

**Irrigation and Drainage**  
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**Lecture - 40**  
**Tutorial**

Hello this is the lecture number 40 on Tutorial. So whatever we learned in the last, I mean last few or four lectures on this week, we are going to see some of the problems which are frequently asked in I mean GATE examination and other competitive examinations and also some additional problems.

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**Example W8.1:**  
If an irrigation water source has the concentrations of  $\text{Na}^+$ ,  $\text{Ca}^{++}$  and  $\text{Mg}^{++}$  as 28, 10 and 5 milliequivalents per litre, respectively, then the Sodium adsorption ratio (SAR) of this water is (Gate 2015)

**Solution:**  
Sodium Adsorption Ratio (SAR)

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$
$$SAR = \frac{28}{\sqrt{\frac{10+5}{2}}}$$

= 10.22 milliequivalents per litre (Ans.)

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Let us see so here, for example in this example, if you see if an irrigation water source has a concentration of sodium, calcium and magnesium, so 28, 10 and 5 milliequivalents per litre, right respectively. So, then the sodium absorption ratio SAR- S A R of this water is so this is a direct formula based what you call the problem.

So, the values are given. if you know the problem; I mean the equation of SAR which is equal to sodium, plus divided by square root of calcium, plus magnesium by 2, so this will give a SAR value. So the values are given, sodium milliequivalents per litre 28, whereas calcium 10 and magnesium 5. So putting all, the values the SAR value is equal to 10.22 milliequivalents per litre ok.

So, remember this formula. So if you this is since the formula is available you can directly put the values and get the answer.

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**Example W8.2:**  
 A tile drainage system draining 12 ha flows at the design capacity for two days in response to a storm. If the system is designed using a drainage coefficient of 1.25 cm the amount of water removed from the drainage area during two days is (GATE 2008)

**Solution:**  
 Given,  $A = 12 \text{ ha} = 12 \times 10^4 \text{ m}^2$   
 drainage coefficient = 1.25 cm = 0.0125 m

Drainage coefficient =  $\frac{Q}{A}$   
 $0.0125 = \frac{Q}{12 \times 10^4} = 1500$   
 $= 1500 \text{ m}^3/\text{day}$   
 $= 3000 \text{ m}^3 \text{ in two days}$

Diagram: A rectangular area with a drainage coefficient of 1.25 cm/d.

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And, then the example 2: which is given in 2008 GATE exam. So a tile drain system draining 12 hectare of flows at the design capacity for two days in response to a storm ok. So, if the system is designed using a drainage coefficient of 1.2 centimetre, so remember the drainage coefficient is the depth of water being drained from a particular area during 24 hours ok.

So, the amount of water removed from the drainage area during two days right. So, for one day the drainage coefficient that is 1.25 centimetre a day right. So this is the drainage coefficient of the particular area. So that means, if you have an area, so this results is 1.25 centimetre per day. So, in two days how much, so right?.

So area is given 12 hectares, so 12 into 10 power 4 metre square and drainage coefficient 1.25 centimetre. So, drainage coefficient is equal to Q by A right, so the discharge we need to find out what is the discharge. So, the Q we do not know and this is known ok. So, knowing this and this we have to find out Q.

So, drainage coefficient for 0.0125 Q by area is given right, and then so that that will give 1500 so, the Q is equal to 1500 metre cube per day, but for two days this is 3000 metre cube in two days.

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**Example W8.3:** *FC* A soil has a field capacity of 25%, *PWP* permanent wilting point of 11% and *FC-PWP* *SG* apparent specific gravity of 1.6. Irrigation is applied after depletion 40% of the available moisture to crop with root zone depth 600 mm, electrical conductivity of the saturation extract of the soil is 10 mmho/cm and that of the irrigation water is 2.5 mmho/cm. Determine the leaching requirement and the total depth of the irrigation. (GATE 1998)

**Solution:**  
Given,  
Field capacity (FC)= 25%  
Permanent wilting point (PWP) =11%  
Specific gravity (SG)= 1.6

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So, then the example 3; so the soil has a field capacity 25 percent right, so this is FC, and permanent wilting point so that is permanent wilting point, which is 11 percent and apparent specific gravity, right specific gravity SG so which is equal to 1.6. The irrigation is applied after depletion of 40 percentage of available moisture,. So the available moisture, so that is field capacity minus permanent wilting point, so that will give the available moisture. And to crop with the root zone depth of 600 mm. So, electrical conductivity of saturated extract of the soil is 10 millimole per centimetre and that of irrigation water is 2.5 millimole per centimetre. So determine the leaching requirement and the total depth of irrigation.

