Environmental Quality: Monitoring and Assessment
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Lecture – 2
Classification of the Chemicals of Concern

In the last lecture, we have covered some fundamental aspects of the environment. In this lecture, we will take a closer look about the pollutants that are involved, a study.

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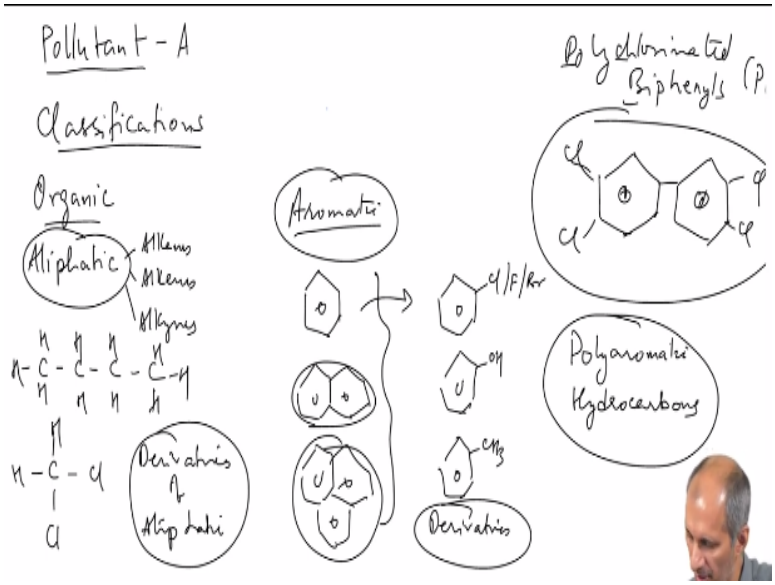

So, when we call something as a pollutant in our discussion, we will give it this nomenclature A, A can be anything. So, What is a pollutant? So, in this context, we are talking about toxicology which means there is some material, there is substance, because A is the substance, any substance okay. So, what are the possible classifications of this substance that you can think of? So, what broad classifications can you think of for any substance? It is important only from the point of view of classification.

There is no other importance to this, other than that you can group, one group one set of things and because lot of things will change, what we discuss subsequently will change based on this. So, I am talking about properties of the chemicals, in a sense basic properties. Toxic, nontoxic is a much more refined classification and that is **"Professor - student conversation starts"** Eh odor**,** no in general, when you go to chemistry, what is your most fundamental classification? States of matter. More general classification based on that? **(()) (01:52)**.

No, I want a little more general classification, what kind of branches of chemistry exists? Organic and inorganic. That is one classification that can be made**,** organic and inorganic yeah. In organic chemicals what, can you make further classifications in organic chemicals? From a point of view of chemistry, aromatic, nonaromatic. Aromatic, aliphatic and those kind of things. **"Professor - student conversation ends."**

So aliphatic, aliphatic includes single bonded, double bonded, triple bonded compounds or carbon chains, carbon those things like alkanes, aliphatic things like alkanes, alkenes, alkynes and so on and you have aromatics. So alkanes, alkenes, alkynes you have a general compound. For example, you can have C-C-C-C, a compound which looks like this okay and so on. This is an example of an aliphatic compound, but you can also have compound that for example, I can have C, single compound.

So, if you have methane for example. I can also remove one methane and put a chlorine, I can remove 2 hydrogens and put 2 chlorines okay. These compounds are derivatives of aliphatic compounds. For example, this is dichloromethane. You can have three CCl3 or CHCl3, it is chloroform and then CCl4. They are all compounds of interest in application and environmental sciences. So, we have aliphatic and aromatic derivatives of aliphatic compounds.

Then we have aromatic, which is aromatic by definition is anything that has a benzene or a phenyl compound. So, this is simple, this is benzene. So, here you can have multiple rings, 2 rings and you can have 3 and so on, it can keep going. So, these are simple aromatic, they are aromatic compounds. So say benzene itself I can again substitute one hydrogen with chlorine or I can have some other compound like a hydroxyl group or I can have another compound with I have benzene here or any other bromine whatever I want and anything else here.

