**Water Supply Engineering**
**Prof. Manoj Kumar Tiwari**
**School of Water Resources**
**Indian Institute of Technology - Kharagpur**

**Lecture 19**
**Treated Water Storage**

Hello friends so we will continue our discussion from the previous lecture where we were talking about the raw water storage system. So, as we started discussing about the water storage structures in this week and in the previous class we deliberated on the raw water storage system this particular class will be focusing on the treated water storage systems.

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So, what we are going to cover is the general information about the storage of the treated water and then, what are the various types of storage reservoirs, what are the various zones in the reservoirs and we will talk about the ESRs which are Elevated Storage Reservoirs or some people refer to as Elevated Service Reservoirs both are referred as ESRs. And then, we will touch upon the water quality in the reservoirs.

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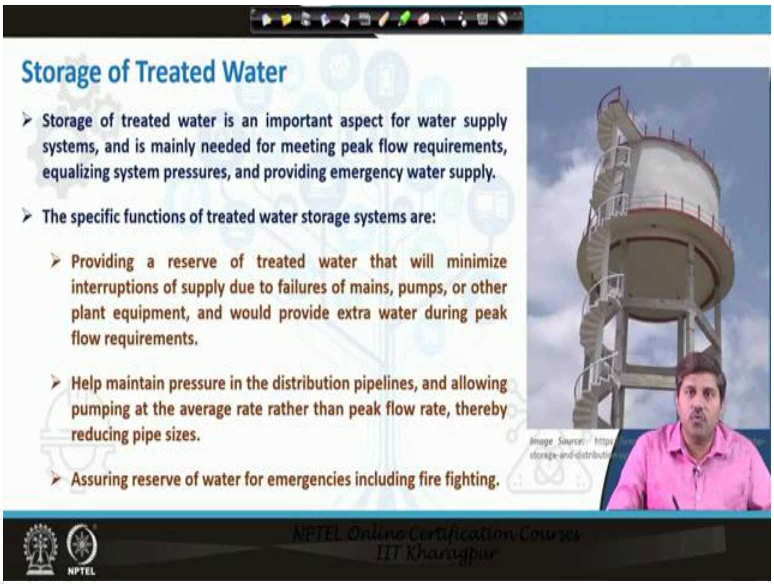


So, last class we did talk about the storage of the raw water and various concerns and design issues related to the structures of the raw water storage. The objective of raw water storage is to ensure that sufficient water comes at the treatment facility or the the consistency of water availability is ensured at the treatment facility so that water is treated and then supplied. As we were just discussing that raw water storage are not compulsory.

Many places it is not built when the source is sufficient and sustainable in its own means. So if you are considering a lake, or say a reservoir, or say a river, which is having sufficient water, we do not need a separate raw water storage structure because we can consistently pull the water from the source itself and bring it to the treatment facility. But once we treat that water, the next step is to make that water available to the end consumers.

So the distribution of treated water is the major objective of any water supply scheme or any water supply project. And in order to ensure the uninterrupted distribution or uninterrupted supply of the treated water to the end consumer staff, we generally consider the provision of storing the treated water, because if we are not storing treated water anywhere that means we just like the outcome of the treatment facility, the clear water which is being produced from the treated from the treatment facility, has to be directly put through the mains and that should actually reach the end consumers.

So we need round-the-clock pumping and there is no chance of failure. If any pump failure happens, if any problem in the treatment plant happens, if any issue happens, before the water reaches the end consumers our supply is going to be interrupted, or supply is going to be disturbed and consumers is not going to get water, which is not an ideal scenario. So in order to overcome or avoid that, we generally go for providing storage of the treated water.

Storage of raw water is generally avoided in most like if it is necessary then only we will consider. But storage of treated water is in most cases should be provided and is actually provided. So, storage of treated water is basically a very important aspect of water supply systems and it is mainly needed for ensuring that sufficient water is supplied during the peak flow requirements. It also helps in equalizing the system pressures. And it provides the emergency water supply.

So, emergencies such as if fire break down case is there so we need large quantity of water so if you have stored water you can supply immediately. If you have no storage facilities it becomes difficult to provide water for such emergencies, . So, the specific functions of a treated water storage system is basically providing a reserve of treated water, which will minimize the interruption of supply, as we were just discussing, if we have storage or reserve of the treated water, which can directly be given to the consumers.

