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NPTEL ONLINE COURSE

ECOLOGY AND ENVIRONMENT

Risk Assessment and LCA: Lecture 1

Definition of Health Risk

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Ecology and Environment

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Hello. Welcome to this module on risk assessment and lifecycle analysis as a part of the ecology and environment course. My name is Ravi Krishna from the chemical engineering department at IIT Madras. In the next few lectures, we will be discussing aspects about health risk assessment and several factors that cause health risk, and we will also discuss why – how we can manage this kind of health risk.

So, as the slide shows a general overview of what we will be addressing in this particular module. Public health concerns about health effects due to environmental factors. We know that, we see newspaper, news in the media, public media and also we see it around us sometimes there are a lot of concerns about public health. The earliest big, large-scale incident about public health was the London smog somewhere in the mid-20th century where there was a lot of smoke in London and people did not know where it was coming from. It is around about 1940s or 50s and in the 50s around World War II, that time and people did not know where it was coming from, and it caused a major outcry and a public health problem. That was one of the first instances of that. The other instance is smog in Los Angeles and more recently dust in New Delhi. So, these are all issues that the public faces, when we are looking at a certain issue in the public domain and people are worried about it, and then we seek answers.

Why Health Risk Assessment?

- Public concern about health effects due to environmental factors
 - London Smog
 - Smog in Los Angeles
 - Dust in New Delhi
- Questions are raised as the cause of these health effects?
 - Were these health effects observed earlier?
 - What is causing the health effects?
 - Is it because of pollution?
 - Pollution has a connotation that someone is releasing something into the environment?
 - Therefore, who is responsible? (Liability)
 - Is it possible to control or remedy the ill-effects of the pollution (Environmental Management)
 - Who will pay for it? (Compensation)
 - Is it possible for us to predict? (Risk Assessment)
- Is there an organised methodology for this entire process
 - Life Cycle Analysis (LCA) and associated tools
 - ISO

The questions that are raised as this kind of health effects are you know, were these health effects observed earlier. The first question people ask us is something that is new, and it was not seen earlier. And the next question obviously is what is causing these health effects. So, there is something some factor that is responsible for these health effects. And in the case of London smog and the Los Angeles smog and dust in Delhi, it is visible. So, the physical manifestation in the cities whether preceded the health effects and people obviously were afraid that something will happen to the health. But oftentimes you do not see that. You do not see a physical manifestation. You first see the health effect, and then one tries to investigate what is the cause of these kind of problems. For example, you might have a health effect that is arising from drinking water from a particular well but you will not you might not even see what is causing it and so, therefore, investigation of those kind of effects becomes much more difficult, but it all comes under the same scope in that there are health effects and then we would like to know what is causing them and is it because of pollution. Sometimes people assume that pollution is a cause of it and the reason we do that whenever we have health effects there are multiple reasons why one can have health effects. One can be – one can have a genetic predisposition to that or a particular which is nothing related to an environmental factor. So, these kind of reasons also exists for health effects. So, we would like to isolate if it is an environmental reason that is causing this problem.

So, and if it is established that it is because of pollution into the environment, the next question one would like to ask is who is causing it, who is responsible, and this comes the question of liability. The liability is a very important aspect. We will discuss this briefly in one of the modules later. So, who is responsible because as we talked about there are different cases in our society where one particular section of the society is responsible for environmental pollution, and the rest of the society has to bear the consequences which is health risk or any other form of risk, then there is a responsibility of the person who is polluting, to take care of it, to pay for it, and the scope of that is what is classified as liability. And then the next question people ask is okay it is done, the damage is done, or it is being done so we know who is responsible. So, is it possible to control or remedy the ill effects of pollution? This comes under the purview of what we call as environmental management and the next question when you do all this, and there is a cost involved in this, and that is who will pay for it. This comes under liability and also compensation. So, there are health effects which means there is going to be expenses, medical expenses and there are some compensation is given either to a society at large or to the government or some some such entity which is determined after an investigation, and the last question that one would like to ask is is it possible to predict this health risk, and what we mean by predicting this health risk is, there are different classes by which or different types of events by which this kind of health risk can arise. One is due to normal operation; business as usual. People are

