Watershed Management

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Module No. # 10

Lecture No. #39

Water Recycling

(()) and welcome back to the video course on watershed management in module number ten, lecture number thirty nine. Today, we will discuss about water recycling; so some of the important topics covered in today's lecture include: water recycling, uses, benefits, water management solutions, water recycling treatments, primary treatment, secondary treatment, tertiary treatment, conventional and modern techniques. Keywords for today's lecture: water recycling and waste water treatments.

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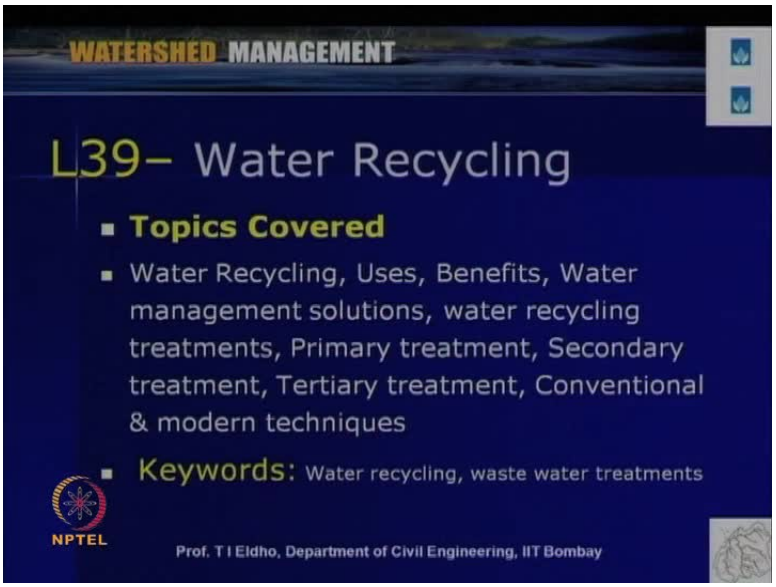

So, as we were discussing in the last lecture, this water conservation is very important. As far as the water management in a watershed basis in a watershed is considered or in a district or in a city is considered, we have to look say, which way we can go for water conservation so that is one aspect. The conservation is one aspect and then, still we may

have lot of water stress or say, water scarcity in many areas. So, then especially in urban areas say, where say, we need huge amount of water for say, domestic industrial and other purposes but availability is much less.

So, there say, other than water conservation I mean, by reducing the amount of use of water and the most efficient way utilization, so that is what has we discussed in the last lecture about the water conservation. But say, especially in urban areas we can go far water recycling. Water recycling is mainly say, we can give some treatment to the waste water or the effluent generated from the particular domestic or the industrial or whichever sector we consider and then say, we can use for other purposes so that is in a general way what we can define as water recycling.

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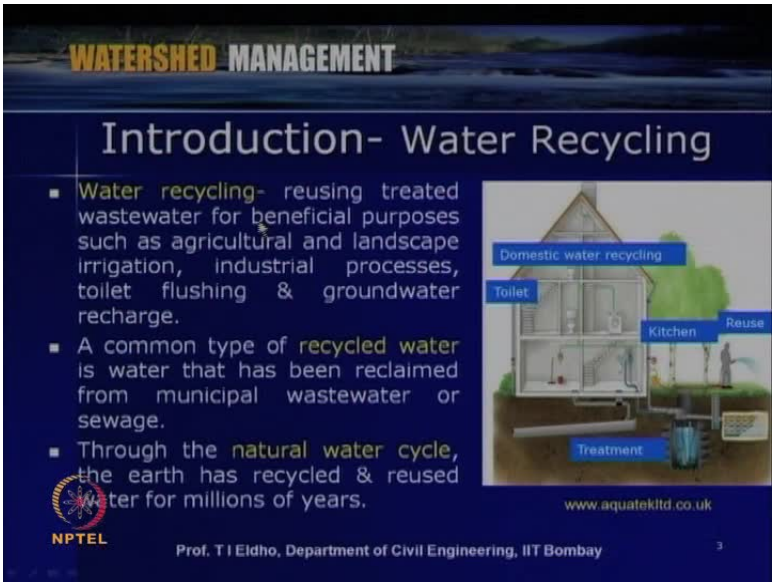

So, other than water conservation we have to go for water recycling so that the water stress or the non-availability of water we can sort it out in certain way so when we discuss about the water recycling so as I mentioned water recycling is reusing treated waste water for beneficial purposes such as agricultural and landscape, irrigation, industrial processes, toilet flushing and groundwater recharge.

