will be a ready kind of reference when we talk of different terms.

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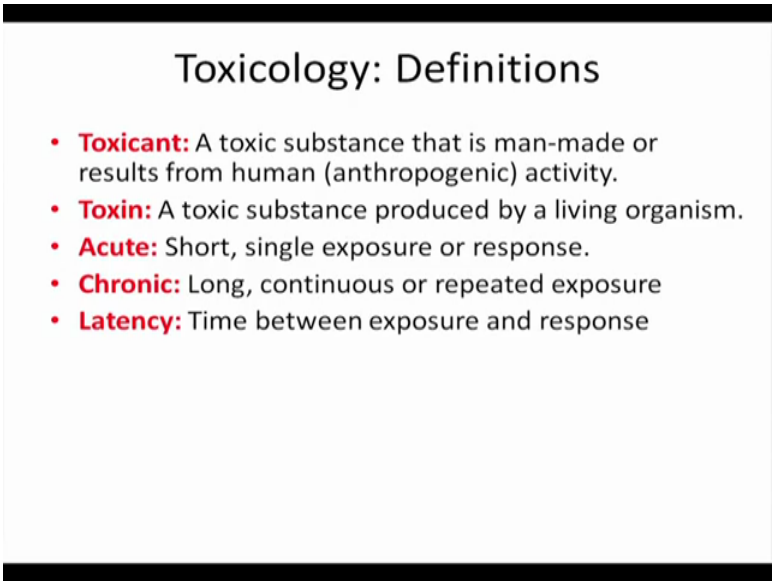

So, when we look at the toxicology of course, there are different definitions are there, there are different terms one term is toxicant, toxicant is and then you see those red colour bullet red colour phrases are the different terms which you hear a lot and then I will try to explain it what does it means. So, toxicant is a toxic substance which is manmade or results from human activity. So, we call them anthropogenic even if you remember from the previous video we define this term anthropogenic and biogenic is something which is natural and anthropogenic is something which is manmade. So, if you are manmade thing especially say a after world war 2 we are making lots and lots of chemicals organic chemicals we are producing chemicals and many of these chemicals we do not know their environmental impact what will happen to them when they are exposed when they are get released into the environment.

So, toxicant is a toxic substance that is manmade or results from human activities. So, because of our activity that gets produced. Toxin is a substance which is produced by a living organism. So, many times you do hear that certain product from the forest or certain or certain plant species are toxic they have some adverse health impact and that is what those are actually already there it is produced by living organisms and they are name as toxin and then the in terms of the impact. So, this toxicant and toxin are the type

is basically this is classifying the type of chemical either it is a manmade chemical manmade chemical becomes toxicant or if it is on or like a chemicals produced by living organisms which is coming from a natural sources that is the toxin. Now in terms of their impact we have 3 terms for that in terms of the impact it is coming out and the terms as you can see from the slide the terms are acute chronic and latency and we will go one by one on each one of them.

Acute means short single exposure like you just had a exposure for a very small period of time say you walk in to a room the room had hydrogen sulphide gas or the chlorine gas being leaked into that room you just walked in you realized that you and you came out. So, that is your short single exposure. So, that is your acute impact.

Chronic is something where you have a long continues or repeated exposure. So, you are working in a factory setting eight hours a day or you your see there something realising into your house many of the houses we do not see that much issues of radon in India, but recently I was talking with one of the colleague and we are they he was suggesting that there are cases of radon even showing up in Indian houses, but if you are in certain parts say North America especially can see in that West Virginia, North Carolina those areas they have the problem of radon and if they have a basement which many of those houses have because of some other reasons.

So, the basement they do keep on testing for radon. Say for example, if you rented a basement apartment in that area and there you are exposed this radon day in and day out may be say 8, 16 to 18 hours per day where we amount of period that you spend inside your inside your room. So, that is your long continuous and repeated exposure. So, that kind of exposure will call chronic. Similarly factory settings somebody working a factory 8 hours a day, 5 to 6 days a week, so that is again long continues as well as repeated exposure. So, that should chlorine part. So, acute was short single exposure chronic is long continues exposure.

Then the third impact term the last on the slide is latency, latency is the time between exposure and response its it does not say if you get exposed to a certain chemical on to on today and it does not mean that you will get sick just right now for some chemicals yes you may get sick immediately, but for many many many of these toxicants or toxin it takes a long period of time it may take few days to few weeks sometimes few years or

sometimes even to few decades because if you it takes time for you to have a response in terms of whether you get what whatever what kind of impact you have on your body or if you talking about the environmental impact. So, there are that is the latency period, it is a time between the exposure and the response. So, these five terms make sure you kind of understand this and you remember because we will be using this again later into the class.

