Water Supply Engineering
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Lecture 18
Raw Water Storage

Hello friends we are in the 4th week, now and in this course water supply engineering. So, far we have talked about the basic introduction and about various sources and uses of water and then in week two we talked about the demand estimation. So, how demand is estimated and in earlier week we discussed about the abstraction of water through water intake systems. So, we did talk about the surface water and groundwater abstraction systems and then the convinced systems and pumping.

So, now this week will focus our discussion on storage structures. So, what we are going to discuss is about the water storage systems.

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So, what kind of structures we make for storing water and storing water is actually essential component in the overall water supply system because in order to get this unity of supply we have to store or retain water at somewhere. So, one storage is of course the source itself from where water is abstracted but after that we may require to store the raw water or store the treated water or storing both at times.

So this particular class will be focusing more on to the raw water storage system so what we are going to discuss in this particular class is about general concept of storing water for our water supply system. And then how we store raw water so what are the instrument of stream draw water storage system what capacity of raw water storage system we should look for. Some design considerations and then one of the problems that we face with raw water storage is the sediment in the reservoir.

So how or what are the some of the means to control this sedimentation. So, this is what we are going to discuss in this class.

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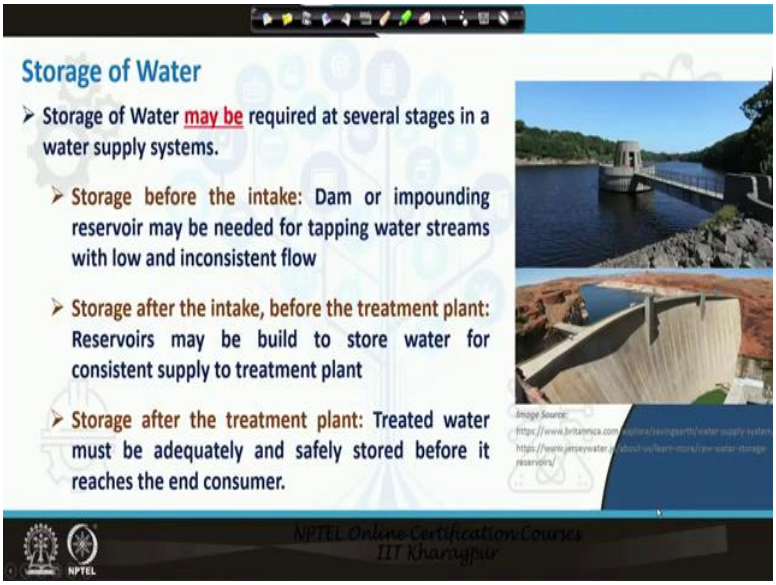

So as we said the storing water is actually an important aspect in the water supply system and it may be required at several stages in the water supply system. When we say it may be required that means it is not certainly that we have to have a water storage system at fix all specified places we may or may not require storing water at certain stages let us say for example raw water storage system.

So at times we may need to store raw water at times we may not need to store raw water when we have a sufficient source available we do not need a separate storage system for raw water. Let us say you are pumping water from a sufficiently big lake then probably you do not need to build a reservoir or some storage system for raw water. Similarly for treated water also depending on what kind of supply resumed we are going into whether it is a 24/7 supply or intermittent supply system we may require storing water at specific places or with specific reservoir capacities.

So, there is no set rule that we have to have this much capacity storage at this particular places in a water supply system and that is why we say that storing water is more so on to the actual field condition and the designers purview that how much storage should be provided and where it should be provided or whether there is actually a need of storage at certain point. So, but as we said that it may be actually required at several stages in a water supply system and these stages could be storage before the intake.

So, storage before the intake means we are actually talking about storing the raw water before the intake structure itself. So, like what could be the cases when we require to store the water before the intake? So, let us say we are targeting a river for abstracting water and it is not having sufficient flow or it is not having sufficient flow in some particular seasons. It may have a good amount of flow in say wet season but in dry season the flow is were quite low and it is not good enough to be abstracted water in this low flow condition from the river.

