Infrared Spectroscopy for Pollution Monitoring
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Lecture- 02
Environmental Analytical Science

So, I was trying to correlate the environmental pollution control along with spectroscopy, so how do you define the environmental pollution. It is a big term and requires lot of considerations, but in short we can define it has the temporary or permanent change occurring in our surroundings such as air, water, land which affect the quality of human life, that is more important now either temporarily or permanently, either way you can define. It may have short term effect or long term effect or permanent effect depends.

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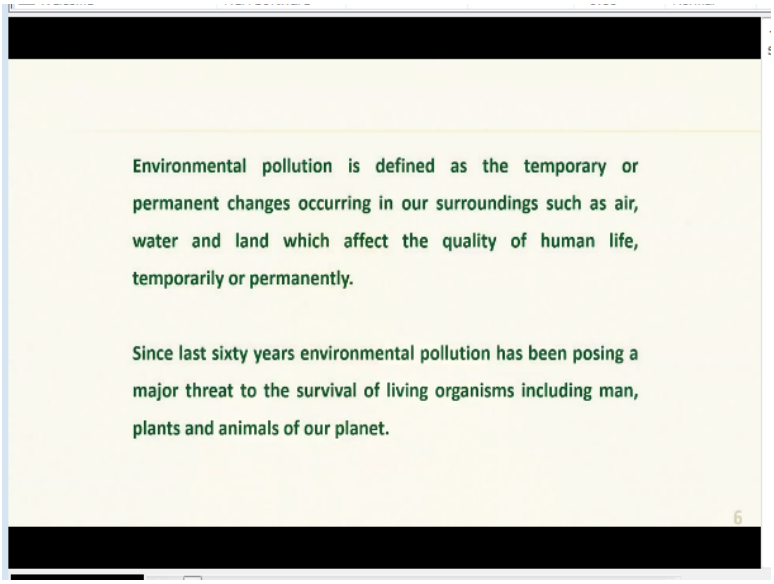

So since last 60 years we have seen that environmental pollution has been posing a major threat to the survival of living organisms that includes man also and several plants and animals of the planet. I think all of you know that there are at least about 150000 plants, species.

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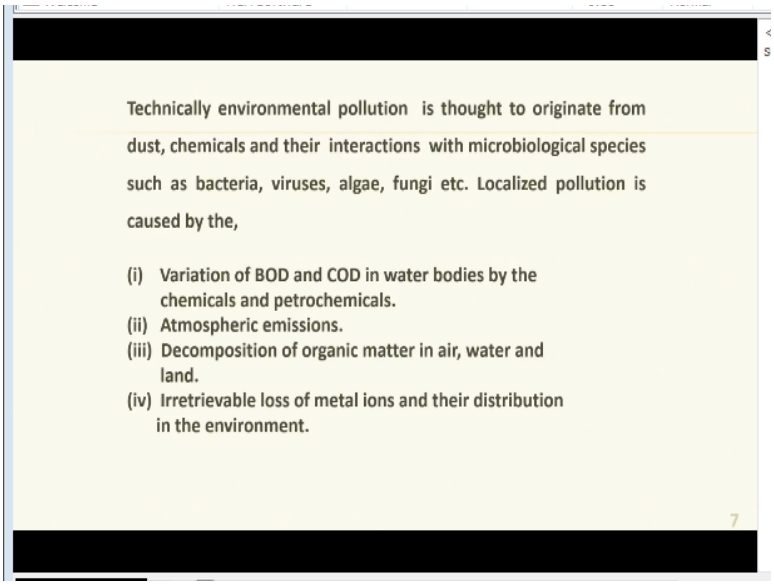

And about 75000 animal species are in the danger of a extinction, that is because of the changes in the environment occurring, changes in concentration of the carbon dioxide, pollutants etc. etc. temperature, variations and then composition of the air, composition of the land, composition of the water so many other factors. In general what you say is man cannot move as easily as animals.

If I find that one particular environment is causing a pollution man cannot translocate to the some other area immediately. But plants and animals, plants also cannot translocate, but within a limited system a pollutant entering a plant body can be translocate into either leaves or in the stem or in the flowers and they can be disposed off to certain extent. Animals themselves can move away somewhere else.

But man cannot move from one area to another so easily, because our whole ecosystem, agriculture, industry, and several schools, colleges, buildings and several other ecosystems are associated with the land environment. And it is difficult for us to move around, so that way man is a handicapped animal right. So, technically environmental pollution is thought to originate from the dust, chemicals and their interactions with the microbiological species such as bacteria, viruses, algae, fungi etc.

