Watershed Management

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Module No. # 10

Lecture No. # 40

Water Reclamation and Reuse

Namaste and welcome back to the video course on watershed management. Today in module number ten, lecture number forty - the last lecture; we will discuss about water reclamation and reuse.

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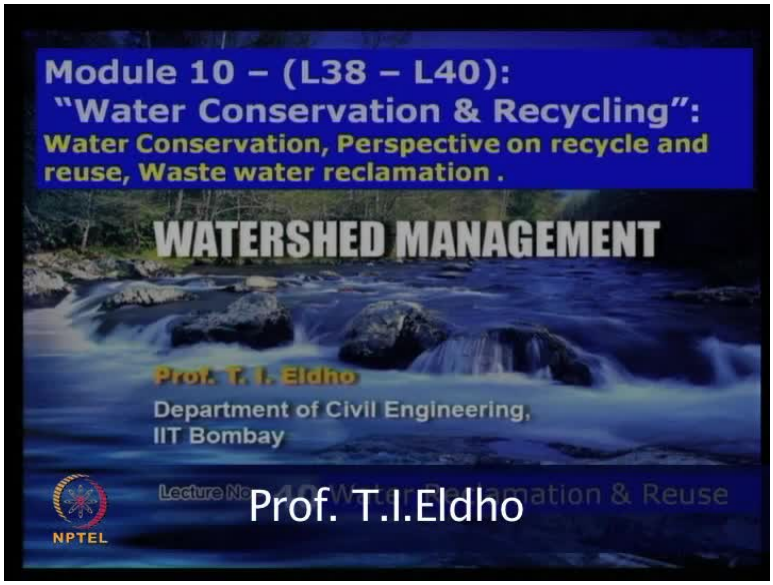

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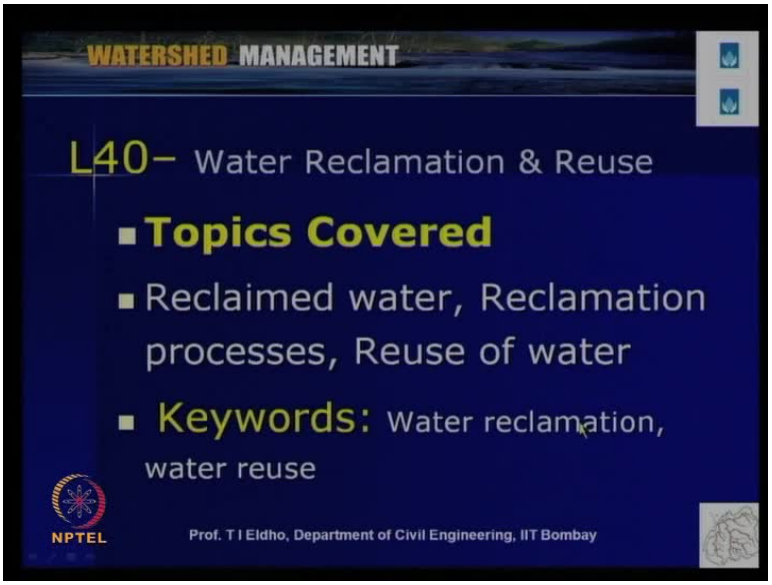

Some of the topics covered today include reclaimed water reclamation processes reuse of water then summary of the course so keywords for today's lecture include water reclamation and water reuse. So, as we are discussing in the last two lectures water conservation, water recycling and water reuse is very important aspects as far as water saving is concerned or wherever water scarcity is there the way which we can go ahead is, conserve the water use very effective way the water or most efficient use of water. Then, recycle or reclaim the used water and further reuse. So, that should be the way we can say go ahead with the available limited resources so that, we can have the best utilization of the water.

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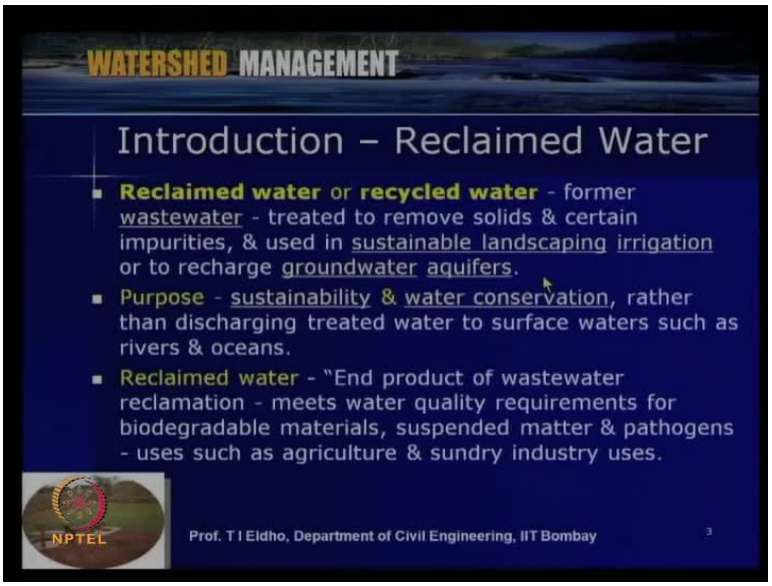

So, when we look into the reclaimed water so reclaimed water or recycled water as we were discussing in the last lecture. It is former wastewater so treated to remove solids and certain impurities and used in sustainable landscaping irrigation or to recharge groundwater aquifers. As we were discussing in the last lecture we can use this reclaimed water or recycled water say mainly for non-potable purposes such as say, irrigation purpose or the some industrial purposes or some domestic purposes like say flushing toilets like that. Or say some type of potable use but through may be by recharging to the aquifer systems as groundwater recharge or we can say send this purified water reclaimed water to the surface water sources which we can further utilize.

We can mainly use the reclaimed water for non-potable purposes but sometimes in the water scarcity is there we can further use the reclaimed water for say potable purposes also through groundwater recharge and other ways. So that way when we look into the reclaimed water the main purpose is sustainability and water conservation rather than discharging the treated water to surface waters such as rivers and oceans so as we know that the wastewater without treating many locations as we were discussing some of the lectures also earlier.

Water quality is a problem say, water pollution is a major problem; so especially industrial or the municipalities when they send the wastewater without treat… without appropriate treatment to the surface water sources like lakes rivers or to the sea then the existing say natural water will get further polluted and this wastewater disposal is a major issue. So that way when we look into water reclamation or the water recycling and then reuse we can see that say we are trying to conserve the water and then further as far as water as a resource is concerned say it become more sustainable. And then say we can see that the amount of wastewater say if you are reclaim the wastewater through recycling then the amount of wastewater to be to be treated or to be sent to the surface water source like rivers lakes or the sea become reduced so that way we are getting environmental benefits also that way it is a economical also.

So when we look into reclaimed water, we can see that end product of wastewater reclamation meets water quality requirements for biodegradable materials suspended matter and pathogens so that say the uses such as agriculture and industrial uses we can meet with respect to the reclaimed water.

So when we look into the reclaimed water we have to see that as we were discussing the last lecture also we have to see what is the use what is the intended purpose or the use using that reclaimed water. Then, what is the source of that the wastewater coming from say whether it is coming from domestic sources or industrial sources? How much treatment to be given? So, we have to work out say what kind of treatment to be given and what type of reuse will be possible. Accordingly, we have to see the type of use type of reuse as far as the wastewater is concerned.

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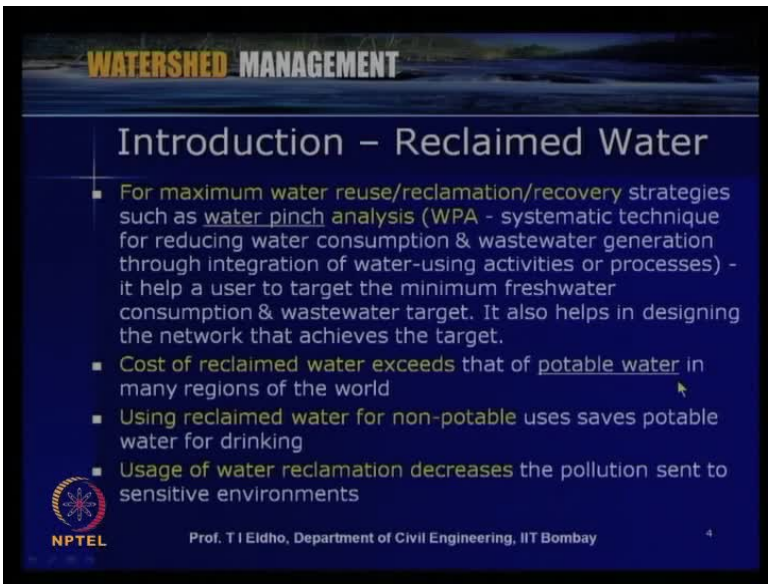

Now, when we look into the reclaimed water say, for maximum water use or reclamation or recovery, we have to say select appropriate strategies, strategies such as water pinch analysis. Water pinch analysis - an analysis which is done in many countries - it is actually a systematic technique for reducing the water consumption and wastewater generation through integration of water using activities or processes.

This water pinch analysis its scientific method say so that we can identify how much water is to be reclaimed or how much water is coming as wastewater and then how we can say go for systematic technique of reducing the waste the water consumption and the wastewater generation. So this kinds of analysis like water pinch analysis helps a user to target the minimum freshwater usage and the wastewater target. So water pinch analysis important as far as when we look into water conservation and then it is a wastewater

generation wastewater treatment with respect to all these things. So that way this kinds of analysis helps to helps in designing the network that achieves the target.

The target is the efficient usage of available water so then we want to use the less water as far as the consumption is concerned. So that wastewater generate will be also less and then that way we can conserve the water and then we can choose appropriate methodology for reclaiming or recycling or reuse.

So as far as the cost of reclaimed water say, when it exceeds that potable water, in many regions of the world, we can see that say most of this wastewater when we have to give appropriate treatment that will suit say to the standard of potable water. Then, we have to work through say not only primary or secondary but tertiary treatment. And then say nano filtration or the reverse osmosis that kinds of processes as we discussed in the last lecture we have to give and then the cost of the reclaimed water go up.

