Environmental Soil Chemistry
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Module No # 07
Lecture No # 39
Soil Pollutants (Contd.,)

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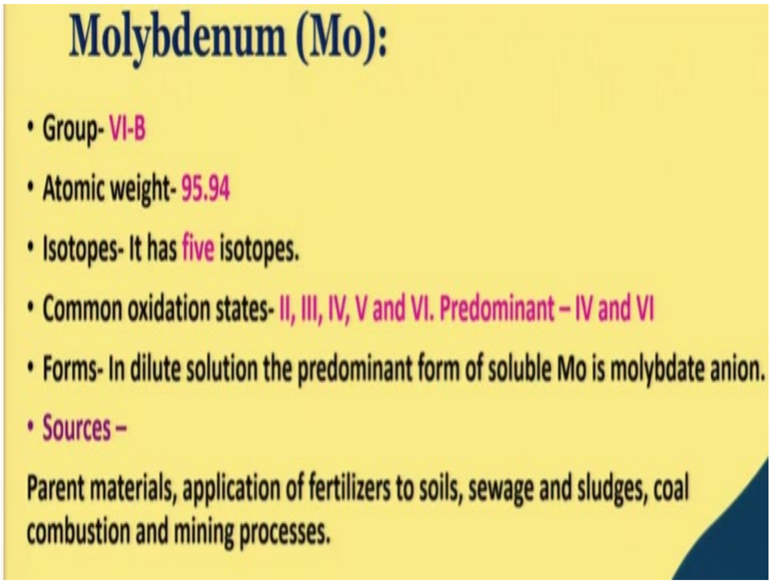

Molybdenum (Mo):

- Group- VI-B
- Atomic weight- 95.94
- Isotopes- It has five isotopes.
- Common oxidation states- II, III, IV, V and VI. Predominant – IV and VI
- Forms- In dilute solution the predominant form of soluble Mo is molybdate anion.
- Sources –

Parent materials, application of fertilizers to soils, sewage and sludges, coal combustion and mining processes.

Welcome to this fourth lecture of week 8 of this NPTEL online certification course of environment soil chemistry. We are talking about some of the important in organic pollutants and so we have covered a lot you know some important trace elements which are potential pollutants for soil. So we in the last lecture we have discussed about the molybdenum that is Mo and we started discussing it the sources remember the sources of molybdenum varies from parent materials, fertilizers, sewage sludge, coal combustion and also mining process.

And it has got 5 isotopes and common oxidation states are basically from 2, 3, 4, 5 and 6 however the predominant form are 4 and 6.

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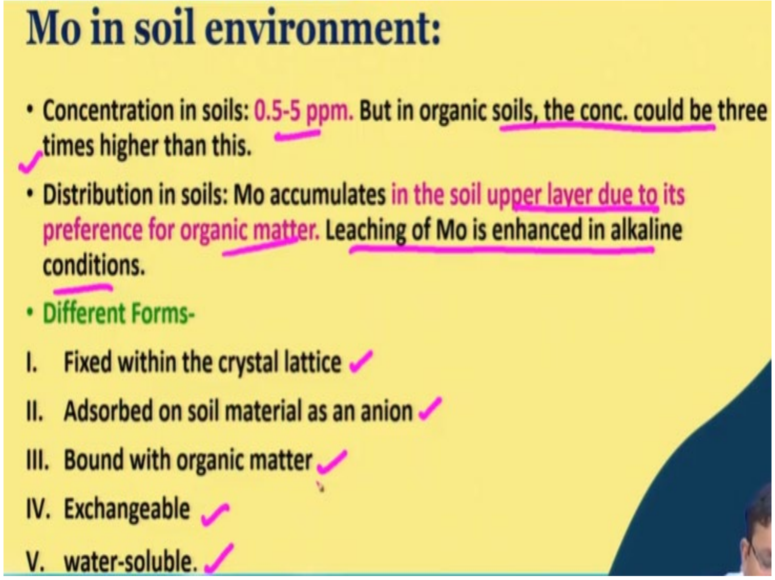

Mo in soil environment:

- Concentration in soils: 0.5-5 ppm. But in organic soils, the conc. could be three times higher than this.
- Distribution in soils: Mo accumulates in the soil upper layer due to its preference for organic matter. Leaching of Mo is enhanced in alkaline conditions.
- Different Forms-

I. Fixed within the crystal lattice ✓
II. Adsorbed on soil material as an anion ✓
III. Bound with organic matter ✓
IV. Exchangeable ✓
V. water-soluble. ✓

So if you consider the molybdenum in the soil environment it concentration varies from 0.5 to 5 ppm And but in the organic soil concentration could be 3 times higher than these because organic matter has more binding capacity of the trace elements due to the chelation action. And if you consider the distribution in the soil molybdenum accumulates in the soil upper layer due to its preferences for organic matter.

One important pattern you have seen that like most of the trace elements like copper you know lead they have high affinity towards the organic matter. So molybdenum also as similar kind of affinity so basically they trained to you know they train to get bound by these organic matter due to the chelation action. And leaching of molybdenum is enhanced in alkaline condition. So molybdenum get leached in alkaline soils.

If you consider some of the different forms molybdenum in the soil environment first all it is fixed within the crystal lattice. Secondly it is adsorbed on soil material as an anion and then bound with organic matter exchangeable and water soluble. So these are the 5 major forms of molybdenum which are present in the soil environment. First of all again fixed with the crystal latter we can see sometime the molybdenum is bound in the crystal lattice

Adsorb on the soil material as an anion this molybdenum presence in the anionic form so it can get adsorb into the soil side where positive charge develop due to pH depend charge. Bound with organic matter we have already discussed and then it is also available as exchangeable as well as water soluble forms.

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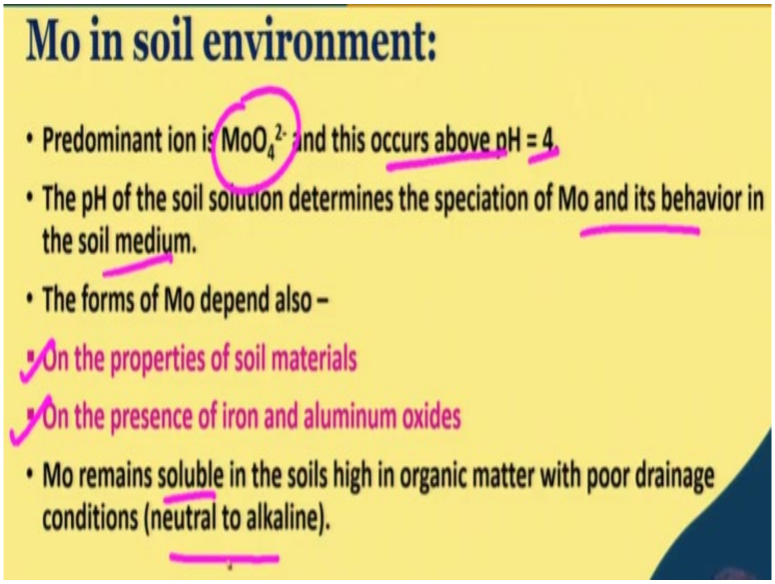

Mo in soil environment:

- Predominant ion is MoO_4^{2-} and this occurs above pH = 4
- The pH of the soil solution determines the speciation of Mo and its behavior in the soil medium.
- The forms of Mo depend also –
  - On the properties of soil materials
  - On the presence of iron and aluminum oxides
- Mo remains soluble in the soils high in organic matter with poor drainage conditions (neutral to alkaline).

