Water and Wastewater Engineering
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Lecture - 3
Water and Wastewater Quantity Estimation

Last two lectures we were discussing about the objective of environmental engineering in detail and we have also seen the philosophy of water and wastewater treatment. Water is an essential commodity for anybody or any living thing so we have to supply adequate quality and quality of water. And it is also essential to collect the wastewater generated and treat it properly and dispose it of properly. Those are the major objectives of this water and wastewater treatment.

Or in other words we can tell that in water supply engineering the major objective is to supply potable and palatable water. This will take care of the quality aspect and we have to supply sufficient quantity. So one aspect is quality and another one is quantity. So we have to supply wholesome water and that too sufficient quantity. That is the major objective of this water supply engineering. And wastewater treatment means when we supply the water definitely the water will be consumed and as a result the wastewater will be generated, this wastewater thus generated should be properly collected, transported, treated and disposed that is very very essential for any community. These are the major objectives of this water and wastewater treatment.

So when we talk about the quality of water…., because I told you, in water and wastewater especially for water treatment the quality and quantity are important. And in last two classes we discussed in detail about the quality. So when we talk about the quality we have to take care of physical, chemical and biological parameters. So for quality we have to take care of physical, chemical and biological parameters. So, these physical, chemical and biological parameters in detail we will discuss afterwards.

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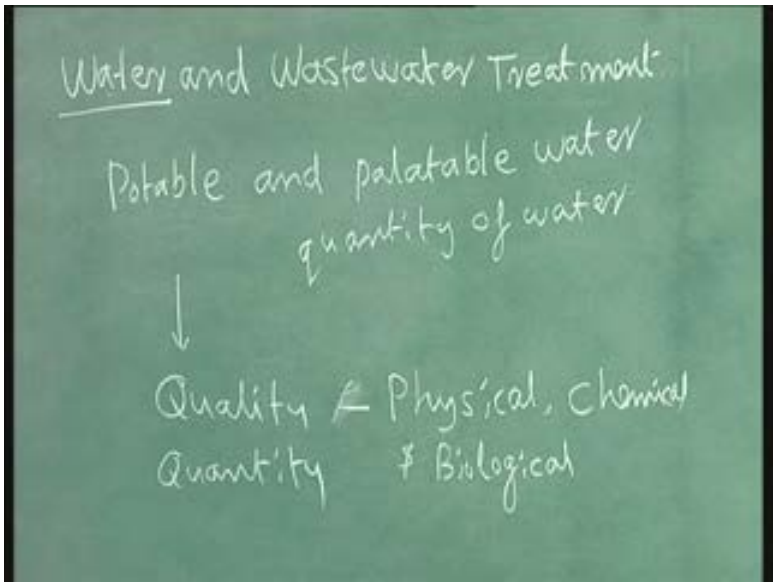

But among these three that means physical, chemical and biological the most important thing is biological that too bacteriological. The water should be bacteriologically safe. The reason is, if a few pathogens are present in the drinking water and if the person consumes that one so the chances of getting infection is very very high. But if the water is not safe in terms of chemical means or if it is not having pleasing appearance if you consume that water only once or twice it may not create that much of harmful effect provided the chemical constituents concentrations are low. But in case of bacteriological quality or bacteriological property if it is having a few pathogens or one pathogen it can cause disease. So bacteriological quality is the most important water quality parameter as far as drinking factor is concerned.

When we were discussing about the water sources we have seen that we have surface sources as well as ground water sources. Surface sources; the examples are; rivers, lakes, ponds etc and ground water we all know how can we get the ground water and another one is ocean or sea water. Because nowadays this is also being used commonly because the water scarcity is there so the ocean water is taken and desalinated and used for drinking water purpose.

So when we talk about the surface water sources, so as we have seen in the last class, when the river is originating from a place it will be passing, passing and finally it will be coming and falling in the sea or ocean so what will happen at this time the point of origin the water quality will be very very good because there is no source of pollution so the water will be having a very high quality so as it passes through what will happen, more and more pollutants will be getting into the river and the water quality will be coming down. So most of the cases when we talk about the surface water sources the water quality is deteriorated because of anthropogenic activities. Anthropogenic activities, that means it is because of man made activities.

We have seen the case of Ganga, Yamuna etc we discussed in detail. So, when it passes through big cities what is happening it will be carrying all the wastewater generated either half treated or partially treated etc that is coming into the river so definitely the quality of the water will be

coming down. The rivers are having a certain extent of self-cleansing capacity. But if the pollution load is more than the self-cleansing capacity what will happen, it will be deteriorating the water quality. So if you want to improve the water quality we have to give proper treatment.

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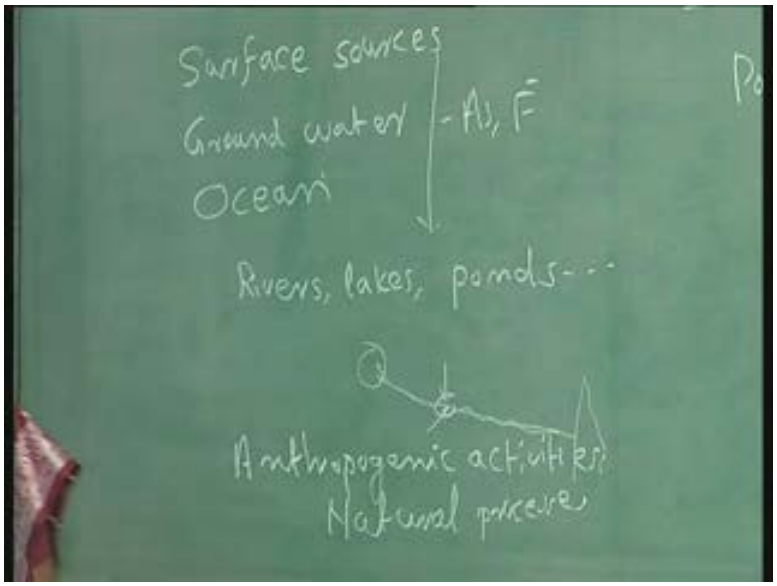

So, in surface sources mostly the pollutants are coming by anthropogenic activities and a very little by natural processes. But when we talk about the ground water the pollutants may be due to natural things because of the geochemical or soil properties of the aquifer because the aquifer will be or the water will be always in contact with the soil and the minerals. So, if the minerals are having the pollutants like arsenic, fluoride etc it will be getting dissolved in the water and definitely the water will be polluted.