So, what is the leaching requirement and the total depth of irrigation for this situation, so here this is the deficit irrigation case. So the field capacity is given 25 percent permanent wilting point 11 percent and SG that is a specific gravity of 1.6 percent ok.

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Root zone depth (RZ) = 600 mm ✓

Electrical conductivity of the saturation extract of the soil = 10 mmho/cm

Irrigation water Electrical conductivity = 2.5 mmho/cm.

Moisture content at the time of irrigation  
 ✓ =  $(FC - PWP) \times \text{depletion in moisture}$

Moisture content at the time of irrigation =  $(25 - 14) \times 0.4$   
 = 19.4% ✓

Irrigation requirement =  $\frac{(FC - PWP) \times SG \times RZ}{100}$

Irrigation requirement =  $\frac{(25 - 19.4) \times 1.6 \times 0.6}{100}$

Handwritten notes: 25%, 19.4%, Impression

So, then next is so you estimate the available moisture content ok. So, the root zone depth is given 600 mm, electrical conductivity of saturation extract of soil, that means what is the salinity level in the soil and then irrigation water electrical conductivity, that is 2.5 millimole per centimetre ok.

So, the moisture content at the time of irrigation so, that means field capacity permanent wilting point and depletion. So, this is when the situation occurs at this water level, there you are going to irrigate ok. The moisture content at the time of irrigation which is equal to field capacity minus permanent wilting point and multiplied by 40 percent depletion, so that will be 19.4 percent. So when the moisture content depletes from 45 to 19.4 percent so then you are going to irrigate: so then irrigation is given ok. So, then irrigation requirement which is equal to: so this is permanent wilting point sorry, this is available water, multiplied by SG multiplied by root zone by 100, so that will be irrigation requirement.

So here, so it is not basically permanent wilting point, so this should be your available, I mean the moisture and threshold moisture contents 19.4. So at this point, we are going to irrigate like 25 minus 19.4 into root zone, sorry root zone depth and then SG specific gravity by 100 will give the irrigation requirement.

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$$\text{Irrigation requirement} = \frac{5.376}{100}$$

$$\text{Irrigation requirement} = 0.05376 \text{ m}$$

$$LR = \frac{EC_{iw}}{5 \times EC_{ew} - EC_{iw}}$$

$$LR = \frac{2.5}{5 \times 10 - 2.5} = 0.053$$

$$\text{Depth of water applied (AW)} = \frac{\text{Irrigation requirement (IR)}}{1 - LR} = \frac{5.376}{1 - 0.053}$$

$$= 5.68 \text{ cm (Ans.)}$$

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So that means irrigation water depth of irrigation water; so that will be. So irrigation requirement is 0.05376 metres ok. So the leaching requirement, which is equal to EC iw by 5 into EC ew minus EC iw, so this is the formula for irrigation requirement; sorry leaching requirement. So leaching requirement, so it is a 2.5 for irrigation water it is given, and then this a millimole per second, and then 5 for 5 is a multiplier multiplication, and EC ew 10 and EC iw 2.5 and it gives a leaching requirement is 0.053 and depth of water applied.

So, there is a formula for depth of water applied is equal to irrigation requirement, divided by 1 minus LR leaching requirement. So, we know irrigation requirement and 1 minus 0.053, so this will give 5.68 centimetre depth of water applied ok.

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**Example W8.4:**  
 An agricultural soil contains 47% pore space, and the moisture content after gravity drainage is 39% (by volume). Find the void ratio, drainable porosity, and drainable water volume from a 20 m × 15 m plot having 1.0 m root zone depth.

**Solution:**

**Given,**  
 Volume of void = 47% ✓  
 water content after gravity drainage = 39% ✓

We know,

$$\begin{aligned} \text{void ratio} &= \frac{\text{volume of void}}{\text{volume of solid}} \\ &= \frac{\text{volume of void}}{(100 - \text{volume of void})} \\ &= \frac{47}{(100 - 47)} \\ &= \underline{0.886} \end{aligned}$$

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Ok Now example 4: so here there is an agricultural soil contains 47 percent pore space, the moisture content after gravity drainage is 39 percent ok. So, initially it is a 47 point pore space then, after gravity then it 39 percent, so this mean by this is by volume. Find the void ratio, drainable porosity and drainable water volume from a 20 meter by 20 meter plot having 1 meter zone depth ok.

So in this 47 pore space is given, then moisture content after gravity drainage is 39 percent, that means this is field capacity level; void ratio, and drainable porosity, and drainable water volume. So, void ratio is volume of void divide by volume of solids that give the volume void ratio. And drainable porosity: so drainable porosity is the water which is drain water per unit depletion in water table, ok.

