Environmental Remediation of Contaminated sites
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Lecture 04
Introduction to Hazardous Waste Laws and Risk Assessment

Hello everyone, welcome back to the latest lecture session. Thus far I believe we have looked at a couple of examples and then looked at the course outline in greater detail. As mentioned in the course outline, we are going to dig right in into the relevant law, at least the one promulgated by the central government anyway. We do have some minor modifications from state to state, but rarely do states have more stringent conditions or such, but anyway, let us look at the relevant law here.

And before we dig into the law, let us look at how you know the law comes about or what are some of the process behind that particular law coming into picture.

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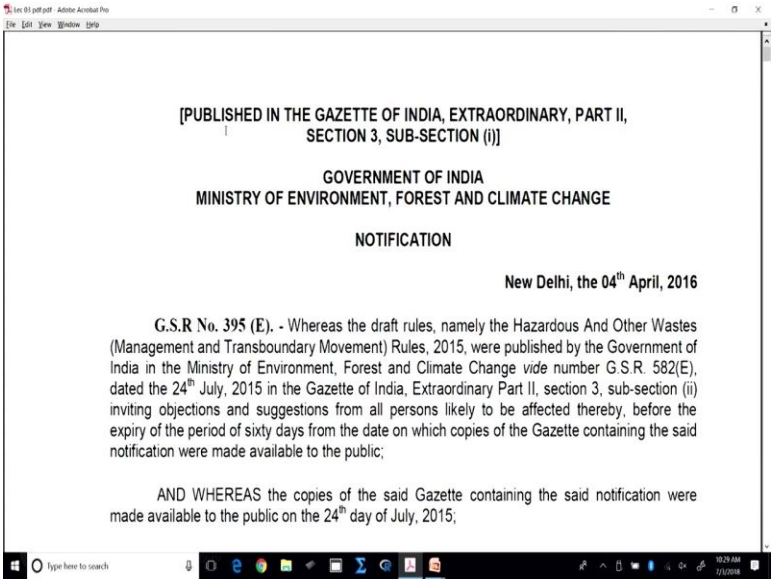
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SECTION 3, SUB-SECTION (i)]

GOVERNMENT OF INDIA
MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE

NOTIFICATION

New Delhi, the 04th April, 2016

G.S.R No. 395 (E). - Whereas the draft rules, namely the Hazardous And Other Wastes (Management and Transboundary Movement) Rules, 2015, were published by the Government of India in the Ministry of Environment, Forest and Climate Change *vide* number G.S.R. 582(E), dated the 24th July, 2015 in the Gazette of India, Extraordinary Part II, section 3, sub-section (ii) inviting objections and suggestions from all persons likely to be affected thereby, before the expiry of the period of sixty days from the date on which copies of the Gazette containing the said notification were made available to the public;

AND WHEREAS the copies of the said Gazette containing the said notification were made available to the public on the 24th day of July, 2015;

So here, looking at this particular aspect here, we see that this is the actual document here. Of the law we have a few aspects that are highlighted, so again this was published in the gazette of India and that is where we have most of the rules and laws and such that are given out.

And what is the relevant ministry, it is Ministry of Environment, Forest and Climate Change. Again that is the relevant industry here. So moving down further, how does it come about. As

we see here, they publish draft rules and they were published in 2015. So draft rules were published, and I believe in gazette of India, as we talked about under some particular document number. And then what do they ask for, they ask for comments or such or any other suggestions, objections from the relevant public or industry or such.

And I believe they typically have 60 days and once you know at the end of this particular 60 day period and depending upon the quality and such of the suggestions or objections that come up, they are considered, taken into account and then it is promulgated into a law by the parliament. We see these aspects here, so objections and suggestions were invited and they give a period of 60 days and then they are duly considered by the central government, and then in exercise of the powers from Environmental Protection Act 1986,

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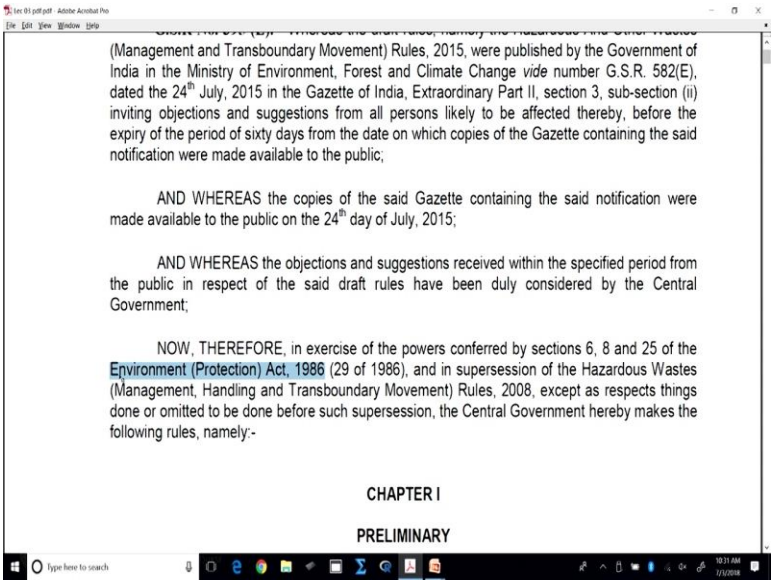
(Management and Transboundary Movement) Rules, 2015, were published by the Government of India in the Ministry of Environment, Forest and Climate Change *vide* number G.S.R. 582(E), dated the 24th July, 2015 in the Gazette of India, Extraordinary Part II, section 3, sub-section (ii) inviting objections and suggestions from all persons likely to be affected thereby, before the expiry of the period of sixty days from the date on which copies of the Gazette containing the said notification were made available to the public;