So let us move ahead and see the predominant ion what are the predominant ions of molybdenum? The predominant ion is MoO_4^{2-} and this occurs above the pH of 4 so obviously when the pH goes beyond 4 then as you know in the alkaline soil you know these not alkaline soil, it is basically when the pH is greater than 4 then you can see the predominance of these ions or anions that is MoO_4^{2-}.

Now pH of the soil solution basically determines speciation of molybdenum and its behavior in the soil medium. Now the form of molybdenum depends on the properties of these soil materials obviously and secondly on the presence of iron and aluminum oxides. Now molybdenum remains in soluble you know remains soluble in the soil with high inorganic matter with poor drainage condition that is basically neutral to alkaline in nature.

So basically you know it comes into the soil solution when the soil pH is you know from neutral to alkaline remains so that is why in the alkaline soil they are more prompt to leaching.

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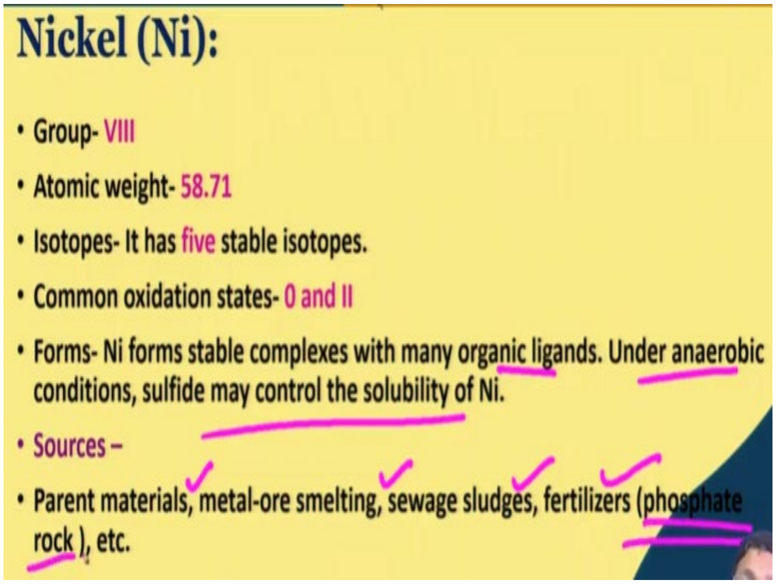

Nickel (Ni):

- Group- VIII
- Atomic weight- 58.71
- Isotopes- It has five stable isotopes.
- Common oxidation states- 0 and II
- Forms- Ni forms stable complexes with many organic ligands. Under anaerobic conditions, sulfide may control the solubility of Ni.
- Sources –
- Parent materials, metal-ore smelting, sewage sludges, fertilizers (phosphate rock), etc.

So another important trace element is nickel belong to the group 8 with an atomic weight of 58.71 it has got 5 stable isotopes with a common oxidation states are 0 and 2. And what are the major forms of nickel? Major forms of nickel are the stable complexes in many organic ligands and also under aerobic condition sulfide may control the solubility of nickel. So nickel sulfide is one of the major forms of nickel.

Now sources parent material just like any other element parent material is one of the major geogenic source. Apart from then in the anthropogenic sources are metal-ore smelting, sewage sludge, fertilizer you know specially phosphate phophatic fertilizers use the phosphate rock are major sources of nickel.

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Ni in soil environment:

- Concentration in soils: 20-40 ppm.
- Distribution in soils: Distribution of Ni in the soil profile is unclear. But Ni accumulates in the soil layers if organic matter and clay is high in amount.
- Different Forms-

I. Exchange sites
II. Specific adsorption sites
III. Fixed within the clay lattice
IV. Adsorbed on sesquioxides
V. Fixed in soil organic matter.

Now if you consider nickel in soil environment it is concentration generally varies from 20 to 40 ppm. Now distribution if you consider the distribution in the soil distribution in the soil profile is not very clear so far. Now nickel sometimes seems to accumulate in this soil layer if organic metal and clay is in high content. So it is not well define but it has got some affinity towards the clay as well as organic matter content.

Now what are the different forms of nickel in the environment one is the exchangeable sites you can see the nickels presence in the exchangeable sites. Specific adsorption sites fixed with the clay lattice the adsorbed on the sesquioxides and fixed in soil organic matter. So these are the some of the forms in which you can see the nickel present in the soil environment.

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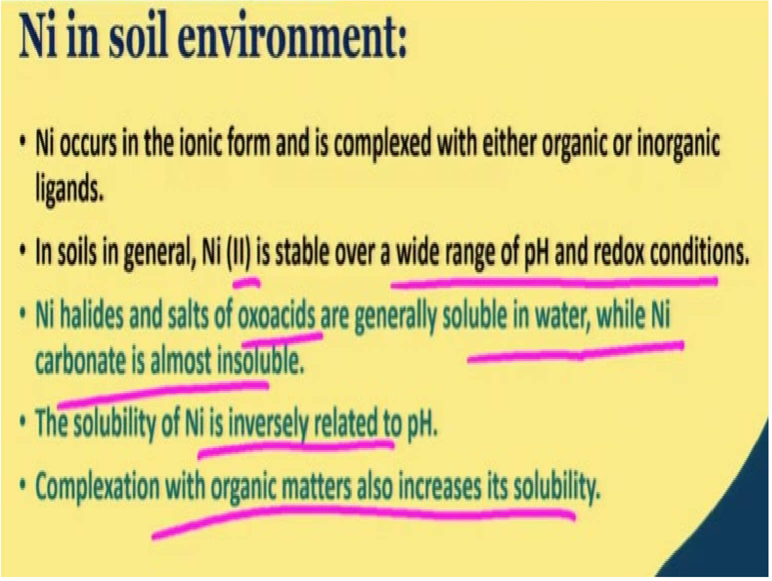

Ni in soil environment:

- Ni occurs in the ionic form and is complexed with either organic or inorganic ligands.
- In soils in general, Ni (II) is stable over a wide range of pH and redox conditions.
- Ni halides and salts of oxoacids are generally soluble in water, while Ni carbonate is almost insoluble.
- The solubility of Ni is inversely related to pH.
- Complexation with organic matters also increases its solubility.

So nickel basically occurs in the ionic forms and it is complexed with either organic or inorganic ligands. Now in soils in general nickel is that is nickel with the oxidation number 2 is basically stable over a wide range of pH and redox conditions. Now nickel halides and you know and salts of oxoacids are generally soluble in water while nickel carbonate is almost insoluble.

When nickel is present as an halides or oxoacids it is soluble however when it is present as carbonate it is almost insoluble. So the solubility of nickel is inversely related to pH so as the pH increase nickel solubility increase and vice versa. The complex session with organic matter also increases its solubility when it increases the complexity you know complexation with organic matter due to the formation of chelates then its solubility increases.

