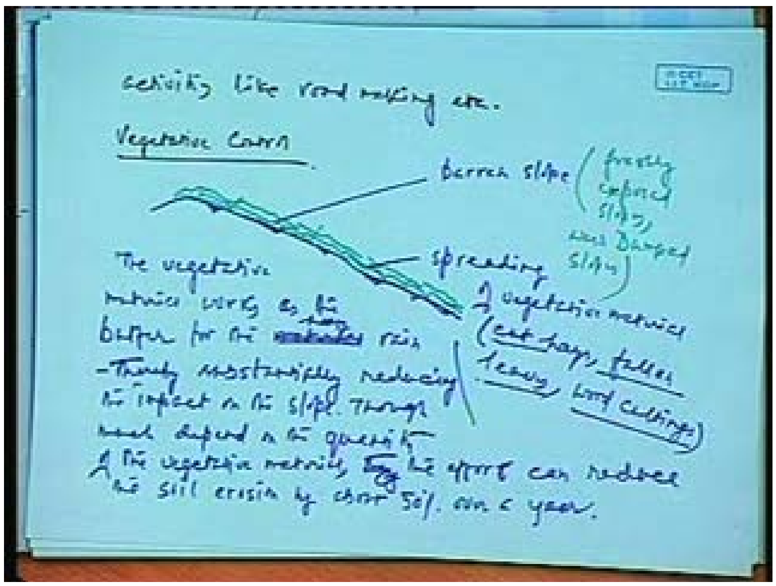
Fundamentals of Environmental Pollution and Control
Prof. Jayanta Bhattacharya
Department of Mining Engineering
Indian Institute of Technology, Kharagpur
Lecture No. # 26
Soil Erosion Prediction

Okay, before we actually go into this, detail of this soil erosion prediction we would need to discuss something more about this mechanical soil erosion control and a continuation of that.

(Refer Slide Time: 00:00:55 min)

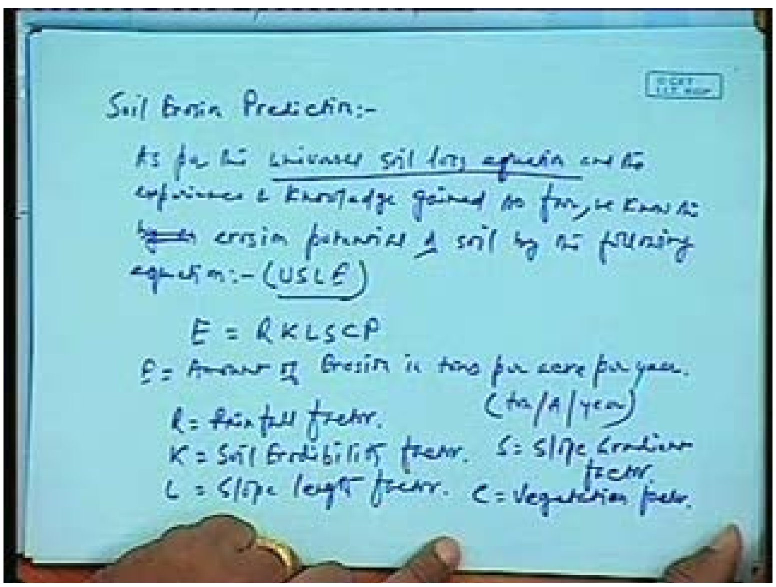


This is a, we call this as in the next one is apart from this mechanical soil erosion control we also use another control for to stop and check erosion, to stop and check erosion like this. This is called, this is vegetative, vegetative control, vegetative control. The vegetative controls are like this I mean you know when you say you know if you are just trying to observe a particularly a slope, particularly a barren slope, how it looks like. So, you know here say here if it is a slope like this say here the slope you know is broken at places like this. The slopes that we generally observe here what is this slope; when it is completely denuded, completely barren, so this is barren slope. Barren slope means you don’t have, you don’t have any large plants you have small plants, shrubs like this structures not even that. Mostly, this barren slope you will find near you know this freshly, freshly exposed, freshly exposed, freshly exposed slopes, freshly exposed slopes, new dumped slopes where are there is no practically no vegetative cover, practically no vegetative cover in such cases what we generally try to do is we have also found talked about this earlier. What we do is generally we try to spread some vegetative material on the surface of the slope, on the surface of the slopes.

