Soil Science and Technology
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Lecture - 47
Toxic Inorganic Substances in Soil

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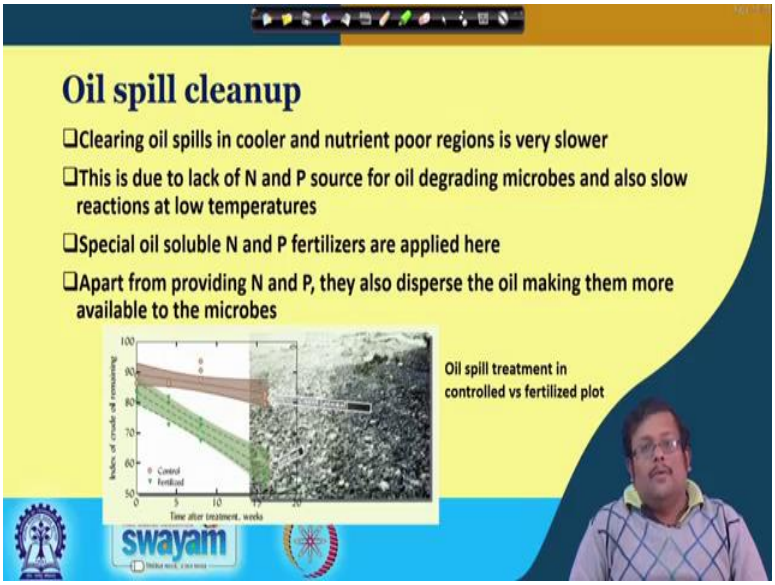

Welcome to this second lecture of week 10 of Soil Science and Technology and in this lecture will be starting from slide where you left in our last slide in our last lecture. And in the in our last lecture we talk we talked about different methods or cleaning or remediating the organic pollutants from the soil. And in this lecture will try to finish this topic and then will start a new topic of inorganic pollution in the soil. So, guys we started with different types of remediation technologies, we started with different physical and chemical methods and then, we talked about different bioremediation technique.

And then, bioremediation, remember it is mediated by biological organisms either microbes are plants. When it is mediated by plants we call it phytoremediation and this by remediation is of mainly 2 types; one is natural and other is enhanced or engineered natural bio natural attenuation. Basically, we do not enhance you know we do not modify the environment of indigenous microorganisms. However, in case of enhanced or engineered by remediation, we modify the ecosystem of you know local ecosystem of

environment of the microorganisms. These are manually you know we talked about 2 types of enhanced by remediation; one is bioaugmentation another is biostimulation.

And so, we talked about the differences and we talked about this how this oil spill cleanup takes place. So, I hope you got a basic idea about this bioremediation and will be also discussing that later on.

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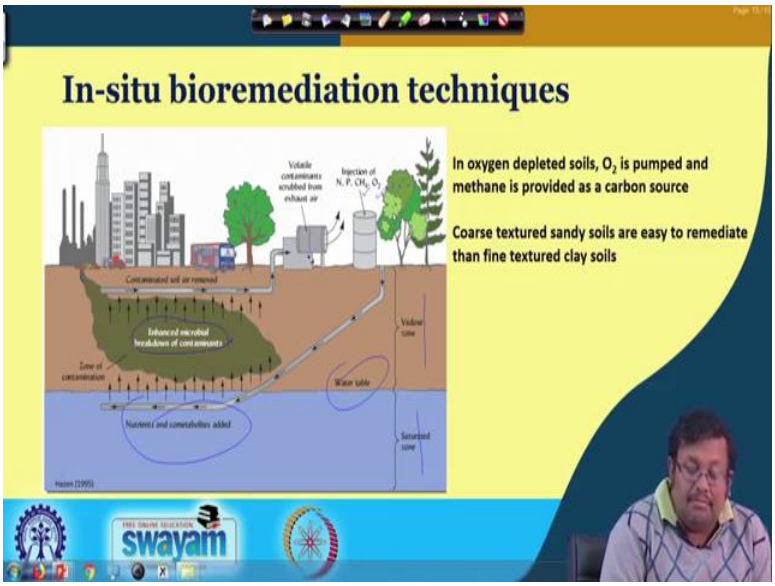

So, let us go ahead and see what is in-situ bioremediation technique and you know a snapshot of in-situ bioremediation technique can be found in this slide. And you can see in oxygen depleted soil, you know oxygen is pumped and methane is provided as a carbon source. You know we are introducing the oxygen from outside as well as we are also introducing methane as a to provide as a carbon source. And so, you can see here, this is the vadose zone and this is a saturated zone and obviously, this is the water table.