So you can see that organic matter chelation by organic matter increases the availability of most of the availability or in other words mobility of most of this trace elements in the soil

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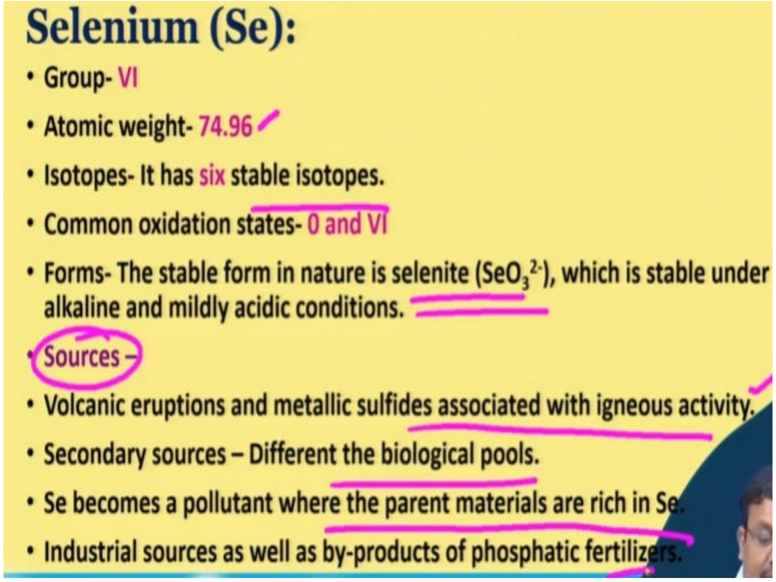

Selenium (Se):

- Group- VI
- Atomic weight- 74.96
- Isotopes- It has six stable isotopes.
- Common oxidation states- 0 and VI
- Forms- The stable form in nature is selenite (SeO_3^{2-}), which is stable under alkaline and mildly acidic conditions.
- Sources –
- Volcanic eruptions and metallic sulfides associated with igneous activity.
- Secondary sources – Different the biological pools.
- Se becomes a pollutant where the parent materials are rich in Se.
- Industrial sources as well as by-products of phosphatic fertilizers.

Another important element is selenium which is denoted by Se now it is a group 6 element with an atomic weight of 74.96 and it has 6 stable isotopes with a common oxidation states are 0 and 6. Now what are the major forms of selenium? The stable form in nature is basically selenite it is the most important stable form, which is stable under alkaline and mildly acidic conditions.

Now if you consider the sources of selenium what are the major sources of selenium? First of all volcanic eruption and metallic sulfides associated with igneous activities. So it is the major sources of selenium secondary sources different biological pools from the selenium can occur from different biological pools also. Selenium becomes a pollutant where the parent materials are rich in selenium.

And industrial sources as well as by products of phosphatic fertilizers so you can see the industrial production of phosphatic fertilizer can produce a huge number of different elements So specifically trace elements causing its toxicity and also in case of selenium specifically volcanic eruption can produce huge amount of selenium. And secondary sources like different biological pools also contribute to the selenium toxicity in the soil

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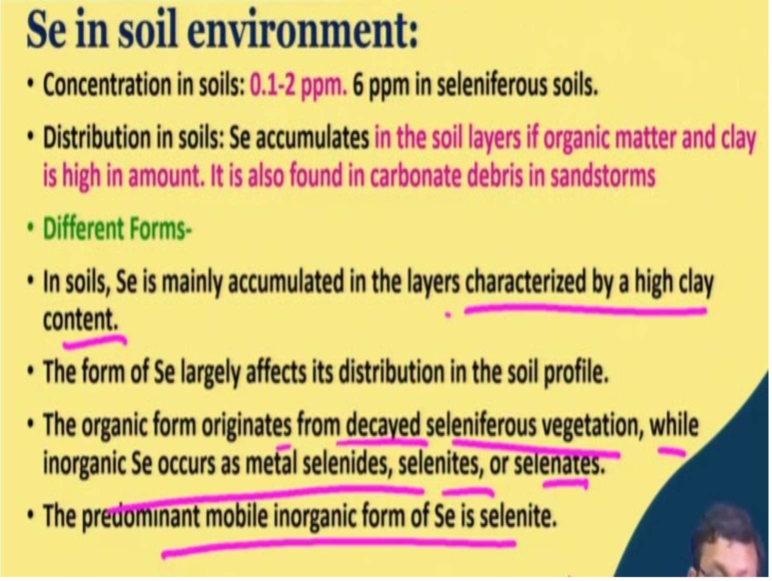

Se in soil environment:

- Concentration in soils: 0.1-2 ppm. 6 ppm in seleniferous soils.
- Distribution in soils: Se accumulates in the soil layers if organic matter and clay is high in amount. It is also found in carbonate debris in sandstorms
- Different Forms-
- In soils, Se is mainly accumulated in the layers characterized by a high clay content.
- The form of Se largely affects its distribution in the soil profile.
- The organic form originates from decayed seleniferous vegetation, while inorganic Se occurs as metal selenides, selenites, or selenates.
- The predominant mobile inorganic form of Se is selenite.

Now in the soil the concentration of the selenium generally varies from 0.1 to 2 ppm and then 6 ppm in basically seleniferous soils that means high selenium content soil basically shows the around 6 ppm. Now distribution in soil because if you; consider the distribution in the soil selenium accumulates in the soil layer organic matter if clay high in amount. It is also found in carbonate debris in sandstorms so what are the different forms?

In soils selenium is mainly accumulated in the layers characterize by a high clay content the forms of selenium largely affects its distribution in the soil profile. The organic form basically originates from you know from decades seleniferous vegetation. So selenium are also comes from plant body so decade plant body also can be an important source of selenium while inorganic selenium occur is the metal selenides, selenites or selenates.

So the predominant mobile inorganic form of selenium is selenite so again in soil selenium is mainly accumulated in the layers characterized by high clay content. And also selenium largely affect distribution of soil profile the organic forms of originates from the decayed seleniferous vegetation. So vegetation which has high selenium in the leaves can also produce decomposed product which produce the selenium in the soil.

While inorganic selenium occurs in the metal selenides, selenites and selenates, and the predominant mobile inorganic forms of selenium is basically selenite.

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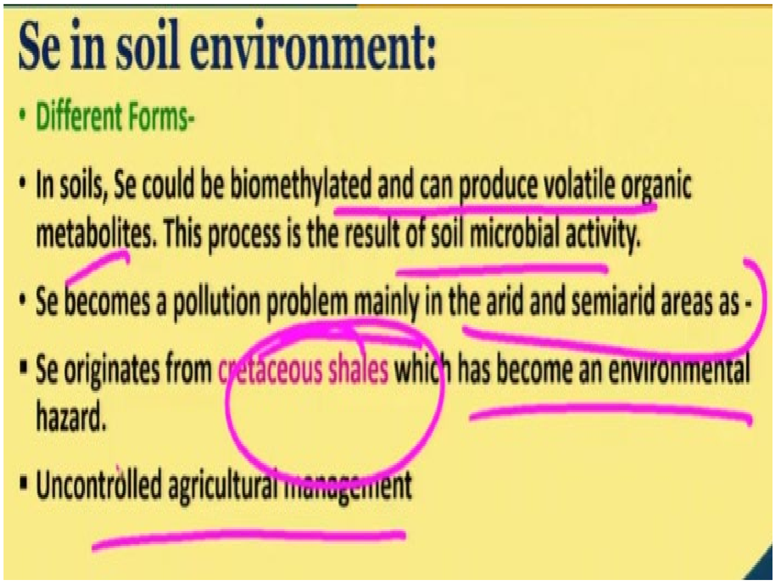

Se in soil environment:

- Different Forms-
- In soils, Se could be biomethylated and can produce volatile organic metabolites. This process is the result of soil microbial activity.
- Se becomes a pollution problem mainly in the arid and semiarid areas as -
- Se originates from cretaceous shales which has become an environmental hazard.
- Uncontrolled agricultural management

So what are the different forms so in soil selenium could be biomethylated and can produce volatile organic metabolites. So it can be biomethylated by different microorganisms. And can be produce volatile organic metabolites this process is result of soil microbial activity has just I have told you. So selenium becomes a pollution problem mainly in the arid and semiarid areas as.

