Soil Science and Technology
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Lecture – 14
Soil Water (Contd.)

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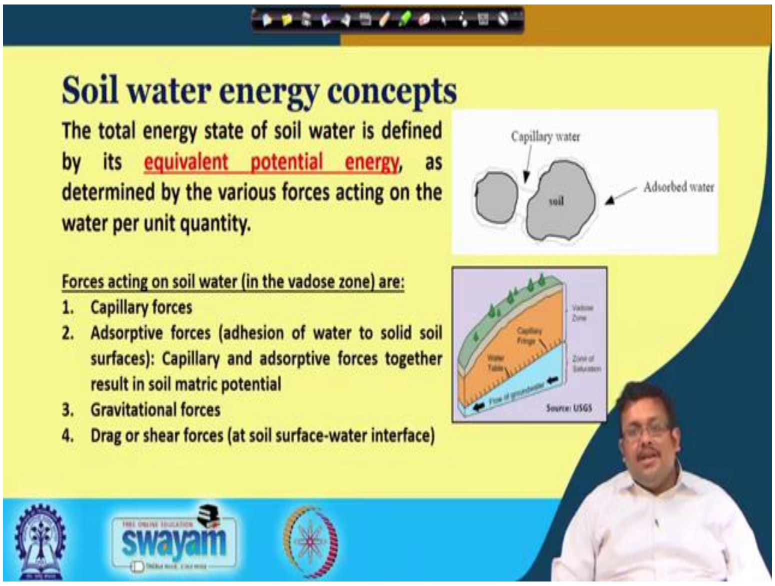

Welcome friends to this new lecture of Soil Science and Technology and we will start from the Soil Water energy concepts because we left there in the last lecture. So, we have discussed about the soil water energy concepts and what are the different forces which act on soil water in the vadose zone we discussed about the vadose zone. Remember the vadose zone is unsaturated zone above the zone of saturation.

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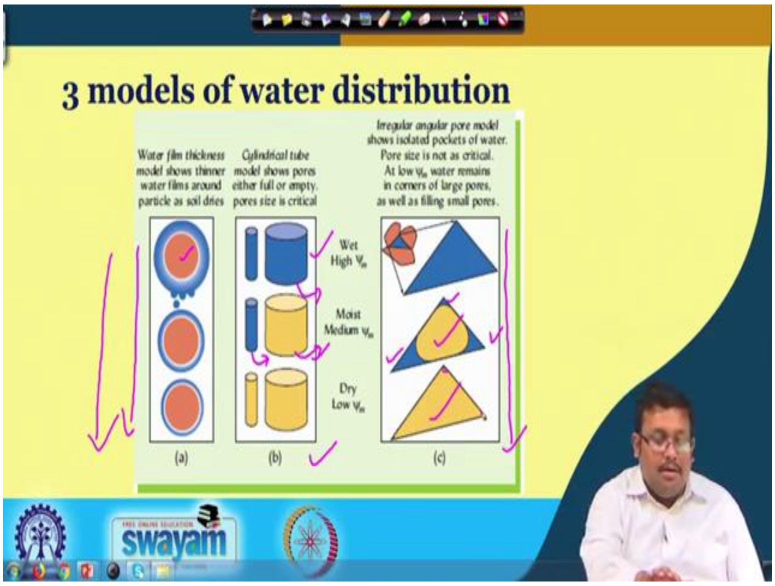

So, let us see what are the 3 models of water distribution. So, the first model you can see here. It is called water film thickness model and it shows basically the thinner water films around particle I mean when these are the particles. So, you see 3 different particles and the thickness of the films of water films continuously going down as your moving from the first one to second one to third one.

Obviously as the thickness of the water film around the particles are going down, their energy or potential energy also decreasing. So, at the top when the thickness of the water is quite high; obviously, that will be in higher energy state and at the bottom when the water is drying out and obviously, the thickness is going down that will be in lower energy state.

So, obviously, the water will move from this position higher energy state to lower energy state. The second model is called cylindrical tube model and it basically shows the implication of different size of the pores you know, water distribution. So, you can see that this is the wettest condition and this is the intermediate condition and finally, it is the dry condition. So obviously, when the soil is getting dried and the water will first move from this larger pores.

This large cylinder is basically implicate you know basically indicating the larger pores whereas; as the small cylinder is showing the smaller pore. So, when the water is. So, when we are drying the soil, the first the water will go away from this larger pores and finally, when the larger pores are emptied and then the water will finally, go from the smaller pores.

The final one the final model is called irregular angular pore model and it shows that irregular isolated pockets of water. So, we can see these are you know these are angular shaped pores and in the angular shape pores if you are started if you start dying these this soil the first you know, the first the water will evaporate from this middle portion and these three corners will hold the water in higher tenacity. And as we further you have you know dry the water from this triangular pore, the water most of the water we will evaporate. However, there will be some amount of water that will still left in this corners because of higher tenacity.

So, these three models of water basically shows the principal through which the water distributes from one area of soil to another area. So, this basically governs the pathway though which the soil water will move from one portion of the soil to another portion of soil. So, let us see what is soil water potential.

