Irrigation and Drainage
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Lecture – 37
Management of Salt Affected Soil (Contd.)

Friends, welcome to lecture number 37. This is a continuation to the previous lecture that is on Management of Salt Affected Soils. So, in this, we are going to solve some of the examples on salt affected soils and also at the end we are going to see how sodic soils, I mean the nature of sodic soils and some example ok.

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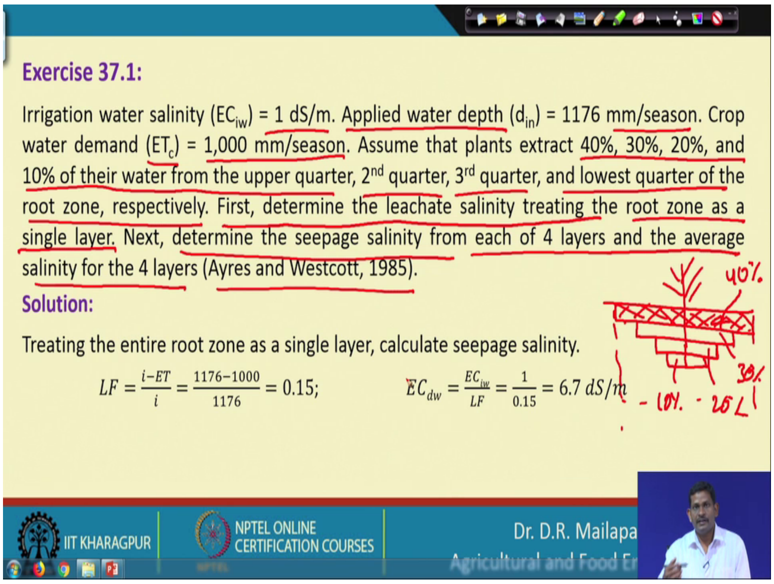

So, the here is an exercise or example. So, irrigation water salinity is given that is 1 decisiemen per meter which is and then applied water depth that is d in is 1176 mm per season. Then crop water demand ET c is 1000 mm season. So, assume that the plants extract 40 percent 30 percent and 20 percent and 10 percent of their water from the upper quarter second quarter third quarter and lowest quarter of the root zone respectively,.

So, that means, suppose you have a plant right you have plant here, so the top quarter and then middle quarter and then the last quarter. So, these are the 4 quarters if you see. So, here the top quarter we assume that it extract you know 40 percentage reserve water. So, this is 40 percent right and then this is 30 percent and this is 20 percent this is 10 percent. So, that means, the roots, excuse me; the roots is generally it extracts 40 percent from the first quarter and the roots extract 30 percent of moisture from the next quarter and second quarter and third quarter and forth quarter like that ok.

So, the questions are here the first determine the leachate salinity treating the root zone as a single layer. So, first you consider the whole thing as a single layer whole root zone as a single layer and find out what is leachate salinity.

In the next, determine the seepage salinity from each of the 4 layers and the average salinity of the 4 layers ok. This is taken from Ayres and Westcott 1985. So, in this example the first you have to find out what is the average salinity level in the root zone and then individual layers root zone layers salinity and then average of this layers, ok.

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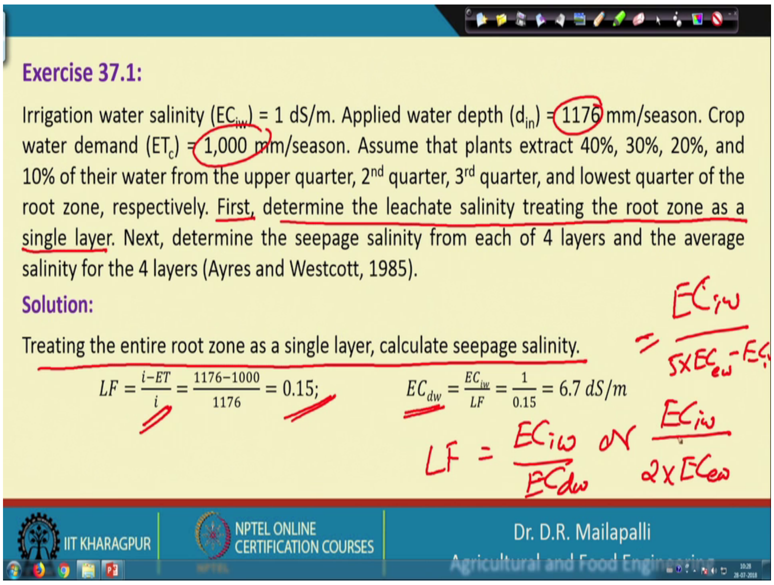

So, treating the first question that first one is determine the leachate salinity treating the root zone as a single layer. So, if you consider the single layer right the seepage salinity you know leachate fraction which is equal to i minus ET by i right; so that means, this is what input the irrigation water minus evapotranspiration and divided by irrigation water.

So, the values are given. So, irrigation water 1176. So, this is given and then evapotranspiration this is 1000 mm per season and divided by irrigation water you get. So, leachate fraction is 0.15 and then corresponding electrical conductivity of you know drainage water.

So, which is equal to so, E C i w irrigation water electrical conductivity and leachate fraction because, we know leachate fraction which is equal to E C i w by E C d w right or in a I mean simple term. So, E C iw divided by 2 into E C e w or again there is another term like E C I/ w divided by 5 into E C e w minus E C iw.

So, this is see these are all you know approximation of you know you know the formulas for leachate fraction. So, we take this and find out leachate fraction in sorry electrical conductivity in drainage water. So, E C i w is given. So, that is 1 decisiemen per meter and their leachate fraction in substitute here and then you get 6.7 decisiemen per meter. So, this is if you consider the whole root zone into one layer, you get the drainage water having. So, there I mean the electrical conductivity for drainage water 6.7 decisiemen per meter.

