Environmental Soil Chemistry
Prof. Somsubhra Chakraborty
Department of Agriculture and Food Engineering
Indian Institute of Technology, Kharagpur

Module No # 07
Lecture No # 38
Soil Pollutants (Contd.,)

Welcome friends to this third lecture of week 8 of this course environmental soil chemistry and in the previous 2 lectures we have covered some of the important inorganic pollutants of soil. For example we have covered nitrogen prosperous then arsenic chloride and salts and we have also covered eutrophication processes, which is mediated by excess enrichment of nitrogen and phosphorous.

(Refer Slide Time: 00:56)

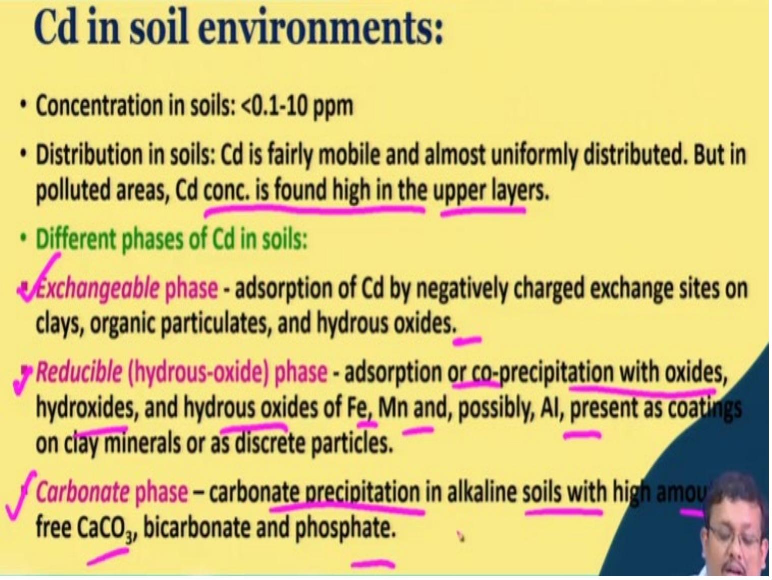
Cadmium (Cd):

- Group- II B (transition metal)
- Atomic weight- 112.41
- Common oxidation states- II (Cd^{2+})
- Forms- The most common one is CdS. Other forms are hydroxides and complex ions (with ammonia or cyanide: $Cd(NH_3)_6^{4-}$ and $Cd(CN)_4^{2-}$). Different complex organic amines, sulfur complexes, and chelates can also be mentioned.
- Cd also forms insoluble compounds, usually hydrated with carbonate, arsenate, phosphate, or oxalate ions.
- Sources- Soil parent materials, sludges and effluents (mainly industrial) fertilizers, atmospheric fallout, and radioactive waste disposal.

So today we are going to start from here and we are going to start with cadmium. Now cadmium it is a group 2B what is the transition metal and within atomic weight of 112.41. It has a common; oxidation states of 2 so cadmium 2^+ is most common oxidation states. So what are among the forms the most common form is the cadmium sulfide and the other forms are hydroxides and complex ions with ammonia or cyanide.

And different complex organic amines and sulfur complexes and chelates can also you know one of the important forms of cadmium. Now cadmium also forms insoluble compounds usually hydrated with carbonate, arsenate phosphate or oxalate ions. And what are the sources of cadmium the major sources of cadmium are soil parent materials, sludges and effluents mainly industrial sludges and effluents, fertilizers, atmospheric fallout and radioactive waste disposal.

(Refer Slide Time: 02:05)



Cd in soil environments:

- Concentration in soils: <0.1-10 ppm
- Distribution in soils: Cd is fairly mobile and almost uniformly distributed. But in polluted areas, Cd conc. is found high in the upper layers.
- Different phases of Cd in soils:

Exchangeable phase - adsorption of Cd by negatively charged exchange sites on clays, organic particulates, and hydrous oxides.

Reducible (hydrous-oxide) phase - adsorption or co-precipitation with oxides, hydroxides, and hydrous oxides of Fe, Mn and, possibly, Al, present as coatings on clay minerals or as discrete particles.

Carbonate phase – carbonate precipitation in alkaline soils with high amou free $CaCO_3$, bicarbonate and phosphate.

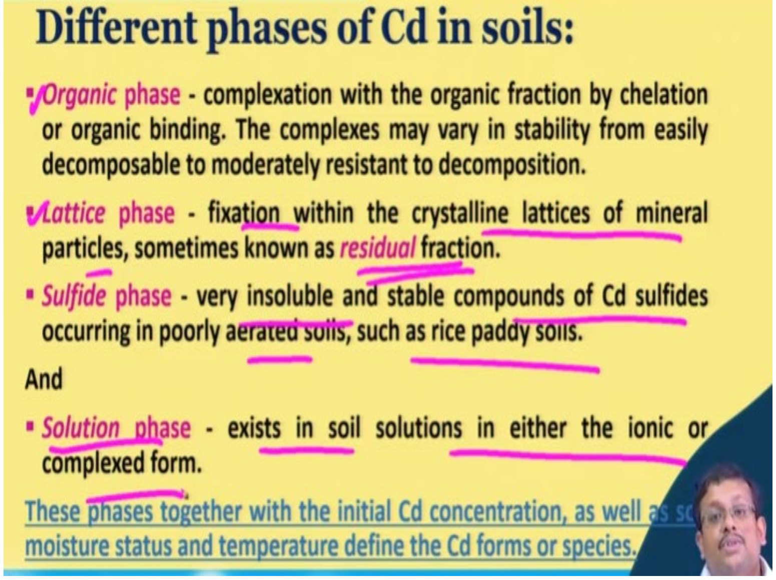
Now what are the sources of cadmium soil environment if you see the concentration of cadmium in the soil it is basically very strong less than 0.1 to 10 ppm. And at distribution in soil if you see the distribution soil cadmium is fairly mobile and almost uniformly distributed. But in polluted areas cadmium concentration found high in the upper layers of the soil. Now different faces of if you consider different phases of cadmium in soils.

First of all is the exchangeable phase which is basically showing the adsorption of the cadmium by negatively charged exchange sites on clays, organic particulates and hydrous oxides. And you know second phase is reducible or hydrous oxide phase which shows the adsorption or co-precipitation with oxides hydroxides and hydrous oxides of iron, manganese and possibly aluminum present in the coatings of clay or other discrete particles.

And third phase it is the carbonate phase and carbonate phase basically shows the carbonate specification precipitation in alkaline soil with high amount of free calcium carbonate, bicarbonate and phosphate. So basically in the carbonate phase obviously there is a high carbonate precipitation in case of hydrous oxide phase you see the dominance of different oxides and hydrous oxides of iron, manganese and aluminum.

So, these phases and also exchangeable phases so these are the 3 major phases you know of cadmium in soil which you can see frequently.

(Refer Slide Time: 03:45)



Different phases of Cd in soils:

- *Organic phase* - complexation with the organic fraction by chelation or organic binding. The complexes may vary in stability from easily decomposable to moderately resistant to decomposition.
- *Lattice phase* - fixation within the crystalline lattices of mineral particles, sometimes known as *residual* fraction.
- *Sulfide phase* - very insoluble and stable compounds of Cd sulfides occurring in poorly aerated soils, such as rice paddy soils.

And

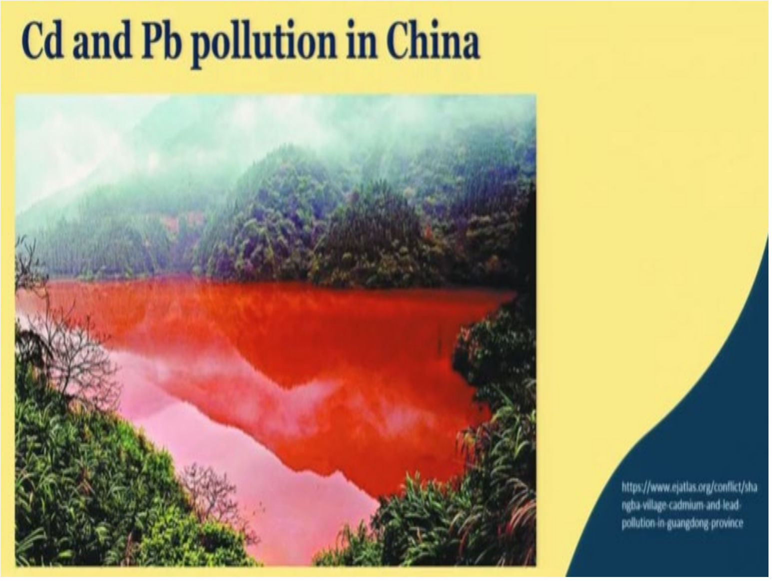
- *Solution phase* - exists in soil solutions in either the ionic or complexed form.