So I can have a CH3 and so on. So, these kinds of possibilities exist. So, these are all derivatives again. I can have NO3. I can have multiple chlorines. So, several possibilities exist here again. So, there are derivatives. There are aliphatic compounds, there are derivatives of aliphatic compounds, there are aromatic compounds, and there are derivatives of aromatic compounds, these are all possible. This list here if we are talking about these compounds are polyaromatic hydrocarbons.

There are multiple aromatic rings here. So for example, this is naphthalene. So this is naphthalene and this is phenanthrene or anthracene. This is one of the two isomers okay. So there is another class which is called as polyaromatic hydrocarbons. Then among the other derivatives of polyaromatic hydrocarbons, you also have a class of compounds which look like this. There are 2 phenyl rings and you can have multiple chlorines associated with this okay. This is one.

So, these are biphenyls, what is the structure, I do not know if it is, yeah it is biphenyls. The biphenyls here and this is polychlorinated. So, chlorine is a very important component from applications. One of the applications of chlorine, I think your common daily usage is for disinfection, which means that it is used for killing microbes to make water safer to drink and all that. So, that function chlorine is an oxidizing agent, it is a very strong oxidizing it will do. It makes things cleaner. So, it will also have the same count if you ingest, it is not very safe for human body also

So chlorine is not a very safe thing in general. So, anything that has chlorine attached to as a derivative, it has a lot of nice properties in industry, but the same thing is also harmful to us. So, whatever compound has been synthesized, people have synthesize several compounds based on whatever fundamental materials you can get to make products that have certain chemical properties which are useful in some products, but at that point in time, we do not realize what can it do if human beings are exposed to it okay.

So, it is not an easy question to answer and discuss, we will get to that little bit and the repercussions of that. So wherever there is chlorine, it is considered as it is flagged, it is marked as a little bit hazardous, more hazardous than this. So you just have methane, methane is nothing, you do not have a big toxicity, but you have one chlorine or two chlorines, the toxicity changes significantly. So, this is one. So, polyaromatic hydrocarbons, then we have this class polychlorinated biphenyls or PCBs.

The PCBs and there are other derivatives of this compound. There is one compound which has an O in between and all that. So, I will have an assignment for this, where you can look at the structure and other properties of this group of chemicals.

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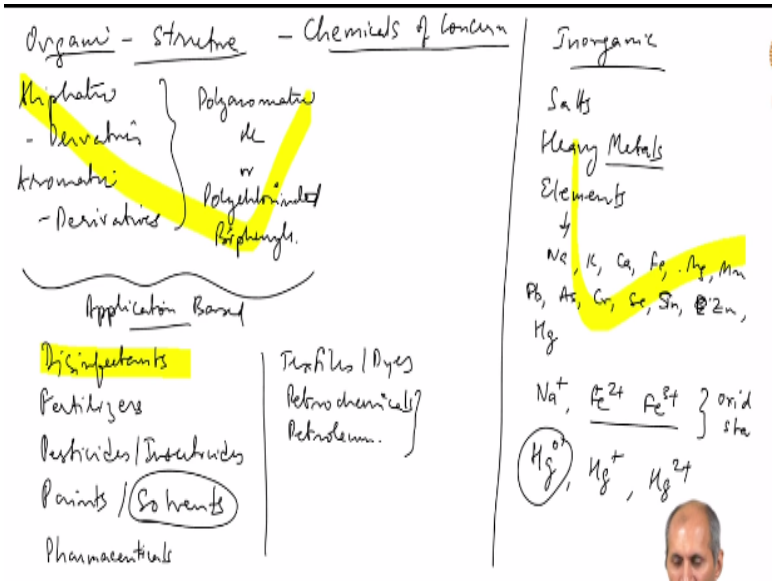

So, here we have some very crude broad description of this thing. So where we have in organic chemicals, we can have aliphatic and derivatives, then we have aromatic and derivatives, and then we can extend this we make another thing as we can have a polyaromatic hydrocarbons or polychlorinated biphenyls. We have some of the chemicals that are listed, it is kind of covers, you can make it as complicated as you want. You have a long chain, aliphatic long chain, aromatic all kinds of possibilities exist in this and the derivative part covers everything okay.