So, the volume of void 47 percent 39 percent once the gravity is done, so what it return soil water returns 39 percent we know. So the void ratio is equal to volume of void, divided by volume of solid; volume of void, this volume of solids can be written as 100 minus volume of voids. So 47 percent is given, divided by 100 minus 47 it will give 0.886 is the void ratio.

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$$\begin{aligned}
 \text{Drainable porosity} &= \text{total porosity} - \text{water content after gravity drainage} \\
 &= 47 - 39 \\
 &= 8\%
 \end{aligned}$$

$$\begin{aligned}
 \text{Drainable water volume} &= \text{drainable porosity} \times \text{drainable soil volume} \\
 &= (8/100) \times (20 \times 15 \times 1 \text{ m}^3) \\
 &= 24 \text{ m}^3 \text{ (Ans.)}
 \end{aligned}$$

And then, so next is the drainable porosity, so which is the total porosity minus water content after gravity drainage. So, this is the another formula, that is a 47 minus 39 8 percent ok. And drainable water volume: so drainable porosity into drainable soil volume. So, drainable porosity 8 percent so that is here and drainable soil volumes so that will be the 20 into 15, this is called area. And the depth is 1 metre so, the total is the 24 metre cube is the drainable water volume.

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**Example W8.5:**

Runoff water from the watershed enters into a drainage area for 5 hours at the rate of 24 m<sup>3</sup>/s. The total rainfall during 24 h periods is 10 cm and infiltration during the same periods is 2 cm. If the total drainage area is 500 ha and the crop can tolerate a ponding of 14 cm, calculate the drainage coefficient of the land.

**Solution:**

$$\begin{aligned}
 \text{Total volume entering the area in 5 hours} &= 5 \times 3600 \times 24 = 432000 \text{ m}^3 \\
 \text{This is equivalent to a depth} &= \frac{432000}{500 \times 10000} = 0.864 \text{ m} \\
 &= 8.64 \text{ cm} \\
 \text{Total depth input on the area} &= (10 - 2) + 8.64 \\
 &= 16.64 \text{ cm}
 \end{aligned}$$

Ok Then the fifth example here: so the runoff water from the watershed enters into the drainage area for 5 hours at the rate of 24 metre cube per second. So, the total rainfall during 24 hour period is 10 centimetre, and infiltration during the same period is 2

centimetre. So, if the total drainage area is 500 hectare and the crop can tolerate ponding of 14 centimetre; so calculate the drainage coefficient of the land.

So, in this example, so there is a there is a land here right and this is of course the drainage area ok. So in this land, you are precipitation and also you got infiltration and this is runoff ok. So here 24 metre cube, so the runoff from the watershed enters into the drainage area for 5 hours at the rate 24 metre cube per second. So the from this area, so there is a 24 metre cube per second, drainage water is taking place into the drainage area.

And then, the rainfall 24 hours is 10 centimetre, this is 10 centimetre in one day at the same time 2 centimetre is I mean infiltrating down. If the total drainage area is 500 hectares, so this is 500 hectares ok, and the crop tolerance ponding 14 centimetre calculate the drainage coefficient of the land, so let us see is well how, So, the total volume entering the area in 5 hours is 5 multiplied by 3600, that is in seconds and 24 metre cube per second. So, that will give the 43200 metre cube and this is equivalent to a depth so that means, volume divided by area so you get this is the depth of water which is going as a drainage.

And the total depth input in the area: so 10 is the rainfall infiltration right, so this is in 24 hours runoff to the drainage area, and then 8.64 is the usual drainage, 8.64. So the total will be 16.64 centimetre going to the drainage; going as drainage.

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Therefore,

$$\begin{aligned} \text{Depth of water to be removed} &= \text{depth input} - \text{depth of infiltration} - \text{depth of ponding allowed} \\ &= 16.64 - 14 \\ &= 2.64 \text{ cm (Ans.)} \end{aligned}$$

This is the drainage co-efficient of the land

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And then so therefore the depth of water to be removed, because the total is 16.64 right; the depth of water, but 14 centimetre is depth of ponding is allowed. So that that means, 16.64 minus 14, that will be 2.64 centimetre. So this is the drainage coefficient of the land, because this is in 24 hours. So, the depth 2.64, we are allowing if you can allow a I mean I mean, if you can drain 2.64 centimetre from that area in 24 hours. So, that is sufficient for growing the crops ok.

So with this, these examples, we finished the tutorial for this week. So, this week, we covered the soil salinity and then sodicity ok. And then the third week third lecture on the drainage agricultural drainage concept and then the agricultural drainage, the introduction so and then the tutorial today's tutorial. So in the next week, we are going to focus on the drainage design, both surface and subsurface drainage and then the tutorials and the case studies. So, all will be coming up.

Thank you.