Wastewater Treatment and Recycling
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Lecture - 09
Quantity Estimation of Sewage Flow

Hi everyone so, we are into week 2 of the discussions and this week we have been talking about the estimation of sewage flow quantity estimation, we will later on talk about qualitative estimation as well.

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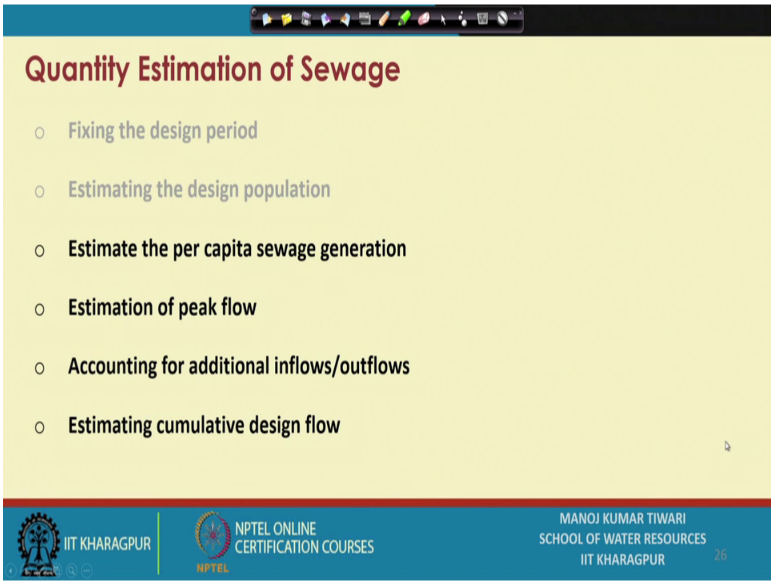

So, just a quick recap that we discussed so far in idea why sewage flow is important and then when we go into the estimating the flow of sewage or estimating an amount of sewage for which sewerage system could be discharged, we discuss the various steps and out of that steps, we did discuss that how we fix the design period using the CPHEEO manual provisions and how we can estimate the design population or what are the various methods for estimating design population.

We will be moving ahead.

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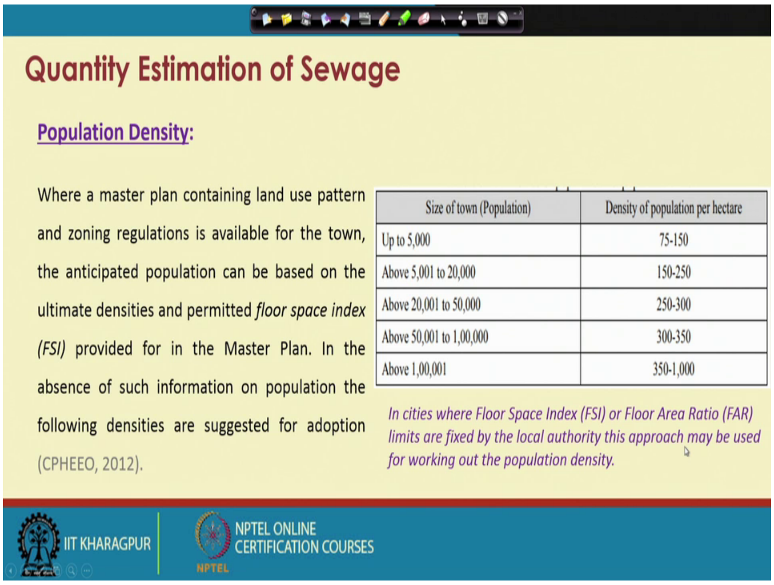

So, when we when we are able to estimate the design population grossly as using the best suitable method, we did discuss several methods in the previous session, which so ever method is most suitable based on the city or based on the edge, area, conditions of the city, we can choose the most appropriate method for designing the for estimating or forecasting the population and thereafter we can have an idea or a estimate of the sewage flow based on the per capita sewage production.

This to act to the population thing we discussed one of the methods as master plan methods when the population densities are fixed. So, once we go on to fixing the density and we know the reason area of the reason it becomes fairly easy to estimate the population. So, population density in a master plan thing can be fixed based on the land use pattern and zoning regulations for the town and the as the manual suggest.

In fact, that it is based on the floors space index or floor area ratio which is FSI or far which limits the sort of area or the population density which limits the population density or which fixes the population density by the local authority local authorities can adopt this approach for fixing a population density and that can be used for working out the population.