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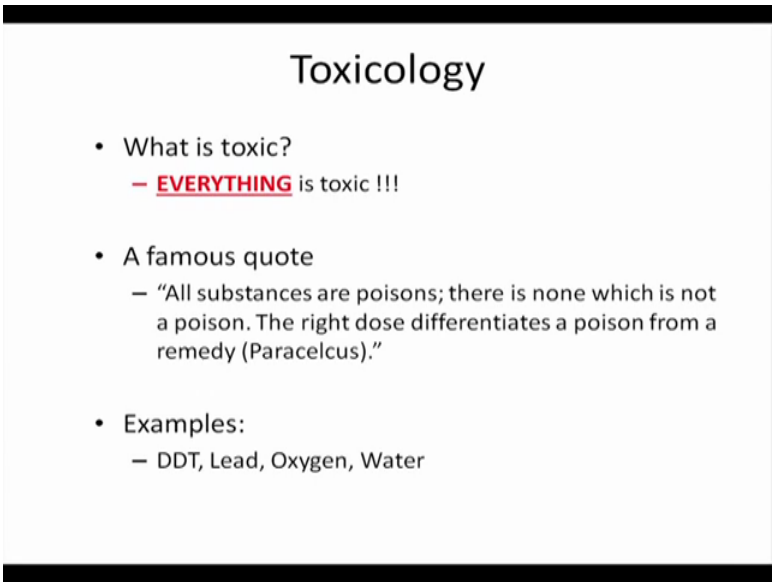

So, what is toxic? Everything is toxic it depends on what concentration you take it in there is famous quote it says that all substances are poisons there is none which is not a poison the right dose differentiates a poison from a remedy think about arsenic we are see; like I am taking to you from West Bengal and Bangladesh we have a there are certain distance in West Bengal and there are a big area in west Bangladesh where we are dealing with this arsenic poison similarly part of West Bengal is also leading with fluoride issues. So, arsenic and if you are if you have looked at this homeopathic medicines or even some of the allopathic medicine we use arsenic am in the if you are familiar with the homeopathy medicine you will see a arsenic am arsenic am means there are little bit of arsenic there. So, on one hand we are using arsenic as a remedy as a medicine, but at the same time we have the arsenic poison issues from the our ground water or surface mostly from the ground water in parts of West Bengal and in a big bunk in Bangladesh.

So, again it kind if you go back to the quote all the substance are poisons there is none which is not the right dose differentiate the poison from a remedy. So, when we are trying to use it as a remedy we are using at it a very low concentration, but when it becomes a very high concentration it becomes bad for us. So, that is same thing if you think about chromium. So, chromium if you are going to get a multi vitamin which many of us take even when you are taking some antibiotic drugs doctor will prescribe you some multi vitamin with that if you look at the content of the multi vitamin you will see it will have some chromium.

So, chromium (Refer Time: 11:05) oxidation state of 3. So, chromium with oxidation state of 3 see we use it as a; we use that element in our body we need that as a multi vitamin, as a source of multi vitamin for our growth, but if you have a too much of a chromium it becomes a problem. So, it becomes a even a carcinogen actually chromium sicks, too much chromium at any oxidation level of sicks it becomes a carcinogen can cause cancer. Some of the examples of what are water toxicant DDT, DDT; we use a lot for spraying and taking care of a like a mosquitoes and other paste, but at high concentration it is toxic. Led again it if the concentration is high becomes a problem, even oxygen you think about oxygen which we need for inhaling and we for our respiration we need without oxygen we will die, but having a if we have too much of oxygen also it will become a problem.

Because if we have too much oxygen your body cells will a start getting oxidise that is why many times you hear the term if you like a antioxidant you will see this acts as an antioxidant means whatever is the free radical of oxygen present in our body this particular compound will go and like a take those free oxygen and take it out of the system. So, that is your antioxidant. So, if you have too much of a oxygen if you inject too much of oxygen in anybody any once body the person is also going to possibly going to die after it goes to high. Then water if you drink too much of water that also is the problem, but we cannot survive without water we need water all the time, but having too much again having anything too much could sensibly become toxic. So, it depends on the difference between the dose differentiates a poison from a remedy as you saw in that particular quote.

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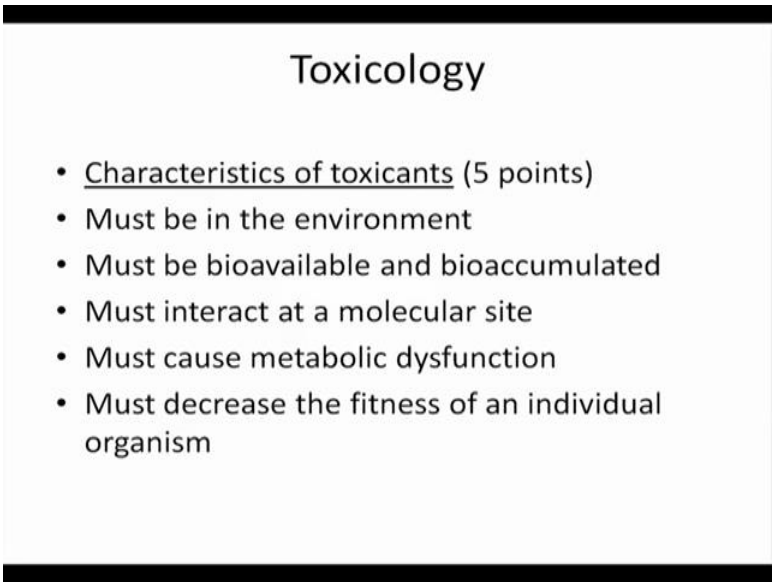