So that way we can see that in many locations so the cost of reclaimed water may exceeds the available natural potable water. So that way we can see that the when we use the reclaimed water for non-potable uses so say if we can use this reclaimed water for non-potable uses like industrial or domestic purposes or agricultural purposes. We can save the potable water for drinking and so that way say the whatever we have to use for other purposes the potable water which we are using that can be reduced by using the reclaimed water so that way we can save the water and then usage of water reclamation decreases the pollution sent to the sensitive environment.

So as we were discussing so when we are reclaiming or recycling the wastewater. So actually the amount of wastewater to be treated and to say before the disposing to the to these surface water sources like rivers or the ocean so that way the amount is reduced and then when we are reclaiming the water. So that way also we can say benefit so that way we can see that when the usage of water reclamation decreases usage of the that decreases the pollution of the polluted water sent to the environment.

So that way say it is as far as the waste wastewater reclamation is concerned say when we are using that way we are saving plus the amount of wastewater we are reducing so that way also we can save . But say if portable water is available as a cheap source then we can see that while going through these kinds of reclamation or recycling the cost may

exceed. But anyway when we look into industry processes or urban areas or cities we can see that this recycling is a good option or reuse of the reclaimed water is a good option as we were discussing in the last lecture.

So when we try to reuse the reclaimed water number of concerns are there about say whether it is whether we are going for non-potable purpose or potable purpose so we have to see all these concerns.

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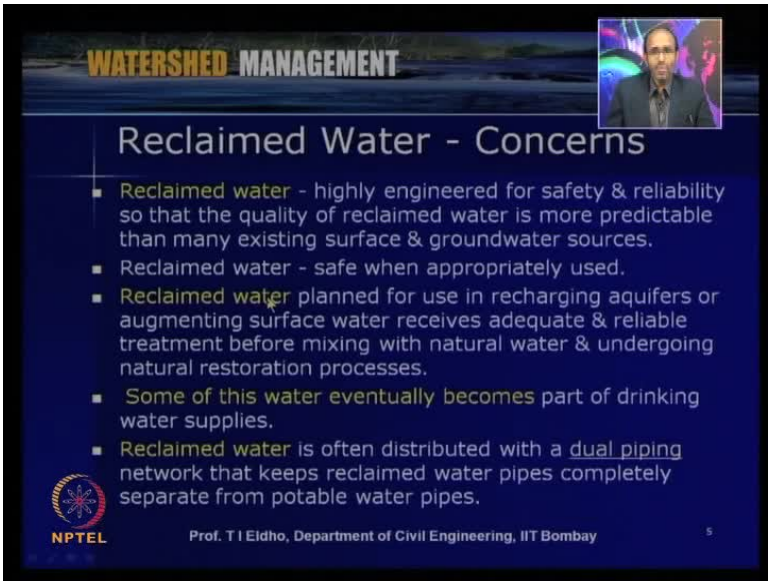

So let look into what are the important concerns when we look into reclaimed water and it is reuse.

Reclaimed water is highly engineered for safety and reliability so that the quality of reclaimed water is more predictable than many existing surface and groundwater sources. So say the water recycling or water reclamation process so it is a systematic process through which say we have to send the wastewater through various stages and then we can see that say we can predict what will be the quality of the reclaimed water which we have to reuse for various purposes.

So that way this reclaimed water is a highly engineered water so that may be sometimes more pure than the natural water available from the existing surface sources or groundwater sources. So that way we can see that when reclaimed water is safe when

appropriately used so as I mentioned we have to see the intended use of the reuse of the wastewater and then we have to give appropriate treatment accordingly.

So reclaimed water say planned for use in recharging aquifers or augmenting surface water receives adequate and reliable treatment before mixing with natural water and undergoing natural restoration processes

So especially if we are planning to use this reclaimed water say for potable purposes or recharging to the aquifer systems or to the when we are discharging to the natural sources of water like your rivers or lakes we should be very careful and then we have to see that it meets the required standards and then reliable treatment is given before missing this reclaimed water

And then some of this water eventually becomes part of drinking water supplies so we can see that say especially say let us assume that there is a long river and then number of cities are there say at different parts of the river. So then we can see that most of the time what happens say the cities on the upstream sides say they take the water from the river and then use it and then after treatment they put back the effluence to the river again.

Then, the downstream sides again cities will be there and then they are say again drawing this water for their purposes. So that way we can see that the water say in many of the water supplies of many cities especially on the riversides we can see that they are using the reusing the water so the water used by one city will be again a reused by another city on the downstream side. So that way when we look into reclaimed water it is often distributed say or it is we have to take care when we look into this kinds of say the effluence what is coming to the natural systems. And then say in a township or in an area when we are trying to reuse the reclaimed water it is often instead of mixing this say if you are directly going to utilize the reclaimed water it is always better to have a dual piping system piping network so that the intended purpose of this requirement water say for example if it is for irrigation or if it is for say flushing systems

So like that it is always better to send this reclaimed water through a dual piping is a especially if you are directly going to utilize the reclaimed water. So that this the reclaimed water pipes completely separate from the potable water pipe pipes. So the user should not get to confused with the potable water pipes and the reclaimed water pipes So

that we should have a dual piping systems network and then the consumer should know which is the reclaimed water and which is the potable water so like that. So then say now let us look into what are the reclamation processes so in the last lecture also we were discussing about the water recycling. So we were discussing various processes we have discussed in detail about this processes.

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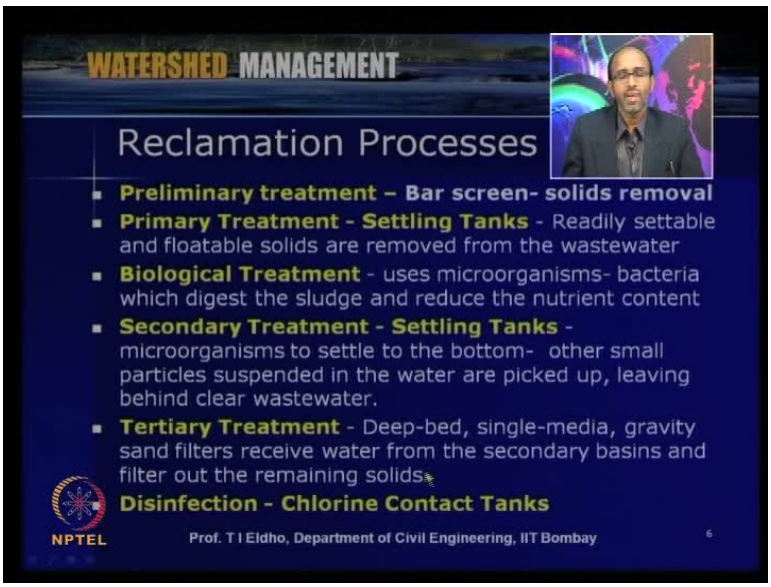

So anyway we will have quickly go through say some of the important processes where the water reclamation or water recycling which we have discussed in the last lecture also as we discussed in the last lecture

So first one is say once we collect the wastewater so we have to give some preliminary treatment like we can send this collected water through bar screen so that solids can be removed. Then the next stage is primary treatment like we can have settling tanks so that the readily settable and floatable solids are removed from the wastewater and then sometimes we can give some type of biological treatment. So using microorganisms bacteria's which digest the sludge and reduce the nutrient content in the wastewater and then say we can have the secondary kind of treatment like settling tanks and trickling filter and all those things what we discussing in the last lecture.

So here in the secondary treatment microorganisms to settle to the bottom other small particles suspended in the water are picked up leaving the behind the clear wastewater.

So many of the agricultural purposes we can use the reclaimed water from the secondary treatment we can directly go for reuse and also me of the industrial process directly we can utilize after the secondary treatment. And then if you want more purified form of the water say reclaimed water then we have to go for the various tertiary treatment which we discussed in the last lecture like a deep-bed single-media gravity sand filters then receive water from secondary basins and filter out the remaining solids. And then we can send the reclaimed water through say like filters like ultra-filters and filtration nano filtration or say reverse osmosis so that the most say purified form of the reclaimed water is obtained.

So like that whatever the depending upon the intended use say after secondary treatment or tertiary treatment we can directly reuse the reclaimed water And then especially if we are going for say potable or other kinds of uses then disinfection is also required like we can mix the water after the tertiary treatment with chlorine contact times the within the chlorine contact. And then that way we can disinfect also the reclaimed water so that way we can directly say reuse the water say even sometimes potable purposes if the sufficient potable water is not available in the considered area.

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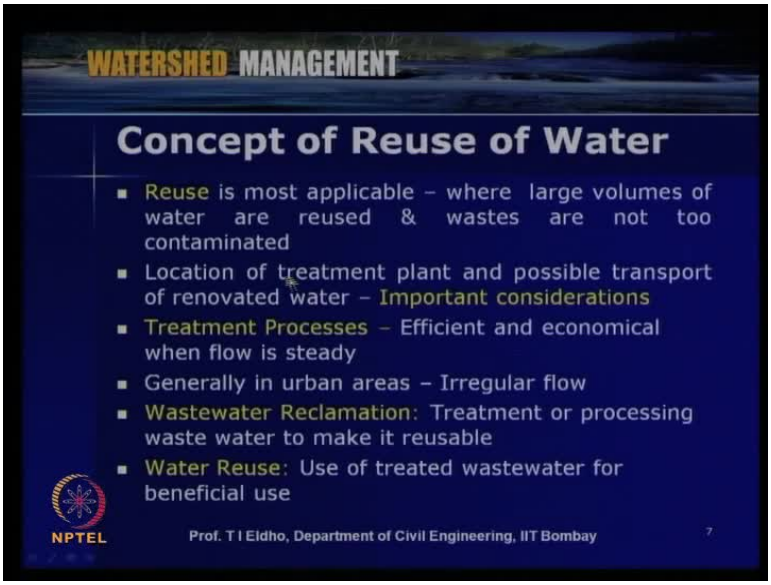

So now let us look into the say with respect to we were discussing about the reclaimed water it is processes and now let us look into the concepts of reuse of water.