These phases together with the initial Cd concentration, as well as so
moisture status and temperature define the Cd forms or species.

So if you go ahead and see other phases among the other phases are organic phase, you know complexation with organic fraction by chelation you know Cadmium shows chelation. And the complex these chelates may vary in stability from easily decomposable to moderately resistant to decomposition. And also cadmium can be found in lattices phase so lattice phase shows the fixation within the crystalline lattice of mineral particles sometime known as the residual fraction.

The another phase is called the sulfide phase now sulfide phase is very soluble and stable compound of cadmium sulfides occurring in poorly aerated sails such as rice paddy soils, sulfur toxicity occurs. And hence also the solution phases now in this solution phase it exist cadmium exist in soil solution in either the ionic or complex form. Now these phases altogether with initial cadmium concentration as well as soil moisture status and temperature define the cadmium forms or species. So these are the major phases of cadmium which we frequently encountered in the soil.

(Refer Slide Time: 05:02)

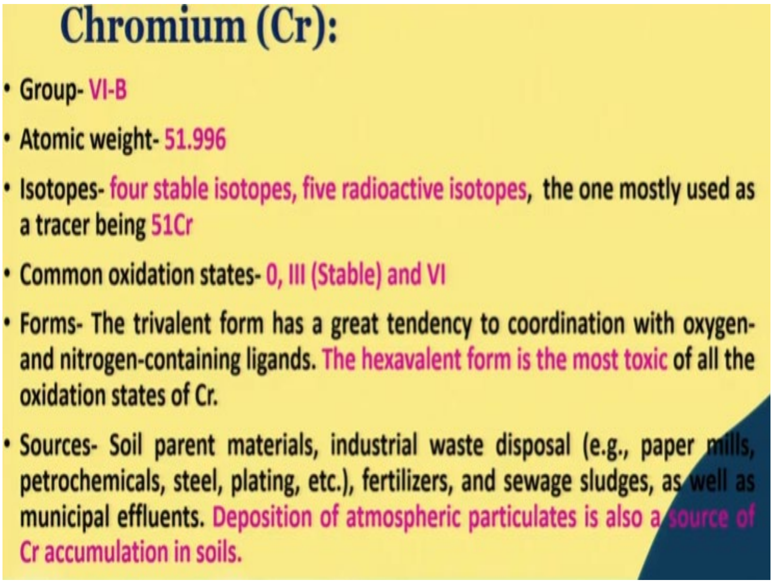


Cd and Pb pollution in China

https://www.ejatlas.org/conflict/shangba-village-cadmium-and-lead-pollution-in-guangdong-province

Now obviously cadmium is one of the major sources of soil pollution as well as water pollution. You can see here I have shown here one picture it shows cadmium and lead pollution in china. So cadmium is one of the you know potential pollutant for soil as well as water.

(Refer Slide Time: 05:21)



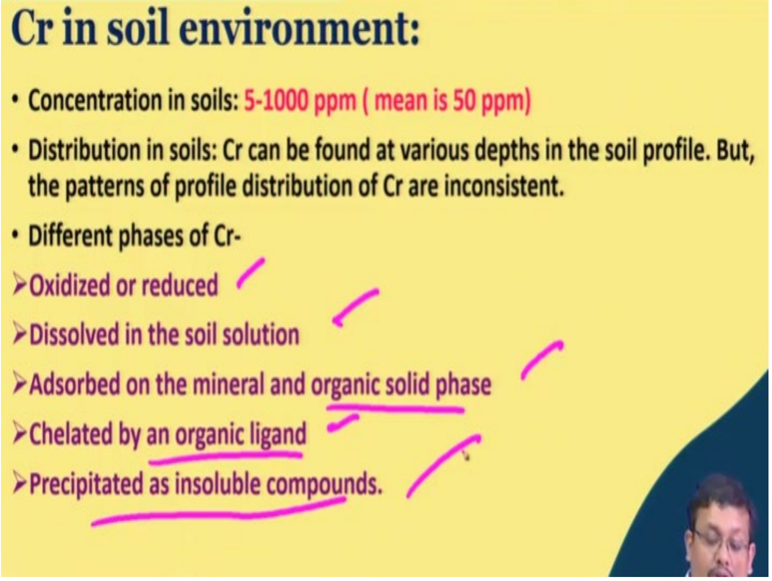
Chromium (Cr):

- Group- VI-B
- Atomic weight- 51.996
- Isotopes- four stable isotopes, five radioactive isotopes, the one mostly used as a tracer being 51Cr
- Common oxidation states- 0, III (Stable) and VI
- Forms- The trivalent form has a great tendency to coordination with oxygen- and nitrogen-containing ligands. The hexavalent form is the most toxic of all the oxidation states of Cr.
- Sources- Soil parent materials, industrial waste disposal (e.g., paper mills, petrochemicals, steel, plating, etc.), fertilizers, and sewage sludges, as well as municipal effluents. Deposition of atmospheric particulates is also a source of Cr accumulation in soils.

Now if I move to the next one that is called chromium is a 6B element with an atomic weight of 51.996 with isotopes they have 4 stable isotopes, 5 radioactive isotopes. The one mostly as the trace varying is 51 chromium now common oxidation states vary from 0, 3 and 6. Among this the 6 oxidation stage is more toxic so the trivalent from a great tendency to coordination with oxygen and nitrogen containing ligands.

The hexavalent form is the most toxic of all the oxidation states of chromium and if you consider the sources of chromium in the soil. Soil parent material, industrial waste disposal like paper mills, petrochemicals, steel, paintings, plating etc., also fertilizers and sewage sludges as well as municipal effluents all these are responsible for supplying the chromium in the soil. And also deposition of atmospheric particulates it is also a source of chromium accumulation in soils.

(Refer Slide Time: 06:24)



Cr in soil environment:

- Concentration in soils: 5-1000 ppm (mean is 50 ppm)
- Distribution in soils: Cr can be found at various depths in the soil profile. But, the patterns of profile distribution of Cr are inconsistent.
- Different phases of Cr-

➢Oxidized or reduced

➢Dissolved in the soil solution

➢Adsorbed on the mineral and organic solid phase

➢Chelated by an organic ligand

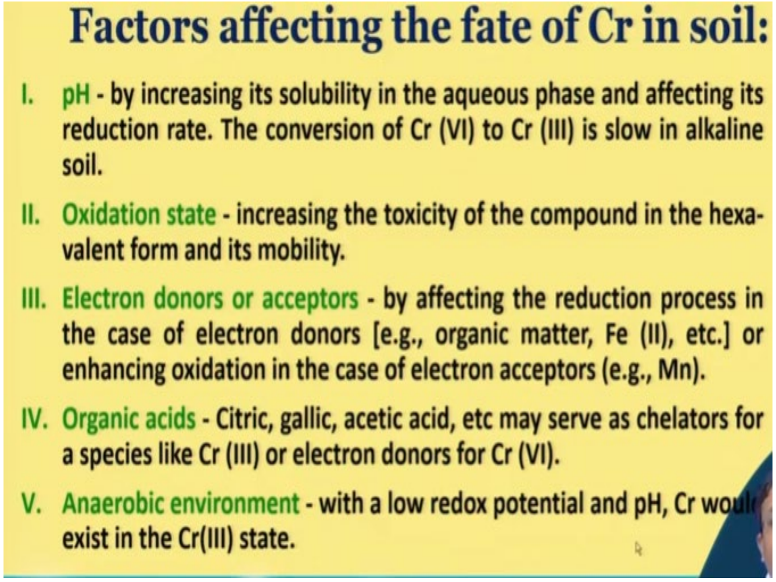
➢Precipitated as insoluble compounds.