So we are actually minimizing the risk of interruptions in the water supply, and such risk may arise due to the failure of mains pumps, or any other plant equipment. So, we minimize that risk and we provide extra water during peak flow requirements. It also helps in maintaining the pressure in the distribution pipeline and allow pumping at the average rate rather than peak flow rate and thus we are able to reduce the pipe sizes as well.

Now if we do not have a storage system that means, we have to have a pipe network even the mains network, which should be able to supply water at peak demand. Because when the demand is the highest that time also we should be able to send that much of water to the storage to the basically distribution network. But if we have say storage reservoirs in between so that means we can lay a pipe system which sends the average demand to the storage reservoirs.

Now the water is stored in these reservoirs and whenever there is a peak demand the more water will be released from the storage reservoirs itself. So we do not need bigger pipe sizes till the storage reservoir so the clear water mains or treated mains. We can have average supply that also would work . So that way it allows basically pumping at an average rate up till the storage reservoirs.

Also it is a kind of, assures the reserve water for emergencies which could be fire fighting or any other emergency. So treated water storage reservoirs are actually as we said that they are integral component of the water supply system. The strategic location of these reservoirs depend on the storage requirement, how much water is to be stored within the system and what kind of fluctuations in the demand and is to be met and what are the other functions of the reservoir.

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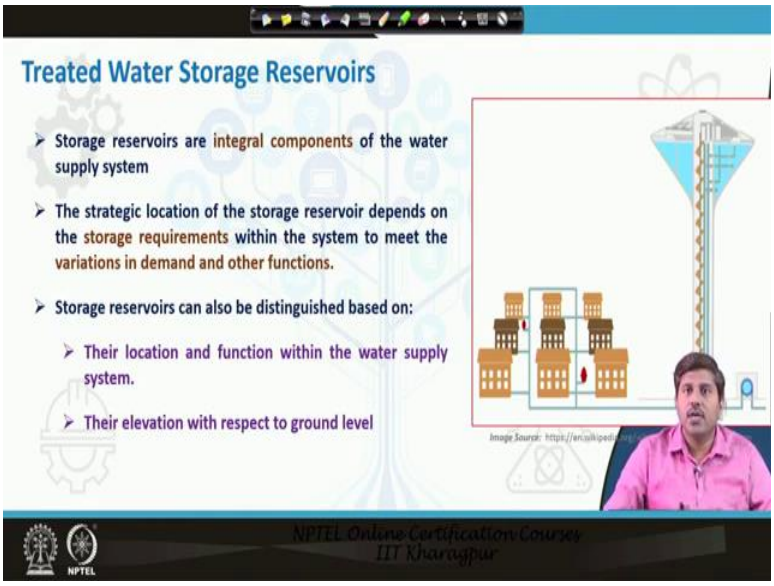


So based on that we can say where to place the reservoir, they the storage reservoirs are basically classified, based on two approaches. One is their location and function within the water supply system and another is their elevation with respect to the ground level.

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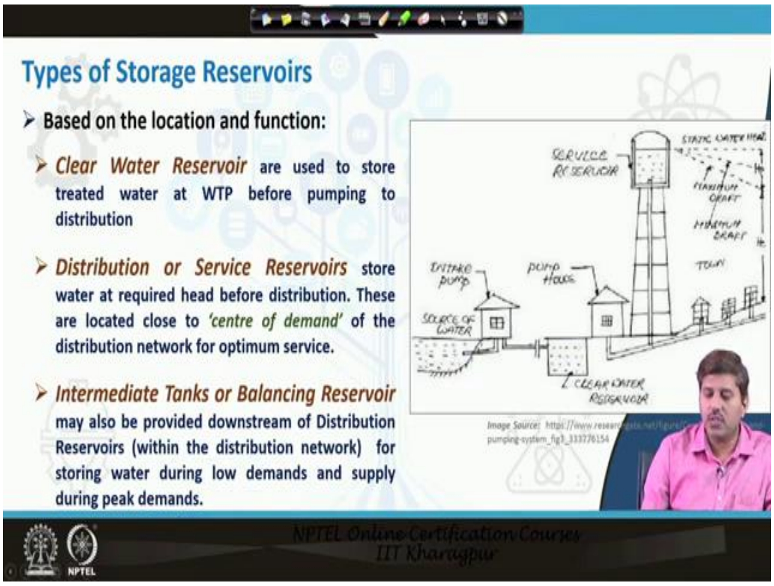

So, if we classify them based on the location and function, so there are basically three types of reservoirs, one is clear water reservoirs which are used to store treated water generally at the WTP site or just after the WTP side before it is pumped to the distribution system. So, let us say if this is our source of water this is our intake system somewhere here we have say WTP or treatment facility.