So, for say the based on the different size of population these are the different population densities per hectare as our CPHEEO manual recommends ok. So, in absence of any detail information where there is a let us say fixed population density is available the manual suggest that based on the typical size of the town roughly how we can fix up the population densities per hectare under the different conditions.

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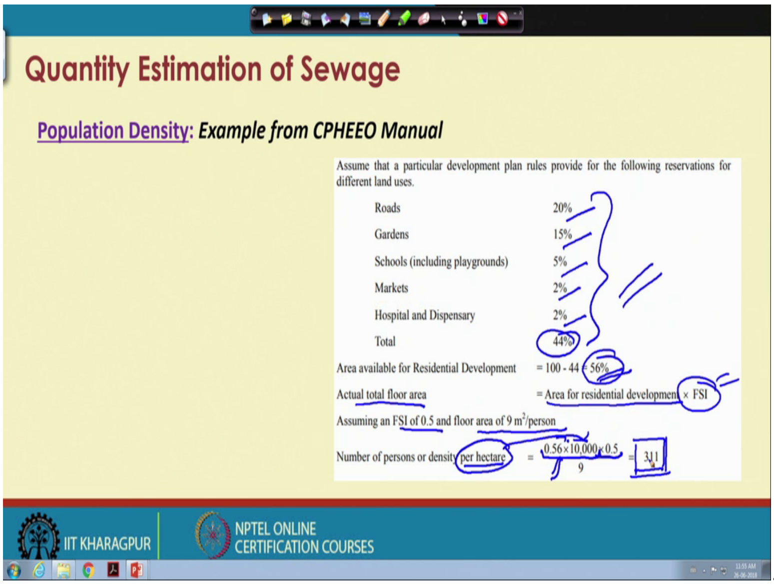

So, like, this is an example from the CPHEEO manual itself so, which says like how we can estimate the population density. So, let us say assume a particular development plan is laid out as such there are 20 percent of the area goes to road, 15 percent to the gardens, 5 percent to the school, 2 percent for market area, 2 percent for hospital and dispensary the medical facilities ok.

So, this if we account total it becomes 44 percent and; that means, the 56 percent area is available for residential development ok. Now the FSI which is basically an actual area in which population resides it is a ratio of actual area to the total available area. So, if FSI is let us say assumed as 0.5 and a total floor area of 9 meter square per person. So, one person let us say occupies 9 meter square of area, now you see that your actual total floor area will be area for the residential development into FSI, this area for residential development is 56 percent of the total available area.

So, if we take if we intend to design the density per hectare. So, one hectare is 10000 square meters of which our FSI is 0.5 so that means, the actual floor area of this in fact, not even this. So, you see that area available for residential development is 56 percent ok, now if area available for residential development is just 56 percent and we are considering a one hectare of area. So, 0.56 into 1 so, this gives this amount gives us the total area available for residential development in 1 hectare.

So, in one hectare; that means, 10000 square metres 56 percent of it means 0.56 of this. So, that becomes 5600 square metres of area will be available for residential development, now if our FSI is 0.5 so; that means, 0.5 we further multiplied because actual floor area will be area for residential development into FSI. So, the actual floor area we need to further multiplied with 0.5 and that gives us 5600 into 0.5 ok. So, ah; that means, 2800 becomes our actual total floor area.

Now, if one person occupies 9 metre square per area. So, what is going to be the population density ok, because in 1 hectare in 1 hectare we have area available as 5800 square metres for actual like residential area for person to be leaving accounting for leaving all other area as well as accounting for FSI. So, of that one person occupies if 9 meter square area so, we divide that area by 9 and then we get the number 311. So, this is going to be the population density of the town or of the zone which we are considering.

So, per hectare the population density in the reason is expected to be 311 numbers ok. So, 311 people are going to live in 1 hectare of area incorporating all these data. So, that is how the manual suggest that we can work out the population density is as well and when we fix the population density and we know what is the total area, for which we need to establish our sewerage system or for that matter water supply or other developmental scheme. So, then we can estimate the design flow or the capacities accordingly because we know that how much total population is going to reside in there.