So we were discussing the recycling and then reuse so where we can reuse the particular type of water and then how we can reuse. So the concept of reuse of water so as we were discussing reuse is most applicable where large volumes of water are reused and wastes are not too wastewater is not too contaminated.

So say if the water coming from say especially say like cooling processes so the water is not much say contaminated so that way we can directly reuse it or say if the waste the waste the contamination in the water is say much less say through after say washing or some other processes then reuse is most applicable And then location of treatment plant and possible transport of renovated water so these are some of the important consideration when we look into the concept of reuse of water. So we have to see that say we collect all the wastewater and then give appropriate treatment and then we have to see that say it is sent to or transported the renovated water to appropriated locations for reuse.

Now other concerns like the treatment processes so as we were discussing earlier so what kind of what type of intend use so accordingly we will be giving say primary secondary or tertiary type of treatment or the modern treatment. So but we have see that the economics also the benefit cost analysis we have to do and then we have to see that benefit say the whatever we are spending the it is beneficial. So, efficient and economical when flow is steady so especially treatment processes so if the say we have to see that sufficient wastewater is keep on coming as a source of wastewater when we are sending this wastewater for treatment through the treatment plant for reuse purposes so that steady flow should takes place.

But, we can see that especially say wherever we go for this kinds of water reclamation or wastewater recycling so most of the urban areas it is the flow will be regular so when say especially for domestic sector is concerned we can see that more water is used in the morning hours and in the evening hours. So in between or in the night time you can see that there will not be a regular supply.

So that kind of problems are there and then now say as far as wastewater reclamation is concerned we have to give appropriate treatment or processing before making it reusable so this is we have already discussed in the last lecture. Then water reuse is concerned so we have to see the use of treated wastewater for beneficial use so say for example say

after secondary treatment say for the wastewater say good amount of nutrient will be present within the secondary treated water wastewater.

So that will be may be more beneficial for agricultural or irrigation since the plants get say nutrients from this water source so like that we have to see the beneficial use as far as the water reuse or the wastewater reuse is concerned. Now, say as far as the reuse is concerned we can have either direct wastewater reuse or indirect reuse.

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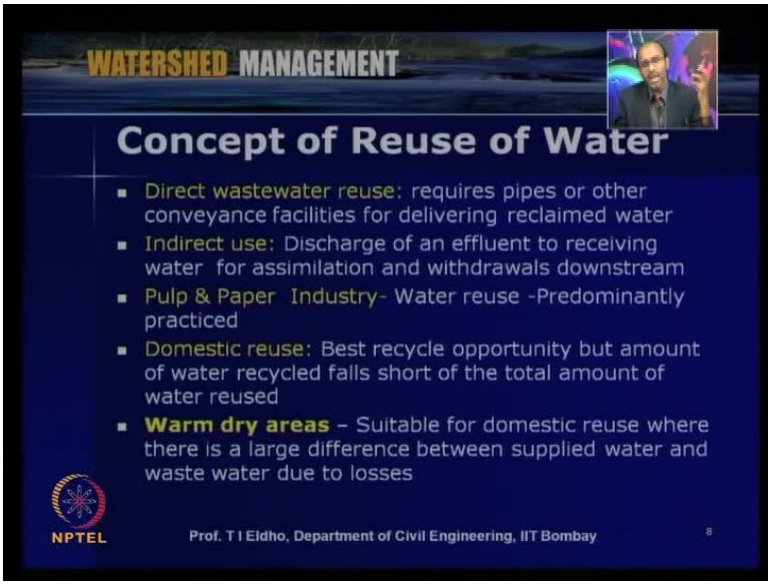

Direct wastewater reuse requires pipes or other conveyance facilities for delivering the reclaimed water. So most of the time we need the dual say system where the reclaimed water another piping system through which we can sent this reclaimed water so that is for direct wastewater reuse so that may be for irrigation or agriculture or flushing or maybe some of the industrial processes.

Now, second one is the indirect use so indirect use say here we are discharging the effluent to receiving water for assimilation and withdrawals downstream so indirect use means say for example say as I mentioned earlier say if 2 or 3 cities are there at different location on the sides of a river then we can see that upstream city.

So that what will be withdrawing the water and then after their use say after treatment the wastewater as effluent will be coming back to the river and then through natural process processes this what will become even reusable for the next city so like that the

indirect use takes place. And also say if we are recharging the treated water to the aquifer systems so then again that what will be pumping back for the direct say other use so that way we can say that there is indirect use.

Then say industries like pulp and paper industries say water reuse is predominantly practiced so through various processes from one processes another processes the effluent coming from they give a some kinds of treatment and then again they reuse for the other process. So like that say especially pulp industries textile industries paper industries say this reuse is very common and then as far as domestic reuse is concerned.

So best recycle opportunity but amount of water recycled falls short of the total amount of water reused. So domestic reuse is concerned wherever water stress or water scarcity is there we can keep on reuse but the of course, there will be some shortage since the consumption or other purposes say some water will be lost in between so say we have to see the best recycle opportunity as far as domestic reuse is concerned.

Then, warm and dry areas say the reuse is suitable for domestic reuse where there is a large difference between supplied water and wastewater due to losses so especially warm and dry areas we can see that evaporation and other losses will be much more. So that way if the water sufficient natural water is not available potable water is not available we have to look into the to the reuse concept.

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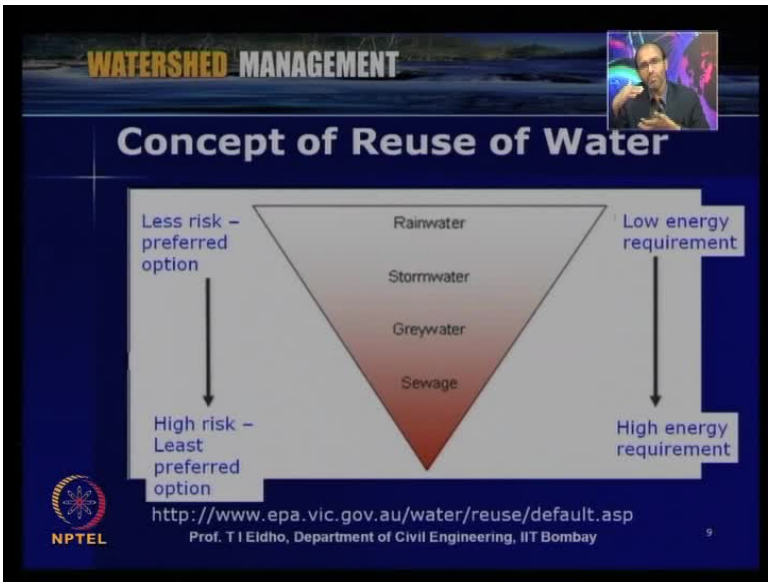

When we look into reuse say in the concept of reuse is concerned say we can as we were discussing in the last 2 lectures say as far as the water recycling say we can either say use the rain water the storm drainage water or the grey water which is not much polluted and then the sewage water so these 4 categories of water is available for reuse.

Actually, the first two categories say less risk and then preferred option say like rainwater use or the storm water use and then grey water sewage water is say high risk and least preferred option especially for domestic purposes and then I especially rainwater and storm water say the reuse the advantage is that it is a low energy requirement so no need of much treatment we can directly utilize. But, as far as the sewage water or the grey water is concerned we have to go for high energy type requirement and then we have to go for various kinds of treatment.

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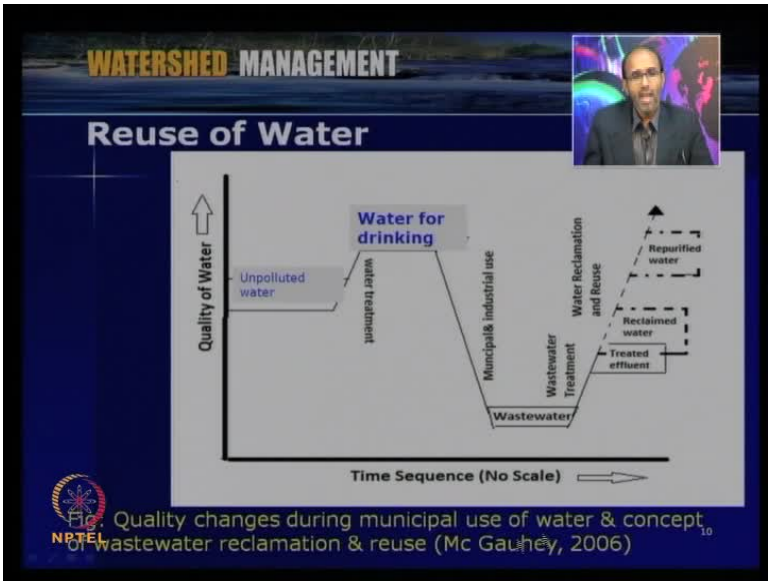

So that way we have to see what type of reuse we are looking for and from what source we are looking for the reuse then as far as reuse of water is concerned say with respect to the quality of water say and the times you can say for example and polluted water we can directly use for drinking.

Then say through after some appropriate water treatment and then as far as the municipal and industrial use in concerned directly the wastewater will be coming and then that wastewater we can treat appropriately and then water reclamation or recycling is possible

and then further reuse is possible and then say after this wastewater treatment the treated effluent and then we can reclaim the water and then repurify and further utilize. So this is the quality changes of during municipal use of water and concept of wastewater reclamation are used as given by Mc Gauhey in 2006.

