Environmental Quality: Monitoring and Assessment
Prof. Ravi Krishna
Department of Chemical Engineering
Indian Institute of Technology – Madras

Lecture – 1
Introduction

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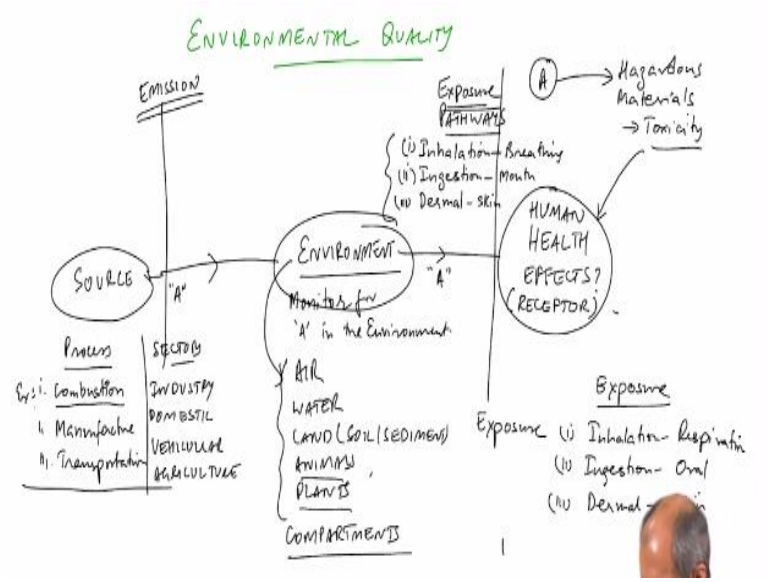

Welcome to this course on Environmental Quality, monitoring assessment. In the introduction video for this course, we have outlined the main objectives, the motivation for this course and the contents of this course. So, we will go over the detailed aspects of the purpose of this course and what it aims to achieve in terms of its material. So, we will start with the basic question of why are we interested in the environment? Okay. What is our interest in the environment? So, from an environmental health perspective, one of the main reasons why we are interested is in terms of health.

So, for example, if people observe a health effect in a series in a group of population, group of persons in a certain populations and there is a perceptible or measurable health effect, the question that comes naturally is what is the cause of this health effects? So, the cause of this health effects and why is this happening, and so one of the things that naturally what people will do is to investigate if this health effect is coming through an environmental pathway okay. So, there are different reasons why people may have health effects.

One could be something that the body itself is generating and there is something that is happening within the body and physiologically it is triggered, but they could also be triggered by effects from the environment. So, we are talking about something getting in from the environment. What we mean by environment is anything that is in contact with a human specifically talking about human health effects, anything is in contact with humans. Let us say that there is a particular entity, a particular material A that enters the humans and if that particular chemical or material A is not good okay.

So the technical word for something that is not good what we talk about is if it is hazardous. If hazardous materials, it can also be described hazardous materials have a certain toxicity, and based on this toxicity, the information of this particular material that the hazard coefficient or how hazardous or how toxic a particular material is needed for us to determine whether human health effect can be seen as possible to have a health effect. So, this is coming from the environment.

The question is how does it enter, how do we get in contact through the environment? We have what is called as pathways of exposure. See the other word that we are using here is this thing called exposure. Human beings are exposed to this particular chemical A, material A, and what are the different ways in which we can be exposed, they are called as exposure pathways. So, one of the exposure pathways is by inhalation, just by breathing, inhalation essentially means breathing.

The second one is ingestion. Ingestion is by the oral route, and the third predominant thing is the dermal or the skin contact. So, the exposure pathways, we have so first one is inhalation which is essentially respiratory, and ingestion is oral route, and the third is dermal which is the skin. The 3 ways in which chemical can get in contact with human beings can enter the system and then it has an effect on different organs or different functions of the human physiology.

So, once we investigate, whenever our first step is we see a human health effect, we now have a guess, we want to try to investigate to see whether it is coming from the environment. So, we need to monitor, we need to look for A in the environment. So, if you find this particular A in the environment, then which phase of the environment because this what part of the environment. So environment consists of several things, environment consist of air,

environment consists of water, consists of land in which we have soil, sediment, etc, any land based this thing, we have animals, we have plants.