As selenium originates from cretaceous shales which has been become an environmental hazard. So this selenium problem is major you know is more prevalent in basically arid and semiarid region. And also the selenium toxicity can occur due to uncontrolled agricultural management and also from cretaceous shales which known as the major environmental hazards. So this is how the selenium.

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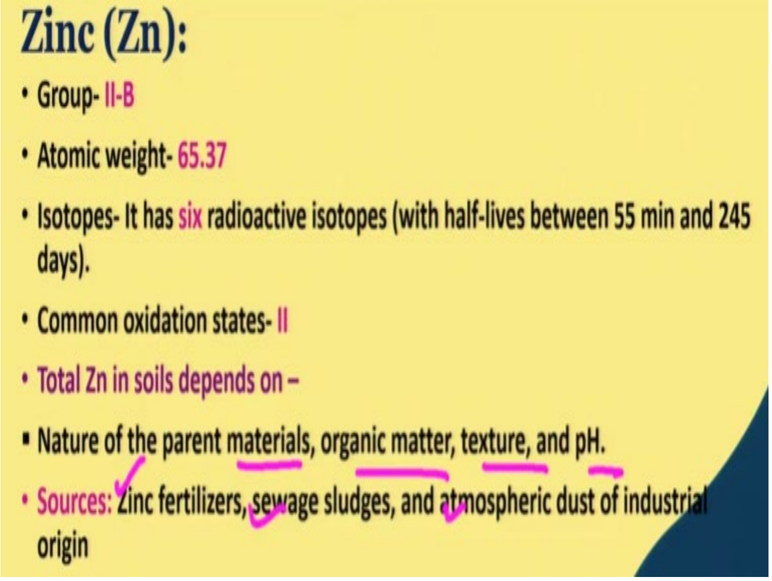

Zinc (Zn):

- Group- II-B
- Atomic weight- 65.37
- Isotopes- It has six radioactive isotopes (with half-lives between 55 min and 245 days).
- Common oxidation states- II
- Total Zn in soils depends on –
- Nature of the parent materials, organic matter, texture, and pH.
- Sources: Zinc fertilizers, sewage sludges, and atmospheric dust of industrial origin

The next important trace element is zinc belongs to group 2B with an atomic weight of 65.35. It has 6 radioactive isotopes with half-lives between 55 min to 245 days it has common oxidation state of 2, total zinc in soil basically depends on the nature of parent materials and then organic matter texture and pH. What are the sources of zinc in soils? Basically zinc fertilizers, sewage sludge and atmospheric dust of industrial origin so these are the major sources of so we can see most of the sources are anthropogenic in nature.

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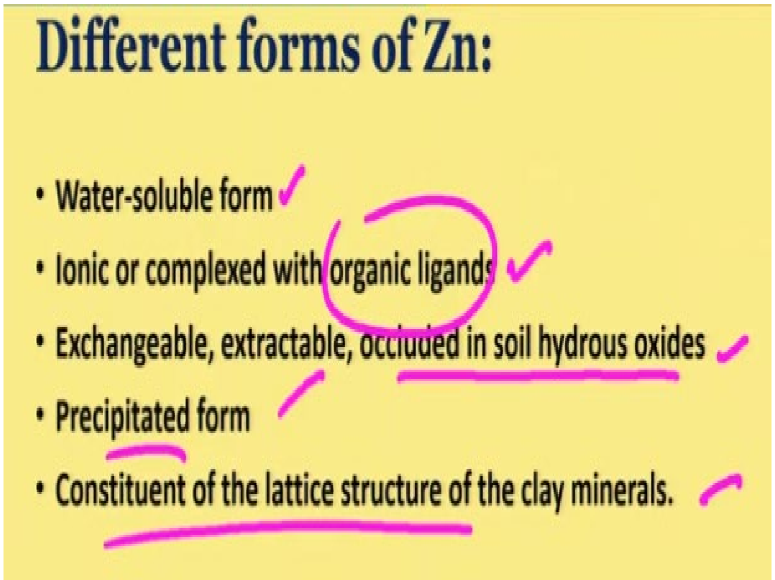

Different forms of Zn:

- Water-soluble form
- Ionic or complexed with organic ligands
- Exchangeable, extractable, occluded in soil hydrous oxides
- Precipitated form
- Constituent of the lattice structure of the clay minerals.

Different forms of zinc if its consider different forms of zinc you can see water soluble forms of zinc are is important and also ionic are complexed with organic ligands. Then exchangeable extractable occluded in soil hydrous oxides precipitated form and constituent of the lattice structure of the clay minerals. So you can see in all 5 forms the soil in the soil when the zinc is present first of all again water soluble form.

Then ionic complex with organic ligands just like any other trace elements exchangeable extractable occluded in soil hydrous oxides. It is just like other elements in the soil and precipitate form and also constituents of the lattice structure of the clay materials. So you can see that the generalized these 5 forms of more generalized in which all the most of the trace elements are present in the soils.

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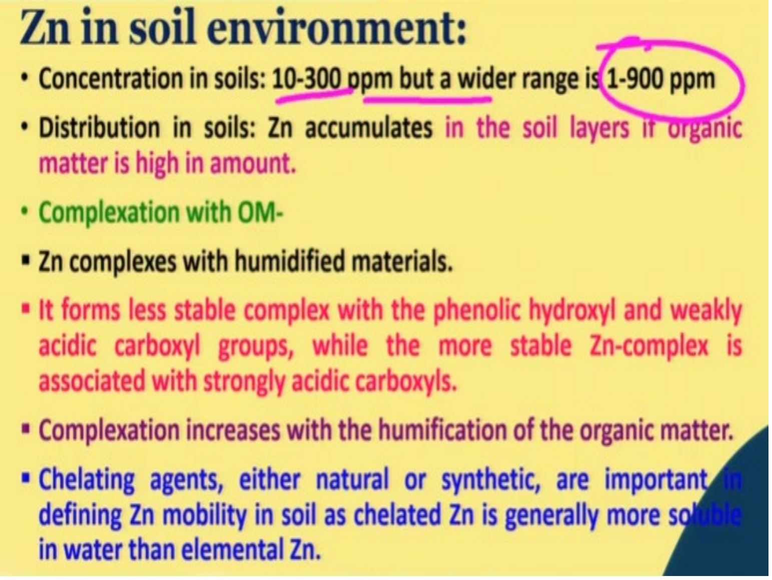

Zn in soil environment:

- Concentration in soils: 10-300 ppm but a wider range is 1-900 ppm
- Distribution in soils: Zn accumulates in the soil layers if organic matter is high in amount.
- Complexation with OM-
  - Zn complexes with humidified materials.
  - It forms less stable complex with the phenolic hydroxyl and weakly acidic carboxyl groups, while the more stable Zn-complex is associated with strongly acidic carboxyls.
  - Complexation increases with the humification of the organic matter.
  - Chelating agents, either natural or synthetic, are important in defining Zn mobility in soil as chelated Zn is generally more soluble in water than elemental Zn.