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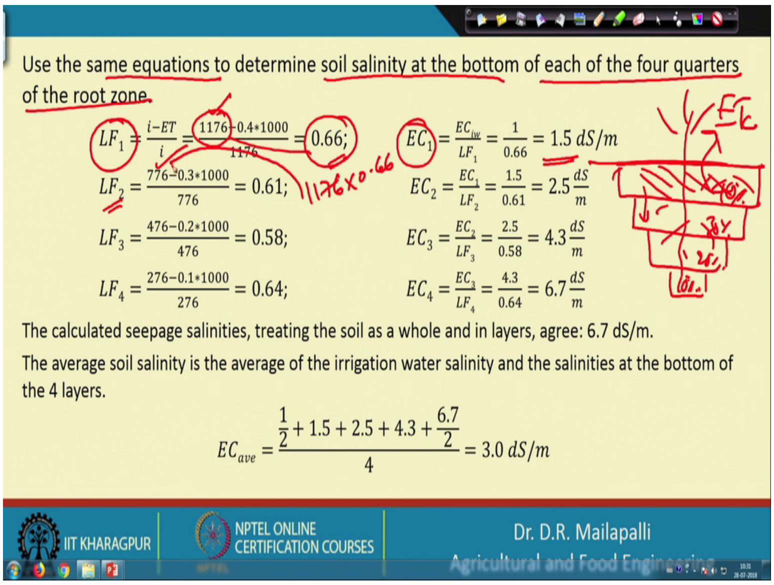

So, let us go to the next you know. So, layer by layer if you consider. So, we are going to use the same equation to determine the soil salinity at the bottom of each 4 quarters of the root zone. So, you consider you know the 4 quarters. So, first quarter second quarter third quarter and 4th quarter. So, let us say this is all root zone.

So, we expect 40 percent of water will be taken by this portion and 30 percent 20 percent and 10 percent of soil moisture will be extracted at the lower quarter ok. So, let us find out leachate fraction for each quarter. So, that is for first quarter L F 1 (Refer Time:

06:14) the same equation i minus E T by i ok. So, i is 1176 here E T is you know 40 percent is contributing to E T right the out of total. So, if this is E T E T c.

So, 40 percent from this; so, 40 of E T like 0.4 times E T divided by 1176 you get. So, this is a leachate fraction for the first quarter and then and then the corresponding E C 1 is E C i irrigation water divide leachate fraction. So, then you get one point 5 decisiemen per meter ok. So now, leachate fraction 2, the layer the next layer if you go; so, this 40 percent is over.

So now, let us find out. So, when this 40 percent water goes into the next right. So, that means, so, what is the 40 percent is gone and the remaining 66 percent right, 66 percent. So, this 66 percentage of 1176 right; so, that will give 776, 776 that will give. So, that means so, you get 1176 multiplied by 0.66 you get 776 ok.

And then, the similarly, but the third quarter the third quarter will have a second sorry second quarter you have a 30 percent; so, of E T.

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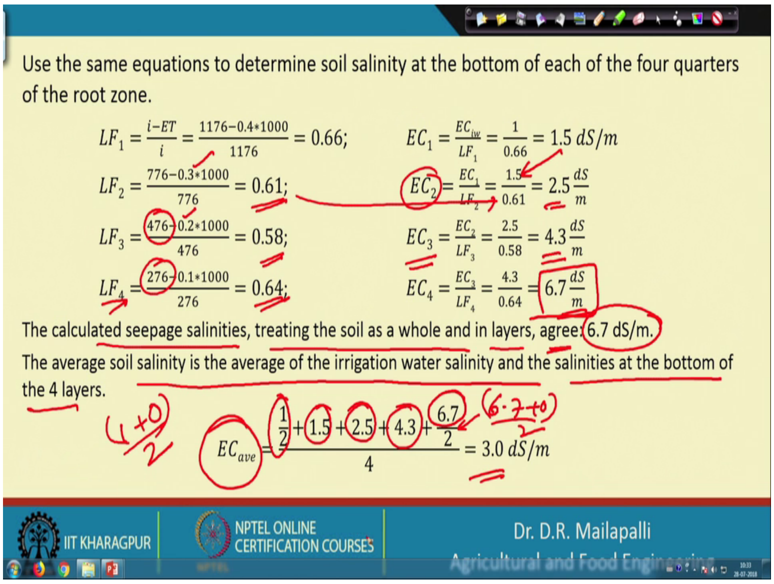

So, this is clear and 776 and you get 0.61 and a corresponding E C 2 is E C 1 into L F 2. So, E C 1 is this L F 1 is this one ok. So, then you get 2.5 and similarly L F 3; that means, for third quarter. So, 0.61 times 776 ok. 0.61 times 776 you will be 476 minus this since it is 20 percent of for moisture extraction. So, that will be it 20 percentage of E T c and you get 0.58 and E C 3 will be E C 2 minus L F 3 and you get 4.3.

Similarly, for L F 4. So, L F 4 is 476 multiplied by 0.58 you get 276 and you get this and then E C 4 is this ok. So, in this way for each layer or each quarter you can find out what is leachate fraction as well as the electrical conductivity ok. So,. So, to calculate seepage salinity treating the soil as a whole and in layers agree say 6.7 decisiemen per meter.

So, here. So, in the previously we also got 6.7 decisiemen per meter. So, that means, it is really matching and the average soil salinity is the average of the irrigation water salinity and the salinity is the bottom 4 layers. So, let us see E C average equal to for each layer the electrical conductivity we collect and then average them

So, the first layers since it is one decisiemen per meter. So, that is 1 plus 0 divided by 2; that is the average for that right and similarly for the last one 6.7 right. So, 6.7 plus 0 divided by 2. So, that you get this one and this is the first quarter second quarter third quarter layers and finally, you get the average as 3.0.

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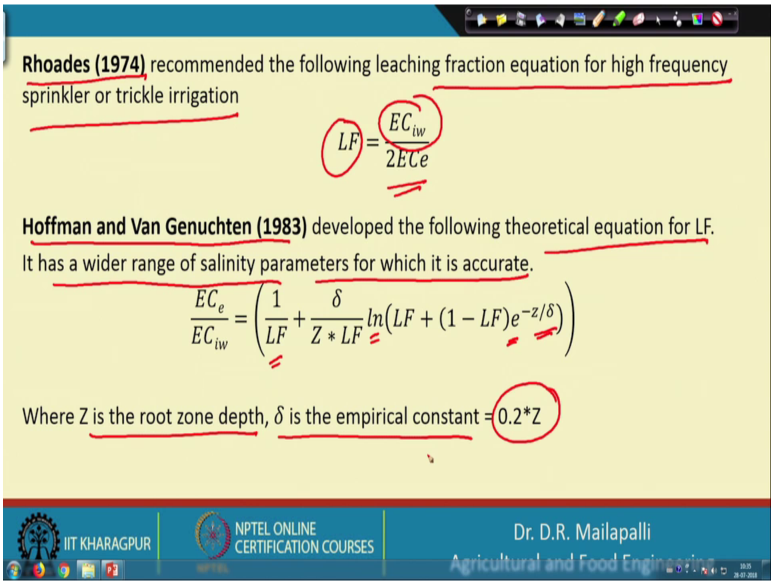

Next, so, here; so, Rhoades 1974 recommended the following leaching fraction equation for high frequency sprinkler and trickle irrigations ok. So, leaching fraction for sprinkler and trickle irrigation; so, leachate fraction is estimated with E C electrical conductivity of the irrigation water and 2 multiplied by E C into E C soil equivalent extract soil extract equivalent what we can salinity.

