Life Cycle Assessment

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Lecture – 10
Environmental Risk Assessment

So let us; this is the last module for this particular week, which is the week 2. So, in this particular module, we will try to wrap up of what we have learnt so far and in terms of this particular week we started with risk assessment, we looked at the toxicology aspect, we looked at some of the toxicants, we looked some of the chemicals impact now will try to see that and if you remember correctly I also mention to you about a term called bio availability. So, we will discuss that bio availability a concept little bit more and then we will get into that concept of the I would not concept the details on environmental analysis because we have been talking about that for we have been using lot of numbers of certain milligrams per litres certain micrograms per litre. So, I will try to explain to you that how these numbers are calculated, how this environmental analysis is done.

So, in this particular module the focus would be on the biology, on the bio availability and also we start looking into environmental analysis aspect.

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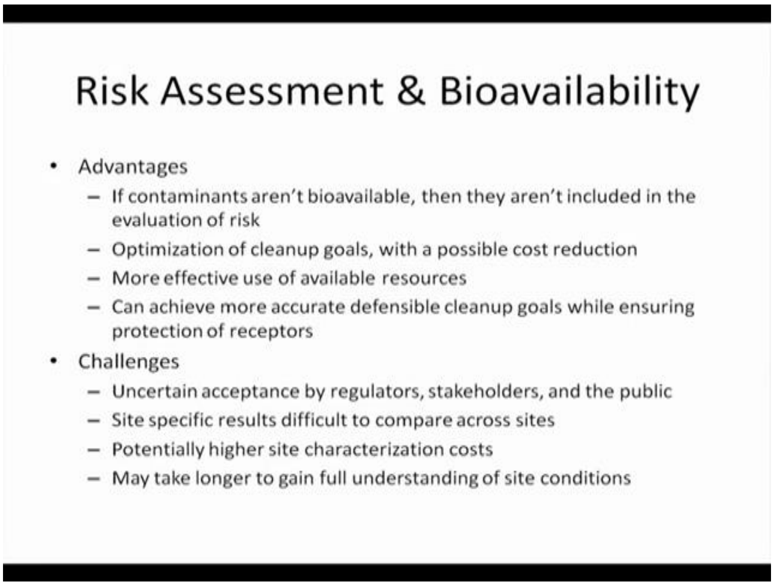

So, what is bio availability and how it is related to risk assessment as I was explaining to you earlier many times things may not be bio available. So, although it is present there might be a contaminant present in the environment, but it is not bio available. So, what does it mean I can if you will remember from the previous example we talked about that copper especially in the in a water body because of the presence of humic and fulvic acid the organic acids copper gets bond up with organic acid and then it is not bio available. So, it is there, but it is not it cannot be used up. So, what is the advantage of having this bio availability concept in the risk assessment? You become more realistic.

So, if the continents are not bio available then they are not included in the evaluation or risk if it is not available we do not have to worry about incorporating them in the risk because it is not going to impact that also helps in the optimisation of the cleanup goals because if something is not bio available we can think about that it is there, but it is not bio available. So, it is not going to impact why should we worry about the cleanup or we that reduce the cost of clean up as well. So, as you know like wherever you are in the world everywhere budget is always a limit budget is a limitation whether you are in a very rich country on a very poor country everybody has limited budget.

So, for the limited budget if you can reduce the cost and I am not saying reducing reduction of cost at the expense of environmental protection and what we are trying to do here is by incorporating this bio availability concept we are making it more realistic we are making it more I would say we are making it more scientific decision in terms of clean up and all that and it leads to more effective use of available resource. So, that is and then it is you can achieve more the accurate defensible cleanup goal while you also protect the receptors. So, that is the advantages of having this bio availability concept built in to the risk assessment.

