Basic Environment Engineering and Pollution Abatement

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Lecture: 50

Tutorial 10

Hello everyone. Now, we will have a tutorial session and we will solve some numerical problems on the basis of discussion we have made in last 4 classes.

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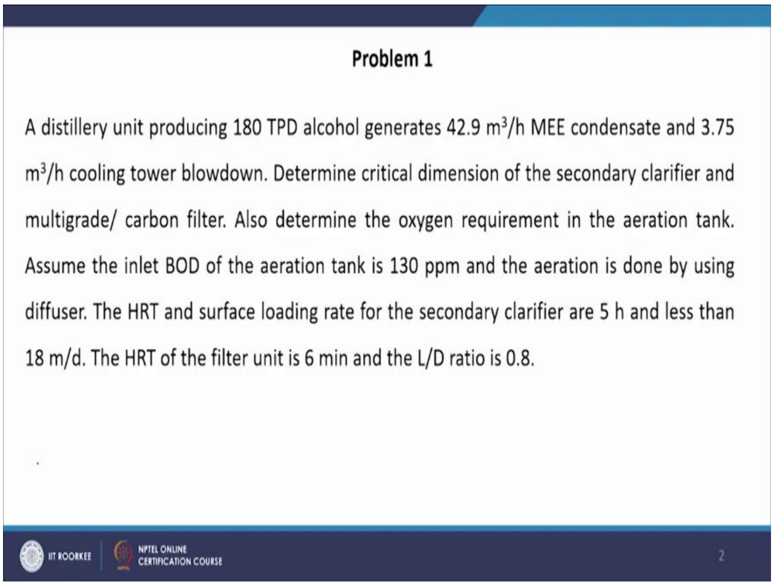

Our first problem, statement is a distillery unit producing 180 TPD alcohol generates 42.9 m^3/h MEE condensate that is multi-effect evaporator condensate and 3.75 m^3/h cooling tower blowdown. Determine critical dimension of the secondary clarifier and multi-grade or carbon filter. Also determine the oxygen requirement in the aeration tank. Assume the inlet BOD of the aeration tank is 130 ppm and the aeration is done by using diffuser. The HRT and surface loading rate for the secondary clarifier are 5 hour and less than 18 m/d that is m^3/m^2day. The HRT of the filter unit is 6 minute and the L by D ratio is 0.8.

So, now, we have to solve this problem. And we know that this problem is basically based on the treatment of wastewater in a distillery unit and in this case, as MEE condensate is there that means thermal process is used for the condensation of spent wash.

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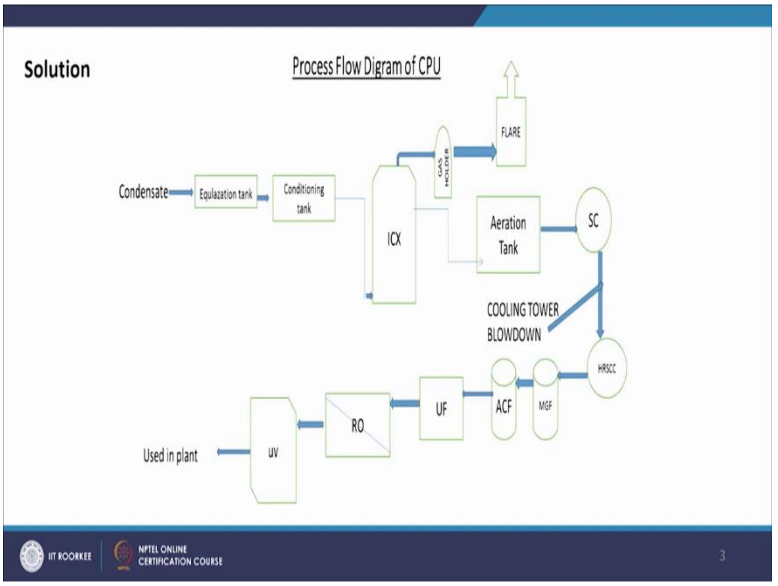

And you see the flow sheet for the water treatment. So, we have MEE condensate. So, this condensate is coming into the equalization tank and then equalization tank to conditioning tank. So, here pH adjustment takes place and then it is going to ICX that is biological tower. So, here anaerobic condition prevails and biogas is produced and the gas is lost, it is flared. Through the flaring the gas is burnt and the water which is coming out from ICX goes to aeration tank and in aeration tank oxygen is supplied microbial seeds are provided and remaining organic compound present in the water is degraded here.

So, we have to calculate the oxygen requirement in this tank and after this the treated water goes to secondary clarifier and the water enters into the HRSCC and the sludge goes for dewatering into a decanter. And another water stream that is provided in the problem statement that is cooling tower blowdown. So, that directly does not enter into the equalization tank. It enters here with the treated water after secondary clarifier and then in the HRSCC both streams are added.