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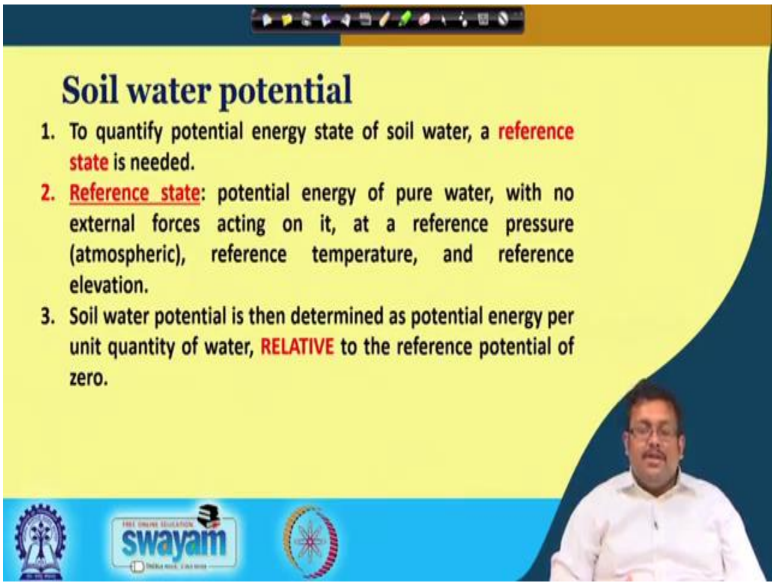

So, to quantify potential energy state of a soil water reference state is needed. Remember that we need a reference state for quantify the potential energy of soil water because whatever we will be expressing in terms of potential energy that will eventually shows the total soil water potential. And this reference state is basically potential energy of pure water with no external forces acting on it at a reference pressure that is the one atmospheric pressure, reference temperature and reference elevation.

So, if the water is present in a pool that water which is present inside the pool is considered as a reference state with zero potential energy. Soil water potential is then determine and its potential energy per unit quantity of water relative to the reference potential of 0. So, the water which is present in this reference state are considered as a potential energy of 0. And whenever we are talking about soil water potential, it always determine the potential energy per unit quantity of water relative to that the reference state.

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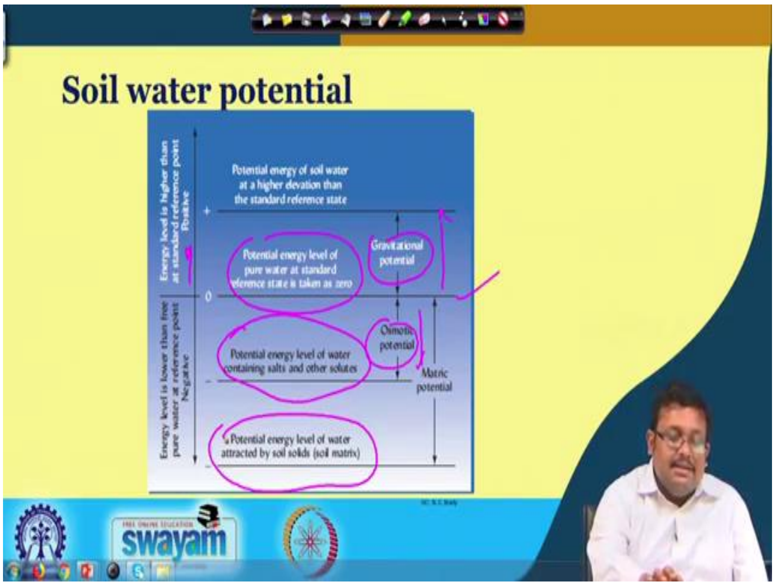

So, if you see this picture, this picture gives a broad overview of different soil water potentials. Now you can see this line. This line is showing basically potential energy level of pure water at standard reference state which is taken as a zero. And obviously, here the potential energy of soil water at a higher elevation than that of the standard reference state. Suppose here and this we will form the gravitational potential which is another important potential. And energy level is obviously, higher than a standard reference point positive.

So, whenever we are going in this direction, energy level will be always positive and below these reference state, there will be osmotic potential. So, what is osmotic potential? Potential energy level at of water containing salt and other solutes, we will discuss this later on. And as a result there will be negative we know there will be we know the now the energy level is lower than free pure water at a difference point. So, it is negative in sign and finally, here will be potential energy level of water attracted by soil solids or soil matrix and we call it matric potential. This is also negative.

So, you can see the manifestation of different potential like gravitational potential osmotic potential, matric potential you know and their relative position as compare to this you know pure you know or reference state which is taken as zero. The potential at remember that the potential at this reference state is always taken as zero.

