Soil Science and Technology
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Lecture - 30
Submerged Soils

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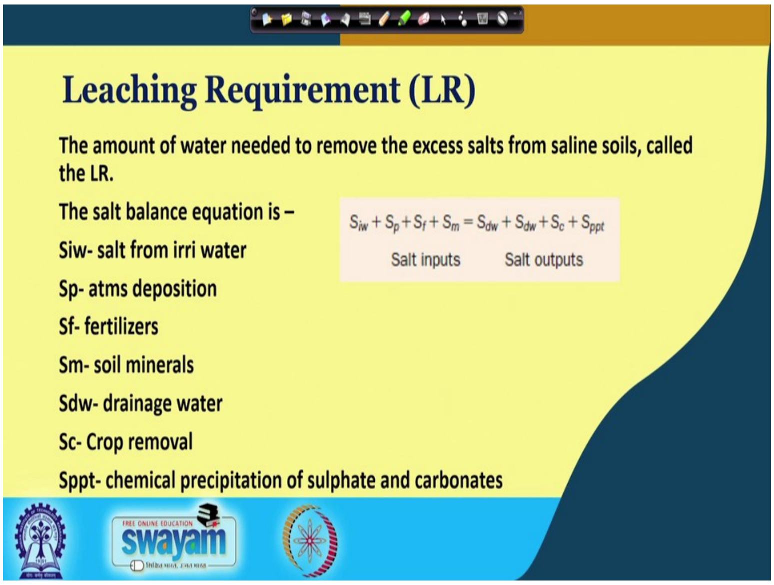

Welcome friends to this new lecture of Soil Science Technology in week-6. And in this final lecture of week-6, we will try to finish the soil salinity, and alkalinity, and then we will try to finish the submerged soil. So, in the last lecture, we stopped here while discussing about the leaching requirement. So, we discuss about the salt balance equation by you know discussing this four inputs and four salt outputs. So, let us see what is leaching requirement.

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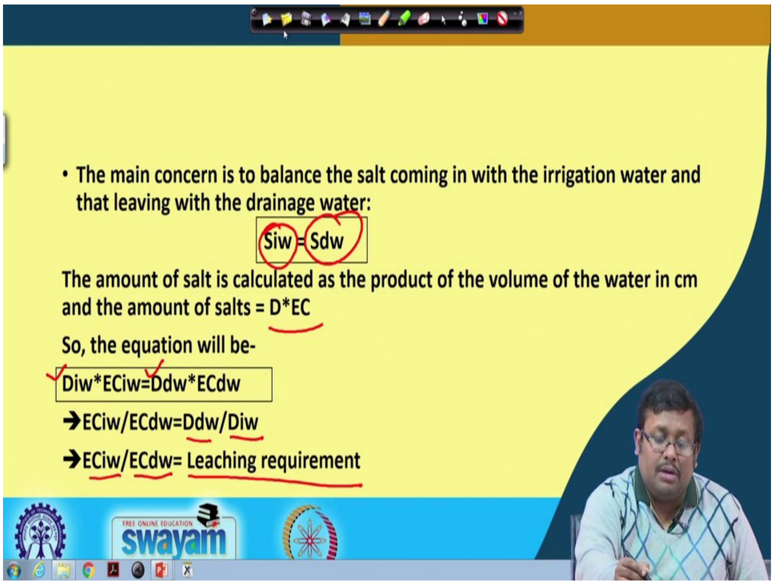

So, the main concern is to balance in case of leaching requirement the main concern is to balance the salt coming in with the irrigation water and the leaving the salt that is leaving with the drainage water. So, obviously we will be concerned about whether the salt which is coming irrigation water equals to the salt which is moving you know through the drainage water or not.

The amount of salt is calculated as a product of the volume of water in centimetre and the amount of salt. So, obviously the, you know the volume of water in centimetre and the amount of salts. So, you can see it is a multiplication factor D multiplied by E C. So, the equation will be DiW multiplied by ECiw, so Diw is basically the volume of the water in of the irrigation water of and Ddw is the volume of drainage water, and ECiw and ECdw are the respective electrical conductivity or salt concentration. So, obviously so in from these equation we can see ECiw by ECdw is equal to Dcw by you know Ddw by Diw. So, ECiw by ECdw is basically termed as leaching requirement. So, this is the formula of leaching requirement.

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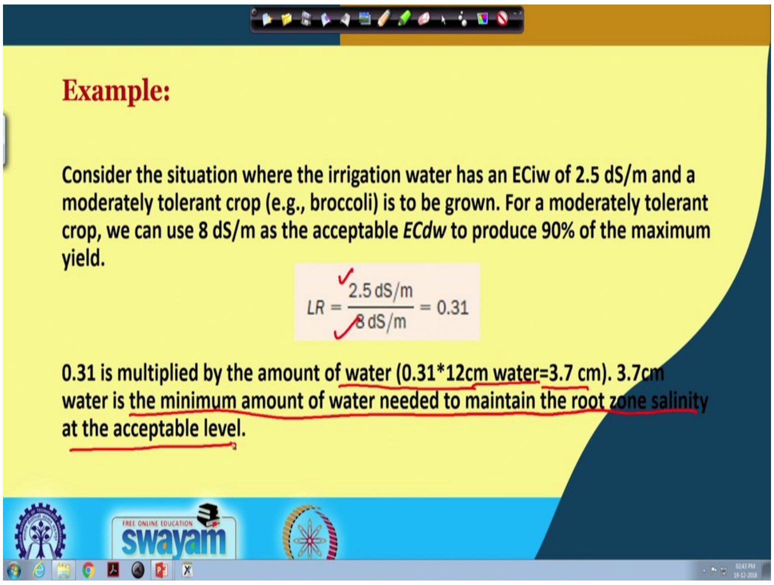

So, let us go and see one example numerical example of leaching requirement. So, here consider the situation where the irrigation water has an ECiw of 2.5 deci Siemens per metre and a moderately tolerant crop like broccoli is to be grown. For a moderately tolerant crop, and we generally we can use the 8 Deci Siemens per metre as the acceptable e d ECdw to produce 90 percent of the maximum yield.

So, obviously you know here we can see the leaching requirement is leaching requirement is ECiw by ECdw. So, 2.5 by 8 that is 0.31. Now, 0.31 is basically multiplied by the amount of water. So, 12 centimetre of water, we can see here. So, if there is a 12 centimetre you know of water, so that is 3.7 centimetre or this 3.7 centimetre water is the minimum amount of water needed to maintain the root zone of salinity at the acceptable level.

