Micro Irrigation Engineering
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Lecture-03
Soil Water Concepts

Yes, welcome to the third lecture on soil water concepts. This particular lecture is important from an irrigation point of view. And particularly while selecting a particular type of emission device, we are required to know how the hydraulics of soil water takes place when we are applying water through micro-irrigation drippers.

In this particular lecture, we will deal with soil, its different properties, type of soil, how soil and water are related, and how these soil water concepts have been used, and then different forces affecting soil water movement.

When we talk of soil, the soil is a mixture of minerals, organic matter, gases, liquid, and a myriad of organisms that support plant life. There are several horizontal layers and these layers are known as horizons. They are rich in organic matter and then followed by rock layers. Any soil consists of solid material, it consists of pores, and these pores will have air or partly filled with water or fully filled with the water.

Now when we look at different types of soils, which are in our country, so different soil groups have been classified based on the colour or disintegration of the basic parent rock material. If we look at the pie diagram, what we see that red soil dominates in the country and it is covering about 105 million hectares of land area which is about 34%. Then next in the order is black soil, alluvial soil, then these your desert soil, hills, and terai soil, and alluvial soil.

So, these soils are distributed if you look at the right side of our Indian map and you may see that the large part of the area with this red colour which we are seeing it is being covered in this

group. So, in this area basically, you may see that the red soil dominating the area. Next in the order is the black soil and then other soil.

So, they are distributed in different parts of the country and they have got different water retention properties, they have got different water drainable property, water drainage property. They have got different properties accordingly irrigation water is to be supplied through micro-irrigation drip emitters. Or even conventional irrigation system also these soil groups their water holding capacity, they play an important role.

Now when we look at black soil regions, so these black soil regions are dominating the Deccan Plateau. And the Deccan Plateau area is located in Maharashtra, Gujarat, Madhya Pradesh, Karnataka, Andhra Pradesh, Telangana as well as in Tamil Nadu. Why does this black soil it has form? It is the compounds of iron and aluminum. These soils are low in nitrogen, zinc, organic carbon and they are rich in manganese as well as calcium.

They have got typical properties when it comes in contact with the water, it swells. But when there is a deficiency in moisture content, when the soil dries, the cracking problem comes. So, there is a problem and particularly with drip irrigation, it is highly as suitable rather than giving water or conveying water through the irrigation channel also it is a great problem.

Now, the major dominating crop in these soil regions is cereal crops, oilseed crops, citrus, fruits and vegetable crops**.** When we look at these crops you can see citrus, fruits, vegetables, sugarcane, they are you know highly suitable for a drip irrigation system. Alluvial soils are another group which is you know form due to deposition of the rocks material due to this overland flow from the river areas and then it gets deposited.

So, these regions are available from Punjab means all the northern parts of the country where their several rivers are flowing, they are dominated by alluvial soil regions. And the majority of the cereal crops, as well as vegetable crops, are being grown in alluvial soil regions.

Red soil regions as I told you that these red soil regions are dominating in the states like Tamil Nadu, Karnataka, Andhra Pradesh. And these soils, if you see this are formed due to the decomposition of crystalline rocks, and granites or gneisses are from the rocks. So, they have formed and these soils are rich in minerals and as well as iron, potassium, manganese. But they are deficient in nitrogen; you must as well as, in phosphorus rice, millet, tobacco, and vegetable crops are being grown.

The laterite soil is formed due to the high temperature. So, weathering of rocks, as well as heavy rain fall, takes place due to these climatic variations and that is causing the formation of laterite soil. These soils are rich in iron and aluminum but as such these soils have got acidic. These soils are suitable for the cultivation of tea crops, coffee, rubber, and then many other crops which are suitable to grow, apply micro-irrigation system, sprinkler irrigation system and you may find that these crops are being irrigated in different regions.

Arid and desert soils, arid and desert soils you know it are found in the arid and semi-arid regions where the annual rainfall is less than 500 millimeters. A large part of Rajasthan, Punjab Kandi area of Punjab, Haryana there you will find that arid regions are available. Then in the presence of phosphate and nitrates, and availability of soil moisture means irrigation such soils are it becomes fertile.

There are several examples it shows when irrigation is being given it was all desert in the Rajasthan area due to the application of Indira Gandhi canal command those areas have become green. So, forest and mountain soils are the name it says that these regions are falling the hilly slopes. They are such soils are brown in colour and coffee, tea, and tropical fruits are being grown.

And once we analyze their physical properties, chemical properties accordingly irrigation water, as well as certain amendments in the soil, can be made, and then it can be made productive.

Peaty soils and marshy soils either name says means water stagnates for a longer period, these soils are not having adequate means of soil air. So, the cultivation of crop it becomes difficult and say particularly peaty soils they are deficient in copper.