AND WHEREAS the copies of the said Gazette containing the said notification were made available to the public on the 24th day of July, 2015;

AND WHEREAS the objections and suggestions received within the specified period from the public in respect of the said draft rules have been duly considered by the Central Government;

NOW, THEREFORE, in exercise of the powers conferred by sections 6, 8 and 25 of the Environment (Protection) Act, 1986 (29 of 1986), and in supersession of the Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008, except as respects things done or omitted to be done before such supersession, the Central Government hereby makes the following rules, namely:-

CHAPTER I

PRELIMINARY

they were replacing the previous law which was Hazardous wastes (management, handling and transboundary movement). So there was already a particular law existing in 2000, so this particular law which came about in 2016, now supersedes this particular law and what is this current set of rules are called Hazardous and other wastes (management and transboundary movement rules) of 2016.

And I believe one key aspect where this differs from the previous particular set of rules, the one in 2008 is that the emphasis is now on minimizing proliferation of this hazardous waste as in they want to prevent generation of hazardous waste and also promote recycling of these

hazardous wastes whenever feasible. At least I would say that is one particular aspect that the current rules give a greater push to.

So before we dig further let me show you a few of the major aspects that we are going to come back to and look at later on. So different definitions and such we are not going to go into that in greater detail though. So as we just went by; again obviously by law we have different definitions for different aspects, this is what I was trying to get at. So here it is the procedure for management of hazardous and other wastes.

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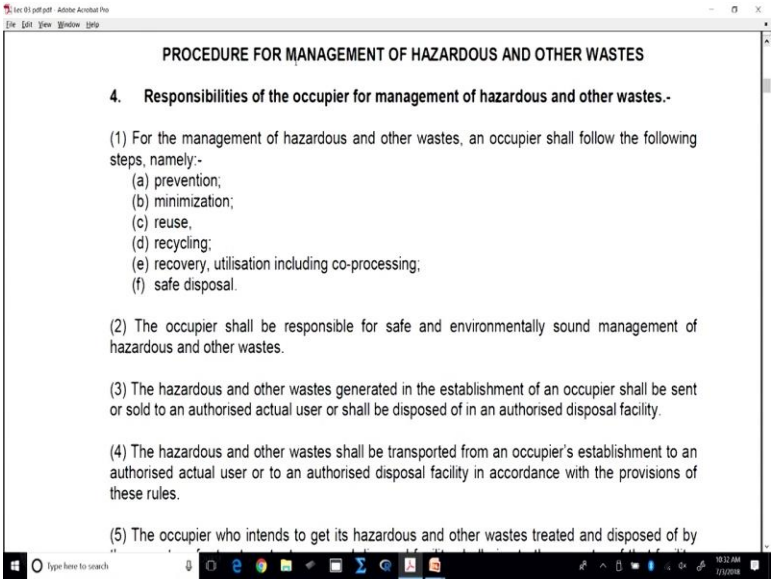

So here the key is that its prevention, minimization, reuse, recycling, recovery, and safe disposal. So these are the key aspects upon which the relevant thrust is upon; as in prevention, minimization, reuse, recycling and then recovery, and then safe disposal. So these are the aspects that are going to be considered. And then moving on to the other relevant aspects, we have the responsibilities of the state government and so on. We are going to come back to this in greater detail later on though, but there are few other aspects that I would like to highlight here.

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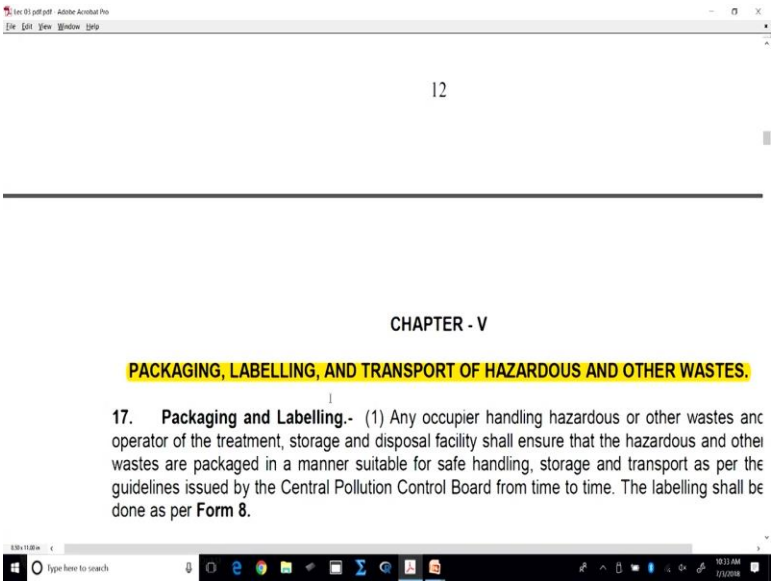

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CHAPTER - V

PACKAGING, LABELLING, AND TRANSPORT OF HAZARDOUS AND OTHER WASTES.

17. **Packaging and Labelling.-** (1) Any occupier handling hazardous or other wastes anc operator of the treatment, storage and disposal facility shall ensure that the hazardous and othei wastes are packaged in a manner suitable for safe handling, storage and transport as per the guidelines issued by the Central Pollution Control Board from time to time. The labelling shall be done as per **Form 8.**

So one aspect that is usually given short shrift in Indian context is the packaging, labeling and transportation of hazardous and other wastes. As in, I guess from time to time in news you might have seen examples of hazardous waste being spilled open onto the roadways and that leading to considerable contamination of a wide area, or hazardous substances traveling over considerable distances and affecting people.