So, this you know 3.7 centimetre of water is a minimum amount of water that needed to maintain the root zone salinity at the acceptable level. So, this is how we calculate the leaching requirement. And let us move ahead.

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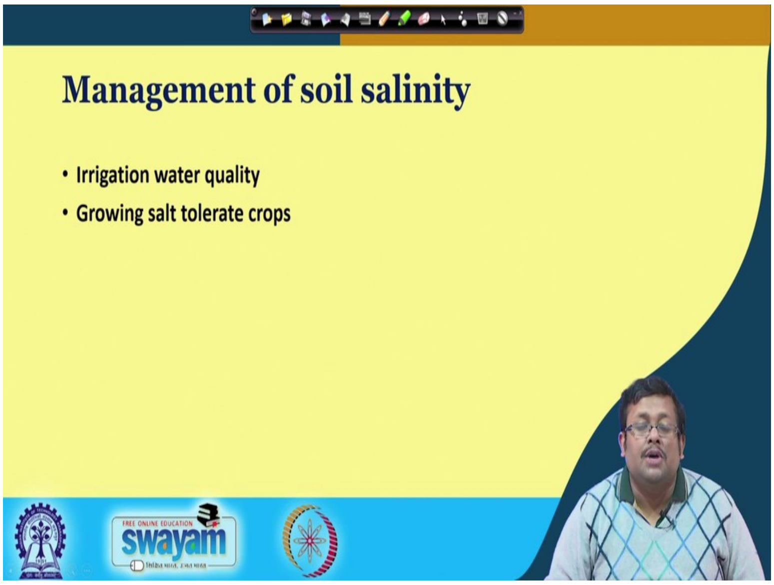

And see some more you know more aspects of soil salinity, obviously how to manage the soil salinity, obviously irrigation giving the irrigation water; you know good quality of irrigation water is the one of the major way of controlling the soil salinity. Irrigation water testing has to be done before applying the irrigation water into the soil, because soil sometime irrigation water itself is saline.

So, the quality of irrigation water is very much important. And split application of irrigation water is always better than ponding of irrigation water. And Secondly, the growing of salt tolerant crop is very much important for managing the salt you know soil salinity, it is the most effective way for getting some productivity from this region of problematic soils.

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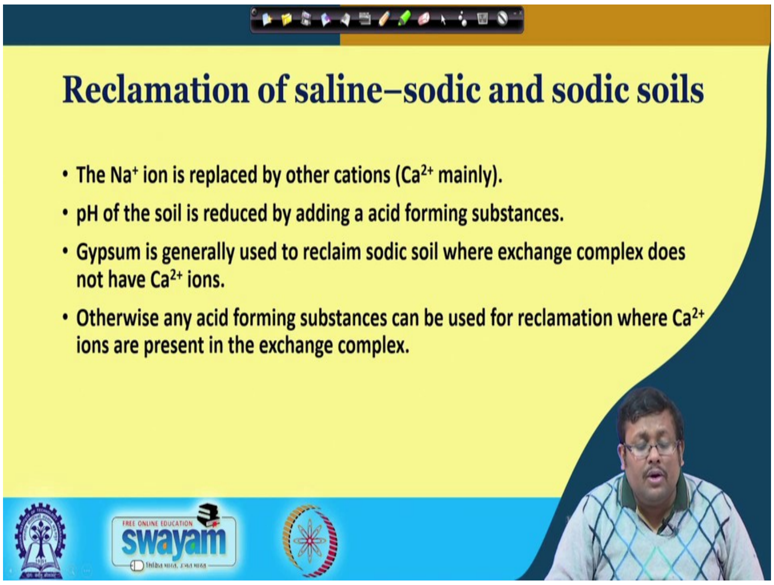

So, management of soil salinity you know. At the reclamation of saline-sodic and sodic-soil obviously, the sodium ion is replaced by cations like calcium. And pH of the soil is basically reduced by adding the acid forming substances.

Generally, gypsum we use now gypsum is generally used to reclaim sodic soil where exchange complaints does not have calcium ions. So, otherwise any acid forming substance can be used for reclamation where calcium ions are present in the exchange complex. So, when the exchange complex is not having any calcium, we can add gypsum. And if the exchange complex is having the calcium, we can add any acid forming substances, which will further reduce the pH of the sodic soil.

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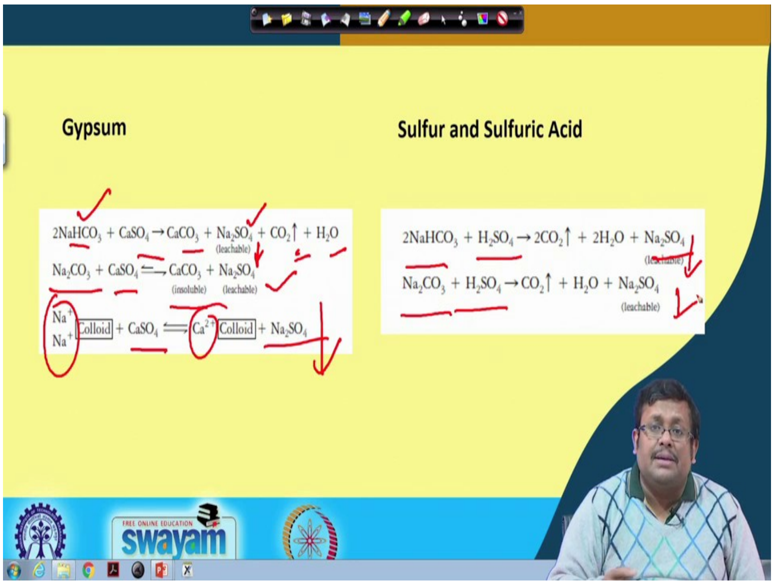

So, when we add the gypsum, you can see sodium gypsum formula is you know you know basically it is calcium sulphate. So, sodium bicarbonate as you can see reacts with calcium sulphate to produce the calcium carbonate and sodium sulphate which is leachable, and carbon dioxide and water at this you know this is for sodium bicarbonate. And in case of sodium carbonate obviously, the calcium sulphonate again reacts to form insoluble calcium carbonate, which is precipitated out and leachable sodium sulphate, which is getting out from the soil.

And obviously, when the colloidal exchange complex is dominated by sodium, when you add calcium the one calcium cation can replace two sodium to form sodium sulphate, which is basically leachable, and you can see the exchange complex is again occupied by calcium. So, these are the ways through which gypsum reclaim the soil sodicity. If the gypsum complex is already having the sodium already having the calcium, then you know obviously we have to use some other salt you know acid producing compound.