doing something some activity, and as a result of that, we would like to know if a health risk can be predicted based on that activity. The second aspect is if there is a sudden accident, that kind of thing, would it be possible for us to predict an emergency response or prepare ourselves for an emergency response. The idea of health risk assessment or risk assessment in general. Risk assessment is the term used very widely. It is used for economic risk, risk for environmental health, risk for financial risk, risk for other things also social risk assessment. So, in the entire purview of risk assessment, health risk is very important because it pertains to human beings and therefore we are asking all these questions. And finally, we would like to ask, is there an organized methodology? It seems like it should not be a knee-jerk reaction where something happens or a reactive process where something happens, and then we group around and try to evolve a solution but is there an organized methodology. Where right from the beginning we incorporate the principles of the risk assessment and reduce. When we do risk assessment it implies that we are – we have a goal for reducing the risk and therefore can we implement these principles right at the stage of the design. And this is where this lifecycle analysis or LCA and the associated tools that we use with it comes into play. Along with this, there is also organizations which are regulatory bodies and international body agencies which also have guidelines. One of those is the ISO guidelines. The ISO number for environmental assessment. They have, they keep revising their guidelines and in order to help people to plan this process of risk assessment in a more organized manner.

So, with this introduction, we will go ahead in this module in this particular lecture and talk about environmental health risk and the definition of that. So, we address the following questions; what is environmental health risk? In this particular lecture and then how does it happen? And how do we characterize it? In a sense how do we quantify it? Because we need solutions. We also need to quantify risk because there may be several risks and we would like to know which one is the more severe one, so we can address that first because our resources are limited. And there are different types of health risk and how can technology help in this. This lecture and the following lectures, there are a few lectures that we will cover this question in. One of the things that has come out in the discussions also in the other modules when we talk about ecology and environment, we also talk about economics as a consequence or as a very important factor in it which determines how effectively we do some of these things. For example, in the previous slide, we said we have there is liability, there is compensation, and all that and the reason why people are focused on this is all of this cost money. Doing environmental health risk assessment and preventing it and managing it costs money. And in general, people see environmental management as an overhead. What we mean by overhead is, it is not essential to the economic activity of a particular process. It is seen as an externality. It is seen as something it is, as a nuisance in some sectors. So, the goal in the current scenario in the way the governance is going is that we would like to incorporate environmental management into the basic design of a particular process, whoever the process may belong to, it may be an industry, it may be a government, it may be any other agency that is trying to do something including remediation work.