So, here HRSCC we are getting another settling, so the clarified liquid is passed through the tertiary treatment unit. So, this is our MGF and ACF, multi grade filter and activated carbon filter then it goes to UF, RO, UV and then used in the plant. So, we have to find out the dimension of this ACF and MGF. We have to find out the dimension of this SC, secondary clarifier and we also have to calculate the oxygen requirement in this aeration tank. So, these are the task we need to complete.

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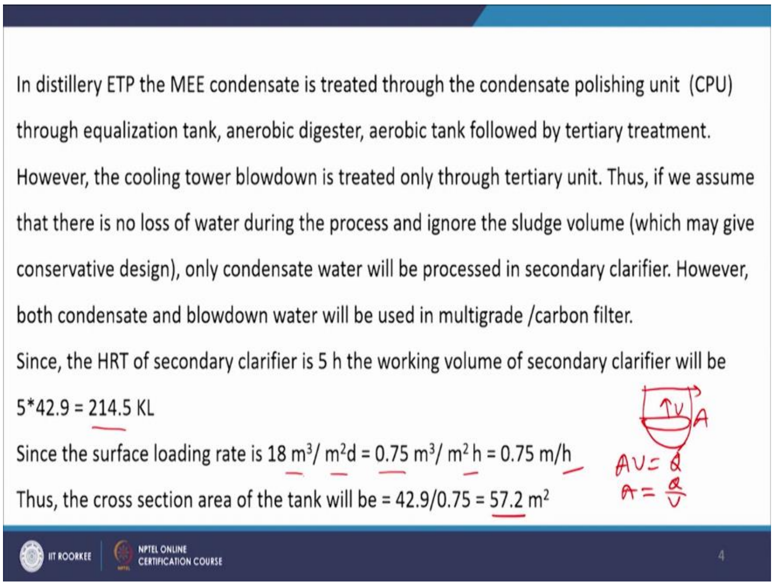

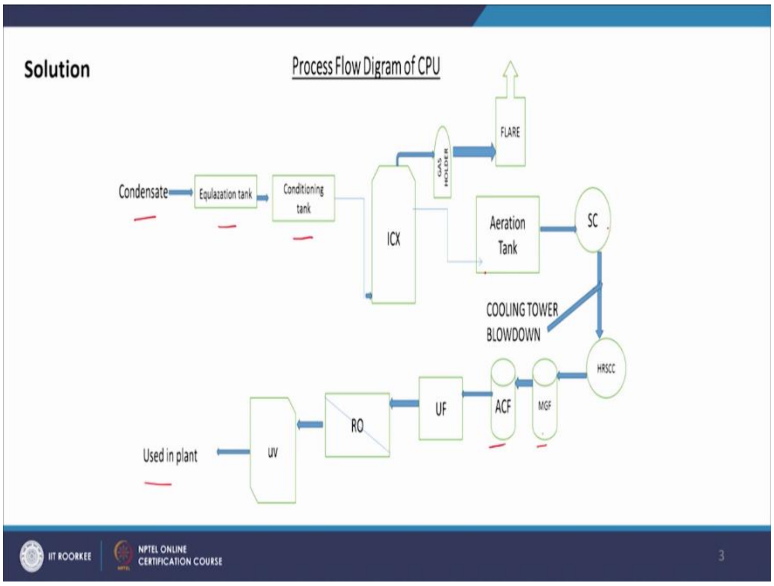

Now you see, in distiller ETP, the MEE condensate is treated through the condensate polishing unit through equalization tank, anaerobic digester, aerobic tank followed by tertiary treatment. However, the cooling tower blowdown is treated only through tertiary unit. Thus, if we assume that there is no loss of water during the process and ignored the sludge volume only condensate water will be processed in secondary clarifier. However, both condensate and blowdown water will be used in multi grade and carbon filter.

Now, we have taken one assumption that we are assuming that the sludge volume is negligible. So, although there will be some sludge production, but by this assumption the design will be more conservative, so, there will be no harm.

Now, since that HRT of the secondary clarifier is 5 hour. The working volume of the secondary clarifier will be 5*42.9 = 214.5 KL.

Since the surface loading rate is 18 m^3/m^2day = 0.75 m^3/m^2-h = 0.75 m/h.

Thus, the cross-section area of the tank will be A = Q/V= 42.9/0.75 = 57.2 m^2

So, if we get the value of area then we can get the diameter.