So, that way say, for example, if you consider domestic purpose is concerned, see if this is the residential building then we can see that the water coming from the sinks we can separate it and then give some treatments like a say, preliminary and primary treatment

and then we can directly use for say, irrigation like this and then say, for example the water coming from the toilets also we can do some kinds of say, through it can pass through a septic tank or it can be given some treatment and then directly use for other purposes.

So, that way say, a common type of recycled water is water that has been reclaimed from say, the waste water or sewage so it can be say, either from the industrial sources or it can be from the domestic sources or as such the municipal waste water. As we can see that when we look into the hydraulic cycle actually the nature is also doing the same. So, through the natural water cycle the earth has recycled and reused the water for say, for millions or billions of years.

So, the water is coming as precipitation and then it will go through the hydraulic cycle and finally it is evaporated and then finally again coming back as a rainfall. So, the nature is also doing in one way or another way of natural water recycling but say, as far as the in terms of water recycling here what we are discussing here is, what way we can say, give some treatment and reuse for various purposes either for agricultural, industrial, domestic or other kinds of purposes; so that is the in terms of water recycling.

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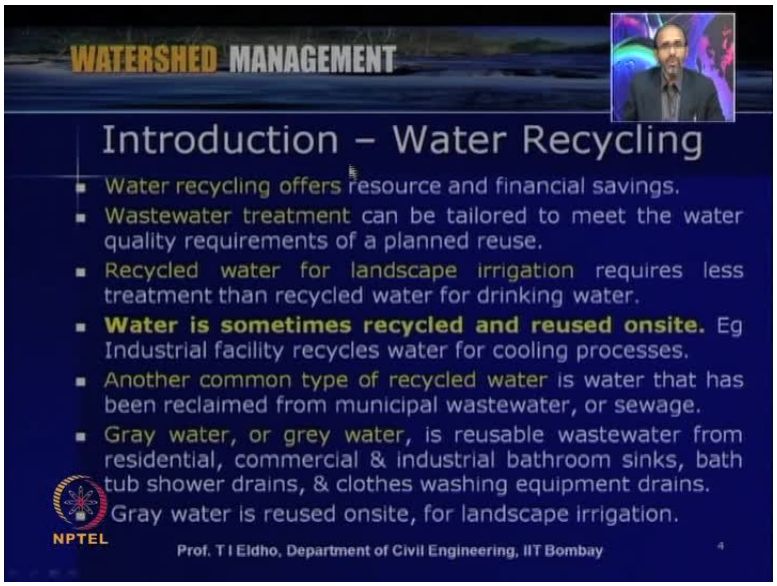

When we look into water recycling we can see that when we critically analyze the water recycling so actually it offers the resources as water as a resource and then that way we

can see that lot of financial savings we can obtain through the water recycling. So, the advantage is that the waste water treatments say, we can tailor-made to meet the water quality requirements of planned reuse. So say, for example, if we are going to use the waste water for say, irrigation or the agricultural purposes so it may we do not have to give for complete treatment may be a preliminary or primary treatment or secondary treatment may be sufficient depending upon the quality of the waste water.

So, then say, recycled water for landscape irrigation say, for example requires less treatment than recycled water for say, for a domestic or drinking purposes so if you are planning to use say, for example drinking then we have to go for entire cycles of treatment like preliminary primary secondary and tertiary treatment and even say, reverse osmosis, so that kind of treatment is required if you are going to use for drinking.