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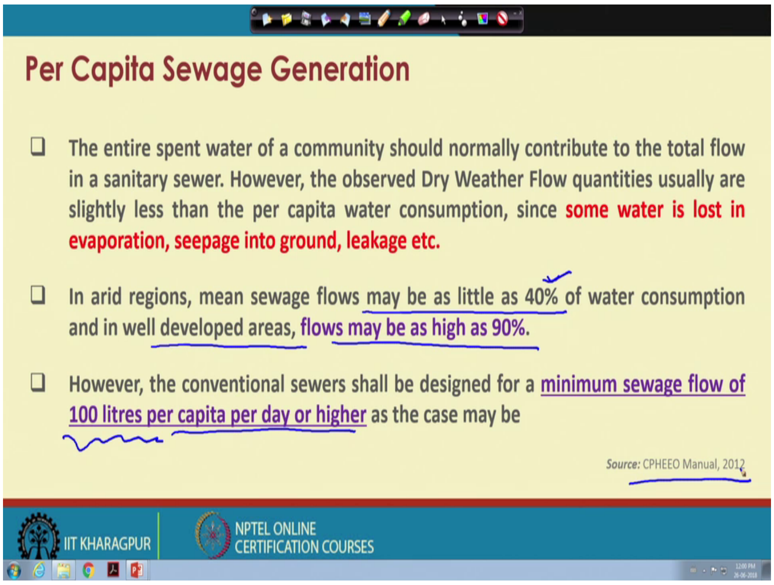

So, once we figure out the population what the next we need is per capita sewage generation because will multiply the total population with the design population with per capita sewage generation in order to estimate the total flow now this estimation of per capita sewage generation is a bit tricky ok, because the entire spent water out of a community. What is sewage, sewage is the water that we have used. So, what is ever our water demand is or, how much water is supplied to us we are using it and eventually discharging it to the sewer lines.

So, theoretically all the water which is consumed by household or a family should lead to the sewer line. So, that way the estimation for the estimating sewage flow the best proposition is to take the water demand or how much water is being supplied. So, the amount of water is being supplied to a household should be amount of sewer generated from that household, but it is not that easy or that simple there are various addition and substraction to this flows due to various different reasons ok. So, what typically is seen that the observed dry weather flow means when we discount for the entries of groundwater of rainfall means particularly the rainwater or storm water.

So, if we discount for the entry of storm water the dry weather flow quantities usually are slightly less than the per capita water consumption. So, what is ever water is consumed is actually not entirely getting converted to the sewer or entirely getting converted to the sewerage. So, there are some water lost in the evaporation, seepage into the ground or leakages and that practically reduces the amount of sewage generated as opposed to the amount of water consumed.

So, this amount of losses or the reduction varies depending on the area, depending on the reason, depending on the water consumption patterns. So, all there are variety of factors that control this and in arid regions or dry reasons it could be as low as just 40 percent of the total water consumption. So, if a household say is consuming 500 litres per day. So, he may just produced 200 litres per day of sewage out of 500 litres of the water consumption ah.

That is the lowest limit typically generally it is as high as 80 to 90 percent and particularly in the well developed areas where there is a proper sewer line there is a properly paved area road surface and all that. So, they are the flow may be as high as 90 percent. So, this our CPHEEO manual recommends that it typically 80 to 90 percent is what is to be taken for the design purpose ok, depending on the status of the city.

However, the conventional sewers shall be designed for a minimum sewage flow of 100 litres per capita per day or higher. So, what is ever condition is, what is ever generation is there, even if let us say it is generating 40 percent only that does not mean that one a family, which is consuming or let us say per capita consumption is 120 litres per capita water consumption is 120 LPCDLPCD. So, in that case the 40 percent of this becomes a little less than 50, 48 LPCDLPCD.

But the sewerage system should not be designed for less than 100 litres per capita per day. So, it should be designed either 100 litres per capita per day or higher as the case may be. So, far the cities with where there is a let us say water consumption is pretty high. So, for city say people are consuming 200 litres per capita per day of water and approximately 80 to 90 percent of this is getting converted so; that means, 160 to 180 LPCD LPCD LPCD sewerage is water are used water is getting generated. So, there it should be designed for that flow and not 100, 100 is the minimum value as per CPHEEO manual.