What are these vegetative materials? This vegetative material depending on, depending on the availability and the requirement, we generally spread vegetative material, spreading of vegetative… What are these vegetative materials? Mostly cut hays, fallen leaves, fallen leaves say, say wood cuttings are generally spread all over the, all over the barren surface of the slope, all over the barren surface of the slopes. So, this say they work, the material works as, works as the buffer for, buffer for the rain, buffer for the rain, buffer for the heavy rain, heavy rain thereby, thereby substantially, substantially reducing, thereby substantially reducing the impact on the slope, impact on the slope. Though much depend on the quantity, though much depend on the quantity of the vegetative material they can, they can, the effort can reduce, the effort can reduce the soil erosion by about, by about 50% over a year, by about 50%, by about over a year. So, much depends on, the much depends on the vegetative material works as the buffer for the heavy rain thereby substantially reducing the impact of the slope, though much depend on the quantity of the vegetative material therefore can reduce the soil erosion by about 50% over a year. So, this is also another very standard technique, this is also very standard technique of you know is just in case you know just to suggest you another important thing is that when you are we generally cut grasses you know in our gardens or any other places or collect leaves they can be a very important resource, this can be very important resource. Particularly, in areas where there are very little vegetative growth, this vegetative growth and very little rainfall, this kind of, this kind of material if it is spread over a large surface area they can substantially improve the quality of the soil over time and not only that can reduce erosion to a substantial amount over the years.

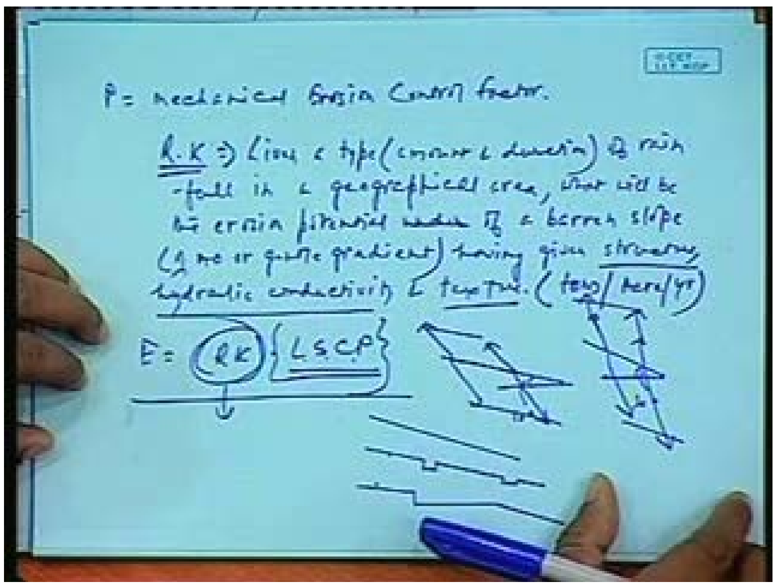
So, having to say this, having to say all this thing, now we can see that you know this is how this the erosion can be checked and controlled and at the same time you know there is a necessity for in most cases for how much this would be required, how much vegetative control required, how much mechanical soil erosion structures are required can be found out with the prediction of the soil erosion, with the prediction of soil erosion. So, we are going back to the main topic of the class now is the soil erosion prediction.