Now if you see the chromium in the soil environment the concentration of the chromium generally various from 5 to 1000 ppm with a mean of 50 ppm. Now distribution if you see the distribution in the soil chromium can be found at various depths in the soil profile. But the patterns of profile distribution of chromium are inconsistent. Now what are the different phases of chromium? We have seen different phases of cadmium.

Now the different phases of chromium are oxidized or reduced phase and oxidized or reduced phase. Then you can see the dissolved in the soil solution then you can see the; adsorb on the mineral organic solid phases. The fourth phase is chelated by an organic ligand and also you can see as you know chromium as precipitated as insoluble compounds. So again it is oxidized on reduced phase you can see dissolved in this soil solution to the solution phase.

Then adsorb on the mineral organic solid phases you can see chelated be form we can also see and precipitated form of chromium can also be found.

(Refer Slide Time: 07:29)



Factors affecting the fate of Cr in soil:

I. pH - by increasing its solubility in the aqueous phase and affecting its reduction rate. The conversion of Cr (VI) to Cr (III) is slow in alkaline soil.

II. Oxidation state - increasing the toxicity of the compound in the hexavalent form and its mobility.

III. Electron donors or acceptors - by affecting the reduction process in the case of electron donors [e.g., organic matter, Fe (II), etc.] or enhancing oxidation in the case of electron acceptors (e.g., Mn).

IV. Organic acids - Citric, gallic, acetic acid, etc may serve as chelators for a species like Cr (III) or electron donors for Cr (VI).

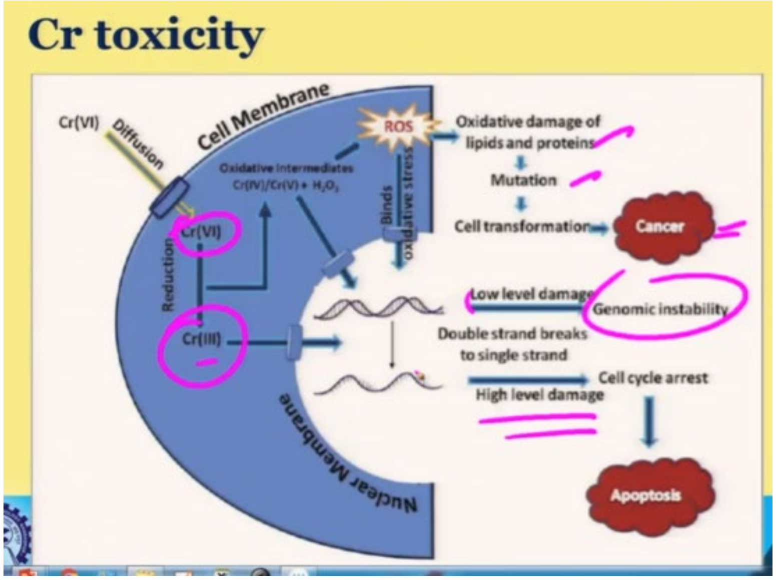
V. Anaerobic environment - with a low redox potential and pH, Cr woul exist in the Cr(III) state.

So what are the factors which effects the fate of chromium in the soil now the major factors which affect the fate of the chromium of the soil are pH oxidation state electron donors or acceptors, organic acids and also anaerobic environment. And each of them has profound influence on their fate of chromium in the soil. For example in the anaerobic environment with a low redox potential that means with anaerobic conditions and pH.

Chromium mode exist in the chromium state so it is relatively non-toxic now what is the influence of the organic acid like citric acid, gallic acid you know acetic acid these acid may serve as the chelates for is species like chromium 3 or electron donors for chromium 6. So, organic acids as major influence on the mobility of the chromium; and also oxidation state like increasing the toxicity of the compound of the hexavalent form and is mobility.

So if you see the you know if you see side by side chromium 3 and chromium 6 you can be more you know the chromium 6 is more toxic to than you know then the chromium 3. So oxidation state as the major influence so this is the factors such influence is the fate of chromium in the soil.

(Refer Slide Time: 08:46)



Cr toxicity

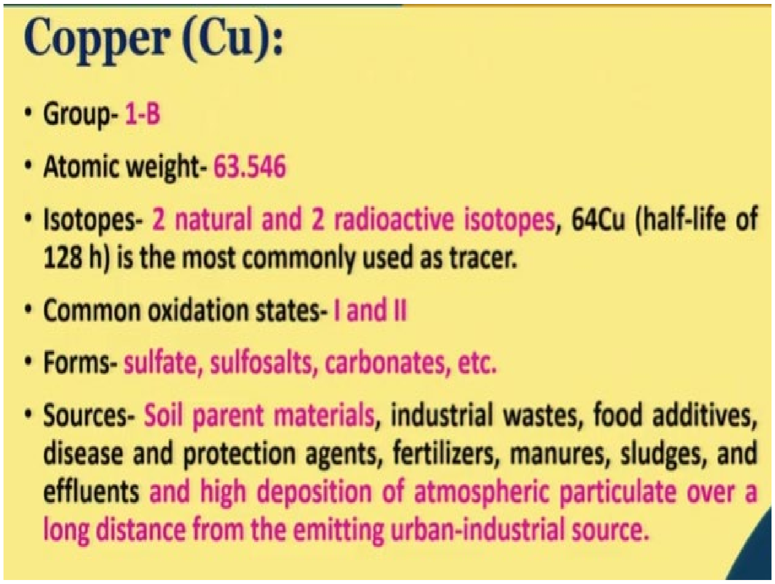
So if you see the chromium toxicity how the chromium you know produce is toxic influence in the animal body. So you can see basically when chromium is diffused within the nuclear membrane it is basically the chromium 6 itself it is not you know it is really it is not producing any harmful effects. However it is being reduced to chromium 3 and these reduction and chromium 3. This chromium 3 basically enters and then it produces different types of problem

For example in case of high level damage it can you know there are 2 types of damage where you can see from this chromium 2 one is low level damage which basically strand breaks to single strand which basically shows genomic instability. However in case of high level damage you know see this sales cycle erase which is known as apoptosis. Now also these; chromium 6 to chromium 3 transition may also turn into oxidative intermediates.

For example chromium 4 that means tetravalent chromium and also pentavalent chromium and these you know and this tetra valent chromium and penta valent chromium can also produces this genomic instability. And also it ultimately produces the oxidative damage of lipids and proteins which can produce the mutation and cell transformation which can ultimately produce the cancer. So this is how the chromium can be a potential carcinogenic and this is how the produce the toxity impacts in the cell.

Remember that the chromium 6 itself is not acting it is basically reducing the chromium which enters into the cell to produce different types of ill effects.

(Refer Slide Time: 10:38)



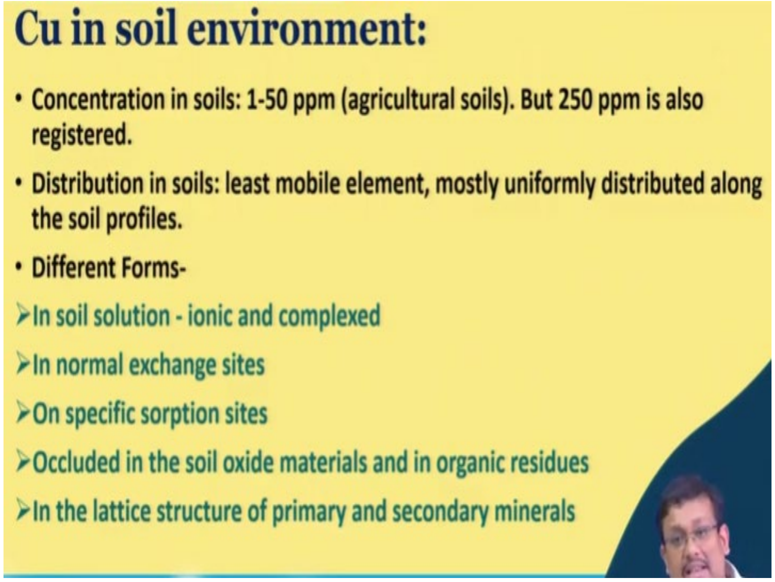
Copper (Cu):

- Group- 1-B
- Atomic weight- 63.546
- Isotopes- 2 natural and 2 radioactive isotopes, 64Cu (half-life of 128 h) is the most commonly used as tracer.
- Common oxidation states- I and II
- Forms- sulfate, sulfosalts, carbonates, etc.
- Sources- Soil parent materials, industrial wastes, food additives, disease and protection agents, fertilizers, manures, sludges, and effluents and high deposition of atmospheric particulate over a long distance from the emitting urban-industrial source.