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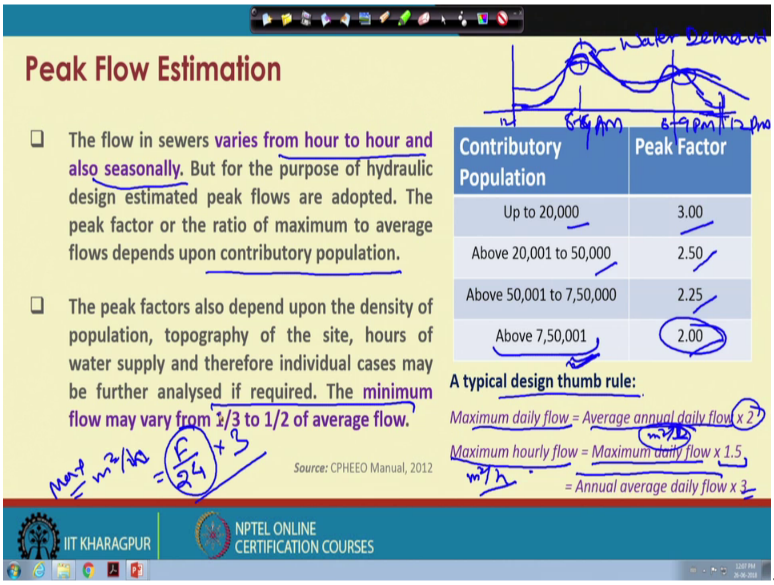

So, that way the estimate is done for per persons sewage generation, now this per person sewage generation again is not consistent over and year ok, because there are variation in the flow as there are variation in the water demand, there are variation in the sewer generation as well and flow in the sewer varies from hour to hour and from season to season as well.

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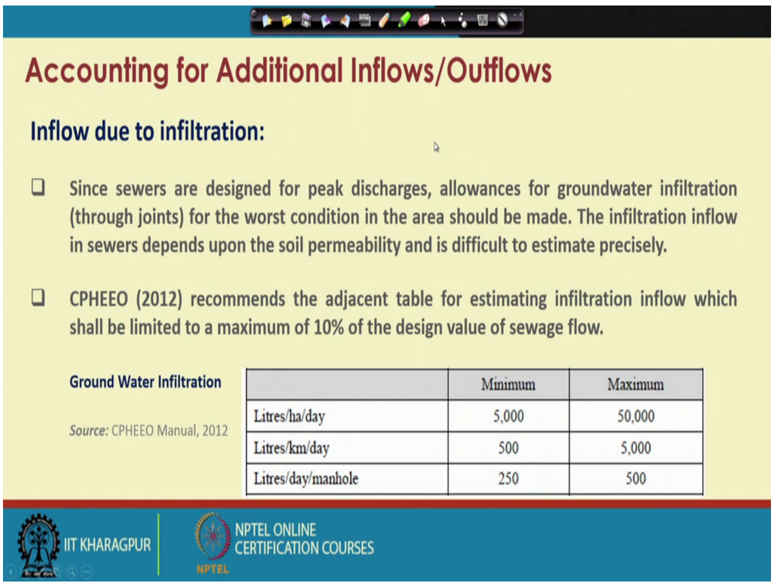

So, if there are flow is varying hourly and seasonally so, we have to design obviously, for a peak flow ok, because our system should be sustainable. So, our system should be able to withhold when there is a maximum flow coming in the sewer lines so, for that purpose the peak flow is estimated right. Now this peak factor again is the ratio of maximum to the average flow and it depends on the contributory population which population is contributing and how is the water consumption pattern.

So, typically if you see the generally diurnal water pattern if you see. So, let us say this is 12 midnight ok, now the water demand in the night is going to be very little and as in the morning it peaks up shoots up. So, around let us say 8 or 9 A M or 7 to 9 AM this will be highest and then it further decreases and in the evening it will again peak not as high as morning because morning many people take bath and do all those household activities and evening there is cooking and some other requirement. So, maybe around 6 to 9 we will see another peak and this further goes on down to around 12 p m the same level.

So, this is how our water demand curve look likes. So, if we see the sewage generation it is not this sharp ok, but we will see similarly like when there is a peak. So, we will see a peak over here and then there is a deep and then again there is a there is a peak something like this ok. So, it is relatively little smoothen, but still you will see the peaking in the morning and in the evening as opposed to the night and as opposed to the night and in the afternoon hours.

So, the again our CPHEEO manual suggest that based on the contributory population which population is contributing we can take the peak factors. A population is only up to 20000 the peak factor should be 3 a population is up to 50000 from 20000 to up to 50000 it should be 2.5 for higher population 2.25 and population above 7.5 lakhs it should be taken typically on the range of 2. So, whenever we design sewerage system for major towns major cities population is most cases higher than this. So, this is much more applicable and the common peak factor which is adopted as 2.