These exposure pathways are also linked to this compartment, these are called as environmental compartments. The exposure pathways are linked to environmental compartment. So, if there is a chemical that is present in any of these compartments and it can enter a human being through this exposure pathway okay. So, when we monitor or we measure a particular chemical in the environment, and we know that we can guess whether it is coming through the human being, so one of these exposure pathways.

So, that is one linkage. Then if you find this in the environment if you find a chemical that is not supposed to be there in the environment, then the next question that we are asking is where is it coming from? So, we are implying that there is a source for this particular hazardous material coming into the environment. So, the source is usually a process, a process is a very generic term, process can be anything. For example, one example of a source is if you have a combustion process, that is you are burning something.

Combustion is a reaction and the reaction results in byproducts and this one of the byproducts is chemical okay. So, this combustion process results in the generation of a particular material which can be hazardous, so that is a source. So, you have automobile combustion of fuel, industry uses a variety of fuels, and you have all kinds of activity, economic activity and commercial activity and domestic activity that goes on which can release various chemicals into the environment, into air, into water and different compartments of the environment and it can propagate.

It can move from one place to another place in the food chain, so the animals, to plants and so on. So, this is a process. A process such as example, we have here is combustion, we have industry, manufacture, then we have transportation. You can classify these sources and processes in whichever way you want. Sometimes, this classification is based on a sector such as we have transportation industry which means that it is vehicles, all vehicles together.

Sometimes it is based on process, so vehicles can generate a pollutant into the environment by various methods, just the fact that the vehicle is running irrespective of the emission from the exhaust, is an exhaust emission that happens from vehicles that is one kind of emissions

that is happening from vehicles. There is also a secondary kind of effect that it causes what is called resuspension, vehicle induced suspension. So, this also can cause. So, this classification can be in terms of process or in terms of sectors.

So, we call it as industry, you can call it as domestic, you call it as vehicles, vehicular sector and so on, and agriculture and this kind of sectors, but it can also be divided in terms of processes. So, processes cut across different sectors. So, you can have combustion at home, we are combusting LPG or kerosene or something. You can also have combustion in the vehicular sector, we can have combustion in industry where such as power plants, we are burning something and so on.

So, that is a matter of convenience and how we want to deal with it from a management perspective, that sector wise distribution or process wise decision, but from a point of view of chemical movement, we are talking about it goes from a source through the environment and through a human. The term that we use here in this is called as a receptor. So, the receptor here is something that someone that receives the pollutant, exposed to the pollutant okay. So, this section here is where we have emission, we have exposure here and we have emission here.

So, there is a particular source and it is releasing a certain chemical at a certain amount and it gets into the environment, and in the environment, you have an opportunity to get exposed to it okay. So this in effect forms the basis for what we are looking at in this course, and we will summarize this in the next slide here.

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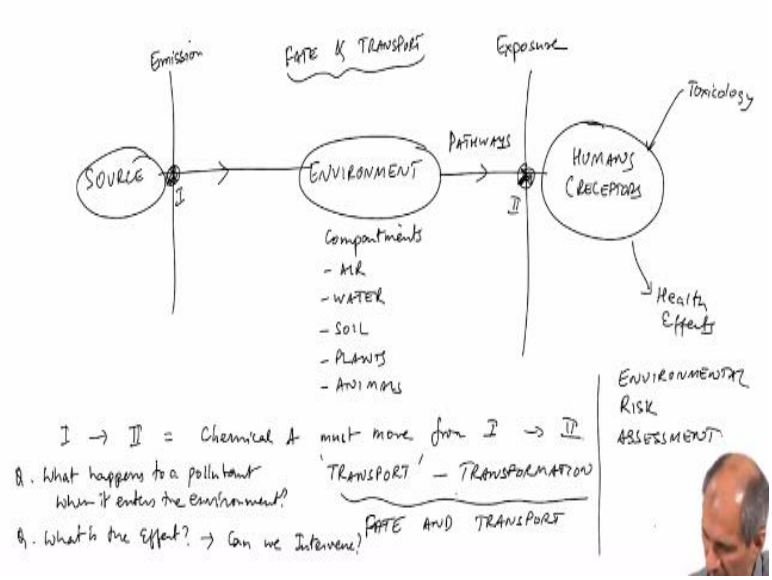

So we have the environment which consists of different compartments, so on and it is coming from a source. To this, we input toxicology information and this results in health effects. We are talking about this one is the exposure, this one is the emission, we have pathways. So there is another layer to this, is that when a chemical enters the environment at the emission point, so there is a point here. So there is a point of emission and there is a point of exposure right. From here to here from the point say, we call this as I to point II, from I to II, the chemical has to move.