Now, how you characterises toxicants what are the toxicants, what we look at them. First off all if we are going to get a exposed it should be available in the environment is it not? It must be present in the environment then only we get exposed, if it not present in the environment say am sitting in a room and that room does not have any of these toxicants am not going to get exposed. So, to get expose first of all it has be in our environment it has to be in our surroundings then even if it is available in the surroundings it should be bio available bio available and some cases bio accumulated.

Bioavailable means that it should be say if I give you an example for example, say if you think example of a copper in a water if you have lake or a pond and you have too much of copper present. So, copper what happens is copper has a tendency to bind up with the organic matter. So, when you look at any river or any lake or a pond you see that green colour in those water the green colour essentially is a organic acid humic and flumic acid. Copper, any copper present it has a tendency to bound up with this organic acid. So, there this is my copper these organic acids make a layer on around top of. So, now, this layer on top any bacteria trying to come in because there is layer on top there this bacteria not able to penetrate to the layer and my copper is there, but this is not available to the bacteria. So, if it is not available to the bacteria it is not it will not be toxic to that because bacteria cannot get there. So, if it cannot get there will be no impact.

But if it is available copper at a very low concentration even at the microgram per litre even like in 1 to 10 micrograms per litre concentration copper is toxic to certain aquatic spices including fish and that. So, again since it was not bio available it is not toxic sense similarly if we inject something say if you inject something chemicals by mistake, but if does not if it is not bioavailable to our system if it cannot our blood does not absorb that chemical it will just go out our when we go to the toilet either through urine or the fee gal matter things will go out of the system, but we will not be toxic. So, that is the concept of the bio available it should be available to the spices which is getting exposed to that.

Bioaccumulation is when things gets accumulated in the food chain we talk about especially the mercury pollution mercury gets accumulated from the one spices to higher spices in water and many times it will becomes to the fish. So, that is why may we say that pregnant women we try to avoid them having too much of fish because if especially if it is there mercury pollution is an issue in that area, then even if it is bio available it must interact at a molecular site. So, it should do some type of interaction in our body. If it does not interact with the body system whether I am talking about human body or a animal body any spices body whatever it is getting whatever is getting exposed to it has to interact with the body if it does not interact no reaction. So, no interaction means no reaction no reaction means no negative impact first reaction has to happen to have to get impact.

Now, one its react next thing is it has some sort of metabolic dysfunction. So, it has to create some type of metabolic dysfunction then only it is harmful if it does not create dysfunction, it is not harmful and then it must be increase the fitness of an individual organism. So, these are the one of five point has as important then only things will we will be a toxicant will act it is toxicant otherwise it will not be there.

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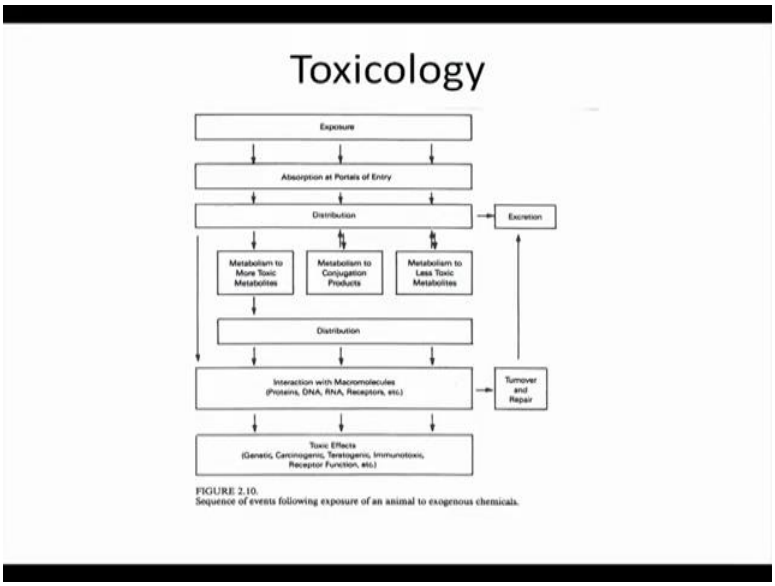

So, if you look at, it is a not very great picture, but if you look at up close there is toxicology its exposure is important whatever I said in the previous slide it is kind of a summary of that. So, its exposure and then from the exposure it has to be absorbed. So, things have to be absorbed at the port at the portal of the entry, needs to be a distributed and then from the distribution it gets if it gets exceeded; that means, it is not that much of a problem.