So, obviously you know we are adding some H_2SO_4. So, you can see sodium bicarbonate is reacting with H_2SO_4 to produce sodium sulphate, which is again leachable. And in case of sodium carbonate is again reacting with H_2SO_4 to produce sodium sulphate, which is again reachable. So, these are some of the ways to manage chemically the sodic soils.

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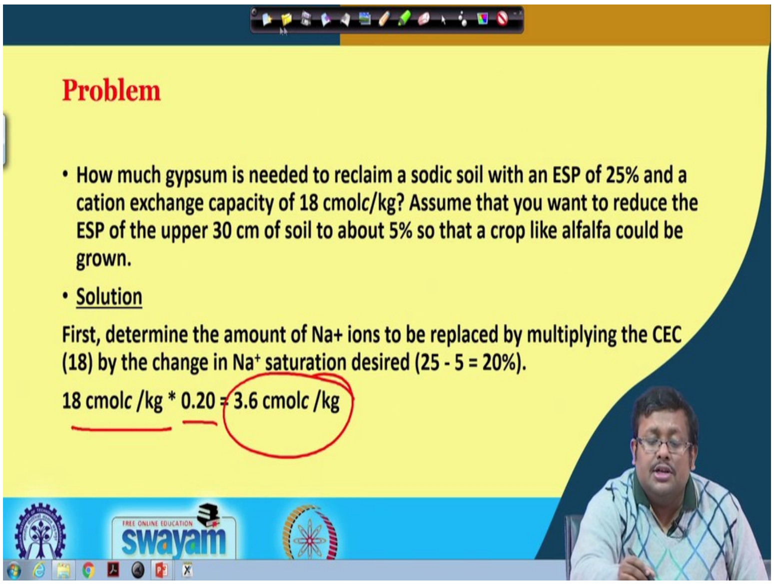

So, there is another problem, we must solve. Now, how much gypsum is needed to reclaim a sodic soil with an ESP of 25 percent and catenation capacity of 18 mole charge per kg. Now, assume that you want to reduce the ESP of the upper 30 centimetre to about 5 percent, so that a crop like alfalfa could be grown.

Now, in case of solution you can see, we have to first determine the amount of sodium ions that to be replaced by multiplying the CEC which is 18 in our case by the change of sodium saturation desired. So, our initial sodium saturation was 25 percent. Now, we want that you know you know now we want that it has you know to this sodium saturation percent should be 5 percent. So, the reduction is 25 minus 5 that is 20 percent you can see here. Now, obviously now the next step we are multiplying 18 charge per kg with 0.20 or 20 percent. So, we are getting 3.6 cent mol charge per kg, so this is the first step.

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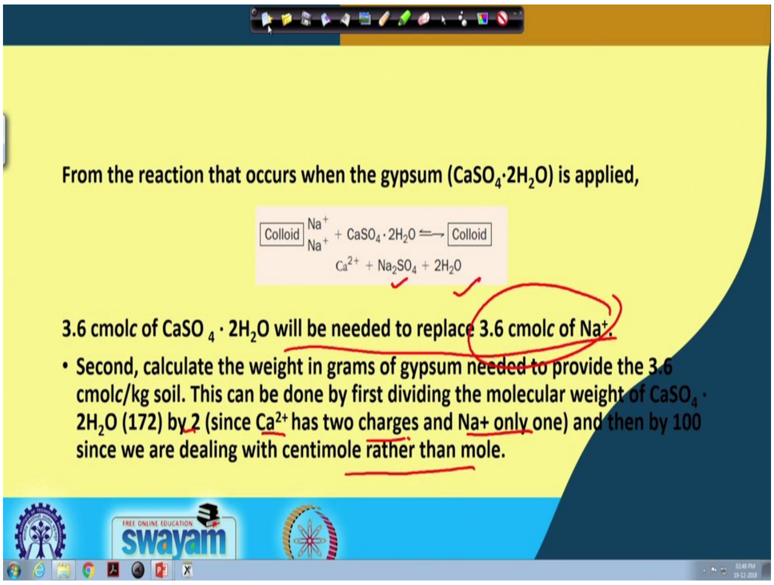

So, let us see the second step. So, from the reaction that occurs from the gypsum that is calcium sulphate $2H_2O$ is applied you can see here two sodium is getting replaced by one calcium you know calcium, and ultimately it is producing the colloid with calcium and sodium sulphate and water.

So, you can see here from this reaction 3.6 centimole charge of calcium sulphate $2H_2O$ will be needed to replace 3.6 centimole charge of sodium, it is you know that. So, 3.6 centimole charge of sodium, we have already calculated that has to be replaced by 3.6 centimole charge of calcium sulphate.

Now, secondly calculate the weight in grams of gypsum needed to provide these 3.6 centimole charge per kg of soil. Now, this can be done by first dividing the molecular weight of calcium sulphate $2H_2O$ that is 172 by 2, because calcium ion has two valency two charges, and sodium has only one, and then by 100 further. Then we have to divide it further by 100, because we are dealing with the centimole rather than the mole. So, basically if we see in the next slide.

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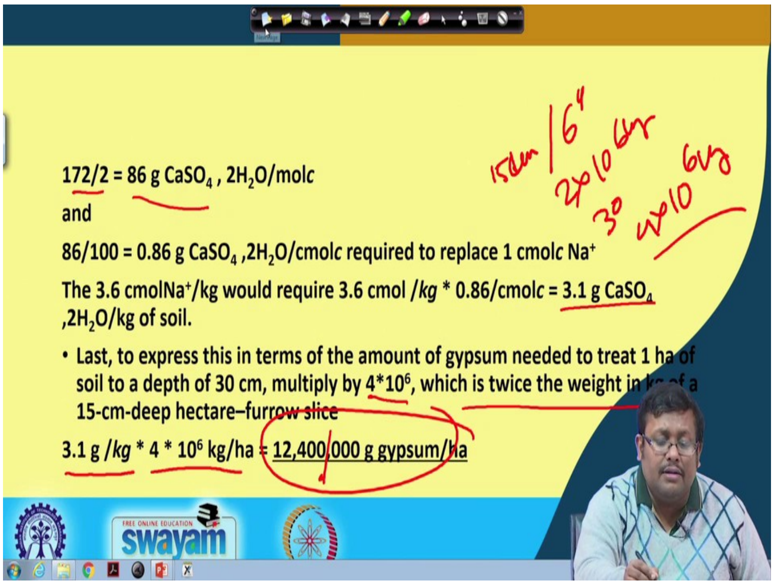

Ultimately, we are dividing the 172 by 2 that is 86 gram of calcium sulphate; we need 86 gram of gypsum or molecular charge. And then further we are converting it to you know 0.86 gram of gypsum per cmol charge or centimole charges required to replace 1 centimole charge of sodium.