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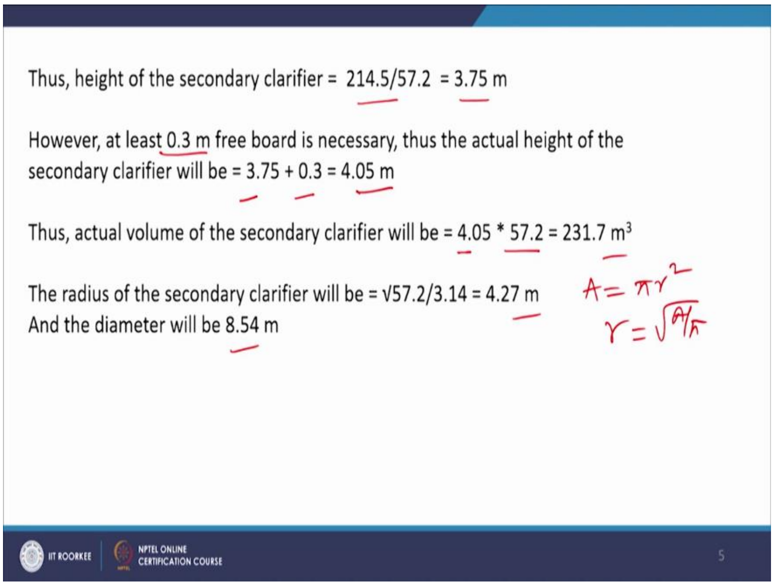

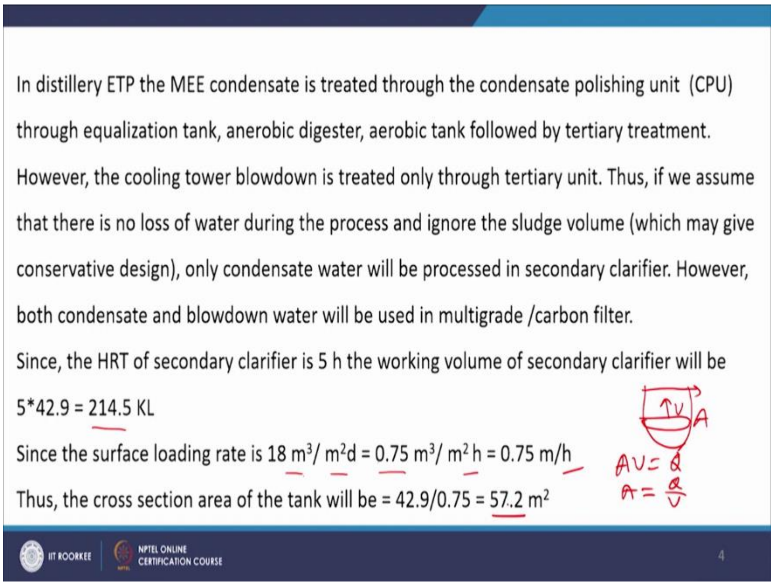

Thus, height of the secondary clarifier = 214.5/57.2 = 3.75 m

However, at least 0.3 m freeboard is necessary, thus the actual height of the secondary clarifier will be = 3.75 + 0.3 = 4.05 m

Thus, the actual volume of the secondary clarifier will be = 4.05 * 57.2 = 231.7 m^3

The radius of the secondary clarifier will be = $\sqrt{57.2/3.14} = 4.27$ m

And the diameter will be 8.54 m

So, one problem is solved.

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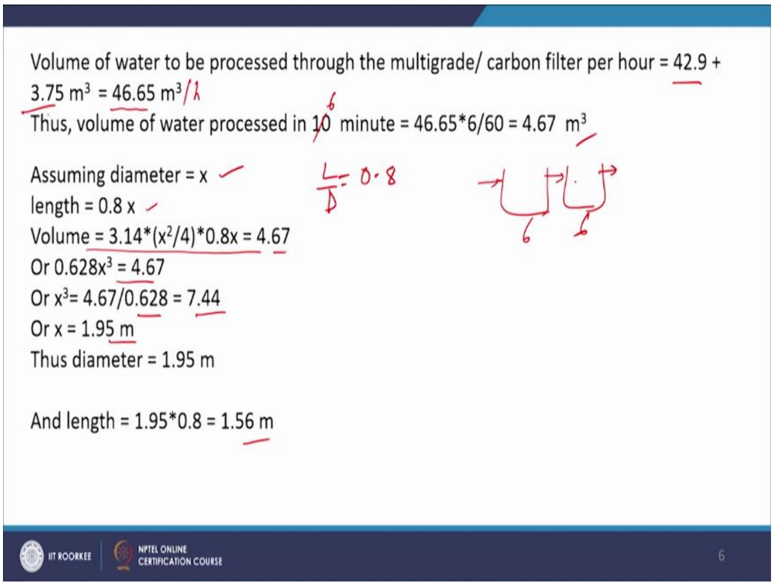

Now, in the second case, we have to find out the dimension of the filter units. So, in this case it is a unit of tertiary treatment. So, both condensate and the blowdown water will be passing through it.