So in general there are specific ways that they need to be labeled so that it is easier to identify and classify, so that in an emergency situation the relevant responders can act accordingly if they have the relevant information. As in you do not want to spend time figuring out what the waste is about, how do I get more information about this waste? So these aspects obviously are relatively given short **shrift** and that is the reason that I wanted to point out. So then again as I mentioned we are going to come back to these aspects later on.

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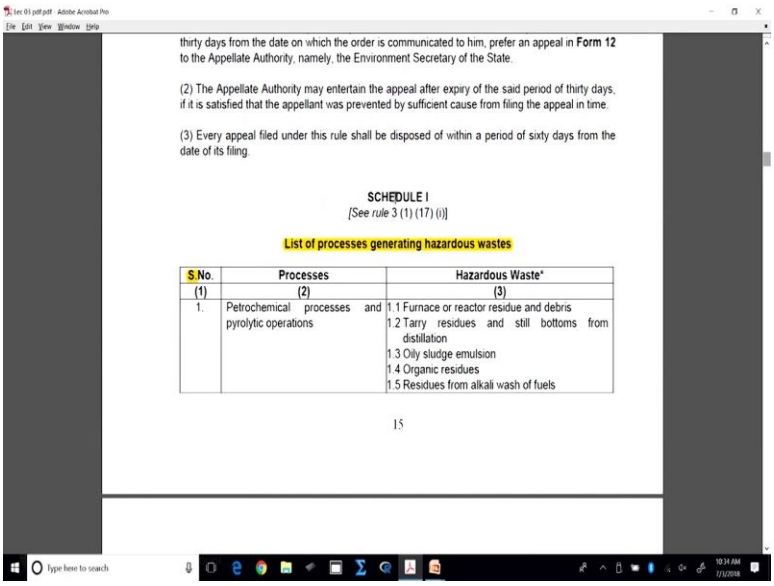

thirty days from the date on which the order is communicated to him, prefer an appeal in **Form 12** to the Appellate Authority, namely, the Environment Secretary of the State.

(2) The Appellate Authority may entertain the appeal after expiry of the said period of thirty days, if it is satisfied that the appellant was prevented by sufficient cause from filing the appeal in time.

(3) Every appeal filed under this rule shall be disposed of within a period of sixty days from the date of its filing.

SCHEDULE I

[See rule 3 (1) (17) (i)]

List of processes generating hazardous wastes

S.No.	Processes	Hazardous Waste*
(1)	(2)	(3)
1.	Petrochemical processes and pyrolytic operations	1.1 Furnace or reactor residue and debris 1.2 Tarry residues and still bottoms from distillation 1.3 Oily sludge emulsion 1.4 Organic residues 1.5 Residues from alkali wash of fuels

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Then here we come back to Schedule I. And what does that contain? It contains a list of those processes that are listed as those processes that generate hazardous waste. So let us say, you have a particular industry out there or you are the owner of a particular industry and some of your processes are listed in this particular category, so then obviously you would need to be on your toes and look at whether the process is listed; if so generally the waste generated from that particular waste would be classified as hazardous waste.

For example, here we have petrochemical process and then the usual kinds of hazardous waste that are generated from this particular set of process and then we have an exhaustive list of such processes. Again, while I do say that it is an exhaustive list, keep in mind that as India becomes more industrialized, we have new kinds of industries coming into the picture and so on. The laws or rules, in my limited experience, are still playing catch up. So again there are still some loopholes, but at least right now because it is 2018 and the rules came about in 2016 they are relatively up to date. Again that is one particular aspect that I want to point out.

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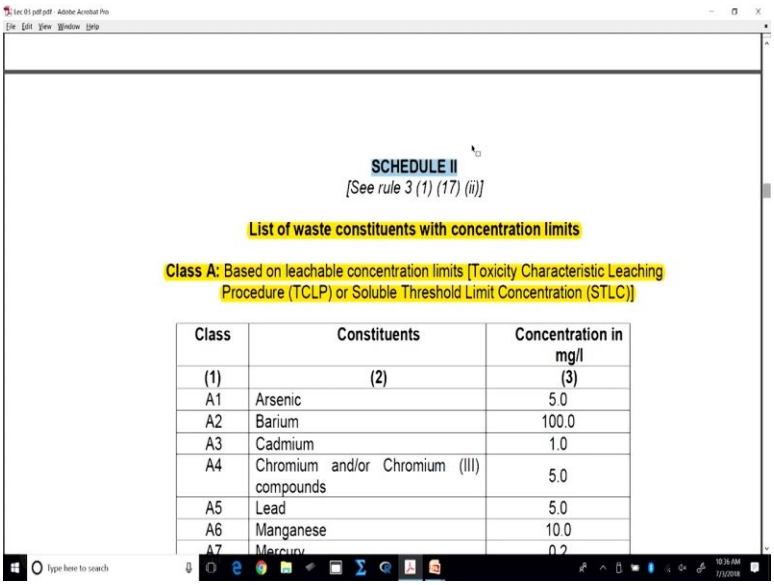

SCHEDULE II

[See rule 3 (1) (17) (ii)]

List of waste constituents with concentration limits

Class A: Based on leachable concentration limits [Toxicity Characteristic Leaching Procedure (TCLP) or Soluble Threshold Limit Concentration (STLC)]

Class	Constituents	Concentration in mg/l
(1)	(2)	(3)
A1	Arsenic	5.0
A2	Barium	100.0
A3	Cadmium	1.0
A4	Chromium and/or Chromium (III) compounds	5.0
A5	Lead	5.0
A6	Manganese	10.0
A7	Mercury	0.2

And then moving on to Schedule II. Schedule II gives you an idea about the different hazardous wastes and their threshold concentrations. And keep in mind that we are going to look at: how do I come about this concentration. For example, I have soil that is contaminated with some particular toxic compound. How do I know if this contaminated soil classifies as hazardous waste or not? So what do I need to do?