So, the 3.6 centimole charge sodium per kg would require 3.6 centimole per kg multiplied by 0.86 centimole charge. So, we are getting 3.1 gram of calcium sulphate or $2H_2O$. So, we are basically getting 3.1 gram of gypsum per kg of soil. Last to express this in terms of amount of gypsum needed to treat 1 hectare of land to a soil depth of 30 centimetre, we have to multiply by 4 into 10 to the power 6, which is twice the weight of kg of 15 centimetre deep hectare-furrow slice.

So, if the furrow slice depth is 15 centimetre which is also 6 inches, so that the weight of these 15 centimetre furrow slice is basically 2 multiplied by 10 to the power 6 you know kg. However, in case of 30 centimetre, obviously that will be doubled. So, 4 into 10 to the power 6 kg, we have to multiplied by that.

So, 3.1 gram per kg multiplied by 4 into 10 to the power 6 kg per hectare, and we are getting this. So, basically we are getting 12,400 kg of gypsum per hectare. So, this is the, this is the final solution of this problem. So, guys I hope that you have understood this understood this solution. And if you have any further queries, you can email me regarding its regarding its explanation, I will be more than happy to answer it. So, let us move ahead, and go to our next topic that is submerged soils. Obviously, submerged soil we will cover.

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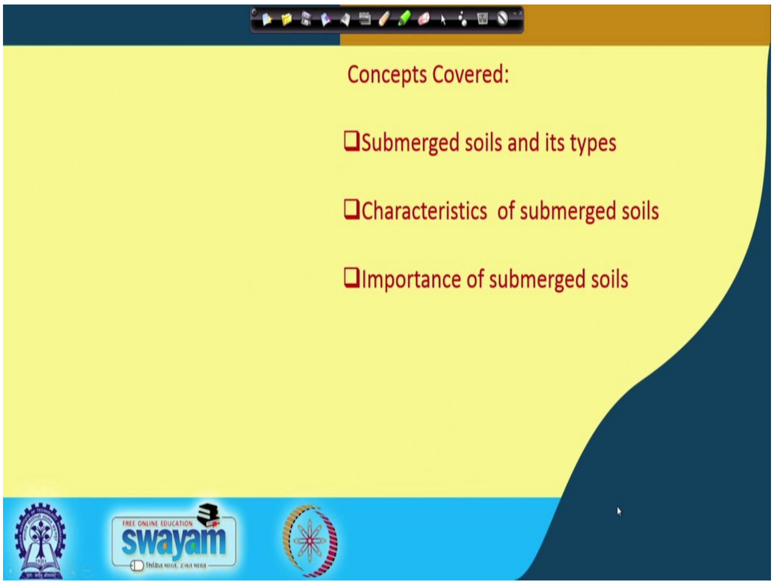

The submerged soil its types, and then characteristics of different submerged soils, and importance of submerged soils.

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So, you know that submerged soils are the you know soils that are submerging water for a sufficient period of time to give the distinct horizon development differentiating from other soil is called submerged soil. First submerged soils material generally influence the type of soil, which develops from it. Secondly, the type of aquatic life and crop it supports and finally, the capacity of these sediments to act as a sink for terrestrial waste. So, these are important influences of submerged soils.

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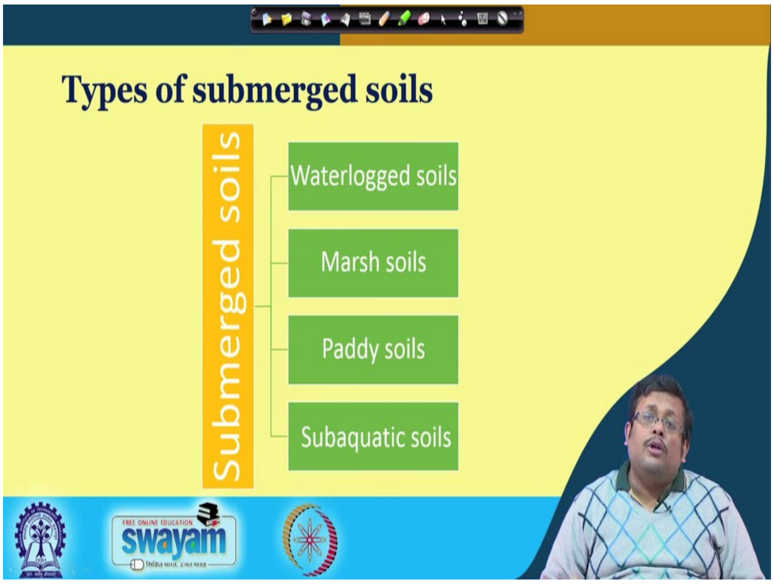

So, there are four types of submerged soils. What are those first of all waterlogged soils, secondly marsh soils, third is paddy soil, and finally subaquatic soils.

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So, in case of waterlogged soil, we call it gley soil. So, characteristics of these waterlogged soils are given by these distinctive gley horizons. So, you can see distinctive gley horizon, you can see here. So, a mottle have a partially oxidized gley horizon. So, this gley horizon have a partially oxidized gley horizon. And a mottled intermediate zone and bluish green permanent reduced zone, you can see it is bluish green permanently reduce zone.

And obviously, the waterlogged soil can be found in any climatic zone. And saturation may be due to the impervious soil layer or high groundwater table. So, this is the characteristics of waterlogged soil or gley soil.

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Second important marsh soils. So, mostly permanently saturated or waterlogged, these are mostly permanently saturated waterlogged. And they are basically characterized by plant residues in surface horizon or premature or permanently reduce G horizon or gley horizon.

So, they can be found in fringes of lakes, streams or estuaries or deltas as you can see here. And when exposed to aeration, it gives basically raise to acid sulphate soil. We have already discussed acid sulphate soil in soil acidity. So, this marsh soils are the region where the acid sulphate soil can be found.