The volume of water to be processed through the multigrade/ carbon filter per hour = 42.9 + 3.75 m^3 = 46.65 m^3

Thus, the volume of water processed in 6 minutes = 46.65*6/60 = 4.67 m^3

Assuming diameter = x

length = 0.8 x

Volume = 3.14*(x^2/4)*0.8x = 4.67

Or 0.628x^3 = 4.67

Or x^3= 4.67/0.628 = 7.44

Or x = 1.95 m

Thus diameter = 1.95 m

And length = 1.95*0.8 = 1.56 m

So, now, we are able to find out the dimension of each filter unit.

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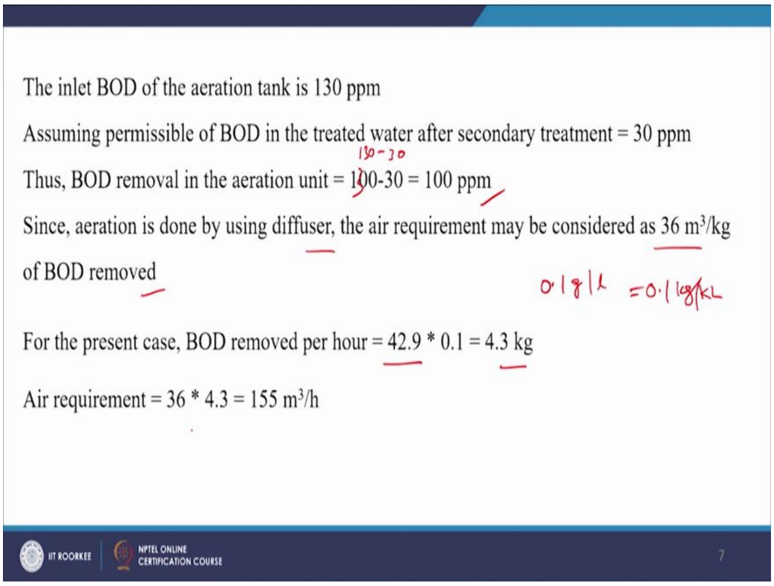

Next part, we have to find out the air requirement in the aeration chamber. So, in the aeration chamber, we have seen that the wastewater after treatment in the bio tower it enters into the aeration chamber.

The inlet BOD of the aeration tank is 130 ppm

Assuming permissible of BOD in the treated water after secondary treatment = 30 ppm

Thus, BOD removal in the aeration unit = 100-30 = 100 ppm

Since, aeration is done by using diffuser, the air requirement may be considered as 36 m^3/kg of BOD removed

For the present case, BOD removed per hour = 42.9 * 0.1 = 4.3 kg

Air requirement = 36 * 4.3 = 155 m^3/h

Now, we are able to solve the problem completely.

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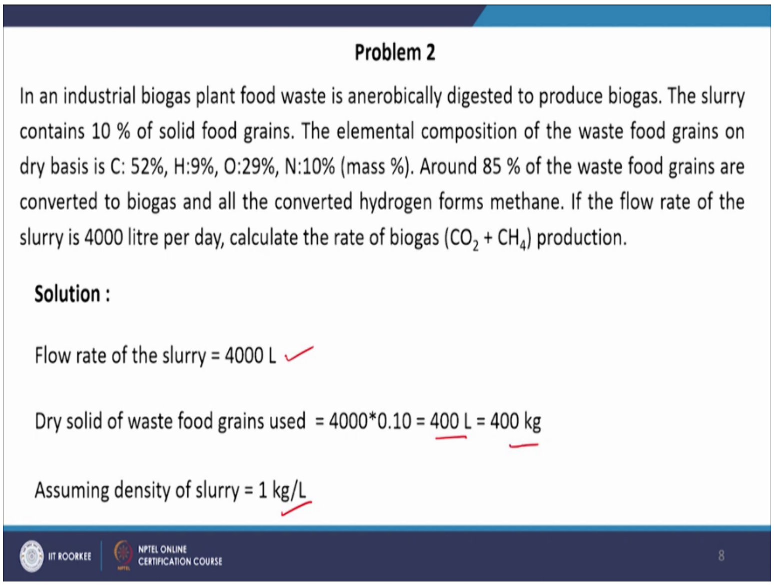

Now, we will see the problem number 2. Statement is in an industrial biogas plant food waste is anaerobically digested to produce biogas. The slurry contains 10 % of solid food grains, the elemental composition of the waste food grains on dry basis is carbon 52 %, hydrogen 9 %, oxygen 29 %, nitrogen 10 % on mass bases. Around 85 % of the waste food grains are converted to biogas and all the converted hydrogen forms methane. If the flow rate of the slurry is 4000 L/day. Calculate the rate of biogas that is (CO_2 + CH_4) production.

So, this is one another problem related to anaerobic digestion and we have to calculate the rate of biogas production. The composition is given and the C, H, N, S for elemental analysis is also given.