So, localized pollution also can be caused by several factors some of them I have written here one is variation of BOD and COD. And I am not going to explain to you what is BOD and COD except that it is biochemical oxygen demand and chemical oxygen demand. When I do a course on environmental pollution you will see what you can do with the BOD and COD. Basically most of these chemicals demand oxygen from the air or from other source to oxidize the components, the organic components to carbon dioxide and water.

In general you do not consider carbon dioxide as a pollutant, but quite often technically it is not a pollutant, but it is a softer effect. For example carbon dioxide generally is implicated in the earth's temperature increase and ozone holes this that and several other things are there okay. So, even though carbon dioxide by itself is not a pollutant but we have to consider it as one of the important contributors to the climate management.

And carbon dioxide content keeps on increasing it comes from human resources, human sources, automobiles and natural sources also to quite large extent. But local variation of BOD and COD in water bodies definitely causes change in the water environment that increasing it is oxygen from the water bodies okay that is why we had written that variation of BOD and COD in water by the chemicals and petrochemicals.

And then we also have something known as atmospheric emissions that also causes localized pollution from industries. And then we have decomposition of organic matter, you eat something, throw it somewhere and then it starts decomposing, it gives you a trouble and then it gives a smell and then the smell mixes it with air, water or land or something like that, then that is the another part and the other part is last part is irretrievable loss of metal ions and their distribution in the environment.

If I tell you some of the facts about metals in the environment you will be shocked, basically I have a certain amount of you know logic. Now imagine that in India we are about 125 crore people right about 50% of the peoples are males approximately even though it is males are more about 960 for 9 how much is that about may be 943 lady girls for 1000 people men or something like that, that is a current level.

But approximately 50-50% if we take 60 to 0.5 crores of men are there and these people out of 60 to there are quite of few who are above 16 and they all shave regularly, another for 10% do not shave. So, that makes it about 50 crores and if I use one shaving blade per month every month we are throwing 50 crore shaving blades in the environment. Nobody knows what is happening to they, what is the fate of the shaving blades in our environment right.

So, the shaving blades are all very special metals, tungsten, stainless steel, carbon, chromium then what else is there platinum, they are all coated to make them sharp, work better. But at the end of it is useful life what happens to the shaving blade, the shaving blade ends up somewhere on the soil or in the municipal waste buckets and once it reaches there the cows will come and eat them, they cannot distinguish the shaving blades.

They eat the blades, they get cut, they get wounded, they hurt and then gangling section so many myriad problems, that is only with respect to shaving blades I am talking to you. But then there are ladies hair pins, millions and millions of hair pins use and throw, use and throw plus there are metal ball bearings. You know and then stable pins thousands of thousands and millions of materials which are coming into the environment.

Their value is so small that you do not bother to collect the bother to recover and use them. So, the result that all of them end up in the environment. So an atmosphere which was supposed to be pure since millions of years is being initiated by the metal ions which we are using and throwing. We have so many computers, they contain 53 elements which man never used earlier about 10 years before.

So, these gold ion, gold material 1 gram gold, 10 gram use and throw use and throw use and throw, E-waste is another part, so many other things are there. I do not want to go into the details of that kind of problems. But there is a very strong component of the environmental pollution coming from irretrievable loss of metal ions and their distribution in the environment.

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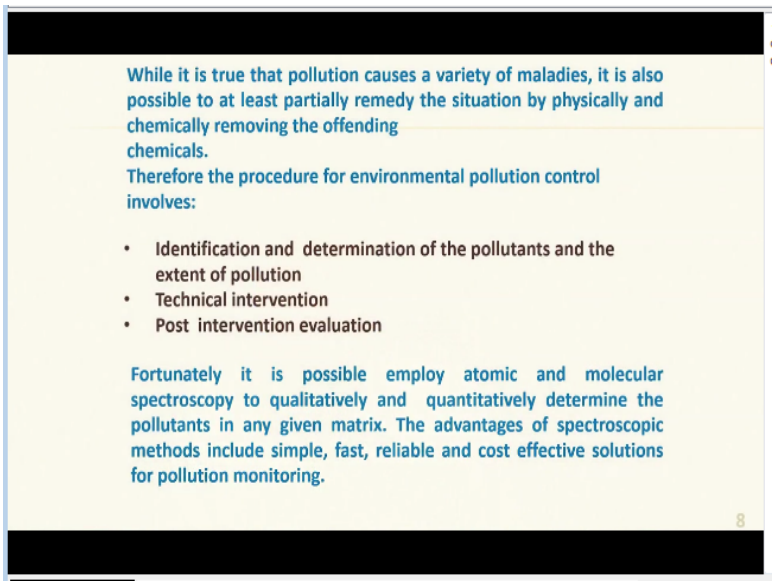

Now you can see that while it is true that the pollution causes a variety of maladies. It is also possible to at least partially remedy the situation okay by physically and chemically removing the offending chemicals. So therefore the procedure for environmental pollution control what does it involve, if I know there is the possibility for environmental pollution I must have a plan to solve the environmental pollution problems.