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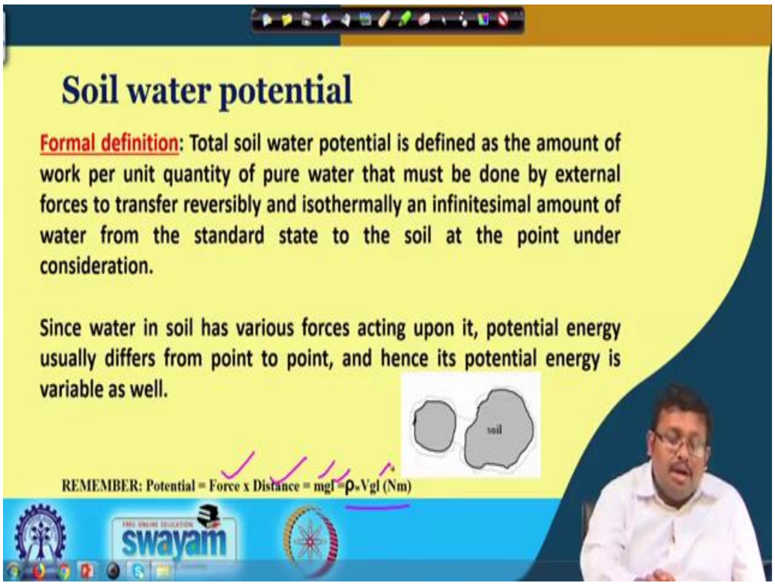

So, the formal definition of soil water is total soil water potential is defined as the amount of work per unit quantity of pure water that must be done by external forces to transfer reversibly and isothermally an infinitesimally amount of water from the standard state to the soil at the point under consideration.

So, since water in soil has various forces acting upon it, potential energy usually differs from point to point; obviously, and hence it is potential energy is variable where the potential is a variable, this is the this is the acting force through which water is moved from one portion of the soil to another portion of soil. So, remember that potential is defined as it is a multiplication of force and distance. So, if the force is you know basically denotes by mg and the distance is by l.

So, this is the final expression where is the rho w is basically the density of water and volume of you know and this is the volume a, g is the gravitational acceleration and l is basically the distance. So, it is expressed in newton meter and so, this is then expression of general expression of potential.

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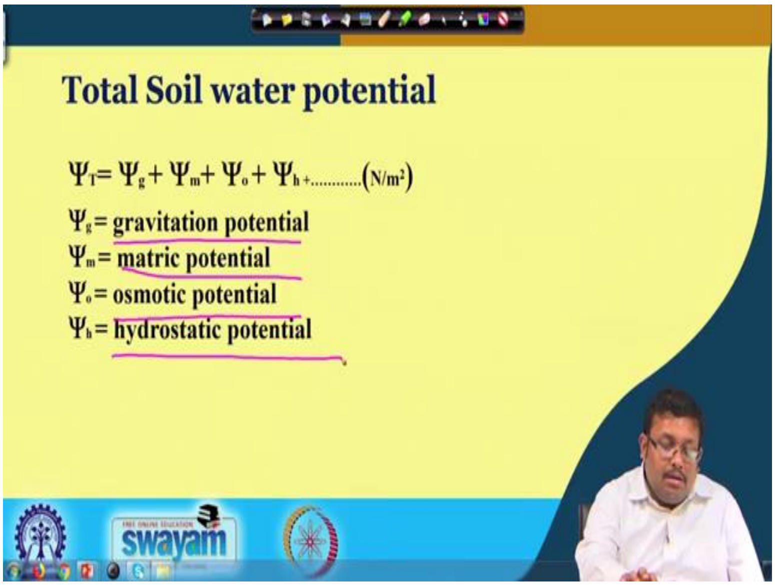

So, total soil water potential is basically as I have showed you in that last picture, it is basically combination of 4 different potentials. One is gravitational potential; another is matric potential, then osmotic potential and hydrostatic potential. And it is basically expressed in terms of newton per meter square. So, let us see them one by one.

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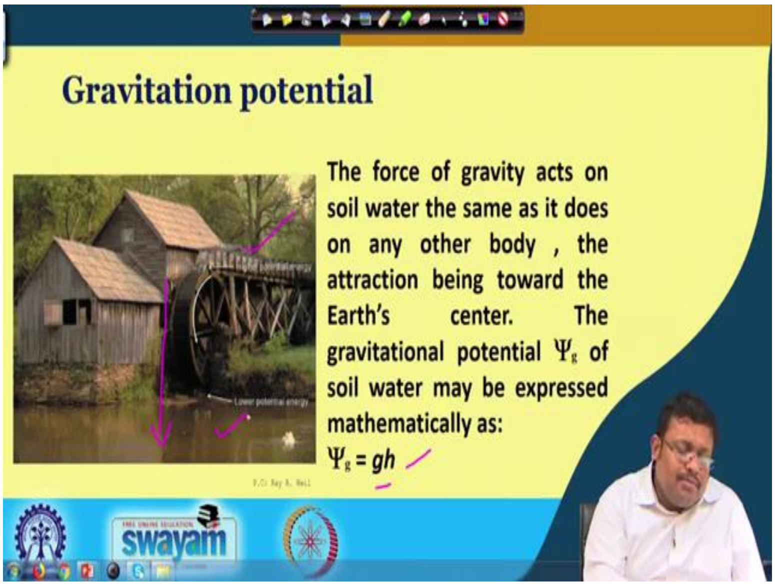

So, let us start with a gravitational potential. So, the force of gravity when the force of gravity act on soil water, it acts same as it does on any other body. When the attraction being towards the earth centre and the gravitational potential which is psi g of soil water may be expressed mathematically as psi g equal to g multiplied by h where g is the gravitational acceleration and h is the height.