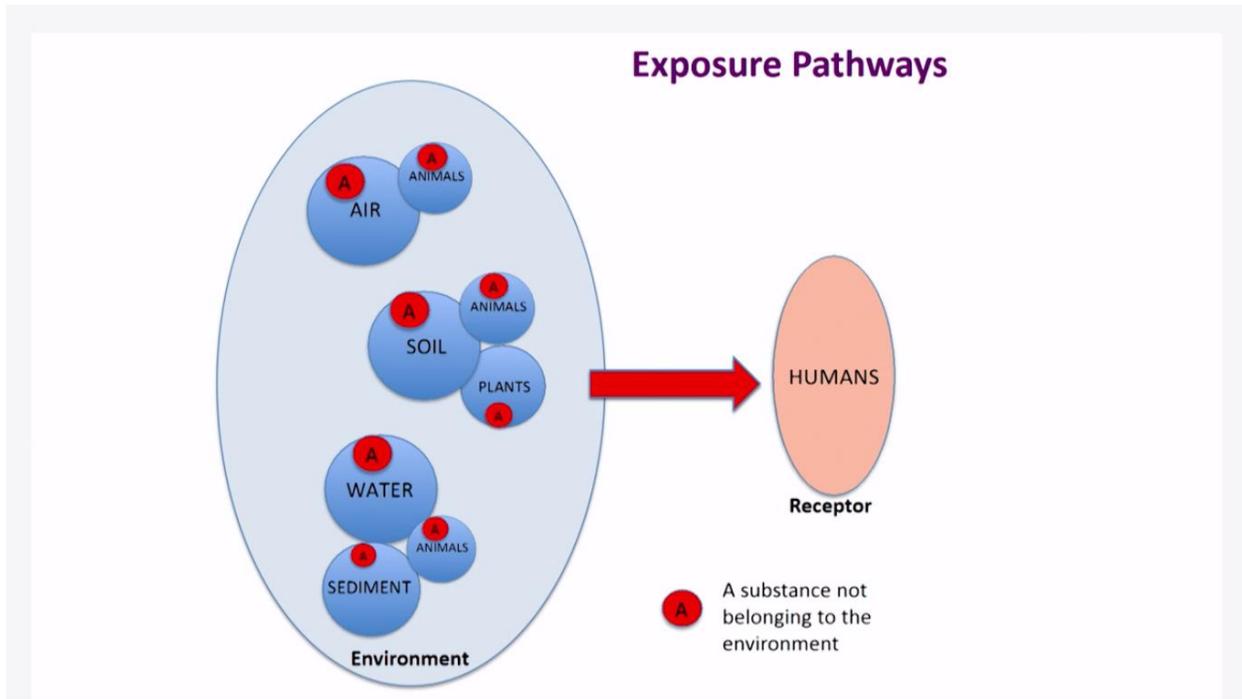
What are we really worried about?

- Health effects such as
 - Respiratory ailments
 - Shortness of breath
 - Allergy
 - Gastric ailments
 - Gastroenteritis
 - Dysentery
 - Long term illness
 - Cancer
 - Effects to other critical organs

And Many More

So, what are we really worried about? We are worried about health effects. Health effects such as respiratory ailments, it includes shortness of breath, allergy, you know something some problem with the stomach, the gastric ailments or long-term illnesses such as cancer or effect to other critical organs and a lot more. So, when we see, we look in newspapers we are always concerned that we have an ailment we would like to see if there is an external factor involved in it and this external factor usually is an environmental factor. For example, how do we get these health effects? This one possibility as I mentioned earlier is a predisposition of the body to react to certain things, but sometimes it is also inherent. There may be a deficiency that may be happening, but there are environmental factors that may be responsible for this. The most commonly seen environmental effect is allergy; nasal allergies. When we go out on the road, many people suffer from nasal allergies. We have runny nose. We are sneezing and that kind of thing. And so we know we can relate that we have a respiratory ailment. So, it must be something that we breathe, something in the air that we breathe. Air is clean. We usually do not expect this kind of behavior, but if there is something harmful in the air we breathe, we may have a respiratory ailment. Similarly, if something is there in the food or the water we drink we get – we may get ailments to the digestive system or other internal organs, and we also can have ailments to the skin or eyes when we have direct contact with these harmful substances.

In the environmental jargon, the method by which a chemical can get into the body or a person can get exposed to a particular harmful substance is called as an exposure. As an exposure to that particular material and there are different pathways as we have discussed here already. If you breathe, it is called as an inhalation pathway and if we eat it is called as an ingestion pathway and if you have come in contact with it for eyes and the skin it is called as a dermal pathway.



So, these pathways are related to media in the environment. So, we have in the environment we have air, we have soil, and we have water. The three are the major compartments in the environment. We also have sediment. Sediment is something is the mud that is present under water in lakes, rivers or the ocean floor. We also have animals and plants that live in these media which survive in these media and which rely on this environmental media. Together we call this as an environment. So, when we are talking about environmental pathways, we are talking in relation to human beings. Humans are taking material from the components of the environment. So, we eat, we breathe the air, we drink the water. We also rely on the animals and plants for our food and so if there is a harmful substance and so the human beings here are called as receptors. A receptor is a general term that is used in environmental – in the convention of environmental sciences, is anything or anybody who receives a particular substance. So, this can be anything. A receptor need not be a human being. It can be a plant. It can be an animal. It can be air, water, soil or a building. So, in the context, overall context of this, we do not differentiate between the classes of receptors; anything can be a receptor. A sensor can be a receptor. So, it is a general term but in the context, in our context, we are worried about human health risk assessment. So, our receptor here in most of the cases is a human being.