Some of the challenges it is sometimes it is very difficult to convince the regulators regulator the stakeholders in the public saying that it is there, but it is not bio available that the argument is made that it is not bio available right now, but what will happen in future? I will give you an example for example, say if you are thinking about in an anaerobic system in an anaerobic system is where anaerobic means absence of oxygen in absence of oxygen where you have too much of a sulphide another sulphide in similar materials present most of the heavy metals has a tendency to be in a solid form.

They will make sulphate they will precipitate out and they will in a solid form, but for some reason say there is a air intrusion in future air gets intruded into the system now you are sulphide if it becomes sulphate as you know sulphide will become sulphate when it gets exposed to air because of the oxygen sulphide will react with oxygen and I will goes to sulphate most of the sulphate compounds are soluble say again if you think about lead sulphide copper sulphide they are in a precipitate form there in a solid form as long as they are in an anaerobic condition, but if lead sulphide gets exposed to oxygen it becomes a lead sulphate next time the water touches lead sulphate it gets into the water because lead sulphate is soluble. So, although it was not bio available earlier it may become bio available later. So, those kinds of things we need to be there so that leads to a more site specific results, rather than having a generalized result you will have to do a site specific study.

So, on one hand, we were saying that by incorporating this bio availability concept we can reduce the cost, but on the other hand if you have to do a detailed site specific study that is an additional cost as work. So, you have to have a balance between the 2 and then that will lead to the potentially higher side characterization cost and also it is longer to gain full understanding of the site conditions because you need to make sure that you got your factors you are considering their correct.

So, it gets more science it gets more technically challenged when you are trying to incorporate this bio availability concept, but at the same time in one way it is a good thing to do it is a good thing to do because you are becoming more and you are actually becoming more; you learn more about the site you are doing it in a more authentic way more saying that it may lead to based on we will have to do it. Now the kind of a cost balance of what is the additional cost of incorporating bio availability in terms of the characterization and all those things that we need to do and as opposed to the cleanup cost and then we need to save in terms of a economics which works. And also its not only the economic aspect whenever you get to go for economic aspect is one aspect whenever you are trying to go for any cleaning you may be using some other chemicals and that chemicals also has a environmental footprints. So, if you want to do a life cycle analysis of a different contaminant contamination removal system there this things are incorporation of bio availability may serve better in one versus another again it has to be done, but this is some of the concept which is being used in terms of risk assessment today.

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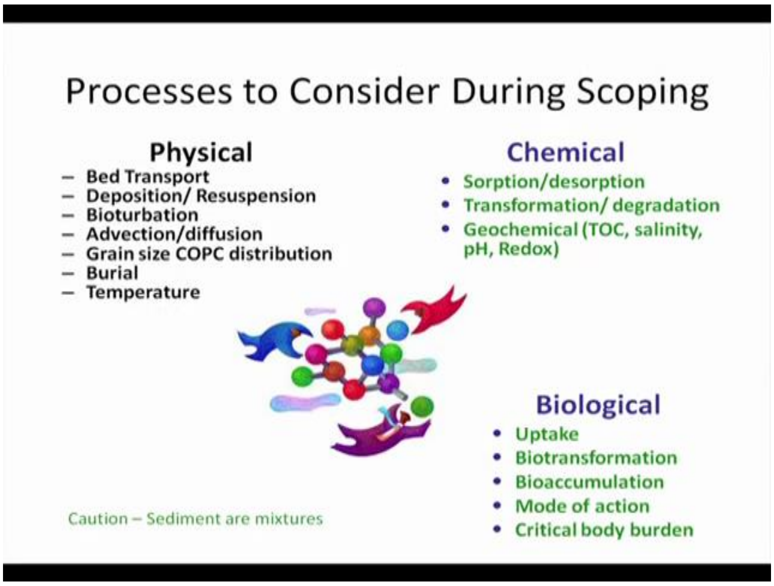

So, now what is the, in terms of the process to consider we do in the scoping of contaminant removal? We look at the physical process chemical process and the biological process; physical process are your, physical is your transport like the bed transport, deposition, bio turbation, advection, diffusion and we will talk about some of these later in the class as well like advection, diffusion, dispersion, grain size distribution, grain size of the part of the whatever is a contaminant of interest burial, temperature all these impact in terms of their fate and transport. Chemical, shops in desorption transformation degradation then there are some geochemical in terms of the total organic carbon, salinity, pH, Redox that impacts the fate of the chemical present. In terms of the biological weather is there is a biological out take there is a bio transformation bio accumulation mode of action critical body burdens all these different factors goes in terms of the scoping of a remediation system.