(Refer Slide Time: 00:08:26 min)



As per, as per the universal soil loss equation, as per the universal soil loss equation and the experience and knowledge gained so far, as per the universal soil loss equation and the experience and knowledge gained so far, gained so far, we can find out this, this say soil erosion potential, soil erosion potential of a slope by an equation, erosion potential of soil by following equation which is known as universal soil loss equation, which is known as universal soil loss equation universal, universal soil loss equation USLE. Now, according to this E is equal to RKLSCP, this E is you know E is the amount of erosion, amount of erosion, amount of erosion in terms remember these terms per acre per year, per acre per year. So, this can be, this can be found out like this. How it is found out here, what are the factors here? See, R is the called the rainfall factor, K is the soil, soil erodibility factor, L is the length factor, this is a slope length factor, S is the slope factor, slope gradient factor, C is the vegetative factor or vegetation factor, vegetation factor, vegetation factor and P is, P is known as the mechanical, mechanical erosion control factor, mechanical erosion control factor, okay.

(Refer Slide Time: 00:12:42 min)



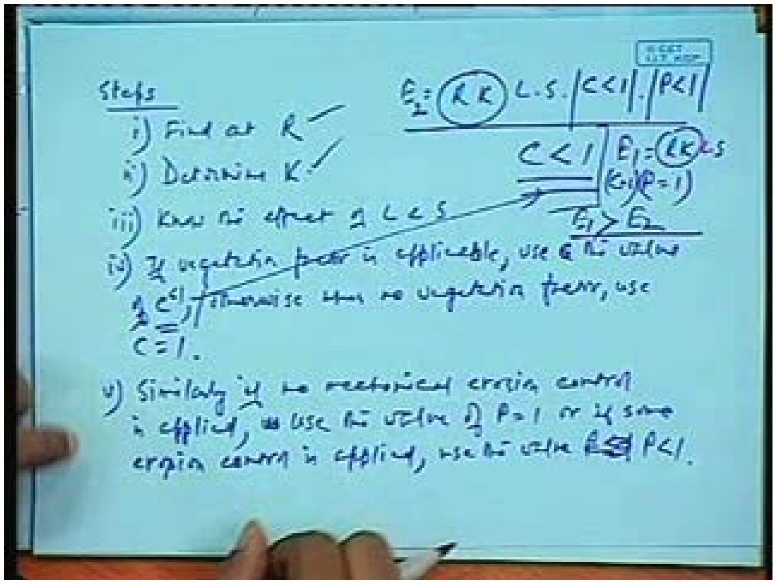
Now, if we just investigate you know trying to understand this, this soil and the factors that you can see here R is for the rainfall factor, K is the soil erodibility factor, L is the slope length factor, slope length factor, S is the slope gradient factor and the C is the vegetation factor. Now, here one interesting P is the mechanical soil erosion control factor. Now, what is interesting here to observe is the how this equation has been constructed. The most important part of the equation is R and K, R and K. What it means is this is basically R is means this, given a, given a type that is amount, amount of rainfall and duration, amount and duration, given a type of rainfall in a geographical area, given a type of rainfall in a geographical area what will be the erosion potential, what would be the erosion potential under of a barren slope of, what will be the erosion potential that is erosion potential in terms of I am coming back to this, erosion potential of a barren slope of no or of no or gentle gradient having given, given structure, conductivity and texture, hydraulic conductivity and texture in terms per acre per year.

This is what is R, RK signifies, R and K both multiplied, R and K both multiplied signifies the given a type of maximum rainfall in geography, what will be the erosion potential of a barren slope having given structure of hydraulic conductivity and texture. I will come back to that again. So, what you are trying to do here is all these if we just identify, if we just discuss again RK, the value of RK is essentially modified, being modified by LSCP, LSCP. What it, what it means is like this. Suppose is the construction of the equation is like this say you have a, you have identified that in a particular area there is a gentle slope having a particular structure and hydraulic conductivity and also say hydraulic conductivity or permeability as you can explain and texture.