But if its metabolised to more toxicant if its metal metabolism is happening to more toxic metabolites or if it put some conjugation products or those make less metabolic toxic metabolites then it gets distributed in the body interacts with protein DNA, RNA and all that then there is a if it is our body will try to excreted it out the kidney is our waste water plant you know. So, that it will try to exceed all these like a bad stuff out of the body if it can do that then its stunt over and repair and goes to the excretion system and thrown out to the body. So, it may have little impact, but if it cannot be removed by this DNA then its goes to the toxicant part where you have a genetic oestrogenic heterogenic. So, those impact comes in comes in picture.

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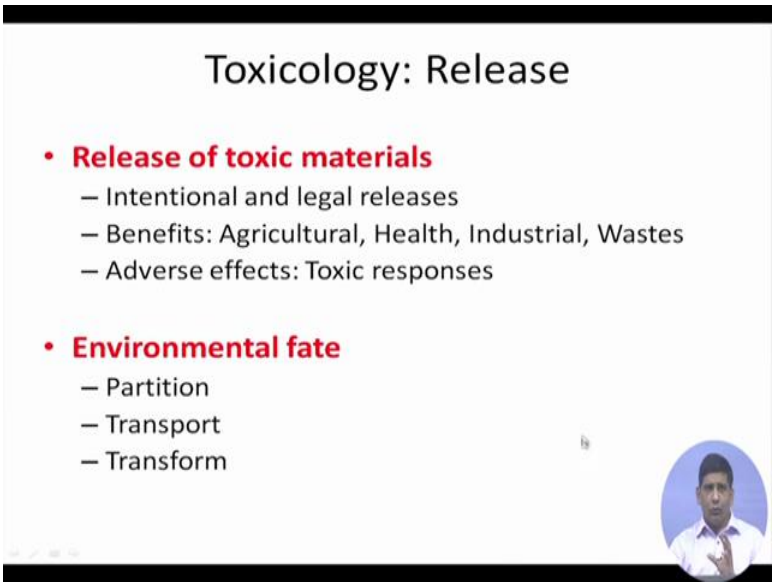

So, that is how the toxicology works. So, in terms of the toxicology first the things to come where the things to come into the environment they has to be release of toxic material and this release could be either would be intentional release and legal release. So, intentional release is when say if you are burning many times you may have seen people burned garbage along the side of the road they will do the street sweeping they sweep the road they put it in the corner and then torch it. So, when you are torching it they are actually realising lots of chemicals into the environment especially if you have plastics and other things present there you are getting a lot of you may have get PAH polysetlic trimetric hydrocarbon could potentially have some dioxides furnace and other things of there as well. So, that is the intentional release.

Legal release is when you walk through a any of this plant you see a big chimney it is having all these smoke coming out. So, this smoke is all though it may meet the air pollution quality standard what whatever is needed from the environmental protection agencies, but still there will be traces of these pollutants coming out. So, that is the legal release then you have agricultural wastes health care waste industrial waste solid waste all these things will have release of toxic chemicals and the adverse effect is the toxic response.

Then other thing is the important is look at the environmental fate. So, it is not only the things coming into the environment where it will end up where it will end up we try to

find out with this 3 concept one is what known as the patrician; patrician means say if you have a chemical release take the example of a truck carrying petrol for some reason gets in a accident and gets damaged on the side of an highway now you have this petrol leaking from this truck and getting into the getting into the surface now part of it could stains surface could part become part of the become gets mixed up with the soil part of it since petrol is volatilize it can volatilise if part of it can go into the air part of it can also travel through the soil and potentially go into the ground water if there is a rain event part of it can mix with the rain and can go to the surface water. So, that is the patrician. So, patrician means at what fraction of these chemical will end up where whether it would in the soil whether it will be in the sub surface or the surface layer of the soil whether it will go to the air whether it will go to the water and we need to careful because based on where they end up the exposure is different. So, we need to find out that.

And the second part is the transport like how these chemicals will move; say if it is in the top surface of the soil whether it will go through the soil layer whether it will go into the sub surface if it goes to the sub surface easily; that means, the more chances of ground water pollution. If it does not go through the sub surface easily then less chances of ground water pollution also depends on how deep is the ground water, what kind of soil we have in the in that layer if there is a soil has too much of effect layers soil has too much of organic matter where these chemicals may gets bound up we may not see that much of problem.

Then transform is whether the chemical will transform to some other form of after being exposure to the environment sometimes they get transformed into a more harmful chemical especially TCE titan ethylene when they transformed into the environment they produce dotter products more dangerous than the original TCE.