So in the soil the concentration basically varies from 0 to sorry 10 to 300 ppm but wider range from 1 to 900 ppm is also possible. Now if you consider the distribution in the soil zinc accumulates in the soil layer if organic matter is high in amount just like other trace elements. So basically it produces the complex session with organic matter and zinc complexes with basically humidified materials.

So it forms less stable complex with the phenolic hydroxyl and weakly acidic carboxyl groups while the more stable zinc complex is associated with strongly acidic carboxyls groups. And complexation increases with the humification of the organic matter so as the humification of the organic matter increases complexation also increases. Chelating agents either natural or synthetic are important in defining the zinc mobility in soil as chelated zinc is generally more insoluble water than elemental zinc's.

So basically when we do the chelation the definition of chelation says it increases it solubility and mobility so you can see here zinc mobility is dependent on chelated zinc which are more soluble in water than elemental zinc.

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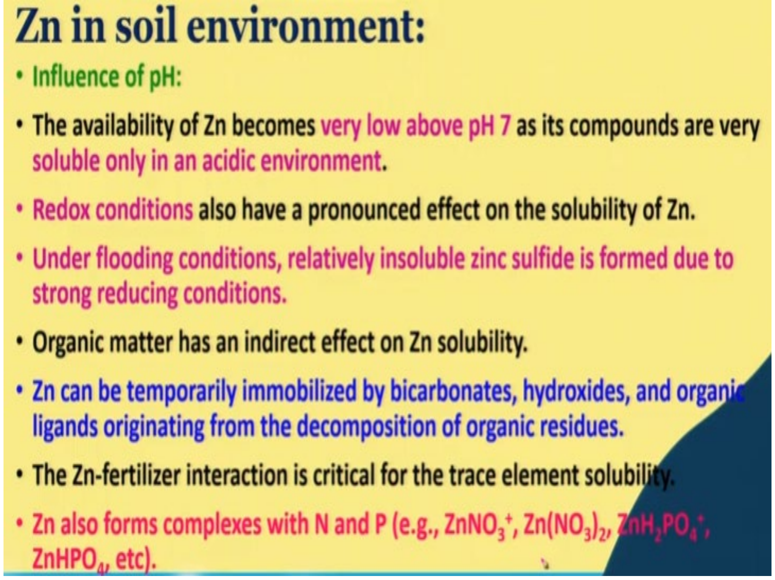

Zn in soil environment:

- Influence of pH:
- The availability of Zn becomes very low above pH 7 as its compounds are very soluble only in an acidic environment.
- Redox conditions also have a pronounced effect on the solubility of Zn.
- Under flooding conditions, relatively insoluble zinc sulfide is formed due to strong reducing conditions.
- Organic matter has an indirect effect on Zn solubility.
- Zn can be temporarily immobilized by bicarbonates, hydroxides, and organic ligands originating from the decomposition of organic residues.
- The Zn-fertilizer interaction is critical for the trace element solubility.
- Zn also forms complexes with N and P (e.g., $ZnNO_3^+$, $Zn(NO_3)_2$, $ZnH_2PO_4^+$, $ZnHPO_4$, etc).

Now what is the influence of pH for this zinc availability in the soil. Now availability of zinc become very low above pH7 as its compounds are very soluble only in acidic environment. And Redox conditions and also have a pronounced effect on the solubility of zinc. Because under flooding condition relatively insoluble zinc sulfide is formed; due to this strong reducing conditions.

So you know when there is a submerge condition the flooded condition the redox condition will go down to negative which will produce the confession or sulfate to sulfide and this sulfide will react with zinc to produce zinc sulfide. And these zinc sulfide is basically insoluble so the solubility and mobility of zinc in submerge soil condition varies and which ultimately depends on the redox potential

Zinc can be temporarily mobilized by bicarbonate hydroxides and organic ligands originating from the decomposition of organic residues. And the zinc fertilizer interaction is basically critical for the trace element solubility. So zinc also found complexes with nitrogen and phosphorous and you know you can see here zinc nitrate, zinc phosphate etc., you can see so it can form the complexes with nitrogen and phosphorous too.

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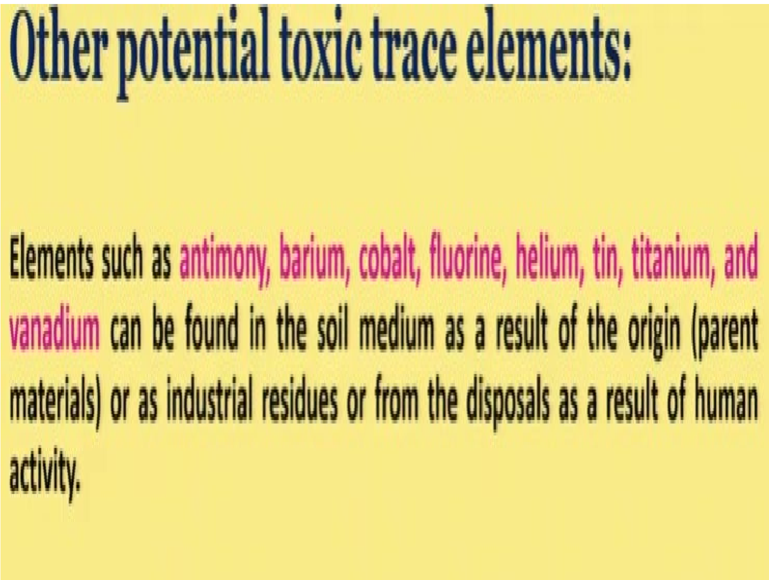

Other potential toxic trace elements:

Elements such as antimony, barium, cobalt, fluorine, helium, tin, titanium, and vanadium can be found in the soil medium as a result of the origin (parent materials) or as industrial residues or from the disposals as a result of human activity.

So we have discuss a lot of important potential toxic elements starting from arsenic then mercury, cadmium, lead, zinc, selenium then copper and so and so forth. So elements also there are some elements such as antimony, barium, cobalt, fluorine, helium, tin, titanium and vanadium can also be found in the soil medium. As the result of origin that is, parent material or as industrial residues or from disposals as a result of human activity.

So these are some of the other potential toxic trace elements like antimony, barium, cobalt, fluorine, helium, tin, titanium and vanadium which can also originates in environment due to geogenic activities are also different anthropogenic activities.