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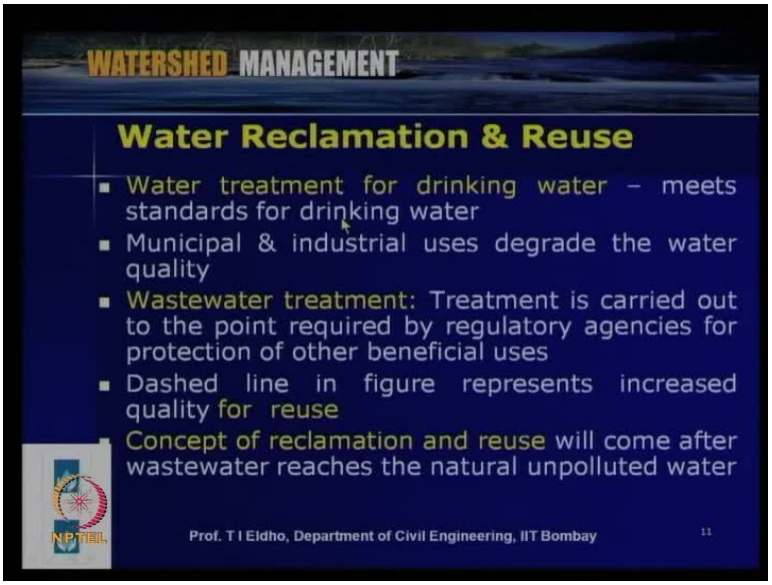

So when we look into water reclamation and reuse so water treatment for drinking water say we have to meet appropriate standards. So as we were discussing say the PH range like this is 0.528 or the GDS requirement or the BOD or COD all these kinds of requirement we have to see especially if we are trying to use the reclaimed water for drinking purposes we have to go for strict measures for quality control then say especially if you want to reuse the municipal and industrial water so that is will be much degradable water so the quality issues are there and we have to go for appropriate waste treatment.

The treatment is carried out to the point required by the regulatory agencies so what kind of treatment to be given say especially for drinking or other purpose we have to see as per the norms of the regulatory agencies for protection of other beneficial uses. So here in this figure say when we look into this say the dashed line in the figure represent increased quality for reuse and the concept or reclamation and reuse will come after the wastewater reaches the natural and polluted water.

So if the reclaimed water if you are putting to natural and polluted water then how the effect all these aspects we have to study appropriately then only we can send this effluent to the natural water sources from which if you are directly say using the water for various purposes we have to see the standards are kept as far as the reclaimed water that will be mixing with the other sources of water.

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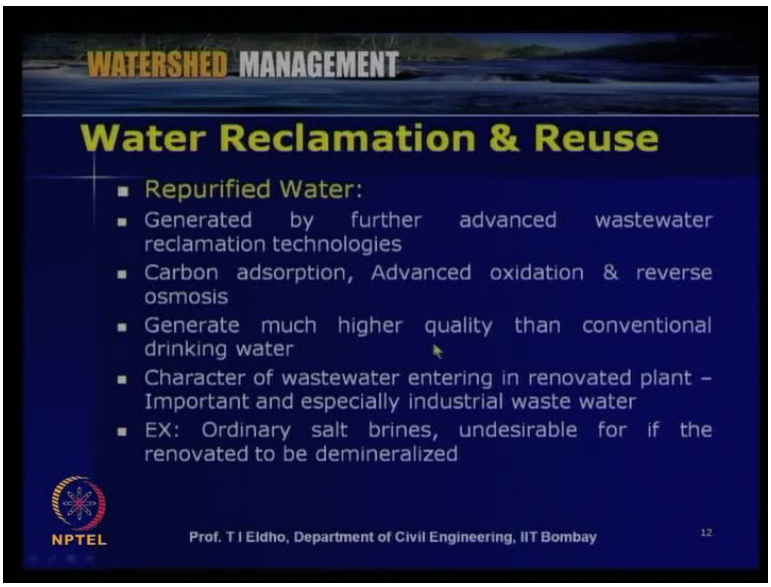

So that way we have to see the repurified water I mean, the water reclaimed and then again purified so this the water generated by further advanced wastewater reclamation technologies say like a carbon adsorption, advanced oxidation and reverse osmosis.

So, as we were discussing in the last lecture say many of this advanced treatment the water become much more purified form and generate much higher quality than the conventional drinking water what we are directly taking from the rivers lakes and other sources. A character of wastewater entering in renovated plant is important and especially industrial wastewater is concerned. We have to see which way the treatment to be given and what kind of reuse we are looking for say for example ordinary salt brines. Then, this undesirable for if the renovated to be demineralized say if the u c's not the water should not how much mineralized this thing say if the water say if we are going to reclaim from the salt brines.

Then, say if you have to remove all the salt content from the reclaimed water then it will be much more expensive and then so that way we have to see the cost of the reclaimed water.

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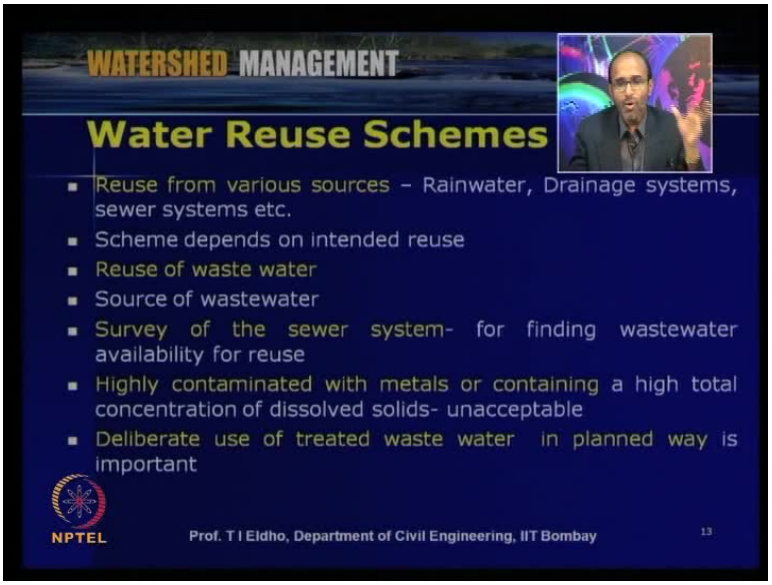

So when we look into reuse of water then various schemes we can see that say reuse from the various sources so as we were discussing the source we have to see like a rainwater drainage system sewer systems, etcetera. Then, the particular schemes we have to adopt depends upon the intend reuse as we discussed earlier and the reuse of wastewater is concerned say when we are look into the reuse of wastewater.

We have to see the source of wastewater whether it is coming from the domestic source industrial source whether it is a say the whether it is highly contaminated or whether it is only say only some tedious source small kinds of type of pollutions are there. We have to do appropriate survey of the sewer system for finding wastewater availability for reuse.

So, when we look into the reclamation water wastewater reclamation and reuse say particular area we have to study the system we have to study the quality of the wastewater coming. We have to collect the samples from the various sewer systems and then say we have to identify the parameters within that wastewater so before going for appropriate treatment that is to be given for the wastewater. Highly contaminated wastewater with metals or containing high total concentration of dissolved solids

generally these are unacceptable for most of the users especially domestic or industrial purposes are concerned.

Then the deliberate use of treated wastewater in planned way is important say as we were discussing some of the case studies like the Rashtriya chemical fertilizers Mumbai in Chembur plant say they are deliberately using the treated wastewater for their industrial processes. So, that way they know the quality of the wastewater and then accordingly they have put a system of treatment as far as the reuse scheme is concerned.

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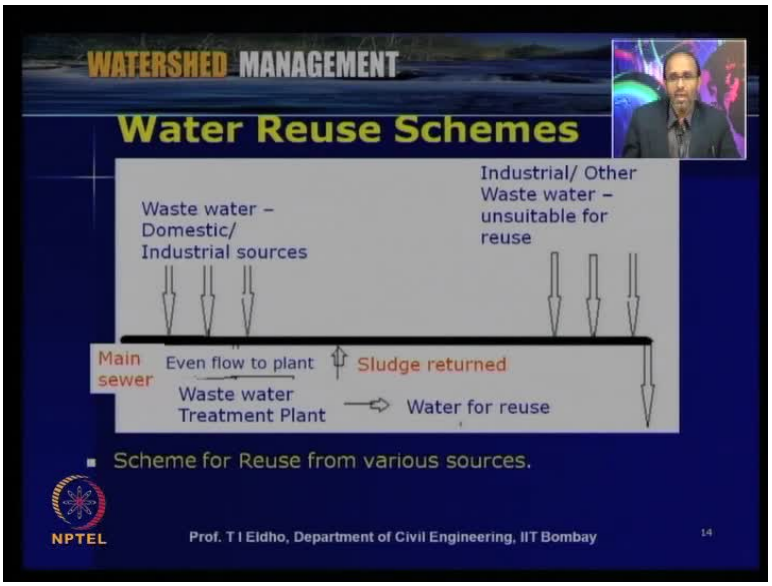

So, that way when we look into the reuse schemes water reuse schemes we have to study the sewage water the at various locations like main sewer. Then, the main sewer may be wastewater may be coming from the domestic sources or industrial sources after treatment then say sometime we can directly say if not much polluted we can directly put into the wastewater treatment plant.

So, then, we have to after the treatment we have to send that water for reuse and then from the treatment plant say the sludge is returned back to the main sewer which will be again further mixed with the other highly polluted wastewater say like which is not suitable for reuse and then all this mixed will be sent to further say sewage treatment and then the treated effluent will be sent to the natural sources like rivers lakes or oceans.

So, that way, when we look into the water reuse schemes we have to study the various aspects like the quality of the wastewater from where we are taking the wastewater and what kind of treatment to be given and then what will be the intended reuse so like that we have to plan the reuse schemes. So, when we look into reuse schemes say we can see as I mentioned it can be unplanned reuse schemes or the planned reuse schemes.