And let us say there is a substance “A” that does not belong to the environment. So, it is a natural environment it is not there. So, it is a substance that is introduced. So, in the context of things when we are talking about health risk assessment, we have a health effect, and we want to know what is the cause of this? We are saying, is pollution a cause of this? And the reason we ask is there are some natural causes also which can cause some of this ailment. For example, pollen is released by trees, by flowers in a particular season and we all know that during a particular season people are very susceptible to nasal allergies. They say it is a season and a lot of pollen is in the air, and therefore certain cities have a lot of pollen, and therefore somebody is susceptible to this kind of this thing. And that is the reason I classify this as a substance not belonging to the environment which is the signature of pollution. Somebody is doing something which does not belong in nature and therefore if it is released in the environment, so what happens? So, if a substance that does not belong in environment comes through and it goes into every part of the environment and if it enters every face of the environment, then it can enter the human beings. And when it enters human beings and over a period of time a constant exposure of this particular environmental phase to human beings, this thing grows, it accumulates in the human being. And at a certain point when it accumulates a human receptor can fall sick. So, this, in general, is the exposure pathway, and then it will manifest as health effects.

Toxicology and Health Effects

- Acute Effects
 - Physiological effects observed within a short time (seconds, minutes, hours)
 - Examples
 - Irritation of eyes, skin, respiratory tract; depression of central nervous system; headache, nausea; loss of coordination, vomiting; mental weakness; etc.

So, toxicology is a term that is used in order to formalize this health effect. So, the health effect is an effect. Toxicology is the reason why one may have a health effect. So, when we talk about health effect, there are two kinds of health effects. One is called an acute health effect which is where the effects are seen immediately in a very short time scales, for example, this time scales are seconds, minutes and hours. So, for example, if you go into a room where there is a harmful chemical immediately you your eyes are irritated, or you have sneezing. You know that it is a quick effect. It is an acute effect, but it is quick, fast and if some of these acute effects can also lead to fatalities in certain cases where extremely poisonous substances are there, and it can lead to fatalities.

Toxicology and Health Effects

- Chronic Effects
 - Effects are not observed immediately
 - Physiological effects seen after prolonged exposure and are manifest after a long time
 - Days/ Months / Years / Decades
 - Several categories of chronic effects
 - Gradual Internal organ damage
 - Teratogenicity – Birth defects
 - Mutagenicity – Affects genes
 - Carcinogenicity – causing cancer

CHRONIC EFFECTS ARE MORE DANGEROUS SINCE IT IS DIFFICULT FOR THE RECEPTOR TO REALISE THERE IS EXPOSURE AND MAKE AMENDS

On the other hand, we have something called as chronic effects where the effects are not observed immediately. And physiological effects are seen after prolonged exposure and are manifested. What we mean by manifested, is symptoms start showing up very late and some of sometimes it can be months, years or even decades before it shows up and for the same reason why it has to show up, for it to show up it needs to accumulate in the body to some certain extent and several categories of chronic effects, we have gradual internal organ damage. Then we have teratogenicity which is birth defects. Mutagenicity which is transmitted by genes to the next generations and then we have carcinogenicity which is cancer-causing. So, there are different chemicals that are known or suspected to cause cancer or suspected to cause some of these things, and we will see what we mean by suspected reasons.

The chronic effects are in a sense more dangerous because we do not see the effect immediately. Somebody is exposed to something for a short period of time they say it is everything is fine they go on with their business and they keep doing it for 10 years without realizing that there has been a slow exposure over a period of time and therefore they may be exposed to something that may cause a long-term ailment. So, that is called as a chronic, and a lot of things that we see in the environment in terms of pollution and contamination and the health effects come under this category because the concentrations of some of these chemicals are very small, but due to accumulation over a long period of time, it can cause an effect.