And then marshy soil most of these soils are available in Bihar, coastal parts of Odessa, Tamil Nadu, West Bengal, and Uttar Pradesh and they are deficient. So, accordingly, the soil amendment is to be done when we want to bring this soil into cultivation. Saline and alkaline soil are also problematic soils and these are available in the arid and semi-arid regions of the country. If they are to be brought under cultivation, then we need to apply a sufficient amount of gypsum or calcium treatment, so as to bring it otherwise these soils are not suitable for cultivation.

So, those are the different types of soil according to their physical properties, chemical property their treatment is to be done and these are to be brought for the cultivation of a specific crop and using an appropriate irrigation system. Now the next part when the soil comes in contact with the water, how does it behave? And then any soil material if you take it, it consists of minerals, it consists of organic matter.

And then the in-between these soil particles, there are pore spaces, there are pore spaces in these pore spaces, water is available as well as air is available. In these pore spaces depending on the way the soil composition exists and their porosity, it exists the root proliferation takes place. And so, a proper understanding of soil water is important for plant growth and is very important for an efficient irrigation system.

When we say about soil water, a very important component involves soil texture. Soil texture means the relative proportion of sand, silt, and clay in a given soil. So, when if you see sand, sand when you are putting water or even without water you feel like a coarse grain and there as well as gritty. When you see at the clay these are the finer particles, and when it comes in contact with water it looks like it is sticky.

And then silt, you feel silky is smooth when it is brought to the in contact with the water when we apply water. When they are in different proportions means loam, when I say it is the combination of sand, clay, silt in different proportions accordingly the nomenclature is being given. Whether it is a sandy clay loam, whether sandy loam, whether it is a silt clay loam. So, different proportions make that type.

So, this is the diagram, this is the triangular diagram that gives the grouping that which category a particular soil it belongs with. Just now when I was telling you the different proportions. So, you can see here suppose let us say it is sandy soil. So, in sandy soil, this side of this triangle it is showing the percentage clay. This is showing percentage sand, this particular side shows the percentage silt.

And if you take a particular triangle, let us say this particular triangle, so this is a sandy soil where 90% it is sand and 10% clay. But when they all three are putting it so different triangles you can see it forms a different. So, their nomenclature has been made based on their proportion it is there. Now when we say clay, silt, or sand, they are classified based on the size of the particles available.

So, when we say clay means it is less the size of the soil particle is less than 0.002 millimeter, when I say silt, the silt means the soil particles are in the range of 0.05 to 0.10. Now sand could be of different grades, it can be very fine sand, it can be fine sand, it can be very medium sand or it can be very coarse sand. This means the particle size which is say 1 millimeter to 2 millimeters means it is very coarse sand. So, accordingly, their grouping has been made.

Now after knowing the soil texture, how these soil particles are arranged. It Means sand, silt, clay they are arranged, how they are it has been made a soil aggregate. So, individual soil particle looks like this, of course, this it looks here a bigger side but it could be as small as less than 0.002 millimeters. Now when these soils are forming together it becomes soil aggregate. Now when it is soil aggregate, how they are making the different structures?

So, you can see here right side this is your granular structure. This is a platy structure, this is you know wedge structure. So, how these soil particles are arranged each other, can be a blocky structure, it can be prismatic structure, it can be columnar structure. So, depending on the arrangement of the particles they make it and the root growth, root penetration, proliferation will depend on the type of soil particles, how they are arranged each other.

Now, if we look at in this diagram if it is sandy soil and water is being given say from the top you are either it is irrigation water whether it is rainfall water, we were putting it. So, what happened? Since it is sandy soil, particle size is large, the micropores are also large, so the water becomes easy, and then it starts draining very fast. In sandy loam soil, particle sizes are small and then it is moderate means drainage of water from the soil column when it is a sandy loam soil, it will be lesser than the sandy soil.

When it is clay soil what happened? The particle sizes are small, the pore sizes are also small means it consists of fine pores. So, the movement of water is slow, very slow, and depending on the particular type of this thing.

Now I was telling you any soil system consists of the grain, it consists of the pores. Now if it is a grain means it is a solid and when we take it as a 1 say 1 cubic meter volume of a soil column. Now in proportion wise, if we are making it, so some part of the proportion volume is having solid, some part it will have the pore space. So, we can say the 1 cubic volume of this soil column, has some space where the pores are there.

And some have got solid particles; this can be expressed in terms of the mass of air. This can be expressed say, so this pore space consists of air, it can consist of water. So that depends you know how much pore space whether is completely fully dry soil, there is no moisture content. So, it is the only entire volume of the pore volume is full of air. So, it will say Va plus Vw is simply V_V, that is a volume of a void, the total volume of void.

So, if we can say if it consists of air, water, and solid, the one part we are putting a mass of air, another one we are telling a mass of the water, the mass of the solid particles. And when we are summing together it becomes the total mass of the soil particles or soil column, and this can be expressed by volume of air, the volume of water, volume of solid.