Now if we move to the another important trace element that is copper. Copper belongs to group 1B with an atomic weight of 63.546 and isotopes it as 2 natural and 2 radioactive isotopes 64 copper which is which is half-life of 128 hour is the most commonly used as tracer. And common oxidation states are 1 and 2 and basically you can see the copper as copper sulfate copper you know sulfate salts copper carbonates etc., in other forms.

Now what are the sources of copper? The sources of copper are soil parent material, industrial waste, food additives, disease and protection agents, fertilizers, manures, sludges and effluents and high deposition of atmospheric particulate over a long distance from the emitting urban you know industrial sources.

(Refer Slide Time: 11:29)



Cu in soil environment:

- Concentration in soils: 1-50 ppm (agricultural soils). But 250 ppm is also registered.
- Distribution in soils: least mobile element, mostly uniformly distributed along the soil profiles.
- Different Forms-

➢In soil solution - ionic and complexed

➢In normal exchange sites

➢On specific sorption sites

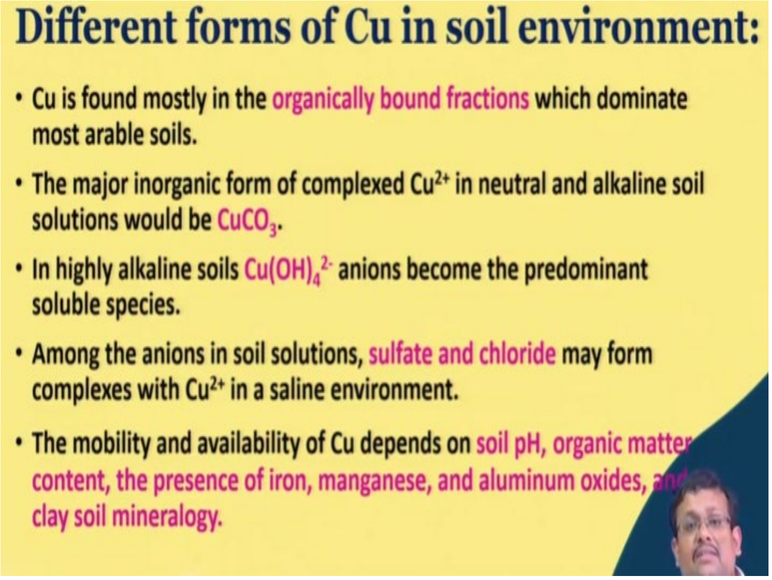
➢Occluded in the soil oxide materials and in organic residues

➢In the lattice structure of primary and secondary minerals

Now what are the copper in soil environment now if you see the copper in soil environment concentration in soil basically varies from 1 to 50 ppm in agriculture soil. But 250 ppm is also registered but distribution in the soil will see the least. It is the least mobile element when mostly uniformly distributed along the soil profile. And what are the different forms of copper in the soil you know majorly it can be found in soil solution and either ionic or complex form.

In normal exchangeable soil on specific sorption sites or it can be seen as an occluded in the soil oxide materials as in you know and in organic residues. And also the copper can be found in the lattice structure of primary and secondary minerals. So these are the different forms of copper which you can see in the soil environment.

(Refer Slide Time: 12:24)



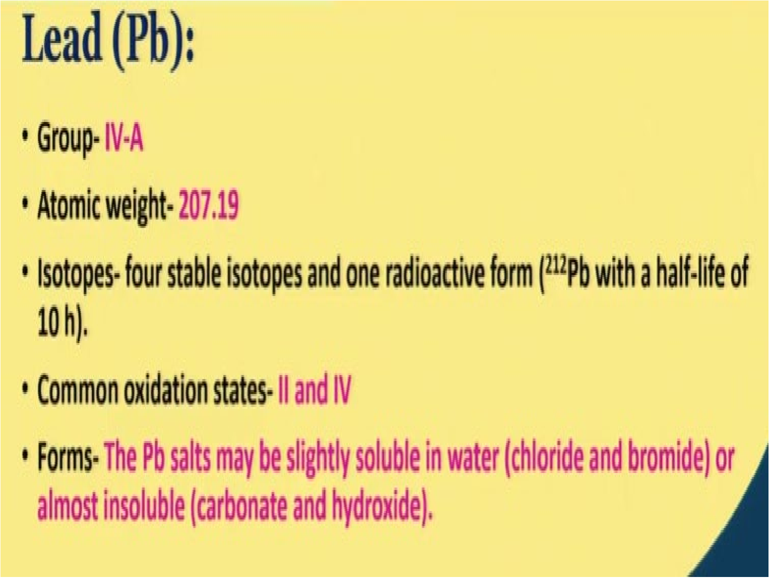
Different forms of Cu in soil environment:

- Cu is found mostly in the organically bound fractions which dominate most arable soils.
- The major inorganic form of complexed Cu^{2+} in neutral and alkaline soil solutions would be $CuCO_3$.
- In highly alkaline soils $Cu(OH)_4^{2-}$ anions become the predominant soluble species.
- Among the anions in soil solutions, sulfate and chloride may form complexes with Cu^{2+} in a saline environment.
- The mobility and availability of Cu depends on soil pH, organic matter content, the presence of iron, manganese, and aluminum oxides, and clay soil mineralogy.

Now what are the, you know copper is found mostly in the organically bound fraction which dominates most arable soils. So copper is one of the major trace which shows tremendous binding capacity or tremendous affinity towards tendency to be bound by the organic molecules. So the major inorganic forms of complex copper to neutral and alkaline solution would be basically carbon carbonate.

Now in case of highly carbonate alkaline soil obviously there will be hydroxyl ions so obviously you can see the $CuOH_4^{2-}$ anions become more predominant soluble species. Among the anions in the soil solutions, sulfate and chloride may form complexes with Cu^{2+} in a saline environment. The mobility and availability of copper depends on soil pH, organic matter contains the presence of iron or you know manganese and aluminum oxides and clay soil mineralogy. So all these, factors basically influences the mobility and availability of copper.

(Refer Slide Time: 13:29)

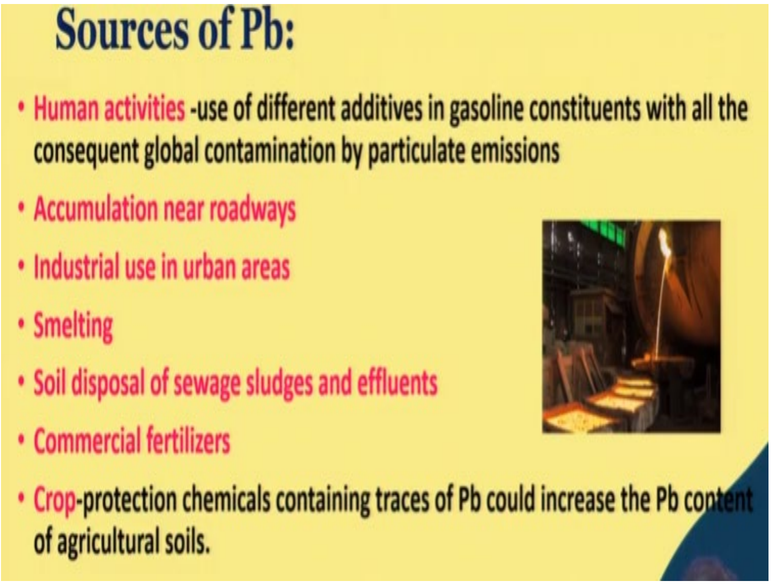


Lead (Pb):

- Group- IV-A
- Atomic weight- 207.19
- Isotopes- four stable isotopes and one radioactive form (^{212}Pb with a half-life of 10 h).
- Common oxidation states- II and IV
- Forms- The Pb salts may be slightly soluble in water (chloride and bromide) or almost insoluble (carbonate and hydroxide).