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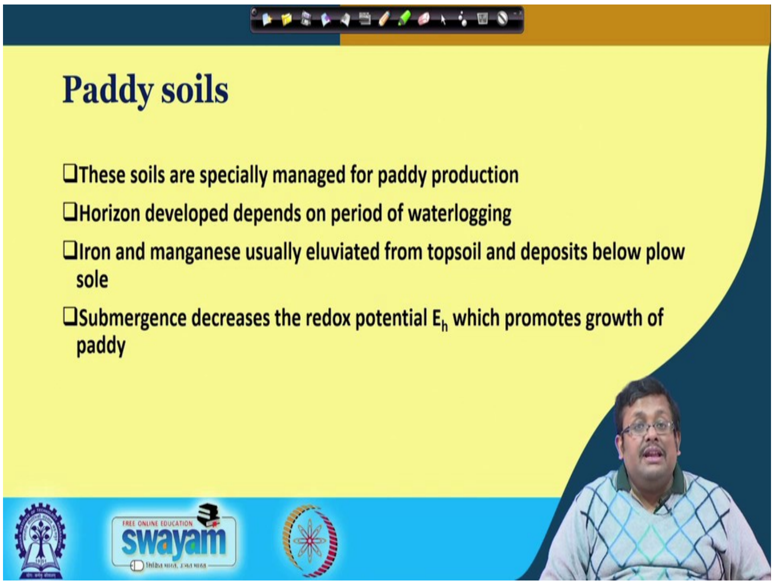

Now, final paddy soils. Paddy soils are specially managed for paddy production. And horizon developed depends on period of water logging. We generally do paddling for making a imperviously at those there is always standing water at the base of the plant. And iron and manganese usually eluviated from topsoil and deposits below plow sole from this paddy soil. At submergence decreases the redox potiential Eh which promotes the growth of the paddy.

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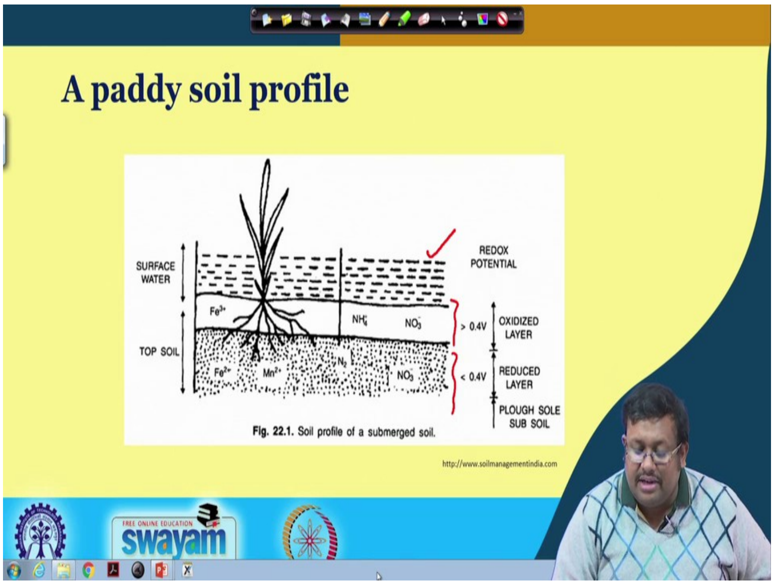

Now, if you see the paddy soil profile obviously, you will see obviously this is the surface water. At just below the surface water is very thin oxidized layer. And below the thin oxidized layer, you will see permanently reduced layer, where all the reduced fraction of different minerals and different nutrients are present will discuss them later on.

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So, another is subaquatic soil. The uppermost layer of unconsolidated aqueous sediments of lakes, oceans and river are called as subaquatic soils and their permanently submerged cumulative soils. And finally, they have varied horizon development you can see the subaqueous subaqueous soil profile.

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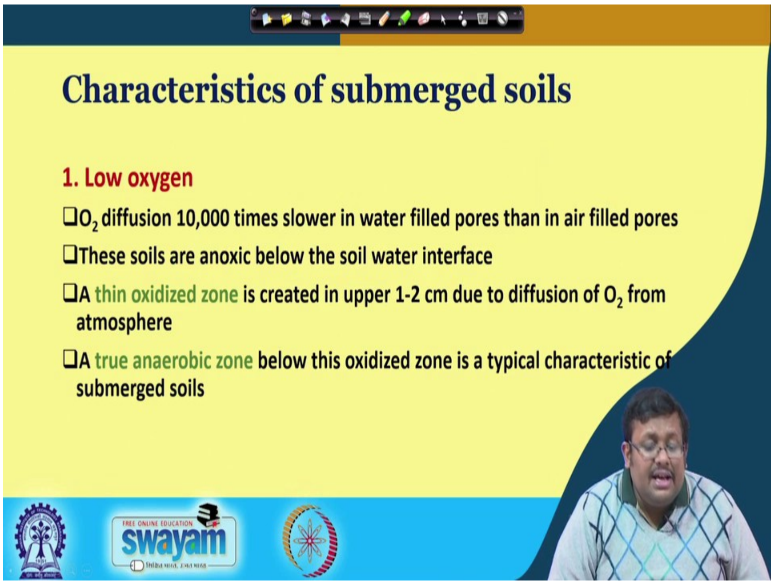

And you know let us see, what are the characteristics of the submerged soils. So, first important characteristics is low oxygen. Obviously, the oxygen diffusion is 10,000 times slower in water filled pores than in air filled pores, and in this type of soil specially. At this soils are anoxic below the soil water interface; because of low oxygen diffusion they are basically anoxic in nature.

And a thin oxidized zone is created the upper 1 to 2 cm due to diffusion of oxygen from the atmosphere. So, as I showed you in case of paddy soil profile, there is a thin 1 to 2 cm upper oxidized zone due to the diffusion of oxygen from the atmosphere. And finally, a true and anaerobic zone below this oxidised zone is a typical characteristic of a submerged soils. So, just below the oxidized zone, you will see an anaerobic zone.

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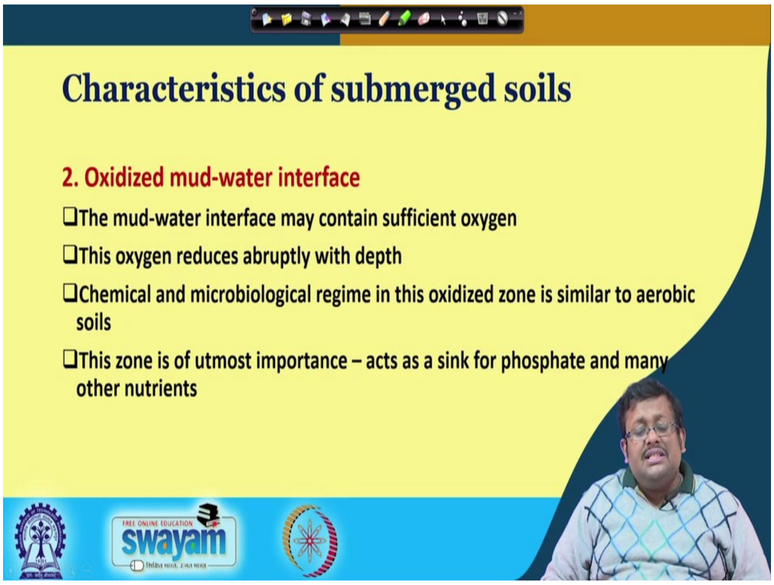

Second is oxidized mud-water interface, obviously the mud-water interface may contain sufficient oxygen. And this oxygen reduces abruptly with depth obviously. And chemical and micro microbiological regime in this oxidized zone is similar to aerobics soils. And this zone is of you know utmost importance, because it acts as a sink for phosphate and many other nutrients.