So, then we may need to basically put a dam or impounding reservoir where we can store the water during the high flow seasons and use that when the flow is low. So, this is very common actually in many rivers when there is not sufficient flow for the supply purpose or some other purpose we construct dams or reservoirs and this could be in stream or off stream also at times. So, we construct dam, dam would actually mean stream but there are reservoirs basically even if say we are not constructing a dam when the flow in the river is high we route that flow to a reservoir fill that reservoir.

And when the flow is low instead of abstracting water from the river we actually abstract water from the reservoir or even in the high flows conditions also because reservoir is filled. So, instead of tapping the river directly we can tap that reservoir the off-site reservoir and abstract water from there. So, we can put our intake in that reservoir instead of actually putting into the river or going for a construction of them in the river.

But anyway in all the cases we may need a dime or impounding reservoir to store water in such cases. So, that is basically storage before the intake then there is a possibility of there could be cases when we act need storage after the intake but before the treatment plant ok again so as we said that we may actually need a separate reservoir at time. So, what we can say that we actually intake put our intake in the river we draw the water fill a reservoir and then pump water

from that reservoir for treatment facility ok or fill a reservoir right before the treatment and then from that reservoir we take the water for the treatment purpose by gravity or pumping or whatever appropriate energy means.

So, that way there we may require a storage after the intake but before the treatment plant here also we are talking about raw water storage primarily because it is before the treatment plant ok and then the most prominent requirement is actually after the treatment plant so storage after the treatment plant means we should store the treated water in adequate quantity and safe environment so that it reaches the end consumer.

So, generally water supply systems are not as such that we withdraw water and directly send it to the; like we after the treatment plant so once we treated the water and directly send it to the consumer. Instead what we go for the treated water is stored in the reservoirs ok and from that reservoirs it is actually supplied to the consumer. This ensures the safety say for some reason the pump station at treatment plant is not working or treatment system has failed or for some reason we are not able to basically send water to the distribution network ok.

So in that case if you do not have adequate storage provision it could be a situation of crisis. So, that is why having a storage facility after the treatment give this resilience to the system so that it can actually be relied upon in the even in the situation of crisis or for managing the demand. Many times in fact the in order to manage the peak demands and fluctuations also these storage reservoirs after the treatment plant helps a lot.

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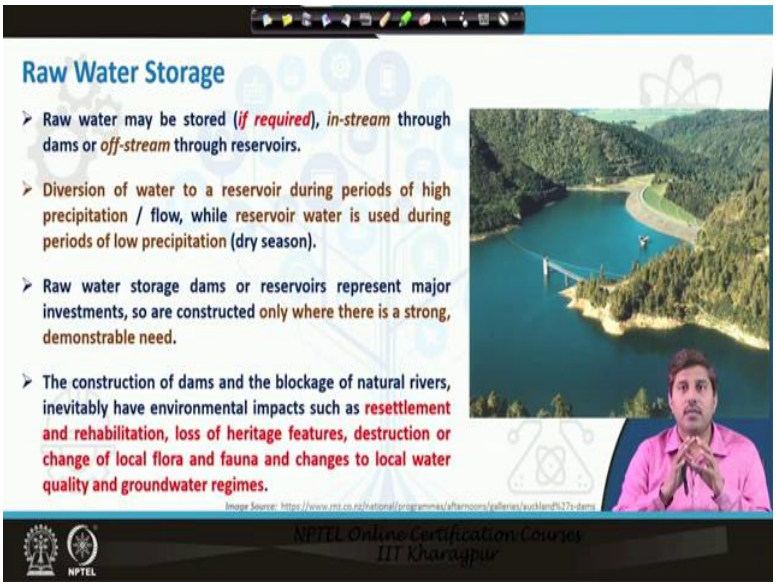

So, this was actually about general storage of water now we will in this particular class we will be focusing more on to the raw water storage. So, raw water must be stored in stream through dams or off stream through the reservoirs. Now again the raw water storage requirement will depend on case to case basis project to project basis if we are having a project where the source itself has sufficient quantity of the water round-the-clock then we will probably not require a raw water storage system at all.