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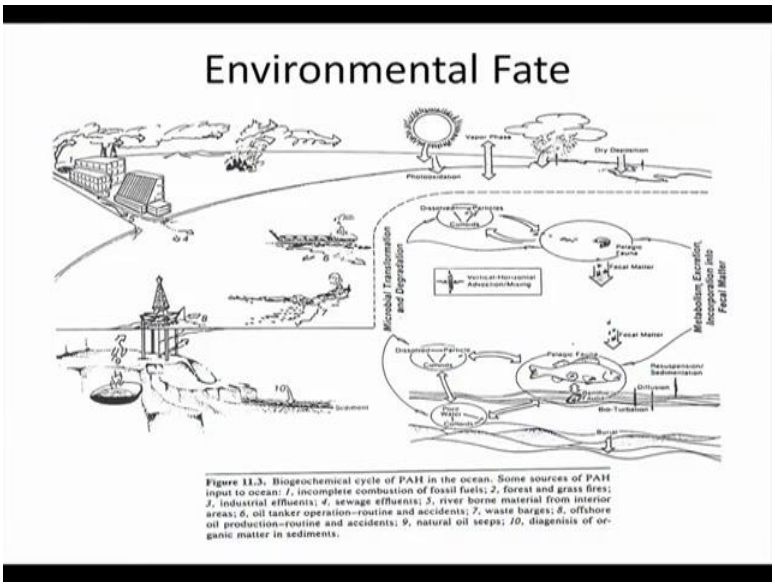

So, this slide kind of social the whatever I was trying to explain in the previous one where its environmental fate like things may move around. So, here if you look at if you have a chemical release and then the release may have a there is wrapper surface depends on whether if its vaporised it can go into the wrapper surface they could be some dry deposition it can go into the water in the water it can get dissolved it could be in particle form could be in polite forms then things may be taken up by other spices there and then it they it they may excreted that is part of the fee gal matter the fee gal matter may can get deposited into the sediments then part of it could be taken up by other spices which can go into the soil. So, these are how things can move around.

Similarly, you may have some of the like they power plant things being released into the environment. So, these are like how things may move around see affluent here is sea way treatment plant often from sea way plants, so all these things kind of things moving around into the environment for different kind of chemicals.

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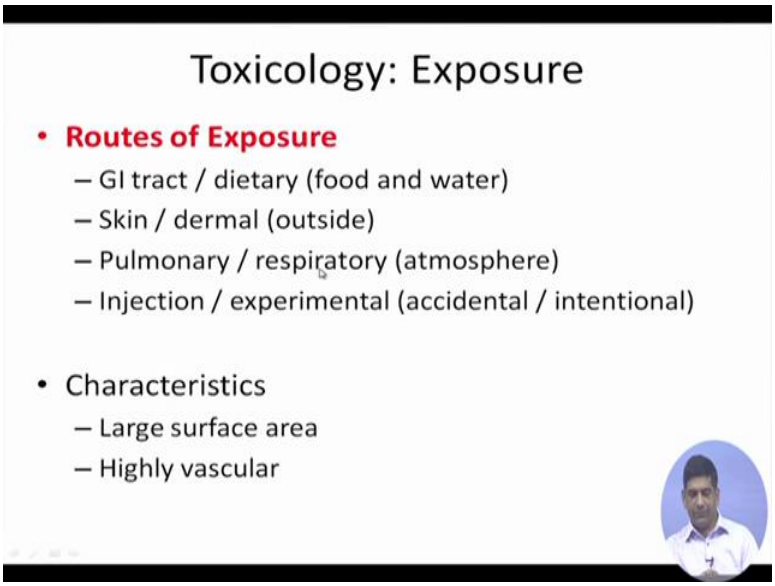

So, exposure as we one of the exposure is when we take food and water when you eat something you are exposed to chemicals if you are eating that food is contaminated one exposure other exposure could be skin or dermal exposure that outside that you touch pulmonary through the inhalation to the inhale when we take our like a breathing that is another like a exposure that too we can we can take some of these ait pollutants with that.

And injection where you may have injection experimental or accidental or intentional if somebody is trying to harm you. So, that is then in terms of the characteristics if it is the large surface area more the surface area better is the reaction and if it is a highly vascular. Then it also leads to this kind of problem.