I need to conduct the TCLP test or the Toxicity Characteristic Leaching Procedure test. As you see here, Class A type of compounds are regulated compounds, they are based on leachable concentration limits from the TCLP test or Toxicity Characteristic Leaching Procedure, and the TCLP was developed by EPA. So more or less what does it mean? It tries to replicate the worst possible conditions out there, as in the test tries to reproduce the conditions that would come about if this waste is not treated and is dumped in a municipal landfill.

And there the presumption is that or the assumption is that acids are formed in the municipal landfill, acids come into contact with this particular toxic waste and then the contaminants are going to leach into this particular acid and then again you have your contaminated leachate potentially contaminating your groundwater. So the conditions in the test tried to mimic this worst case scenario; as in you add acetic acid, which is what you presume would be formed in your landfill and you would mix it vigorously or end over end mixing for 18 hours.

And then look out what would be the concentration after this equilibration over 18 hours in this particular leachate or the acetic acid. And then you are going to look at the relevant concentrations and if the concentration in this particular acetic acid after it has been in contact with your contaminated soil or contaminated mixture for 18 hours, turns out to be higher than this value then you would need to classify that particular waste as toxic waste or hazardous waste. So that is one particular aspect.

So again we are going to discuss this in detail later on, but these are the aspects that you need to keep in mind for now. Again a relatively exhaustive list of different compounds that keeps changing from time to time. And TCLP method is well defined.

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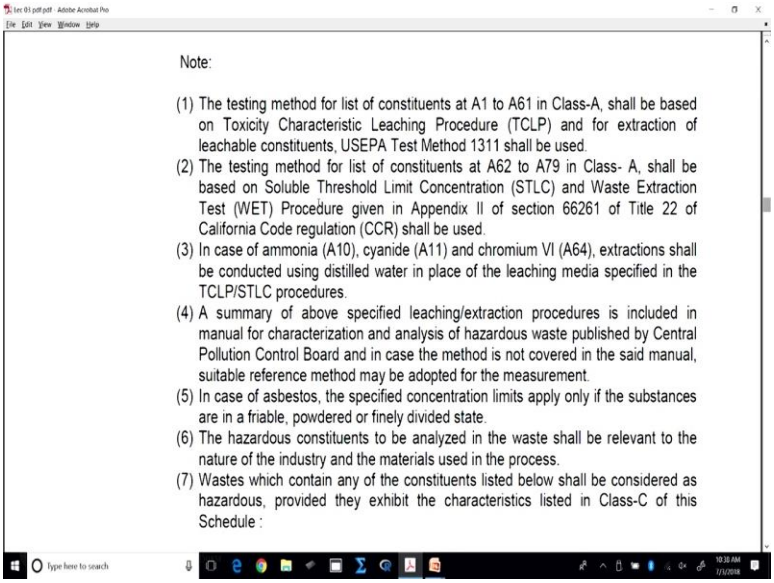

And for some types of compound there is also this Waste Extraction Test or WET, and that was, I believe taken in from the California Code of Regulations.

So typically California has the most stringent regulations and they developed this WET or Waste Extraction Test. That is in general relatively more stringent compared to the TCLP test. Again for some compounds obviously it looks like we need to look at the WET test, again just a brief over view. And there is one final aspect.

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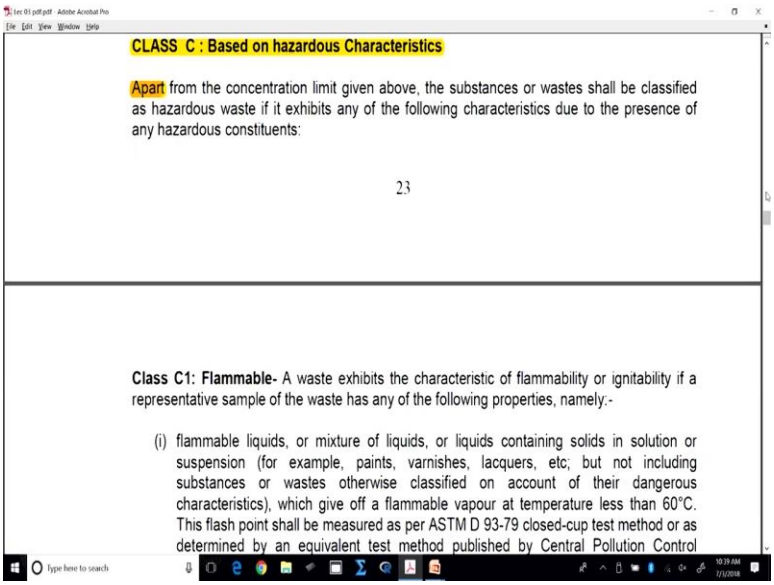

Other than looking at these listed contaminants, we also have another classification to consider whether waste is hazardous or not, and that is based on its characteristics, as in if a compound exhibits or is deemed to be flammable.

So again, flammable we have the relevant conditions. If it is corrosive, if it is reactive or explosive, as we see here. So if it is flammable, corrosive, reactive or explosive, and toxic, again based on the LD50 test. LD50 test meaning the lethal dose at which 50% of your particular test population dies, but usually that is not looked at. We now move on to reference doses and slope factors for either the nontoxic or carcinogenic compounds, so more on that later.