So the next major trace element that is lead. Lead belong to 4A group 4A with an atomic weight of 207.19 isotopes as far as isotopes are concerned it as 4 stable isotopes and 1 radioactive isotopes that is 212 Pb with half-life of 10 hour. And common oxidation states are basically Pb II and Pb IV now what are the major forms? The late salt; maybe slightly soluble in water in case of you know chloride or bromide if it is lead chloride lead bromide or almost insoluble if it is lead carbonate or lead hydroxide.

(Refer Slide Time: 14:11)



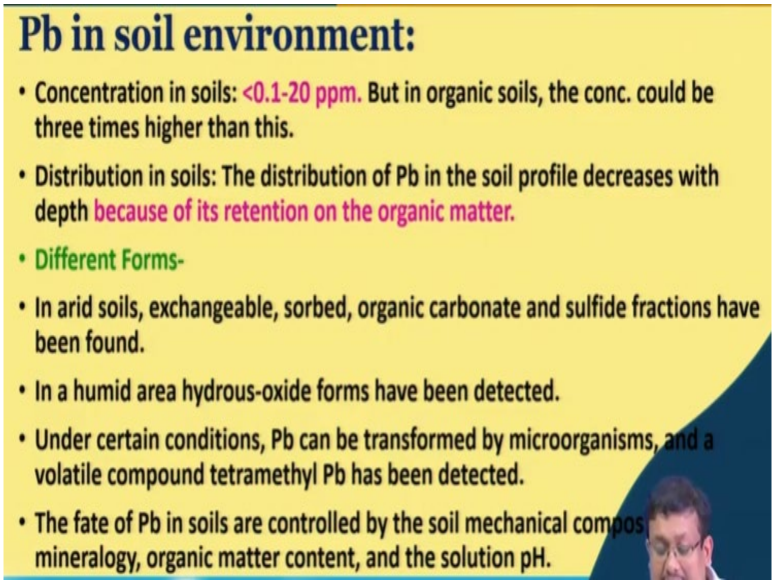
Sources of Pb:

- Human activities -use of different additives in gasoline constituents with all the consequent global contamination by particulate emissions
- Accumulation near roadways
- Industrial use in urban areas
- Smelting
- Soil disposal of sewage sludges and effluents
- Commercial fertilizers
- Crop-protection chemicals containing traces of Pb could increase the Pb content of agricultural soils.

So what are the sources of lead? So the major important source of lead in the environment is the human activities. Now use of different additives in the gasoline constituents with all the consequent global contamination by particulate emissions. Also accumulation near roadways industrial use in urban areas, smelting you can see the picture of smelting here in the steel industry. And also soil disposal of sewage sludge and effluents commercial fertilizers.

You know all these are major sources of all you know sources of lead and crop protection chemicals containing traces of lead could also increase the lead content of agriculture soils. So basically we apply huge amount of pesticide that also can influence and increase in concentration of lead. We will discuss that in later you know in our next lecture when we discuss the organic toxic organic you know organic pollutant of soil.

(Refer Slide Time: 15:12)



Pb in soil environment:

- Concentration in soils: <0.1-20 ppm. But in organic soils, the conc. could be three times higher than this.
- Distribution in soils: The distribution of Pb in the soil profile decreases with depth because of its retention on the organic matter.
- Different Forms-
- In arid soils, exchangeable, sorbed, organic carbonate and sulfide fractions have been found.
- In a humid area hydrous-oxide forms have been detected.
- Under certain conditions, Pb can be transformed by microorganisms, and a volatile compound tetramethyl Pb has been detected.
- The fate of Pb in soils are controlled by the soil mechanical compos mineralogy, organic matter content, and the solution pH.

Now if you consider lead soil environment the concentration various from 0 less than 0.1 to 20 ppm. But in organic soil the concentration could be 3 times higher than this now distribution in the soil if you see that the late distribution in the soil in soil profile the decrease with depth because of its retention of the organic matter. Just like copper lead also shows high affinity to be bound by organic matter

So obviously as a depth increases as organic matter concentration decreases lead concentration also decreases. So what are the forms of lead? In arid soil exchangeable form organic carbonate and sulfide fractions have been found. In a humid area hydrous-oxide form have been deducted under certain condition lead can be transformed by micro-organisms and volatile compound you know tetramethyl lead has been detected.

And the fate; of lead in soils are controlled by the soil mechanical composition mineralogy organic matter content and solution pH. So these are the major forms of lead in the soils.

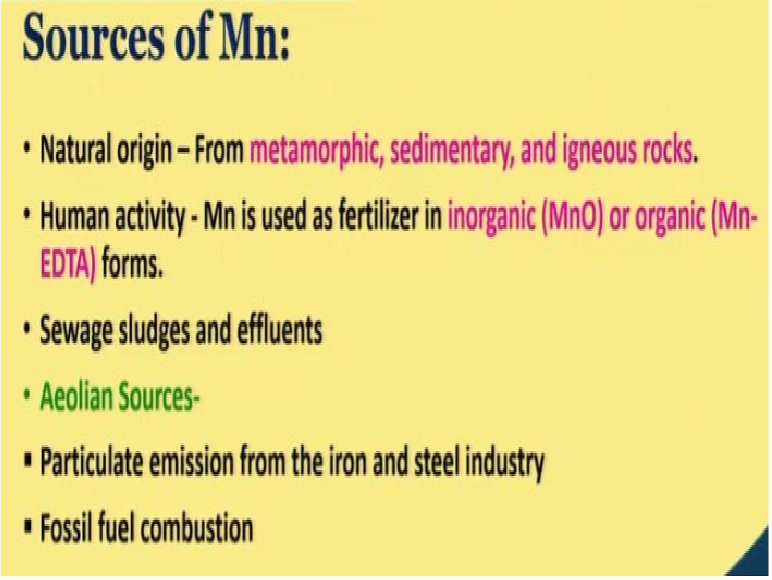
(Refer Slide Time: 16:25)

Manganese (Mn):

- Group- VII-A
- Atomic weight- 54.938
- Common oxidation states- II, IV, VI and VII.
- Forms- The lower oxides of Mn are basic and the higher ones acidic.

So if you consider the next one that is manganese belongs to you know group 7A with an atomic weight of 54.938. When it as 4 common oxidation states 2, 4, 6 and 7 and the forms are you know if you consider the forms of manganese the lower oxides of manganese are basic whereas the higher oxides are basically acidic in nature.

(Refer Slide Time: 16:52)



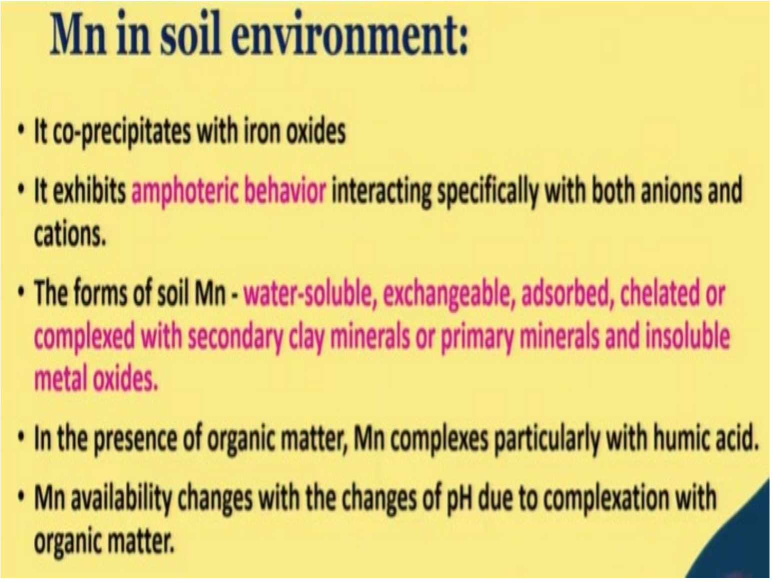
Sources of Mn:

- Natural origin – From metamorphic, sedimentary, and igneous rocks.
- Human activity - Mn is used as fertilizer in inorganic (MnO) or organic (Mn-EDTA) forms.
- Sewage sludges and effluents
- Aeolian Sources-
- Particulate emission from the iron and steel industry
- Fossil fuel combustion

Now what are the sources of manganese natural origin I mean it manganese can occur naturally from metamorphic sediment and igneous rocks. You know that the differences between the metamorphic segmented in igneous rocks and also due to human activity you know manganese is basically used as fertilizer in inorganic you know or organic forms. In the organic forms basically manganese EDTA and incase of inorganic MnO form can be used.