So, there is a typical design thumb rule if you see. So, the maximum daily flow should be average annual daily flow into 2, 2 times while if that is about the daily flow now for few things like for pumping and all that how much the capacity of pump is to be installed. So, pump does not work on a daily basis pump have to manage basically the hourly flow also at times. So, maximum hourly flow can also be determined by applying another peaking factor. So, maximum hourly flow is the maximum daily flow means the day on which the flow is maximum 1.5 times of that maximum daily flow.

So, the further peaking factor of 1.5 is adopted ok. So, that maximum hourly flow will be equal to maximum daily flow times 1.5. Now we already know that maximum daily flow is average annual daily flow times 2. So, if we do it on a average annual daily flow basis so, maximum hourly flow will be average annual daily flow times 3. So, that is how it can be used only caution is that this hourly flow is also for a day ok, it is not do not get confused with the units. So, it is not that hourly flow is in metre cube per hour and here you take in metre cube per day so, that will not work.

So, hourly flow also, if you are taking metre cube per hour here, you should take metre cube per hour here also. So, the average annual daily flow let us say on a particular day the flow is F. So, if you want to estimate the maximum hourly flow in metre cube per hour maximum daily flow. So, then it has to be F by 24 because F is for a day, remember it is a daily flow. So, F by 24 becomes your average daily flow per hour into your peaking factor 3. So, that will give you the maximum daily flow per hour. So, that is how it is estimated.

Typically this peak factor depends on the density of the population topography of the site, whatever what are the hours of supply and therefore, basically it can be individual case to case basis depending on the city depending on the town, the minimum flow varies from 1.3 to 1.2 of the average flow. So, your sewer lines should have at least should be designed that it actually gets at least one - third or one - half of the average flow which is design, flow less than this will basically create the issues with the hydraulic connections.

Now, this is the typical like we discussed how we can estimate the per capita inflow per capita sewage generation and how the peaking factors are taken up. So, how we can estimate the maximum and get an idea of the allowable minimum flow that way. There are quite a few inflows and outflows or additions and substraction to the sewer to the flow which is generated and one must account for that also. So, some of those factors one of them is basically inflow due to infiltration right.

So, since the sewer are designed for peak discharge, the allowance for the ground water infiltration through joints if it is occurring because that is the worst case scenario if you are designing for a peak condition; that means, we are designing for a highest flow and in a highest flow let us say even in the peak condition if there is some ground water infiltration is also taking place through joints so, that should also be added. So, there has to be or there should be provisions or there could be provisions made for infiltration in the sewer line depending on how permeable is the swell and how what are the conditions, how deep it is, where is the water table, all those factors will come in picture.

If your sewer line is below water table this infiltration are likely to be much higher if you are sewer line is above water table. So, then this kind of infiltration can only occur when there is a rainfall or when there is a let us say storm water flow then only there is a possibility of leakage through this joint otherwise because it is in a drier zone so, there would not be any inflow through this joints. So, that is sort of one of the possibility, but it is very difficult to estimate precisely because it is through faulty joints and these kind of thing. So, how it is not practically possible to get an estimate of how much joints are faulty, how much discharge is can take it depends on so many other factors also.

Therefore the manual again recommends sort of in the form of the table that you see here that how we can estimate the infiltration inflow which shall be limited to maximum of 10 percent of the design value of the seepage flow. So, litres per hectare per day minimum 5000, maximum 50000 litres, per kilometre per day minimum 500, maximum 5000 litres per day, per manhole 250 and 500 minimum and maximum range. So, this is how the ground water infiltration is estimated as per the CPHEEO manual.