So, what are the steps involved it does not require a genius to define the steps okay. So, the requirement first and foremost requirement is you identify what it is very simple. You identify the pollutant, you determine the quantity of the pollutant and the extent of pollution that is the first part right. And then secondly we need to find the technical means for solving the problems a technical problem normally requires a technical solution right.

So, if there is a air pollution problem you cannot organize a 500 10 kilometer run and shout let the way let there not be any air pollution let there not be any air pollution like that. Air pollution will not go, so we need a technical solution to a technical problem. So that is what I call it as technical intervention okay. So most intervention supposes I plan something and executed after the technical intervention I must also know what is happening after the technical intervention.

Whether pollution has reduced or not again I need the monitoring of the environment, whether it is air, water or solid waste right. So, these are the 3 steps basically one if identification and

determination of the pollutants and the extent of pollution that is number 1. Number 2 is technical intervention which requires specialized knowledge, special application and the last one also requires technical knowledge that is post intervention evaluation.

So, fortunately it is possible for us to employ atomic and molecular spectroscopy to qualitatively and quantitatively determine the pollutants in any given metrics. And as I told you a metrics can be air, water or solid okay, so the advantages of spectroscopic methods basically include that first engaged they are all very simple techniques all you do not have to do even if you are a chemist you still do not have to do many things.

When you are doing a spectroscopic analysis, all you got to do is probably take the sample and then put it in a sample holder, put it in the spectrophotometer, let the spectrophotometer do the job okay. Once you get the data that interpretation and application and other things are different. But actual work involved in the spectroscopic measurement of human intervention is very very very less. So, the spectroscopic methods offer the advantage of simplicity.

I can train a person who is not a spectroscopist, I can just teach him okay Baba. You take the sample put it in this box, put it in this spectrophotometer or IR instrument or AS, let machine do the job. So, there will be a machine operator machine you will operate the machine but spectrophotometer has what a computer, it will do the analysis, it will collect the data, it will do everything, it will plot your graph.

It will tell you what is the concentration, so many other things it can do. So to do the spectroscopic job you do not have to be a spectroscopist, but if you are a spectroscopist it helps, that is the catch we want to know where are we standing with respect to a spectroscopic technique. So the spectroscopic techniques offer as advantages that are fast, that are reliable, that are cost effective solutions.

They should be fast also; you cannot wait for hours together whenever a disaster is happening right. You cannot wait for months together or hours together whenever there is sports competition there are always 3 guys standing on the podium number 1, number 2 and number 3.

And you have to take their urine analysis and see that their not into drugs, so you cannot make them stand for 1 hour, one and half hour to just to determine whether they are into their drugs or not.

So, I need a spectroscopic method to analyze their urine very fast, may be within a few seconds, maybe within a few minutes. So, from the time they win the competition by time they come to the podium, their samples must be collected analyze the results obtained. And they are interpretect and then brought to the podium to give them the numbers. So they should be simple, fast, reliable and cost effective also.

Without cost affection or without cost effective techniques there is no pollution monitoring okay. It can be very, very, very costly process, if you do not know what to do. So, if you know what to do you can arrive at lot of short terms compromises, without comprising the quality that is the beauty. So we have the advantage spectroscopic methods offer these are the examples these advantages that is simple, fast, reliable and cost effective solutions for pollution monitoring. So what is the environmental analytical science then decide about something about the atomic structure.