So, when we are injecting the nitrogen phosphorus in terms of fertilizers as well as methane as the carbon source and oxygen through this channel. And ultimately it goes you know nutrients and other co-metabolites added. And you know you can see here, this is a zone of contamination and this contamination basically occurs from this you know from these industrial processes.

And ultimately these NP methane and oxygen ultimately enhance the microbial breakdown of the contaminants here. And these break down of the contaminants through

microbial activity in the in-situ; that means, we are not excavating the soil and transporting the soil to any other area. Here, we are using the in-situ you know the in-situ process.

And you can see the microbes which are present here are the breaking down the contaminants. And ultimately the contaminated soil are removed and the volatile contaminants scrub form enhance exhaust air. So, this is an example of how this in-situ bioremediation can help in remediating you know contaminate soils and remember that coarse textured sandy soils are easy to remediate then find textured clay soils. Because, of easy to easy of you know water movement through the sandy soils and easy of movement of air and water through this sandy soils.

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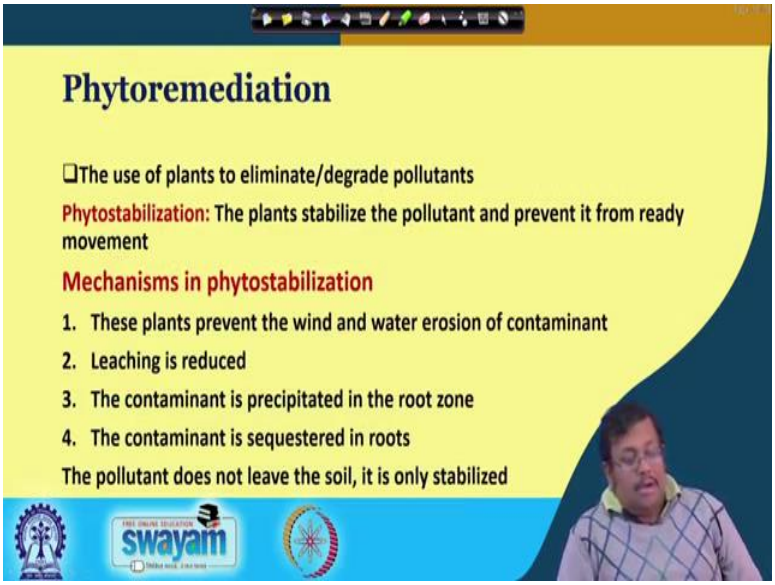

So, let us talk about brief in phytoremediation, obviously, the phytoremediation is a use of plant to eliminate or degrade pollutants and phytostabilization is when the plant stabilize the pollutants in prevent it from ready movement. So, it is a terms phytostabilization. And the mechanic of mechanism of phytostabilization and basically 4 types and you know the plants either this plants prevent the wind and water erosion of contaminants.

And then you know leaching is reduced third is the contaminant is precipitated in the root zone and 4th is the contaminant is sequestered in the root zone. So, remember that

the pollutant does not leave the soil, it is only stabilized. So, these are the 4 ways through which this phytostabilization takes place.

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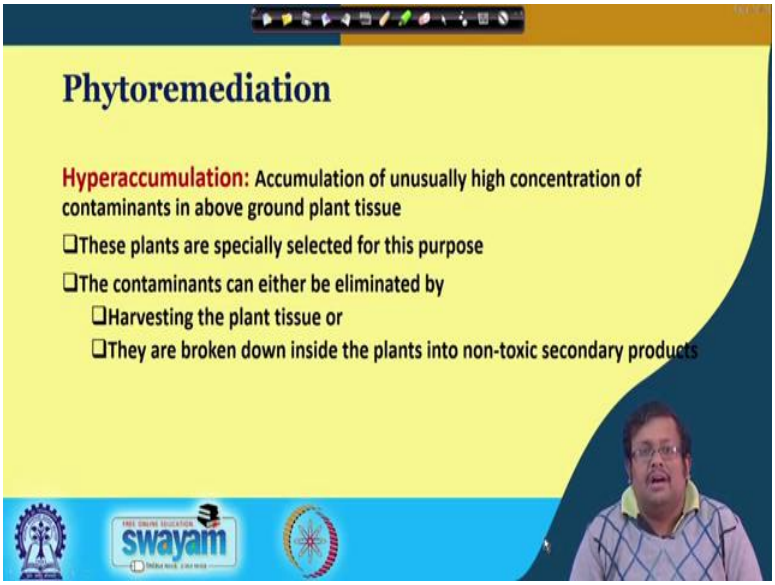

And you know hyperaccumulation is another important term; obviously, will be discussing these in details when will be talking about the remediation of inorganic pollutants from the environment. But, let us you know in this lecture, let us you know the focus on this term.