So, for ground water the pollutant can be mainly from natural sources. But in surface water it is because of the anthropogenic activities. And if we talk about the diseases, whatever diseases we talk about most of the diseases are having some relationship with water as the disease may be caused because of the pollutants present in the water. So the diseases can be classified into four categories like; waterborne, water wash, water base or the insect vector which is staying in water or the insect vector which is having some relationship with water. But I am going into the details. But just remember that the water quality is very very important for our well being.

So, if you want to improve the water quality for a particular beneficial use we have to go for the treatment and the extent of treatment is depending upon the raw water characteristics and the beneficiary use. Extent of treatment is depending upon: 1) Raw water quality because if the water source is highly contaminated then definitely you have to go for high degree of treatment or the extent of treatment required is very very high and second one is beneficiary use. For example, if the water is going to be used for drinking purpose then the quality should be very very good so we have to give very high treatment or the extent of treatment is very very high. But if it is used for navigational purpose or some recreational purpose the extent of treatment

required is not that much or the water quality parameters set for recreational water is not so stringent as that of drinking water.

So, whenever we talk about the treatment these two parameters are very very important; the raw water quality and the beneficiary use because the water quality parameter is not a fixed parameter, it varies from one use to another use.

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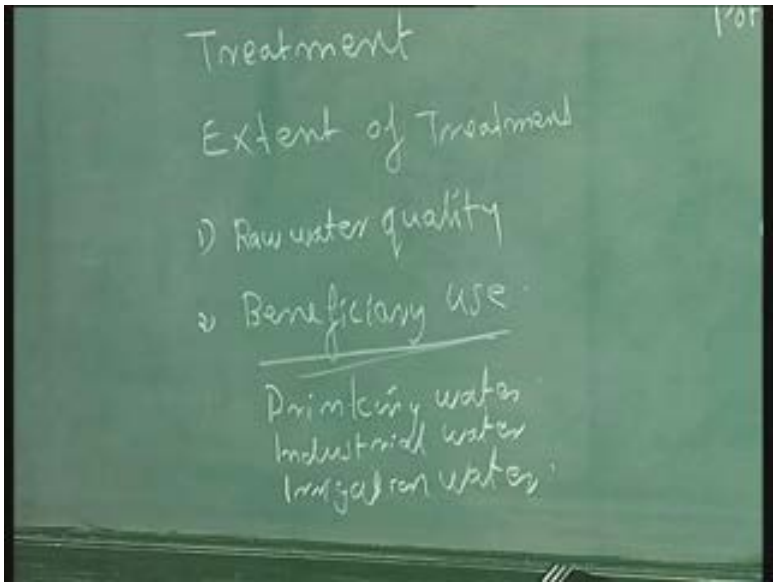

For example, for drinking water we have a particular water quality criteria. When it comes to industrial water it is very different because in water quality parameter for drinking water the most important one is bacteriological safety. But when it comes to industrial water depending upon the process the parameter will be varying. For example, if you are going to use the water for boilers etc then hardness is very very important. Otherwise if the water is used for textile industry then if it is having color or the presence of ion it is harmful because it will be creating problem to the textile industry. So similarly if you go for irrigation water the water quality parameter is entirely different. So, depending upon the beneficiary use we have to decide what type of treatment we have to go and to what extent we have to go. So this is about the quality parameter.

But we have also seen that when we talk about water treatment, quality is important, along with quality it is also essential to provide sufficient quantity of water. So whenever we design a water treatment system we know that these are the processes we have to give to achieve the specified quality. But we don't know what is the quantity then how can we design the treatment plant, it is very very difficult. So this quantity is very very important.

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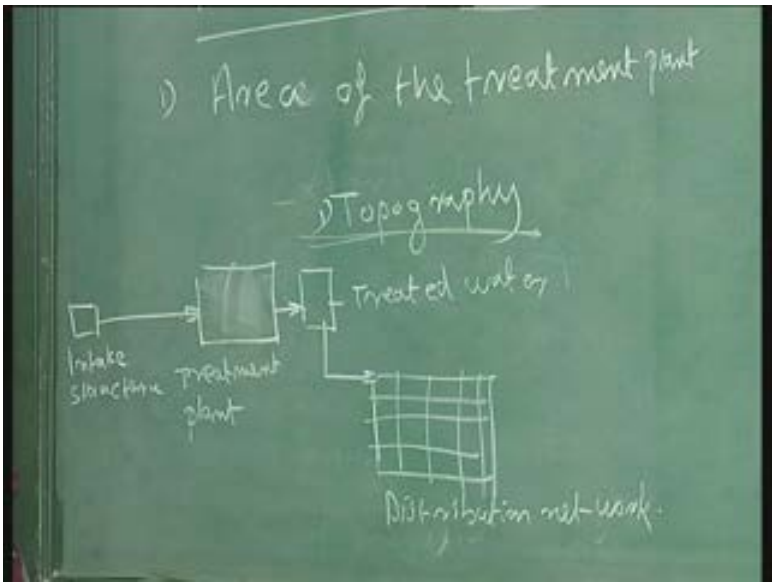

Now we will see what all are the important points one has to consider before going for a water treatment plant design. We have seen what is the importance of water treatment to improve the quality and we have to treat enough quantity of water. So the points to be considered are; first one is the area of the treatment plant. Why it is important? It is because we know the distribution network layout, we know where the population is settled and what is the area to be served, we have an idea but where to situate the water treatment plant, how can we decide this one.

Various points are there while selecting the area of the treatment plant. The topography is very very important. The reason is, because we know that the water distribution network is there somewhere like this (Refer Slide Time: 13:49) you have the water distribution network and you have the water treatment plant somewhere here and you have the treated water, this is the treatment plant and this is the treated water and you have to distribute it to this entire area, this is the distribution network and your intake structure is somewhere here, this is the water source it can be either a river or lake or a pond whatever be the thing this is the intake structure.

So where to put this water treatment plant? This is very very important. If it is close to this one the length of pipes and so on can be produced. But why was telling is, I was telling that the topography is very very important, the reason is, here if we can make the flow under gravity then the pumping cost can be reduced. So it is always advisable to put the treatment plant in an elevated place. So what will happen, all the treated water will be collected in an elevated place so from there the water will be flowing under gravity, you don't have to give any pumping station for anything in between so it will be flowing automatically under gravity so you can reduce the pumping cost considerably. So the topography is very very important. But sometimes it may not be possible because we have to see where the intake structure is coming and where your highly elevated land is available. So those things you have to consider carefully.