So again, generic overview: here we have set of rules and they were promulgated in 2016, and this is an relatively up to date and exhaustive set of rules. It obviously contains, the process that are listed as generating hazardous waste and obviously the types of hazardous waste generated, so that is something out there. And again the kinds of contaminants and the threshold concentrations above which a particular waste is deemed to be hazardous waste.

And then again you have the relevant classification based on the characteristics as in corrosiveness, toxicity, flammability and so on. So again, at this particular point in time we are going to look at only these aspects, but again over the due course we are going to look at this particular set of laws and the other particular promulgations or aspects in greater detail. So again, I will move on to the next aspect for now.

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As I mentioned earlier we are going to look at risk assessment. So let us say, after conducting this particular TCLP test according to the relevant regulations in the hazardous waste rules, I found out that this particular waste is hazardous. So what do I need to do now. For that first, if I have contaminated soil, let us say side view, and this is contaminated soil here and I have a population cluster here, so I need to look at what is the risk posed by this contaminated soil to this particular populace out here.

How do I go about that? Obviously as I mentioned earlier we need to have some scientific basis that would allow us to quantify it, as in I cannot be subjective. If I say high, the industry guy who contaminated this particular soil might say, okay the risk is relatively low. And obviously depending upon the type and kind of media out there, it can lead to sensationalism too. Again, to be able to cut that out and give greater clarity, you are going to look at risk assessment. So obviously we are going to move on.

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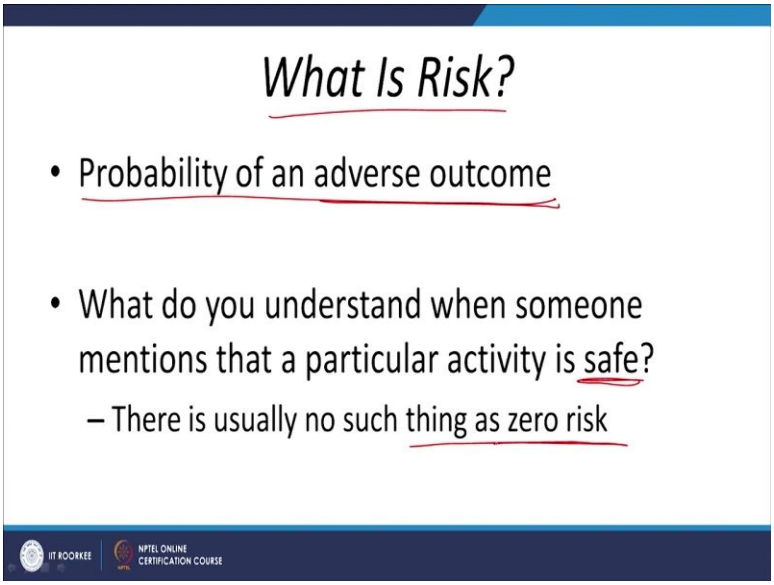

So again, when we talk about it, what is risk and then we talk about taking risks in life so on and such. What is risk now? Anyway I would say that it is a calculated gamble, whenever I say I am taking a risk, it means I am taking a calculated gamble with a certain objective in mind. As in I have certain objective in mind, and I do know some of the ill effects or adverse effects, but I am trying to balance between them and if I think that the chances of these adverse effects are relatively low I am going to go ahead taking this particular risk.

And then risk can be death, risk can be feeling tired and such and so on. For example, I need to get to a particular place, public transport is relatively cheaper, private transport costlier, but public transport might lead to my condition or appearance being remarkably poor by the time I arrive at my destination. So maybe I am not going to take that, so I am evaluating the risks here and so maybe I will go with my private transport and such. Risk can be probability of adverse effect or adverse outcome.

So what is risk, again it is just nothing but probability of some adverse outcome. So in our context, as in remediation of contaminated sites or contamination, what do we typically look at with respect to risk now. We look at effects of the toxic compounds on humans, sometimes we see hair fall, lesions, or carcinogenic tumors. So in this context, usually we look at adverse human health effects. So let us move on.

We did talk about this briefly. So different people have different levels of acceptability of risk. Let us say, I am travelling somewhere out there on a busy destination, a person used to that particular travel or who needs to travel by that route everyday because he knows his livelihood depends upon him traveling through that, for him that might be acceptable risk based on his perceptions.

But a person, who is relatively well off, I am just giving a generic example here, might feel that okay the risks are too great in traveling by that particular route and by that mode of transportation, and might choose other modes of transportation. But here in this context of contamination and so on, obviously what do we need to look, at we need to look at how do we go about quantifying risk.

So what is acceptable risk here. We do have a number here, typically I believe 10^{-6} or one in a million. So the chance of contracting this adverse outcome or facing this adverse effect or outcome is greater than one in a million chance then we say that the risk is too high, certainly for carcinogenic effects. So in this context, when people say it is safe, again keep in mind that it is relative, as in there is no such thing as zero risk.

When we say it is safe, what does it mean; the probability of the adverse outcome going through or occurring is remarkably low. So again, objectives of risk analysis obviously as I talked about it earlier, I am going to try to balance my particular benefits with risks or possible adverse effects that I am going to receive. So once I can quantify the risk, then I can look at the relevant benefits or such, and then I am going to come to a relevant balance.

So in this context of contamination, how is that going to help? As in it will help set target levels of risk. For example, the risk right now turns out to be 10^{-4}. How will this help me now? It helps me in such a sense that I know that the acceptable or regulatory thresholds of risk for carcinogenic risk are 10^{-6}. Then I need to look at what are the remedial options available out there such that the risk comes down from 10^{-4} to 10 power 10^{-6}. So risk analysis obviously helps in such a way.