And also when we apply sewage sludge and effluents into the soil that also behave as a major source of manganese. And also Aeolian sources like particular emission from iron and steel industry and also Fossil fuel combustion. So these are the major sources of manganese in the environment.

(Refer Slide Time: 17:41)



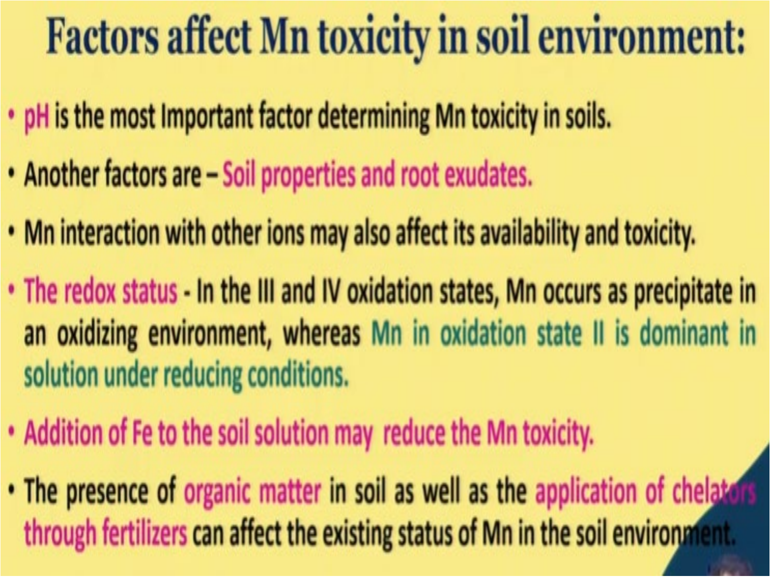
Mn in soil environment:

- It co-precipitates with iron oxides
- It exhibits amphoteric behavior interacting specifically with both anions and cations.
- The forms of soil Mn - water-soluble, exchangeable, adsorbed, chelated or complexed with secondary clay minerals or primary minerals and insoluble metal oxides.
- In the presence of organic matter, Mn complexes particularly with humic acid.
- Mn availability changes with the changes of pH due to complexation with organic matter.

Now if you consider the manganese in the soil environment it co-precipitates with iron oxides. It exhibits the amphoteric behavior inherently specifically with both anions and cations. And also you know the forms of soil manganese are water soluble exchangeable, absorbed, chelated or complex with secondary clay minerals or primary minerals and insoluble metal oxides

So basically you can see the manganese could be present as the water soluble form exchangeable form adsorb from chelated or complex with the secondary clay minerals or primary minerals or insoluble metal oxide. Manganese oxide is one of the major oxides present in the soils and in the presence of organic matter manganese complexes you know particularly with humic acids. So basically also we can see the complex session of manganese with organic fraction of soil. Now manganese availability changes of pH due to the complex session with organic matter.

(Refer Slide Time: 18:42)



Factors affect Mn toxicity in soil environment:

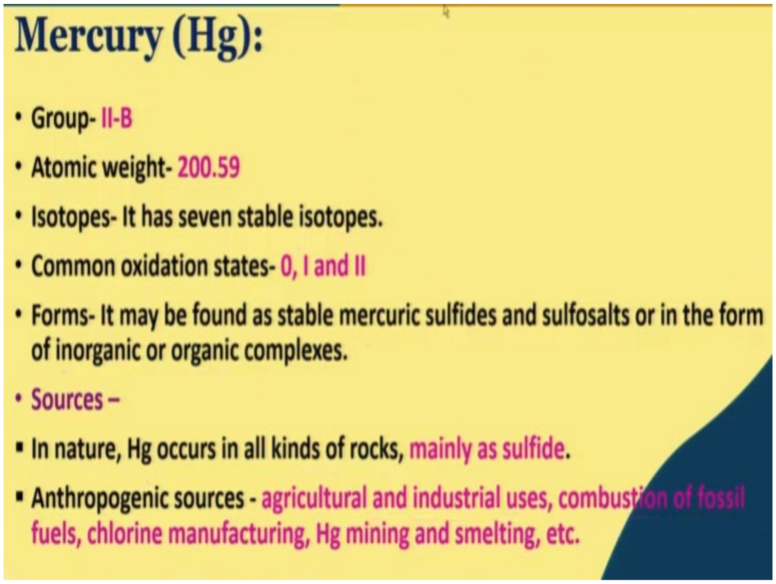
- pH is the most Important factor determining Mn toxicity in soils.
- Another factors are – Soil properties and root exudates.
- Mn interaction with other ions may also affect its availability and toxicity.
- The redox status - In the III and IV oxidation states, Mn occurs as precipitate in an oxidizing environment, whereas Mn in oxidation state II is dominant in solution under reducing conditions.
- Addition of Fe to the soil solution may reduce the Mn toxicity.
- The presence of organic matter in soil as well as the application of chelators through fertilizers can affect the existing status of Mn in the soil environment.

So these are some of the you know important factors which you know which manganese which influence the manganese toxicity in the soil environment. First of all the pH is the most important factor determining the manganese toxicity in the soil. For example if the soil is acidic in nature that shows more concentration of you know manganese as compared to the alkaline soil. And another factor is soil properties and root exudates.

Manganese interaction with other ions may also affects is availability and toxicity let us consider the redox status. So in the 3 and 4 oxidation states manganese occur as precipitate in the oxidizing environment. Whereas the manganese in oxidation state 2 is dominant in solution under reducing conditions. Now addition of iron to the soil solution may reduce the manganese toxicity.

And the presence of organic matter in soil as well as the application of chelators through fertilizers can affect the existing status of manganese in the soil environment. So obviously the presence of organic matter through its chelating action also can affect the status of manganese in the soil environment.

(Refer Slide Time: 20:06)



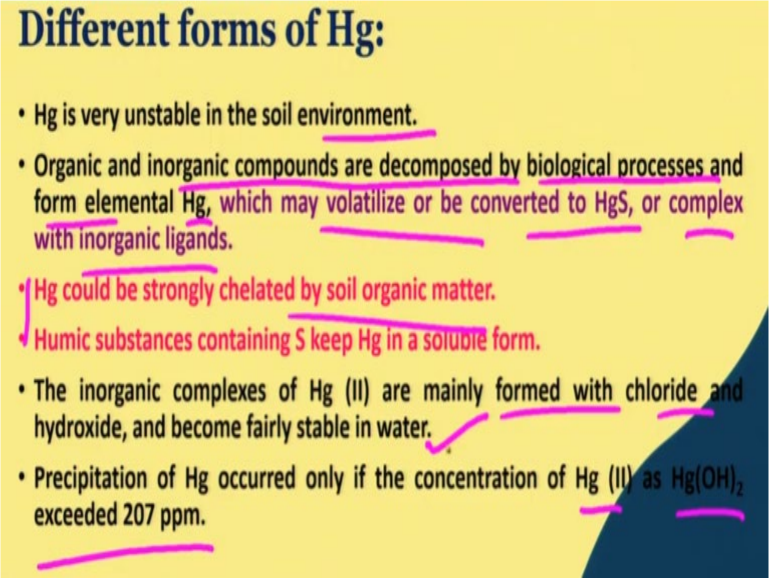
Mercury (Hg):

- Group- II-B
- Atomic weight- 200.59
- Isotopes- It has seven stable isotopes.
- Common oxidation states- 0, I and II
- Forms- It may be found as stable mercuric sulfides and sulfosalts or in the form of inorganic or organic complexes.
- Sources –
- In nature, Hg occurs in all kinds of rocks, mainly as sulfide.
- Anthropogenic sources - agricultural and industrial uses, combustion of fossil fuels, chlorine manufacturing, Hg mining and smelting, etc.