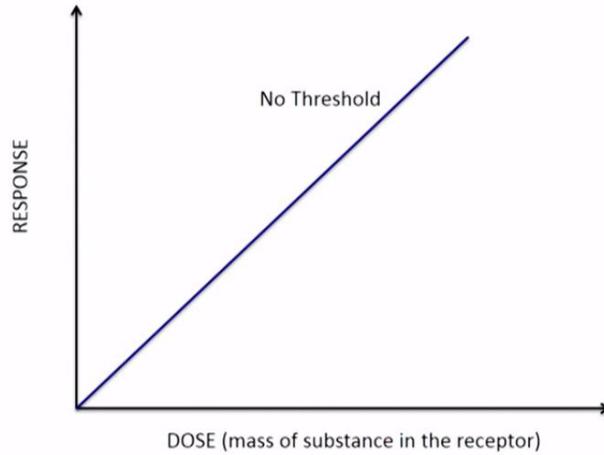
Toxicology

- Index of Toxicity
 - Two different substances A and B have different toxicities – say, Mercury and Common Salt
 - 1 mg of Mercury may have a greater health effect than 1 mg of salt.
- Toxicology of a substance is characterised in terms of a Dose-Response Curve

So, we need an index of toxicity or toxic. What we mean by index is the following. So, there are two different substances A and B have different toxicity, say Mercury and common salt. Obviously one milligram of mercury if you ingest one milligram of mercury and one milligram of salt the effect is not the same. Some one milligram of Mercury which is likely to be more hazardous than, more dangerous more toxic to a human being than one milligram of salt.

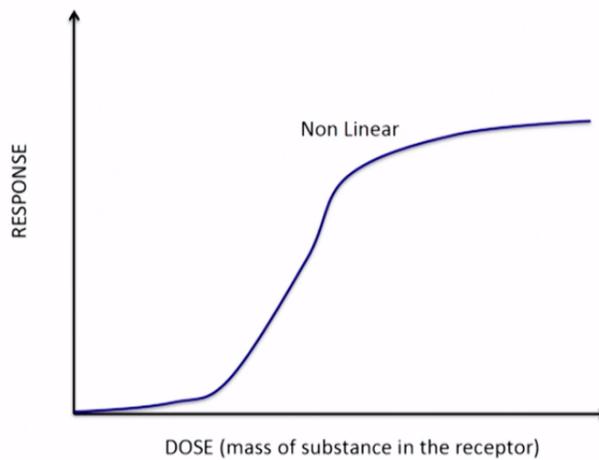
So, in order to characterize the toxicology, we use what is called a dose response curve. The dose response curve is a relationship of the response of a receptor such as a human being to the amount of substance that is ingested by the receptor.

Dose Response Curve



So, in this, the dose response can be a straight line like this which says that for every nonzero amount of material that is ingested there is a positive response, there is a certain response. We just call it as a no-threshold response. There are also responses which is called a threshold where below a certain dose nothing happens. There is no response at all, and there are also things like nonlinear responses here.

Dose Response Curve



So, one of the things that one has to keep in mind is dose response, the response is only limited by the way in which we can measure the response. So, as we have gone ahead in technology in medical diagnostics technologies, this response, our sensitivity of the responses which means the capacity, the capability of our - for us to detect a response has also increased and therefore we are now able to see a lot more response of health effects symptoms that earlier we were unable to see until it reaches a certain point. This directly relates to technological advances in diagnostics and in the ability for us to measure certain components in the system. So, this dose response relationship curves will change over a period of time as and when we have new information available. So, this is not set in stone, and this is liable to change. As you keep hearing news reports that some substance which 20 years back was considered to be safe is now considered unsafe. That is because we know more about the response because we are able to measure responses more accurately now than 20 years ago.