But there we have another type of classification that people also use, in very specifically it is application based. So this is based on the structure, chemical structure and composition, but application based from a utility point of view, you can also classify the chemicals of your interest or chemicals of concern. So, one of the things we are looking at these are all what we call as chemicals of concern. There are thousands and more lakh of compounds available to us. We are concerned about some of them, we are not concerned with all of them.

So, these are chemicals of concern. So, anything can become a chemical of concern if there is evidence for us to believe that it can cause human health problems and then we need to track its this thing. So, application based chemicals of concern, they are all the same compounds okay. They are nothing different from what we have, it is not a separate compound, but application based classification. So, what would you suggest application based classification, this means chemicals that are used for specific application.

“Professor - student conversation starts” So, what kind of applications can you think of? Industrial or domestic? Anything, industrial, domestic, whatever. Agriculture. Can you be more specific in agricultural, disinfectant, fertilizers. Okay disinfectants. Can you expand the disinfectants? What kind of disinfectants? Disinfectant is you are talking about water disinfectant or any other kind of in the same class of disinfectant. Disinfectant have very limited definitions, used for water treatment and all that, but is there a larger application of chemicals that you can think of other any application.

Where are chemicals used? So, when we will classify the large industries which use this as magnitude of, fertilizers. Fertilizers, we put it there, anything else related to agriculture? Pesticides, yeah. We have pesticides and insecticides, yeah. Any other class of chemicals, application based, paints. Now what is used in paints? You see advertisements about paints and all that. So people advertise that paints are something free, lead, yeah lead is there, but that is a good point lead, other things that also there in paints.

What is the main thing that people advertise? What is in the paint, VOCs, yeah but what is the VOCs, VOCs are right, VOC is a classification, we will come to that. So, what is the big class of chemicals that is used in industrial or including paints. **(()) (14:11)** polymer, no. So when you paint, normally, you have a suspension, right, but when you apply a suspension, what needs to happen? The polymer thing, yeah there is the paint that sits on the wall, but it is wet and becomes dry. So, what is the difference?

Why does it become dry? It has volatile component. What is the volatile, why do you have a volatile component there? What is the purpose of the component? Any other major applications in industry which chemicals are used in, are you familiar with that? Adhesives okay. So even in adhesives the same thing, pharmaceuticals where I am trying to get to a particular application, I think related to paints, coatings, thin films, paints, all of them have one particular component, which people have tried to replace over a period of time, no, it is solvents.

People use solvent for various applications. Solvents means they dissolve all other things, they will bring it into a solution of suspension, then you apply it wherever you want, then you have to get rid of the solvent, that the solvent the easy way of getting rid of them, for example if you paint, you want the paint to be dry fast enough, which means the solvent has to

evaporate. When it evaporates, it is volatilizing, it is in the air and that is the VOC that was mentioned. We have not come to the term VOC yet, but we have heard it in public media and all that.

The property of a solvent is that it must be able to have high solubility for a lot of materials that you are working with, you must keep them bound and all. Also solvents are used for cleaning in processing industry. People clean several components of this thing, so they use solvents to clean. They want surfaces to be clean, they use a solvent and we use solvent for a lot of things okay, in very specialized industry and in bulk industry in factories and all that. We also use a lot of solvents in semiconductor industry and all that.

So all kind of industries use solvent, that is there. Anything else? Pharmaceuticals is one big class of chemicals, a lot of pharmaceuticals. Any other application based; textile, dyes, petrochemicals. **"Professor - student conversation ends."** Anything before petrochemicals? Petrochemicals are what, chemical derived from petroleum, that is petrochemicals slash this petroleum based products themselves. Petroleum itself is as a matter of concern because this petroleum is a mixture of lot of compounds, you do not know what is there in it.

Depending on where it is coming from, it may have a bunch of things, and when this is a process, petrochemicals is when you make a particular fuel or something, you will add certain things to make it work in an engine and so on, so you have additives in it. So, there are additives that are put into this which make it more functional for whatever application you are using. So, these are some of the big classifications. You can think of many more okay.