If you have done this, suppose this slope here as you can see this slope, now this slope there if this slope is increased say here it is say, say about say 10 degrees, if this slope is increased to say 30 degrees. So, erosion would increase here essentially should increase for the same condition right. Similarly, similarly if you just think across this slope, think across this slope, across this slope, if this width of the slope further also increases, if this width of the slope further increases, if it is increased on both sides than its usual value here towards this, the erosion also increase. Isn’t it? Now, this is LS, the effect of L and S, length of the slope and width of the slope, all right. The stiffness of the slope or length of the slope and stiffness of the slope okay, length of the slope and stiffness of the slope, right. Then C is, C is now if you are using any vegetative, vegetation factor like if you are using say mulches, the hays, the cut hays or paddy or whatever you are spreading on the soil, the erosion would come down, should come down. So, we are using C as a factor which if it is applicable on the slope to bring down the quantity of erosion, so C and then finally is the P, P is the mechanical soil erosion control. So, understandably if there is a slope like this and if there is a slope having a say, having a diversion ditch or having a terrace or having a terrace like this or like this say in case, in such cases we can say that the erosion would be reduced. Isn’t it?

So, all these LSCP are actually the factors which would be working as an operator on this value of RK. This is the basic principle of this equation RKLSCP. So, we would start with RK, the basic value. So, basic value of the slope and then if we are controlling the other factors like the length of the slope, the stiffness of the slope then the vegetative factor and the mechanical soil erosion control factors then we can identify, we can predict what would be the soil loss in terms of tons per acre per year. This is also you know just to suggest only a linear analysis that is you know across a line that it only tries to understand. This is what it says is a tons per acre per year, so this is RKLSCP okay.

(Refer Slide Time: 00:21:16 min)

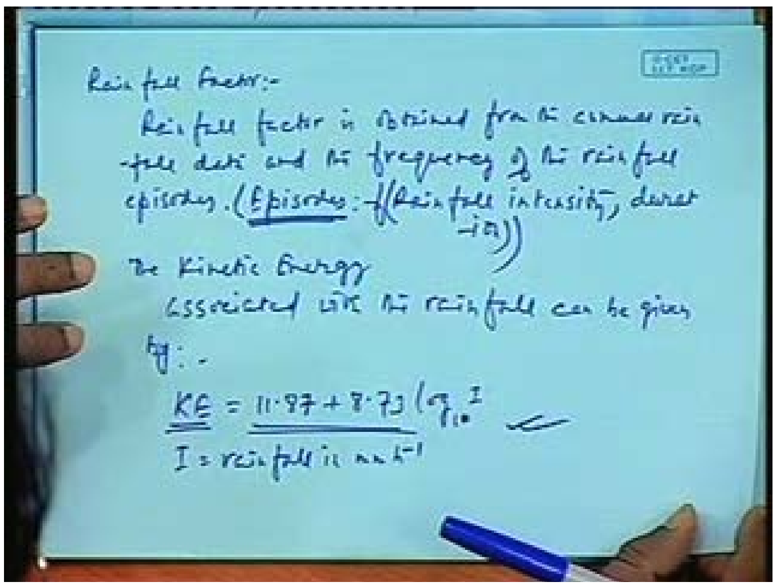


Now, this is the nature of the function as I have said so they would, so the steps are, the steps are, so find out R, determine K and S, a vegetation factor is applicable use C, if vegetation factor is applicable use the value of C otherwise when no vegetation factor may be use the value of C is equal to 1, okay. Similarly, if no mechanical is applied, similarly if no mechanical erosion control is applied use the value of P is equal to 1 or if some erosion control is applied you can write here also C less than 1, use C less than 1. So, you know it is C less than 1, use this one is use C less than 1, this is C less than 1. So, let me explain this again find out R, R can be found out by the geographical location. There is nothing much to find out you know from the meteorological data, from the geographical data you can find out R. Determine K, K is the basic property of the soil, K deals with the property of the soil that can be determine K that has to be determined say as you have found out for the texture, as you have found out for organic matter in soil the K has to be found out. Know the effect of L and S length and slope should be known generally as a, as a, as a parameter it is given if the vegetation factor is applicable use the value of C less than 1, if it any kind of vegetative factor is used that means some form of hays, some kind of mulches have been used say then we will say that C would be less than 1 otherwise when no vegetation factor is used use C is equal to 1.