So, you can see this is the water wheel and; obviously, the water will always try to move from this higher gravity to you know higher position to the lower position due to gravitational attraction. And obviously, the water at this height will have higher potential energy than that of water here with lower potential energy. So, while water will always try to move from this higher elevation to lower elevation and this is called gravitational potential.

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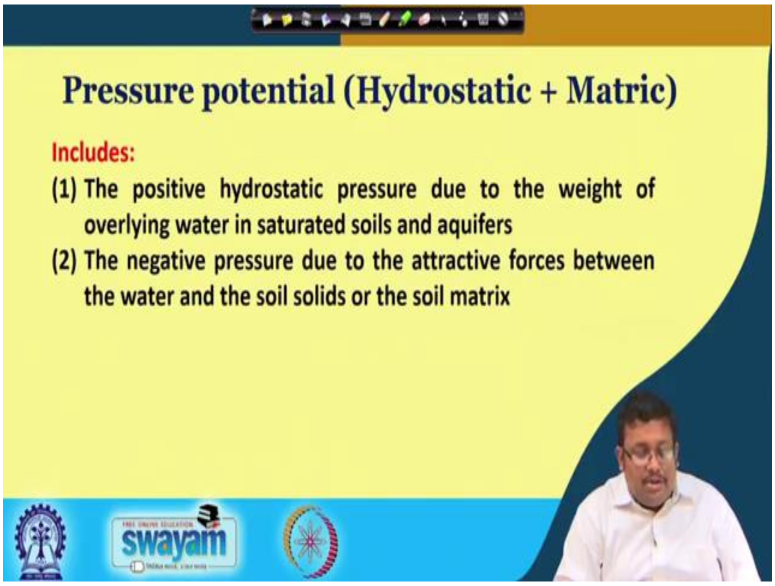

So, the second one is called pressure potential. Remember that the pressure potential is basically the combination of both hydrostatic and matric potential. Now it basically includes the positive hydrostatic pressure due to the weight of overlying water is saturated soil and aquifers. We will discuss that later on and the negative pressure due to the attractive forces between the water in the soil solids of the soil matrix.

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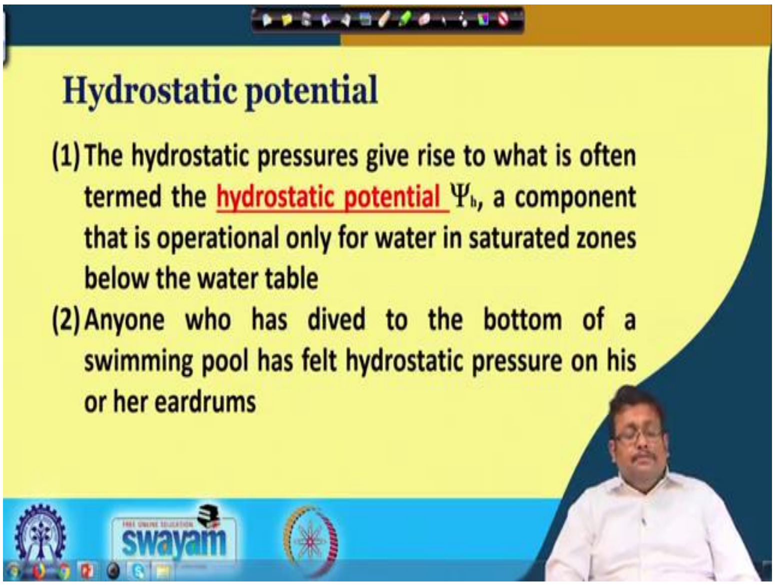

So, basically as the definition says, this is the height. The first one shows the hydrostatic potential and the second one shows the matric potential due to the soil matrix.

Now, let us start with the hydrostatic potential. The hydrostatic pressure gives rise to what is often termed as hydrostatic potential and it basically we denote this by phi h, a component that is operational only for water in saturated zone below the water table. And generally when you are swimming into some swimming pool and go in you know some time you go down to the swimming pool, you will see you will field this hydrostatic potential in your ear drums.

So, these hydrostatic potential is only operate you know only can be found at a saturated zone below the water table.