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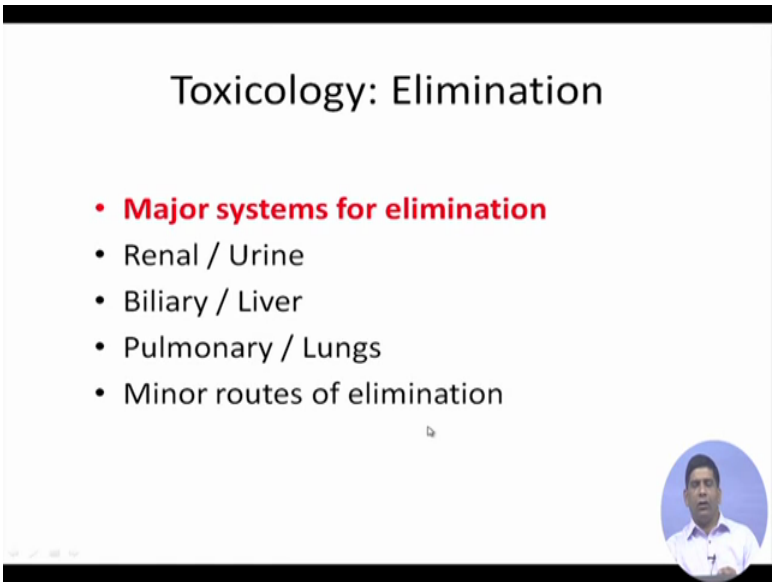

So, and how the toxicant come out our body through urine through liver function lungs function through exhale minor outs of elimination as part of sweat and other things also do come out.

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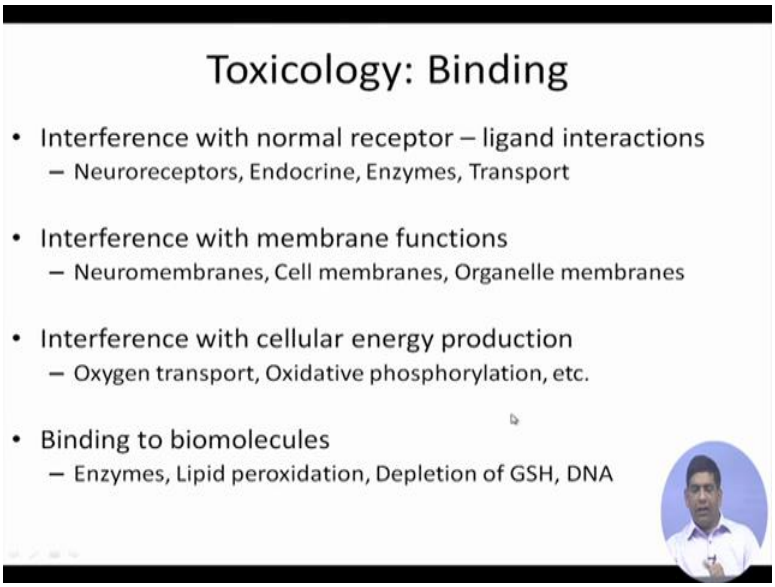

Then there are toxicology has to can bind up which we are talking earlier. So, it may interfere with the normal receptor like a ligand interaction where the neuro receptors endocrine enzymes transport those things are taking into picture. There could be interference with the membrane functions it will have a neuro membranes or the cell

membranes. So, they becomes that is again part of that. So, that is it interacts with the membrane function.

There could be interference with the cellular energy production. So, like a because of the oxygen transport ox oxidative phosphorylation. So, that is we are we interfere with the cellular energy production. So, like a because of the oxygen transport oxidative phosphorylation. So, that is where interfere with the cellular energy production or even the binding with the biomolecules in terms of the enzymes led. So, there are different ways this toxicant can react with our body with different cells or different DNA and other stuff what is present over there.

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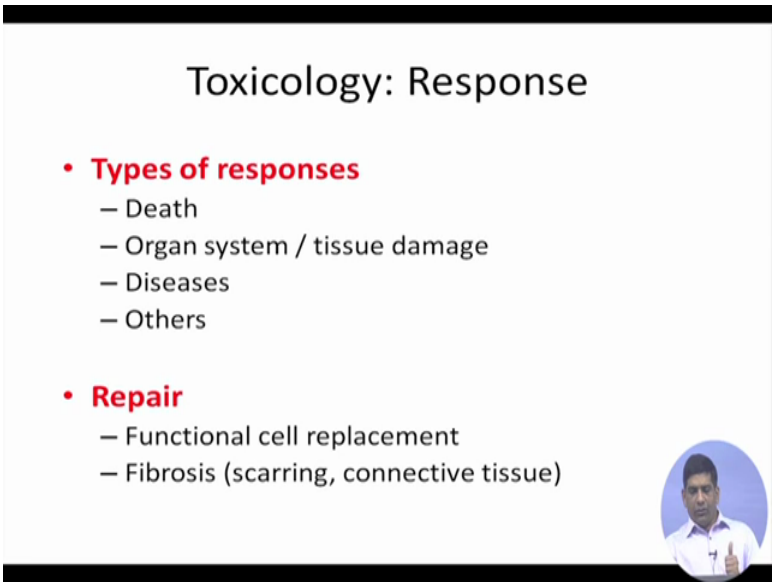

So, in toxicology one thing we talked about is the exposure the other thing is the response. So, response is either it can lead to death some chemicals do lead to death immediately if you have like if you have familiar with if you remember we had the issue of a what say terrorist of Nigerians in Sri Lanka, LTTE which is very much wild out now we do not hear about LTTE anymore, but LTTE which was liberation tiger of Thamililum; it is said that they all the volunteers or all the people working for LTTE they used to carry a necklace with the capsule cyanide. So, if they are caught they will eat that cyanide and they will die immediately. So, they do not want to be caught if because if they are caught they may release some other secretes of the organization. So,

to avoid that and of course, there will be tortured. So, they avoid all that just take those cyanide capsules. So, that will lead to immediate death.