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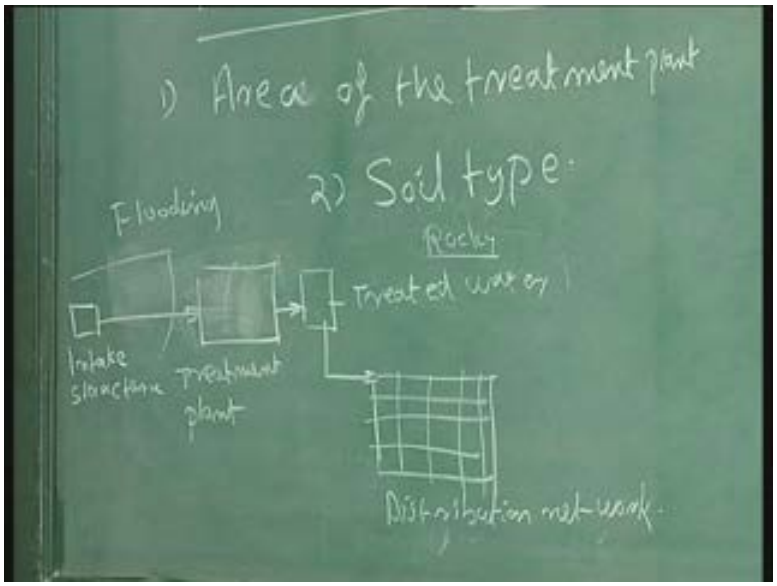

Second one is soil type. This is also very very important because the treatment plant, water treatment plant involves many units. So you have to go for soil excavation and all other activities. If the soil is very very hard or if it is rocky then what will happen, the construction will be very very difficult or the excavation is very difficult. But if it is very soft soil or the bearing capacity of the soil is very less then what will happen, it may not be able to support the structure then you have to go for other structural design or other structures to support the water treatment system. So the soil type is very very important. And you have to consider other activities also or other processes also.

If you are situating or you are locating your water treatment plant near the intake structure and your source of water is a river then what will happen, if your treatment plant is very close to the river, at certain times there are chances of flooding of this river so what will happen, so entire water treatment plant will be in this area and it will be affected by the flooding so it is always advisable to take proper care to avoid flooding. Either you can situate it away from the flooding region or provide dikes so that the flood water will not be entering in the water treatment plants. That is coming under area of treatment plants. So whenever we go for the water treatment plant design before that we have to select a proper area for situating the water treatment plant.

Second aspect is, I hope this is clear and second aspect is design period. What do you mean by the design period? In a water treatment system you have an intake structure, if it is a river or something like that we may have to provide dams or those type of structures to store the water. Then from that you will be having an intake structure, then you will be having treatment plants, then you will be having the overhead tank, distribution network, many pumps, pumping stations etc. So when we design that one how long or……. what is the design period or…….. for how long we have to…… or the facility whatever we are designing how long it can serve the people, so that is meant by the design period. How long it can serve the population in that region? So this design period is very very important. Though we are going to construct a dam now it is not

designed for population at present, it is designed for around 50 years. That means it should be able to serve the demand for the coming 50 years. So this design period is very very important.

In most of the water treatment plants the design period is 30 years 30 to 40 years. But for different units, design periods will be varying. When we talk about the design period it is not only the service period, we have to consider the time between the design and commissioning of the plant because we decided to set up a treatment plant in a particular city or a town and we have designed the treatment plant, to execute the design and commission the treatment plant it will take some time. So when we talk about the quantity we have to project the population for that period also. So, if you have a design period of 30 years and your design and commissioning period usually varies from 2 to 5 years so this time also should be added to this design period whenever we predict the population at that time.

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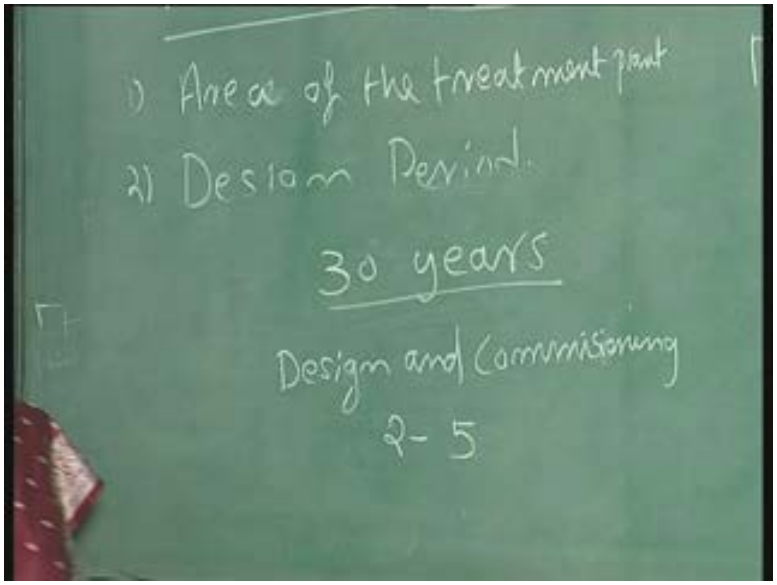

So whenever we talk about the design period this plus (Refer Slide Time: 20:40) the design and the commissioning period both the things should be included, that is meant by the design period. I have already mentioned that the design period for various units will not be a constant, it will be varying and the variation is depending upon various parameters.

First I will give you the design period for various components in a water treatment system. For example, dams, the design period is around 50 years and when it comes to water treatment units it is 30 years, pumping stations it is 30 years but for pumps it is only 15 years and distribution system we give 30 years but for overhead tanks usually we give or for the treated water collection tanks we give a time of around 15 years. So it will be varying from 50 years to 15 years. Why there is this variation? Why can't it be constant? We know that once the dam is constructed the cost involved is very very high and if you want to expand it, it will be very difficult, the cost involved for that one will be very high so it is always better to design it for a long period.

But when we talk about the pumping stations, pumping stations we can design for 30 years and if you design a pump for 30 years for constant population what will happen, you will be buying a pump now and it will be continuously working and you know that the mechanical part will be undergoing wear and tare and after 10 to 15 years those pumps will become useless or it will not be functional. In such cases what will happen, even if you design for 30 years and buy the pumps of high capacity and put it in the treatment plant it will not be able to serve for such a long time then it will be a mere waste. That's why for pumps we are giving less design period.