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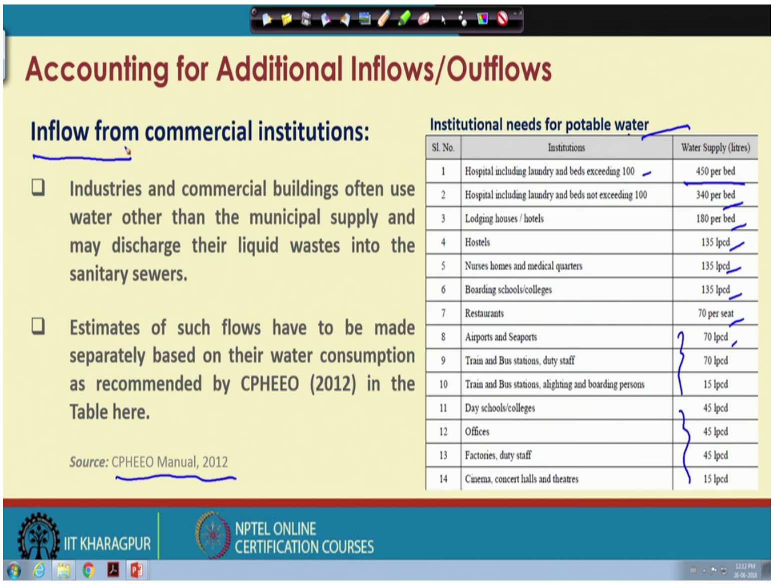

There could be additional inflows from the various commercial institutions ok. So, like small industries or institutions or commercial buildings often like use municipal water supply and they also discharge their liquid waste to the sanitary sewers. So, such flows are also to be estimated now how much they are discharging will be depending on how much water they are getting.

So, again it depends on their water demand ok, or their need for the water and the manual recommends the institutional need for the portable water by these different types of organizations. So, that kind of list is available at CPHEEO manual like hospital which includes laundry and beds exceeding 100, they typically need 450 per bed, the smaller one needs typically 340 per bed, hotels and lodging houses 180 per bed, hostels 135 LPCD LPCD, nursing homes medical quarters 135 LPCD, boarding school colleges again 135 LPCD, the restaurant 70 per seats, airport and seaports.

So, that way there are different categories for which water demand or water supply is met and it is perceived that they also generate this much amount of the water which is being supplied to them comes in to the municipal sewerage line. And this also should be accounted and added as an additional inflow to the sewer line. So, the accounting for this also has to be insured.

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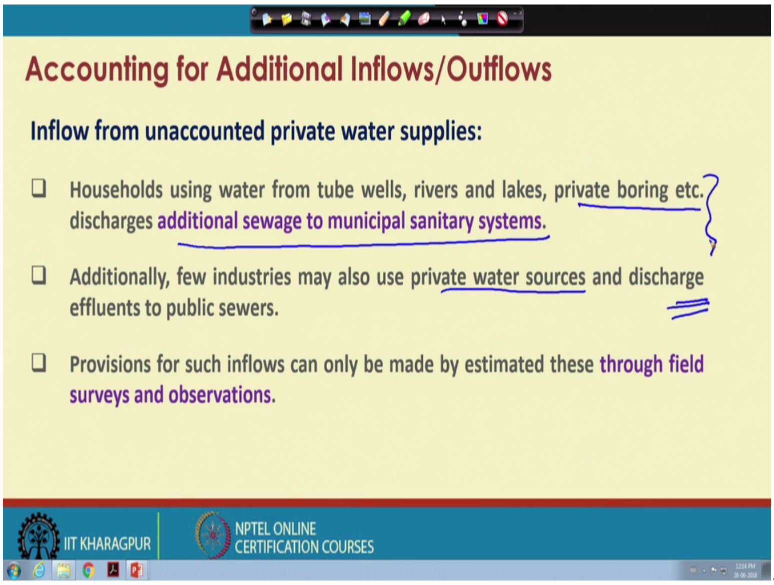

Then there are inflows from unaccounted private water supplies ok. So, there are various household switch use water from tube wells, water from rivers or lakes, water from their private boring etcetera. So, the one which is not accounted by the municipality if I am if somebody is having boring in their home and pumping water from there after use they will of their typically if they are connected to sewer line they will discharge is to the sewerage system has only ok.

But in the record of municipality that water is not there because municipality is seeing the pipe supply ok. So, they might have a record of that pipe supply sent to that area of that particular household, but the amount of sewerage generated is much larger over there. So, there is additional sewerage to the municipal sanitary system, which comes from the sources.

There could be few industries also which use their private water sources and discharge effluent to the public sewers although this is not allowed and government is more and more enforcing on the 0 liquid discharge for the industries that which so ever industries whether they are using private water sources or municipal supplies, they should captured their entire influent, they should treat it, remediate it and reuse it within their periphery and should not discharge to the sewer sewerage systems or river bodies or other sources.