For example, if there is a chemical that is released in a factory, and there is a human receptor, who is sitting or living maybe 5 kilometers away from this factory. It takes the chemical to move from that particular emission source through the factory, it must move from I to II. So in the process of its moving from I to II, so there is a transport involved in this. Then in the process of its moving, it can also undergo some transformation and this transformation can be a variety of processes.

It can react, it can absorb, it can assimilate into something else, and so on. So, we combine all of this into what is called fate and transport okay. So in this section, the sector in the environment, a chemical move from point I to point II, we are looking at fate and transport. So the fate and transport is a very important section because this determines what is the amount released at a source and what is the amount that is reaching and exposure at the human receptor level.

So, this course is looking at these kinds of this entire information from the emission to fate and transport exposure, toxicology, health effects, this is entire picture. Focus is in the central portion where we are looking at the several objectives the things that we can do in order to assess chemical behavior from its source to receptor and this forms what we call in general it constitutes a part of what we call us environmental risk assessment and helps us answer questions, a variety of questions.

So, one of these questions can be it helps us answer questions as to what happens to a pollutant when it enters the environment? Then the other question that you can ask is what is the effect, which means that how much of effect? Can you quantify the effect? Then it helps us, this question helps us in answering more advanced question as to can we do anything about it, can we intervene and it helps us make these decisions. This entire information in this slide will help us make that kind of decisions for that is all.

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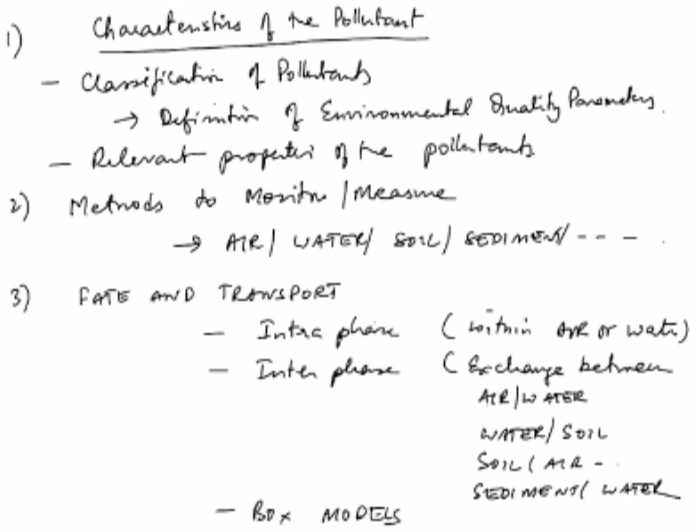

In the next slide, we will look at how we can do this. The first thing that we need to do is to understand the characteristics of the pollutant, because we are talking about the pollutant fate and transport and the pollutant toxicology and all that, so which means that we need to know a little bit more about the way in which the pollutant behaves in the environment. So, we look at characteristics of pollution, we are looking at classification of pollutants we first look at.

Since I am giving an outline for this course in terms of what we are going to be doing, first we are looking at classification of pollutants in terms of how we can define, definition of the water quality parameters, I am sorry not water qualities, environmental quality in general,

then the property, relevant properties of the pollutants okay. We will also look at the methods to monitor or measure. So, this we are going to be doing in different phases, we are going to find out whether we can monitor in air, water, soil, sediment, anything else and other area. So we are going to look at fate and transport.

So, here we are going to look at intraface, first intraface transport, which means within air or water, and we also look at interface transport, this is exchange between different phases. For example, you can have air to water interface such as and then we can have water and soil, we can have soil and air and so on. So, we can have different interfaces, there are sediment and water and so on. We will also look at what we call as box models, simple box models in order to try to monitor model the pollutant behavior in a given environmental system okay.