So, the solvents include a wide range of thing, anything, water is a solvent, but water is not considered as a hazardous thing, but there are other solvents which people can use. Acid is a solvent, yeah and a lot of organic solvents in the air okay. Now, you go to the other class of inorganic compounds. So, if you look at the application based things, you look at the left hand side here, we have disinfectant, fertilizers, pesticides, paints, pharmaceuticals, textile, dyes. A large number of these are organic compounds.

If you go and look at the structure of many of these things, they are all organic compounds and they fall under the classification that we have given here, this classification that we have all looked at. These classifications they will correspond to these classifications very easily.

So inorganic compounds, we are looking at inorganic compounds. **"Professor - student conversation starts"** Can you give me examples of inorganic compounds that are of concern, very quickly? Salt. That does not contain, salt, of what, what do you have in salt? What is definition of salt? Somebody said salt. If you do not know anything about the inorganic chemistry, simply when you say inorganic, something that does not have carbon that is a broad definition. Carbon may be there in some form, but it is not classified as the organic part.

What can you think of inorganic compounds? Heavy metals. **"Professor - student conversation ends"** Heavy metals, so in general, all metals, many metals is inorganic. So, we have elements, so what we will generally classify them as elements, so elements are anything. We have sodium, potassium, calcium, iron, so on, magnesium, manganese, aluminum. Then we have classification things like lead, we have arsenic, we have chromium, we have selenium, we have tin, we have zinc, we have mercury, and so on. So, they are elements.

So, these elements they are fundamental entities, but usually some of them sometimes are found as elements as this themselves, but they are also found sometimes as ions, bond with something else. So, they are formed in the form of a compound. We have sodium, we have iron. So we take the case of iron for example. So, we can have iron as 2+, iron as 3+ and this is called as the ionic state, it can have different what we call as oxidation states or valency, oxidation state is a more generic term.

So, depending on the oxidation state, it will bind with different other things to form another compound okay. So, that compound whatever is formed, it may be more stable in the environment or less stable in the environment, maybe soluble, maybe insoluble and so on. So, these kinds of things depend on the oxidation state of the chemicals and so it is a little more complicated. So, here what we are doing here, for example, if you take case of mercury, mercury is a very well known toxic compound, element.

Mercury is found as Hg0, Hg0 when you say is the elemental form, so it is not attached to anything, it is present as mercury itself, but you can also have mercury 1 and mercury 2+ and it binds with different things. Mercury will bind with different things okay. So, this is a form of, typically an element is present as elemental form, if this is elemental mercury, or it is present in the form of some other component, as a salt usually, or an oxide okay

So, all these elements usually you will find it in the form of salt or oxide depending on where it is formed, where do you have it. People have also made compounds, synthesize compounds to have multiple elements in one compound for a particular application. So, this sometimes are very specialized things. So, it may or may not be important depending on where it is being used, the only compound is used, see the application based this thing if we saw that we have a large number of applications, but there is only one small application somebody in one factory is using it only for that this thing, chances are it may not be of widespread so that.

Sometimes they make a very specialty compound for one particular application and it is very small and people may not know about it at all okay. So, this is a very expansive. So you look at this list. If I want to find out what is there in environment, it is a huge task right? Even from this list itself, potentially I can have a large number of, I can go across this entire class of compounds, I have to do some way of even to find out what is there, it is very hard, the analysis of any of these compounds to find out.

If somebody comes and asks a question, I will give you a water sample, please tell me what is there in the water sample. Any of this could be there in the water sample, technically, right. I have a problem because I have to spend a lot of money and energy and time in order to find out what else is there, all of this is there, and then we have also this entire range of compounds here. So, is there a way in which I can, then it becomes matter of engineering decision making that I have to spend my money and resources and time where I can guess whether one of, which of this is likely to be there.

I also need a ranking. I need to be able to prioritize whether something is there or not. If I am looking for a particular compound and if the likelihood of that not being there is high, then I do not have to spend my time looking for that. So, I must have some rational reason why I am looking for a particular compound okay. This will link into our next topic in the next section of monitoring and analysis, I have to make decisions of which one to monitor, which one to measure, because it costs money to do all of these things.

These are all linked back to that if I have infinite resources, I have 100 people working on one sample, I can do everything in the world. Unfortunately, we are not in that scenario. We

have to make decisions in which we rank things, and then the highest, most this thing gets the priority.