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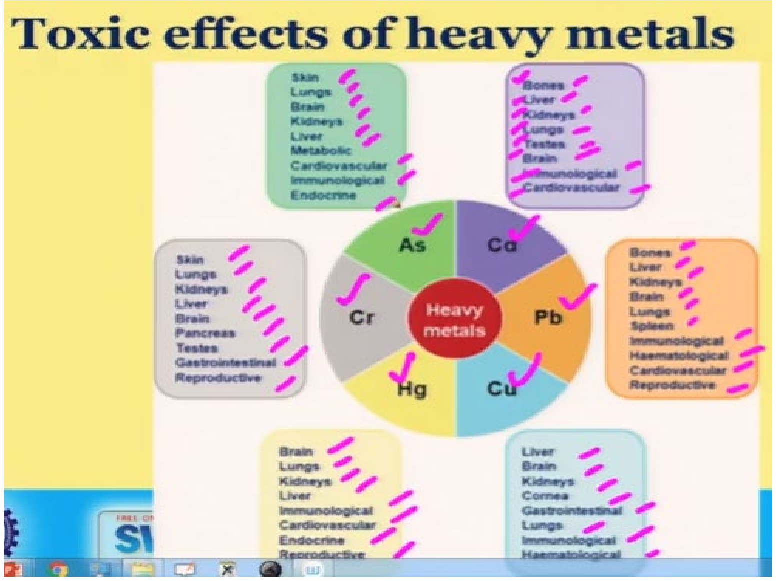

Toxic effects of heavy metals

As:
Skin
Lungs
Brain
Kidneys
Liver
Metabolic
Cardiovascular
Immunological
Endocrine

Cd:
Bones
Liver
Kidneys
Lungs
Testes
Brain
Immunological
Cardiovascular

Pb:
Bones
Liver
Kidneys
Brain
Lungs
Spleen
Immunological
Haematological
Cardiovascular
Reproductive

Cu:
Liver
Brain
Kidneys
Cornea
Gastrointestinal
Lungs
Immunological
Haematological

Hg:
Brain
Lungs
Kidneys
Liver
Immunological
Cardiovascular
Endocrine
Reproductive

Cr:
Skin
Lungs
Kidneys
Liver
Brain
Pancreas
Testes
Gastrointestinal
Reproductive

Now if these slide basically shows the toxic effects of different heavy metals and we have only consider here the major heavy metals trace heavy metals like arsenic, cadmium, lead, copper, mercury and chromium. And their ill effects in the human you know as far as the human health is concerned are given here. For example it is importance force it is important for our bones and it regulates you know it is important for the liver, kidneys, lungs, testes, brain and immunological processes as well as cardiovascular processes.

And so obviously the cadmium toxicity can affect bones, livers, kidneys, lungs, testes, brain, immunological process as well as cardiovascular process. In case of lead if effects bones, liver, kidneys, brain, lungs, spleen, immunological processes, haematological processes, cardiovascular processes and reproductive processes. Copper toxicity influences liver, brain, kidneys, cornea, gastrointestinal and then lungs immunological process then haematological processes.

Mercury influences mainly brain then lungs, kidneys, liver, immunological, cardiovascular, endocrine and reproductive processes. In case of chromium it affects skin lungs, kidneys, liver, brain, pancreas, testes, gastrointestinal system as well as the reproductive system. And arsenic it influence it impacts the skin lungs, brain, kidney, liver, metabolic system, cardiovascular system, immunological system and also endocrine system.

So you can see these are the major you know heavy metals which are producing toxic effect for human body and these are some of the major areas in which it can produce the toxic effect or toxicity effect.

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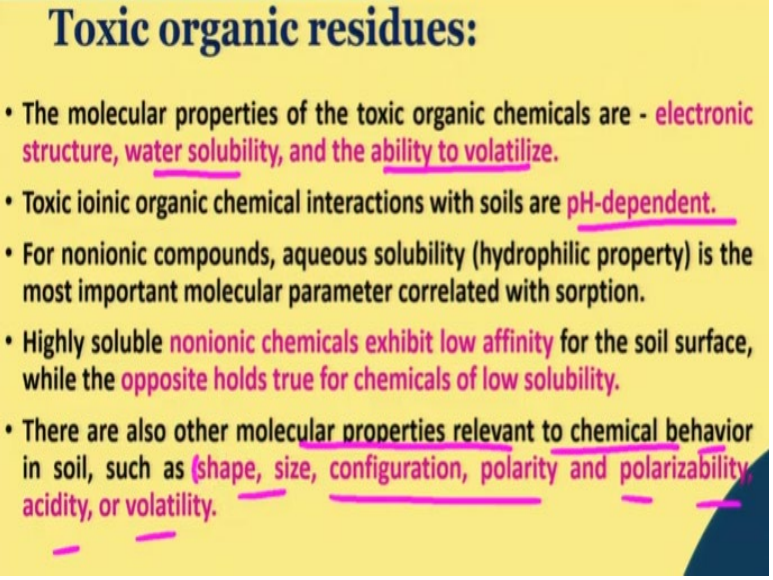

Toxic organic residues:

- The molecular properties of the toxic organic chemicals are - electronic structure, water solubility, and the ability to volatilize.
- Toxic ioinic organic chemical interactions with soils are pH-dependent.
- For nonionic compounds, aqueous solubility (hydrophilic property) is the most important molecular parameter correlated with sorption.
- Highly soluble nonionic chemicals exhibit low affinity for the soil surface, while the opposite holds true for chemicals of low solubility.
- There are also other molecular properties relevant to chemical behavior in soil, such as (shape, size, configuration, polarity and polarizability, acidity, or volatility.

So we covered the important toxic inorganic pollutants now we are going to start the toxic organic residues. So the molecular properties of the toxic organic chemicals are basically electronic structure their water solubility and the ability to volatilize. These are the 3 major important molecular properties of the toxic organic chemicals one is electronic structure then water solubility and third is the ability to volatilize. Now toxic ionic, organic chemical interaction the soils are basically pH dependent.

So for non-ionic compounds aqueous solubility that is hydrophilic property is the most important molecular parameter correlated with the you know with sorption. And highly soluble nonionic chemicals exhibit low affinity for the soil surface while the opposite holds true for chemicals of low solubility. And there are also other molecular properties relevant to chemical behavior of soil such as shape, size, configuration, polarity and polarizability, acidity and volatility.

So all these are you know other molecular properties relevant to chemical behavior of soils and these are the important properties like shape, size configuration, polarity and polarizability, acidity and volatility. So this is basically an overview of toxic inorganic substances.

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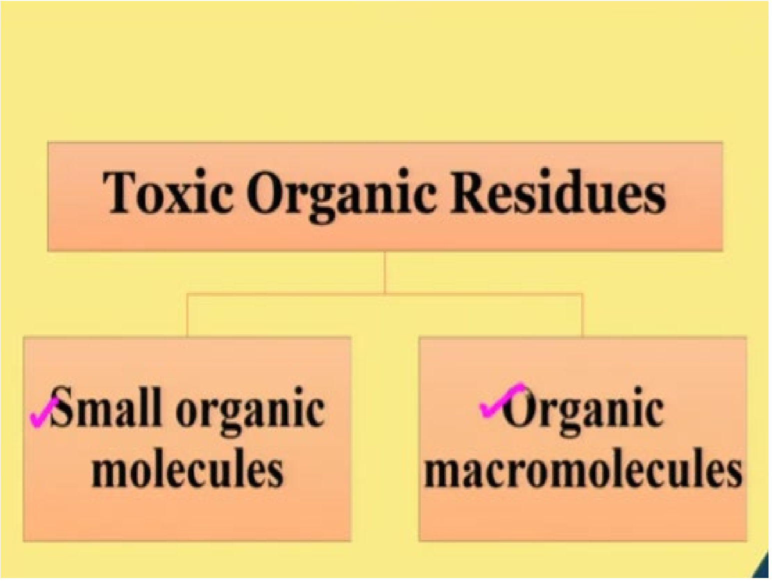

Toxic Organic Residues

Small organic molecules

Organic macromolecules

So let us move ahead and see the classification of the toxic organic residues. So if you see the classification of toxic organic residues they are basically here you can see the toxic organic residues can be subdivided into small organic molecules as well as organic macromolecules. So what are the differences between these small organic molecules and organic macromolecules will see.