Flow rate of the slurry = 4000 L
Dry solid of waste food grains used = 4000*0.10 = 400 L = 400 kg
Assuming density of slurry = 1 kg/L

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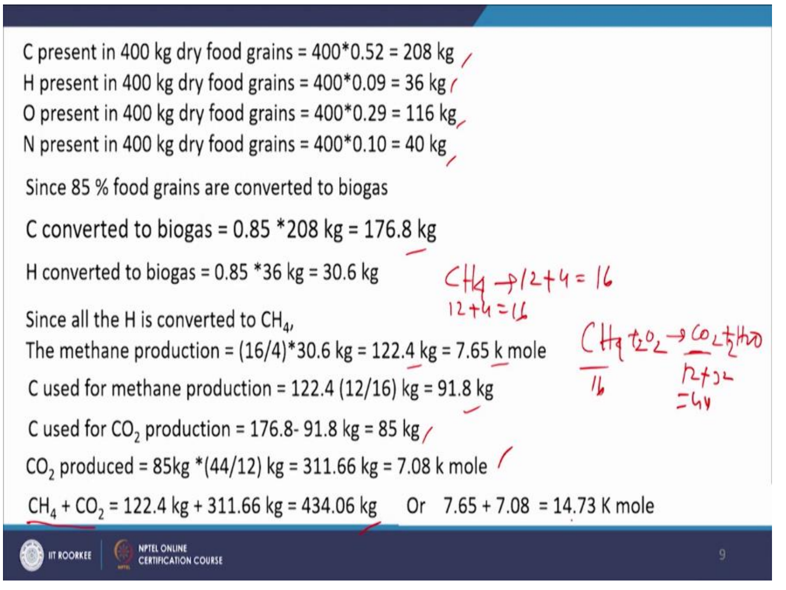

C present in 400 kg dry food grains = 400*0.52 = 208 kg

H present in 400 kg dry food grains = 400*0.09 = 36 kg

O present in 400 kg dry food grains = 400*0.29 = 116 kg

N present in 400 kg dry food grains = 400*0.10 = 40 kg

Since 85 % of food grains are converted to biogas

C converted to biogas = 0.85 *208 kg = 176.8 kg

H converted to biogas = 0.85 *36 kg = 30.6 kg

Since all the H is converted to CH_4,

The methane production = (16/4) *30.6 kg = 122.4 kg = 7.65 k mole

C used for methane production = 122.4 (12/16) kg = 91.8 kg

C used for CO_2 production = 176.8- 91.8 kg = 85 kg

CO_2 produced = 85kg *(44/12) kg = 311.66 kg = 7.08 k mole

CH_4 + CO_2 = 122.4 kg + 311.66 kg = 434.06 kg or 7.65 + 7.08 = 14.73 K mole

So, 14.73-kilo mole gases will be present in the produced biogas.

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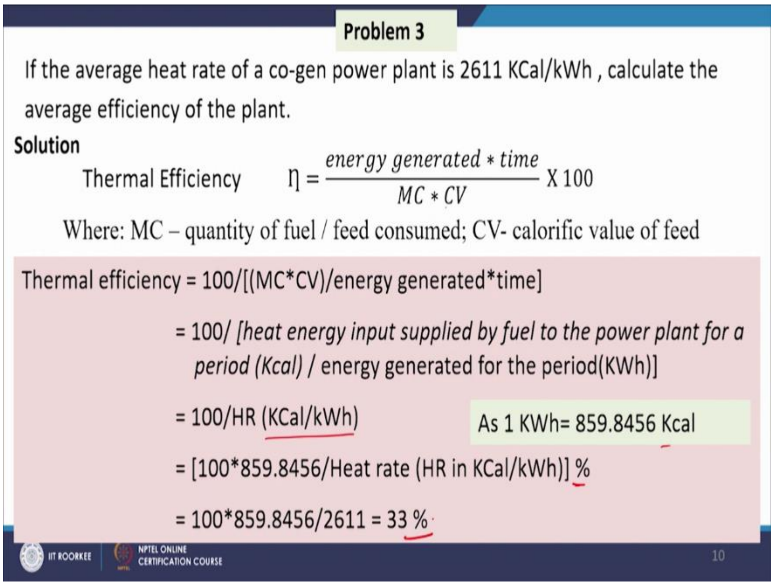

Now, problem number 3. Statement is the average heat rate of a co-gen power plant is 2611 kCal/KWh. Calculate the average efficiency of the plant.