This is the outline, if time permits, we will cover a few more topics that are relevant to this, but this is the minimum that we will be covering in this course.

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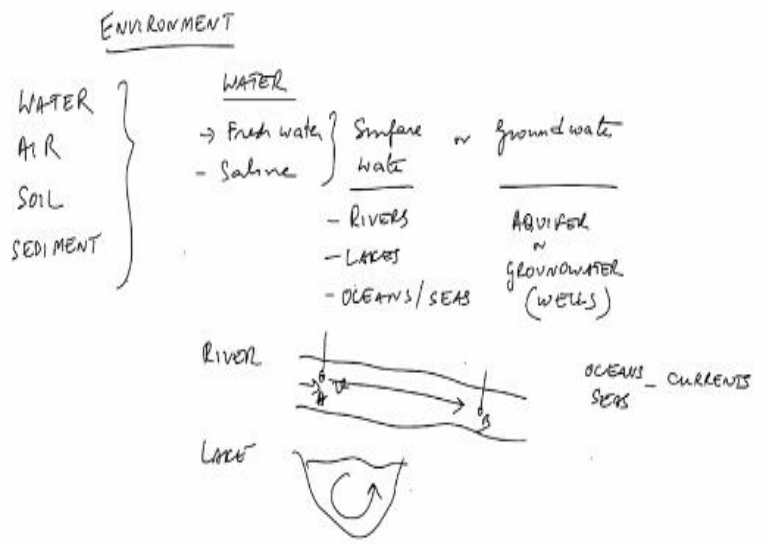

So, we will look at the first preliminary step we are interested in this. We are defining what is environment. So, what is environment? We look at the environment, the environment as we see around us, which is a couple of main things. One of the we are looking at water, we are looking at air, we are looking at soil, we are looking at sediment. These are the main natural compartments of the environment okay. So, here in water when we are talking about water, the classifications of water, the water can be classified again under various things.

So, this water we can call it as freshwater and saline. You can also classify this in terms of surface water or groundwater. So, freshwater and saline water indicate the quality of the water, what kind of water it is, what is the salt content that kind of things. Surface water indicates the physical state, where is it present, the location of this. So surface water, the example of surface water as the name suggests it is something that is exposed to air. So surface waters here we have rivers, we have lakes, we have oceans and seas.

Groundwater is groundwater, just what we call us an aquifer or which is under the ground, which is under the soil, so for example, the common source we have groundwater is wells okay. So, in terms of what we are interested in this, the reason we are classifying in this is each of these water bodies are different. They do not have the same characteristic. For example, the river, you know that river flows from one point A to point B, has a velocity and it flows from one point A to point B.

A lake in contrast does not flow, it is fairly static, but it does have internal flows, but it is not moving anywhere from different place to this place. It is all contained in the same thing, but there is a flow within a lake, and we will talk about that later. But a river goes from point one to point B over long distances, so we have rivers that are few thousand kilometers long, and we have rivers that are very short also, and we also have oceans and seas, which generally seems static, but they are also moving.

They are moving from place to place because of the wind movement and they are very large, so you cannot classify them as lakes. They are moving from very large spaces, they also have currents, which means there are rivers inside the ocean surface. So, these are in the context of fate and transport of pollutants, if I drop a chemical in the river here, it is going to go down to some place downstream and something can happen to the chemical in the process of it going from point A to point B, here where point A to point B.

Same here in terms of for a lake, it is not going from anywhere from very far away, but within a lake it will move from point A to point B within the lake. So, there is in terms of its fate and transport, there can be a significant difference if the pollutant is in the river or a lake or an ocean okay.