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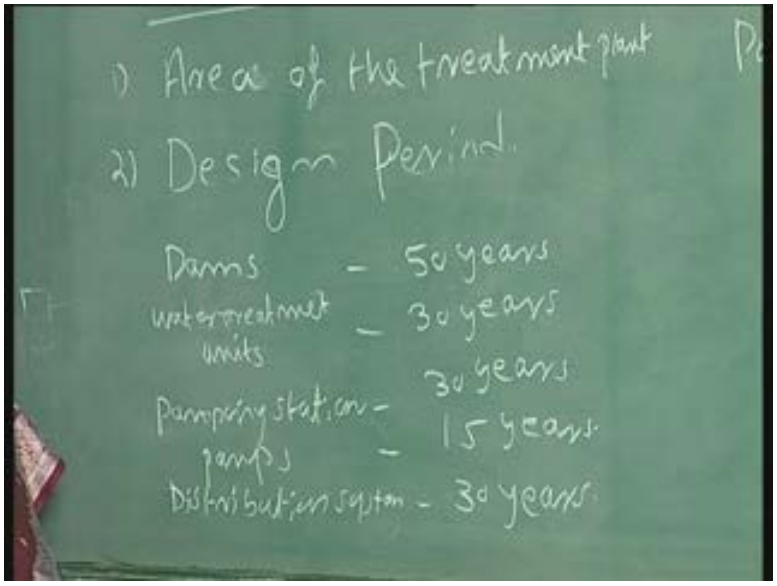

So the design periods are decided based upon the service time. The service time can be provided by the particular unit. For dams it can provide the service time of 50 years but for pumps it cannot be.

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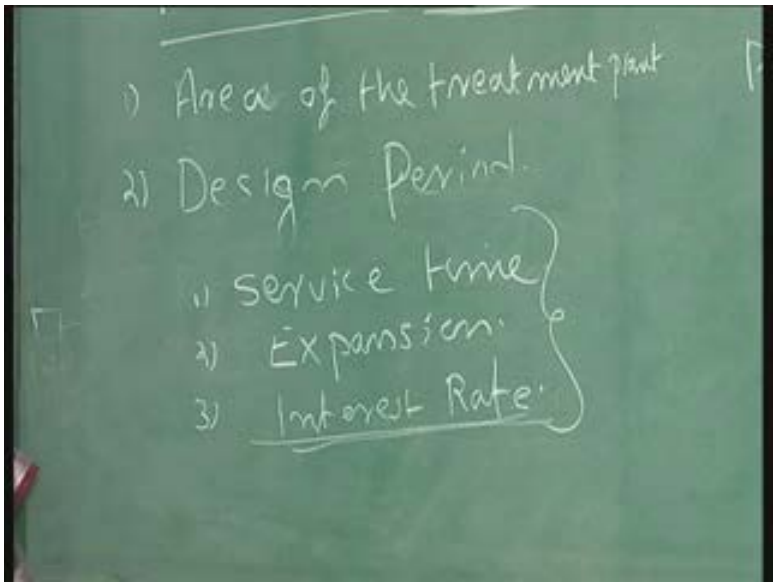

Second one is what is the cost involved in expansion or what are the chances of expansion or is it possible to expand the facility in stepwise. Then if it is possible then it is better to go for a short design period and keep on expanding as and when it is required. And third one is the interest rate. if the interest rate is very high then what will happen, we are investing lot of money for the treatment system, and if the interest rate is very high and if you design it for a long period the cost involved will be very very high. So if the interest rate is very high it is advisable to go for a less design period or the design period can be reduced and if the interest rate is less then we can go for a long design period. These factors should be considered whenever we go for deciding the design period. But whenever we talk about the water treatment unit or water treatment facility design this design period is very very important. Thus, we have already discussed about area of treatment plant and design period and other important points to be considered are, third one is population to be served.

We have seen that the design period is varying from 20 to 40 years and we know what is the present population, if it is an existing city and if it is a new area then we won't even have the existing population so we should be knowing what will be the population in that area during the design period. So according to that one we have to design the facility.

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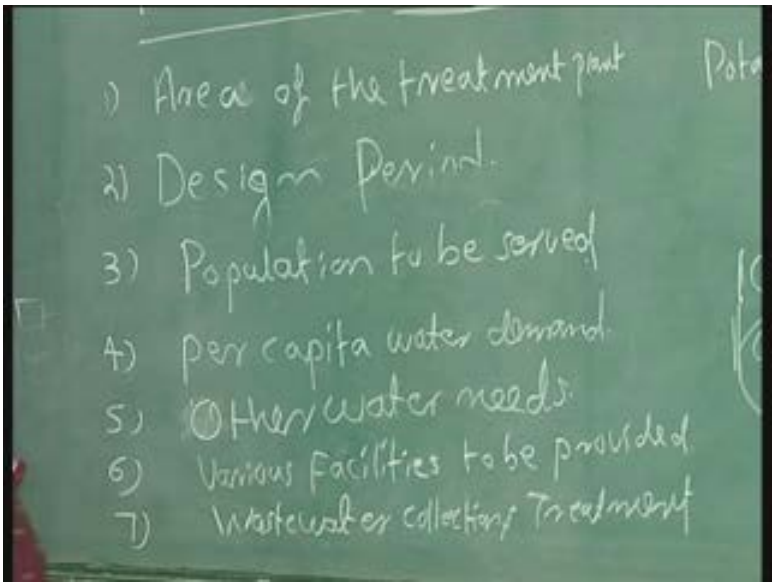

Population to be served is very very important. And fourth one is per capita water demand. We have seen that quality as well as quantity is very very important. So if you want to find out the quantity what is to be treated? We should know what is the population to be served and what is the per capita water demand. So if you know the population and per capita water demand we know what is the total water to be supplied for the domestic purpose. And other point is, other water needs in the community. Apart from the domestic water need there are various other water needs in a community. Thus, we should have a clear picture about other water needs then only we can calculate the quantity of water to be treated properly.

And sixth one, we should have an idea about the various facilities to be provided. What are the various facilities in a water distribution system or a water treatment system, we will be discussing in detail when we talk about the water distribution system. But we should have an idea about various facilities like where to provide, how to provide etc. And the last one is wastewater collection and treatment. This is also very very important because you are supplying water and some portion is used for drinking purpose and cooking purpose, all other water whatever is being used it will be coming as wastewater. So you should have proper wastewater collection and treatment provisions. When we talk about the area of the treatment plant the provision should be there for the wastewater collection and treatment and disposal. These are the important points to be considered before going for the design of a water and wastewater treatment plant.

Once again the important points are; one is area of the treatment plant and we have seen what are all the important points. One is the topography, second one is the soil type and third one is other physical hazards which can occur in that area. So those things have to be taken into account before finalizing the area of the treatment plant.

Next one is design period. This is very very important and design period will be varying for different facilities depending upon the chances of expansion or the cost involved in the

expansion and what is the service time for that unit and what is the prevailing interest rate. Then other one is population to be served. How can we find out this one? Then what is the per capita water demand? Then what are the other water needs in that area then what are all the various facilities to be provided and the last one is wastewater collection and treatment facilities. So these two points we have seen in detail (Refer Slide Time: 29:10).