But, for other purposes like irrigation or the industrial reuses the that say, we do not have to give that much treatment so that way we can see that we can save water so that way we get the financial savings and then also we can reduce the amount of waste water to be treated for various purposes. So, that way when we look into water recycling so water is sometimes recycled and reused onsite so that means say, in an industrial site there itself we can simply say, give some treatment and directly utilize so industrial facility recycles water for cooling processes.

Then, another type of the recycled water is, water that can be reclaimed from municipal waste water or sewage so we can see that as far as the municipal waste water is concerned the water the waste water is collected from various sources and then the it will be totally heterogeneous type of waste water and then again that also we can give some treatment and then say, reuse. So, that way we can see that gray water or a gray water is say, a reusable waste water from residential commercial and industrial bathrooms sinks bath bathtub shower drains cloth washing equipment drains, etcetera.

So, the waste water we can collect from various sources and then actually when we deal with the municipal waste water it will be mix of many of these things and then we have to give appropriate treatment before we reuse for the intended purposes. So, gray water say, reused onsite say, for example for landscape irrigation like that.

So, that way when we look into water recycling say, it depends upon the quality of waste water and then say, what grade of treatment we have to give to that waste water and then what purpose we are going to use that treated water so accordingly say, we have to give appropriate treatment and then appropriate use we have to identify as far as the waste water is concerned.

So, when we look into literature, we can see that the recycled water we can use for different purposes so even though with say, complete set of treatments staring from primary, secondary to tertiary and a treatment like say, ultraviolet or the reverse osmosis type of treatment, we can use for portable purposes. But say, when we look into literature we can see that the recycled water is very rarely used for portable purposes only say, in some cases where totally fresh water is not at all available.

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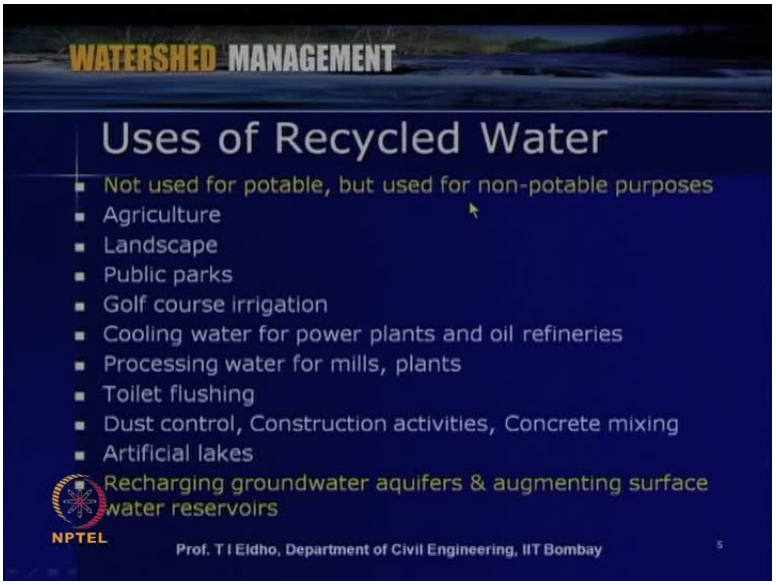

We can see that the recycled water is not generally used for portable purposes but used for non-portable purposes. So, some of the important non-portable purposes here I have listed like a agricultural so we can use for irrigation so only thing is that if say, the particular product we are directly using for the consumption human consumption or the say, raw vegetables like that. Then we have to give say, better treatment as far as the waste water is concerned otherwise there is possibility of contamination even of the vegetables or fruits.

So, that way depending upon the purpose of irrigation we can give appropriate treatment so agriculture landscape public parks golf course irrigation cooling water for power plants and oil refineries then processing water for mills plants then the recycled water can be used for toilet flushing then we can use the recycled water for dust control construction activities concrete mixing then we can have artificial lakes by using the recycled water and then say, as I mention if you are going to use for portable purpose we have to give appropriate treatment to the waste water.

So, say, Now,adays may in some of the arid and semi-arid regions the recycled water is used to recharge ground water aquifers and then augmenting surface water reservoirs but this is after going through a series of treatment to the waste water so that a good quality recycled water is obtained and that can be used for say, even to recharge ground water aquifers or augment the surface water reservoirs.