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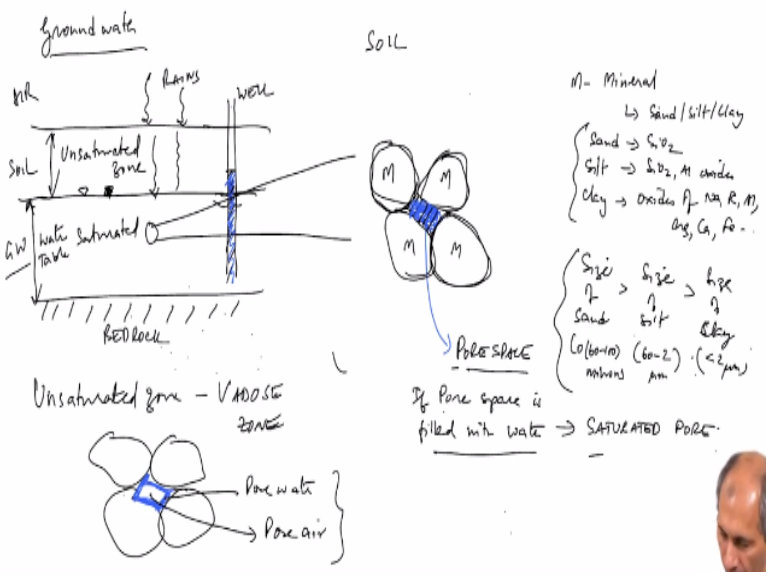

In contrast to this, groundwater, groundwater is something that is seen under a soil surface. This is soil surfaces air and groundwater what we call as groundwater is water that is present inside the soil somewhere here. So, this layer can be called as a ground war zone. So, to understand groundwater, I think we need to understand the structure of soil. So, we look at soil. If I take a small portion of this, soil may contain different fractions, the structure of soil, I am simplistically representing the structure of soil.

The soil contains a mineral fraction okay. So, this is we call this as M. So this mineral fractions is made up of sand, silt and clay. If you have sand, it is predominantly silica, silt is also predominantly silica and also we have aluminum oxides, and then clay it is oxides, the various oxides of sodium, potassium, aluminum, magnesium, calcium, iron and so on. So, the variety of again that is one. Second differences sand silt and clay. The size of the sand is much larger than the size of silt, is much larger than the size of clay.

This is the order of about 60 to 100 microns. This is an order of between 60 and 2 microns and this is less than 2 microns roughly. This size ranges are variable and can be from place to place people have definitions of the size based on this. So, you have a compositional difference between sand silt and clay and you also have a size different between sand silt and clay. So, these are present as a group and these are formed under long term geological processes that is one.

You also notice that one of the big differences is in between these two particles if you pack them, there is a gap. So, in this zone, this is called as a pore space, yeah, if the pore space is

filled with water, then it is called as a saturated pore. So, essentially groundwater is this layer where the pores are all saturated with water, that is the definition of groundwater. So, we represent it usually by the layer, the region in the soil, which contains this where the pores are saturated with groundwater is the water groundwater zone or the water table.

The water table is the upper limit, the upper limit of this thing, is the upper limit of this region. So, in this region, above this is called as the unsaturated zone. So, this is the saturated which is the groundwater, and this is the bedrock where below this there the water cannot percolate further. So, when it rains, the water can get in, percolate through this thing and it settles on top of the bedrock and it builds up to the level of the water table. So you access the groundwater by digging a well.

Now you drop a well here and the ground water from this zone goes into the well and comes up to some particular level okay. So this is how you access to groundwater. You access it using a surface well or dug well or a bore well which goes very deep depending on how far the water table is. So the water table can go up and down depending on the season and how much water has been used and how much rains have been received and so on. So these are all part of this.

So the unsaturated zone is also called as the vadose zone. So in the unsaturated zone, the structure, the pore space need not be fully filled with water, it is filled partially with water and the rest of the gap is filled with air. So, this is pore water and this is pore air. So this is the unsaturated zone okay.