And then, Hoffman and Van Genuchten in 1983 developed the following theoretical equation for L F it has a wide range of salinity parameters for which it is accurate. For example, here, so, they gave the equation E C e divided by E C i w. So, which is equal to 1 by L F plus delta by z into L F and ln of L F plus 1 minus L F into exponential minus z by delta where z is the root zone depth and delta is the empirical constant; So, which is given as 0.2 times ok.

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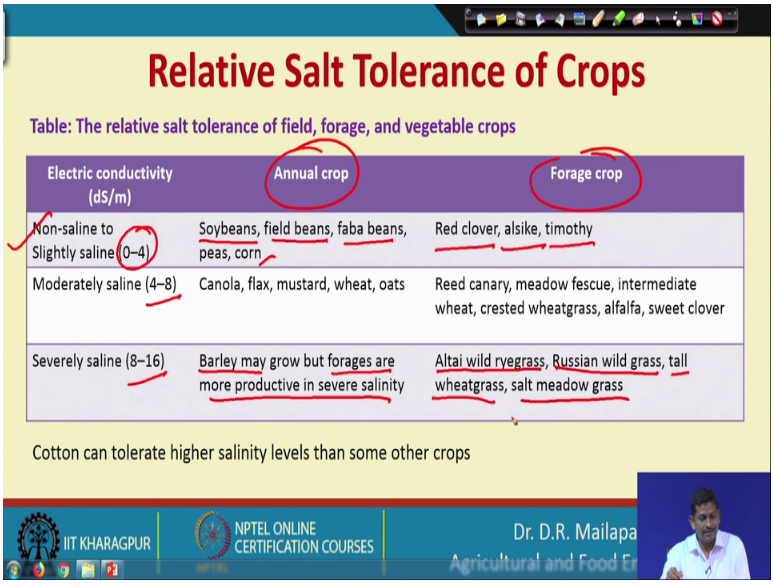

So here, so this is the relative a salt tolerance of the crops. If you look at some of the crops, both annual crops and forage crops. So, the electrical conductivity which is in decisiemen per meter for non saline to the slightly saline, so, it is varied from 0 to 4 for moderately saline. It is 4 to 8.

And severely saline, it is 8 to 16; so, annual crops under this category that is non saline to slightly saline. So, soybeans field bean faba beans and peas and corn. So, all these things all these annual crops fall under non saline to saline soils. And forage crops red clover alsike and timothy. So, these forage crops you know come under non saline to slightly saline soils ok.

Similarly, for severely soil saline soil barley and then barley may grow, but forages are more productive in severe salinity, ok. So, and then for forage crops Altai, wild ryegrass, Russian wild grass, tall wheatgrass and salt meadow grass. So, these mostly the grass crops or severely, I mean can sustain for severely saline conditions.

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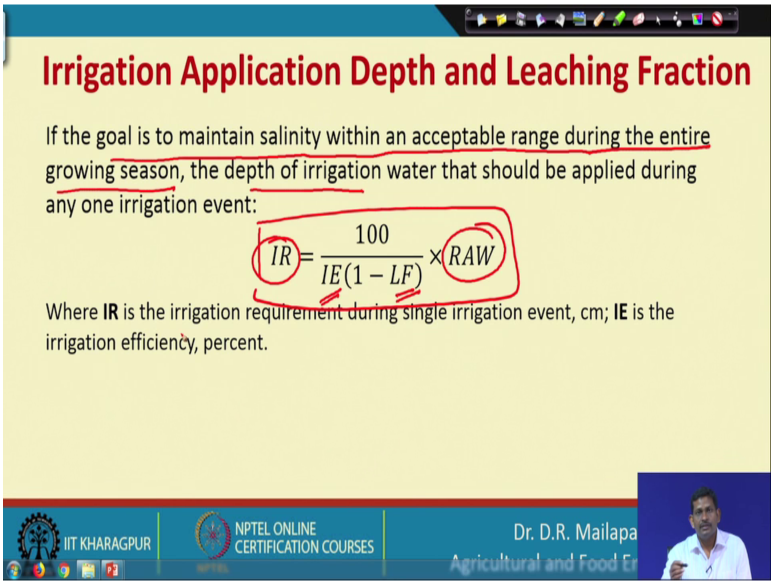

And then, irrigation depth irrigation application depth and leaching fraction; so, this is we have talked about earlier, but still. So, if the goal is maintain the salinity within acceptable range during the entire going season. So, the depth of irrigation water that would be applied during any irrigation event is estimated using this equation.

So, suppose you know suppose if you know the seasonal values and for each irrigation. So, what is irrigation requirements; so, that you can maintain the salinity throughout the season. So, here 100 by 1 minus L F into R A W that is readily available water and this is irrigation efficiency a leachate fraction. So, knowing these values you can find out the irrigation requirement for that particular irrigation I mean in order to remove the salts.

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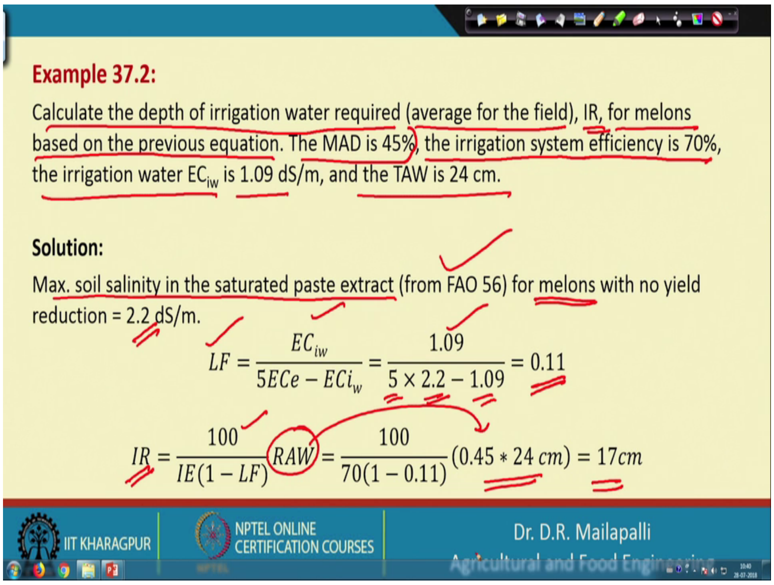

And, the next is example; so, based on the irrigation requirement for a particular irrigation; so, calculate the depth of irrigation water required. So, average for the field. So, that is irrigation IR as per the equation; so, for melons based on the previous equation ok. So, the MAD is 45 percent that is management allowable deficiency, so, then the irrigation system efficiency 70 percent. So, the irrigation water E C i w is 1.09 decisiemen per meter and total available water is 24 centimeter.