So we can have a clear water reservoir right here so that it actually stores the clear water or treated water. And then, from here through a pump house it is pumped to the next reservoir which is service reservoir or distribution reservoir. So the distribution or service reservoir stores water at required head before the distribution. So, these are typically located at the centre of demand.

And generally their major function is to supply water to the city or town by gravity mostly by gravity, from this reservoir. Then at times we may have intermediate tanks or balancing reservoirs also. Now, again this is also an optional step we not necessarily that we have balancing reservoir or intermediate tanks in between. But many times we may need that we may provide such storage downstream of the distribution reservoirs.

And these will actually be within the distribution network. So like, this is before the water goes to the distribution system. This is generally right before the distribution ideally in the center of city. Even if it is not in the centre of city it should be close to somewhere and then generally like used for the supplying water. Many times after the service reservoir, we may provide intermediate tanks our balancing reservoir for storing water during low demands and supply during the peak demand purpose.

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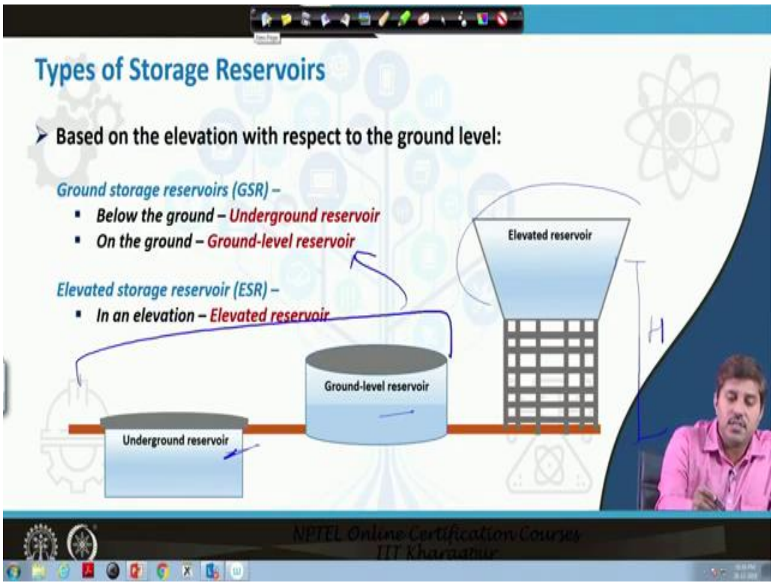


So that is why they are known as balancing reservoirs. Then, other way to classify the storage reservoirs is, based on the innovation with respect to the ground level. Now, the criteria gives us three types of reservoirs. There are ground storage systems which may be on the ground or below the ground. So if it is on the ground, it is says as ground level reservoir and if it is below the ground it is says as underground reservoir.

So we may have underground reservoir or ground level reservoir which are actually the generally known as ground storage reservoirs. And then, we have a limited storage reservoir which is ESRs. This is typically at an elevation, so we lift the storage system reservoir from the ground and we provide certain head there. So these reservoirs are typically known as Elevated Storage Reservoirs or Elevated Service Reservoirs and generally pronounced as ESRs.