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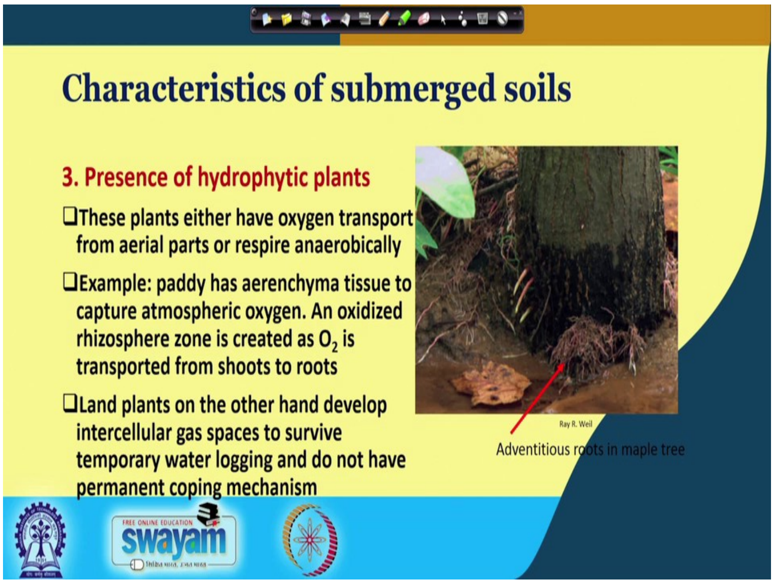

Thirdly the presence of hydrophytic plants is characterized by the submerged soils. So, these presences of these hydrophytic plants you can see if the submerged soils, these plants either have oxygen transport from aerial parts or they can respire anaerobically, you can see here the adventitious the adventitious roots of maple tree. And obviously, you know in case of paddy you have seen the aerenchyma issue to capture the atmospheric oxygen. So, an oxidized rhizosphere zone is created as oxygen is transported from shoot to the roots.

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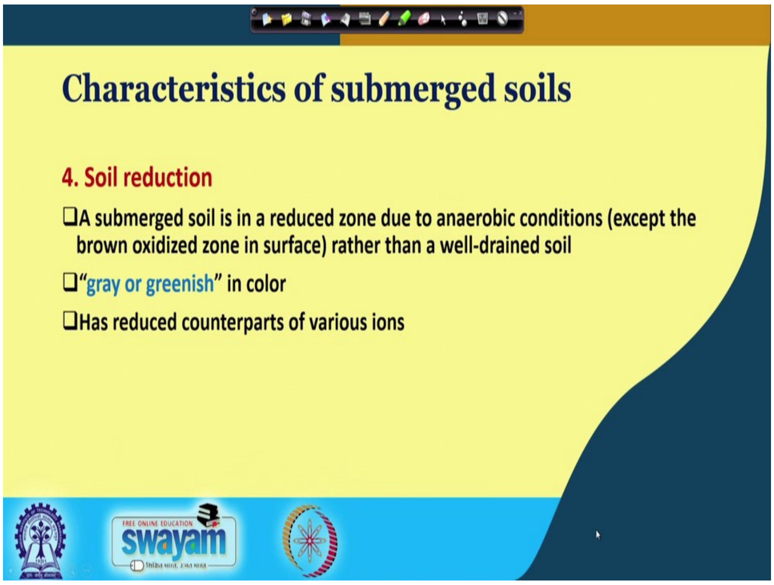

And finally, the soil reduction obviously, a submerged soil is in a reduced zone due to anaerobic conditions except the brown oxidized zone at the surface that is 1 to 2 cm oxidized zone. And rather than a well-drained soil obviously, and will get a gray or greenish color in this type of soil. And finally, it has reduced counterparts of various ions this anaerobic zone basically contains different reduced counterparts of various ions.

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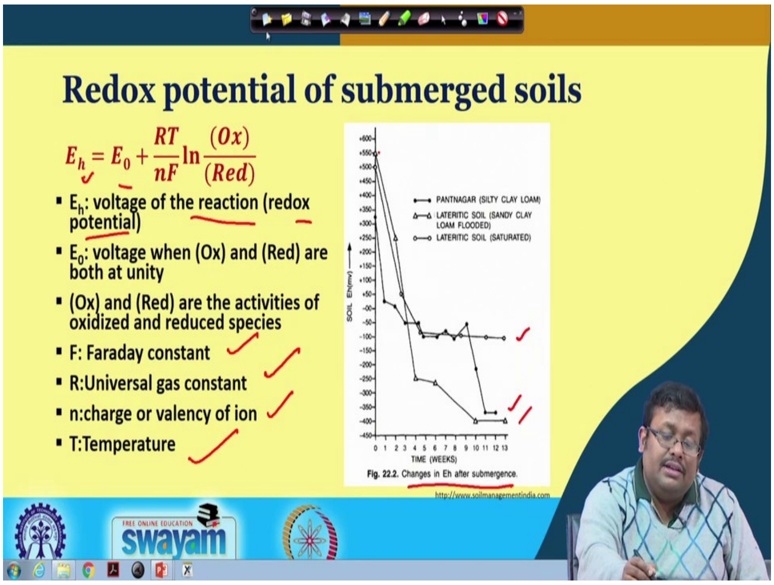

Now, very important concept is redox potential. The redox potential formula is E redox potential generally terms in terms of Eh. The Eh is basically E_0 plus RT by nF ln log of Ox by Red. The Eh is the voltage of the reaction that is redox potential E h is basically is redox potential. And E_0 is the voltage when oxidized and reduced reduction you know both at unity at that of you know Ox and Red are the activities of the oxidized and reduced species.

So, basically E_0 when the oxidized, and you know and the reduced species are having the, you know at the same concentration. The F is the faraday constant, R is the universal gas constant, N is the charge of valency of ion, and finally T is the temperature. So, you can see E h basically you know represent whether a soil are oxidized or not.