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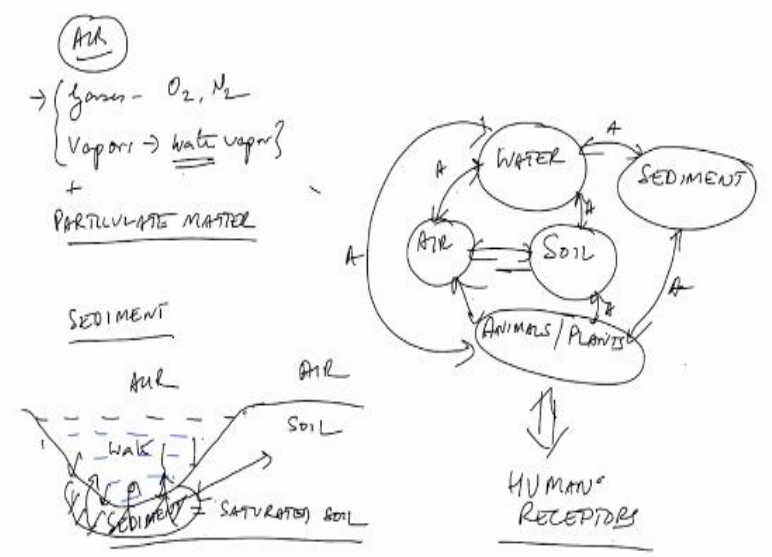

No air consists of 2 compartments. We are talking about air, primarily air contains a lot of gas, gases such as oxygen, nitrogen and so on. It also contains vapors like water vapor. What we mean by vapor is a gas is something that is in the environment in the conditions of the temperature and pressure in the environment exists as the gas phase, a vapor is something that exists as gas phase and you know solid or a liquid phase. For example, water exists as liquid water at room temperature, but there is also some amount of vapor.

So, this applies to a lot of things. So, you are talking about water and water vapor. So there is water vapor in the atmosphere and we are breathing in humidity, the water vapor. Similarly if you have another chemical such as benzene or some hexane or acetone or any other solvent, they also are volatile, which means there at room temperature you will also see a liquid and you will also see a vapor So, there is a presence of this and this is important from an environmental point of view and exposure point of view.

So, these 2 are there. In addition to this, we have particulate matter just suspended in the air. So, the air phase consists of all of these okay. So in the environment, there is a chemical that enters water, it can move to the soil, it can move to the air, it can move to the plants, animals. So, there is a lot of interaction in the environment, you have water, you air, you have soil, you have sediment. So, what is sediment, before we go on further, we like to give a brief this thing on sediment. Sediment is something that is underwater.

For example, you have a lake. This portion is, so this is sediment, is anything under water is sediment. The structure of sediment is very similar to that of soil and in fact the saturated

soil, which means that all this water is in contact with the sediment, which means it has gone in and saturated the mud under the water okay. So, under a river or under a lake or oceans, you have sediment in which the pore space is there, all that pore space in the sediment solids are filled with water.

So, this structure is very similar to that of an aquifer, and this is of great importance from an environmental standpoint because large sections of the environmental problems in developing nations or developed nations come from the disposal of chemicals into water bodies, it be rivers, lakes or the ocean and a large number of chemicals go and settle in the sediment bed because they are unable to go in the water, it means they are insoluble in water. So, many of them get settled in the sediment.

So, over a period of time, this chemical can get released into the water. So, that is one of the significance of having a pollution in the sediment zone that is there. So, there is exchange between sediment, and the sediments have a connection to soil because the region next to the sediment is soil. There is a natural connection between them as there is a connection between soil and groundwater and the lake water and so on, and there are animals and plants which live in both soil sediment.

So, if there is a chemical, this chemical has interaction between air and water, chemical has interaction between soil and air, chemical has interaction between soil and water in terms of groundwater, in terms of sediment chemical can interact between, I have put two-way arrows because the chemical can move in both directions, then we have this, then we have this, then we have this, we can also have this and so on. So, wherever I put the chemical, a particular A, it can move into a different phase.

Then all of this, this entire zone, then we all have this, this entire zone can have human receptors, can have interaction with the human receptor. So, this in essence is the overall picture of the environment and its relationship to this problem that we are talking about. So, in the context of this course, what we are going to be studying is the relationship between in terms of the chemical properties and in terms of its transport and fate between each of these phases, the chemical, in order to understand that, we need to understand properties of the chemicals and the properties of the environment itself, the environmental property becomes important.