So, hyperaccumulation is basically accumulation of usually high concentration of contaminants in above ground plant tissue and these plants are specially selected for these purposes. And the contaminants can either be eliminated by harvesting the plant tissue or they are broken down inside the plants into non toxic secondary products. So, again this hyperaccumulation is basically terms the name itself is hyper accumulation; that means, enhance accumulation it is the high concentration of contaminants in the above ground plant tissue.

And these plants are specifically you know selected for this type of hyperaccumulation and ultimately when this hyperaccumulation takes place this highly contaminated ground tissues of ground tissues can be harvested or they are broken down inside the plants into non toxic secondary products. So, this is how this hyperaccumulators basically work, we will discuss in details about this hyperaccumulators. So, will be discussing the heavy metal phytoremediation in our coming lectures of week 10.

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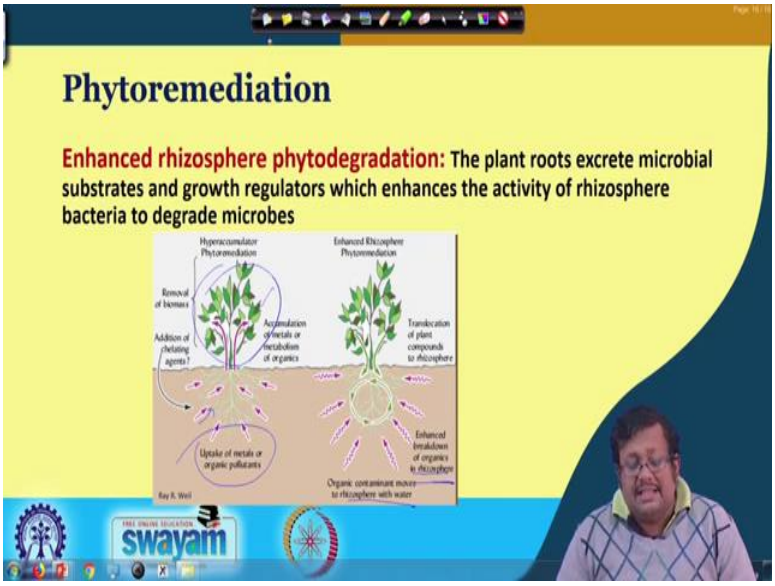

So, let us see what is the enhanced rhizosphere phytodegradation, you can see here in this picture; obviously, the hyperaccumulator phytoremediation you can see, this an this a plant and this an uptake of nutrients uptake of metals or organic pollutants through this roots. So, ultimately accumulation of metals on metabolism of organics here.

So, this is hyper accumulator plants and ultimately if you remove this total biomass the total a heavy metals which are hyperaccumulated in the body parts or in the dry tissues will be removed. And obviously, this movement of uptake of metals and organic pollutants will be enhanced by addition of chelating agents.

So, another is enhanced rhizosphere phytoremediation and obviously, you can see translocation of plant compounds to rhizosphere. So, enhance breakdown of organics in rhizosphere, in organic contaminants move into the rhizosphere with water and ultimately it you know it shows the enhance rhizosphere phytoremediation. So, in this case basically, transformation of plant compounds in the rhizosphere and this enhance breakdown of organics happen in the rhizosphere zone. And so, this the plant roots excrete microbial substrate and growth regulators which enhances the activity of the rhizosphere bacteria to degrade the; to degrade the different types of you know organic pollutants.

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So, if you talk about again phytoremediation; phytoremediation is advantageous where a large area is contaminated to shallow depths with moderate amount of pollutants. And it is less expensive, it is less disturbance to create less disturbance to soil and it is, but it takes longer time to remove the contaminants. So, this is you know one of the problem of phytoremediation takes longer time to remediate the contaminants.

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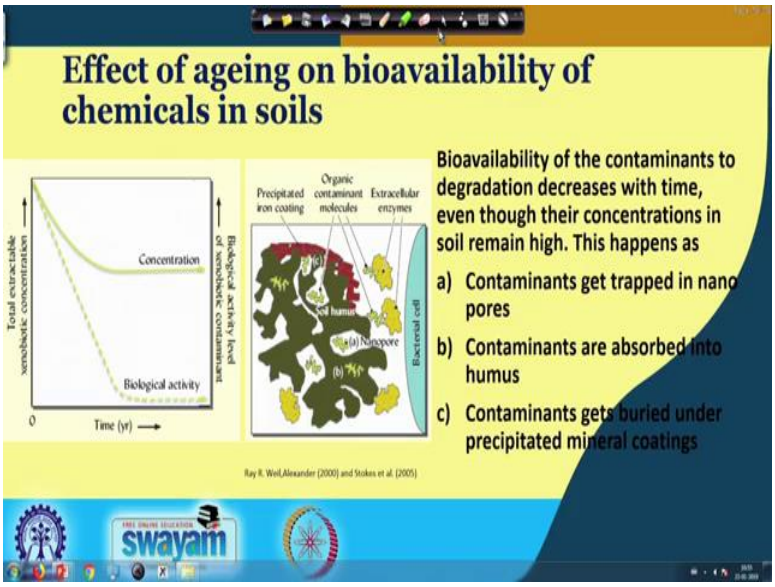