So, as we said if you are pumping water from a river which is consistently having substantial amount of flow or we are pumping water from a lake which is having sufficient amount of water available in it all the time then we actually would probably not require the raw water storage systems at first place. But in case as just we are discussing if you are having the sources which are not consistent or which are having huge flow variation in dry and wet weather season then we may need to store.

And we can store it in stream through dams or through separate reservoirs at beside the storage or at near the treatment facility. So, diverse enough water to a reservoir is done during a period of high flow k or high precipitation and when the season when basically the flow is low are in the dry season water is used from the reservoirs. The raw water storage dams or reservoirs generally as we said that would actually should be the raw water storage reservoir should actually be installed when there is a clear-cut demonstrable need for these.

So, these are costly system we all know that how much amount it takes to construct a dam or those kind of thing even in a small reservoir. So, the cost of construction might not be that much but land area requirement is huge so there is a basically cost footprint of that and since these are a costly system so it should be constructed only when there is a strong and clear-cut requirement for these storage structure.

And that is why we are emphasizing that the raw water storage is an optional step and should be considered only if there is there is a strong requirement for this otherwise we do not need draw water storage in a general supply scheme. So, but if it is required so as we said that it will actually have implications on the cost of the project the cost of the project is going to increase and further particularly in the case of construction of dam or blocking the natural river there are lot of environmental impacts associated.

So, there is resettlement and rehabilitation and particularly for the larger dam projects. Though larger dam projects are not usually for the municipal water supply systems. Larger dam projects are used for feeding canals or irrigation water which actually imposes a much greater demand. The municipal demand is barely 6 7 8% of the total water uses. So, we do not need that big of reservoirs or that big of dams particularly for feeding the municipal water supply system.

But in case even if you are say putting a smaller dam or smaller reservoir you are obstructing the flow of river. So, then there is going to be effect on natural and local flora and fauna ok there is going to be repercussions on the local surface and groundwater systems in terms of both quality as well as quantity. The downstream of the river of the dam or whatever barrage we are putting through will get lesser amount of water lesser groundwater recharge.

So those implications would be there and for larger projects one of the major challenges in resettlement and rehabilitation because a large area is basically captured and for that if there are societies are people living in there they need to basically resettle at some alternate locations. So, that becomes a huge social base crisis.

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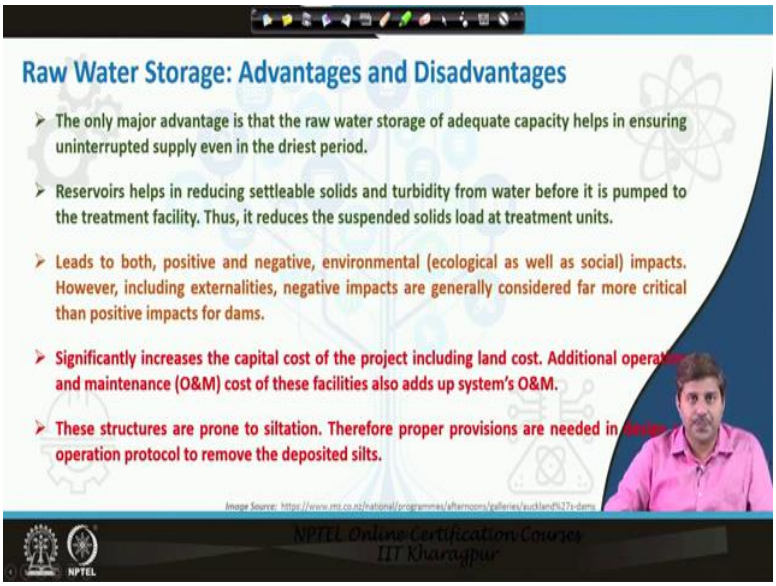

So, if we talk about the various advantages and disadvantages of raw water storage system. The only major advantage is that adequate capacity storage would help in ensuring uninterrupted supply and that to- in even in the driest period. Because if you do not have a storage and you are in a systems where there is a risk of low flow in the dry conditions. So, then the supply may reduce but if we have a separate raw water storage system in such cases we basically are kind of

assuring uninterrupted water supply and that is the only major advantage that we get of the raw water storage system.