So, what is in effect happening here is this? See, this E, this is the basic value RK that I have said okay. Now, if it is say LS also you would find out LS. Now, suppose if C, we are using C is equal to less than 1 multiplied by P is equal to less than 1. So, what is happening here is we can say now that you know you can say that is in a particular value like this say here the total erosion potential has been reduced because this one are less than 1, less than 1. So, we would find say if we find this value as this is value we call it as E, E 2 and this one is as RK, RK, LS and C P where C is equal to C is equal to 1 and P is equal to 1. Then we can very well say E 1 being more than E 2, not very complex actually what I am trying to say is if, if you have done made some, if you have made some mechanical soil erosion structure on the slope then the value of P would be less than 1 otherwise if you have not done anything then P is equal to 1, okay.

Similarly, if you have done if you have, if you have spread some hays, some vegetative material on the surface of the slope then C would be less than 1 otherwise C would be equal to 1. When nothing has been done C would be equal to 1. So, as you can see in slopes where this mechanical soil erosion control has been made then some vegetative material also has been spread, the erosion potential has gone down from its earlier position that is only it tries to suggest okay. Now, having to say this, this is the nature of the function that we have explain, this is how this is what is the nature of the function, this is how it would work. This is how it has to be explained, the nature of the function has been, has been explained to you having gone from here having further you know developed from here, we can very well now, now discuss about say this the each of these factors in greater details.

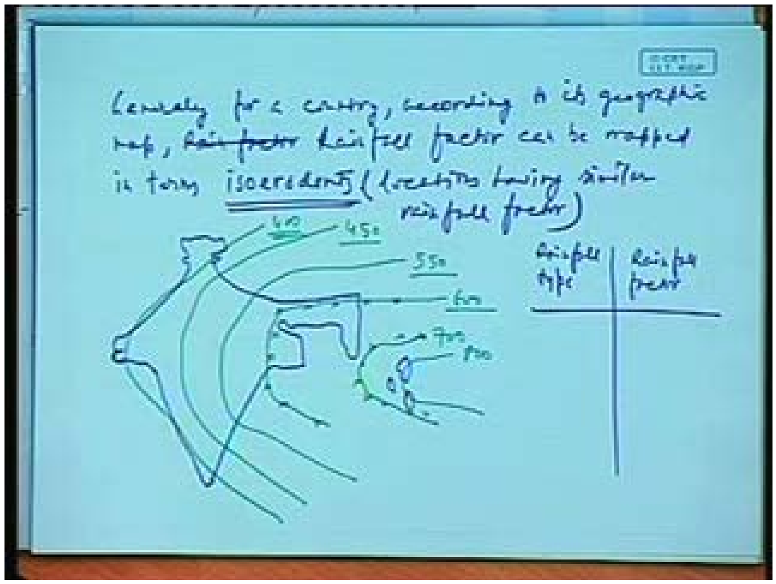
(Refer Slide Time: 00:28:48 min)



So, rainfall factor, rainfall factor, factor is obtained from the annual rainfall data and the frequency of the rainfall episodes. The episodes are rainfall intensity depends on is a function of episodes rainfall, this is a function of rainfall intensity and duration and episodes are rainfall intensity and duration, this is called the episodes. So, what is episode means you know is a, is a when it is drizzling for 2 hours, drizzling for 1 hour, heavy rainfall for 10 minutes, heavy rain very medium rainfall for 2, 2 hours. Each of them have different effects on the soil surface. The rapidity has a great impact, the duration of the where the duration also has an impact at the same time, the rapidity, the intensity of the rainfall also is of great importance. Just to suggest you know the, what is just to suggest in cases like kinetic energy this is the generally with the rainfall. The kinetic energy associated with the rainfall, with any rainfall, with the rainfall is can be given by, can be given by an equation where it is and is generally an empirical equation which is much used that is 8.73 log 10 I where, where I is the rainfall, rainfall in, rainfall in millimeter per hour, per hour and KE can be in the form of a potential energy which is say the sorry in the form of kinetic energy, this can be, this is I mean the, the kinetic energy in terms of standard equations of kinetic energy that we can mb square, half mb square kind of this thing can be found out here. So, this KE you say just a just for your, for your interest though will not be able, will not use this but you know just for your information rainfall in millimeter per hour plus

11.87, 8.73 it should be and in terms of I think you know this is be in Joules that is what we should use here. So, this is kinetic energy can be known like this. Yeah, what is… 11.87 okay, 11.87 okay.