Now let us consider one of the major important trace element as far as the toxicity is concerned mercuric. Now mercury belong to group 2B with an atomic weight of 200.59 it as 7 stable isotopes and it as 3 common oxidation states 0, 1 and 2. And what are the important forms? The forms are it may be found in stable mercuric sulfides and sulfosalts or in the form of inorganic or organic complexes we will see that in details.

Now in the nature the major sources of if you consider the major sources mercury occurs in all kinds of rocks mainly as sulfides as we have already discussed. And also it as got anthropogenic sources like agricultural, industrial use, combustion of fossil fuels, chlorine manufacturing, you know then mercury mining and smelting etc. So, all this process influences the concentration or enrichment of mercury in the soil environment.

(Refer Slide Time: 21:11)



Different forms of Hg:

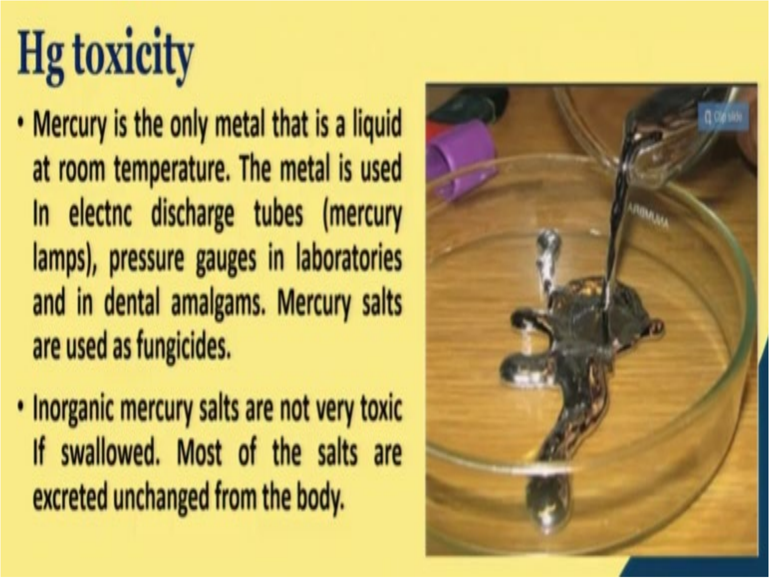
- Hg is very unstable in the soil environment.
- Organic and inorganic compounds are decomposed by biological processes and form elemental Hg, which may volatilize or be converted to HgS, or complex with inorganic ligands.
- Hg could be strongly chelated by soil organic matter.
- Humic substances containing S keep Hg in a soluble form.
- The inorganic complexes of Hg (II) are mainly formed with chloride and hydroxide, and become fairly stable in water.
- Precipitation of Hg occurred only if the concentration of Hg (II) as $Hg(OH)_2$ exceeded 207 ppm.

Now what are the different forms of mercury? Mercury is very unstable in the soil environment we have to remember that. Now remember that organic and inorganic compounds are decomposed by biological process and form elemental you know mercury which may volatilize or be converted to mercury sulfide or complex with inorganic ligands. So basically organic inorganic compounds are decomposed by biological process for element and form elemental mercury.

And these elemental mercury produce also can be volatilized and then converted to mercuric sulfide or complex with inorganic ligands. Now one of the important thing is this mercury would be strongly chelated by soil organic matter. And humic substances containing sulfur keep mercury in the insoluble form. Now the inorganic complexes are you know so we have covered the organic forms.

Now inorganic complexes of mercury 2 are mainly formed with chloride and hydroxide and become fairly stable in water. Now sometime we see precipitation of mercury occurred only if the concentration; of you know mercury 2 and $HgOH_2$ exceed 207 ppm. So these are different forms of mercury which we can see in the soil environment.

(Refer Slide Time: 22:43)

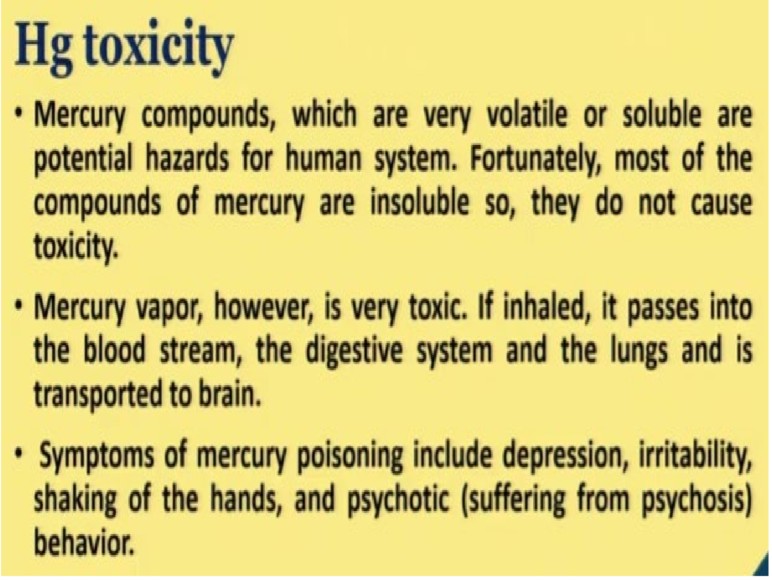


Hg toxicity

- Mercury is the only metal that is a liquid at room temperature. The metal is used In electnc discharge tubes (mercury lamps), pressure gauges in laboratories and in dental amalgams. Mercury salts are used as fungicides.
- Inorganic mercury salts are not very toxic If swallowed. Most of the salts are excreted unchanged from the body.

Now let us talk about mercury toxicity mercury is the only metal that is liquid at room temperature, and the metal is basically used in electric discharge tube like mercury lamps then pressure gauges in laboratories and in dental amalgams. And also mercury salts are also uses fungicides. Now inorganic mercury are not very toxic if swallowed most of the salts are excreted unchanged from the body.

(Refer Slide Time: 23:14)

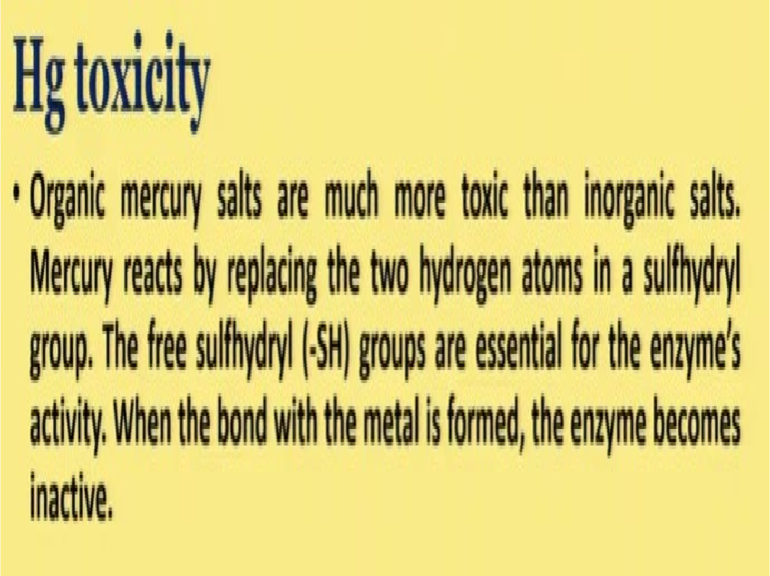


Hg toxicity

- Mercury compounds, which are very volatile or soluble are potential hazards for human system. Fortunately, most of the compounds of mercury are insoluble so, they do not cause toxicity.
- Mercury vapor, however, is very toxic. If inhaled, it passes into the blood stream, the digestive system and the lungs and is transported to brain.
- Symptoms of mercury poisoning include depression, irritability, shaking of the hands, and psychotic (suffering from psychosis) behavior.

Now mercury toxicity mercury compounds so which are very volatile or soluble are potential hazards for human systems. Fortunately most of the compounds of mercury are insoluble so they do not cause toxicity. Now mercury vapor however is very toxic if inhaled it process into the blood stain and digestive system and the lungs and is transported to our brain. So symptoms of mercury poisoning include depression, irritability, shaking of the hands and psychotic you know behavior. So these are some of the ill effects of mercury toxicity.