So, in this equation, so, the given or MAD is given E C i w is given taw is given. So, once you know taw and MAD you can estimate raw, ok. So, then irrigation requirement can be easily estimated. So, equation L F that is leachate requirement E C i w by 5 into E C e minus E C i w this is we know the previous equation; so, 1.09 5 times.

So, this is given 2-point. So, this one we get it from FAO 56 for maximum salinity in saturated paste extract for melons for a particular crop melons. So, that is around 2.2 decisiemen per meter. So, that value get and irrigation water you got and finally, the leachate fraction will be 0.11.

So, for so, remember for finding out leachate fraction you must know the irrigation water electrical conductivity and I mean the electrical conductivity of soil right. So, that is why. So, we do not know the electrical conductivity of soil for that particular suitable for the particular crop and we adopted from FAO. So, the now, now i r is equal to 100 into i e 1 minus L F into raw is 45 percentage of TAW ok. And then finally, you get 17 centimeter irrigation requirement.

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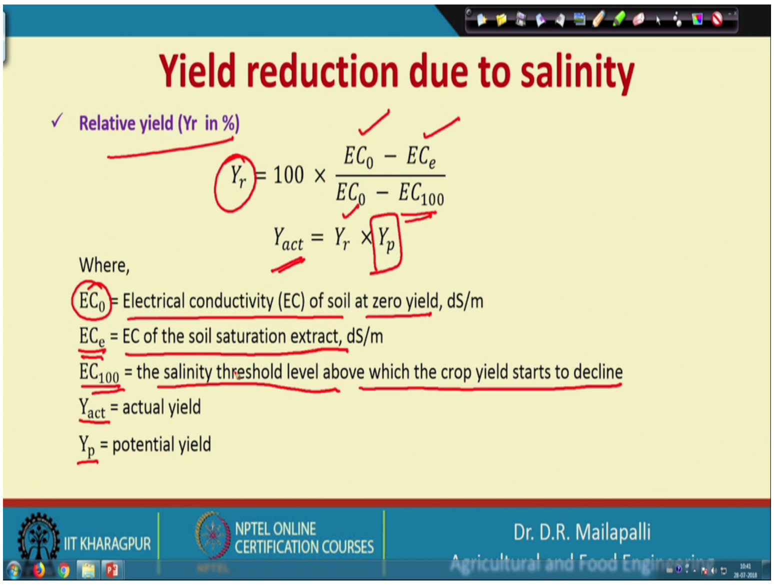

And then, yield reduction due to salinity, so, this is estimated with the relative yield that is Y r in percentage. So, where Y r is E C naught right. So, that is maximum yield when you achieve when there is no salinity and E C e that is soil equivalent electrical conductivity divided by E C e E C naught minus E C 100. Now, E C naught is electrical conductivity of salinity 0 yield when there is yeah. So, when there is yield is 0 that is E C naught.

So, that means, is extreme E C value and E C e that E C of the soil saturate extract right that is decisiemen per meter again E C 100 that is salinity threshold level above which the crop yield starts to decline. So, so, this is the maximum yield you will achieve. Then, after that, the plant shows you know the E C decline in E C, then Y act is actual yield Y p is a potential yield. So, putting these values, you get first you find out Y r once you know the Y r and then multiplying with the potential yield, you get actual yield.

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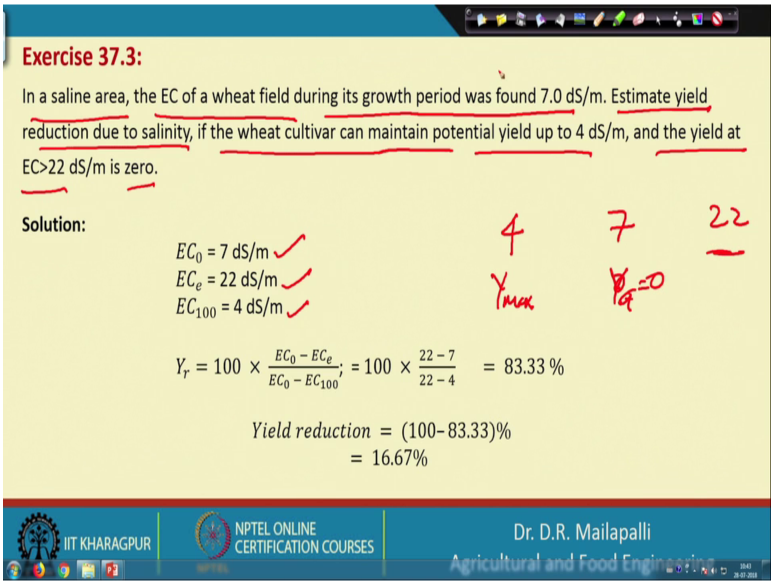

So, here is an example. So, in a saline area, so, E C of wheat field during it is growth period was found 7 decisiemen per meter. So, this is E C of the during growth period you got and estimate the yield reduction due to serenity if the wheat cultivar can maintain a potential yield up to 4 decisiemen per meter and the yield at E C greater than 22 decisiemen per meter is 0.

So, here what happens? So, E C 0 is equal to decisiemen per meter and E C e 22 E C 100 is 4 decisiemen per meter ok. So, that means, 4 decisiemen per meter 7 decisiemen per meter and 22 this for soil anyway. So, for 4 you expect another is the maximum yield. So, yield is maximum here, then at 7, then after that yield is yield is declining and it is 7 yield is going to be 0 ok.

So, Y e Y let us say, actually what we see here and this is for soil anyway. So, putting the values Y r is equal to 100 into E C naught minus E C e E C naught minus E C 100 and you put 22 27 22 minus 4. So, 83.33 percent is the relative yield. So, then yield reduction will be 100 minus 83.33 percent and that will be 16.67 percent ok.