So, guys let us see the last topic of this you know the last important point of this first topic, that is effect of ageing on bioavailability of chemical in the soils. If you can see the

graph here, it says that although the concentration of a particular you know xenobiotic consider xenobiotic compound is higher, you know after a certain period of time the biological activity gets lower down for the lower down.

In other words bioavailability of the contaminates to degradation decreases with time and even though their concentration is soil remain high and this happen as the contaminants get trapped in the nano pores and contaminants are absorbed into the humus or contaminants get buried under the precipitated mineral coatings. So, we can see here as the time goes on after a certain period time, although the concentration of the contaminants high, the biological activity is low. So, the bioavailability of this contaminants basically decrease with the time.

So, there are couple of ways, there are couple of reasons you can see the contaminants are you know these are basically organic contaminant molecules and these organic contaminant molecules either absorb the soil humus. You can see here or they can trapped into this nanopore or either the contaminants gets buried under precipitated mineral coatings.

So, these are you know, this you can see this is a precipitate iron coating the red shape and this is buried under this precipitated iron coating. So, there are three methods, the first method is contaminant trapped into the nanopores and then you know absorbed in the humus and then finally, it is precipitated you know iron you know buried under the precipitated iron coating.

So, this how you know this deduction in bioavailability of the contaminants to degradation occurs with time. So, guys we have covered this first topic of this week 10 lectures. So, we have got a basic idea about how different methods are you know, how different methods act to remove the organic pollutants from the soil, and will be discussing these phytoremediation techniques in details in our coming lectures and let us go ahead.

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And the ok, one more thing will I want to mention that this all these process make you know, processes make the contaminant less prone to environmental risk. These ageing process and this trapping of organic molecules inside the nanopores, as well as trapping of this molecules, you know burring the of the molecules. You know benit this iron coatings and all these processes make the contaminant less prone to environmental risk. And bioavailability should be taken into consideration before taking remediation activities and removal of contaminant should be based on the bioavailability rather than it is total concentration.

So, bioavailability is very very important term and you should consider all the aspects regarding bioavailability while taking a decision of bioremediation or remediating the organic pollutants. So, let us move ahead and see the you know, talk about our next topic that is soil contamination with toxic inorganic substances.

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So, guys you know the soil contamination not only occurs through organic pollutants, it also occurs through different inorganic substances, like heavy metals and will be discussing those in this topic. So, the concepts which will cover are basically what are the toxic inorganic substances and then, what are the you know sources of this pollutants and then, how the accumulate the soil and some, will talk about some important toxic metals and finally, you know some toxic metals in sewage and sludge.

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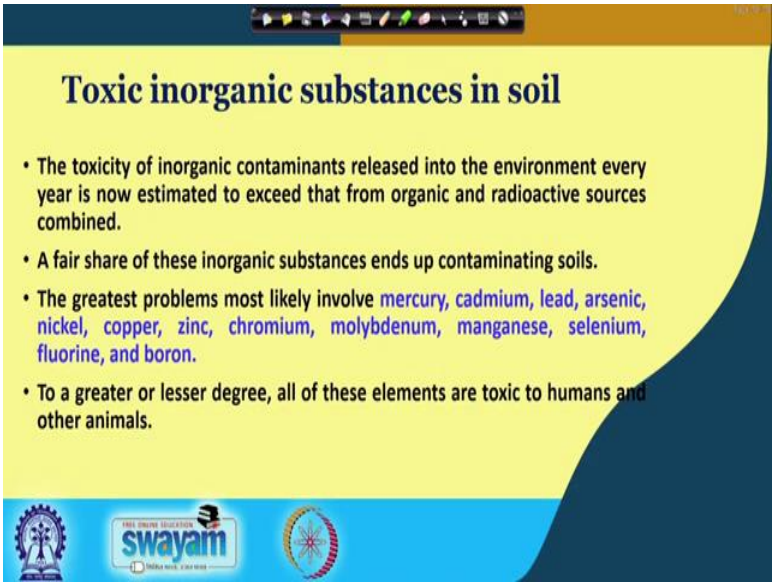

So, what are the toxic inorganic substances in the soil? So, toxicity of inorganic contaminants released into the environment every year is now estimated to exceed that form you know organic and radioactive sources combined. So, inorganic contaminants, you know inorganic contaminants share say huge portion of the total contaminant which realise each and every year in the environment.