Now, the next one is what is the population to be served during the design period? How can we find out the population to be served? We will discuss that one in detail.

Population prediction: We know that sometimes we will be having an idea what is the existing population in a particular place. But we have to find out what is the population, what will be the population in that area after say 30 to 50 years based upon your design period because when you design a water treatment plant or when you construct a water treatment plant that plant is supposed to serve the community for 30 to 50 years. So, for example, if you have only 10000 people in that town at present but what will be the population after 30 years or after 50 years so that facility should be able to serve that many people at that time. But unless we know what is the population after 30 years or 50 years we will not be able to design the facility. So this population prediction or population forecast is very very important when we talk about the water treatment plant and wastewater treatment plant design.

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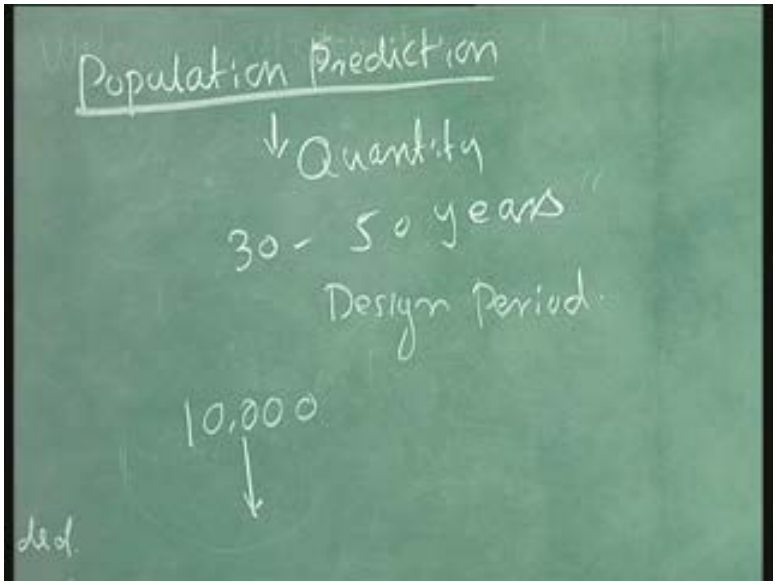

This (Refer Slide Time: 30:58) is very very important when we want to find out the quantity of water to be treated because first we have to finalize the quantity of water to be treated and based upon that one only we can go for the treatment units. Because for quality we know that what all are the processes we have to provide to achieve that quality but quantity is based upon the population and each facility is supposed to serve for a specified design period so we have to predict the population at that period then only we can find out what is the quantity to be treated. That is the need of population forecasting or population prediction.

What all are the various methods used for the population forecasting we will discuss in detail now. There are various methods available for the population prediction. Population will be varying because of three factors; one is because of birth. If the birth rate is more then it will be increasing the population. Second one is death so it will be decreasing the population and third one is migration. This migration may increase or may decrease the population depending upon how the migration is taking place.

If the migration is in then it will be increasing the population and if the migration is out outward then the population will be decreasing. So, if you can find out what is the birth rate, what is the death rate and how the migration is varying then we will be able to predict the population correctly. But most of the time it will be very very difficult. So, in most of the population prediction methods what people do, they we will be predicting the birth rate, death rate and migration based upon various parameters separately and sum it up so you will be getting what is the net population after a particular or after a specified period.

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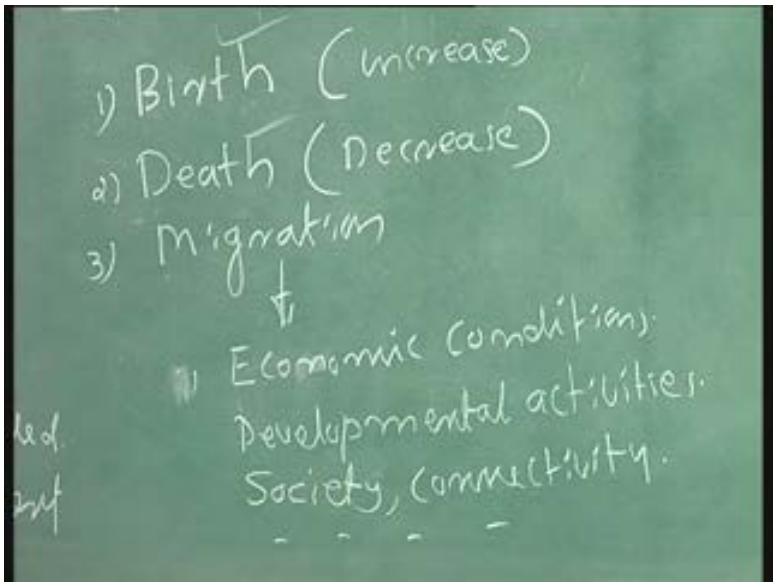

And you know that the migration is depending upon various factors. The migration rate will not be a constant; it will be depending upon economic conditions. economic conditions what I mean is, if some area some new projects are coming or some new industries are being set up in that area then definitely more and more people will be coming to that area for job and for other reasons so definitely the migration rate will be very very high.

Second one is developmental activities. If a place is having more developmental activity then definitely people will come and like to stay in that area. So, developmental activities also will influence the migration rate.

Then we have the society. If that society is having facilities for education, medical etc then definitely people will like to come and stay there.

Then we have connectivity. Similarly, we can write n number of reasons which can affect the migration. So we have to take into account all these factors when we predict the population. So, taking into account people have developed various methods for the population forecasting. Those are; first one is demographic method, arithmetic method or we can write it as arithmetical increase method second, third one is incremental increase method, fourth one is geometrical increase method, fifth one is graphical method, logistic growth method then seventh one is zone method. Like that we can write various methods. And these are the most commonly used methods for population prediction.