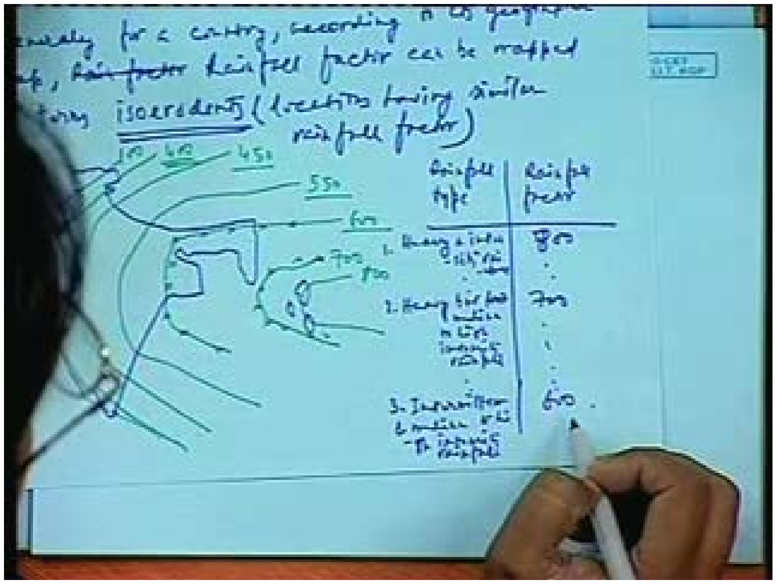
(Refer Slide Time: 00:34:03 min)



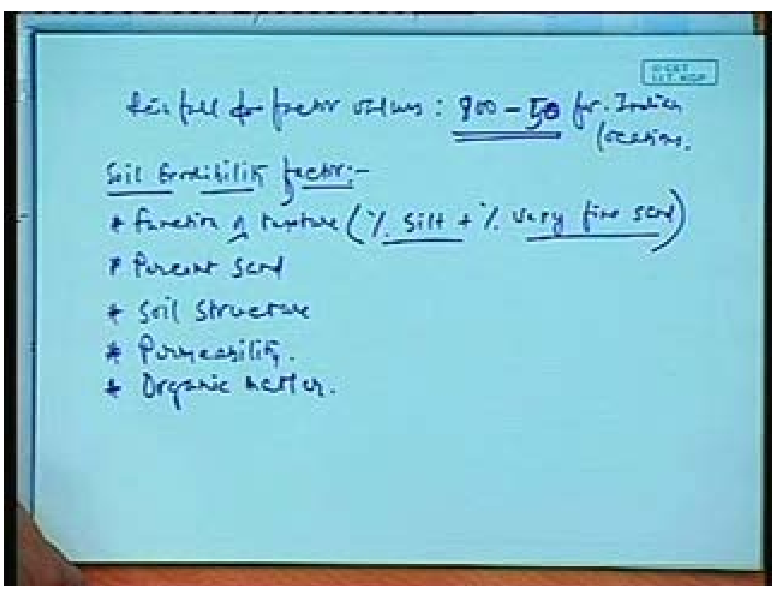
Now, this having said this, having said this, so here this rainfall intensity, the rainfall factors, the episodes under as I have explained the rainfall factor, see generally for a country according to map rainfall factor, rainfall factor isoerodents, isoerodents is this I mean locations having similar rainfall factor, similar rainfall factor. So, you know if you just try to say you know how it is generally done is not done for, India is not still done but you know how it is generally done is like this. So, if you can see this, how this isoerodents are made say you know isoerodents are like this, say like this contour maps that we do say you know something like this say if this is a high rainfall area, say this high rainfall areas like say if it you consider the northeast then you have this Andaman Nicobar's having higher rainfall. So, here you can see this is what is known as the isoerodents. This is how the isoerodents are made. So, this is how this say for India isoerodents may be looking like this. So, here you can see this isoerodents forming like this.