A fair share of these inorganic substances ends up in contaminating soils and the greatest problem most likely involve in these metals. You know mercury, cadmium, lead, arsenic, nickel, copper, zinc, chromium, molybdenum, manganese, selenium, fluorine and boron. So, all these are responsible for environmental or in another soil pollution. And each of them are producing the potential health hazards. So, to a greater or lesser degree all of these elements are toxic to human and other elements.

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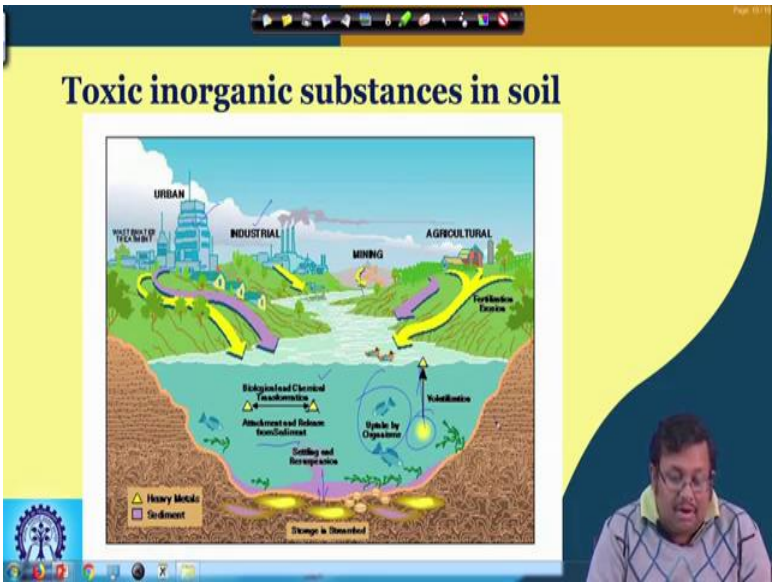

So, you can see water how this toxic you know inorganic substances in soil moves in the environment. So; obviously, they are the different sources like industrial sources, urban sources. You can see you know the sediments are coming from different wastewater treatment, pumps and this industrial heavy you know the heavy metals are coming from the industrial effluents as well as they are coming from different urban waste water as well as you know other sources.

And heavy metals are also coming through mining discharge and also different types of agricultural you know agricultural runoff also. So, all these are coming through different

sources and ultimately you can see inside the water body there are you know there under going different types of these heavy metals. And undergoing different types of biological and chemical transformations and you know ultimately you know leading into the attachment and released from the sediments.

So, and you know settling into the you know settling into the sediment and further resuspension and storage in the streambed. Then it gain in uptake by different types of microorganisms and sometime this heavy metal get volatilize. So, these are some of the ways through which this toxic inorganic substances move for soil to water and then you know ultimately get stored in the stream bed and also settle down at the below of any you know any stream of water bodies, so, this is very important.

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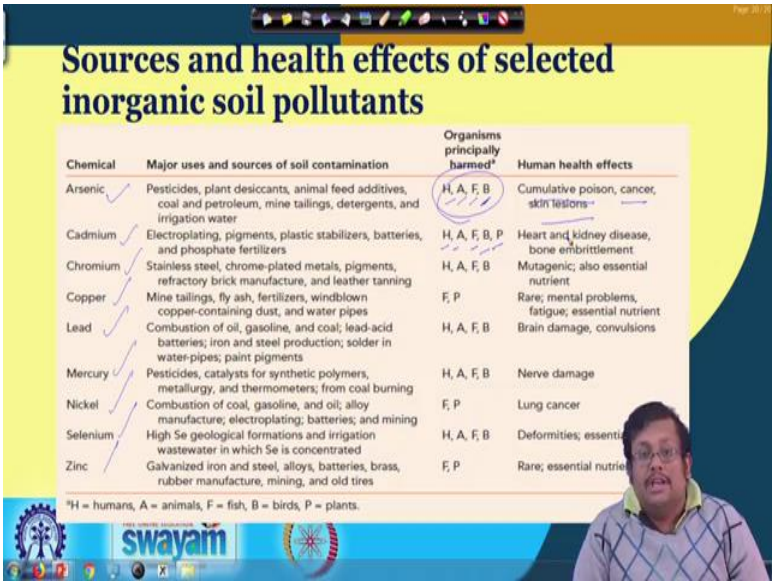

Now, if we see what are the different types of chemicals are inorganic substances, which are responsible for this heavy metal pollution. Obviously, these are the this shows the list and obviously, arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc, all these are highly you know toxic pollutants and there are major source.