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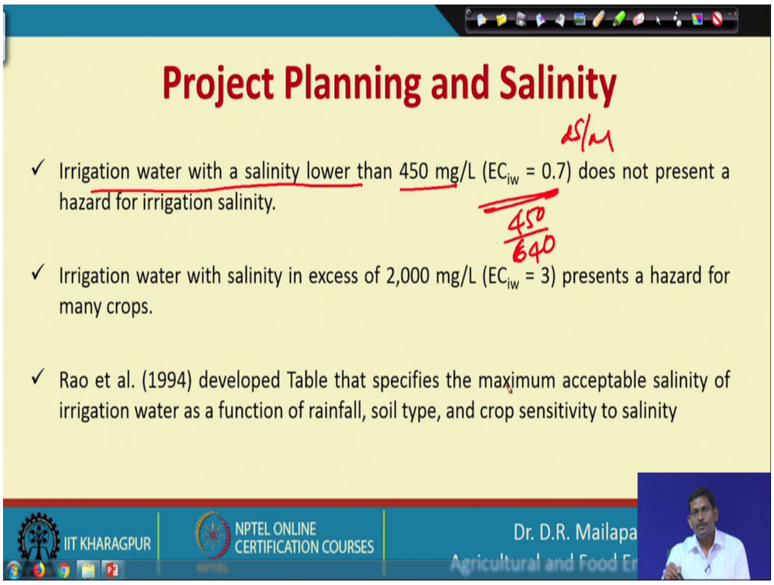

So, project planning and salinity; so, how to plan if you have a salinity issue in the soil? So, first thing is. So, irrigation water with saline water lower than 450 milligram per liter. So, that when you divide with 640 you get you can convert that into you know decisiemen per meter ds meters. So, that E C I/ w is equal to 0.7.

So, that will be 450 and 640 right. So, if you remember the equation, in order to convert the in order to convert; I mean electrical conductivity into concentration. So, we need to multiply with 450 ok. So, sorry 640. So, this way you get E C I/ w 0.7. So, does not present a hazard for irrigation salinity.

So, remember if E C i w irrigation water 0.7 decisiemen per meter and it does not I mean this is happy to use it is an irrigation it does not show any does not present any hazard for irrigation salinity. So, irrigation water with salinity in excess of 2000 milligram per liter. So, that is equivalent to E C i w 3 present a hazard for many crops. So, most of the crops are sensitive when E C is equal to 3 decisiemen per meter and the Rao et al 1994 developed a table that specifies the maximum acceptable salinity of irrigation water as function of rainfall soil type and crop sensitivity to salinity.

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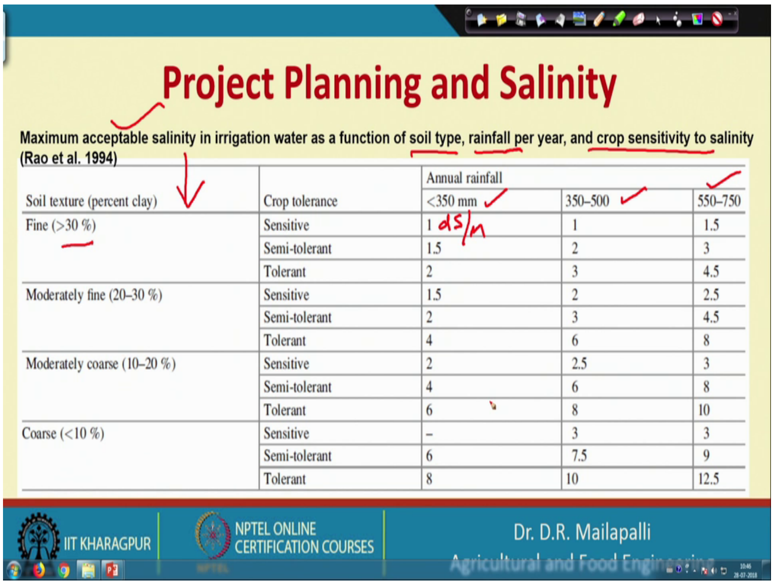

So, let us see the, I mean the table here look at this in this table the soil texture is given in this and then these are the annual rainfalls. So, less than 350 mm and 350 to 500 mm 550 to 700 mm; so, these are the annual rainfalls.

And for example, for fine texture soil there is more than 30 percent of clay. So, sensitive the crops sensitive crops with annual rainfall, right; so, can have one decisiemen per meter. And then, semi tolerant crops can grow up to 1.5 decisiemen per meter right and tolerant 2 decisiemen per meter. So, like that. So, the maximum acceptable salinity in irrigation water as function of soil type rainfall and crops sensitivity to salinity can be you know can be known.

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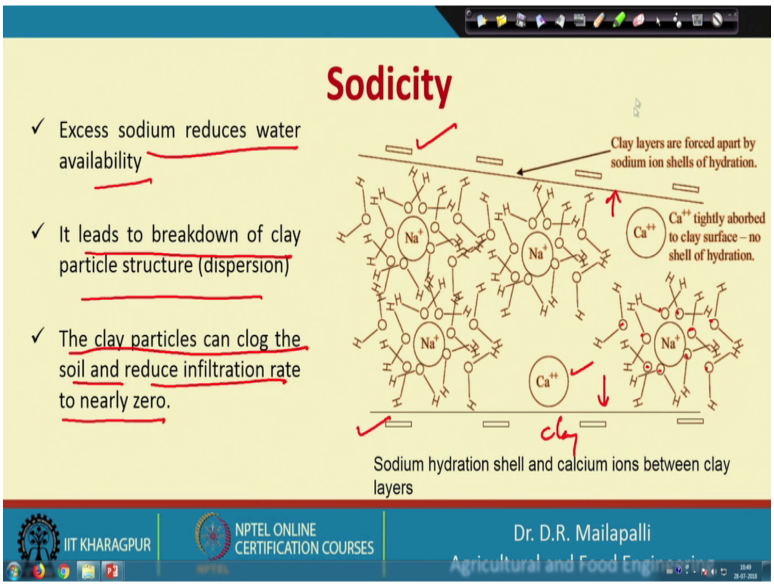

So, next is the sodicity so sodicity so salinity we target mostly for you know the sodium sorry the salts. So, any salts in the sense, salts in the sense even the sodium calcium you know potassium magnesium. So, all those salt. So, combining, but in some places what happen is sodium you know percentage will be more sodium portion will be more. So, that is we call the sodicity. So, we are targeting the sodium. So, excess sodium what happens? It reduces the water availability.

So, what here if you see this picture, so, these are the clay you know the particles clay particles the sodium. Since, it is the clays are negatively charged and sodium is positively charged, right and sodium is like the single valence right one positive the compared to calcium. So, calcium will attach in strongly compare with the clay particles right compared to sodium particles or sodium molecules you can say.

So, that is why in order to I mean, show it is activity what happened the sodium will have like 6 around I think the 10. If you see this 1 2 3 4 5 6 7 8 9, there is a one more 10. So, these 10 hydration bonds; so, this hydration will be created around the sodium molecules, I mean molecule. So, so what happen? So, in that case, what happen? Whatever the amount of water which will which will be absorbed here to the sodium and that hydrostatic pressure will be created that will push the clay layers away ok, clay layers away; so, the clay particles away.