So, here in such cases the isoerodents like you know say Andaman Nicobar, the isoerodents would be, isoerodents would be between say, say about, say isoerodents say let us start it from 700 isoerodents here, this is 600. This is say, say 550, this is say 450, this is 400 like this, this is, this is how this isoerodents are made. So, depending on the rainfall, depending upon the rainfall areas, depending on the rainfalls that we generally observe here so in this Andaman Nicobar areas starting from here, so we are going towards the, more towards the arid region towards the west, okay. This is how this isoerodents are made, higher rainfall areas. So, we can have another isoerodent like say over 800 like this. So, this isoerodents, this isoerodents are isoerodents can be once this isoerodents are available, so we can find it like this we can say, say you say rainfall factor say rainfall type, okay.

(Refer Slide Time: 00:39:16 min)



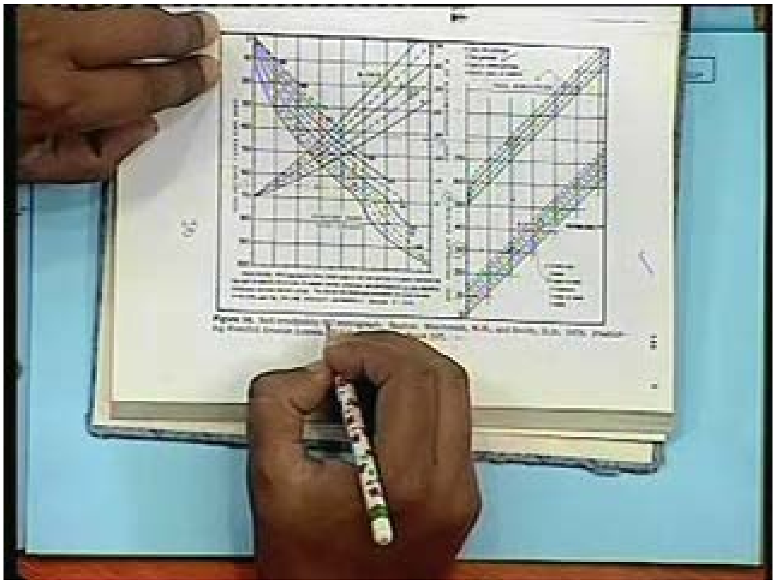
The rainfall type is says, say heavy… long and high intensity rainfall, it is not, rainfall is not required to be written. Heavy and say if there we will have a rainfall factor say of 800, 800, right Then heavy but low intensity rainfall, medium to high, medium to high intensity, intensity rainfall. So, you will have it is 700, so like this you know this is how, this is rainfall factor would be given. So, I will give you, you know I'll talk to you in the, this tutorial class you know how this is to be found out. So, the basic principle is like this, say then we would come to say intermittent, intermittent and intermittent but intermittent and medium to, medium to high intensity, intensity rainfall. So, you have the value like say, say that the value that we have said is about 600, so 600, 400 like this, 400 it can be finally say you know in some portion it can be even 200 or 10 or 100 like this. So, these are known as the isoerodents.
(Refer Slide Time: 00:41:48 min)



This isoerodents are generally found out and depending on that the value of the rainfall factor and the rainfall factor values, factor values can be between 800 to say 200 for, 200 for say 200 or say even 50 say 50 you can write 50 for Indian, Indian locations okay. So, you have a high dispersion of rainfall in India, we have several areas which are always under drought, there are several areas where there are heavy rainfall. So, we have a wide variety of you know rainfall factor that is possible, this is how the rainfall factor is identified, this is how the rainfall factor is established okay all right. Then comes the, this much is clear, isn't it. This is clear, somewhat clear, so rainfall factor values are like this. I will give you in the during the tutorial class I will give you more about this how this rainfall type is generally found out, the basic principle is this.