For example, in case of arsenic, pesticides, plant desiccants, animal feed additives, coal and petroleum, mine tailings, detergents and irrigation water are the major sources of arsenic. And organisms principally harm that human and then, animals then, fish then, birds. So, all these are in adversely affected by this arsenic and ultimately human health

effects you can see cumulative poisons, cancers and skin lesions are some human health effects of this arsenic pollution.

Cadmium: cadmium also coming from you know it is also you know important pollutant of soil. And this cadmium comes from electroplating, pigments, than plastic stabilizers, batteries, and phosphate fertilizers and you can see they contaminant all of the human there you know human and then, animals and then, fish then, bird and plants. And they can cause heart and kidney disease bone embrittlement.

In case of chromium, it basically comes from stainless steel, chrome-plated metals, pigments, refractory brick manufacturer and leather tanning. And we can see you know except plants it can also harm this human, animals, fish and bird. And human health effects it produce the mutagenic effect and also we remember that it is also access essential nutrients. So, these are some of the important this table basically shows the snapshot of you know important inorganic soil pollutants and how they affect, what are their sources and what are the positive you know harmful human health effects.

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So, how we do accumulate in the soil? Obviously, some of these toxic metals are being released to the environment in increasing amount and the inorganic toxins do not decompose and degrade rather they usually remain in the soil and so, accumulate from year to year. In many places the metal contamination is historical resulting from polluting activities that are no longer practiced.

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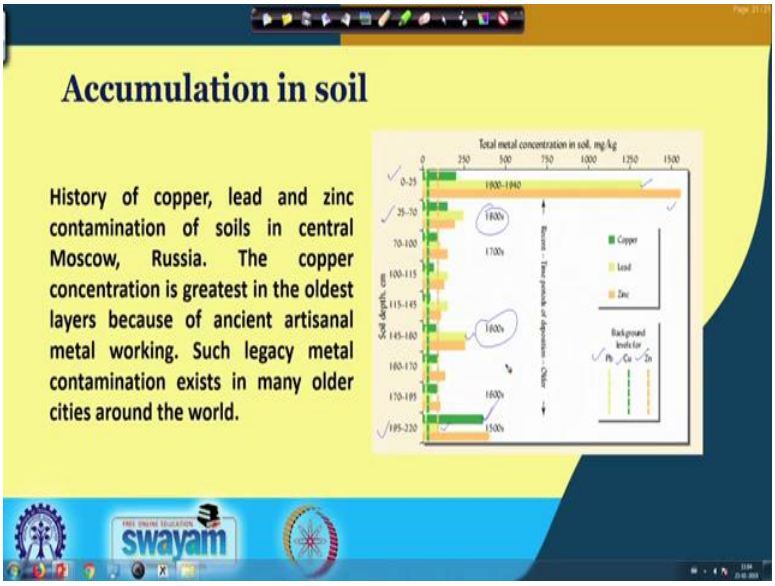

So, if you can see this chart this shows the history of copper, lead and zinc contamination of the soil in central Moscow, Russia. And you know some of the trains you can see here in the x, you know this is basically different PDA, you know different consent different depth of soil. So, it is the surface soil 0 to 25 centimetre, then 25 to 70 centimetre, all the way up to 195 to 200 centimetre or 220 centimetre.

And these dotted lines are shows the background levels of these lead, copper and zinc. And as we can see in 1500s; obviously, the zinc concentration was quite high and which ultimately you know defeated in 1600 and so and so forth in 1800. And then again we show measure increase in zinc concentration due to industrial activities. And also for lead also you can see the same you know in case of lead; obviously, in the in case of lead; obviously, in the you know in the in this 1500s; obviously, there are low less you know less concentration of leads.

However, in 1600 there is an increase of lead concentration and ultimately you know the total you know the final you know in 1900 to 1940 due to industrial process there is a you know several folds increasing zinc concentration.

And in case of copper concentration is greatest in the oldest you know copper concentration is greatest in the oldest layers because of ancient artisanal metal working you can see copper concentration was higher in oldest layers. Because of you know artisanal metalworking you practice in the ancient period and ultimately it get reduced.

So, this shows the total metal concentration scenario or how they get accumulate historically in the soil.