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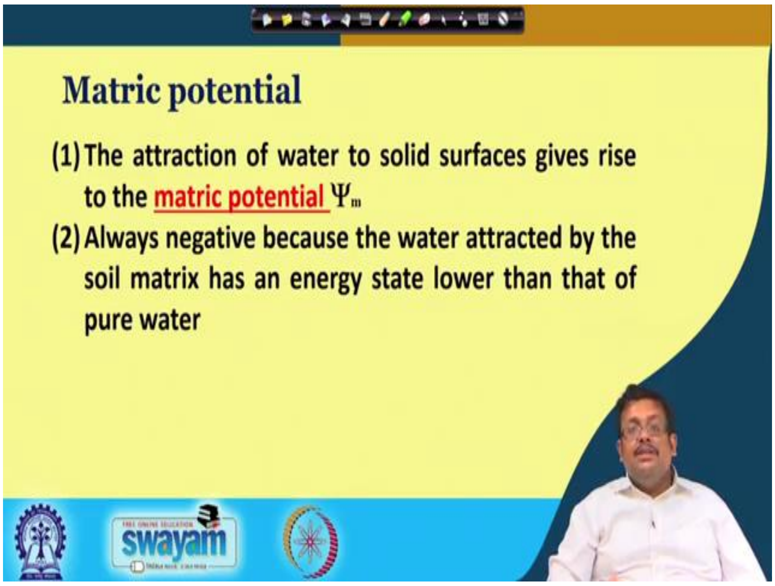

And matric potential is basically the attraction of water to solid surfaces give raise to matric potential which is psi m and remember that is always negative because water attracted by the soil matrix has an energy state lower than that of pure water. As I have already showed you in this diagram that the matrix potential and this osmotic potential is always negative because the water attracted by the soil matric has an energy state which is lower than that of pure water which is considered as 0.

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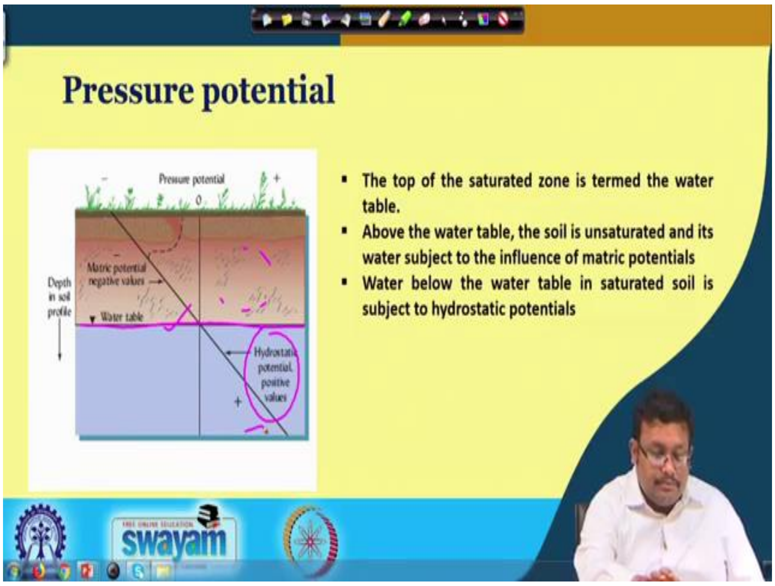

So, this picture gives a better understanding of the pressure potential considering both hydrostatic potential and matric potential. So, as you can see the top of the saturated zone. So, this is the water table and the top of the saturated zone is termed as the. So, this is the top of the saturated zone we call it water table and above the water table the soil is unsaturated and its subjected to the influence of matric potential; obviously, due to the attraction of different soil matrix and water below the water table is saturated soil is subjected to hydrostatic potential.

So, hydrostatic potential is always positive; however, the matric potential is always negative and matric potential is governed by the capillary rise. However, the rise may not be always linear and sometime it may be irregular due to irrigation and different types of water inputs. So, basically you know what I try to convey that the pressure potential is combining two different potential one is hydrostatic potential, another is matric potential.

Hydrostatic potential always can be found at a lower level at a level below the water table and it is always positive. However, the matric potential is always negative.

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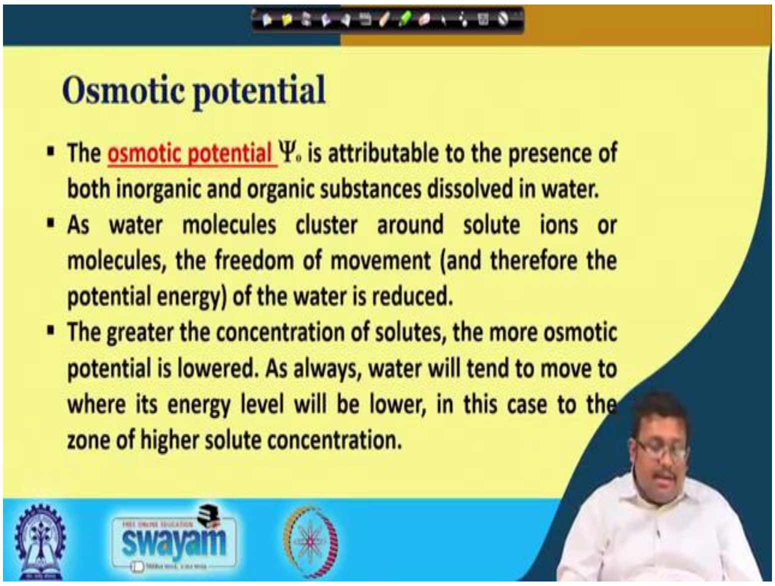

Now osmotic potential; the osmotic potential or psi o is attributable to the presence of both inorganic and organic substances dissolved in water and remember that has water molecule cluster around the solute ions or molecules, the freedom of movement of the water is reduced or in other words the potential energy is also reduced.