So obviously again, as we discussed, different programs or different remedial options, different levels of attenuating the risk or decreasing the risk. So I am going to choose the relevant

alternative accordingly. So again, even after remediation, you are still going to have some risk and I am going to be able to analyze that particular aspect.

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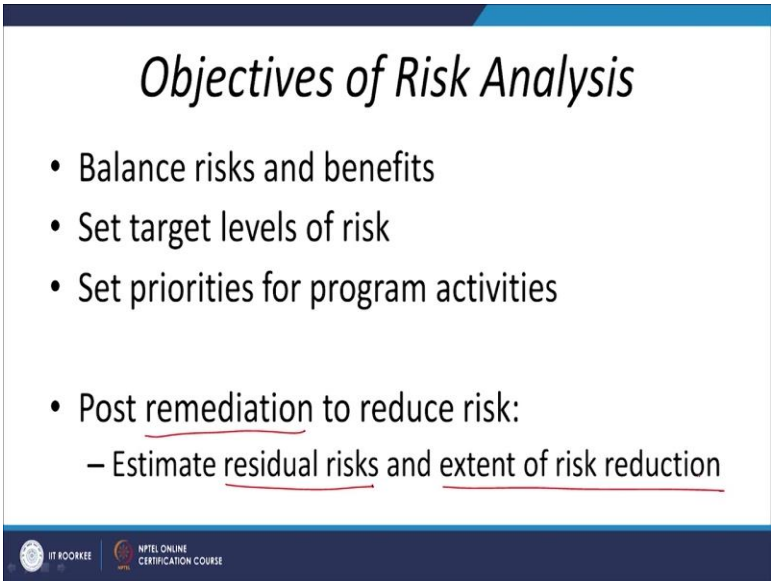

After my remediation, what is the residual risk and how much risk have I reduced. So obviously depending upon that I will choose from one alternative to the other, again based on the amount of resources I am putting into. I mean we do not live in an ideal world, so in an ideal world I guess we have unlimited money, resources and will power, but that is not the case.

So obviously in this context, it is a balance between the level of risk that we can decrease it by, and also the amount of resources that need to be put in.

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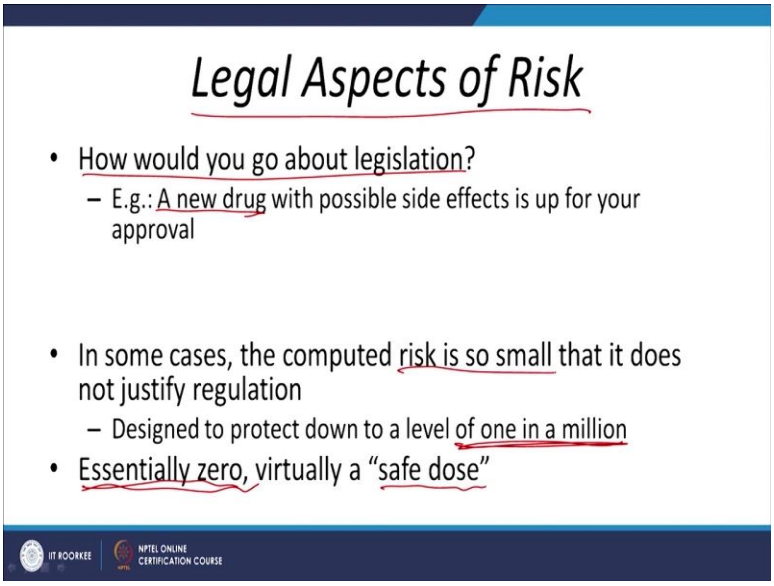

Legal aspects of risk, in general, in Indian context, it is not clearly defined though, but it is relatively clearly defined out there; but one particular illustrative example that I would look at or try to look at is: how do you go about legislating a new drug. As in different pharmaceutical companies, obviously they are working for profit and obviously for the betterment of human health too. So again, how do they go about it. They do their tests and such and then come up with drug for a particular kind to treat a virus, antibiotic or any other disease and such.

So how do we go about.. if there will obviously be side effects. You are taking any medicine in general; depending on the dosage, level of usage, frequency and duration, there will be side effects. And different kinds of people, I mean infants relatively more side effects, pregnant ladies more side effects. The susceptible population relatively more side effects, relatively healthier and such population relatively less side effects, in general.

Again, how does a regulator come up with such mechanism to be able to decide which side effects pose an unacceptable risk or not. For that obviously after clinical trials, we come up with again as I mentioned one in a million chance of risk. So the risk is greater than one in a million chance of any toxic side effects, can lead to a greater chance or the probability is greater than one in a million then we say that the risk is unacceptable.

So if it is below that it is more or less we define that at our current levels that it is essentially 0 or it is a virtually safe dose. Safe dose meaning, the risk is so small that there is no further

regulation or such that is required in this context; again, just an illustrative example. So why are we looking at that.