There is additional benefit one can say is that when we are actually storing water in a reservoir or dams because the it is more or less stagnant water there or the kind of flow rate is drastically reduced even in a continuous systems. So, what happens that the sediments present or settleable solids present in the water they will settle down and in order as a result basically the settleable solids and turbidity will reduce.

And when we pumped that water to the treatment facility so we are actually giving lesser suspended solids load at the treatment units so that is another advantage. As we were just discussing there are environmental impacts and these environmental impacts could be both positive and negative and even like we should consider the ecological as well as social impacts under the environment overall environmental impacts.

And if we include all the externalities generally what is perceived is that negative impacts are far more critical than positive impacts for dam and that is why we see lot of oppose for the bigger dam projects. But it does not mean that it is only going to have negative impacts there are positive impacts also which are lesser highlighted but they are. So, the net evaluation should actually I believe show the total positive and total negative impact including the externalities including the intangible impacts because there are impacts that could be tangible in terms of money like financial numbers.

So we can easily get those but there are impacts which are intangible and many times we do not give due emphasis to these intangible impacts both positive or negative. so, these externalities or intangible impacts should also be incorporated in the calculation in order to get a fair value of the net environmental impact including both ecological and social impact in positive and negative terms.

The major disadvantages are that it will significantly increase the capital cost of the project and because we are having a new unit or storage unit so of course operation and maintenance of this unit would also be there. So, it will add up to the system's operation and maintenance cost also and another major problem is these structures are prone to siltation so there would be sedimentation taking place or silt deposition taking place.

And we need to take care for this in the design and operational protocol to remove the deposited silt from the from these kind of reservoirs raw water storage systems whether it is a dam or it is a upstream reservoir. And as we said that this siltation is problem for the structure but it eventually improves the quality of water which is pumped for the treatment facility. So, it is in a way like it may be a negative impact for the structure itself but it is a positive impact for the water quality.

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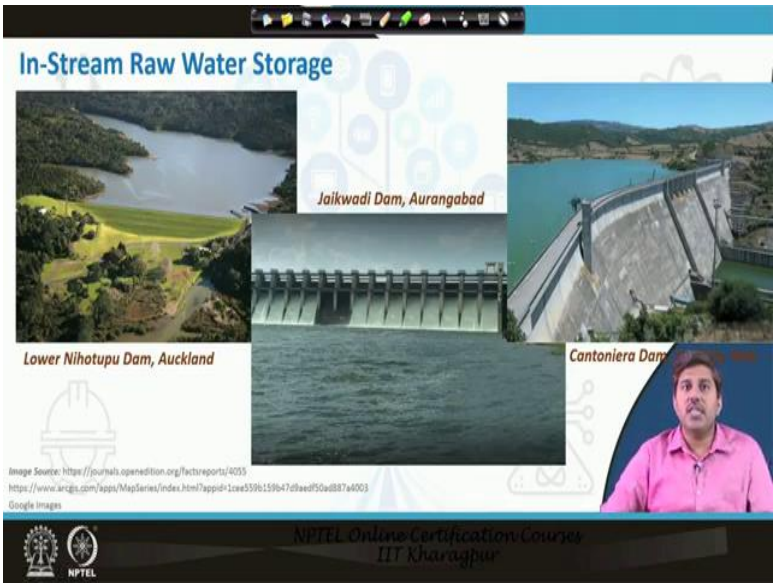

So, these are some of the examples of in-stream draw water storage systems where we basically construct dam. So, like this one you see is the dam in Auckland which is used for the water supply of Auckland so there are several dams and all of the Auckland actually gets water supply through these kind of dam impoundments. And one of them is this lower New Yorker dam. This is the Jaikwadi dam in Aurangabad which serves major irrigation project as well as source of water for the water supply to the city of Arungabad.