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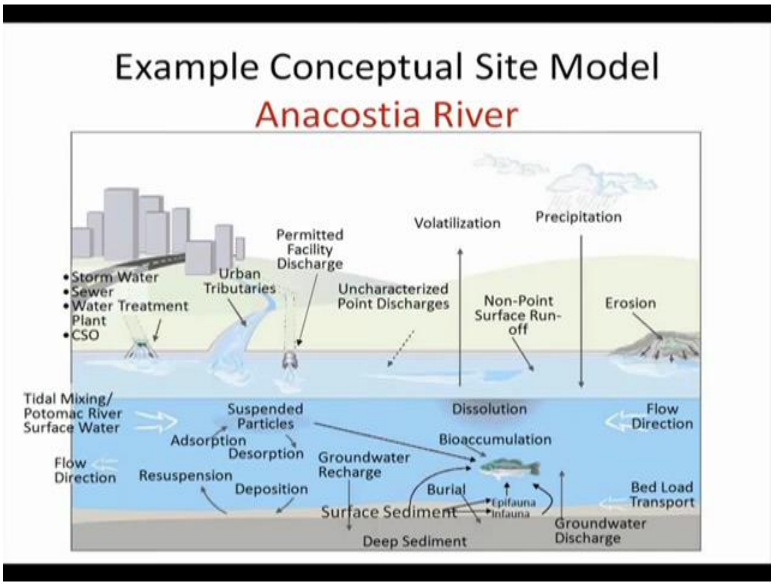

So, if you look at a one example in terms of this conceptual site model into from this Anacostia River. So, here you have things from getting discharged from the storm water sewer water treatment plant and CSO is a combined sewer order for us combined sewer overflow. So, that is comes into this river they could be some permitted facility discharge coming in, there auburn tributaries that bring in some contamination non point surface runoff can come as well there could be some erosion from these surface over there. So, all these things are bringing some sort of contamination into the system.

Now some will get volatilized and go up precipitation may bring some contamination as well now here you will have in that whole water system you have some mixing, you have like a surface water also can come in surface water or the river water other river can makes it, you have some suspended particles where there is some dissolution happening as well. Suspended particles may get absorbed desorbed and then suspended particle may be consumed by this fish which fish can may bio accumulate, some of this can go into the sediments. So, that is where it ends up in the sentiment form then when it goes into the sediments things may come back in terms of the bed load transport and also and depending on the floor direction it will move in one direction or the other.

So, it again this is which is all this is what we need to look at when we are trying to do any of this risk assessment part we need to look at all these different factors for which is on that particular model that all these factors need to be incorporated. So, it becomes really complex exercise it is not an easy exercise to do, it is lot of complex exercise and this is what is comes under a typical fate and transport course like if you have taken a fate and transport course we will try to have some of the basics of that later on in this particular courses as well. But this just the description of this whole model that itself is a course which is a fate and transport course which is taught in many of these like a universities and including in IITs we teach this course of a fate and transport of contaminants. This is here just talking about the water system similar things can be done for the air as well as for the soil.

