Micro Irrigation Engineering
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Lecture-19
Irrigation Water Quality

Dear participants, now we are starting a new lecture and this is lecture 19 of the subject of micro irrigation engineering. This lecture deals with water quality, water quality is very important from an irrigation point of view. If it is beyond the permissible limit it spoils the soil and is hazardous to the crop growth and sometimes in the poor quality water having heavy salts, heavy metals, available in the water this will be extracted by the plants and it may come to the food cycle. So, one has to be very careful while using poor-quality water for irrigation purposes.

Now in this particular lecture, we will be covering the topic of the parameters which are considered as suspended or dissolved materials in the irrigation water. What are the different indicators which can be used with respect to water quality and the effect of water quality on micro irrigation system mainly emitter clogging? When we say emitter clogging means the opening from the drip emitter, the diameter of the outlet of the drip emitter is very small. And what happened when suspended particles or dissolved salts with the water cause the clogging of emitters.

So we will discuss in detail emitter clogging that is the main concern about us with respect to this subject. What are the different management practices that can be used while using poor-quality irrigation water?

Now, water quality when we ask that what is the water quality? So water quality refers to the characteristics of a water supply that influence its suitability for a specific use. So, for irrigation water, usual criteria include soil salinity, sodicity, and iron toxicity. Now, what we see here when we look at the plant and when we are giving irrigation water and this irrigation water contains salt and when we are applying so, what happened when the plant evapotranspiration takes place. So, transportation from the plant, as well as evaporation from the soil when it takes place what

we find the salt available in the water remain in the soil or when it is without vegetation what happened salts remain behind and that causes the accumulation over a long time and this soil become saline soil or it becomes sodic soil or some certain iron, salts which are available this will remain in the soil that will be harmful to the plant growth.

So, when we talk of irrigation water quality, there are certain materials, that are suspended in the water or it is dissolved with water. So, suspended material comes from the eroded soil particles means when the water transport or the overland flow takes place from the land surface and when the velocity of overland flow increases so, through runoff it comes and erode this soil and that will come to the stream and when we are using this stream water for irrigation.

So, that will remain suspended or there are certain small size seeds this could be also available in the water, leaves flowing along with the stream so, plant leaves that also come, there is some certain other flowing material that becomes debris and that is also not good from an irrigation point of view particularly when we are using micro irrigation when we are using sprinkler irrigation. So, this may choke the system when we are using it. Suspended particles that are greater than 50 to 100 microns such particles are possible that can be removed by using micro irrigation filters. And suspended particles which are less than 50 micron that can be removed by flushing of filters regularly, time to time flushing of lateral pipe, flushing of main pipeline submain pipeline or we have to use appropriate device brush say it is for screen filters or the brush has to be used, nylon brush has to be used or there some other way. So, dredging which is done to remove the particles which are between 50 to 100 micron.

Now dissolved particles have the name say that it is dissolved so, there is some total concentration of ion usually called salinity. So, some certain ions are available in the water with some certain percentage and these ions could be in the dissolved form. So, these ions can be cation it can be anion or it could be in other forms. So, cations mean when we say cations it means they are positively charged ions.

They can be in the form of calcium, magnesium sodium, or potassium. When we say anion it could be in the form of bicarbonate, sulfate, or chlorides. Other suspended materials could be in

the form of carbonates, nitrates, or some other trace elements of metals that could be boron or some other heavy metals. So, as salinity increases the crop yield also decreases, which means this should be within a permissible limit.

So, a high concentration of exchangeable sodium can cause soil particle dispersion, and what happened this changes the soil structure and also this reduces the movement of water in the soil. So, that causes accumulation of salt and that salt becomes like sodic salt. So, specific management practices are needed to bring this soil again in to be productive.

So, sodium, chlorides, boron, and other ions are toxic and if they are in high concentration they become hazardous to the plant to grow or they hamper plant growth.

There are different property which deals with the water quality and these properties say pH, electrical conductivity, total dissolved salt, calcium, magnesium, sodium, potassium. So these instruments which are used to monitor these parameters, say when we are talking about to know what is the pH of irrigation water. So, this can be used determined by using a digital pH meter. If one wants to know the EC, so one can use an EC meter. For total dissolved salt one has to filter the material. How much is this salt available. Then one can use it Gravimetric method means one has to dry the sample and get how much amount of salt is available in the water by using the gravimetric method. For calcium, magnesium, sodium, potassium these parameters can be measured using a Flame photometer and there are specific wavelength ranges that are applicable and that can be used to identify these elements that mean 554-nanometer Flame photometer can be used for calcium. Similarly, for other elements, one can see that these are methods wavelengths measured which are used for knowing these elements.