Similarly there was a incident in few years back in one of the university in US in Duke University I remember correctly there was a lady who has working on in the lab and for some reason she just had a wrong set of gloves working with mittal mercury, mittal mercury as you may have hard is highly poisons highly toxic. So, she had a wrong set of gloves this mittal mercury pass through her gloves into the skin and by the time the paramedic arrived which in US system does not take much time all thought it was a Sunday, but within 10 to 15 minutes she was gone. So, that is leads to immediate death.

So, some of the chemical do lead to like a very quick response, but some takes a longer time of that is depends on the latency period that we talked about earlier, but it may have at impact on the organ system it can damage your tissue it can lead to all different types of diseases. There could be other kind of impact we may feel dizzy you may not feel like working you get a headache and so those kind of things happens when you are those are the type of response.

Some of these response our body has our own immune system for different people the immune system is different as I was trying to explain you in the previous module as well that it depends on how of fit the person is sometimes for the same kind of weather condition one person may get cold cough and cold and that, but the other person may be just not get anything. So, it depends on how good the body is in terms of taking care of those kind of those kind of impact.

So, that is, but our body can repair our itself that is what if you like when you go to sleep 7 8 hours want to sleep lot of cell replacement takes place. So, your body gets like a there they repair by themselves and they there also some connect tissues. So, fibrosis those things happens where things gets repaired and replaced. So, then you may not see the impact, but over the time if we get too much exposure to those chemicals over times our body also kind of physically kind of a fight between the bodies repairing system and the toxicants impact if whichever wins that kind of leads to that. So, as we get older our immune system becomes weaker or body cannot repair itself that faster. So, that is why we start seeing the impact of some of these toxicants coming in there.

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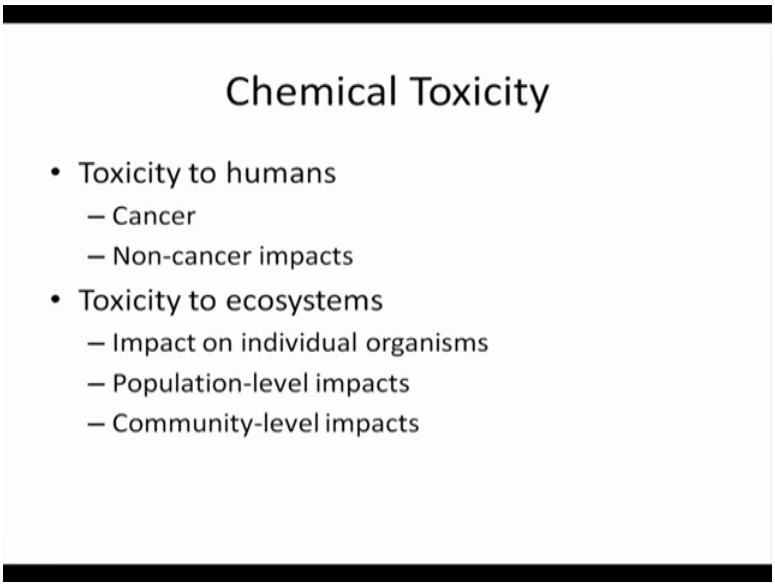

So, in terms of the chemical toxicity we talk about the toxicity to humans we saw some of these talked yesterday as well, we look at the cancer impact and the non cancer impact and. So, then toxicity to the eco system you can look at the impact on individual organisms it could be the population level impact or it could be the community level impact. So, individual organisms means that you are we have a toxicants say for example, any toxicant which is bad for a aquatic spices that is released into the one pound or a river or a lake and then you see that lot of fishes died or lot of other organisms like a one particular kind of organisms are getting impact. So, that is will be individual organism. So, when you are looking into one particular organism when you are looking at multiple types of organisms that is becomes your population level. So, where you have a fishes dying as well as other equitizes fishes dying you see the reduction in the like a growth of l g and all that. So, it is a multiple spices.