So, we have discussed in our previous class also that thermal efficiency

Thermal Efficiency Ƞ=(energy generated*time)/(MC*CV) X 100

Where: MC – quantity of fuel / feed consumed; CV- calorific value of feed

Thermal efficiency = 100/[(MC*CV)/energy generated*time]

= 100/ [heat energy input supplied by fuel to the power plant for a period (Kcal) / energy generated for the period (KWh)]

= 100/HR (KCal/kWh) As 1 KWh= 859.8456 Kcal

= [100*859.8456/Heat rate (HR in KCal/kWh)] %

= 100*859.8456/2611 = 33 %

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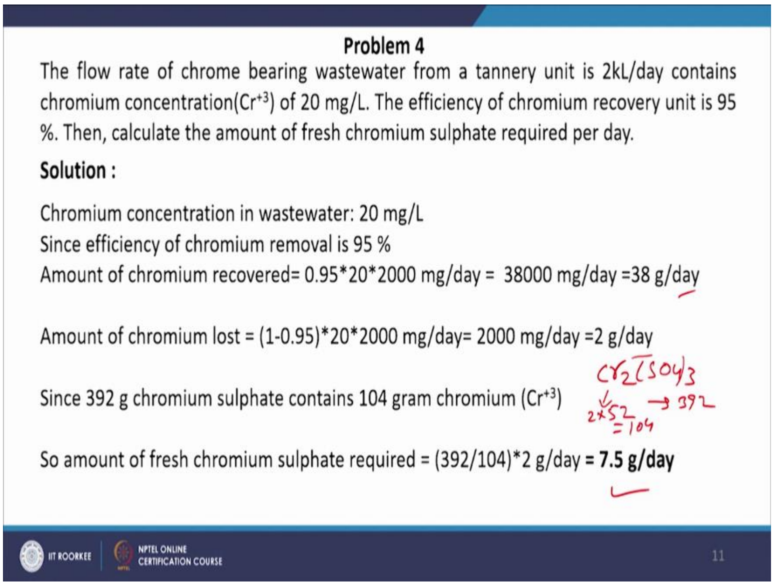

Next problem number 4. The statement is the flow rate of chrome bearing wastewater from a tannery unit is 2 kL/day contains chromium concentration or Cr^{3+} of 20 mg/L. The efficiency of chromium recovery unit is 95 %. Then calculate the amount of fresh chromium sulphate required per day.

So, this is a problem related to chromium recovery in a tannery unit

Chromium concentration in wastewater: 20 mg/L

Since the efficiency of chromium removal is 95 %

Amount of chromium recovered= 0.95*20*2000 mg/day = 38000 mg/day =38 g/day

Amount of chromium lost = (1-0.95)*20*2000 mg/day= 2000 mg/day =2 g/day

Since 392 g chromium sulphate $Cr_2(SO_4)_3$ contains 104-gram chromium (Cr^{+3})

So amount of fresh chromium sulphate required = (392/104)*2 g/day = 7.5 g/day

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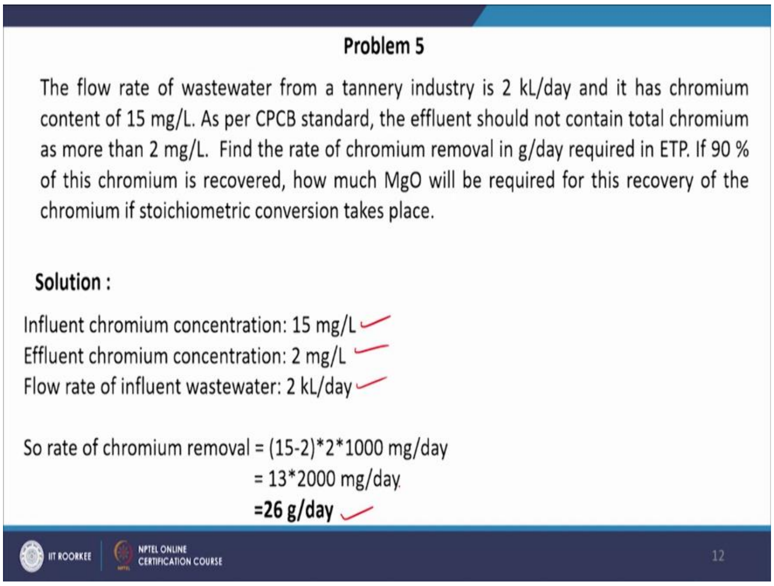

And next, we are coming to volume number 5. And the statement is the flow rate of wastewater from a tannery industry is 2 kL/day, and it has chromium content of 15 mg/L. As per CPCB standard the effluent should not contain total chromium has more than 2 mg/L. Find the rate of chromium removal in gram per day required in ETP. If 90 % of this chromium is recovered, how much MgO will be required for this recovery of the chromium if stoichiometric conversion takes place.

So, here we will see that how much chromium is removed. So, that chromium removal may be taking place at the chromium recovery unit or in the effluent treatment plant.

We are assuming this that some part is recovered and some part is being removed in a treatment unit.