And Cantaniera a dam in Italy so that is also one of the major water supply project in the Italy.

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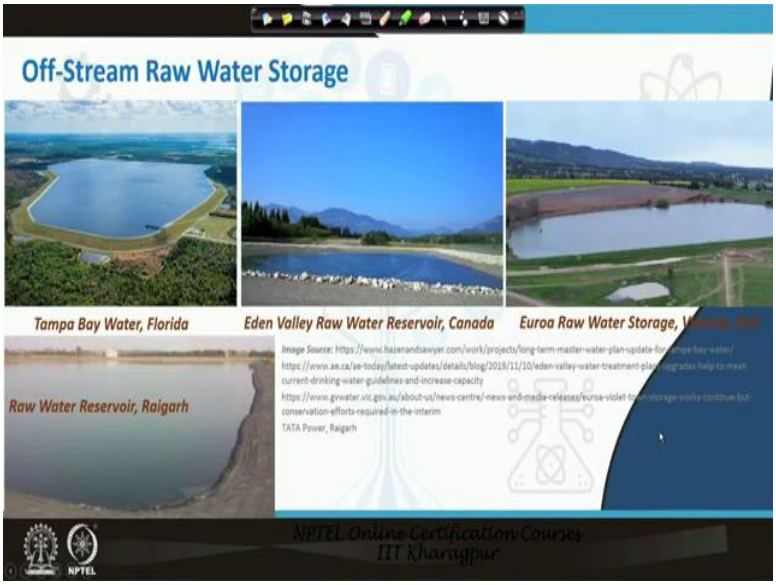

This some of the off stream storage; so this is the Tampa Bay River in the Florida this is Eden Valley raw water reservoir in Canada. Euroa raw water storage in the Victoria Australia this is a raw water reservoir in the Raigarh. So, that way we can see several structures across the globe in the different countries continents and many places separate off stream draw water reservoirs are used for storing water for the purpose of ensuring water supply.

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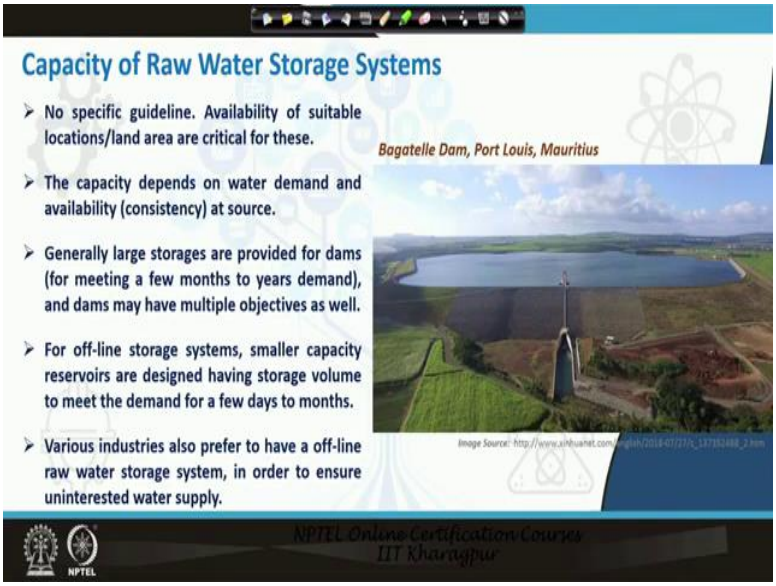

These raw water reservoirs off stream reservoirs are also important for industrial point of view so many industry because they may not actually get a consistent source over a period of time so then they kind of store raw water and then feed the water for the different industrial processes from this raw water reservoirs after dew treatment though. So, or figuring out the capacity of these raw water storage system there is actually no specific guideline for the capacity of raw water storage system.

It totally depends on the requirement and the geography available. So, what location we are considering for it how much area is available what kind of geography is available and what is the availability of water in the source that we can pump through and more some important what is the requirement. So, the capacity will depend on the water demand and availability at source so how much water is required and how much water is available at the source.