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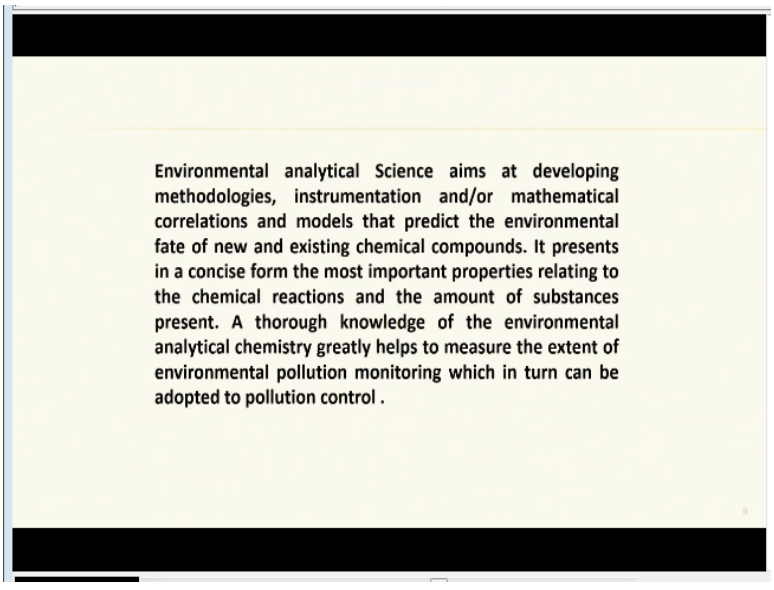

We said something about spectroscopy, we said something about pollution control right, now we are talking about what is environmental analytical science. So, that aims at developing

methodologies, so that job of the analytical chemist is to develop a methodology given a matrix. Again I am coming back to the matrix because sometimes our requirement is ultra-trace sometimes it is trace, sometimes it is minor components or sometimes it is major components.

If it is something like a trace the drugs the sports persons take that will be in nanogram level. So, if they are detected it means that taking right, so job of the chemist is always to develop methodology to ensure that the technique is not affected by the complexity of the sample okay. Now again there are other aspects of analytical evaluation that is after you develop a methodology we also want instrumentation okay.

And then we want mathematical correlations and models we need that predict the environmentally fait of new and existing chemical compounds. So all these things are basically the job of chemist okay, now many of you are not chemical engineers or maybe chemical engineers many of you may not be chemist. But a new methodology needs to be brought whenever there is a challenge to the environment.

So this challenge involves change in the methodology, so who will decide that, the change in the methodology should be such that the matrix should not be affected, number 2 matrix should not interfere, number 3 matrix should not matter, that is known as specificity. So it must be sensitive, it must be selective and then it must be specific. These 3 properties we normally look for sensitivity, selectivity and the specificity. If all the 3 are satisfied and analytical chemist satisfy.

So the methodology is taken care of what about instrumentation yes instrumentation also is important because it shares the time. If I have the most modern instrument with the computer background supporting me, collecting the data, transferring the data, printing out the data, making the calibration curve, making the analysis, making the statistical evaluation, several other things which are required if I do manually which may take our some specific amount of time can be done in a few seconds.

So instrumentation is important and also mathematical correlations like statistical deviation and then coefficient of variation that is also required, standard deviation is required, relative variation

is required. And all the significance 95% confident level, 98% confidence level, student effect and all those technical statistical evaluation will tell us how significant is the change of the environment with respect to particular pollutant.

So the models that predict the environmental fate of new and existing compounds are also required. This cannot be done by chemist, that requires a little bit of more understanding of mathematics, physics and other principles probably chemical engineers will do that job with the help of chemist and other people. So that is why you know environmental chemistry or environmental science itself is a great science involving all these people, contributors.

So it presents in a concise form the most important properties relating to the chemical reactions and the amount of substances that are present there. So a thorough knowledge of the environmental analytical chemistry it greatly helps us to measure the extent of environmental pollution monitoring also, pollution monitoring which in turn can be adopted to pollution control okay.

So the knowledge of chemistry is important, knowledge of mathematics is important, knowledge of instrumentation is important. Only when you have all the 3 then only we can say that yes I have understood a little bit about the spectroscopy. In the spectroscopy again there are lot of other nuances, how to interpret whatever could be the interferences, how to eliminate the interference, all those things you will in during our course.

I have mentioned this in spectrophotometry and atomic absorption and ICP also, who will see what kind of techniques we can apply for infrared spectroscopy also okay. So this paragraph, this slide what I am going to show you is about spectrophotometry, it just gives you an idea about how important are the spectroscopic techniques in the environmental management, just look at the slide what I have here.