So, that is why, so, water availability in case of sodicity will be less and it leads to breakdown of clay particles. So, it will definitely you know breakdown the clay structure. So, because when the sodium molecules absorb lot of water, what happens if bulges and then it pushes the clay bonds away. So, that is why, the structure is going to dismantle.

So, then the clay particle can clog the soil and reduce the infiltration rate nearly 0. So, that is another. So, one city is going away. So, that is going to clog instead of because the structure is going to disturb the clay particles will easily pass through you know the pores and clog the pores and then, the infiltration capacity in the soil will be reduced.

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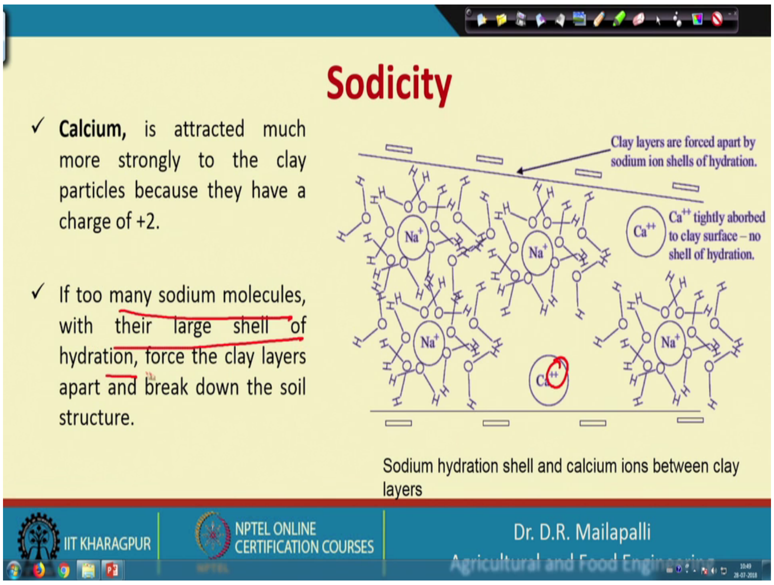

So, next is the calcium which is as I said, the calcium is attracted which most strongly which more strongly to the clay particles because it is valence is 2 right because plus 2. So, it attracts stronger than sodium if too many sodium molecules with their large shell of hydration force the clay particles apart and breakdown the soil structure. That is what I have explained in the previous slide.

So, this is the problem. If we have a sodium now, otherwise calcium what happens? it absorbs or clay particles and your hydration will be less compared to sodium. So, so that that is why, in case of sodium the lot of sodium is a problem because it absorbs water and disturbs the clay structure, ok.

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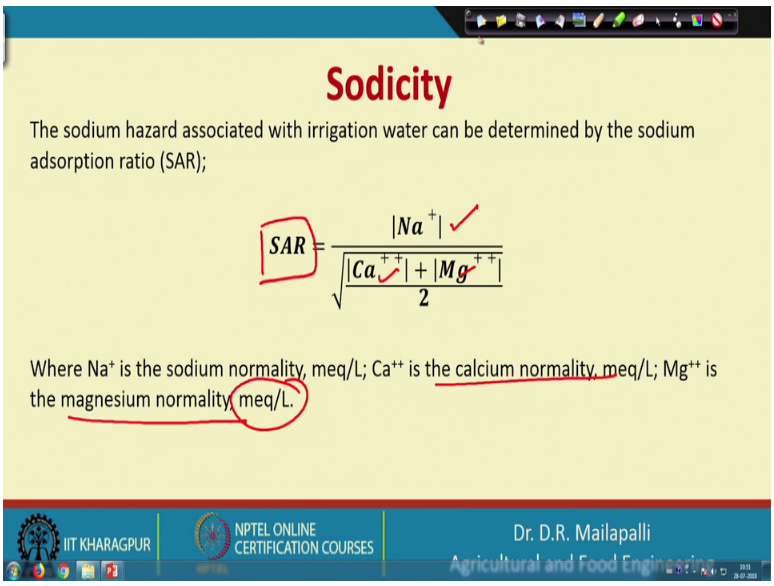

And then, the sodicity is expressed with sodium adsorption ratio. So, that is S A R sodium adsorption ratio that is so sodium right divided by calcium plus magnesium by 2. So, it is a normality sodium normality and calcium normality and magnesium normality. So, this is the unit is meq per liter that is milliequiavalent per liter.

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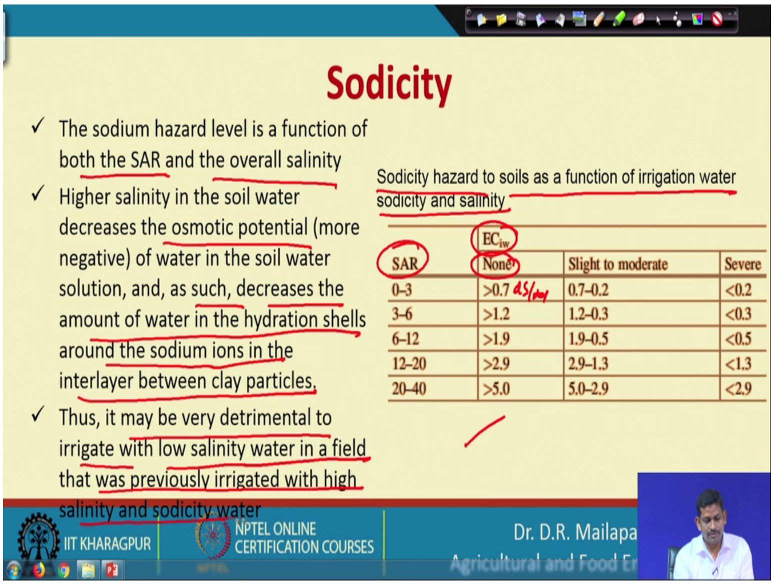

So, here sodicity; so, there is a table. So, this table clearly shows the sodicity of hazard to soil as a function of irrigation water and salinity. So, knowing; so, as you got S A R. Using that equation, now knowing the E C I/ w right, a salinity of irrigation water. Now, we can in sodic soils you can clearly see whether the particular environment is you know I mean hazardous or not. So, non hazardous condition; so, S A R values from 0 to 3 and greater than 0.7 decisiemen per meter will be non hazardous,.

So, this table very important the sodium hazard level in function of both S A R and overall salinity that is what this table gives now higher salinity in the soil water decreases the osmotic potential, ok. And water in the soil water solution and such decreases in amount of water in the hydration shells around the sodium ions in the interlayer between the clay particles.