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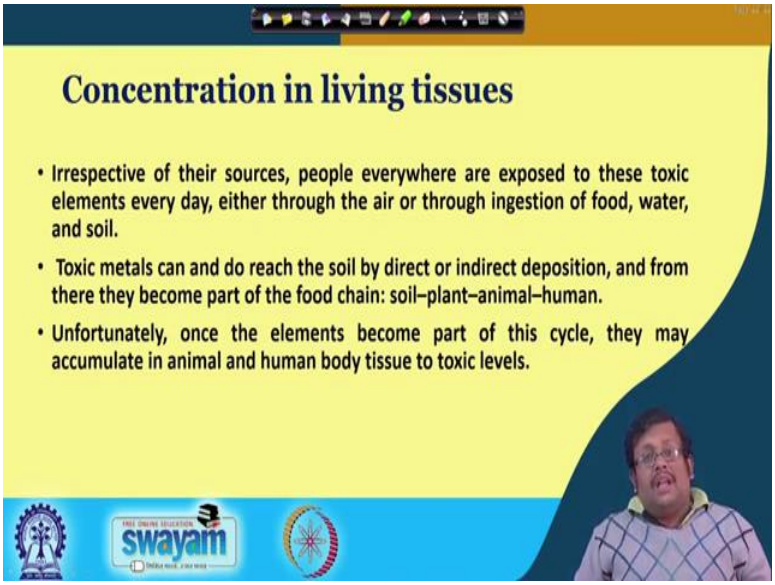

So, how they get concentrate in the living tissues? So, irrespective of their sources people everywhere are exposed to this toxic elements every day, either through the air or through ingestion of food, water and soil. And toxic metals can do you know can and do reach the soil by direct or indirect deposits and from there they become a part of the food chain. And this movement basically occurs from soil to plant and plant to animal and animal to human. Unfortunately once the element becomes part of the cycle they may accumulate in animal and human body tissues to toxic levels.

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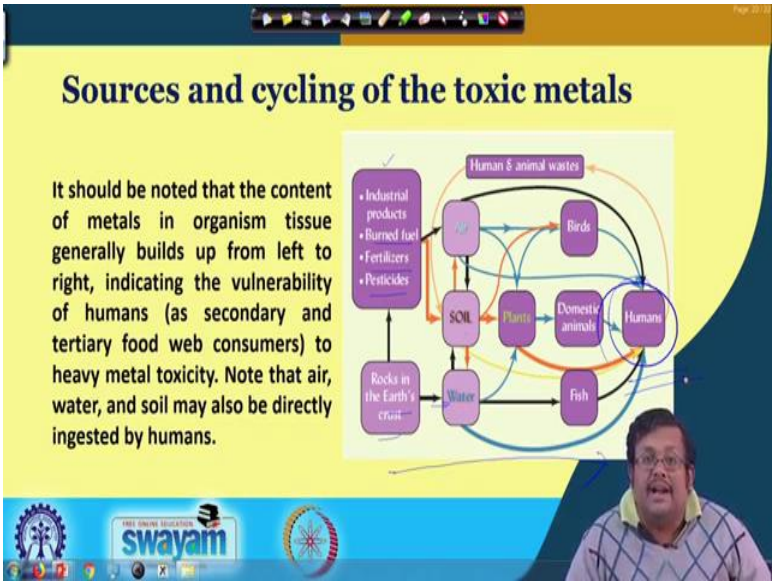

So, this slideshows the sources and cycling of toxic metals as you can see here. So; obviously, these are the sources like industrial products, burned fuel, fertilizers and pesticides. And also rocks in the earth crust from there, this pesticides can occur fertilizers can occur. And obvious, so, basically the major sources are these two and they are basically mixed with water.

So, this rocks in earth crust you can mixed with water and these industrial products, burned fuel, fertilizers, pesticides they can come directly into the air. And obviously, from air you can get it this can be accumulated in the birds, it can be accumulated in humans, from air it can deposit in the soil, from which plant can uptake and from plants to domestic animals and further humans and from soil to water and from water to plants and domestic animals and human.

So, you can see that the content of metal in organism tissue generally bills up from left to right as we grow from left to right, the concentration of the metals you know an organism tissue generally builds up and indicating the vulnerability of the humans. Because you see we are at the final you know humans are the secondary and tertiary food web consumers. So, because we are eating both the secondary as well as tertiary food web consumers to heavy metal and we are much more exposed to heavy metal toxicity and we have to know that air water and soil may also be directly ingested by humans.

So, that is why these heavy metals get accumulated in our body and ultimately results in you know difference science and toxicity or human health hazards.

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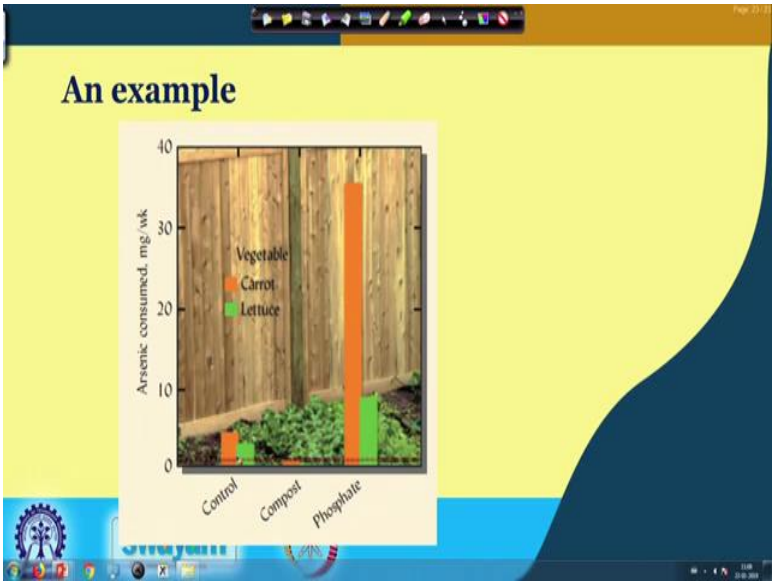