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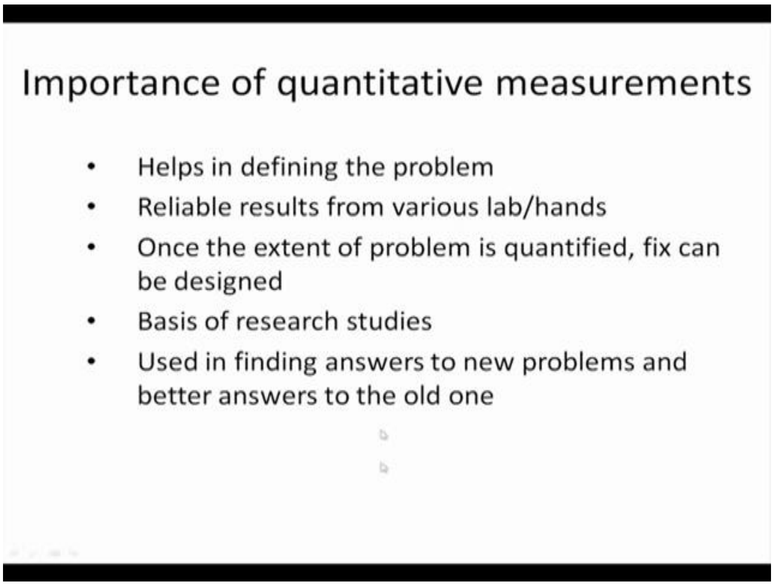

So, this is in terms of making the model system now if you look at all these different things that we talked about adsorption desorption ground water discharge different effluent coming in for all these we need to measure the data. So, we need to have quantitative measurement quantitative measurement means when you have the numbers. So, there is a difference between the qualitative and quantitative we have explained that in a previous module we had a brief discussion on that in a previous module qualitative means where you just know this is better than the other, but we do not have the numbers and in terms of the quantitative here we have we know the numbers we have the numbers in terms of x milligrams per litre or y microgram per kilogram.

So, we have this. So, why is this numbers are imported, why this numbers are important, is because it helps in defining the problem it is you can define the problem much better say you have to design a remediation system. So, in that you need to know what is the concentration present in the content what is the contaminant concentration present based on the level of the contaminant you can design what would be the like how much treatment is needed because you need to meet certain standard in terms of the removal of those contaminant from there. So, for that you need to come up with the removal like a design of the system for that you need to know the numbers. So, it helps in defining the problem the quantitative measurement there are reliable results from various labs. So, we need to have the results coming from the varial lab. So, it is not only the analysis the numbers that is coming in we also have to have a standard methods is standard procedures to arrive at those numbers.

So, because there are various labs presents various people working in the labs. So, everybody should work on the set standard setup of protocol that is the standard methods we talked about. So, as I said earlier. So, once the extent of problem is quantified when you know what is the level of contamination for example, say we got a water system coming in and say only problem is again I take a example of arsenic again and again because arsenic is a one of the most common environmental contaminants especially if you are looking at the groundwater in many parts of the world including in this part of India. So, arsenic say if we have a surface of groundwater sources our drinking water and arsenic is around say 20 microgram per litre. So, first need to know it is 20 micrograms per litre and then we know that we have to treat it to 10 micrograms per litre.

So, to design from 20 microgram to 10 microgram knowing that 10 20 microgram is very important. So, that we know that we need to remove now this concerned we need to bring their concentration down from 20 to below 10 to meet the standard. So, that is what we are trying to say over here when we say that once the extent of the problem is quantified we can fix the design, we fix can be designed from there and that is also the basis of the research studies like we can do the research based on that and we can use that in finding answers to the new problems and also the better answers to the old one.

So, that is if there is a new problem we can find the answer to that and for any old problem we can come up with the better answers. So, that is in terms of how, why the quantitative measurement is important.