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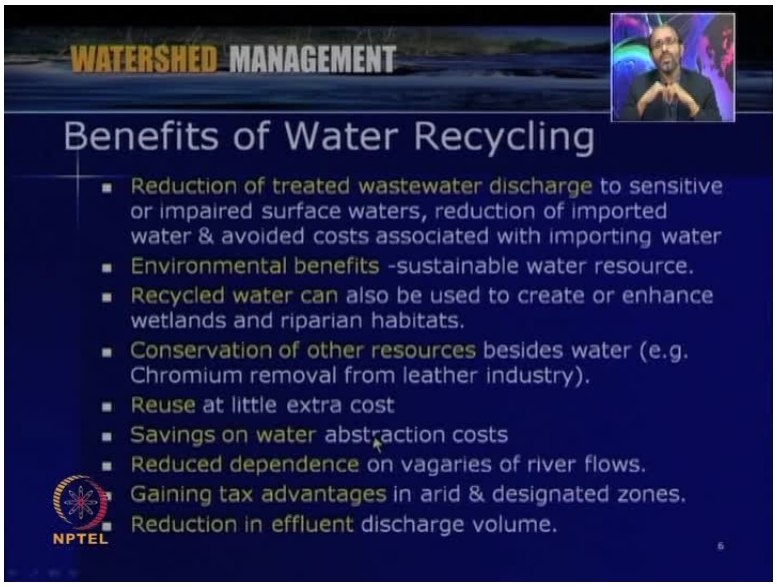

So, that way when we look into the recycling processes so as I mentioned we have to see say, the grade of the waste water and then we have to see what kind of treatments we have to give and then what is our intended purpose of the recycled water.

Now, within this prospective let us look what are important benefits as far as water recycling is concerned so some of the important benefits I have listed here so like reduction of treated waste water discharge to sensitive or impaired surface waters then

reduction of imported water and avoided costs associated with importing water so we can say, recycle the water give appropriate treatment so that we do not have to import water for various purposes.

Then environmental benefits so that way we can see that when we are not using the fresh water we are giving appropriate treatment to the waste water and then we are reusing it so that way we can see that we can achieve sustainable water resource management as far as the environment is concerned. Then recycled water can also be used to create or enhance wetlands and riparian habitats so we can have say, we use this waste water treated recycled waste water say, especially to recycled water to wet lands we can discharge wet lands and then that can be that say, some way of cleaning process will be taking place within the wet lands itself.

Then consideration of other resources besides water like say, we can remove chromium from a leather industry then reuse at little extra cost so only some say, depending upon the use say, for example the water which we are use going to use for flushing in domestic sector or the water we are using for cooling purposes. So, we do not need very high quality water so that way with some minimal treatment we can use the water again so that way we can reuse at little extra cost.

Then savings on water abstraction costs so say, if you can reuse the waste water or the recycled water then we can see that instead of pumping water from the deeper aquifer systems so we can say, cost of the abstraction or the cost of the power cost we can reduce.

So, then reduce dependence of vagaries of river flows then gaining tax advantages in arid and designated zones then reduction in effluent discharge volume so when we are say, gives when we are treating the waste water and then when we are using the recycled water actually we are reducing the volume of the waste water so that way say, before discharging this effluent to the a river or a lake so then we do not have to we will not have that how much volume that we have to give appropriate treatment so that way we can reduce the effluent that which is to be discharged say, to rivers lakes or the sea. So, these are some of the important benefits as far as water recycling is concerned.

Now, say, within this prospective so we were discussing about what is say, water recycling and then how we have to do this and then what are its benefits like that. Now, when we look into overall water management solutions say, within a watershed or within a particular area or a within a within an urban environment is concerned say, we can go for various solutions.