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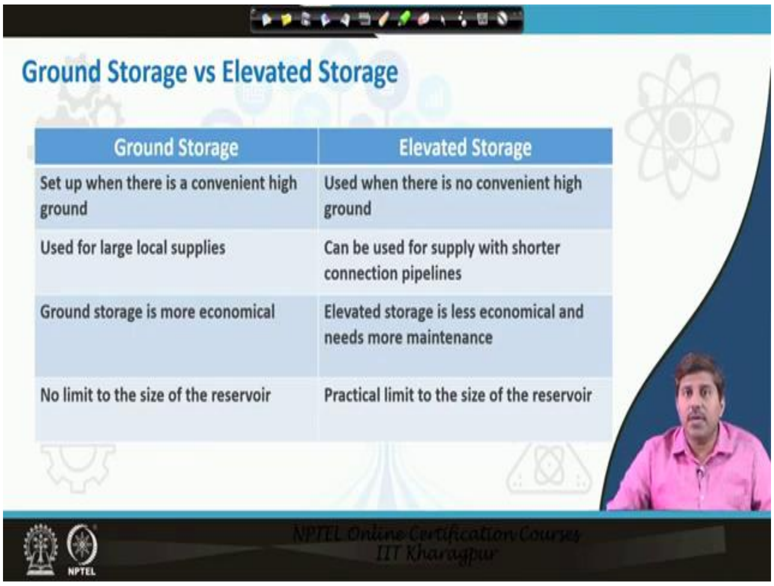

Now the difference between the Ground Storage and Elevated Storage is that Ground Storage is set up when there is a convenient high ground available, . If it is not there we should go for the elevated storage then ground storage is used for large local supplies because putting big sized elevated storage is always a challenge and is a costly affair. So that way ground storage is more economical and we can place any size of the reservoir on the ground, or below the ground.

So large supplies can also be covered using the ground storage whereas elevated storage it can be used for supply with shorter connection pipelines generally. It is less economical and more maintenance would be needed for the elevated storage. And there is a practical limit to the size of reservoir means we cannot build say capacity of reservoir of the very huge size on in an elevated fashion.

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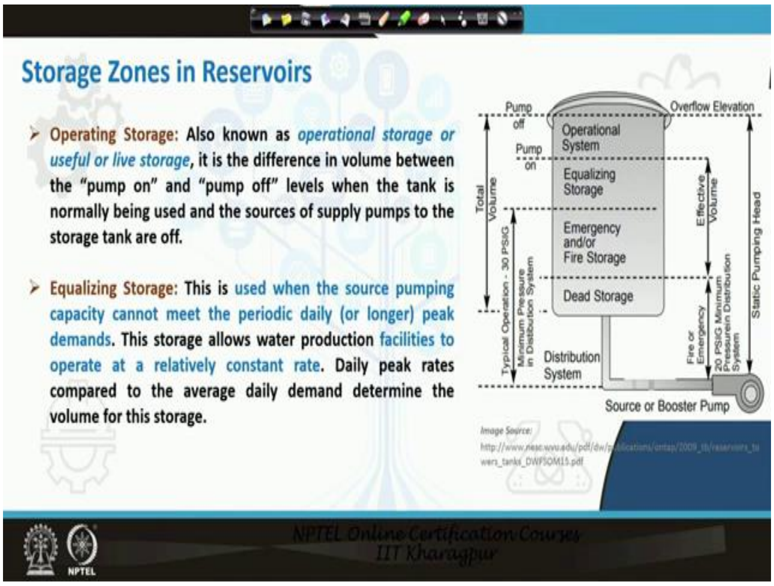


So we have to kind of see how the how much capacity maximum we can put for an elevated reservoir. So, these reservoirs as we said that their function is to basically store the water neutralize the pressure and the kind of ensure the supply during the emergencies so, based on that when we go for sizing of these reservoirs the capacity of the reservoir. So there is a different level or different grade of storages provided in the reservoir. So, there are 4 to 5 different storage or different component of storage are there in a reservoir.

One is the operating storage which is actually also known as operational storage or useful or live storage which is actually the difference in the volume between the pump on and pump off levels when the tank is normally being used. So, when the pump is on means when we are basically we are pumping water from the reservoir. So, there would be some loss of the head and when basically we are having the distribution pumps are off so reservoir is full to its potential.

So, basically operating storage gives us an idea of the amount of water which is basically regularly being used from the reservoir for its regular operation period. So, this is more so basically for the meeting average demand and in the normal run time how much storage is being used on a daily basis that is the operational system or operating storage. Then there are equalizing storage this is used when this source pumping capacity cannot meet the periodic peak demands.

Now this periodic peak demands can be daily demand or even many times can be longer demand seasonal demand. So, if the daily inflow is not adequate enough to meet the peak flows or peak demands so then the level of reservoir would further fall because some of the storage water in the reservoir will actually go for the meeting that peak demand. So, that is basically kind of a difference between the daily peak rates compared to the average daily demands that will determine this volume required for the storage and that is known as the equalizing storage or equalizing component of the storage.