Influent chromium concentration: 15 mg/L

Effluent chromium concentration: 2 mg/L

The flow rate of influent wastewater: 2 kL/day

So rate of chromium removal = (15-2)*2*1000 mg/day

= 13*2000 mg/day

=26 g/day

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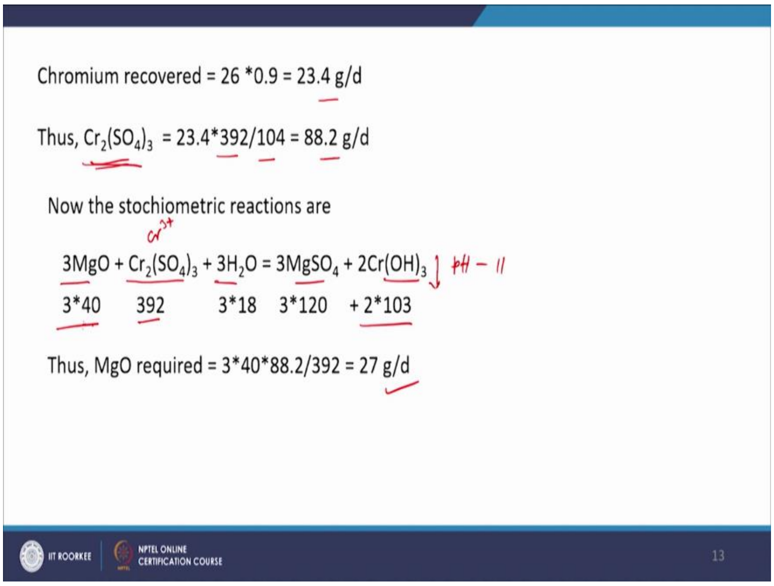

Now, we are considering the 90 % is recovered out of it,

Chromium recovered = 26 *0.9 = 23.4 g/d

Thus, $Cr_2(SO_4)_3$ = 23.4*392/104 = 88.2 g/d

Now the stochiometric reactions are

$3MgO + Cr_2(SO_4)_3 + 3H_2O = 3MgSO_4 + 2Cr(OH)_3$

3*40 392 3*18 3*120 2*103

Thus, MgO required = 3*40*88.2/392 = 27 g/d

So, now we are able to solve this problem also. So, we have solved all the problems in this tutorial class and we have seen that different industries produces different types of pollutants in the wastewater streams.

Now, we will show you one video that will give the working of a sugar industry and I hope you will enjoy it and it will give you more clarification. The video is self-explanatory. Please watch the video.

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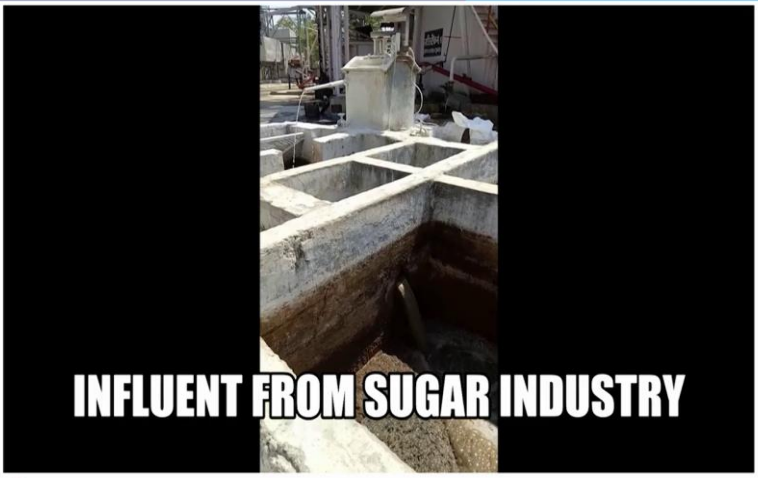

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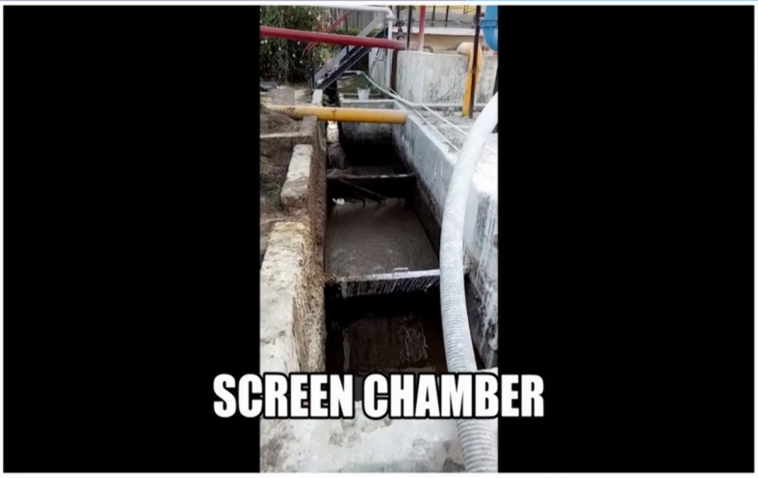