So, these volumes as well as the mass it can be expressed with certain terminology which are important when we are giving water. So, one important parameter is known as particle density or true density. What is particle density? It is given by the mass of solid divided by the volume of solid. When I was putting you 3 points that is the volume of solid, volume of air, the volume of water, so this is the volume of solid.

Dry bulk density is the mass of solid divided by the volume of total volume. So, the total volume is nothing but the volume of solid plus volume of air plus volume of water. Now, the dry bulk density values for the different soil textures, just now I told you about sandy soil, loamy soil, for different soil textures you may see that these values are available.

So, these are used for several structural designs for irrigation purposes when we want to do for different purposes the value of bulk density, as well as particle density, is being used. Now total bulk density when we say total mass, so the mass of solid plus the mass of air plus mass of water, this is referred as a total mass and V t is the total volume. And then other terms depending on the void space means air and water.

So, a total void is expressed as the porosity. So, porosity is basically the volume of void divided by total volume. So, the volume of void means the volume of air plus the volume of water, so this is your total porosity. Now this can be expressed also in terms of bulk density and true density units, so this can be given by 1 minus rho b by rho s, so that can we calculated.

Soil water content someone wants to know how much is the soil water means, how much amount of water present in the soil? This is measured in terms of gravimetric water content, mass water content, or soil water content. Soil samples it collected by using the soil core and then the sample is brought into the laboratory. We weigh the sample along with the water or the sample has got dry soil plus water.

And then we are weighing it and then drying the soil sample at 105 degrees Celsius for 24 hours in the oven we keep and then we find out the dry sample. And then determine the amount of water available in the soil that is the mass of water divided by the mass of solid.

We can express these values in terms of volumetric units. Volumetric units mean the volume of water present in the soil sample. So, this can be given by the volume of water in a total volume of soil. So, which can be also expressed in terms of soil moisture content, so theta v can be given in terms of volumetric water content. So, a volumetric form of water content. So, moisture content by weight you have got and then you are multiplying with this ratio.

That is a bulk density divided by the bulk density of water, bulk density of the soil divided by bulk density of water, and this density of water we consider it as a 1 gram per cc. If we want to express what is the depth of water in the soil layer. So this volumetric water content is there if we multiplied by the depth of soil sample we have considered. So, this one can get what is the equivalent depth of water available in the soil.

Now we come across different types of soil water in the literature. And which are had some certain physical meaning. If we look suppose it is a saturated soil column when we are allowing the water to flow by gravity and the soil sample from the column it is coming out of freely under the influence of gravity, this water is known as gravitational water. And from the potential point of view, this particular potential is 0 for the saturated water.

And when it brings to the field capacity it is up to 0.33 bar, so we say 0.0 the gravitational water is available at 0 potential or 0 metric potential or 0 to 0.33 bar. When another category of water is capillary water, from the potential point of view it is from 0.33 bar to 31 bar. And then hygroscopic water, this is a very a specific condition when the soil is dry and then the soil sample is exposed to the water vapor then because of the pores of a region the soil particles are attracting the soil water molecules and then this water is there that is called hygroscopic water.

So, which is explained like this, when the soil means there are micropores and what went it is gravitational water, water is flowing freely from these pores. When it comes to the capillary water, this is the available water, this water is not available from the irrigation point of view. Capillary water is the only water that is available from an irrigation point of view. And this capillary water basically what happened? When suppose there is a water table and then on the top, there is sandy soil.

So, because of the capillary forces, water starts rising. So, the particle the pore sizes are larger, so the movement of water is lesser and in the case of clay soil the pore size is smaller, so the water is rising. So, the plant takes water for meeting its evapotranspiration requirement that is capillary water. And this water hygroscopic water is from an irrigation point of view, it has no meaning because this water is not available as such for the plant to give irrigation.

There are some forces this is a very important part when I have told you that one part is your gravitation. It is the water held tightly to the soil surface and absorptive forces. So, there are forces that are acting and that are being captured by the soil particles. So, adhesive forces, as well as cohesive forces, are responsible for holding the water that is the capillary water. Now the water when it takes place movement from the soil to the plant root system.

If it is normal clear water without any salinity, the moment of water is not turkish when sufficient water is taking place. But if the water or soil has got salinity, because of the salinity in the water the movement of water is slow. Now the water which takes place from the higher concentration

to the lower concentration, this process is known as osmosis. So, the osmotic effect takes place, so here the adhesive forces and then cohesive forces as well as osmotic forces are important when irrigation water or water movement from the soil to the plant system takes place.

Now, so gentlemen, the participant we have discussed in the lecture, what is the soil? What are the different types of soils? And then what are the different textural parts of the soil? How this soil aggregates its form that is the soil is structure part, soil property, in relation to irrigation water application. So, soil texture, soil structure, soil water quality, and forces in relation to soil water movement that we have discussed in this lecture. Now forthcoming lecture, we will discuss about soil water constant and soil water movement.

These are the books which one can refer to in this particular lecture, thank you very much.