So, higher the salinity in the soil layer decreases the osmotic potential know ok. So, and because of hydration potential is decreasing. So, water available will be very difficult for the plants. So, it may be very detrimental to irrigate with low salinity water in the field that was previously irrigated with high salinity and sodicity water, ok. So, let us go through there is example, ok.

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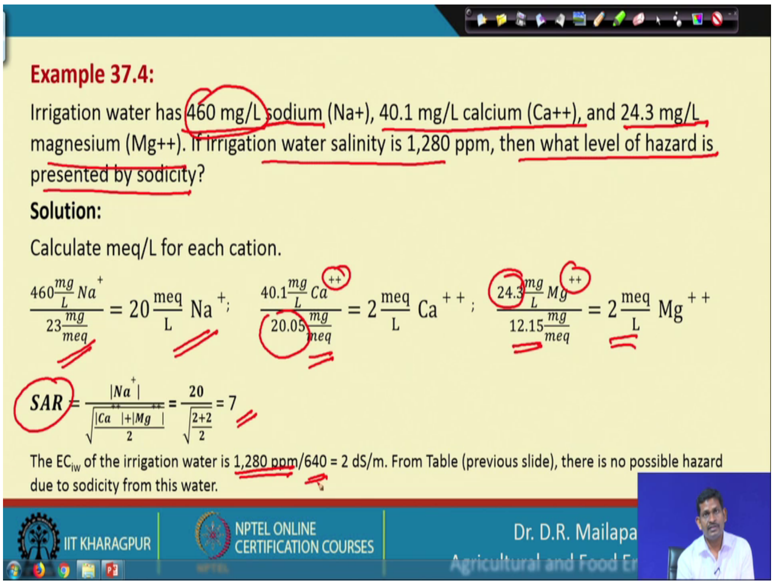

The next example if you see, irrigation water has 600 460 milligram per liter sodium 40.1 milligram per liter calcium 24.3 milligram per liter magnesium. If irrigation water salinity is given, then what level of hazard is presented in the sodicity.

So, first thing is so, the find out what is the milliequivalent of sodium magnesium and calcium. So, let us let us do this. So, 460 milligram per liter sodium can be converted into you know the milliequivalent by dividing the sodium 23 milligram per milliequivalent,.

The similarly, for calcium that is 20.05 milligram per milliequivalent and because if you remember calcium 40 right, since it is 2 valence. So, divided by 2 ok so, you get 20.05 right and similarly here 24.3 because you got 2 valence right and 24.3 divided by 2 you get 20 12.515 milligram per milliequivalent and you get 2 magnesium.

And now S A R which is equal to sodium plus square root of calcium plus magnesium by 2. So, substitute it and you get 7 S A R. So now, if you and then E C i w for irrigation water is. So, this is in ppm when you convert into decisiemen per meter you have to divided by 640 you get 2 decisiemen per meter. So, let us go back to the previous table.

Let us see your salinity level 2 decisiemen per meter and S A R is 7. So, let us see whether it is hazardous or not ok.

So, let us go back and check whether it is hazardous or not see here. So, S A R is 7. So, that means, we are here, ok. This is 7 and then this is less than 1.9, ok; less than 1.9 this 1. So, definitely; so, this is a non hazardous condition, ok. So, 1.9 because this is this is 2, almost 2, right. So, and this is a non hazardous condition.

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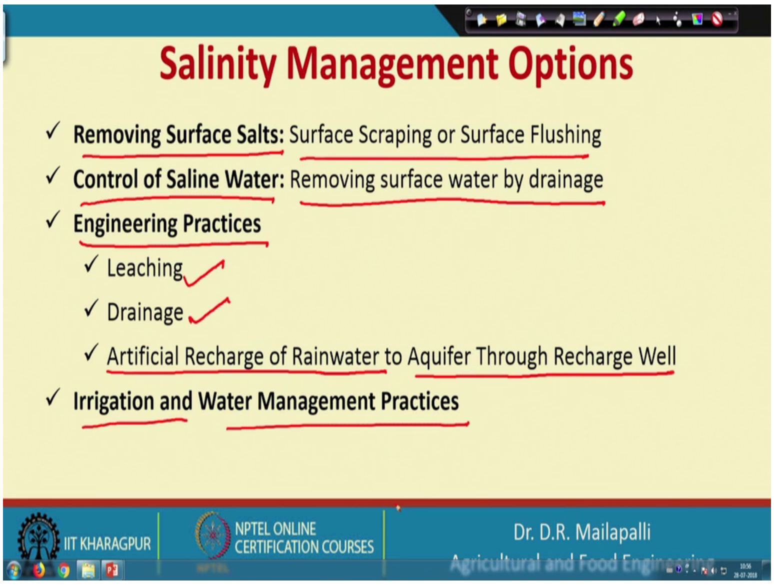

So, salinity management options; if you see the salinity management options, the first one is the remove surface salts. So, if you see you know the white scum or white layer on top of the soil. So, one practices just remove scrap away the salts from the surface and also or you can also surface flushing.

So, use hyzen water to remove you know, you flush the salts surface and the control the saline water. So, for these remove surface water by drainage, so, simple is if you have lot of you know salts present on the surface you can use the drainage system to remove the salts from there.

And then, there are engineering practices like leaching. As we studied earlier, the leaching fraction and other thing and also drainage we are going to study this drainage exclusively from the next lecture and the artificial recharge of rainwater to aquifer through recharge well you can also use recharge wells to remove the salts and irrigation and water management practices.

So, this is onsite management if we have lot of salts in the irrigation water better you know take care of removing either treating the water right or you can go for you know the crop management. So, you can use the crops which are susceptible or tolerant to the particular irrigation salinity levels.