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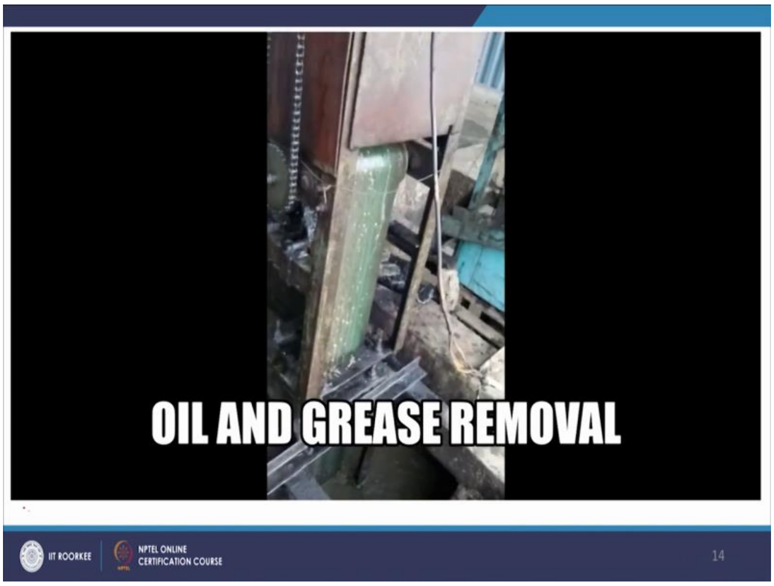
OIL AND GREASE REMOVAL
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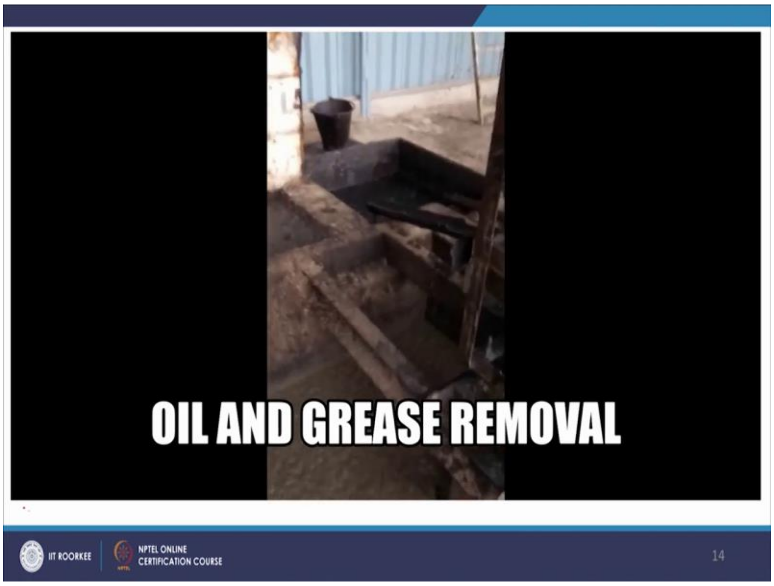
NPTEL ONLINE CERTIFICATION COURSE
14


OIL AND GREASE REMOVAL
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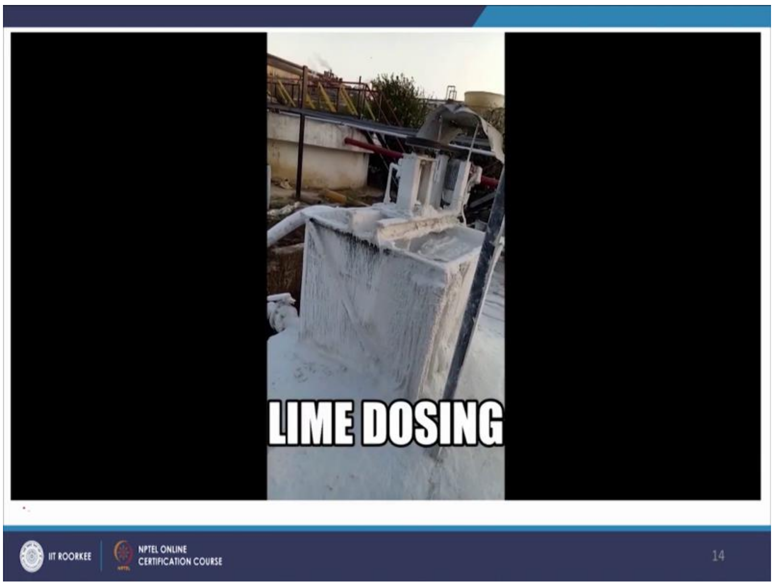
LIME DOSING
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14


AEROBIC TREATMENT


SEDIMENTATION OF SLUDGE


SLUDGE DEWATERING

THANK YOU

Now, I think the video has made many clarity on your thoughts and up to this in this class. Thank you very much for your patience.