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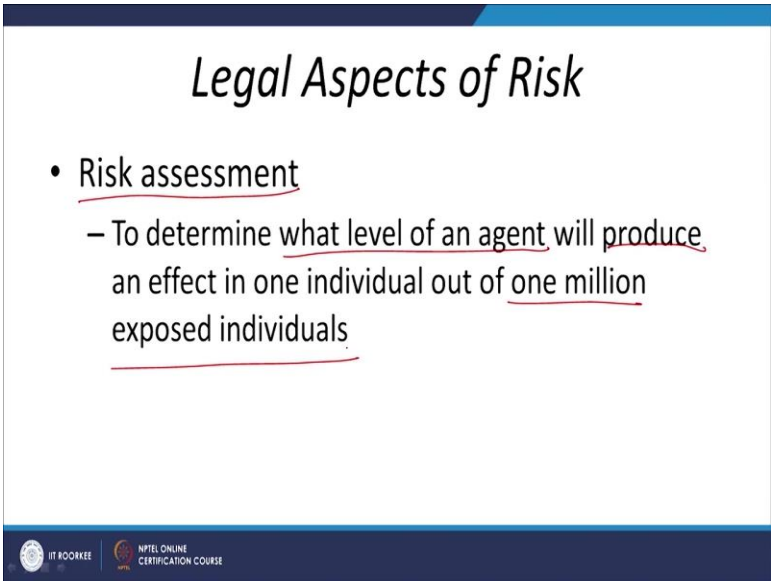

When we are looking at risk assessment, we want to look at the level of agent or this particular contaminant that would produce the adverse effects in one in a million exposed individual. So in this context when I am talking about one in a million it is typically with respect to carcinogens, for noncarcinogens we have different set, and that is going to be the hazard index. We are going to discuss that in due course too.

And in general, all these examples, the reason I am look at one million is it is very much relevant to the carcinogens. So legal aspects, again risk assessment we need to look at reducing the risk to one in a million and that is what we are going to look at. What level of agent will produce this effect in one in a million exposed individuals. So if million people or 10^6 people are exposed to this particular contaminant at a certain set of conditions, well more than one person will be facing the adverse outcome or what else, and then based on that we are going to look at the legal options available for addressing this particular risk.

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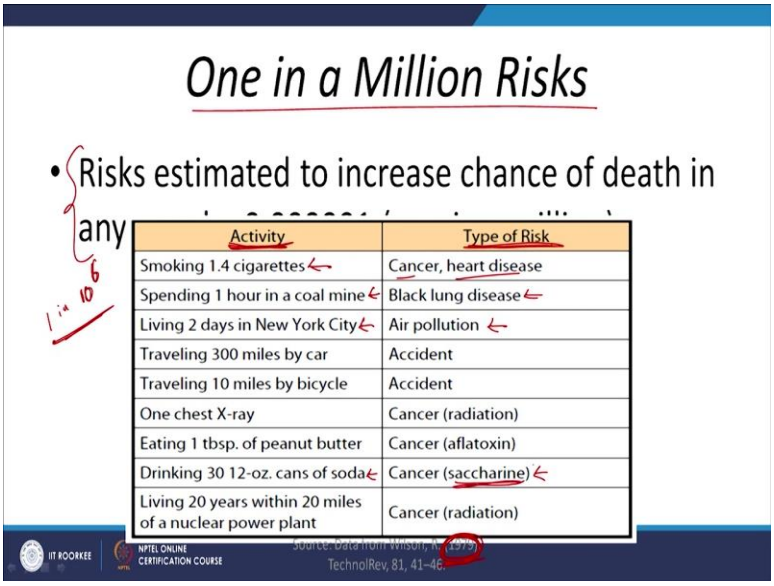

So moving on, I have one particular illustrative example here that I want to look at, as in again on a lighter note. So here we have different activities that can lead to death I believe, not death different kinds of risks and here we have the type of risk. So here again we have different types of activities and the risk associated with it or type of risk, and here it is for a one in a million chance, so 1 in 10^6.

Some of the aspects that are slightly surprising; keep in mind that this data that I have is from 1979, so you know obviously the situation would have changed from then, but again some of the aspects obviously are not greatly surprising as in smoking 1.4 cigarettes will lead to cancer or heart disease at 1 in 10 power 6 or great than 1 in 10 power 6. Well nothing surprising in that or spending one hour in a coal mine will lead to, it seems, black lung disease again with risk equal to or greater than 1 in 10 power 6.

But one on a lighter note, surprising effect is living 2 days in New York City at certain conditions in 1979, due to air pollution the relevant effect seemed to be greater than or the probability of the adverse outcome seems to be greater than 1 in 10^6. Think of this, smoking 1.4 cigarettes or living 2 days in New York City, but this data is from 1979. So now we know the context in Indian cities as in right now, recently in Delhi, the air pollution levels were so high, I believe that was during the sandstorm or dust storm though, that the level of air pollution was so high that the meter could not take the reading.

We usually have air quality index and we measure PM 2.5 and PM 10 and such. The levels of PM 2.5 and 10 were so high off the chart that the relevant readings could not be measured. I wonder what the relevant risk would be for spending one hour or one day in Delhi. Anyway, lighter note, different aspects, 30 12-ounce cans of soda, cancer from saccharine, I believe this is regulated now and so on.

Again, from this set of example, we can see the idea of relative risk as in 1 in 10 power 6 chances of risk, and we see that the type of risks and we can compare the different activities that can lead to the adverse outcome. Again this is on a lighter note, but to help you understand how the risk analysis can let the decision maker look at regulations or policies. As in based on these risks, they are going to look at which of these aspects can I attenuate by looking at changing or tweaking the policies and such or where should my particular emphasis or resources be sent to. Based on that I am going to go through and look at the relevant aspects.