So, government is against this thing, but still there are in practice there were many such industries are there, which either legally or what is ever way they discharge their effluents to the public sewers. So, a provision for such inflows should also be made and this can be made only by estimating these through field service and observations. There is no way to get an accounting of these until unless throughout field survey is made until unless the field observations are properly made and see how much additional water can come to the sewer line from all such sources ok. So, that is another important point, but very difficult to estimate.

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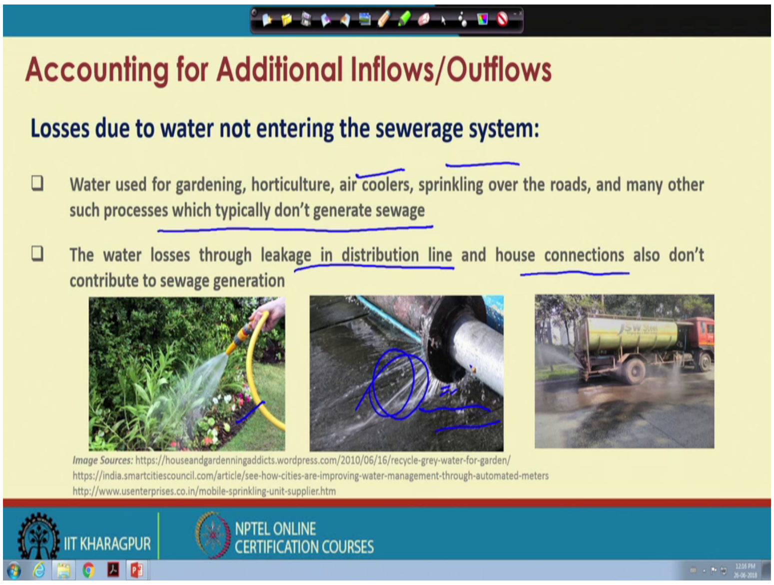

Then there are losses of water which does not enter to the sewerage system gets consumed or gets supplied, but never reaches to the sewerage system and these are the major regions when we say that typically it is designed for 80 to 90 percent of the water demand or water supplied. So, these are the major reasons why it is so, because water which is used for variety or purposes like gardening.

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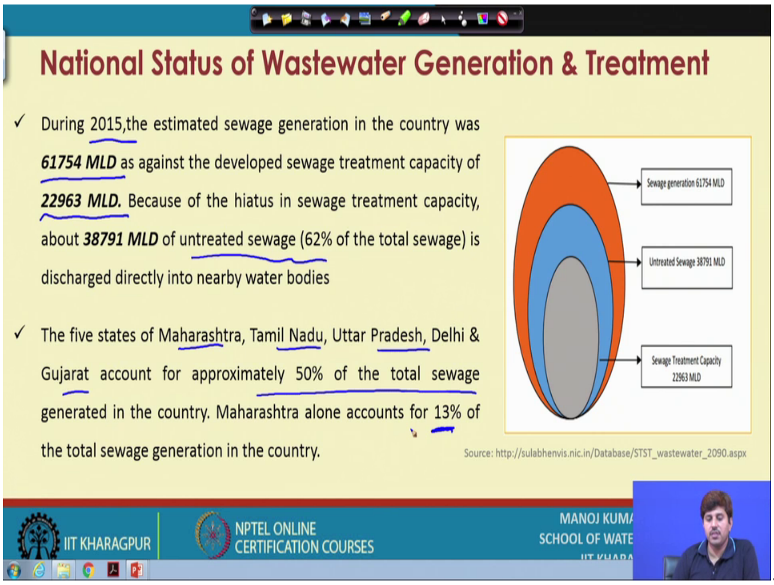

And horticulture, then there is air coolers, the water that we put in our air coolers sprinkling over roads or streets putting water to the flowers all those waters many other such sources many industrial. So, processes also like putting water in the boiler and oiler wherever steam is generated that water actually leaves ok. So, we do not get that water back and that water does not generate sewage and hence does not reach to the sewer line or does not contribute to the sewerage quantity.

So, there has to be accounting or done for this the water losses through leakage in the distribution line like you see here and leakage in the house connection also do not contribute to the sewage generation, because it does not although the municipality when pumping water is monitoring (Refer Time: 28:16) the pumping this much of water to that particular colony, but since large or at least some part of that water is not reaching there.