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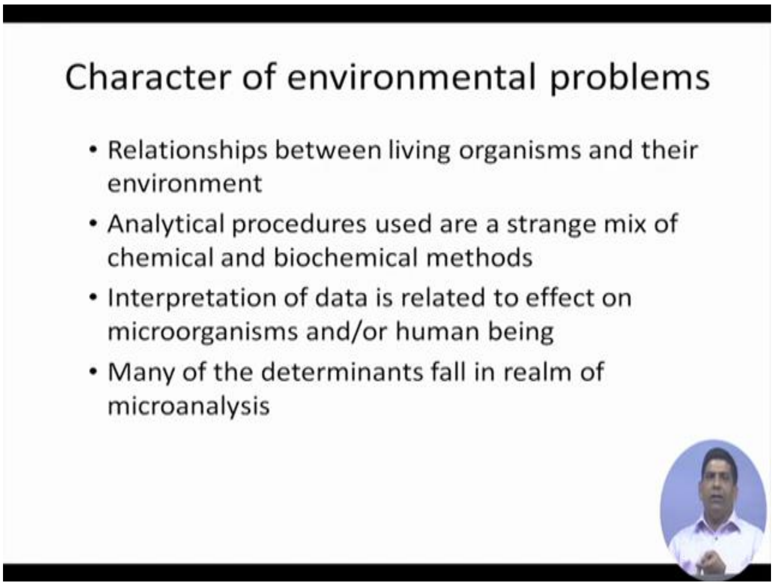

Now when you try to look at the environmental problem environmental problem it is a relationship between the living organisms and their environment that is what the environmental problem is all about we have analytical procedures which we use which we use with the mix of chemical and biochemical methods chemical and biochemical methods both used. If you remember COD is done, COD is the chemical oxygen demand which is essentially a chemical method your alkalinity hardness measurement is a chemical method, biochemical method is very very standard common one would be BOD the biochemical oxygen demand is a biochemical method that is used to do a biochemical would like analysis. Now interpretation of the data it is data is related to the effect of microorganism and or human being how the microorganism is affected.

So, many of these determinants they fall in the realm of what is known as the microanalysis. So, we have to analyse a sample, we have to analyse a sample to come up with the data. So, all these risk assessment, toxicity information or the all these for all this kind of studies we need data and in this particular module we are trying I am trying to explain you how this data is generated and part of it you should know because you have probably done some environmental lab already, but this well at least help you to understand how to collect data in a good way in a correct way rather than a few what is the standard way of collecting the data and what are the things you need to be careful while collecting data.

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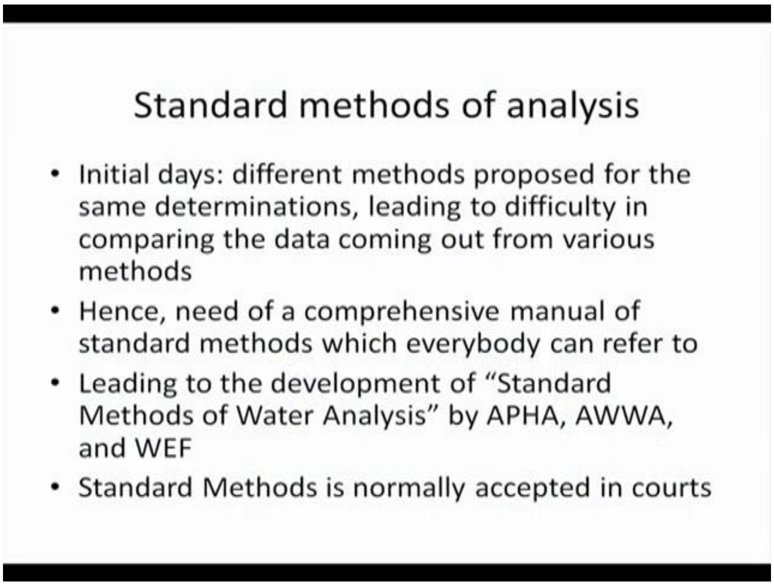

So, as I kind of alluded to earlier we have a standard method of analysis. Now what is the standard method of analysis why do we need again, as I keep on telling you again and again that you need to be always asking you that question of why. Remember when you are a small kid you were the small kid ask lot of questions and when we grow up we stop asking question which is kind of we get so much tuned in that we stop asking question. Many times even we do not know the answer we think that will try to find the answer later on, we will Google it later on and try to find the answer, but that is not you should not let your curiosity go away and that is why many times you hear the phrase let the child in you be alive do not kill the child which is within you because your child within you is very very important for your curiosity to be alive.