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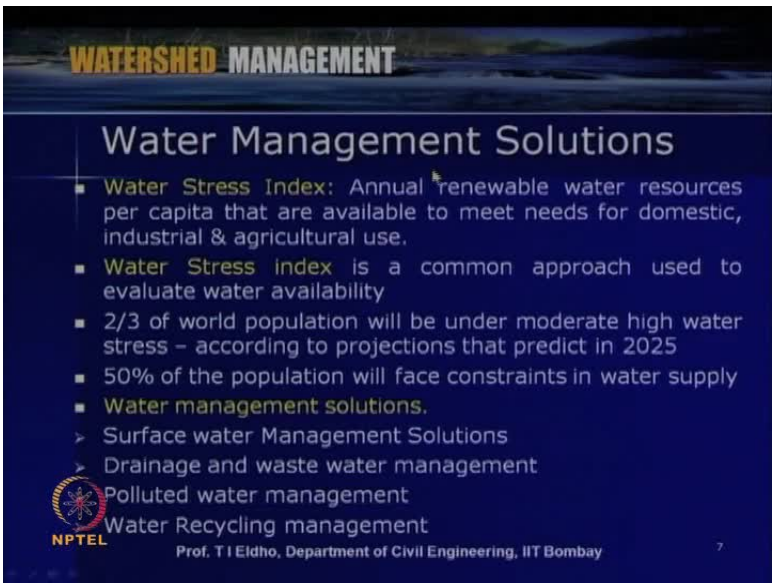

Here, let us discuss see what are the possible solutions so water management solutions so as I mentioned earlier so we have got water stress so that we can indicate in terms of water stress index so actually this is an annual renewable water resources per capita that are available to meet needs for domestic industrial agricultural and other purposes.

So, say, we can come up with an index called water stress index for the particular area based upon the availability of water based upon the various uses so depending upon the supply and demand we can come up with a water stress index so this is one of the commonly used approach to evaluate water availability.

As we were discussing earlier also, about two third of the world population will be under moderate to high water stress according to the projection that predict in 2025 and then 50 percent of the population will face constraints as far as water supply is concerned so that way this water recycling is say, one important solution that we can look into.

So, when we look into water management solutions say, within the prospective of water stress index we can go for water say, water management solutions are concerned we can go for surface water management solutions drainage and waste water management solutions polluted water management then water recycling management so like that we can classify into 4 as far as water management solutions as far as a particular watershed or particular area is concerned.

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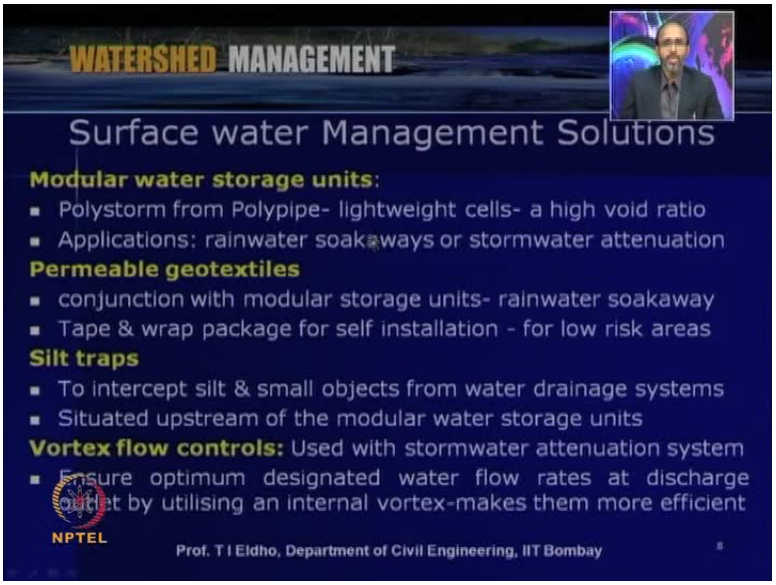

Now, if we look into surface water management solutions so that what we are trying to do is say, with respect to the available surface water say, in terms of say, water available in a particular area or particular watershed or particular urban area say, in terms of water available in in in lakes rivers or the ponds or whatever surface water available so we have to give appropriate treatment say, and then use so for the or the we go for beneficial use.