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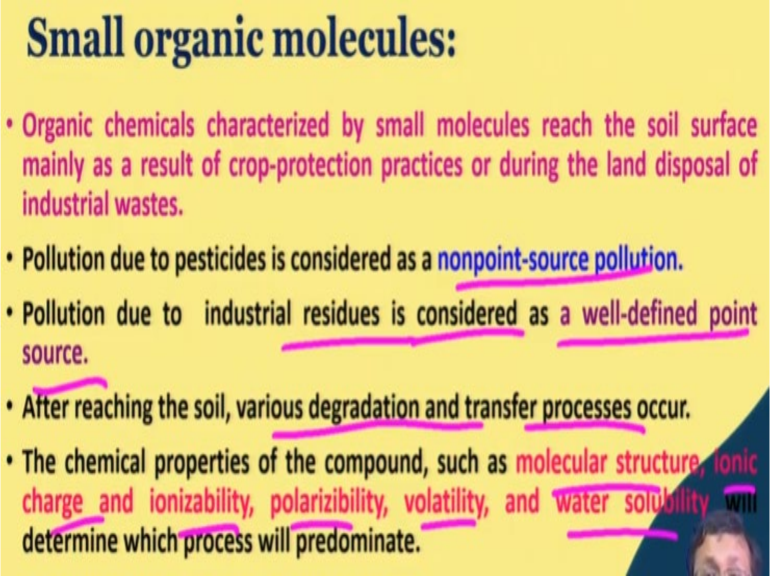

Small organic molecules:

- Organic chemicals characterized by small molecules reach the soil surface mainly as a result of crop-protection practices or during the land disposal of industrial wastes.
- Pollution due to pesticides is considered as a nonpoint-source pollution.
- Pollution due to industrial residues is considered as a well-defined point source.
- After reaching the soil, various degradation and transfer processes occur.
- The chemical properties of the compound, such as molecular structure, ionic charge and ionizability, polarizibility, volatility, and water solubility will determine which process will predominate.

So let us start with the small organic molecules so organic chemicals which are characterize by small molecule reach the soil surface mainly as a result of crop protection practices or during the land disposal of industrial wastes. So, mainly these type of small organic molecules are comprised of the pesticides which we apply for our crop protection. So these pesticides contains huge amount of these trace elements or heavy metals which can further you know which can further produce toxicity effect to the environment.

Now pollution due to pesticides is considered as a nonpoint-source pollution of obviously because pesticides are applied in different agricultural fields. And as a result of that when there is a rainfall and subsequent runoff due to the rainfall this pesticide will move along with the soil particles and creates a nonpoint-source pollution to the nearby water bodies. Now pollution due to industrial residues is considered as a well-defined point source.

Because whatever industrial you know by product are effluents we are getting is basically discharging they are discharging into the water bodies well defined point source. So that is why it is a guide it is point source pollution now after reaching this soil various degradation and transfer process basically occurs. Now the chemical properties of the compounds such as you know molecular structure ionic charge and ionizability, polarizability, volatility and water solubility you know basically determines the process.

You know these basically determine which process will be will predominant so again small organic molecule; basically consist of the pesticides. Different types of pesticides and these pesticides pollution is consider as a nonpoint-source pollution. However the various effluence of byproducts from the industry are known as the point source pollution. And when they reach into the soil they produce different types of degradation and transfer processes.

And the chemical properties of the compound such as molecular structure, ionic charge and ionizability, polarizibility, volatility and you know and the water solubility will determine which process among these like you know nonpoint source pollution are you know various degradation or transfer processes will be predominant okay. So let us see those in details.

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Different small organic molecules:

1. Pesticides
2. Hydrocarbon
3. Phtalates

So difference small organic molecules if you consider different small you know organic molecules we get there are 3 major classes. One is pesticides another is hydrocarbons and third is phthalates. So we will discuss this pesticides hydrocarbons and phthalates from the point of view of their toxicity in the soil environment. As you can see here this is a pesticide spraying into the field creating in major source of soil pollutions sometime because this pesticides as very much persistence in the soil environment okay.

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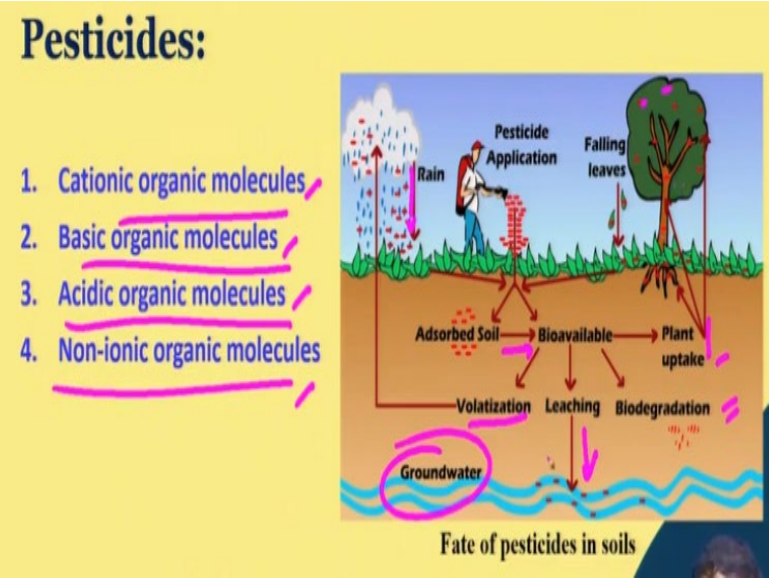

Pesticides:

1. Cationic organic molecules
2. Basic organic molecules
3. Acidic organic molecules
4. Non-ionic organic molecules

Fate of pesticides in soils

Now pesticides are again can be classified into 4 major types one is cationic organic molecules. Second is basic organic molecules third one is acidic organic molecules and fourth one is non-ionic organic molecules okay, again cationic organic molecules, basic organic molecules, acetic organic molecules and non-ionic organic molecules. So you can see in this picture it is showing the fate of pesticides in the soil.

So when we apply the pesticide into the soil some amount; of pesticide get adsorbed into the soil due to the you know due to the presence of different clay mineral as well as organic matter. And from there it becomes bioavailable to different organisms. And also from the direct pesticide application also some amount may come into the may become bioavailable. Now from this, bioavailable pool plant uptake accounts for one of the major.

So from this bioavailable pool plant uptake occurs and also from this bioavailable pool you can see biodegrading by different microbes. And also this pesticide will go you know go to leaching you know from this bioavailable pools ultimately it reaches the ground water. So this is one of the major source of pesticide pollution. And also from the bioavailable source some amount get volatilized get into the atmosphere and a part of this volatilized you know pesticide again come back into the soil solution return into the soil solution through rains.

So you can also see it due to the application of pesticide into the leaves so it can also come back into the through the falling leaves. So plant uptake can incorporate these pesticides in the leaves and bodies and through the falling leaves they can also come back indirectly into the soil. So this is basically showing this slide is comprehensively showing the fate of pesticide in soil. Again when applying the pesticide certain amount of pesticide is getting adsorbed and other portion is getting bioavailable.

Some portion of adsorb soil is converted to the bioavailable form from where plant basically uptakes also biodegradation occurs and leaching occurs. And volatilization occurs and the volatilize pesticide; residue can further come back return to the hot surface in the form of rain. And these plant uptake can produce this pesticide accumulation in the plant body which can further return into the soil through the falling leaves so this basically fate of pesticides in the soil.