So, why we need a standard method? Because earlier what we used to do in the initial days different methods were used different methods were proposed for the same determinants say if you take a very common way of measuring say for example, alkalinity of hardness, you do in one particular way, I do it another way person, x do is in some other way person, y does it in some other way. So, what is the problem there the problem is if the different methods are used we cannot really compare the data, to compare the data we need to use a standard way of doing it we should have to follow a similar procedure say you want to compare the contaminant level or the BOD level of a river a versus river v or pond a versus pond b, but pond a you do BOD in a different method pond b, you do it in a different method that comparison is not proper because the method was different. So, it could be just the method which is giving us the variability it may not be the variability between the BOD levels of those 2 ponds pond water. So, for that reason we have this like what there since they were different methods were proposed for same determinants it was leading to the difficulty in comparing the data it was leading to the data was becoming a data coming out from various methods. So, there was a need was failed there was a need failed that we need to have a comprehensive manual office standard method which everybody can refer to.

So, that is standard method was developed by American public health association and American water works association and world and water environment federation. So, these three you see that APHA American public health association, American west water association and world water environment federation these three organisation they came together and they developed the standard methods for water analysis and this is a like a it is a big volume book you walk into any environmental lab, any good environmental lab in the country anywhere or in the anywhere in the world you will find at least one copy of this is standard methods of water analysis because that is what now it is a standard way of analysing certain parameters.

So, we can compare say even we can compare pond say in from here in IIT, Kharagpur campus to any pond in the country or any pond in the world because we know that all of that pond has been analyse that COD numbers, BOD numbers of the DO number or the alkalinity hardness pH whatever has turbidity is measured with a certain set of in certain set of steps which is part of the standard method.

So, and they are also accepted in courts because these things litigation come up you have to go and present your data especially in Indian context of the national green tribunal, so unless if you are contesting something you need to have a standard way of measuring it. So, that if NGT send some other lab your sample is sent to some other lab and they should be able to they should do it in a similar way as you have done it. So, that it can be compared. So, the standard method is accepted in courts as well.

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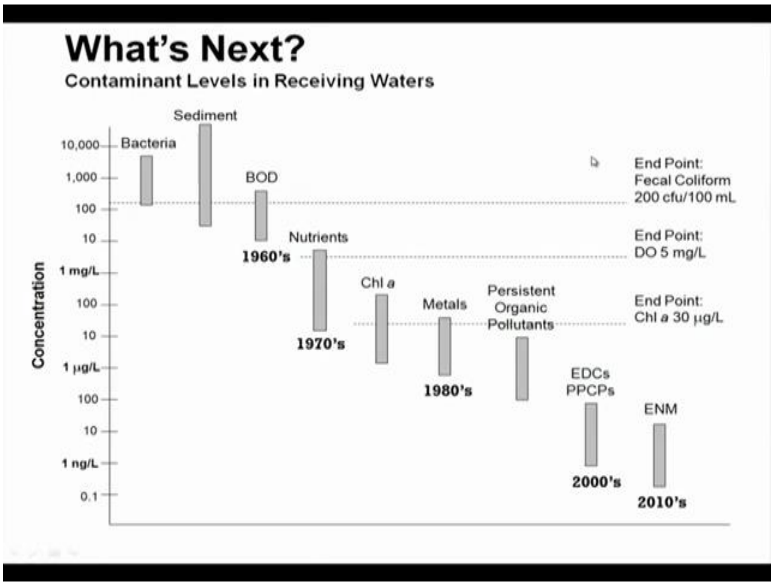