Dose Response Curve

- Response
 - A measurable effect in health
 - But human effects may not be often measurable directly
 - Surrogates
 - Animals
 - More Recent tissue or gene response to replace animal testing

Examples:

LD₅₀ – lethal dose 50 – a mass that will kill 50% of a test population

LC₅₀ – Lethal concentration 50 – a concentration in water or air that will kill 50 % of the test population.

These may be used as indices for toxicity

So, a response is a measurable effect in health and so but then we are worried about human health and how do we measure human health? So, if we take ten people in a classroom sitting and I am working on a blackboard with a chalk piece, and two of them start sneezing when I work with a blackboard when I erase the dust on the blackboard. So, the problem is there is a lot of all the receptors, and we know that from practical experience that in a given population of receptors all of them do not behave in the same way for a particular stimulus. If you have a pollutant that is in this room that is present in the air at a certain concentration, all of us are not going to be experiencing the same level of response and therefore that provides a challenge and it forces us to use statistics as a tool for determining quantitative markers for these kind of things. So, when we are dealing with large populations, we are dealing with society at large. So, if you are dealing with the population in India which is close to a billion, we need to make decisions, policy decisions based on these kinds of responses and therefore that becomes a problem, and you have to use statistics as a tool that will help us make decisions. We are not going to talk about statistics in this course, but it is important to keep in mind that a dose response curve is only as good as its statistical validity and that one has to keep that in mind. But we cannot measure health effects directly in human beings. There are ways to do it in what is called as epidemiology. It is also a statistical tool say we have 100 students in the class, 20 of them fall sick whenever I open a blackboard, I start writing on the blackboard which means that there is some relationship between me writing on the blackboard and their health effect. So, that is said an indirect statistical relationship. It does not have direct proof. You can only have direct proof if you have physiological evidence and sometimes it is not easy to get live physiological evidence. Now it is becoming even easier to do it, but in general, it is not easy because it requires the consent of the human being and therefore that is not easy.

So, we are also talking about toxicology which means that we would like to know what is the toxicity of a particular chemical that I am going to produce now. If I am going to manufacture something which has properties, useful properties for other things that we do. And this is the crux of this of this module in that we are trying to make some process some material that has usefulness in some other aspect of our society, but then we would like to know what is the impact of this. So, in other words, risk assessment is also known as impact assessment or environmental impact assessment or health impact assessment. So, we can not use it on human beings. We can not take a new chemical and dose human beings with it and say what happens to them. That defeats the entire purpose of it. So, people have used surrogates such as animals, in order to test it and you see this very often. We see that this product, certain products are - you will see labels saying that certain products have been tested on animals and it has shown especially mammals because that is similar to the system that human beings have. And it is shown that the response is similar to that of human beings and there has been a lot of controversy about this and some people do not like doing this and many corporations have moved away from this kind of systems, and we see a whole societal response to these kind of things. So, as a population also we are divided in this kind of responses but something to keep in mind.

More recently we have biological methods and biochemical methods that we do not have to do this anymore. We can directly take a particular tissue and then see the response of a particular chemical on that, and we check the entire biochemical response of the system in a human body where it goes and all that. But in the system where we use animals some examples of the toxicity indices that represents the dose response curve are example such as the LD₅₀ which is lethal dose 50 which indicates that there is a mass that will kill 50% of the test population. This is a mass of a chemical or a dosage of a chemical that will kill 50% of a population. This 50% is important because again we talk about susceptibility of different components of a population, different individuals in a population to a particular dose. So, we need some kind of limits, more than 50% which means it is acceptable which is a significant amount of risk, it is not acceptable. It is a significant amount of risk that is that is posed to the population, and therefore it may be taken seriously. This is, of course, controversial because in a population of whatever be the population always the difficult question to answer is what is acceptable risk? So, in this case, it says that at this dose of the chemical, 50% of the population may suffer a fatality. So, is it okay if one in a million suffers the fatality and that is that acceptable health risk, and this is a very difficult question to answer from a societal point of view and as we do several things in our society. Sometimes these kind of questions are linked to economics. So, if we say that having an automobile, running cars on the road has a risk of one in a million. So, one in a million person can have a serious health effect because of vehicles on the road. So, if we are very strict about it, we say we should ban all vehicles. We should ban all combustion devices in our society and our society will collapse. So, here is where I think the concept of sustainability comes into play and it is not an easy question to answer as you would have already realized from the material presented in other modules about sustainability that it is not an easy question to answer. So, it is a question that requires the participation of society at large, even to determine what is an acceptable health risk? And this is something for all of you to ponder about when you look at some of the data and the statistics about this kind of things.