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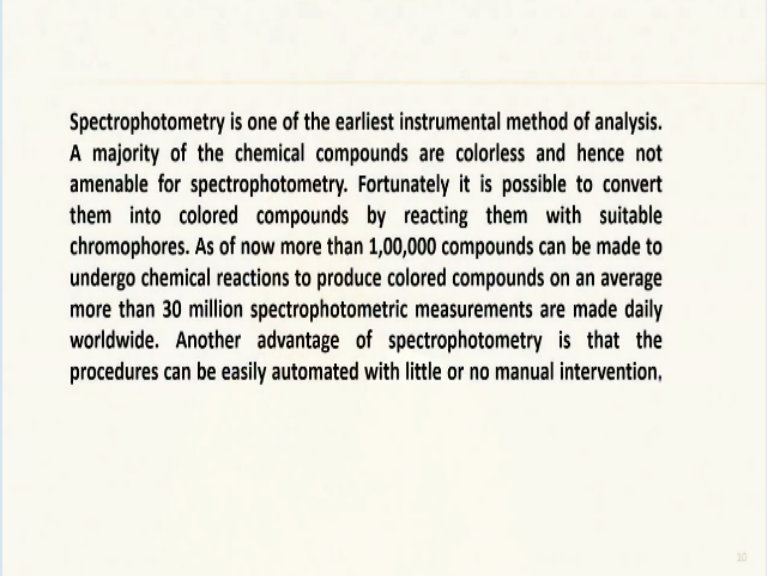

Look at the slide what I have written here, I have written that spectrophotometry that is only color measurement, it is not what I am going to teach you in this course. But I am giving you the simplest spectroscopic technique that is molecular spectroscopy, that is one of the earliest instrument in methods of analysis and a majority of the chemical compounds are colorless and hence not amenable for spectrophotometry because it measures only color.

Fortunately it is possible to convert them into colored compounds by reaction, chemical reactions with suitable chromophore, what is a chromophore. A chromophore is a group of chemicals, group of atoms a functional group that gives that reacts with a metal ion or something like that with reactive moiety to give a colored compound okay. So, as of now more than 1,00,000 compounds can be made to undergo chemical reactions to produce colored compounds.

And on an average more than 30 million spectrophometric are made daily worldwide. So, another advantage of spectrophotometry is that the procedures can be as easily automated okay or with little or no manual interference, no manual intervention. Everything you just put the samples there go home, have lunch and come back your data will be ready. So this is the kind of automation we are talking about in most of these spectroscopic techniques now a days.

Most of them are simple straight forward instrumental methods and which can be automated also. So a little more about spectrophotometry.

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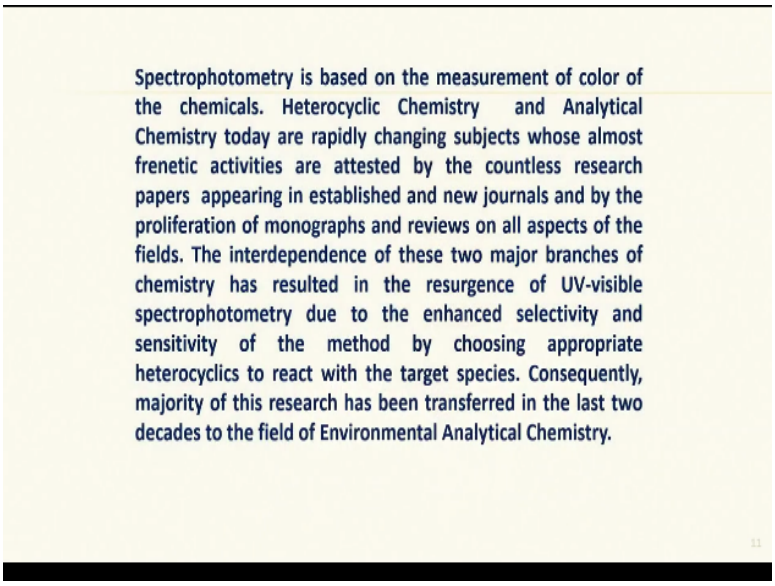

Then it is based on the measurement of color, the chemicals, heterocyclic chemistry and analytical chemistry are rapidly changing subjects, whose almost frenetic activities are attested by the countless research papers. 1000s and 1000s of research papers have been published and being published that appear in the established and new journals and by the proliferation of the monographs, you know these are world treasures of the technical literature.

They are known as monographs and reviews on all aspects of the fields, therefore the interdependence of these 2 major branches of chemistry has resulted in the resurgence of UV-visible spectroscopy okay. And sensitivity again enclose byes, going heterocyclic and then consequently the majority of the research has been transferred in the last 2 decades to the field of environmental analytical chemist, this you should know.

So, quite often we always say that spectrophotometry is the most simplest and most you know easiest way of doing the spectroscopy. So now I am talk about the atomic absorption a little bit and then I will talk about other techniques and then we will try to understand the atomic structure okay. Once you have atomic structure you will study the interaction of radiation with matter, that will be part of the next courses, so thank you very much, have a nice day, bye.