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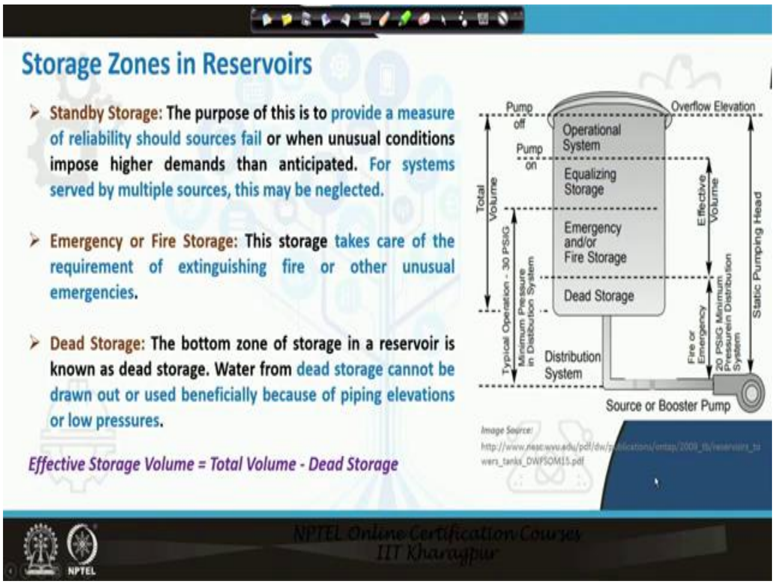


Then we have a standby storage which is also known as contingency storage at times. So, the purpose of this is to provide a measure of reliability when the source fails. So, it is a standby storage mean it is there it remains in the in the reservoir in the standby condition and when there is an unusual conditions. So, unusual conditions could be failure of sources or when there is an unusually high demand for some particular reason. So, then this standby storage can be used.

So, again the standby storage system will depend on the type of sources also if sources are multiple or if sources are very reliable we can actually neglect this also. So, many reservoir does not consider the standby storage while few reservoir when we put a size-two reservoir or capacity to the reservoir. So, we go for providing certain amount of standby storage as well. So, that is standby storage and then another component is the emergency or fire storage.

So this storage takes care of the requirements of additional water during the emergencies like fire extinguishing purpose or any other unusual emergency scenarios when we require more water we can actually provide some water in the storage or in the standby for these kind of emergency purpose as well. Many places this in many cases this is standby storage is also considered a component of the emergency storage.

So this emergency storage will actually be providing a larger volume considering the emergency plus standby storage. And then there is a dead storage which is actually the bottom zone of the reservoir and this water is usually not available because of the various reason let us say if the outflow is drawn from a level. So, if this is my say reservoir this is my inflow in input to the reservoir and my output to the reservoir is here.

So, that that means the water below output is actually dead storage it will never be used or in any case because of the hydraulic even if you are having say outflow here because of hydraulic and characteristic in the reservoir or low pressure zones if you are not able to withdraw some amount of water effectively so that is known as the dead storage which is although there in the reservoir but not of use.

So, when we say the effective storage volume the effective storage volume will actually be the total volume of the reservoir minus dirty storage. Because data storage is something we are actually not we will not be able to utilize even in case of emergencies or any other cases. So, that's practically unutilized able this is your unutilized able storage. So, we reduce the unutilized able storage from the total volume and then we get the effective storage volume.

Again the different sources may come up with a different philosophy so some sources even does not consider the operational system as effective storage because they consider that this is not a storage this is for the daily operation period. So, anyway this much amount of water will be going so reservoir is not storing this so they consider the effective volume only this much. However generally the total volume minus that is dead storage is actually considered as effective volume so many sources or general convention is to consider the total volume as an effective volume.

Moreover there is some freeboard is also provided so when we go for a reservoir you will see that the end on the top there is some freeboard and then there is a operational storage and then then there is basically equalizing or standby emergency storage and then there is a dead storage. So, this is for daily uses this is for general storage. So, water which can be used in case of demand fluctuation in case of emergencies in case of some source failures and this is the what the last portion of the water which probably will never be used.