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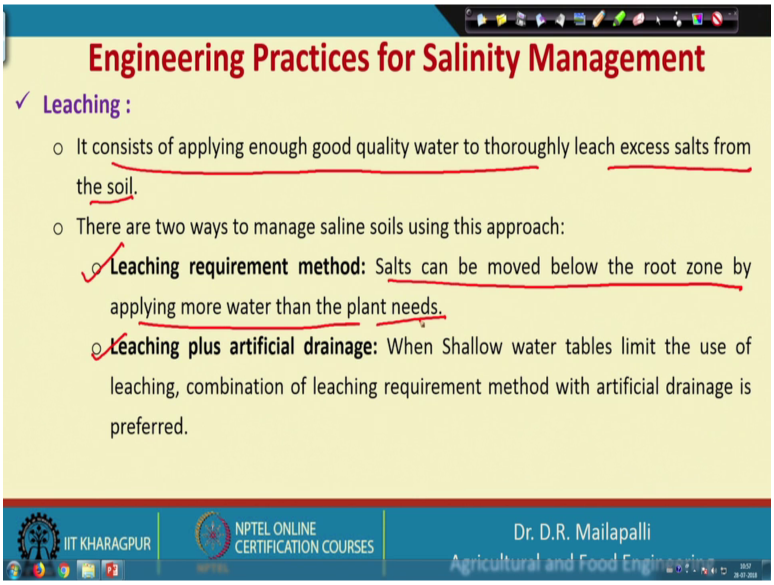

So, engineering practices if you see the leaching. So, the mostly it consist of applying enough good quality water thoroughly leach excess salts from the soil. It can be done to ways. So, leaching requirement method or leaching plus artificial drainage; so, leaching requirement the salts can be moved below the root z1 by applying more water than the plant needs. So, that is what we estimated in previously, right. So, the leachate requirement is extra water, I mean extra water needed to leach the salts. So, that is leachate requirement and leachate plus artificial drainage.

So, what happens in some cases? If you have the root zone which is very nearer shallow right. So, even if you add more water on top of the soil. So, because it cannot you know flush the soils salts because of the clay layer top in the bottom. So, there you have to use in order to remove the salts in addition to the leachate you also use artificial drainage to remove the extra salts from the root zone.

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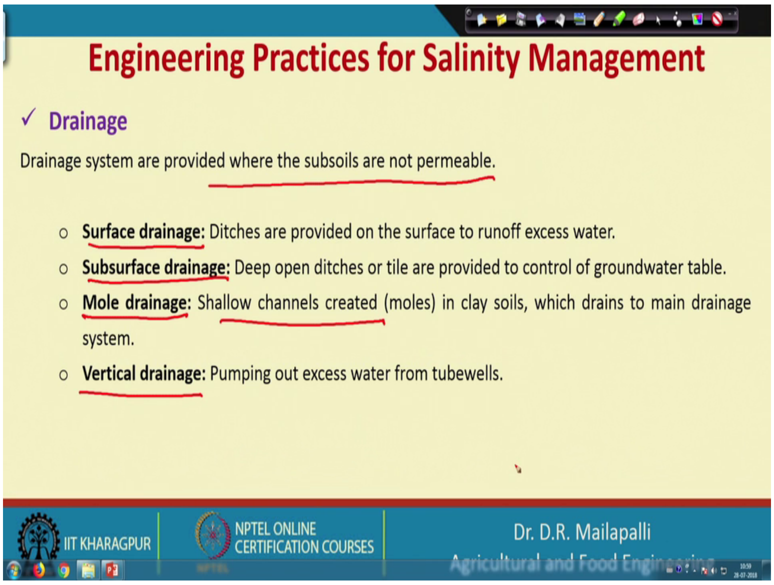

And the next is the drainage; so, drainage the system to provide where the subsoil are not permeable; so, here if subsoil is not permeable right. So, then, definitely it will going to use otherwise the amount of water which is pouring on top will cause water logging. So, we will talk about this drainage in the next lecture and following weeks exclusively.

So, it could be surface drainage, right. So, in I mean making ditches on the surface and removing the extra water from the surface and subsurface drainage. So, this if you have both surface as well as water from the root zone, you want to remove and you can use subsurface drainage by providing deep ditches or tiles

And mole drainage; suppose in some cases, the clay soils are you know causes lot of water ponding or water logging condition. So, so there ordinary you know machineries cannot be used in order to make ditches. So, that is why, there is a mole drainage the moles or a kind of a mole plough will be used to remove the shallow channels and through that the water will be you know removed. So, then the vertical drainage the vertical drainage is kind of you know removing water vertically through tubewells.

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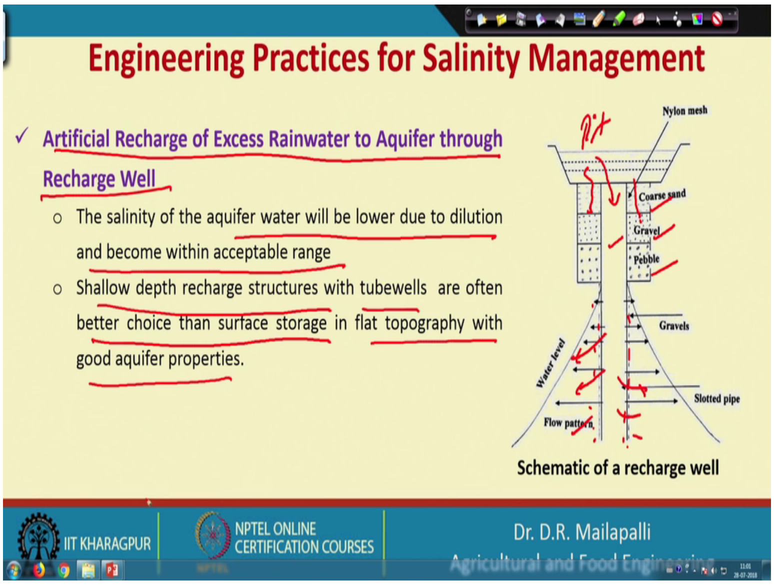

So, then, then the other one is the artificial recharge of excess rainfall aquifer to recharge well. So, if you see the recharge well. So, this is the recharge well and here this perforations to the well through the pipe. And an top suppose this is a recharge pit this is a pit ok. So, this is in such a way that the coarse sand gravel pebbles all other things.

So, water will be entering through these and finally, through the perforations it will be going into the soil and the rest is some of extra water can also penetrate through this one and there is clean water again. So, this way; so, the salinity of the aquifer will lower due to dilution and become within acceptable range suppose we add good water on top.

So, that will dilute the salts present in the soil and the shallow depth recharge structures with tubewells are often better choice than the surface storage in flat topography with good aquifer properties. So, suppose the aquifer is good properties like in the flat lands. So, the better use vertical you know, I mean tubewells. So, tubewells can be a better choice because that can even collect you know more water I mean you can recharge more water through the tubewells.

So, this is all about this in the lectures. So, mostly we focused in this on overall salinity and then the sodic soils or sodicity. You can say the sodicity means containing more sodium ions compared to other salts. So, the mostly the salts we are talking about the sodium, including sodium right magnesium and also the potassium. So, all other salts right and calcium another salt; so, that is a overall salt content present in the soil, ok.

So now, generally sodicity is you know measures with S A R sodium absorption ratio, ok. So, then, so you knowing the sodium adsorption ratio and overall salinity you can you can find out whether that particular condition is hazardous for crop or not yeah.

So, thank you.