So, that is your population level impact then we also see community level impact one of the predominant one we seed these days is the impact on the honeybees I feel, if you follow the environmental news you may have seen that we are because of the use of the certain pesticide fertilisers and those endow sulpha and other kind of like a pesticides and fertilizer insecticide we are seeing and impact of communities of community level be are disappearing bees are dying. So, death of bees are very very serious matter because if the bee is not there, there would be no pollination no pollination means no food no food means we cannot survive for long. So, if the bees are gone from this planet it is very sure

that in few years down the line the humans will start having the big impact as well because without bees we cannot survive on this. So, there are cancer and non cancer.

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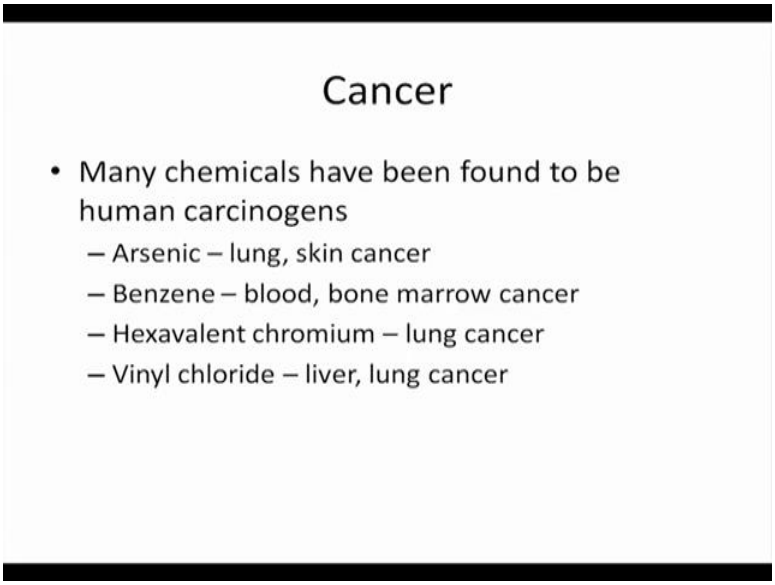

So, we will look at many chemicals have been found to be human carcinogen which we already talk about arsenic which there is a carcinogens lung skin cancer benzene is there which is the blood bone marrow cancer then hexavalent chromium also we talked about it again causes lung cancer vinyl chloride liver and lung cancer and these are just four examples 2 organic, 2 n organic, 2 organic.

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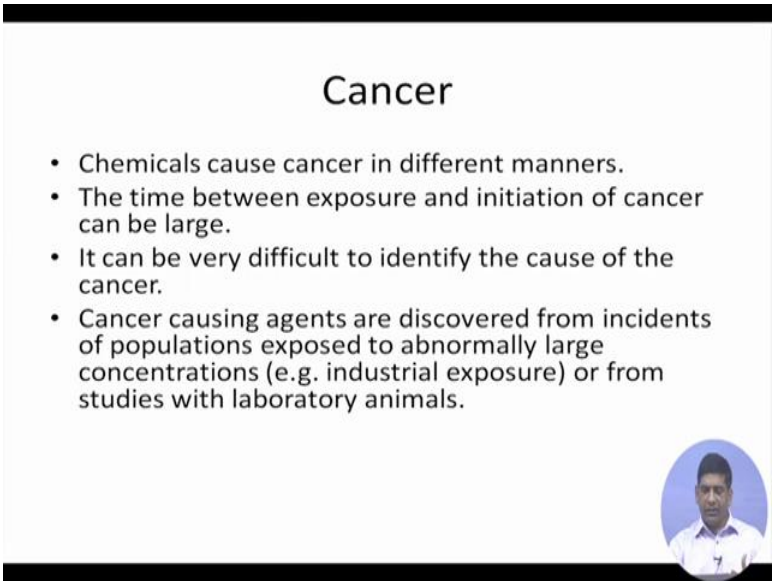

But there are lot of other things are out there well. So, cancer is a chemicals cause cancer in different manners the time between exposure initiation of cancer can be large it can be very it can be very difficult to identify the cause of cancer.

So, you are exposed to arsenic today and say a over a period of 1 week you got exposed to over period of 1 month you get exposed to arsenic nothing happen to you, but 10 years down the line you may you may digest with the say cancer. So, it is very difficult to point the arsenic exposure you had over a period of one month is the cause of the cancer because your expose to several other things as well.

So, the cancer causing agents or usually we look at the incidents of the population normally large concentration or we use it from the laboratory animals. So, that is kind of like if you look at the toxicology aspect some of these where look we were talking about in the risk assessment as well, but especially for those of you who are non biology background we would like these terms are very important because when we are trying to look at this whole environmental impact or lifecycle analysis what we are interested in, we are interested in to find out what is what is the harm it is going to cause to us to our plants to our water, to our soil and the harm is the toxicity aspect. So, if some chemical is does not have any toxicity aspect there would be no harm. So, understanding of this aspect is very important. So, we will continue this discussion again in the next module and till then.

Thank you.