Now, other properties could be chloride, sulfate, and nitrate. So, this can also be used means spectrophotometer is used with a specific wavelength to monitor chloride say it is 515 nanometer and then sulfate, so, a spectrophotometer of a specific wavelength of 450 nanometers is applicable for sulfate similarly for nitrate. Copper can be found out by a spectrophotometer, an atomic absorption spectrophotometer at the wavelength of 328.

Similarly for zinc, iron, and manganese and are the specific wavelength meant for monitoring these ions using the atomic absorption photometer.

Now, one of the very important parameter indicators means one can know that and salinity, alkalinity, and sodicity these are some element, depending on the concentration these salts can be determined. So, the water quality indicator is expressed by taking salt as one of the parameters. So, salt in soil or water reduces the yield. High water table or saline groundwater table this causes the upward movement of salt at the soil surface or because of such rocks where the water quality, groundwater quality itself is saline.

Because of the capillary movement of water, salt also gets deposited on the soil surface and that is another problem. Salts in the irrigation water as such the source of the water itself is having saline this also increases the soil salinity. So, the salt concentration in the root zone rises to 2 to 5 times due to transpiration because as long as the plant is there, vegetation is there, the transpiration process will continue.

What will happen when the plant will transpire the available soil moisture content in this soil will reduce and then the solid concentration at the root zone will evaporate. So by evaporation from the soil surface, will cause an increase in salt concentration in the soil. And the ultimate effect is it comes from the osmotic effect means plant growth depresses to a decrease in the osmotic potential. So, the movement of water retards when the salt concentration in the water or the soil is available.

So, a specific ion effect that is the concentration of specific ions such as sodium, chloride, and boron. So, when it is greater than the expected value from the osmotic effect alone then this is causing the movement of water and these ions affect the movement of water and retard the growth of the plant.

Now salinity is you know the how much is the value of electrical conductivity of the water. So based on the electrical conductivity, soil salinity is measured. So, there are 4 classes it has been made, class one is C 1 class, we say C 1 when this soil salinity is in the range of 0 to 0.25

deciSiemens per meter this is suitable for irrigation. C 2 is the medium salinity this also means there could be moderate leaching that can take place and then this water can be used for irrigation purposes.

This high salinity means which is in the range of 0.75 to 2.25 so by adapting suitable management practices to a certain extent when freshwater is not available good quality water is not available only this salinity means this much of water having this much salinity that is 0.75 to 2.25 is available. So, this water can be used with some certain allowing the growing the crop which are certainly sub certain tolerance or we have to aid suitable management to negate the effect of salinity that can be used. So, very high salinity, if it crosses more than 25 deciSiemens and such water, is not suitable for irrigation purposes.

As per the United Nations salinity diagram classification and not only the electrical conductivity but there is the sodium absorption ratio, these values are also available. So, a combination of sodium adsorption ratio and electrical conductivity these two parameters when they are used so this can, mean this diagram it is suggested to use water for irrigation purposes.

So what we see here is this particular diagram, in the x-axis the electrical conductivity of water is available and on the y-axis the sodium absorption is available. Now this particular another side of this, they are plotted and then one can see that whether this water is having high salinity or low salinity. So this particular diagram is basically it is giving electrical conductivity that is low, medium, and high or very high just now I told you these values are available.

So, as such from the electrical conductivity point of view, this is the scale and when we go for this sodium absorption ratio so 0 to 10 it is given as low, then 10 to 18 this is a medium, and then 18 to 26 is high, and you know 26 is very high from the sodium absorption point of view. Now each individual unit one can see this means this region when we say electrical conductivity of the water is low, however, the sodium absorption ratio is very high. So, when we come to this part means this is not at all suitable for irrigation. This is the way one can use it.

The other way, the salinity is also expressed by using the electrical conductivity of water and total dissolved salt. So, as such when we are using this particular chart. So, TDS and electrical conductivity of water, this two combination one can see that if it is said TDS is less than 450 milligram per liter and the electrical conductivity of water is less than 0.7 deciSiemens per meter this means there is no as such difficulty for using this water means there are no hazards from the effect of this water; it is not affecting much.

This is just slightly to moderate when the range of TDS is 450 to 2000 and ECw is 0.7 to 3. So the degree of restriction for using this water means considering ECw and TDS accordingly one can select and this is the severe case means when electrical conductivity of water is greater than 3 and then the TDS is greater than 2000 then it is a serious concern and one should restrict using this water.

Now the high concentration of sodium, I was telling about the salinity part, now sodicity is another part which is basically how much amount of sodium salts are present in the water. So, which is expressed by sodium absorption ratio? So, high concentrations of sodium as such are undesirable in water because sodium absorbs means onto the soil cations exchange sites, causing the soil aggregates to break down.