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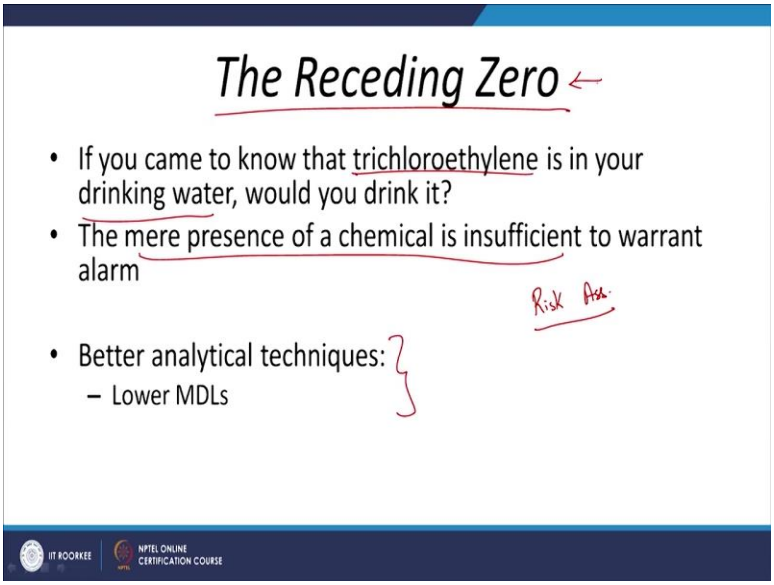

So the concept of receding 0 is relevant in the not just in Indian context, out there too. Let us say, I take water from 10 years ago, I am not saying 100 years ago, 10 years ago, and water from now, 2008 and 2018. And I analyzed the water based on the instruments that were available in 2010 and again based on the instruments that were available in 2018. So obviously the picture is going to be different though. Obviously why is that.

As in water that might have been deemed to be safe might be deemed to be unsafe in 2018, why is that because we do not have the relevant analytical techniques or the equipment to be able to measure some of these trace contaminants that might still end up causing some levels of toxicity or cancer in our particular body now. As in why do I say receding 0, earlier when we say 0 what does that mean, that means I could not detect the concentration below a certain level, so people say the concentration of some contaminant is 0, but because now I have a better analytical technique and my method detection limits are lower, I can still detect the relevant compound even though it is lower than the method detection limit earlier.

So again that is one particular context. So in that context if you have TCE or trichloroethylene, which is toxic and carcinogenic in your drinking water, would you drink it; and most people when I pose that in the class though they say, obviously it is a trick question, would say no. Some people would try to be smarter, yes; but again the key here is you need to ask the relevant questions. As in the poison lies in the dose, as in any particular compound out there is toxic depending upon the amount of dosage.

Just because TCE, a toxic compound is present in your glass of water does not mean you need to look for alternatives, you need to know what is the concentration of the relevant compound in this particular glass of water. And at this particular instance of me taking this or ingesting this particular glass of water what are the risks associated with me contracting that particular adverse outcome or such.

So the presence of mere chemical is insufficient obviously to warrant alarm; that is why we need to look at risk assessment. Just because there is some compound present does not mean I need to be alarmed I need to know depending on the level of ingestion of that water, how often do I drink water, how much water do I drink and what is the concentration out there, I need to be able to choose and then look at the relevant remedial options. And thus again, I need to look at risk assessment.

So obviously we talked about better analytical techniques in the context of the receding 0. As in water the I deemed to be safe in 2010, if I analyze it again in 2018, because of the proliferation of advanced analytical techniques we can may be come to a different conclusion. The water in

2010 is actually unsafe, again unsafe in the context of having compounds of concern; again receding 0. So purity past and present I think I covered that.

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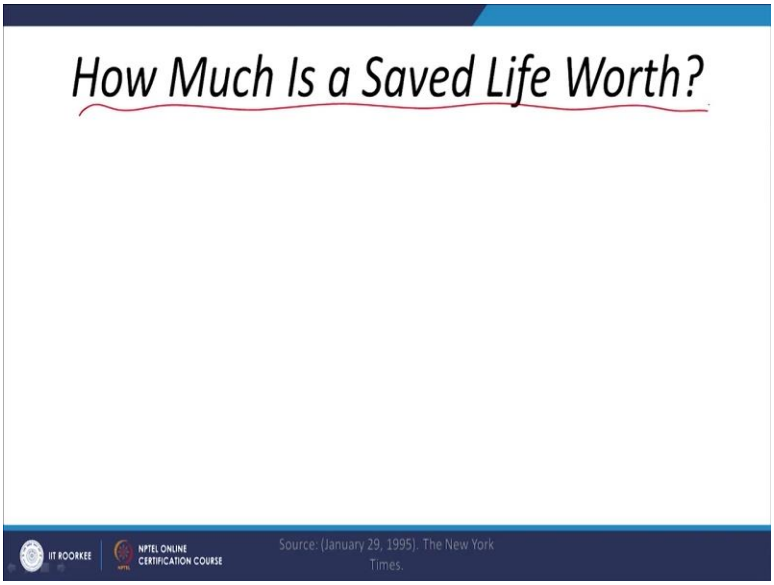

So in this context, before we go for risk assessment, one aspect to consider is look at the holistic idea out there. So risk assessment you are conducting that because you want to look at the risk posed to the human health. And then you are going to put in resources; but again resources are limited resources, our resources are typically limited. So in general how does a particular government go about deciding whether to take some measures or such.

If it is contaminated site depending upon the public outcry and political will power, obviously it goes through, and obviously though we have regulations or policy makers. So how do they decide, which particular aspects do I need to regulate, which one do I not regulate. So it obviously depends upon the costs involved. And for that obviously I need to look at what now, how much is a life worth. You still will be able to put up a particular value to this particular life of a human being. Only then can you come up with the amount of resources that you can spend.

Again I am slightly out of time, so we will catch up on this particular aspect in the next lecture session. And thus far today, we have looked at the relevant aspects of the background with respect to risk assessment, have tried to emphasize why do I need to go for risk assessment. And in the next class obviously we are going to look at how to go about risk assessment. With that thank you for today and I will look forward to meeting you in the next session.