So, that way some of the things what are generally used to give appropriate treatment for surface water include modular water storage units permeable geo textiles silt traps vortex flow controls so modular water storage units means say, we can have systems like a polystorm from polypipe a light weight cells with a high void ratio so applications include rain water soakaways or storm water attenuation. So, this we can say, we can give appropriate treatment for rain water or the storm water and then we can use for various purposes.

Then as far as permeable geo textiles are concerned this is in conjunction with a modular storage units say, just like rainwater soakaways then tape and wrap package for self-installation for low risk areas like that. Then, third one is especially used for storm water systems silt traps so here we intercept the silt and small objects from water drainage systems then situated upstream of the modular water storage units so that is say, what how we can silt traps. Then, vortex flow controls so this is used with storm water attenuation system to ensure continue to ensure optimum designated water flow rates at discharge outlet by utilizing an internal vortex makes them more efficient.

So, like that say, available say, from rain water or storm water as a surface water source we can give appropriate treatments and that recycled water we can use for the say, particular use like either domestic or the agricultural or other industrial purposes.

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Then Now, second one is drainage and waste water management so here say, the water say, which we are draining that we are trying to use effectively so we can have pumping stations say, for example for small applications like a packaged tank and pump systems designed to lift small quantities of a waste water to reach existing drain or sewer

Then we can have pumping stations say, for example for large applications like a packaged chamber and pump systems to lift large quantities of waste water to reach existing drain or sewer

Then sewage treatment plants like designed for use where septic tank is either impractical and a connection to the main sewer is impossible

Then we can have systems like grease traps and separators were primarily used in catering and commercial premises then to prevent vast amounts of grease animal fats and oils from entering and solidifying in the drainage systems

So, what we are trying to say, these are various systems which we can use say, as for drainage water so the drained water we can directly say, after through this treatment we can use for say, various purposes say, recycled water

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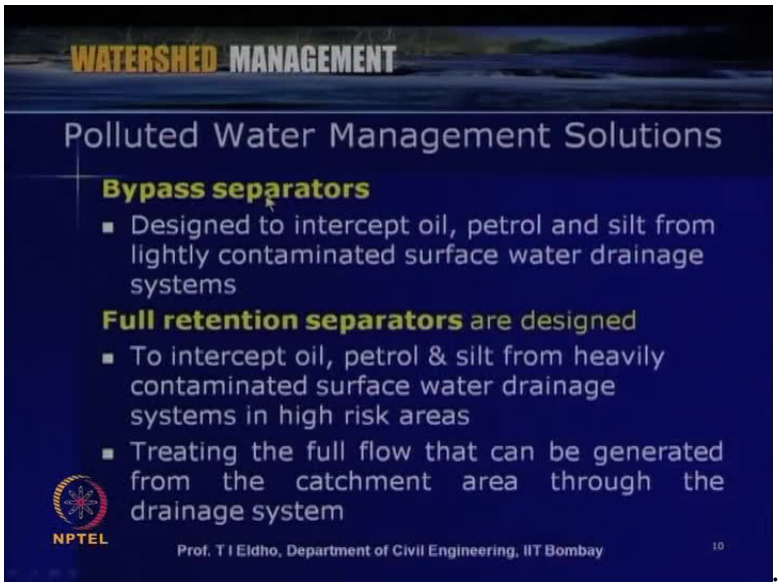

And then third solution is polluted water management solution so here say, we can have bypass separators like designed to intercept oil petrol and silt from lightly contaminated surface water drainage systems

And then like a full retention separators say, like to intercept oil petrol silt from heavily contaminated surface water drainage systems in high risk areas

Then treating the full flow that can be generated from the catchments area through the drainage systems

So, like that what we are trying to so here say, somewhat polluted water say, we say, various type of treatments and then recycled or we are planning to use for particular purpose depending upon the quality of the water