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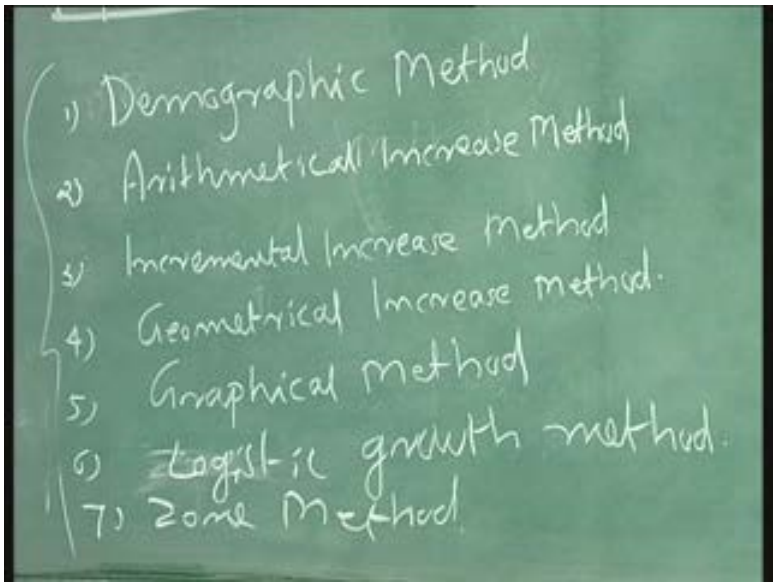

We will see each method in detail, how to find out the population using each method. Then we have to go for one specific method or what all are the advantages and disadvantages of various population forecasting methods we will see in detail now.

First we will see what this demographic method is. In demographic method what we are doing is, it is the simplest method, we are finding out what is the birth rate and we are finding out what is the death rate and we are finding out also the migration. So, if you can find out what is the birth rate and if you can find out what is the death rate and how the migration varies then we can find out what will be the population after say n decades. But to predict the birth rate and death rate you will be having the census data so from that we can find out what is the existing birth rate. And we have to consider all the factors whatever we were discussing namely; the economical factors, the societal factors, the developmental programs, etc. That means how that area is going to be developed in terms of industrial aspects, educational aspects, community aspects, medicinal aspects, etc. So you take into account all these developmental activities in a particular area and find out what is the birth rate from the existing records and find out the death rate how it is going to change and find out how the migration is going to be affected.

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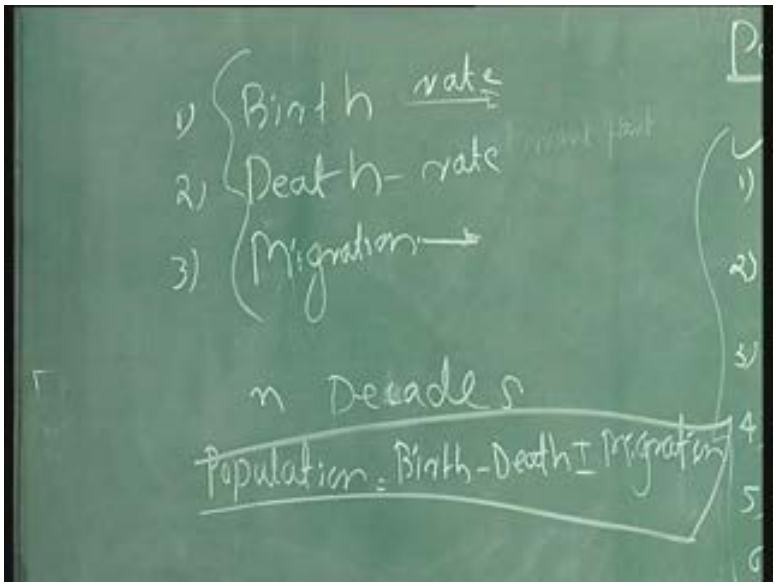

So if you can get proper information about the birth rate, death rate and migration then if you can sum it up then you will be getting what is the population after a particular period. The population will be like this (Refer Slide Time: 39:03): Birth minus death plus or minus migration. Though this method appears to be very very simple we have to be very careful in calculating the birth rate, death rate and migration because that will be affected by various factors so we have to predict what is going to happen in that area, based upon that one we have to calculate the birth rate, death rate and migration. Then you will be getting the population after a particular time then you will be able to find out what is the quantity you have to treat to meet the population requirement. That is demographic method.

Now, the second method is arithmetical increase method. Arithmetical increase method is like this; if any area or any city or any town if you take they will be having the census data so from the census data we can get the past records of population increase. For example, you will be having the population of 1981, 1991 and 2001 and you have to design a water treatment plant for that particular town and you have seen that the design period is usually 30 years so you should know what is the population either in 2031 or 2041 we have to predict this population.

We have the information only up to here; 1981 we have, 91, 2001 and you will be having the data for the earlier periods also like; 61, 71, 81, 91 etc we will be having the entire data and based upon this data we have to find out what is the population after the design period because your treatment facility should be able to serve the population at this time so we have to find out what is the population here. So how can we find out that one? For example, you will be having some population here at 61 and you will be having a particular population here at 71, 81, 91 so you can find out what is the increase in population in each decade.

Therefore, in 61 population say you will be having 10000, and 71 you will be having 16000 like that it keeps on increasing and then you will be having 22000 then say you will be having 28000

so like that it keeps on going, I am just giving some example so you can find out what is the increase in population in each decade.

Therefore, if you take 1961 and 1971 the increase in population is around 6000 this is the increase in population and this is the population. So you can calculate what is the increase during this period, during this period like that and you will be getting up to 2001 what is the increase in population in each decade. From the census data we will be getting the population information for each decade. So we can we will be getting the population in that decade and from that one we can find out what is the increase in population in each decade.

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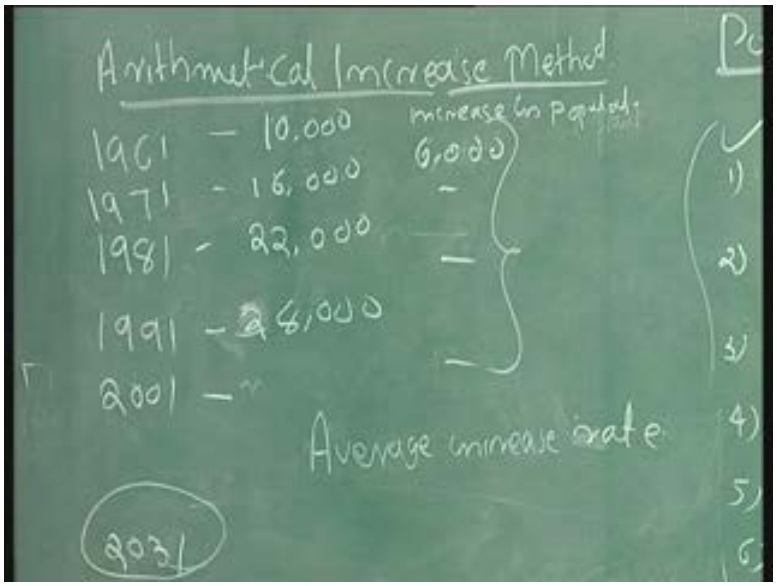

From this information we can find out what is the average increase rate. We can find out what is the average increase rate per decade. For example, here you have 6000, here you will be having 6000 and here you will be having again 6000 and say here you will be having 33000 so the increase is 5000. So you will be having the increase in population. Say, if you sum it up 6000 plus 6000 plus 6000 plus 5000 that is the total increase in these four decades. Then you can find out what is the average increase rate per decade. So, if you want to find out the population at 2031 what you have to do…….this population we will be taking as P0 because this is the last information we have. 2001 population we have so P is equal to P0 plus n into I. So P0 is the population at the non-time and n is the number of decades and I is nothing the average increase rate per decade.