So, in terms of environmental pollutants where if you look at the environmental pollutants today we have here if the x-axis here is actually the different decades which have been marked on different like a columns that you see over here 1960s, 70s, 80s, 2000, 2010. So, anything between here is actually we are talking about 70s here we are talking about 80s, 90 and 2010, 2000s and 2010. So, and on the y-axis you have the concentration and if you look at very carefully on the y-axis your concentration actually is in the log scale. So, you go from 10,000 whatever is the unit say milligrams per litre. So, we go from 10,000 all the way down to nano grams per litre. So, the concentration is going down and here we see different level of contaminants. So, is starting from very beginning we had this bacteria sediments BOD this overall problem of open defecation organic loading in our water bodies.

So, is it again this particular graph comes from a study done in the western world, so where the open defecation problem is not that much there even they have controlled in terms of the excreta from the animals has also been control to certain extent. So, that is why they are saying that this problem was in 1960s. In a country like India where we actually live in different decades at the same time part of India lives in 2010s, 2016 right now, part of India still lives in 1950s because of the nature of development is not uniform throughout the country and we do have right now as you know the government is pushing for that Swachh Bharat mission building of toilets and because we still have lot of open defecation happening in the country.

So, we will have this problem of the earlier problem that we have of this bacteria sediment if you look at into the graph this bacterial problem the sediments and the BOD this problem is still exist in India and many developing countries, but as we have made progress with the industrial revolution or I will say with the agricultural revolution first where we had with the Harit Kranti in India and agricultural revolution and the other parts of the world we started having problems of the nutrients and these nutrients are essentially coming from the fertilizers those storm water runoff from the fertilizers is creating the problem of these nutrients. So, from this BOD COD problem bacteria and sediment problem because of the open defecation in all that and some erosion we have gone into this nutrient problem, now as you go in to the nutrient problem your concentration goes from like few order of magnitude below.

So, you what you are doing is your its becoming at what does it mean, it is at the low concentration also at a very low concentration as well we have the problem of these nutrients in terms of its toxicity and environmental impact then metals again we are going now to the micrograms per litre. So, metals in 1980s on the industrial revolution lot of metals and organics released into the environment I was talking to you earlier in one of the module persistent organic pollutants that is another thing came up with lots of this persistent dioxins furious PCBs those are our POPs and several other compounds. So, this persistent organic pollutants becomes a problem in which is started we started seeing the problem in nineteen like a 1990s around that particular time and again we are going to microgram per litre level now. Then EDCs, PPCBs which is endocrine disrupting compound and PPCBs is your pharmaceuticals and personal care product, it is your medicines. If you remember like it is in not in the medicine that we consume these days we are consuming a lot of medicine and here in even within the IIT campus whenever we like whenever I go to this hospital which we have in campus we see many people actually coming out of that hospital with almost 2 small bags of medicine.

So, this is like we are consuming a lot of medicine after longevity our people are living for longer life, but after certain age many of us are living base actually because of the different medicines that we are consuming, but if you consume that medicine what happens not entire medicine gets used up in the system if you are taking 100 g, 100 mg tablet your body may just required 10 mg or 25 m g, but you are given 100 mg tablet because medical sciences not advanced enough. So, that the 100 mg that you take through your mouth they assume the 10 mg will reach the bay reach the portion what where it is needed. So, it is may not its basically trial and error it is a guess work. So, that is why higher dose is given to us. So, rest what will happen? Rest will go into our urine or will go to the faecal matter and will get excreted out. So, if it goes to the urine and faecal matter it goes to the waste water treatment plant from there it will go to surface water.