So, that based on that probably a reservoir sizing can be done. The large storage which are provided for dams are generally for meeting demands for much larger period. And this generally dams are not at particularly the larger dams as we said earlier also are not only focused on the municipal water supplies. The major objective of the dams is rather feeding the irrigation canal or storing water for irrigation purpose not letting water go to the sea and get basically merge into the sea and turn into the saline water.

So, that is the major objective of most of the large dams in India. In a broad many places the this kind of dam or reservoirs are strictly used for the meeting domestic or municipal water supplies and those store water to feed the city for a period varying from few months to few years times. Like there are reservoirs which can store water so that it can uninterrupted a feed a city major city for say 3 year or 5 years that period.

There are smaller dams which can feed say for up to 6 months. So, that way dams store much larger water and particularly the larger dams but as we said that they do have a multiple objective as well they may have objective of the irrigation feeding irrigation can ask they may have an objective of industrial supplies they may have an objective of the municipal supplies. So, that way there could be the different objectives hydropower generation is another major objective that dams are constructed for people.

So, that is about the dams for offline storage system smaller capacity reservoirs are typically designed and they have a storage volume to meet the demand which may vary from a few days say 30 days 50 days 100 days or that many to few months actually. So, they are the kind of offline storage system generally offline storage system because it is not a dam impoundment it is not in the river stream where all the water is being retained.

So we have a capacity of generalizing the water to off stream storage system or pumping water to off state off stream storage reservoir. So, if these reservoirs are not usually that bigger capacity but still substantial water is stored and which may actually be sufficient to feed the city or town for a few months at times as just we were talking about there are various industries also who preferred to have offline raw water storage system in order to ensure the uninterrupted water supply.

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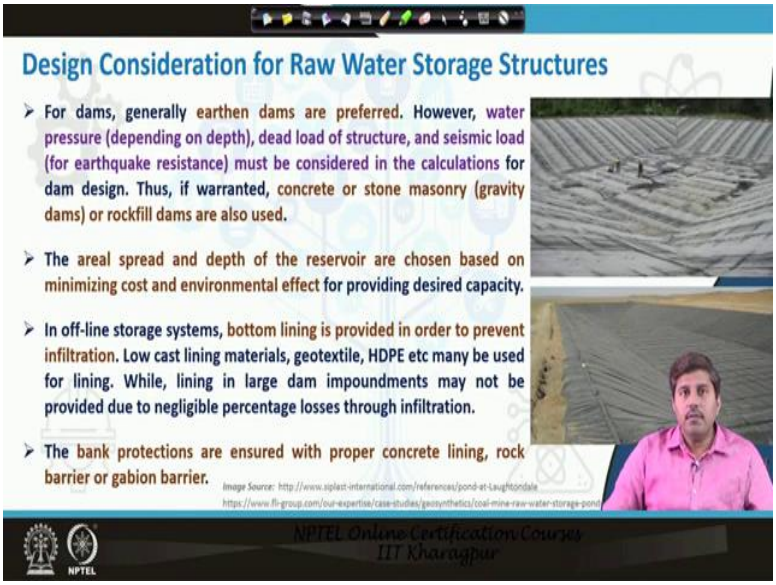

For designing these raw water storage structures one of the major criteria is that basically if we are designing bigger systems say for dams so we must include all the forces acting upon. So, what is the water pressure what is the dead load of this structure what is the seismic load of the; seismic a load that might come which is required for earthquake resistance. So, all this is calculation for the dam design and usually urbane dams are preferred.

But if say the resistance or the capacity bearing capacity is not that good so we may go for a concrete or stone masonry dams which are gravity dams or rock fell dams. And these dams because of their heavy structure they are kind of sufficiently strong enough to bear all the forces. The areal spread and depth of the reservoir would be chosen based on the minimizing cost and the environmental impacts.