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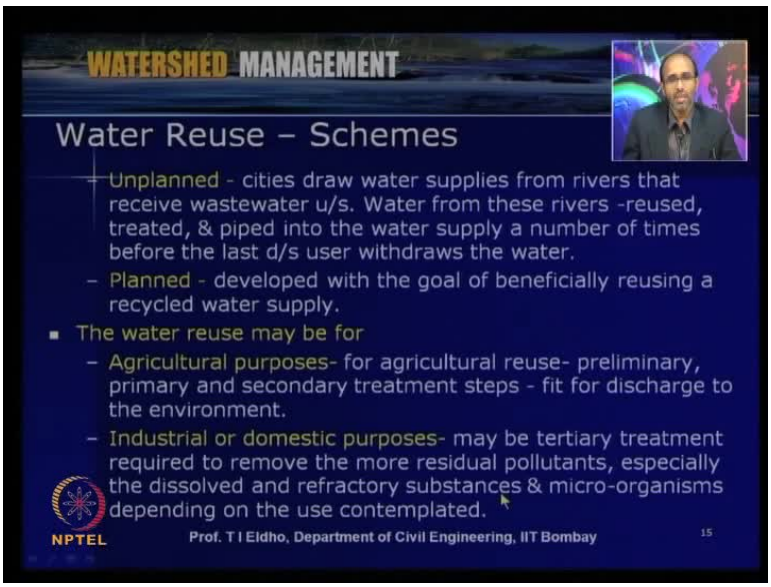

Unplanned reuse schemes as I mentioned earlier, cities draw water supplies from rivers that receive wastewater upstream and then water from these rivers are reused treated and piped into the water supply a number of times before the last downstream user say last city with withdraw the water.

So, that way so the especially on the banks of the rivers say long rivers we can see that a number of cities will be there on both sides so that way we can see that these are all unplanned. The cities are developing and then they need water and then that way say we cannot plan say in advanced so this as this is called unplanned schemes reuse schemes.

So, then planned scheme is say especially for a industry is concerned or particular locality is concerned say we can identify the quality of the wastewater and then we can go for appropriate treatment and then beneficially reuse the recycled water. So, that way the water reuse maybe for say then accordingly whether it is unplanned or planned we

have to see the intended use especially the planned use maybe for agricultural purposes or industrial or domestic purposes.

Especially, for agricultural purpose are concerned for agricultural reuse say we may have to go for preliminary primary and secondary treatment as we discussed in the last lecture. Then, industrial domestic purpose are concerned we may have to go for tertiary treatment also and then to remove the more residual pollutants especially the dissolved and refractory substances and microorganism depending on the intended use as far as the reuse is concerned.

So, that way when we look into the reuse schemes whether it can be a unplanned reuse scheme or the planned reuse scheme so accordingly we have to go for the treatment and the reuse.

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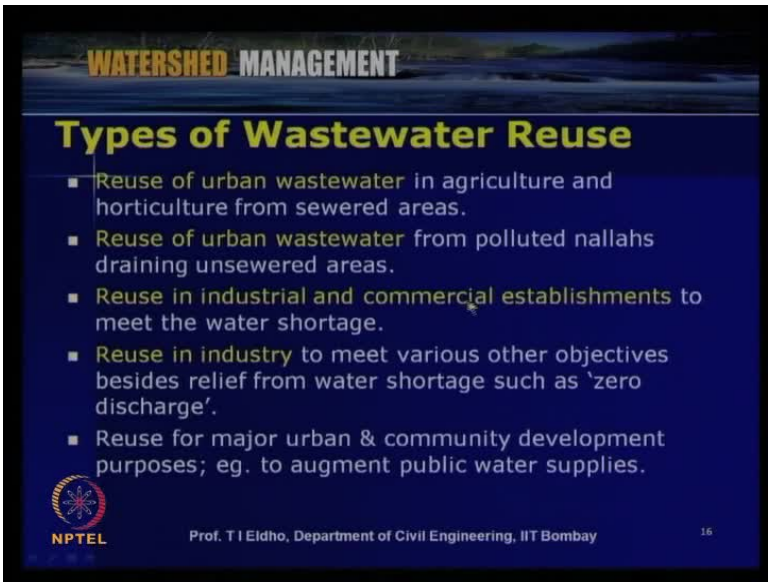

Now, let us look into the different types of wastewater reuse so the reuse of urban wastewater in agriculture and horticulture from sewered areas. So, as we were discussing earlier we can give some primary or secondary treatment and then directly we can reuse it. Then, reuse of urban wastewater from polluted nullahs draining unsewered areas so there the wastewater will be much more polluted and then we may have to give more treatment depending upon the intended use and then reuse in industrial and commercial establishments to meet the water shortage.

So, as we are discussing some of the case studies earlier we have to we can even collect the wastewater and then send to appropriate treatment plants. So, that the concerned industry get sufficient water through this process of water reclamation and reuse so that way say now a days we can see that many of the industries are looking for zero discharge.

So, whatever the water they are using they are keep on reusing through reclamation various reclamation process finally there will be only sludge will be sent for further waste treatment otherwise say we the most of the some of the industries can achieve the zero discharge. So, now say as a part of environmental sustainability the major motto of the most of the industry is to achieve the zero discharge level.

As far as reuse is concerned, for major urban and community development purposes we can say we can use the wastewater say example to augment the public water supply. So, like through recharge to the aquifer systems or after appropriate treatment we can put this the effluent I mean, the wasted the treated wastewater which is in a good form. We can I mean, as a good form of the water that can be sent to the water sources like rivers, lakes and the aquifer systems.

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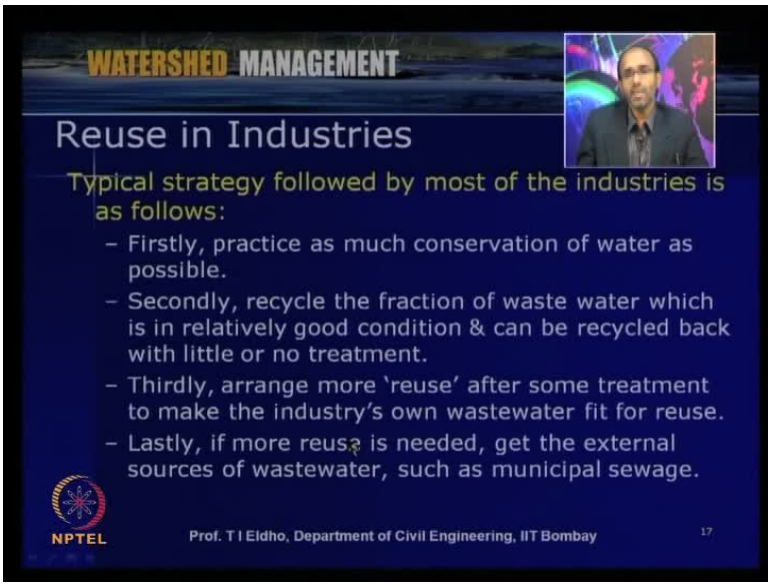

As far as reuse in industries are concerned, so say some of the typical strategies followed by the industries here I have listed say first one is of course, most of the industries are

looking for water conservation. Most efficient use of the available water and then reduce the usage is concerned as we were discussing in one of the previous lecture.

Firstly, practice as much conservation of water as possible so that is the first aim of the industries. Then, secondly recycle the fraction of wastewater which is in relatively good condition and can be recycled back with a little or no treatment. So that way, the industries can save lot of money since, if they have to buy again freshwater that will be more expensive. If we, if they can recycle some with some treatment of the water then that can be with little or no treatment that can be directly utilized for other processes.

Then, thirdly we can arrange for more reuse after some treatment to make the industries own wastewater fit for reuse. So, the third aspect in reusing industry is concerned they have to correct all the effluent or the wastewater coming from various plants and then they have to give appropriate treatment and reclaim the water and then go for the reuse.

Then finally, as we discussed in some of the industrial plants like RCF in Mumbai, if more reuse is needed get the external source of wastewater say, from the municipal corporations, they can get the wastewater of the municipal sewage can be obtained.

Some of the industries in places like Mumbai and Chennai they are doing this. They buy the wastewater from the municipal corporations and then they give appropriate treatment and then that can be reused. So, that way the reusing industries concerned first one is water conservation second one is say the recycle with water with the relatively good condition without much treatment. Third one is, there are own say reclaimed water through appropriate treatment reuse. Then lastly they can get the wastewater from the municipal corporation and then reuse.

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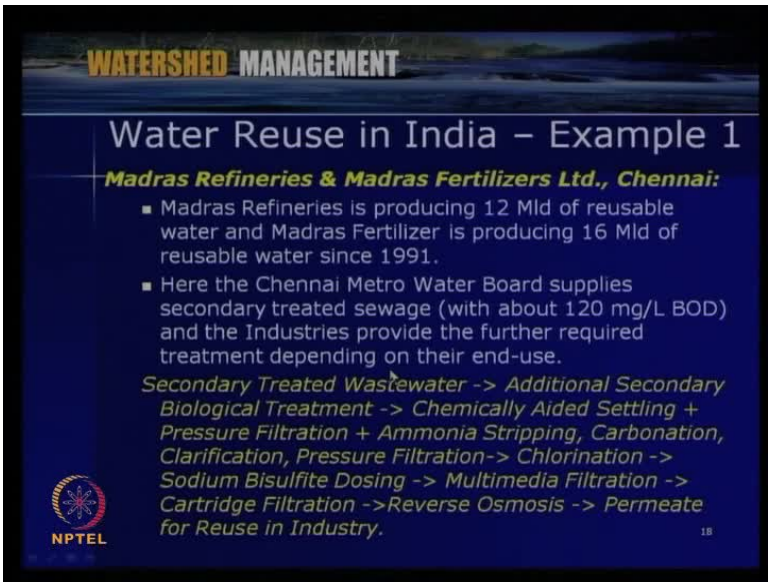

So, as far as the way water reuse in India is concerned, we have discussed two cases in the last lectures. So, again here two more examples I have put here. Water reuse in India say, first the madras first example is Madras Refineries and Madras Fertilizers limited, Chennai.

Madras Refineries is producing about 12 million liters per day of reusable water and then Madras fertilizers producing about 16 million liters per day of the reusable water since 1991.So, through various processes they are treating this their own wastewater and then they are recycling it and then reusing it here the Chennai also this industries say whatever the scarcity of water is there they buy the wastewater from the Chennai metro water board and then the water board supply the water after second treatment so about one twenty milli which has about one twenty milligram BOD. These industries get this water and give appropriate treatment depending upon their end-use. So, like say they get the secondary treated wastewater then, they go for additional secondary biological treatment.