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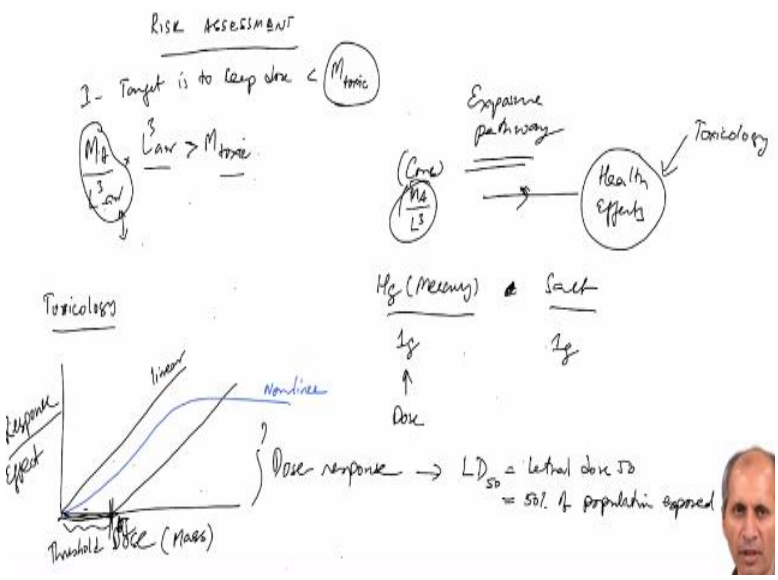

The last section I want to cover in this introductory class is the issue of what is its role in risk assessment okay, health risk assessment. So, we are talking about health effects from toxicology. What is this toxicology mean? The definition of toxicology, toxicology is defined in terms of dose response or toxicology in its very strict sense we will talk in terms of, so when we talk about dose, we are talking about mass. Dose is essentially mass.

So for example if I have a chemical, I have a Mercury and salt, both of them, one of them is known to be toxic, the other one is not known to be toxic, but if what I mean by this relative toxicity is if I have 1 gram of mercury and 1 gram of salt, 1 gram of mercury can have a very strong effect as 1 gram of salt. So, in terms of this if this gram here is what we call as dosage and the effect the response is the health effect. This health effect could be impairment of some function or it could also mean fatality in a given population.

So, this dose response is expressed in terms of relationship. So, a dose response could be like this, which means at zero as soon as the dose increases here, there is a response or it will also be like this, which means that there is a threshold. This is all linear, it could also be a linear or a nonlinear curve, it could be a relationship that could be like this, which is a nonlinear relationship. So, this information which is called as dose response is expressed in terms of toxicological indices.

For example, dose response is we will say in terms of one either different examples of this, one such example is called as LD50 which is lethal dose 50, which means it is a defined as

the dose at which 50% of the population of this receiving the response will die. So, this is derived from experiments conducted with animals, that is the basis of that. So, it is a number, the reason we are saying 50 is that you will notice that this dose response is not uniform for everybody.

If you take a population of 100 people in a given population, all of them do not respond in the same manner for a particular dose, they all respond differently, and that is the nature of the way receptors interact. So, this is the reason we need the statistical significance of a response of a particular thing and as unfortunate as it might be all risk, the way we measure this in terms of probability, in terms of the statistical this things and because and one has to make decisions based on that and other parameters in society. So, this is the way we do it.

So, we are talking about a particular health response. If you do not want a response, for example, if you say I do not in the case of the threshold level, I say there is a particular dose that I want. So, this is particular dose, let us call it as point I, the target is to keep dose below mass toxic. So, if goal is to keep it mass toxic less than this, so what we are looking at is this exposure pathway. The exposure pathway is in terms of concentration.

There is a concentration here in, let us say this concentration here in terms of mass of a chemical over volume of air, there is a certain amount of air that you are breathing. So, if M of A, this is a mass of this thing per volume of air multiplied by the volume of air that you breathe, if this is greater than M toxic, then this concentration is considered to be dangerous. So from a risk assessment point of view, we are looking at concentrations in the environment, we are looking at this concentration, mass over volume, and we will go over this again in terms of the definitions of our these things, but this is general structure.

So this is useful in determining what is the exposure standard, how much of chemical in the environment is acceptable, and so on. So we will stop here with this particular module, and in the next lecture, we will discuss a little more about the nature of chemicals and the classification of this chemical. Thank you.