So, that is why osmotic potential is also negative just like as matric potential. In case of matric potential if you remember it is basically due to the attraction of soil matrix to the water and as a result the freenesss of the water to move to any other place is restricted. And as a result there potential energy get decreased. So, this is why the potential energy of the matric potential and the osmotic potential is always negative than that of the reference state.

At a greater the concentration of the solutes the more osmotic potential is lower than; obviously, water we will tend to move to where its energy level will be lower in this case; obviously, to the zone of higher solute concentration. So, water will always move from a zone which has got lower solute concentration to the zone which has got higher solute concentration because higher solute concentration means lower osmotic potential and as a result of that water will move from higher energy state to lower energy state.

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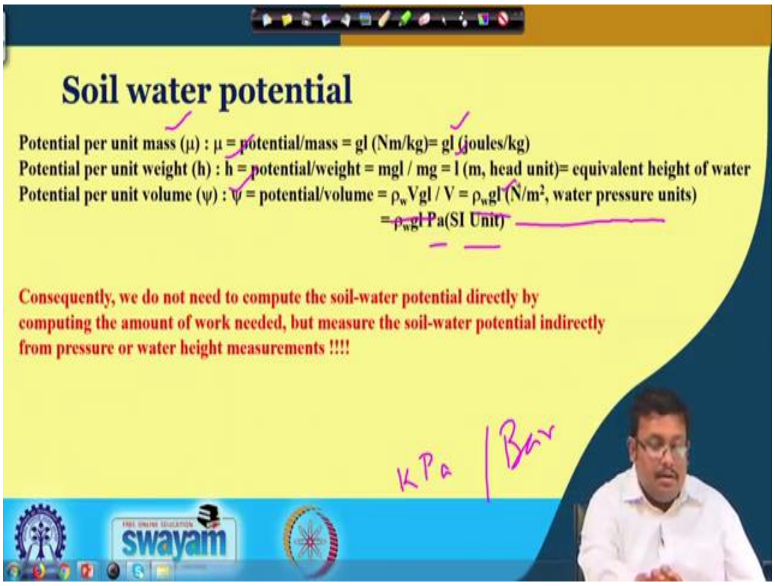

So, how you can express the soil water potential? So, soil water potential can be expressed in 3 different ways. One is potential per unit mass, another is potential per unit weight, another is potential per unit volume. So, potential per unit mass or nu is basically you know expressed in terms of joules per kg and obviously, it is multiplication of two terms one is g that is gravitational acceleration and l that is the length. And basically the because the water height I would say and potential per unit weight that is expressed in terms of h is basically at you know basically expressed in terms of l that is head unit and which is also equivalent height of water as we have already covered in case of capillary movement of water.

And finally, at most importantly potential per unit volume will be using most this potential per unit volume and we generally we use this as psi and it is basically the multiplication of this rho w Vgl and by V. So, we are getting rho wgl and it is newton per meter square which is the water pressure units and; obviously, the SI you did the similar SI you know the equivalent SI unit is called Pascal as you denoted by Pa.

And generally we denote the soil water potential in terms of either kilo Pascal or bar, we will discuss this later on. So, basically you can see comparing all these three that is potential per unit mass or potential per unit weight and potential per unit volume that we do not need to compute, the soil water potential directly by computing the amount of what he did.

But measure the oil water potential indirectly from pressure or water height measurements. So, we can see all of these contain this l component. So, if we can measure these components, we can basically compute the soil water potential; we do not need to compute the amount of work needed.

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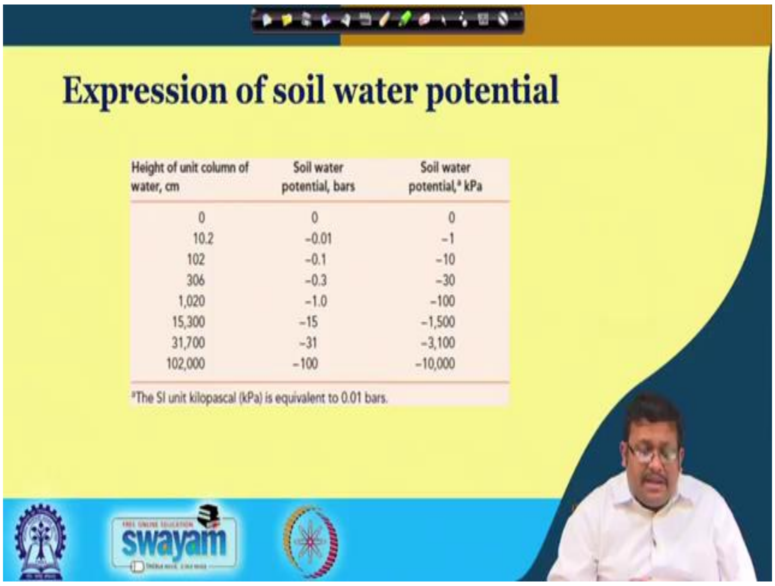

So, expression of soil water potential as you can see we can express the soil water potential either height of unit column of water mean centimeter or in bars or in potential or in you know kilo Pascal.