Soil erodibility factor, soil erodibility factor, this soil erodibility factor, this soil erodibility factor depends on this three properties of the soil, three properties of the soil. This is you know firstly is a one part of the texture and function of, function of texture that is percent silt plus percent very fine sand, very fine sand, percent silt plus very fine sand. You remember you know in the soil classification that I said you know the USDA, US department of agricultural, agriculture soil classification is somewhat different from the European and universal systems you know we can see that there, there the percent silt and very fine sand, function of texture if you know this and then we can also this and also another is this percent sand, percent sand and then goes to this, from also, this also is about the soil structure, soil structure and permeability and permeability okay and permeability. And also you know this is one thing I missed here soil organic matter, soil organic matter, soil organic matter, soil organic matter, so soil organic matter these are the things you know which play their role into the computation in the calculation of this soil erodibility factor.

(Refer Slide Time: 00:45:41 min)



Let me give a brief example you know we how this soil erodibility factor can be found out here. Just see this, just see this you know this particularly soil erodibility nomograph K, for K we find out this is from a very standard reference which mayor Handsmith prediction or predicting soil erosion losses, USDA agricultural handbook. You see here that if you just try to observe this you know try to observe these values here, you see this, this part is percent very fine sand percent silt. Can you read this? This can be, this is readable very very fine sand, very percent silt plus this… the percent sand would be about percent sand about say about 5%, this one is 5%. This you have found out, these are experimental values, you have found out so you find a plot where this plot cuts with this 65% line.

So, here is the point, here is the point that you can find out. Can you, can you see this? What we are trying to find out? We know what values, we know we need to know the, the values that we need to know is percent, percent silt and very fine sand. We know that also we know what is the percent sand we have. So, the soil, the percent sand is the sand of size 0.1 to 2 mm, 0.1 to 2 mm percent sand we know. So, if it is 65% so you know it is talking about a very fine soil mostly the very fine soil and having say 5% percent sand.

Rest of the material, rest of the material would be clay and other grabbles and things like that. So, here you can see, so 65% and plus 5 %... organic matter in the soil, percentage organic matter in the soil. What is the percentage organic matter in the soil? Say the percentage organic matter in the soil we have found out say at 3% okay, 3%. So, this value is where this is the dotted line where it this one if you run this parallel to this line, this one where it cuts okay then from here onwards this gives you the first approximate value of K. The first approximate value of K here you can very well find out it to be about 0.28. Isn't it? 0.28, isn't it? This way you can find out. Now here try to say this what, these are experimental values that we have found out sand, silt, clay and organic matter we know that. So, from that we can have a first approximation of the value of K. This K needs to be further refined, the value of K needs to be further refined. So, what we do for to further refine this value of this K, what we do is we generally run to the map for soil structure which is given as 1 2 3 4 one is given as very fine granular, very fine granular soil structure, fine granular, medium or coarse granular blocky, platy or massive. So, here our soil comes under fine granular, as you can see most of the fines and silt constitutes most of the soil. So, this one is two, these two here, so here it is getting connected here as this value of two here, it is connecting to this line of two soil structure, two soil structures, two.

So, here from there as we drop it down further, we finally find out this permeability connect with the permeability value 6 5 4 3 2 1, this 6 5 4 3 2 1 values you can see the very slow, slow, slow to medium, medium to moderate, moderate to rapid, what should be this soil understanding from this soil, what we can find out is this soil should have a very slow I mean slow to moderate or required slow permeability because most of the constituents are silt and sand. So, here this is where it connects here again and at this point, what is this one is basically the value of 4 permeability. The 4 permeability is nothing but here as you can observe here 4, this 4 when again brought back connected to this, we find the final soil erodibility factor, the final soil erodibility factor as 0.3. So, what we started was with 0.28. We have refined the value to 0.3. So, the value of, so the value of K in the nomograph would be 0.3. So, you have found out two values R and K, LSCP will find out later in the class. So, in the next, next day will find out the value of LSCP and also I will show about how for a soil, we can determine the value of, determine the value of its soil erosion potential.