(Refer Slide Time: 23:55)

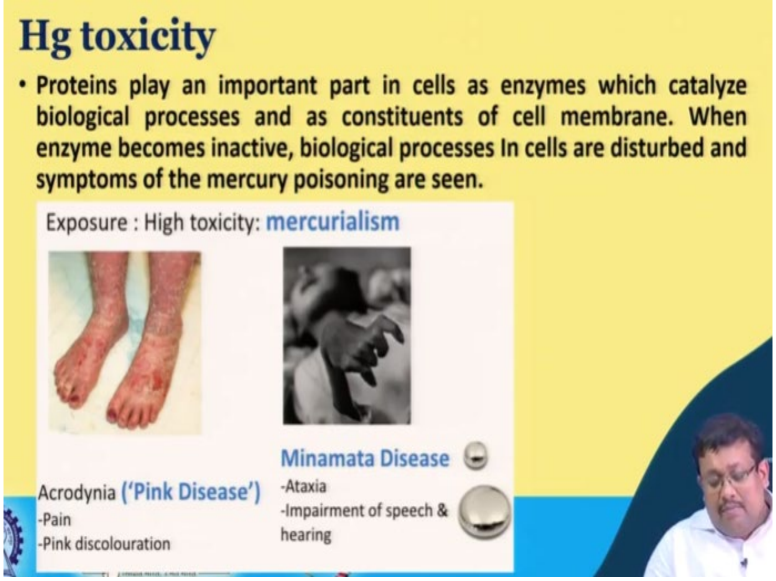


Hg toxicity

- Organic mercury salts are much more toxic than inorganic salts. Mercury reacts by replacing the two hydrogen atoms in a sulfhydryl group. The free sulfhydryl (-SH) groups are essential for the enzyme's activity. When the bond with the metal is formed, the enzyme becomes inactive.

Now organic mercury salts are much more toxic than inorganic salts mercury reacts by replacing the 2 hydrogen atoms in a sulfhydryl groups. The free sulfhydryl group is basically SH group this is so mercury basically reacts the replace in the 2 hydrogen from atom in a sulfhydryl group. So the free sulfhydryl groups are essential for the enzymes activity when the bond with the metal is formed the enzyme becomes you know inactive.

(Refer Slide Time: 24:27)



Hg toxicity

- Proteins play an important part in cells as enzymes which catalyze biological processes and as constituents of cell membrane. When enzyme becomes inactive, biological processes In cells are disturbed and symptoms of the mercury poisoning are seen.

Exposure : High toxicity: mercurialism

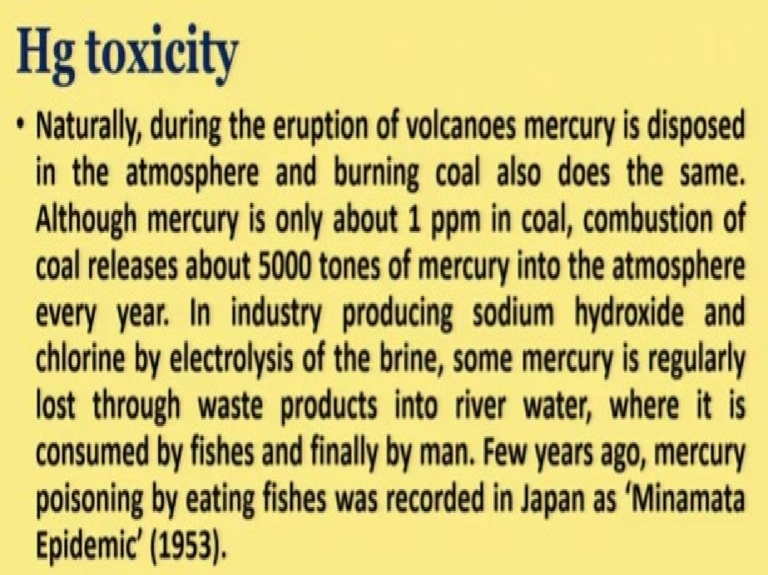
Acrodynia ('Pink Disease')
-Pain
-Pink discolouration

Minamata Disease
-Ataxia
-Impairment of speech & hearing

So these are some of the you know effect of mercury toxic you can see here so proteins play an important part in cells as enzymes which catalyze biological processes and as constituents of cell membrane. Now when enzyme becomes inactive biological process in cells are disturbed and symptoms in the mercury poisoning are seen. So you are see here it is showing a high toxicity of the mercury that is called the mercurialism.

And basically it is called also known as the pink disease or acrodynia it produces pink discoloration as well as pain. And also you can see minamata disease of from mercury you know which ultimately produces impairment of speech and hearing.

(Refer Slide Time: 25:17)



Hg toxicity

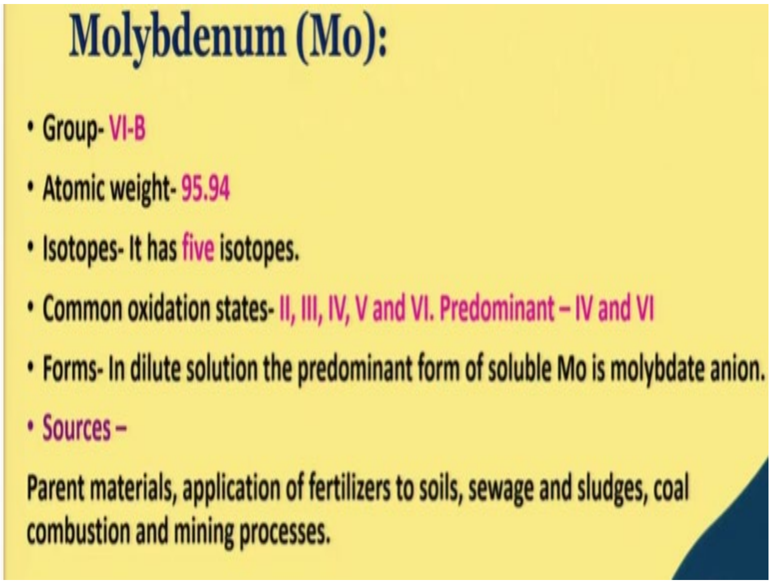
- Naturally, during the eruption of volcanoes mercury is disposed in the atmosphere and burning coal also does the same. Although mercury is only about 1 ppm in coal, combustion of coal releases about 5000 tones of mercury into the atmosphere every year. In industry producing sodium hydroxide and chlorine by electrolysis of the brine, some mercury is regularly lost through waste products into river water, where it is consumed by fishes and finally by man. Few years ago, mercury poisoning by eating fishes was recorded in Japan as 'Minamata Epidemic' (1953).

Now naturally during the eruption of volcanoes mercury is disposed in the atmosphere and burning coal also does the same. Although mercury is only 1 ppm in coal combustion of coal releases about 5000 tons of mercury into the atmosphere every year. So this you can see that you know anthropogenic sources are major you know anthropogenic sources are major source of mercury toxicity.

Now remember that in industry producing sodium hydroxide and chlorine by electrolysis of the brine, some mercury is you know regularly lost through the products into the river water where it is consumed by fishes and finally due to the by you know it enters into the chain of food chain. And basically you know it comes into the human body now few years ago mercury poisoning by eating fishes was recording in Japan as Minamata Epidemic.

And I have showed you in the last slide the in the picture of Minamata disease due to mercury toxicity.

(Refer Slide Time: 26:21)



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.

Another important trace element is Molybdenum we denote this Molybdenum as Mo it belongs to group 6B with an atomic weight of 95.94. It has got 5 isotopes and common oxidation states are 2, 3, 4, 5, 6 however the predominant are 4 and 6. And it basically have you know basically occurs in the dilute solutions basically predominant in the dilute solution and basically the sources of molybdenum parent materials and also the fertilizers in this soils sewage and sludge, coal combustion and different mining process.

You can see that you know these are the some of the important elements which are responsible for you know causing the soil pollution. So let us wrap up our lecture here will start from here in the next lecture and then we will discuss some of the important organic pollutants also thank you very much.