So, remember that the SI unit kilo pascal is equivalent to 0.01, but so, it is basically conversion from one form to another form.

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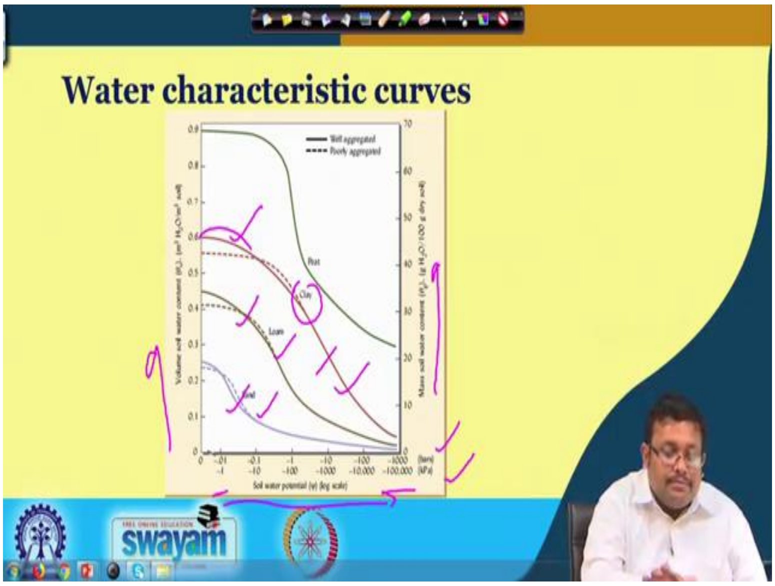

So, this curve is very much important, we call it water characteristic curve. So, in this water characteristic curve, it shows basically the relationship between the soil water potential and volume of soil water content or volumetric soil water content or gravimetric soil water content. So, we can see the x axis we are just plotting the soil water potential in log scale, remember that in log scale both in bars and kilo Pascal.

So, as we are going from by does 1 kilo pascal to by does 100, 000 kilo Pascal , we are basically drying the soil as you know that and similarly from 0 minus 0.01 bar to minus 1000 bar, we are drying the soil continuously. And in the y axis, we are putting either volume of water content or we call it volumetric water content or gravimetric water content or we call it mass soil water content. So, you can see at a given soil water potential, the clay contains higher amount of water the, that of you know core structure soil.

These basically due to the higher tenacity of clay for water, as compare to loam and sandy because in case of clay the total porosity is quite high. As a result you know the total you know the attraction of water by the clay is quite higher than that of sand and loam. However, you will not see this curves you will not see the abrupt bend and it is very smooth as you can see. These smoothness is basically shows the continuous distribution of pore spaces in the soil.

So, there is no abrupt bend or break. Another important thing we can see that there is a dotted line which is basically showing the poorly aggregated soil same soil with poorly aggregation poor aggregation. So, soil structure also effects the shape of the soil water characteristic curve. This is soil water characteristic curve by the way I have written water characteristic of, but it is a soil water characteristic curve. So, you can see in case of a well aggregated soil which is denoted by this solid line.

It contains more amount of total porosity. So, total porosity is quite high in case of well aggregated soil than that of a poorly aggregated or compacted soil. So, as a result of more or higher total porosity that amount of water or tenacity of that well aggregated soil for holding the water is quite high than that of poorly aggregated soil. So, as a result at a given point the well aggregated soil will contain more water; however, as we compact the soil, the proportion of the middle and small size for increases in case of poorly aggregated soil as compared to a well aggregated soil. So, that is why there is a change in shape. So, water is you know release differently from those poorly aggregated soils.

So, these curve basically shows gives us the relationship of change in soil water , how change in soil water potential or in other words how the soil water content vary from one type of texture and one type of structure to other types when you are continuously drying the soil. So, when you are drying the soil based on the soil texture and structure, the water content vary. So, that basically expressed through these soil water characteristic curve.