Then, like a chemical aided settling plus pressurized filtration plus ammonia stripping then carbonation clarification then pressure filtration then chlorination then sodium bisulfate dosing; then multimedia filtration then cartridge filtration then reverse osmosis and then the permeate the water for reuse.

So, these kinds of say flowchart is used for their own wastewater or the wastewater obtained from the Chennai metro water. So, that way what I want to say is, that say depending upon the intended use, depending upon the quality of the wastewater or the contents of the wastewater, we can have appropriate treatment process and then we can reuse that wastewater.

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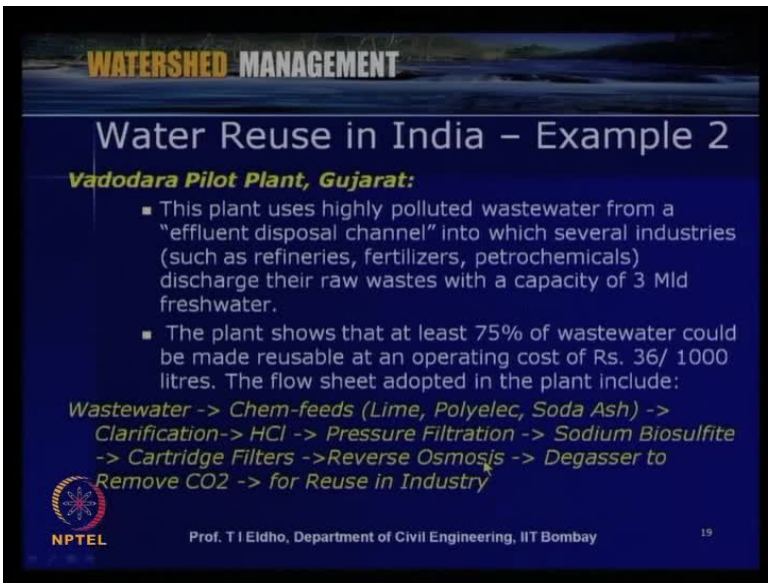

This is example one and in second example here another Vadodara pilot plant in Gujarat. So, this plant uses highly polluted wastewater from a effluent disposal channel into which several industries such as refineries fertilizers petrochemicals discharge their raw wastes with a capacity of 3 million liters per day freshwater.

This plant actually, they are collecting the wastewater which is taken from a nullah or a channel - waste disposal channel and directly they are giving appropriate treatment and then say the capacities about 3 million liters per day plant shows that at least 75 percent of the wastewater could be made reusable at an operating cost of rupees 36 per 1000 liters. So after doing all this treatment it is shown that if the cost is only about rupees 36 per 1000 liters.

The flow sheet adopted in the plant include the following treatments like the collection of wastewater then say they it goes through chemical feeds lime polyele or soda ash depending upon the water quality. Then it will be sent to clarifiers; so then clarification

and then some say HCL treatment is given and then it will be sent through pressure filtration and then it will be sent through sodium biosulfite treatment and then further cartridge filters either ultra-filtration or nano filtration or reverse osmosis will be done and then to remove the carbon dioxide degasification is done and then further the purified water is reused in the industry.

So, again, here you can see that this industry is concerned it is not using their own wastewater but they are collecting the wastewater from the external sources and then go through series of treatment and then that water is used in the by the industry. So, that way we can see that they are having they do not need further fresh source of water, but even the wastewater they are giving appropriate treatment and then reusing for the their intended use. So, that way we can see number of cases of water reclamation and then reuse in India and other parts of the world.

So, as we discussed earlier the water reclamation or water recycling is increasing say a range of above 10 to 15 percent per annum and then say the reuse is also for various purposes and with ultra-modern techniques so even the recycled water reclaimed water we can directly even supply for a drinking purposes.

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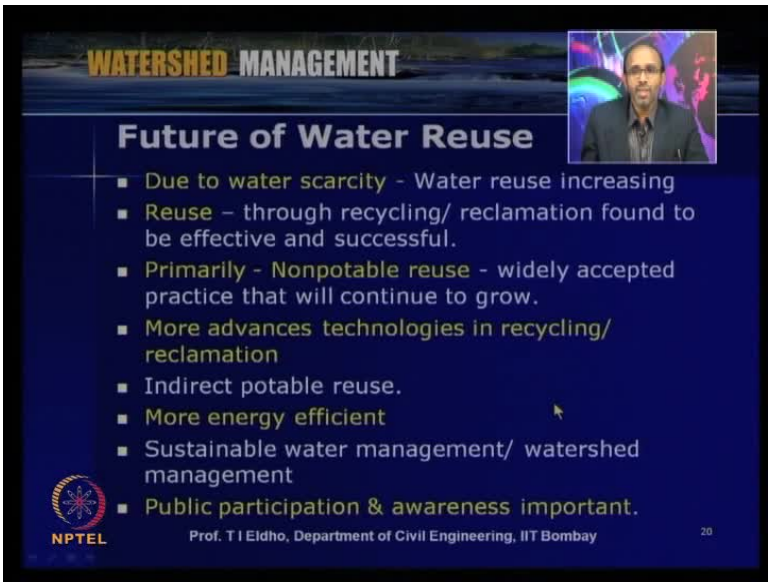

So that way, finally before concluding this part of the lecture let us look into the feature water reuse. Due to the water scarcity or the water stress as we can, we have seen earlier

also, water reuse is increasing. So, reuse can be through recycling reclamation and that in many cases have been found to be effective and very successful. The cost of the initial investment to be done that many of the industries are getting back to the 3 or 4 years of time.

Especially say, this the reclaimed water is a mainly reused for non-potable purposes like agricultural irrigation or industrial processes that is widely accepted and practiced all over the world and then this percentage is increasing say to the range of 10 to 15 percent in many parts of the world. Then, as we discussed in the last lecture, more advanced technologies are available for recycling and reclamation like nano filtration then reverse osmosis. That way, we can produce much better form of water purified form of water that we can even use for potable purposes. But of course, that may be more expensive so we have to see that the intended use and then quality of the contents of the wastewater and then give appropriate treatment and also as we discussed indirect potable reuse is possible.

So like instead directly supplying for potable purpose or domestic purposes, we can put this treated water maybe after tertiary treatment to the for recharging the aquifer systems or that treated water can be mixed with the freshwater sources like lakes and rivers and then we can utilize. So, that is the indirect potable reuse so that way we can, that as we discussed earlier recycling reclamation and reuse.

So,, it is more energy efficient since the money we have to spend for say treatment of the wastewater before putting to the as an effluent to the natural sources so that we can save . That way, we can see that in many cases this will be more energy efficient and then, sustainable water management we can achieve say through the recycling reclamation and reuse.

So, especially when we look into watershed management in a sustainable development way we have to look into the possibility of water recycling water reclamation and water reuse. So, that is a very important aspect as far as watershed management is concerned. Moreover now, the public, the people participation is also essential for recycling and reuse. So that way, the people should know the advantages, its limitations and then they should aware that say where this kinds of the reclamation or recycling can be done and then what are the intended use the of the reclaimed water so like that.

So that way the future of water reuse is much bright and then more places more industries in more cities are going for water reuse water reclamation and water reuse

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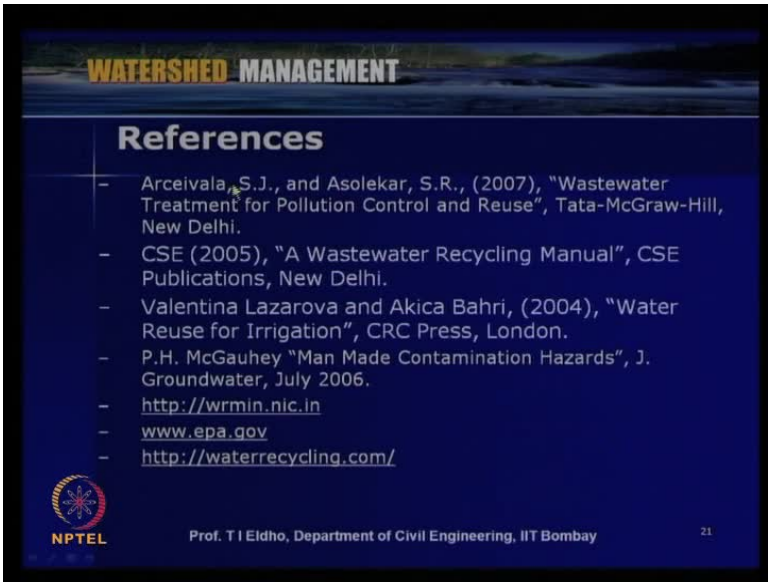

Some of the references used for today's lecture; here I have listed as in the previous lecture also, these are some of the important references used for today's lecture.

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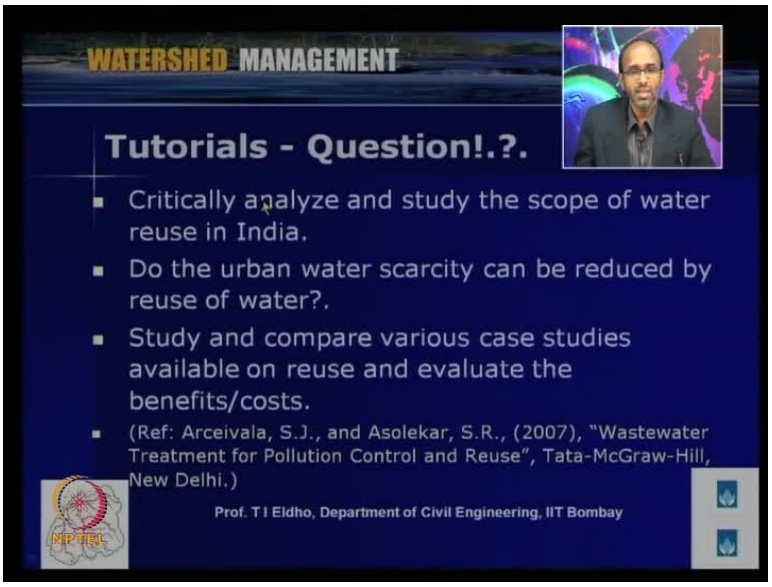

Some of the tutorial questions with respect to the water recycling and reclamation and reuse, what we discussed just now.