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Thus, what we are doing is we are assuming that the increase in population per decade is almost a constant and based upon that one we can find out the population after 30 years or 40 years. This is the most simple method of calculating the future population or the simplest method of population forecasting.

But if you go for this arithmetical increase method if you see any community we know that the population increase is not a constant with respect to time. When the facilities are more and all those things most of the time the population will be increasing at a faster rate. So, if you go for this arithmetical increase method you will be ending up predicting a low value, the actual value. So, arithmetical increase method always predicts a lower value because the population increase is not a constant it will keep on increasing. So this method is advisable or this method can be used for cities which are already well settled.

Arithmetical increase method can be used for predicting the population in well settled areas. That means already the immigration and everything is come to a saturation level and more and more population cannot be accommodated in that area in such cases whatever we are predicting using this arithmetical increase method will give a somewhat reasonable value. Otherwise this arithmetic increase method will be predicting a low value than the actual value. But this is the simplest method used for population forecasting.

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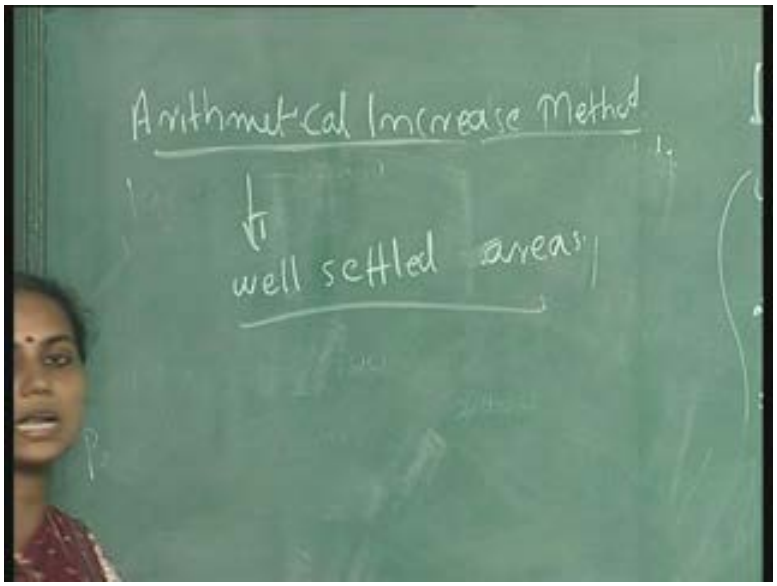

Now we will see what is the incremental increase method, the third method. This incremental increase method is a modification of this arithmetical increase method. In incremental increase method what we do is, same information we have; 1961, 71, 81, 91, 2001. I will give a somewhat reliable data then it will be easy to make out. The population of 1961 is something like this; 72000 then you will be having a population 85000 at 71 and (Refer Slide Time: 47:09)……. this is the year and this is the population, this is the population, all these data we are getting from the census and we can find out what is the increment per decade.

Here (Refer Slide Time: 47:42) it is 72000 and here it is 85000 so what is the incremental increase or what is the increase from 1961 to 1971? It is 13000 and 1971 to 1981 if you consider it is coming as 25500 the difference between these two and if you take that difference here it is 33500 and here if you take the difference between these two it is coming as 40000. So initially the increase from 1961 to 71 is only 13000 and from 71 to 81 it is 25500 and 81 to 91 it is coming as 33500 and 91 to 2001 it is becoming 40000.

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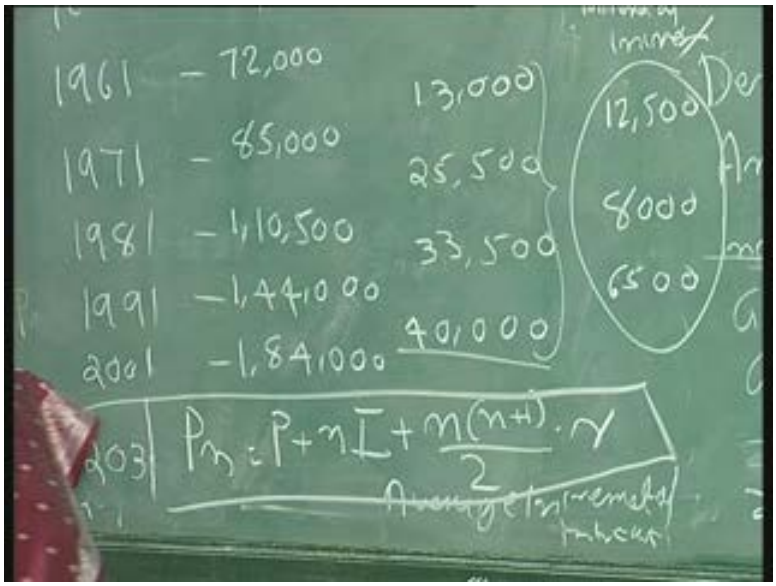

But as we have discussed earlier, in arithmetical increase method what we do, we are assuming that everything is a constant. From one decade to other decade you will be having the population increase as a constant. That is why we can see that initially the rate is less then it keeps on increasing. So when we go for arithmetical increase method you will be underpredicting the population. That's why the modified method of incremental increase method has come. In incremental increase method what is happening, we will be seeing this increase then again another parameter we will consider.

What is the incremental increase? What is the incremental increase in these two things?
Here it was a 13000 increase per decade and this is 25500 so we can find out what is the difference between these two. That means that is the incremental increase per decade. This is 13000, this is 25500 so the difference is 12500. If you predict using this value then you will be getting a population which is lower by this value. That is the incremental increase in the population. And similarly if you take these two things what is the difference that is coming? It is around, it is 8000 this is the incremental increase and for these two things 40 and 33.5 you will be getting 6500. So this is the incremental increase if you see in each decade.

Therefore, if you can find out what is the average increase per decade and along with that one if you add this incremental increase you can predict the population in a better way. That is what is happening in incremental increase method. so if you want to predict the population we can use this formula Pn that means the population in any decade is equal to P plus nI this is the formula we use in arithmetical increase method, along with that one we are adding another term n into (n plus 1) by 2 into r where r is the rate of incremental increase. How can you find out this one? We are finding out the incremental increase and sum it up and find out the average. So that will give you the rate of incremental increase, what is the rate at which incremental increase is happening. So if you can find out this rate and you know this I, I is nothing but summing up this one and dividing by the number of decades so you can get I and you can get r so you will be able to predict the population. So this is the incremental increase method.