So, you can see oxidized soils, the E h value will be higher; in case of reduced soil, the E h value will be lower. So, you can see here as a result of change in E h you know after submerged soils. So, at the beginning there will be high pH, because high E h because of oxidized condition. But, as a result of prolonged submergence, there oxygen will be oxygen will be reduced.

And as a result the Eh or redox potential will be reduced further. So, you can see for all the soils. The final after two weeks of time the final Eh is you know negative sufficiently negative and all you know these this negative E h is basically indicates the reduce reduce condition of the soil.

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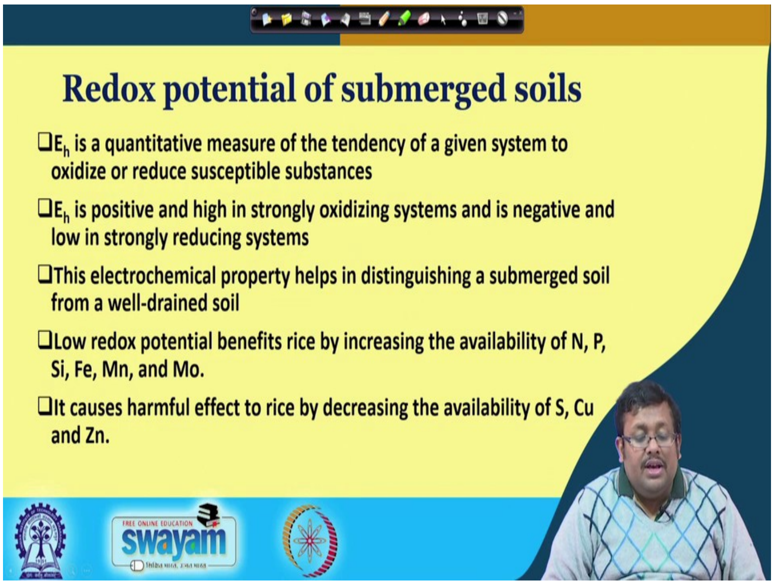

So, redox potential of a submerged soil are having some important implications. First of all E h is a quantitative measure of the tendency of a given system to oxidize or reduce susceptible substances. And E h is a positive, obviously I have told you E h is positive and high in strongly oxidizing system and is negative at low installing reducing condition.

And the electrochemical property helps in distinguishing a submerged soil from the well-drained well - drained area using the E h now. As per is the soil plant, you know plant nutrition is concerned. Obviously, low redox potential that means, in submerged condition, this submerged condition is beneficial for rice by increasing the availability of nitrogen, phosphorus, silicon, and then iron, manganese and molecular.

However, it causes harmful effects to the rise by decreasing the availability of sulphur, copper, and zinc. So, all this sulphur, copper, and zinc became unavailable due to the submergence condition. However, this specially I would like to mention the iron, because the in case of sub merged condition Fe^3 plus will reduce to Fe^2 plus and Fe^2 plus is more mobile. And as a result, it will you know it will be up taken by the plant more easily. So, this so nitrogen, phosphorus, iron, manganese all these became more available to the plants in case of submerge condition.

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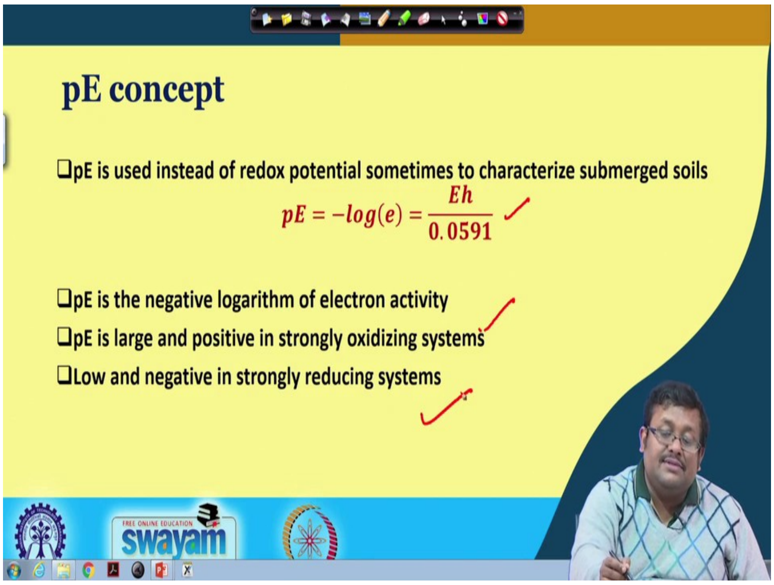

Another another concept is pE. pE is basically used to use instead of redox potential sometime to characterize a submerged soils. Now, pE is basically minus log logarithm of e, which is basically electron activity. And this basically the relation is e you know pE is basically Eh over 0.0591. Now pE is a negative logarithm of electron activity, we already know that. And pE is the large and positive in case of strongly oxidizing system. And low and negative in case of strongly reducing system. So, now a days we use also pE for characterizing the sub merged soils.

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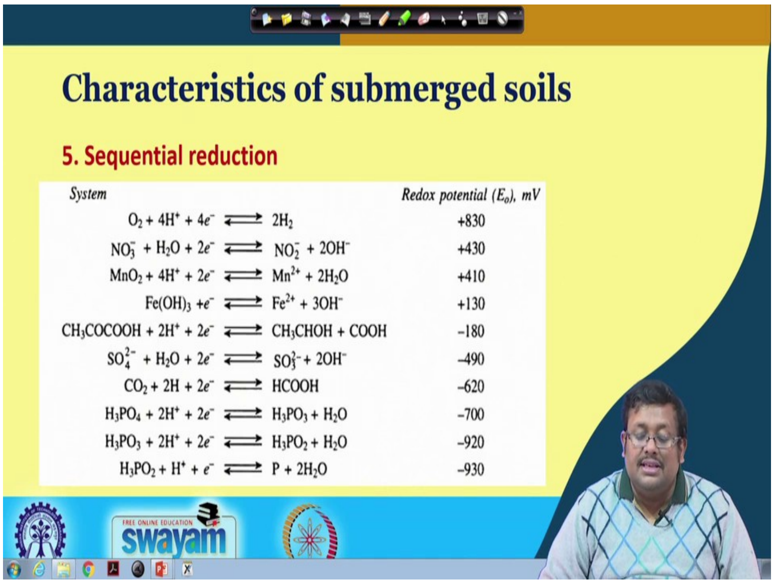

So, in case of submerged soil, you will see sequential reduction of different species just like this. So, this very important reaction, you can see all the species all the different species are getting reduced to their reduced you know and as a result their redox potential is also getting reduced from plus 830 to minus 930.