So what happened when this absorption takes place and the sealing process starts and this soil becomes impermeable and that restrict the flow of water. So, sodium absorption ratios are one of the major parameters which are used. So, just now I was telling you about the US salinity diagram their sodium absorption ratio was one parameter that was given. So, how this sodium absorption ratio is computed; is computed as sodium divided by the square root of magnesium plus calcium divided by 2. So, the sodium absorption ratio that is Na and calcium plus Mg concentrations of these soluble ions is expressed in milliequivalent per liter.

So, sodicity just a few minutes back in the diagram I explained to you low sodium hazard it is given between 0 to 10 sodium absorption ratio, little or no hazards. S2 the medium sodium hazard this is between 10 to 18 and this is an appreciable hazard but that can be used with appropriate management. S3 high sodium hazard this is between 18 to 26 like this you know as

the concentration of sodium increases with respect to calcium plus magnesium, the value it means it is unsatisfactory for most of the crops and it should not be that those soils become highly saline or highly sodic.

Ion toxicity: These are the symptoms in the leaves you can see when there is a high iron concentration of sodium, chlorine, and boron this affects the use of water for irrigation purposes and what happened when sodium is available in high concentrations in the water when we are applying either through surface irrigation or through sprinkler system means it will sprinkle on the leaf of the plant so, this damaging the crop root system, it also damages the plant leaves. So, these types of symptoms are there when the sodium absorption ratio keeps on increases. So there is a permissible limit, and then permissible limit what we see for sodium it is given here it should be less than 3, whether it is surface irrigation or it is a sprinkler irrigation system. Fluoride is less than 4 means there is no effect and then in this table, you can see how these different limits whether it has a moderate effect or it is a severe effect. So, this type of data can become say guidelines.

Now, the most important thing from a micro irrigation point of view, the effect of several dissolved, as well as physical, as well as biological or chemical compounds or elements available in the water they become hazardous from the emitter clogging point view. So, means one has to take care before installing the micro irrigation system what is the specific type of the salts, what are the specific type of constituents available in the water accordingly the measures can be suggested.

So, what could be the causes of emitter clogging? One should learn that it could be physical or it can be chemical or biological. So, the other part is for example now here it is not just one parameter we are doing and other we are not taking. So, they are interdependent, they are you know interrelated. So, one should see that by reducing the microbial slime, the tendency of suspended particles to stick or agglomerate and builds up in micro irrigation lines.

Lines mean your pipeline could be a lateral line, it can be you know sub-main line which is So, build up in the micro irrigation pipelines and emitters. So, are also reduced in addition to small

aquatic organisms such as snail eggs, larva, which are not readily observed and analyzed but can develop into large colonies in the lateral tubing. So this will result in a combined physical and biological problem.

So one needs to know fully that what kind of problems. So physical factors, what are the physical factors? These could be suspended inorganic particles such as sand, silt, clay precipitate, so, these physical items can be controlled by using a proper filtration system. So we will discuss when we will come to the micro irrigations system and filters. We will discuss in detail but what are the basic elements which are causing the clogging? So only the physical thing and then we need to apply appropriate measures.

So for you know physical clogging one should use the chlorination treatment. So, that this can avoid the clogging due to physical clogging. Salinity means the chemical effect is another parameter. So salinity means there are some certain chemicals which are dissolved as a cation as calcium, magnesium, manganese, iron, and anions such as sulfate, phosphates, silicates, hydroxide these are also present in the water and that causes the clogging of emitters. So one has to know about the elements and proper measures that can be taken.

Biological clogging is a serious problem in the micro irrigation system. So, these elements can be sediment plus iron plus hydrogen sulfide. So, means there could be these are things and that deposit in tubing or lateral pipeline. So on the inside, the pipeline the iron as well as hydrogen sulfide are causing the deposition and then it reduces the flow as well as it accumulates on the emitter's outlet.

So, physical, chemical, and biological contributors to clogging as I told you, so, physical could be the inorganic particles. So, here you can see inorganic particles or it can be organic particles, non-aquatic these are all you which are listed here. Sand, silt, clay, plastic then aquatic organisms, and then the snail, fish, insect, larvae, and spider are physical you know suspended solids. Chemicals could be means carbonates of calcium or magnesium, calcium sulfate heavy metal, oil, and other lubricant or fertilizers that also caused chemical precipitation when reacting with the water when they are applied.

So, their reaction also causes chemical precipitation and that is prone to the clogging of micro irrigation emitters. Biological clogging could be due to filament, slimes, or microbial deposits. So iron ochre and there is sulfur ochre and manganese are because of microbial deposits.

Water quality criteria, these are used for emitter clogging hazards so I told that what is based on there the population, how much means this concentration is available in the water. So, when it is given in this number in a minor means they are not serious whether we can say. So, when 50 milligram per liter suspended solid is available we call it a minor. When we say 50 to 100 milligram per liter this is moderate.