So we have to have an idea of what capacity of reservoir we want or dam impoundment we want and what land we need to cover whether that much land is available or not should we go deeper in more in the depth or more in the kind of aerial spread so that all that points will should will be considered for basically specifying the capacity of the impoundment for storing

water. In the off stream storage systems generally the off stream storage reservoirs we should provide the bottom lining.

Bottom lining is essential for avoiding the seepage of the water because otherwise we are storing water and majority of water can actually be lost through seepage. Anyway there would be losses due to the evaporation until unless we cover the surface. Covering surface is also not ideal because it hamper the oxygen transfer of the water and may deteriorate the quality of water. So, partial covering is provided at times and otherwise also like the at least the seepage loss should be minimized and for that purpose we may need to give the lining at the bottom.

Generally low cost lining materials are used at times geotextile HDP etc may also be used for lining. In some cases concrete lining is provided. Lining in large term impoundments may be avoided at times because the overall loss of the water through infiltration is much less much less not in sense of the quantity is less but because the impoundment is quite large. So, if you see the percentage loss it is very low and probably goes for recharging groundwater in the upstream so it is not considered that bad as the storage capacity is already sufficient.

Also the bank protections must be ensured with proper concrete lining or if we are not providing concrete lining at least the rock barrier or gabion barrier must be provided. So, gabion barrier is also basically we put rocks and boulders in a packed form so which basically gives us a gabion barrier.

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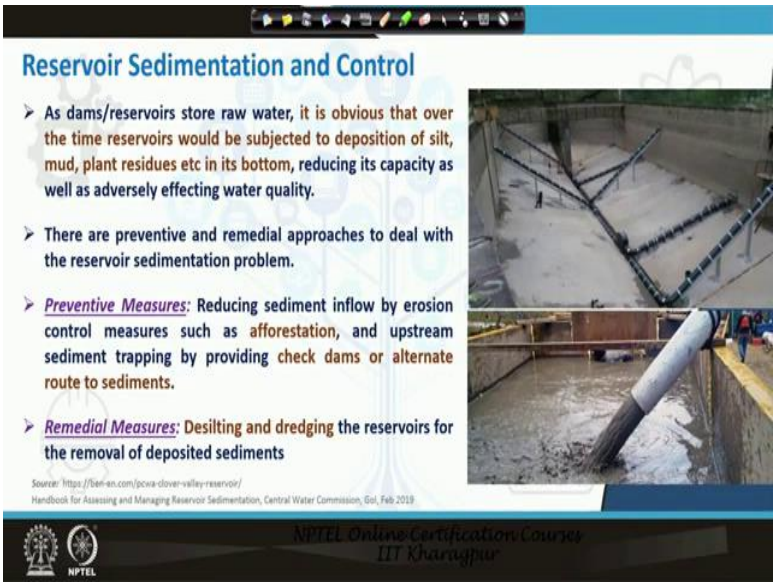

Now one of the problem in these reservoirs raw water storage reservoirs or dam impoundments is actually of the sedimentation. So, because we are storing draw water so it is obvious that over the as basically the time progresses the reservoir would be subjected to the deposition of the suspended materials which can shatter like silt mud various plant residues and debris and these will settle usually in the bottom.

Now as the time progresses the settlement will increase the mass settlement mass will increase and it will eventually reduce the capacity of the dam or reservoir and as well it will adversely affect the water quality because lot of material is settled in the bottom and further filling water some of them will get resuspended and then it can actually some let us say like plant residues and these things might start degrading their itself or some decomposition and those things so it may add certain unwarranted chemicals in the water which generally is not considered for the treatment purpose.

So as a preventive and remedial measure there are two approaches how we can actually reduce this sediment inflow which is actually a preventive measure. Now how we can reduce the sediment inflow to the reservoir or to the dam first is by erosion control measure so we let the lesser sediment or lesser silt come into the water. So, we can reduce the irritability by certain actions such as a forest resin and those things just beside the impoundment or reservoir area.