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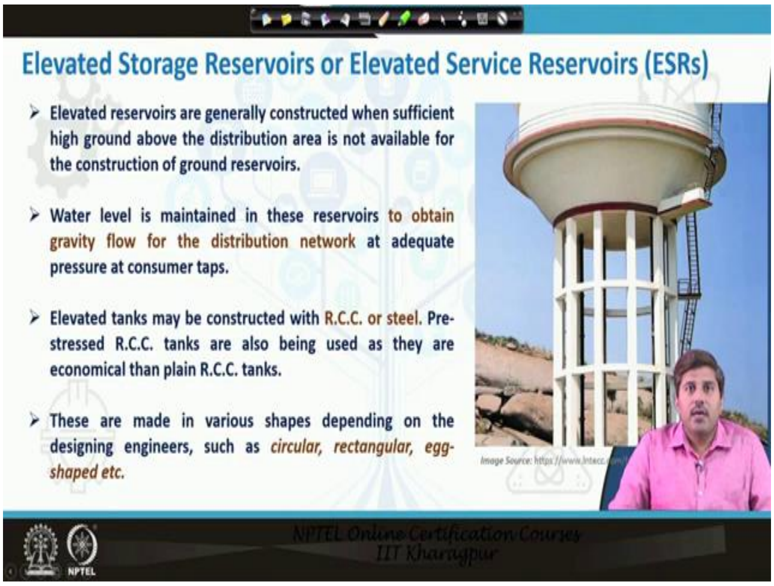


Now the elevated storage reservoirs or a limited service reservoirs as we were discussing earlier are the limited reservoirs and they will be generally constructed when there is no sufficient high ground above the distribution area is available. And if that high ground is not available then we go for the elevated reservoir. If sufficiently high ground is available then we can go for the construction of ground reservoirs.

Water level in these elevated reservoirs is maintained to obtain a gravity flow for the distribution network at adequate pressure at consumer tab. So, the height of the reservoir is chosen such that sufficient amount of head is available so that when water is withdrawn from this reservoir by gravity only so sufficient pressure heat head is available to the end consumer. And generally end consumer we considered the consumer at the farthest point.

So even the consumer which is at the farthest point from the reservoir the water delivery at that consumers house should also actually be above the minimum required pressure. So, that criteria governs the selection of the elevation of these reservoirs. The limited tanks or elevated reservoirs may be constructed with RCC or steel priestess RCC tanks are also used actually and priestess in fact are getting more popular because they are considered more economic than RCC tanks. Many times steel structures particularly if the load is high so steel tanks is also used.

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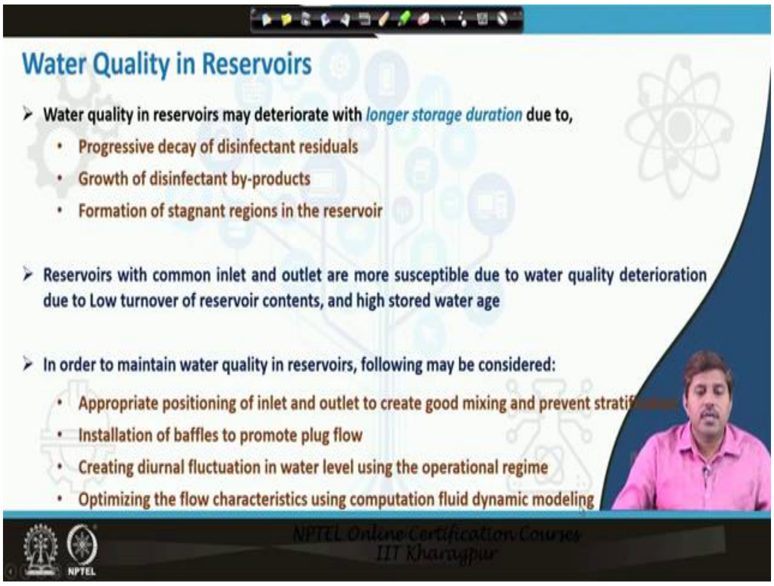


There could be various shapes there could be circular tanks rectangular sank tanks or itze tanks now when we store water in the reservoir one challenge that we see is in terms of water quality. So, water quality in these storage reservoirs may deteriorate over a period of time and generally if the storage time is longer so there are longer chances of the water quality deterioration. Now why it deteriorates so because the water which is coming into the storage reservoirs is treated water.