Critically analyze and study the scope of water reuse in India. Does the urban water scarcities can be reduced by reuse of water? And study and compare various case studies available on reuse and evaluate the benefits and cost.

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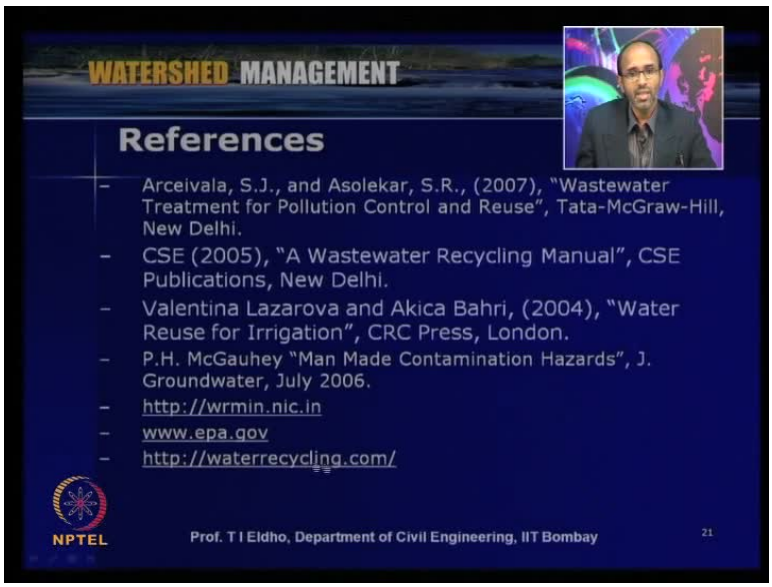

Here, this reference can be number of cases are given and also in websites U S epa website and then also this website and then also CSE publication, these details are available.

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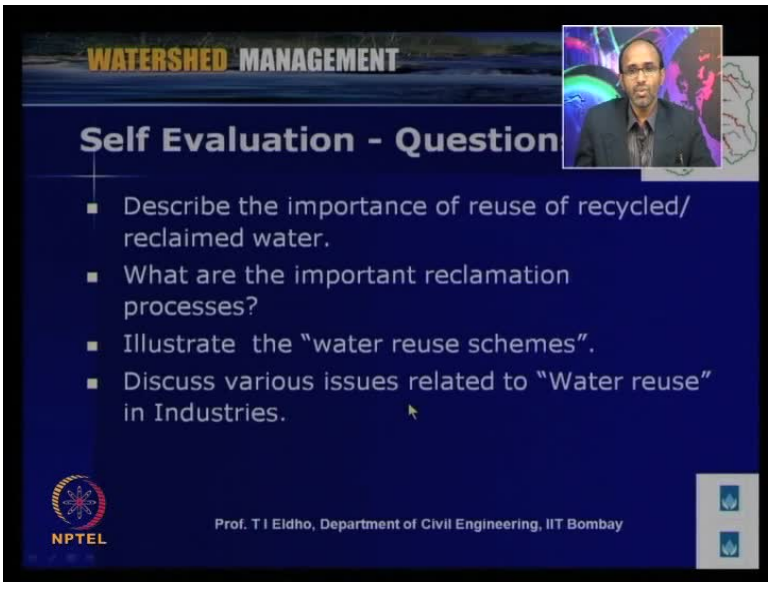

Then few self-evaluation assignment questions: describe the important of reuse of recycled or reclaimed water. What are the important reclamation processes? Illustrate the water reuse schemes. Discuss various issues related to water reuse in industries.

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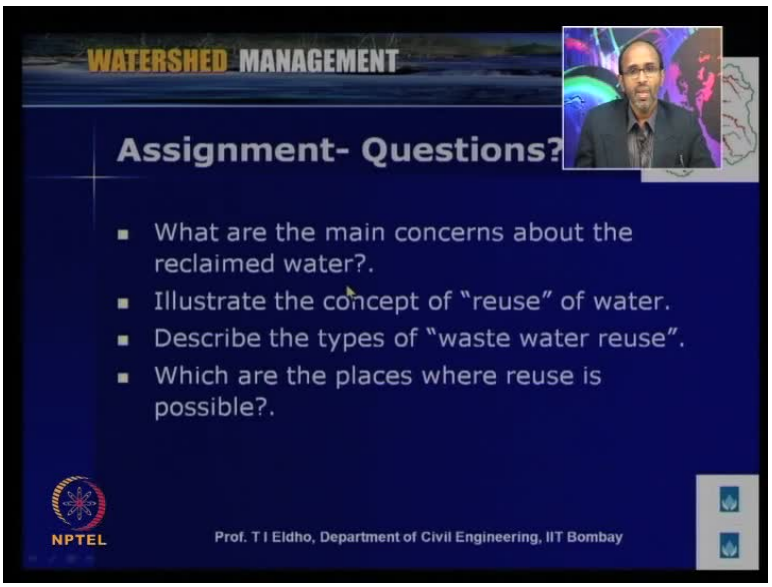

Then, what are the main concerns about the reclaimed water? Illustrate the concept of reuse of water. Describe the types of wastewater reuse and which are the places where reuse is possible? So, all these questions can be answered with respect to the lecture. Just now say, this lecture and now as this is the last lecture as far as this say video course on watershed management concerned.

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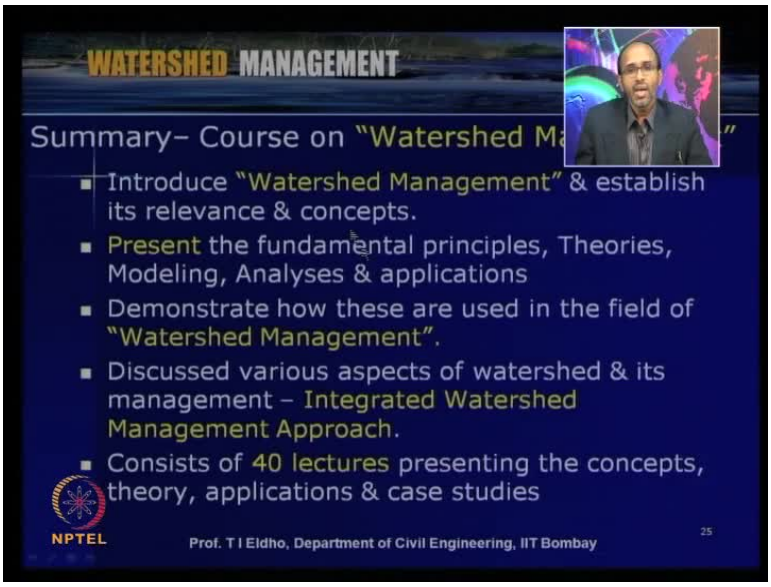

Let us have a quick look into what we have covered. So, let us have a summary of the topics covered and then let us conclude this lecture; so, the summary on the course on watershed management. Here, say in the first lecture I have given the objective objectives of this course and then the various modules which we covered also given. So as I mentioned in the first lecture here, my main aim of this lecture is to introduce watershed management and established its relevance and concepts as far as this watershed management is concerned.

This lecture presents the fundamental principles, theories, modeling analyses and applications; we go through all these 40 lectures. You can see that most of the relevant theories principles modeling all these things were covered in this 40 lecture. Then, the main aim of this lecture lectures is, to where to demonstrate, how these fundamental principles theories are used in the field of watershed management? So, this has been done by showing number of case studies as we can see in these lectures. And, we have discussed various aspects of watershed and its management so like a integrated watershed management approach then river basin management approach so all these aspects were covered in these 40 lectures.

As I mentioned, there were 40 lectures in this video course presenting the concepts theory applications and various case studies. So, as I mentioned in the first lecture, the

course the main purpose of the course is to discuss various aspects of watershed development and management.

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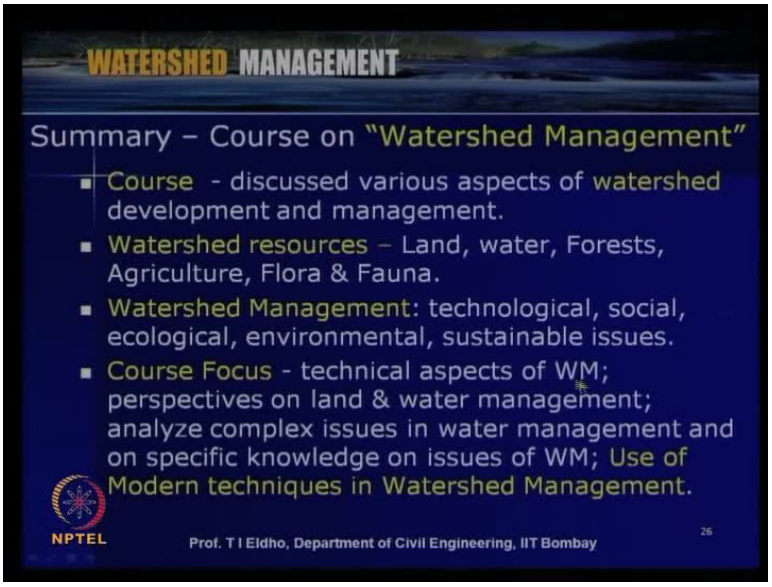

So, we have to see watershed as a scientific area where we can effectively manage various resources like land, water, forest, agriculture, flora and fauna within that area. So, watershed management as we have discussed in this lecture - 40 lectures - various aspects like technological issues, social issues, ecological issues, environmental issues, sustainability, all these aspects we have to look into and all these things were covered in this 40 lectures.