So, that is not going to contribute to the sewer like may not contribute can contribute also let us say if it is across the sewer line and there may go to storm water. So, depending on how the sewerage and storm water collection system is there in the town it is not necessary that this will be going to the sewerage system of an infected does not go to the sewerage system such leakages ok

So, that is another kind of loss which does not contribute to the sewerage system and this should be subtracted ok. So, these are some of the we talk about different additions and these are some of the subtractions which are to be accounted when we go into the quantifying or sort of designing the in for the for the design purpose of sewerage system and we tend to quantify the inflows and outflows these are the points that need to be taken care of that need to be considered.

So, once all this is done we can basically get in cumulative summary ok, how much is the water supply is coming, how much is the losses, how much is the additional inflows means what are the different parts of addition, what are the different parts of subtraction, and then we can get in estimate of the per capita sewage production or total sewage production then peaking factor and that way we can estimate the design flow.

Now quickly will have a look at what is the national status of wastewater generation and treatment. So, the available data in 2015 says that the estimated sewerage generation in the country is over 60000 MLD 61754 MLD ok, of which the treatment capacity is almost only up to 23000 MLD little less than that in fact.

So, one - third is about third we have the treatment capacity and about two - third of water is basically untreated sewage ok, the 5 states that are Maharashtra, Tamil Nadu, UP, Delhi and Gujarat have approximately 50 percent of the total sewage generated in the country and Maharashtra alone accounts for 13 percent of the total sewage generated in the country. So, these are the cities and countries with generate the most amount of the sewage in the country.

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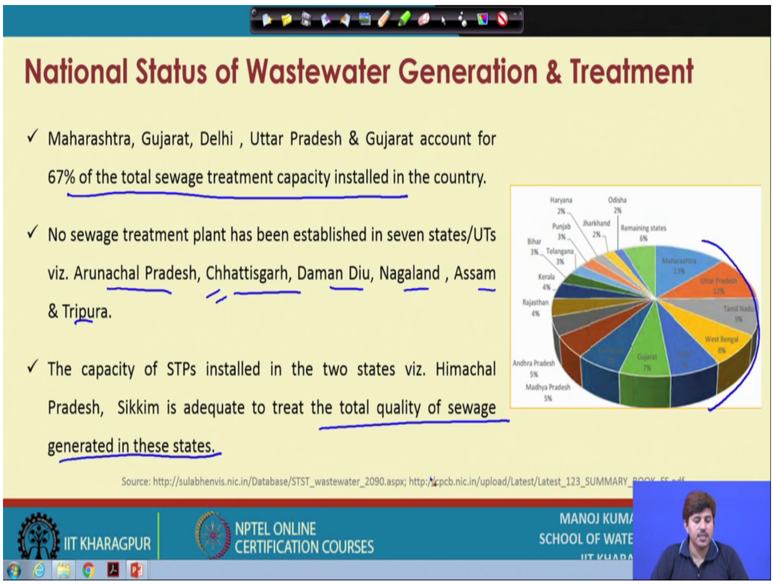

Now, this total account for 67 percent of total treatment capacity installed. So, they generate, but there is higher treatment capacity also in these states. So, this can be seen from here and no sewage treatment plant has been established in 7 states and union territories Arunachal Pradesh, Chhattisgarh, Daman Diu, Nagaland, Assam and Tripura. So, they do not have an STP Chhattisgarh Raipur and all that were actually in the planning so, by now they might be having also.

The capacity of STPs installed in two different states, Himachal Pradesh, Sikkim is adequate to treat the total capacity of sewage generated in these states. So, as per the records of central pollution control board only two states that this Himachal Pradesh and Sikkim have the adequate capacity to treat their total sewage generated and rest states are lacking in this.

So, the condition is not very bright there are lot of issues related to the management of sewerage handling of sewerage. So, lot more amount is being generated and with the increasing population, we are going to produce even more sewage; however, the capacities are limited, but under the Namami Gange and NMCG government is promoting the installation of new sewerage treatment systems, new STPs, new etps, and is trying to capture more and more of the wastewater which is being generated.

So, that the burden or the disposal on to our natural river systems could be limited or could be prevented thereby improving the quality water quality in our natural systems. So, we conclude this here and in the next session we will talk about the some of the aspects of the characterization, because so, far we have been discussing about the quantitative estimation or how much is the quantity of sewage. Now we will focus on the qualitative aspect, what is the quality of the sewerage and how we can characterize the sewage.

Thank you.