So, you can see here one example of how this toxic metals affect different you know accumulates within some agricultural products. Obviously, so, this is a vegetable or you know carrot which was grown you know with the vicinity of this fens and in the fens actually they have quoted some arsenic you know containing paints. So, this due to the presence of this arsenic containing paints the adjacent soil get contaminated.

So, you know there is you know there is a study where they have applied the compost as well as also phosphate and they can see in and you can see that the arsenic consumed within or arsenic accumulation within the control vegetable. That means, when we did not apply any you know there are 2 types of vegetables you can see; one is the carrot and other is lettuce. So, in all the 3 conditions when you are applying no fertilizer or in the control condition; obviously, there is an increase in that shows some accumulation of arsenic within this both of these carrot and lettuce.

However, when you are adding the composed due to the binding action of organic matter the accumulation is very less within both carrot and lettuce. However, when you are adding the phosphate you know it get enhanced, because arsenic can make certain compounds with the phosphorus. So, that shows that how this you know elements gets accumulated within different plants and plant parts.

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So, let us talk about some inorganic contaminants and their reaction in the soil. Let us first talk about with start with arsenic, because this is a major heavy metal, which is creating pollution specially in India as well as in Bangladesh in Southeast Asia. So, arsenic problem in its accumulation in certain orchard soil following the years of application of arsenic containing pesticides. And being present in an anionic form you can see this element is absorbed and as a phosphates by hydrous, iron and aluminium oxides especially in acid soils.

And in spite of the capacity of most soil to tie up the arsenate long term addition of arsenical sprays can lead to toxicities for sensitive plants and earthworms and the arsenic toxicity can be reduced by application of sulphates you know by application of sulphates of zinc and iron, aluminium which tie up with arsenic in the in insoluble forms.

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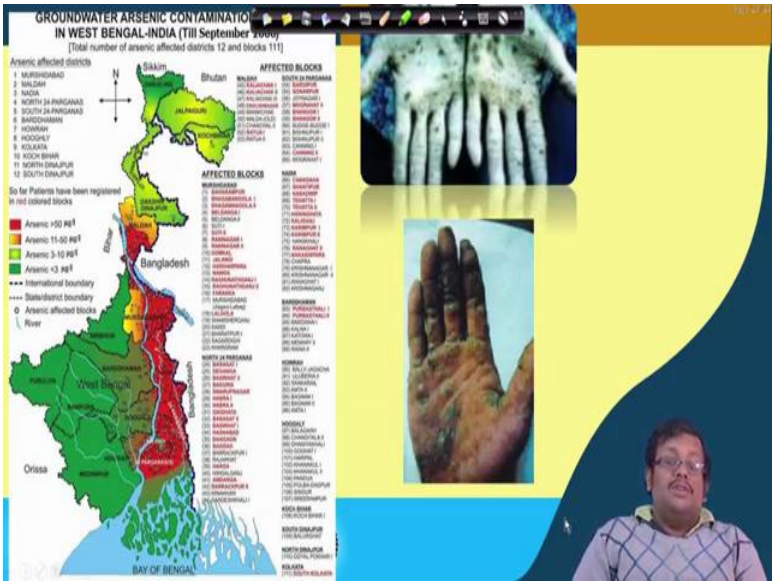

So, you can see this shows the groundwater arsenic contamination scenario of West Bengal state of India. So, you can see these zones are very very you know this you know this zone this red zones and yellow zones shows high accumulation of arsenic. And that is why it is you know it is contamination is very very prevalent in this region and you can see some of the you know toxic health effects. And ultimately it goes towards you know goes towards deleterious health effect an ultimately it produces the carcinogenic effects on the plant body.

So, guys we have you know, let us stop here and then we will be completing the other heavy metals in our next lecture and will try to discussing several other methods to remediate this heavy metals in our next lectures. So, I hope that you have learnt something and in the next lecture will be discussing some of the other important potential health hazards which you know which potential health hazards from different other heavy metals and how to remediate those heavy metals from the soil environment.

Thank you very much.