So, the course focus was the technical aspects of watershed management; then perspectives on land and water management and then, analysis of complex issues on watershed management and on specific knowledge on issues of water management. Also, the use of modern techniques in watershed management was elaborated in various lectures as far as this 40 lectures on a watershed management are concerned.

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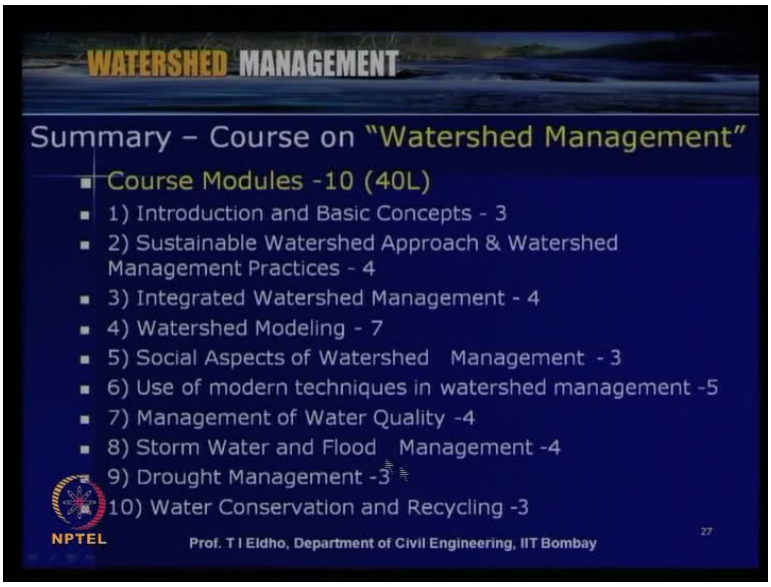

So, the course module actually, the course has been divide into ten modules. So, here the modules as I have shown in the first lecture also. Here again, the ten modules what we are covered in these fourty lectures, the first module was introduction and basic concepts three lectures were given. Then second one was sustainable watershed approach and watershed management practices four lectures were given, then integrated watershed management four lectures were given; then, fourth one was watershed modeling about seven lectures were given. Then, social aspects of watershed management that include three lectures; then use of modern techniques in watershed management that include five lectures management of water quality; so that module include four lectures then storm water and flood management. That module includes 4 lectures, drought management and this module include three lectures and water conservation and recycling which was the last module and that also have three module three lectures. So that way, this video course have got fourty lectures and then, all the aspects of watershed management have been covered in a very systematic and comprehensive way.

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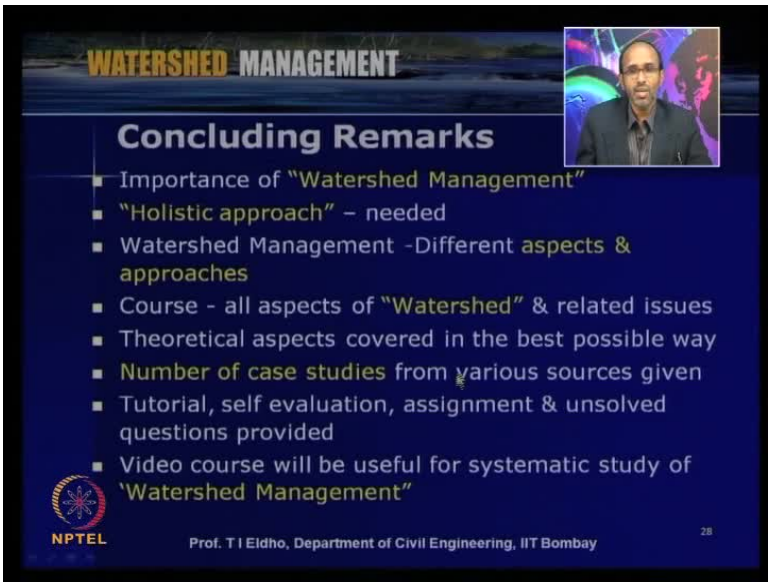

Finally, to conclude, so here the main aim what I was projecting was the importance of watershed management when we are looking for watershed management or when we are going to implement the watershed management perspectives.

So, we have to go for appropriate planning appropriate say management perspectives. As I mentioned in many of my lectures, we have to approach watershed as a in a holistic way it is not only the resource like a land then water or the minerals or the vegetation all these. But, we have to see that everything the not only the people in the area but the various resources we have to go in an integrated way and we should go for holistic approach as far as the watershed management is concerned.

So, that way this course the different aspects and different approaches have been elaborated in a systematic way and all aspects of watershed and related issues were discussed in these fourty lectures. So, as far as the theoretical aspects of watershed is concerned, I have covered the theoretical aspects in a the best possible way within the various modules which we have I have shown in the last slide.

So, for each lectures, number of case studies were presented; so that way this will be useful to the students and teachers and the practitioners. Then, tutorials were given; self-evaluation questions, assignments and unsolved questions, all these provided at the end of each lecture. So, that way this video course will be very useful for systematic study of

the watershed management; say, for a student or for a teacher or for a practitioner or NGO who look into this video course on a watershed management.

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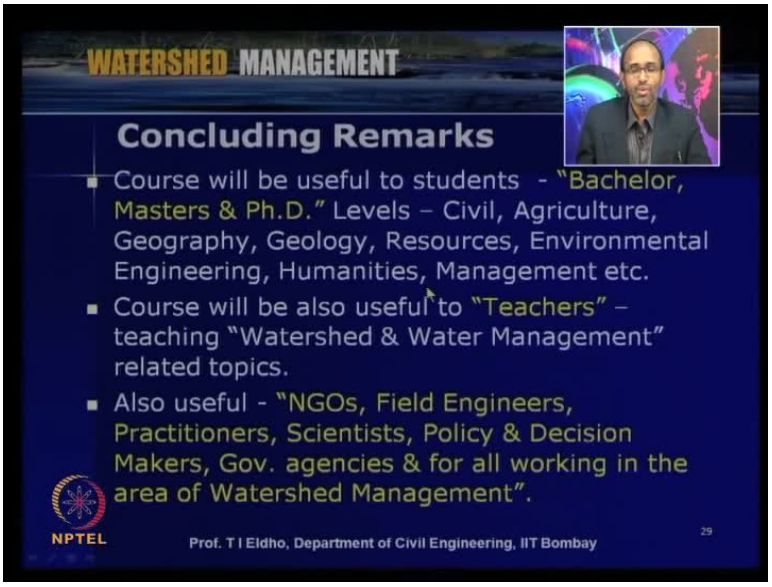

Finally, say this course will be useful to the students on say, bachelors, masters and Ph.D. levels from civil engineering background, agriculture, geography, geology, resources, environmental engineering, humanities management, etcetera. So, that way the syllabus required for each of this specialization I have covered in most in an elaborated way as you can see the topics given in each module. So, we can go through a module wise also you can at say go through the lecture and then get the various aspects for that particular module.

The course will be also useful to teachers who are teaching the subject, either watershed management or water management or say, various issues related to water as described in these 10 modules what we have, what I have already shown in the slide here. So, then also, this video course will be useful to NGOs, field engineers, practitioners, scientists, policy and decision makers, government agencies and for all working in the area of watershed management. So that way I have planned this video course; these fourty video lectures will be very useful to those who are going to work in the area of watershed management or those who are want to study the topic on various topic on a watershed management.

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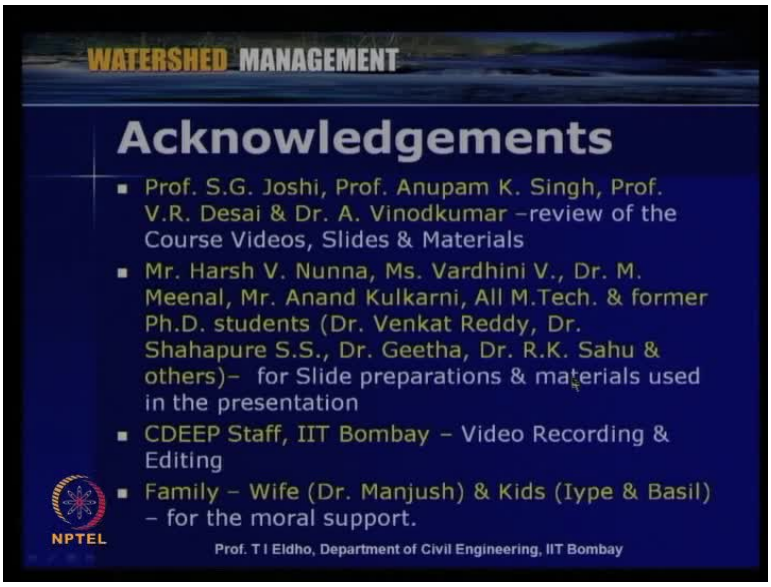

Before closing this video lecture, I want to acknowledge the following people who were helpful to me to make this video course possible. First, I would like to acknowledge some of the possible reviewers of this course; professor SG Joshi, professor Anupam K Singh, professor V R Desai and Doctor A Vinodkumar, who I agreed to review course videos slides and materials. Then, say many of my students have contributed say as far as the slide preparation are concerned.

I would like to specifically mention some names like mister Harsh V Nunna, miss Vardhini, then Doctor Meenal, then mister Anand Kulkarni, then all my former M Tech and Ph.D. students like Doctor Venkat Reddy, Doctor Shahapure, Doctor Geetha, Doctor Sahu and all other.

So many of the case studies which they have done for their masters and Ph.D. thesis, I have included in this video course; I am very thankful to all these students. I am very thankful to all the CDEEP's staff of IIT Bombay. The excellent recording and then the excellent facilities and then also, editing which they have spent lot of time and they are very dedicated staff who have made this video in a very excellent form. I am very thankful to them; without them of course, I cannot do anything as far as this video course is concerned.

So I am very thankful to them and finally, I am thankful to my family; my wife Doctor Manjush and my kids Iype and Basil. So, I hope spent so much of time to prepare these lectures; so for their moral supports I am very thankful to them. Finally, with a big thanks I am say finishing this video course; thank you very much.