Here, n is the number of decades you have to predict. For example, you have 2001 and you have to predict the population in 2031. So 2011 is coming, 21 is coming, and 31 that means three decades are there in between. So here n will be 3 and r is nothing but the rate of incremental or r is the average incremental increase. You know what is the incremental increase we can find out what is the average incremental increase happening. That is what we are getting using this formula (Refer Slide Time: 52:38). So this will be more accurate compared to arithmetical increase method. Or if you go for incremental increase method you will be predicting the population somewhat higher than whatever we can get using arithmetical increase method and this will be more appropriate.

Now we will see what is this geometrical increase method. In geometrical increase method what we are doing is we are finding out the percentage by which the population is increasing and we are assuming that it is increasing exponentially. So using that ratio we can find out what is the population after ten decades. That is what is done in geometrical increase method.

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So here you have the population; at 1961 was 72000, 85000, 1,10,500 like that so we can find out what is the percentage increase. How to find out the percentage increase? This is the population, this was the population in 1971 and in 61 it was this, so 85000 minus 72000 by 72000 will give you the percentage increase. So you can get a value here, for example, this case it is coming around 18.5 18.05, similarly here it is 30, here it will be 30.3 this is the percentage increase. So we can find out what is the average percentage increase.

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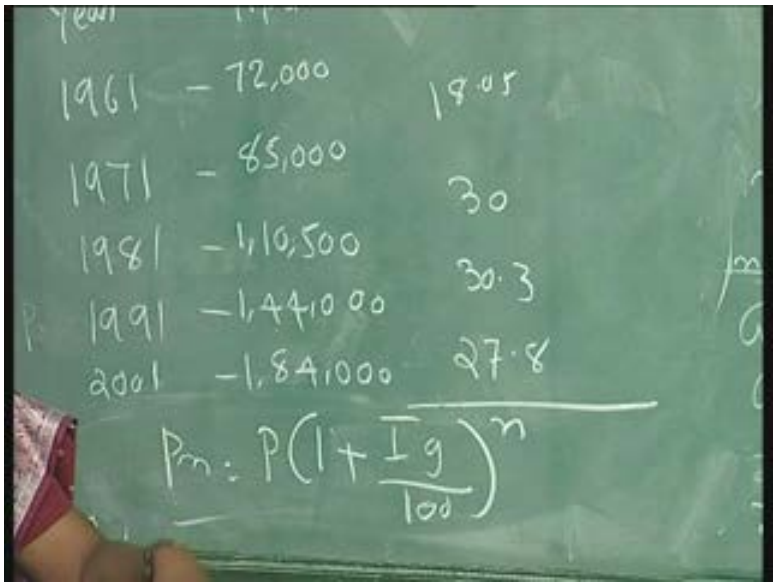

And if you want to find out what is the population after n decades you can use this formula; Pn equal to P into 1 plus Ig by 100 raised to n. Ig is the average percentage increase. Average percentage increase we can find out….. you find out the percentage increase in each decade and from this thing we can find out what is the average percentage increase. So the population after n decades is equal to P into 1 plus Ig by 100 raised to n where Ig is the average percentage increase.

So if you go for this geometrical increase method it will be over predicting the population. This method can be used for some new towns or cities where the population is going to increase at a faster rate. Otherwise what will happen, if it is an old city or a town if you go for geometrical increase method you will be getting a much higher population than what is going to happen there? So, depending upon the condition we have to select, either you have to go for arithmetical increase method or geometrical increase method.

The next method is graphical method. In graphical method what we usually do is like this; graphical method can be used in two ways; one is for the existing cities and second one is for cities of similar nature. In existing cities what we are doing is we have the population and we have the time. This information we are getting from the census. So we plot the population nature per year, and see how it is going on. So you have the data up to say this is 2001 and you want to find out what is the population at 2031 or 2041.

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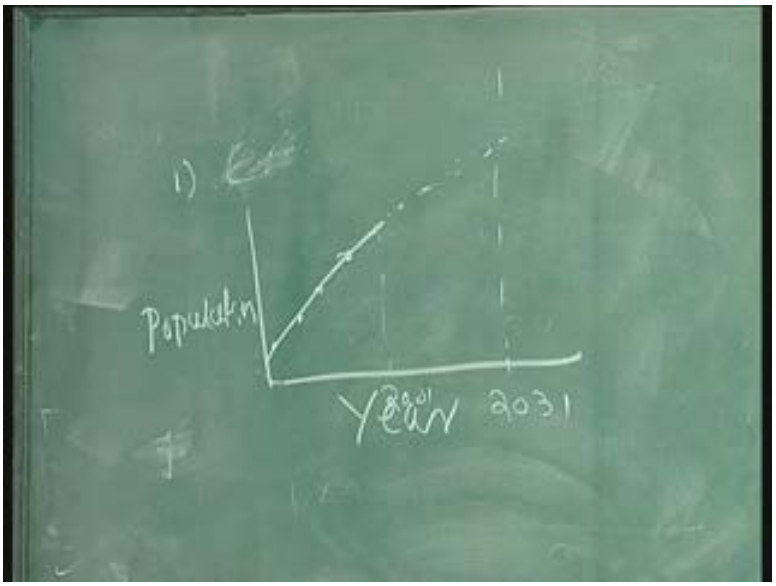

What you do, you have the curve as something like this (Refer Slide Time: 56:41) so now you have to find out what is the population corresponding to this one. So you have a trend how the population is increasing till 2001 so you can extrapolate the points and get the population in 2031. This is the graphical method. This is the case of existing city. That means already you have the information about the population growth so you can find out what is the population after 30 years. But in case of similar cities what we do, we take another city which is following the same growth pattern and same conditions and see how that population or how it is increasing in that city, so, that information can be used to predict the population in the new city. That is the graphical method. It is not very commonly used.

We will see what all are the things we discussed today. We have seen what are the important points to be considered when we go for a water treatment plant. The area is very important, the design period is important and we should know what is the population to be served during the design period. So, if you want to know what is the population to be served during the design period we have to predict the population. How can you do that prediction? We have to go for the different population prediction methods or different population forecasting methods. They are; demographic method, arithmetical method, incremental increase method, geometrical increase method etc. and other methods are logistic growth method and zone method. These two methods we will discuss in the next class. And scientifically this logistic method is the most important one. So those things we will discuss in the next class.