Materials, Receptors and Toxicology

- Even though we have focused our discussion on humans as primary receptors, we extend this definition to all components of the non-human environment
- In some cases we also extend this to structures in the environment
 - Such as monuments
- Therefore every material that is manufactured must be tested for toxicology

So, as I had mentioned earlier, we focus our discussion on human beings as primary receptors, but we also extend it to other components in the environment as we should and because they are all related to us in some way or the other. So, this is the argument that is placed by most people who say that if you have to protect our environment, it is for the future generation. So, and environment must be given a chance to regenerate itself so that it is.

So, as a result of this toxicology discussion, it is now mandatory that every material that is produced must be tested for toxicology. So, whenever you have a material that is produced by a company they have something called as a material and safety data sheet which contains all this information. It must contain toxicology information and exposure information, which means if I am exposed to it by inhalation or by drinking or by skin contact what will happen? And these numbers must be presented, and they must be tested and validated by a government regulatory agency before it can get into the environment.

Exposure and Toxicology

- Based on our definitions of Acute and Chronic Toxic effects, we can infer that
 - Toxicity is likely to be higher for higher mass ingestion
 - Mass = Concentration x Volume
 - For example:
 - If you drink 4 liters of water every day
 - Ingestion of A in 1 day through water
= (mass of A/liter of water) x (4 liters of water / day)

The health effect is therefore dependent on the CONCENTRATION and the TIME of exposure.

So, based on our toxicology effects, we can infer that toxicity is likely to be higher for the higher mass of ingestion. A general rule that we have is that the mass, that the dose that we ingest is equal to concentration multiplied by the volume. For example, if you drink four liters of water every day and ingestion of a chemical “A” in one day through the water, if there is a chemical A in the water that you find, how much of A in the water is acceptable? So, if the concentration or the mass of A per liter of water multiplied by four liters of water a day will give you the amount that you are ingesting every day and this therefore dependent on the concentration and the time of exposure.

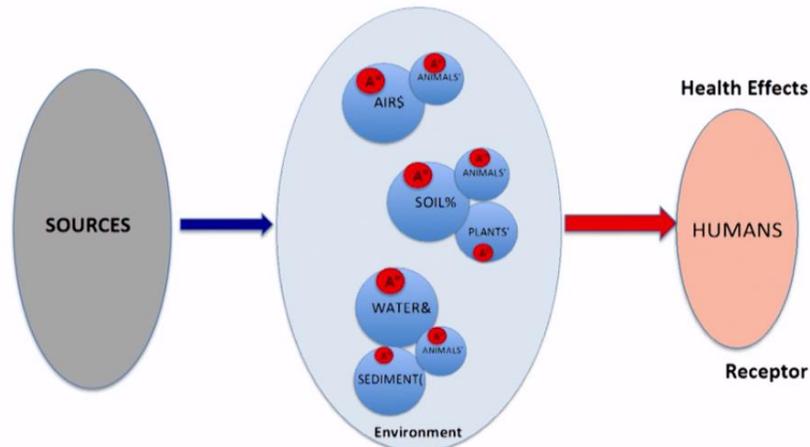
So, over a period of time, you are going to be accumulating a certain amount. The same calculation can be done for the air we breathe. If there is a chemical in there, we are breathing about at a rate of two to eight liters per minute, and you can calculate how much of air. All this assumes that this chemical is accumulating in the body and not metabolizing because the body also has the capacity to react to transform this chemical into something more benign or something more dangerous; both of these things can happen in the body. The body also has the capacity to filter it out. So, nothing may happen. It may just come out, but we do not know. What we in this context we take an approach that is called as a conservative approach we say we call it as a worst-case scenario. In the worst case what will happen.