So, that is how this will come back and our waste water treatment plant as you know those of you who have the environmental background you know the wastewater treatment plant is not designed to remove E disease or PPCBs or even heavy metals, there the ordinary essentially organic removals they are silly focused on BOD remover is a BOD and some nowadays if you go for some tertiary treatment you can remove some of those heavy metals and other stuff and some disinfection at the end if you are trying to use it as a portable water, but otherwise its essentially removal of BOD. BOD is the like a BOD level is what we try to focus on in terms of like E disease PPCB in terms of wastewater treatment plant. So, this endocrine disrupting compound is pharmaceutical personal care product which is becoming a big issue recently. They are not getting treated in the wastewater treatment plant they are ending up in our surface water or in the bio solids.

So, if it goes to the surface water it leads to the where we see that feminization of fish, feminization of alligator or crocodile and if it goes to the bio solids what will happen bio solids is a sewage sludge it is a fancy name for sewage sludge is bio solids. So, bio solids are land applied, land applied means it goes into the agricultural application it goes to the agricultural land. So, this agricultural land when they up take there could be a potential up take of bio solids this chemicals into those the plants that grows on to them, so that going to be a problem. Again going back to the graph if you look at the graph we are now going into the nano gram per litre. So, in particular in those particular graphs we are looking at the nano gram per litre, we again at a very low concentration.

And this last one is the engineer nano material which is the nano material is a new worksheet of contaminants come into the environment and which could be a which is already more focus area today and its lot of research is being done over there. So, what does this tells us if you look at what is the summary from this particular contaminant level its essentially what is telling you is the type of contaminant is changing over every like every few decade or every decade the contaminant earlier our focus was mostly on the bacterial contamination. We were more worried about things coming in play in terms of the organic loading then we started worried about the nutrients the fertilizers the nitrates and the phosphate then come the heavy metals then persistent organic pollutants EDCs, PPCBs engineer nano material and if you remember from the y axis that we looked at its the concentration goes down sorry the concentration unit goes down we are looking at a log scale.

So, some of these newer contaminant they are even harmful at a very low concentration. So, they have certain toxicity at low concentration. So, you may ask that so what a big deal? So, if it is bad at low concentration. So, be it the problem is lower concentration to measure lower concentration its more and more analytical challenges when I say analytical challenges you need more sophisticated instrument to do those at low concentration because at low to measure something at low concentration you need high level instruments they are costly instruments many lives will not have it. So, to do this environmental risk assessment, to do this incorporates this environmental risk assessment in our life cycle analysis we have to analyse this. So, the cost of analysis goes up the challenges of analysis goes up as we have newer and newer type of contaminants coming in.

And these contaminants will keep on coming in like 10 15 20 years ago we did not knew about nano materials, but today nano materials is one of the bigger contaminant you see a lot of even there are journals now which is just focused on nano material there are journals focused on life cycle analysis there is a international journal for life cycle analysis, which is just focus on life cycle analysis studies. 20 years ago nobody was like very few people were doing this life cycle analysis part. So, today we are learning a course on life cycle analysis of course, it is a newer concept, but getting very popular in the Indian context as well government of India from down maybe few years down the line they will make this life cycle analysis as a like a important tool that needs to be done in any project. Many countries in the world like in California or in other places LCA is mandatory now, in addition to EIA which is also done in India EIA is the environmental impact assessment, so you have to do LCA.

So, with this particular graph that you looked at here again we again try to the reason for this chart to is to highlight that newer and newer contaminants are getting into our risk assessment calculation at a very low concentration which has lot of environmental, which has lot of analytical challenges and I will tell you some of those analytical instruments during the next module.

So, with that let us wrap up this particular week which is the week 2 of this particular course. In the third week we will continue into how this like how to analyse these chemicals and what are the instrument being used and then we start looking at some of the examples of how else is done by taking all this information together. So, thank you I hope that you have been enjoying the module. So, far we have been done with 2 weeks. So, it is a 25 percent of the course is done and then we have another 6 weeks to do. So, total we have 8 weeks of lecture in this particular course again,

Thank you, all the best and I will look you, I will see you again.