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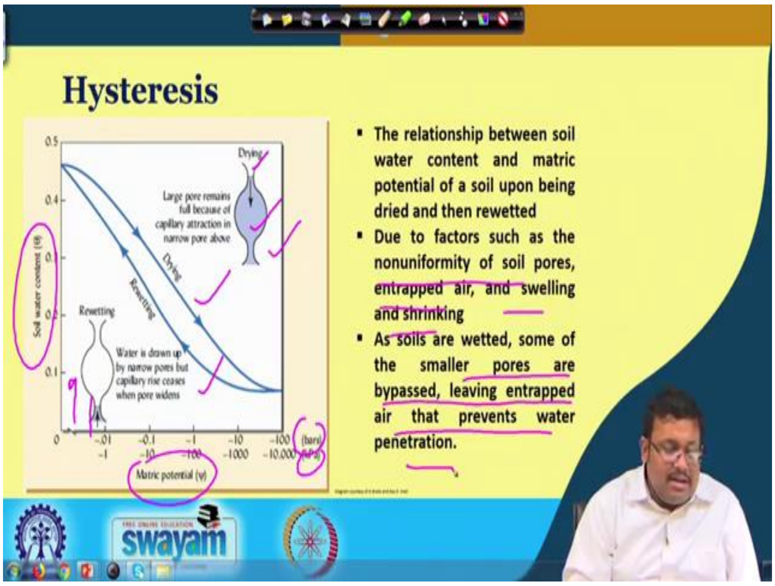

Another important term is hysteresis. So, hysteresis is basically the relationship between soil water content and matric potential and of a soil upon being dried and then rewetted. So, you can see again this hysteresis is basically showing the relationship between matric potential and soil water content and the here we are you know we are we are we are denoting soil water content by the by theta. And so, also matric potential is given either in bar or kilo Pascal. So, you can see the relationship between the soil water content and matric potential for a given soil when we are drying that soil is not similar for the same soil when we are rewetting it.

So, there is a difference and this difference occurs because of several factors. One is either non uniformity of soil pores, entrapped air and swelling and shrinking properties of the soil. So, let us start drying the soil. So, why there is a higher moisture content in case of drying, you can see this is you know this is the drying phenomena and large pore remains full because of capillary attraction in the nano pores above. So, these are large pores and these are narrow pores the capillary movement of water will push more water to these narrow pore. So, as a result large pores remains full and this is called the ink bottle effect.

So, as a result there is higher moisture; however, where we are rewetting the soil water is drawn up by the narrow pores by the, but the capillary rise ceases when you pore widens suddenly. So, as a result of that at a given matric potential, the water content in a drying soil will be always higher than that of the water content when we are rewetting the soil. So, these property of soil water is called hysteresis and as a soil are wetted remember that another factor where the soil are wetted some of the smaller pores are bypass leaving entrapped here that prevents the water penetration. So, this is another important reason for lower water content in the rewetting curve. So, this is called the hysteresis property of soil.

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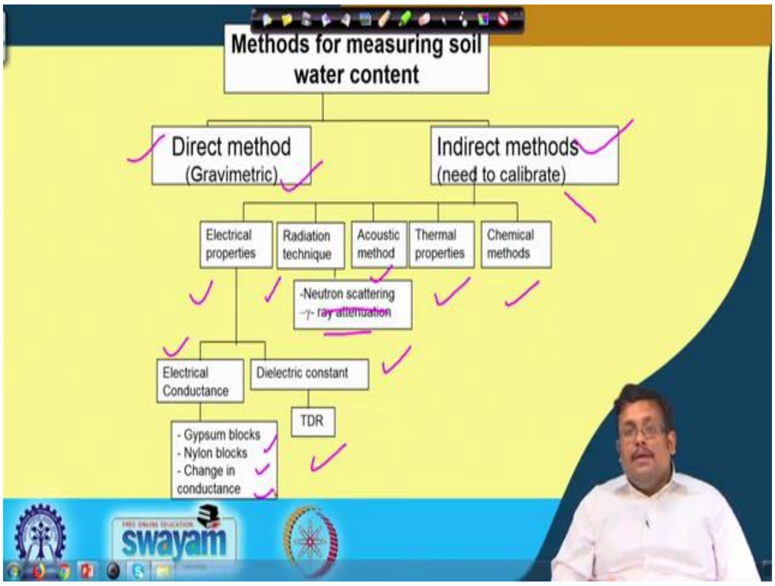

So, we have discuss about the energy concepts of soil. So, let us discus about different methods for measuring soil water content. So, we can broadly differentiate the methods of measuring soil water content into direct method and indirect method. So, direct method we will be discussing about the gravimetric, also we will be discussing about the volumetric method of soil water content.

However, indirect methods are needed to be calibrated for special type of soil or specific type of conditions and the indirect methods can be divided into chemical methods, thermal property method, acoustic methods, radiation technique and electrical property based methods. Radiation techniques are of two types one is neutron scattering another is gamma ray attenuation technique electrical properties base methods are divided into electrical conductance and dielectric constant.

So, based on dielectric constant we use TDR or time domain reflectometer, we will discuss that in details in the next lecture. And based on the electrical conductance, there are gypsum blocks, nylon blocks and change in conductance. So, all these are different methods for measuring soil water content. So, this slide gives you a snapshot of different methods which you use for measuring the soil water content and in the next lecture we will try to discuss them one by one and the next lecture also will be you know discussing about different methods what are their drawbacks, what are their advantages. So, let us rap up here and from next class, we will be starting discussing about different methods of soil water content measuring in details.

Thank you very much.