So, if you take a worst-case scenario, one of the advantages, one of the utilities of this equation that I presented here is that you can determine what is this concentration that is acceptable in water if you drink. If you are alive for say 80 years or 80 years you drink four liters of water a day how much of concentration of A is acceptable in there. So, this is a basis for determining standards for water quality and air quality.

So, you can see that it is a big long equation a sequence of things that need to happen in order to determine the standards and the standards also imply that how much of money should I spend in treating the air and water and how should I manage it.

Sources, Exposure and Toxicology

WHERE DOES **A** COME FROM INTO THE ENVIRONMENT?



So, we have seen that this is there, where does this A come from. The next question we ask is -- so there is A in the environment we are exposed to it, so we are falling sick. So, where does it come from? That is the next question, and it comes from somewhere. It comes from a source, something is responsible for it, and it is releasing it at some rate, and it is getting into the environment.

Sources

- Different types of Sources
 - On the basis of processes
 - Combustion
 - Construction and Demolition
 - Erosion
 - Manufacturing processes
 - Waste Disposal
 - On the basis of product
 - Consumer goods
 - Energy
 - Medicines and specialty chemicals
 - Technological appliances
 - Vehicles

Different types of sources can be based on processes, for example, we have combustion, construction demolition this is a very limited set of process. Everything that we do for our daily lives is a process. So, me writing on the blackboard is a process that is itself is. It may not be very significant. It maybe applicable only to a small group of the population but this classification is done based on the activity or based on the product. So, you have erosion, manufacturing, a waste disposal. On the basis of a product, we have consumer goods. We have energy production. So, there is power plant or nuclear power plant or anything like that, and we have specialty chemicals, we have medicines we have technological appliances such as cellphones, and we have vehicles. And when we have sources, pollutants coming out of sources we have the chemicals of concern or pollutants of concern that can come here, can get into air, water.

Sources and Pollutants

- Chemicals of Concern
 - AIR (gas or vapor phase)
 - WATER (dissolved phase)
 - Suspended solids in water
 - Particulate matter in air (PM)
 - Organic / Inorganic
- Lists based on industry
 - Specific chemicals are associated with specific activity in certain industries
 - Based on their toxicological index, these chemicals can be ranked high as a chemical of concern

They can also be present as suspended solids in water. They can be present as particulate matter suspended in air. They can be organic or inorganic. These are all classifications that people can come up with, and sometimes there are specific chemicals that come out only from a particular kind of industry and it is easy for us to check and based on this toxicological index and the exposure.

So, chemicals are ranked. There are lakhs of chemicals that we manufacture. If you open any catalogue of a chemical company and so how do we rank them. We can not. We have to rank them because some of these chemicals are used in such small quantities they may never get into the environment and even if they do they are in such small quantities. So, the ranking is done based on the amount that gets into environment and also the exposure that we are likely to have and so a combination of this will give you a toxicity index that these chemicals have to be ranked in this particular manner.

- It is not sufficient that a process uses a hazardous material. We have seen that the important aspect here is the exposure?
 - How does a chemical at a source lead to exposure
- How does a material “A” travel from a source to the environment and a receptor
- How long does this take?
- Can we intervene?

So, it is not sufficient that a process uses a hazardous material. We have seen that exposure is important and how that chemical from a particular source goes to the environment and then goes to a receptor, which we call as in the second line which says how does material “A” travel from a source of the environment and to a receptor? How long does it take and can we intervene?

So, this is the next set of questions that we logically will ask, and these will be answered in our next lecture.

Thank you