So if you consider so we have seen there are 4 groups of pesticide one is cationic organic molecules, basic organic molecule, acidic organic molecule and non-ionic organic molecules.

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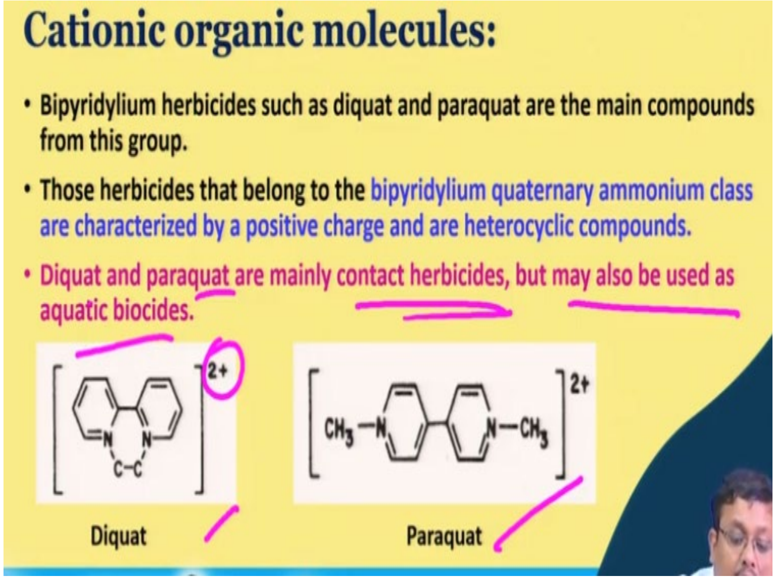

Cationic organic molecules:

- Bipyridylium herbicides such as diquat and paraquat are the main compounds from this group.
- Those herbicides that belong to the bipyridylium quaternary ammonium class are characterized by a positive charge and are heterocyclic compounds.
- Diquat and paraquat are mainly contact herbicides, but may also be used as aquatic biocides.

Diquat

Paraquat

So if you consider in the cationic organic molecules bypyridylium herbicides such as diquat and paraquat at the major compound from this group. Cationic organic molecules so you can see this is the cationic organic molecule here this is diquat and this paraquat. So those herbicides are belong to bypyridylium quaternary ammonium class are characterized by a positive charge you can see here.

And you know are also heterocyclic compounds so diquat and paraquat are mainly contact besides the basically they kill the you know herb or kill the weed just by direct contact it can kill the weed. So that is why it is called as contact herbicides but we also be uses as the aquatic biocides. So these are the 2 major you know examples of cationic organic molecules.

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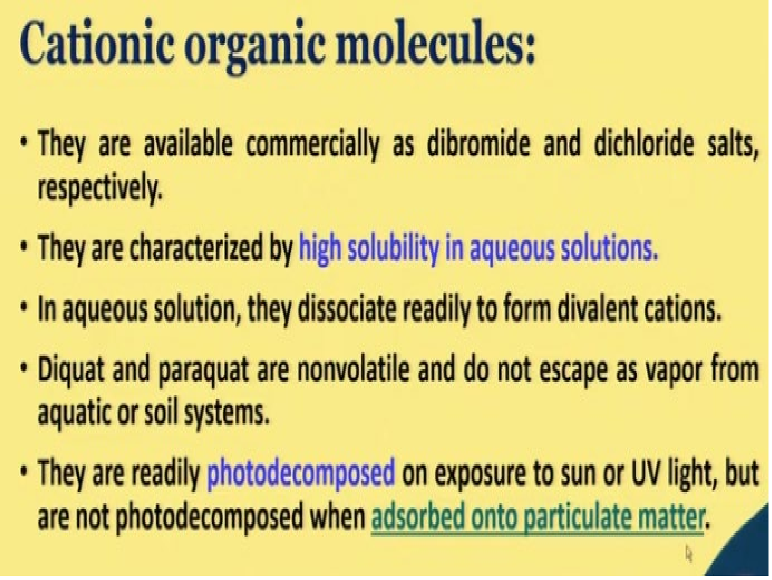

Cationic organic molecules:

- They are available commercially as dibromide and dichloride salts, respectively.
- They are characterized by high solubility in aqueous solutions.
- In aqueous solution, they dissociate readily to form divalent cations.
- Diquat and paraquat are nonvolatile and do not escape as vapor from aquatic or soil systems.
- They are readily photodecomposed on exposure to sun or UV light, but are not photodecomposed when adsorbed onto particulate matter.

So these cationic organic molecule are available commercially as dibromide or dichloride salts and there characterize by high solubility in aqueous solutions. In aqueous solution they dissociate readily to form divalent cations. And diquat and paraquat are nonvolatile and do not escape as vapor from aquatic or soil systems. And they are readily photo-decomposed on exposure or to sun or UV light, but are not photo-decompose when adsorbed on to the particulate matter.

So they are readily a photo-decomposed due to the presence of sunlight or UV light however when they are adsorb into the particulate matter they are not photo-decomposed.

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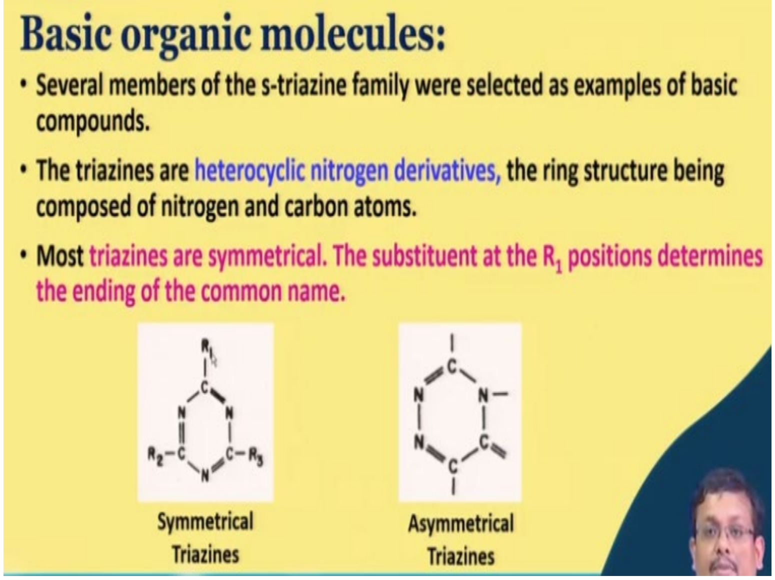

Basic organic molecules:

- Several members of the s-triazine family were selected as examples of basic compounds.
- The triazines are heterocyclic nitrogen derivatives, the ring structure being composed of nitrogen and carbon atoms.
- Most triazines are symmetrical. The substituent at the R_1 positions determines the ending of the common name.

Symmetrical Triazines

Asymmetrical Triazines

The second one is basic organic molecules several members of the s-triazine family were selected as an example of basic organic compounds. Now the traizines are heterocyclic nitrogen derivatives the ring structure being composed of nitrogen and carbon atoms as we can see here this is the symmetrical triazines, this is asymmetrical triazines. So most triazines are basically symmetrical and the substituent and you can see the substituent at R1 position determines the ending of the common name.

So these are the examples of basic organic molecules. So guys let us wrap up our lecture here and we will start from here and we will discuss in the next class the basic organic molecules and also acidic organic molecules and other organic macromolecules. Thank you very much let us meet in our next lecture to complete this week or this module 8 thank you very much.