Similarly for other parameters, it is there. So, they are to be checked, and then one should use carefully irrigation water after knowing these parameters whether it is physical, chemical, or biological.

Similarly, the major constituents are you know the cation, anion just now I have told you. So, these are insoluble scale forming and then anions and these are cations things and then the anion is the carbonate, bicarbonate, phosphate, hydroxide, sulfate and then anion precipitation compounds are in this form they precipitate and they are the major chemical constraints which are dissolved in the water that causes the emitter clogging.

So causes of the emitter clogging there are some studies which have been taken by Gilbert and others what they say that the results of representative eight emitter systems from four water treatment. They did work for more than four years and they analyze that what is the chemical constituents. So they have you know analyzed and they found that the initial cause of restriction was due to physical factors followed by the development of biological and chemical factors.

So, the major factors involved were sand grains which is mainly it is coming due to when we are taking water from the groundwater. So if the pumping is at a very heavy rate at that time the sand comes along with the water or the river flowing water when it is used so this becomes a problem. So one has to use proper treatment and then these particular results have the table that based on

this interpretation was done by Gilbert et al. they carried out this research study in Arizona, USA.

Management practices for using poor quality water: This is important that one has to use gypsum at appropriate quantity. So, knowing the particular concentration of a particular saline level, sodic level of the soil accordingly gypsum has to be applied and then the water is to be given up to certain depth. So, that the leaching of salt it can take place from the soil and then it is better to use localized irrigation like drip irrigation kind of a thing instead of flooding this thing if the poor quality water is available so, dripper has got tendency that it will be not flowing water or overland flow will not take place, it will be isolated at one particular place. So, it will form a bulb kind of a thing so the outer side of the bulb's concentration of this salt will be more. So, to a certain extent, poor quality water can be used by the drip irrigation system. One has to use saline water-tolerant crops which can sustain when the quality of water is poor.

The drainage is a very important component it should be coupled with an irrigation system when we are using surface irrigation or even any other methods of irrigation drainage is important. Mulching is another technique where you know when the evaporation is taking place. So salt which is precipitating on soil and evaporation takes place. So these salts get deposited so in order to check the formation of the crust on the top of the soil so mulching can be done. Crop rotation following a particular rotation of the crop is hazardous to the soil. So, if we take salt-tolerant crops in a specific manner of rotation if we follow to a certain extent, slight poor quality of water can be used for irrigation.

So here there is a list of the crop, these crops are tolerant crops, which can be taken in soils. Field crop cotton, safflower, sugar beet, barley; fruit crops such as date palm, guava; vegetable crops where you can see turnip and spinach. Semi tolerant, these are the list of the crop means most of these crops are the vegetable crops of course in the field crops sorghum, maize, sunflower, mustard, rice, and wheat.

These are semi tolerant crops to a certain extent. So, in Rajasthan conditions where there is arid zone slightly so, or in some parts of Uttar Pradesh also, the semi tolerant crop where there is

salinity problem People take; Rajasthan, Haryana, and Punjab these crops are being taken up in places where the slight salinity it exists and then irrigation water is also saline.

Sensitive crops, these are the highly sensitive crop and this is being taken. So, in sensitive crops, field crops are Chickpea, linseed, beans, green gram, and black gram. Fruit crops apple, orange, peach, strawberry, and radish. So what I see here is that the suitable crops which can be very much usually adopted means drip irrigation can be adopted mainly vegetable crops or fruit crops, where it can tolerate to a certain extent of soil salinity in the water and this is very much the micro irrigation it can be adapted.

Of course from this table, one can see that the crops differ their tolerance limit with the poor quality water. So, growing salt-tolerant crops using poor quality water can be taken considering the certain reduction in the yield or minimizing the reduction in the yield if we take care of the quality of water if we will take care of the quality of soil, the poor quality of the soil.

Now let us summarize this lecture. So I would say that yes we discussed about water quality indicators, we discussed about iron toxicity, we discussed about different factors which are prone to or which are affecting the emitter clogging. So, there could be biological there could be chemical there could be physical. So those parameters are to be taken into consideration while we are selecting a particular type of emission device.

And then adopting a particular management practice using poor quality of water say in case of micro irrigation system and when the quality of water it has got it means that when it has got soil salinity and it has got total dissolved salts or sand or silt is available. So, it is better to use the high orifice sizes like micro sprinklers or bubbler can be used in that case when the physical components like sand or silt it is available in the water and then emitters are getting clogged.

So, this kind of precaution once has to take. Now, in the forthcoming lecture, we will be discussing about different types of numerical problems which we have dealt in the previous classes. So that will be a tutorial.

Then there are books and other reference material, internet references which are available. You may refer for more detail about this particular topic. So thank you very much and good day.