And other approaches are the upstream sediment trapping by providing check dams. So, we can provide check dams before the actual reservoir so that these some of these things are basically retained at the check dam itself or we can provide alternate route to the sediments. So, there is a concept of sediment routing where basically from the dams and these things we provide a separate passage for sediment so that it can go to the downstream and the problem of siltation within the dam or reservoir may actually be reduced.

So, these are some of the preventive measures but if this sedimentation has taken place if siltation has taken place then we have to go for the remedial measures which is typically desilting and raising the reservoir for the removal of the deposited sediment.

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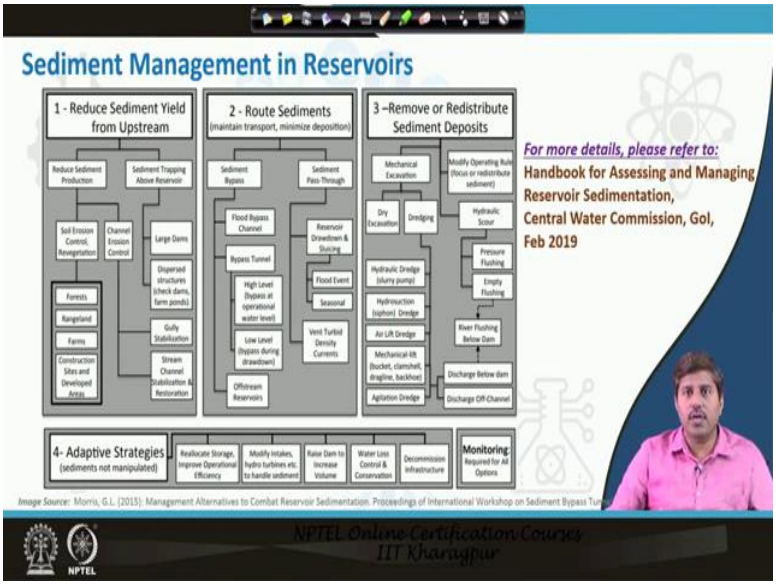

So, when it has already deposited so we need to desilt and raise it in order to basically get the capacity augmentation or the overcome the loss of the capacity which are already taken place due to this sedimentation. So, overall if we see the sediment management in the reservoirs so we can reduce the sediment yield from the upstream and this can be done by the reducing the production itself or sediment trapping above the reservoir.

So, sediment tapping above the reservoir as we said can be done through kind of check dams and those kind of things. And a reduction can be done through soil erosion control so reeve agitations or afforestation and those kind of thing. And the channel erosion control by providing gully and channel stream stabilization. So, these things can help then the other option is rooting sediment so as we said that through sediment routing.

So, we maintain the sediment transport and minimize the deposition. So, we can provide the sediment bypass by flood channel bypass or bypass tunnel or off stream reservoirs. And we can actually let the sediment pass through the reservoir itself. So, reservoir drawdown and sluicing or through providing a vent we can actually ensure that sediment passes through the reservoir itself. Then there is other approach of the removing or redistribute in the sediment deposit which is by dressing.

So, we can go for drag excavation or dressing through mechanical level excavation and we can use technologies kind of hydraulics car or river flushing before the dam those kind of thing can also be used for the purpose. And then there are adaptive strategies which is basically where basically sediment not manipulated. So, we relocate storage we modify intake we raise the dam

to increase the volume so some of these kind of strategies also we can follow which are more so adoptive we are not playing much around with the deposited sediments or the sediment deposition or the dam itself.

We are actually taking some adaptive measures so even if the sedimentation take place we can still get the like dam function or reservoir function can still go uninterrupted and monitoring is of course required for all. So, these are some of the major management approaches for the reservoirs. The more detail of this is actually available in a handbook for assessing and managing reservoir sedimentation which is by Central Water Commission of the Government of India published in February last year.

So this is about the some of the sedimentation issues in the and management strategies for the dam or reservoir control. We did talk about the raw water storage systems how we can actually think about the capacity of the raw water storage systems. Then some of the design considerations and the sediment management practices in the raw water storage reservoirs.

So next class we will be talking about the treated water storage system, so thank you for joining and I see you in the next class.