You can see at the start the oxygen reacts with the protons and electrons to produce the molecular hydrogen, and then this you know nitrates will reduce to nitrite, you know manganese oxide will reduce to Mn^2 plus, and ferric hydroxide will reduce to ferrous and so on and so forth. So, these sequential reduction will occur as a result of submergence an as a you know simultaneously, we will see there is reduction of redox potential.

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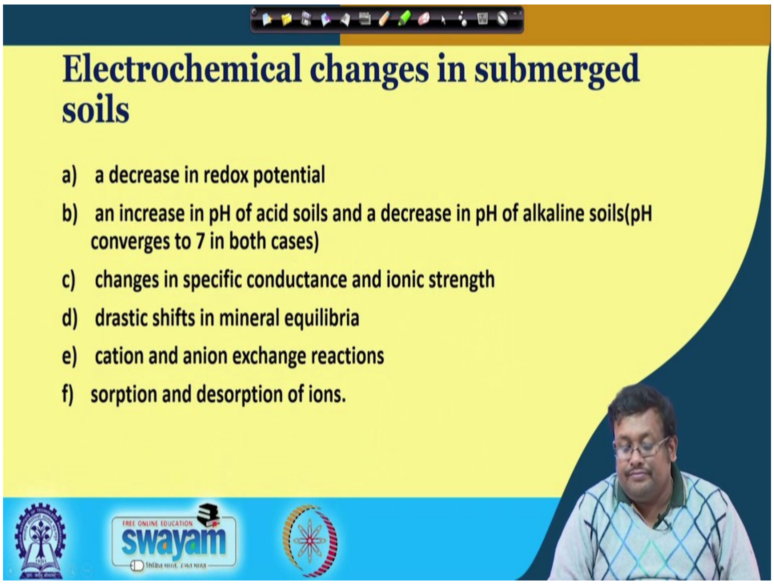

Now, electrochemical changes in submerged soil obviously, obviously they shows a decrease in the redox potential. And obviously, increase in pH of acid soil now, this is very important. And increase in pH of acid soils and decrease in pH in alkaline soil. This is very important as per as the redox soils are conserned, I am sorry submerged soils are concerned.

So, when you start submerging a soil, after a certain time if the soil is acidic, you see their pH is rising. And if the soil is you know alkaline, you see there pH is decreasing. An ultimately after certain period time, it will both of them will reach near to the, you know neutral condition, which is around 6.5 to 7.5. So, obviously ultimately they will converge to 7 pH 7 in both the cases. And also they will show the changes in specific conductance, and ionic strength. And obviously, due to the pH due to this submergence reduction of the pH will see also drastic shift in mineral equilibrium obviously. And then cation and anion exchange reaction and also sorption and desorption of ions.

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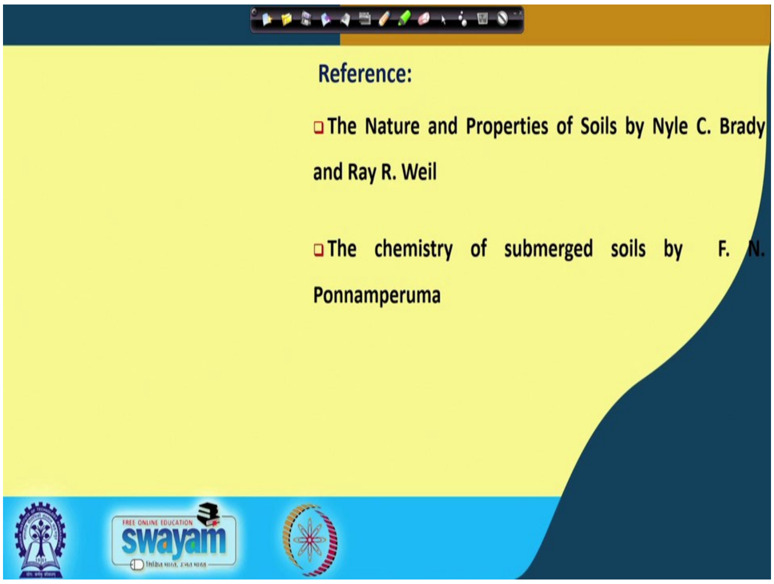

So, guys we have finished this lecture of salinity, and you know and alkalinity, and submerged soils. So, submerged soils is sometime problematic and sometime beneficial obviously. Let us you know submerged soil is required for the cultivation of the rice, because rice required a standing water with the base. And these you know submerged condition, obviously kills the nitrate nitrogen, because it creates the anaerobic zone.

However, it produces the ammonium, which is which is also required for the growth of the plant. And also the phosphorus availability is increased in case of submerged condition, and you know manganese availability increase for the in case of submergence, iron availability increase in case of submergence, however they are availability of zinc sulphur, they are reduced in submerged soils especially in case of rice.

And Eh is one of the major indicator of the submerged soil. When the Eh will be positive, obviously they are oxidized soil. When the E h is negative, they will consider you know they will basically indicate the submerge condition. And in the submerged soil obviously, you will see different you know sequential conversion of different species to their you know to their reduced counter parts, I have already showed you. And also saline-soil, sodic-soil are problematic soil.

The saline-soil and sodic-soil can be managed by the you know different management practices like growing different types of adaptive plants and also you know you know by adding different types of amendments. So, in case of sodic-soil, the common amendment is gypsum. In case of just like in case of acidic soil, the common the common you know chemical which we add for ameliorating the acidity is lime.

So, please remember this thing, you know that demarcation of saline-soil, saline-sodic soil, and sodic-soil, they just divide you know they are divided based on the ECe, then their pH, then their sodium absorption ratio, and their exchangeable sodium percentage. So, please remember these terms and their cut off values, which will be beneficial for you during the exam.

So, I hope that you have learned some basics of you know different types of problematic soils, and how to manage the problematic soil. One more thing, I must mention that in case of saline soil, you must go with the salt tolerant crop as well as you must use the, you know clean irrigation water, salinity free irrigation water, intermediate irrigation water. And also both in case of saline and sodic soil to reclaim the saline sodic and acid soil, another way is to adding some organic matter, because organic matter has some beneficial effects for creating for ameliorating these problematic soils.

So, guys I hope that you have learned something new. And obviously, for this lecture the references are the nature and properties of soil by Nyle C Brady and Weil and the chemistry of submerged soil by Ponnamperuma. So, please read these books for getting more thorough knowledge about these problematic soils. So, we have finish this week-6 of lecturers. And in the next week, we will start from different aspects of soil fertility and plant nutrition.

Thank you guys.