So, we discussed the raw water storage systems in last class but the treated water storages are provided after the treatment facility. So, the water which is coming as inflow to these reservoirs are treated water we will talk about the treatment process starting next week in more detail but just to give you an idea that the last stage of the treatment process is typically the disinfection in order to basically determinate the water.

So the microbial contaminants or pathogens in order to removing that the water is disinfected and many times this disinfection is in fact in the most of the times this disinfection is achieved through chlorination. So, if water is disinfected and generally some amount of these disinfectant is left in the water in order to ensure that there is no risk even if some future exposure to the pathogens takes place. So, these residuals in the water this disinfectant residuals in the water ensures the safety of water for longer period.

But if the water is stored for too long a period then there is a progressive decay of these disinfectant residuals further there is possibility of formation of disinfectant by products if water is having those kind of compound in it this will be discussing more detail in the later weeks. And then there is a possibility of formation of stagnant reason in the reservoir because if we are say having a reservoir where some portion of water like the dead storage or those places are never being used.

Or if we are having a reservoir where it is like the operational storage is only being used and the lower part of the water is not adequately being used and hey are stored for a larger period then there becomes a problem. So, a reservoir with common Inlet and outlet are more susceptible to these because there is no recirculation of water within this and it is basically the what fresh water which is coming into the reservoir as usually leaves the first and the water which is there inside the reservoir is stored there for much longer period.

So high stored water age and low turnover of the reservoir contents leads to the major problems in such reservoirs when basically the inlet and outlet are common or very close or the in means it is not properly designed in order to get the complete recirculation. So, in order to maintain the water quality in the reservoirs we may consider a few steps. So, the first idea is to positioning the inlet and outlet properly so that good mixing happens in the reservoir.

And no stratification takes place so it is not that water is let's say this is my reservoir so it is not that the water in this state is there for say 50 days this is data the water is there for about 20 days. So, it is like there is cross mixing must be ensured and there is no stratification of water should happen that there are different layers of water of different age. So, in that case what happens that the oldest water will have a high risk of getting contaminated and then it will pass onto the other layers as well.

So, we must prevent the stratification and ensure the good mixing in the reservoir and that can be achieved through appropriately placing the inlet and outlet. So, we may have actually say outlet here and inlet at the different labels on the other side. So, many times we actually say take this now if water flows like this so the major part of the tank will actually be subjected to mixing just by placing the inlet and outlet appropriately.

Then installation of baffles to promote the plug flow there are systems where basically plug flow is plug flow is kind of a flow where we ensure that the water that enters on certain time or the water the batch of water that enters after that so it will actually follow is that the water that enters first we leave the tank first or we leave the system first water that enters after we leave the system after. So, that way the amount of time spent by each plug of the water or by each packet a pocket of the water will remain same so, that is what plug flow means.

So, that means there is no kind of stagnant zones in the reactor there is no different age of the like it is not that some portion of water is there for say 100 days and some portion of water entered in the reservoir and went away in just one or a couple of days and some went in a just few hours. So, that is not a plug flow condition plug flow condition means as the water enters in a plug and these basically each plug follows the other way. So, that kind of system should be promoted and for that purpose we can install baffles in the tank.

Now again although we having more discussion onto these earlier but we can provide baffles like say this so these are kind of considered baffles. So, if water entering here so if there is a baffle it will not follow this path it will have to come down here and then it will have to follow kind of this kind of path. So, just by providing the buffer we can ensure that the water follows a follows a specified path and it is not like some portion is stagnant for much larger period and some portion just coming and leaving the tank.

Then we can create diurnal fluctuations in the water level using the operational regime. So, how we operate the tank and again we can use the fluid dynamic modelling or computational fluid dynamic modelling principles in order to optimize the flow characteristics within the tank so that proper flow regime is managed and we do not allow the stagnation of water or holding water in the tank for much larger period.

So, all the point is actually we should not allow the water to stay far longer in the reservoir which may lead to the deterioration in the quality of water. We will be taking up the like how we design or how we estimate the capacity of these systems. So, generally a mass flow curve concept is used for determining the capacity of the storage reservoirs and that we will be discussing in the next class. So, see you thank you.