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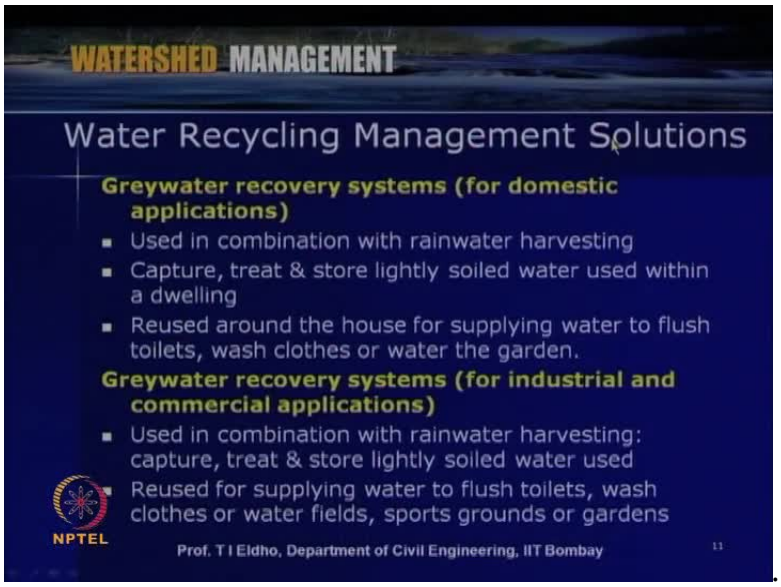

And then finally say, fourth one is the water recycling management solutions so this is what is actually we will be discussing in detail so here the gray water this is actually the gray water recovery systems say, for domestic or industrial or commercial applications so here we can use the recycled water say, in combination with the rain water harvesting say, as far as domestic applications are concerned and then we can capture treat and store lightly soiled water used within a dwelling in a residential area or we can reuse the around the house for supplying water to flush toilets wash clothes or water say, the garden so like that we can use the gray water recovery systems say, for domestic applications

And then next one is gray water recovery systems for industrial and commercial applications so here say, the recycled water is used in combination with rainwater harvesting also we can capture treat and store lightly soiled water so that we can give some mild treatment we can use for the intended purpose

Then we reused for supplying water to flush toilets wash clothes or water fields then sports grounds or gardens like that

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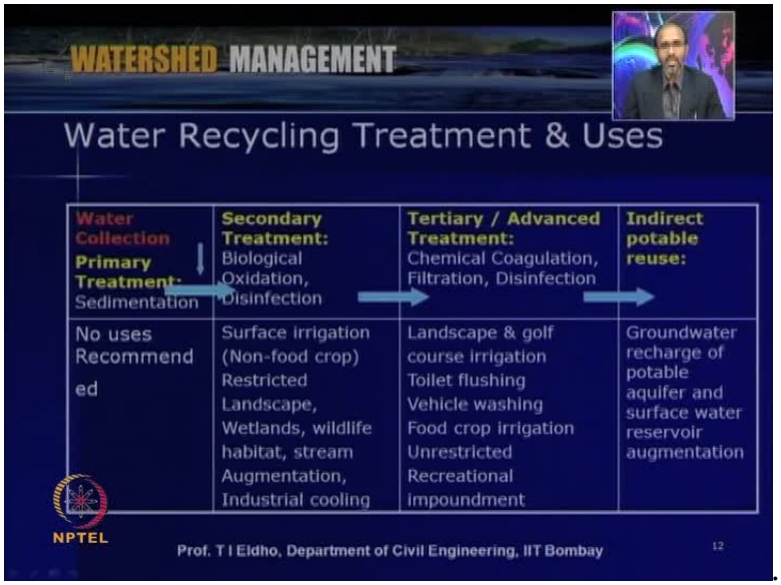

So, that way we can have either the domestic applications industrial applications and commercial applications so only as I mentioned earlier depending upon the quality of the water waste water we give appropriate treatment and that recycled water is used for either domestic industrial or commercial or agricultural applications so that way when we look into water recycling say, we can go for say, different types of treatments and then according to the treatment we can use for particular type of use

So, if we are having the waste water so first one is we have to collect the waste water and then we can give some preliminary treatment like solid waste floating solids all these things we can remove.

And then next one is primary treatment so there say, like sedimentation we can retain the water for some time in say, tanks or pits like that so that the floating materials and other things will be settled down so this is so called a sedimentation process

So, actually this simple treatment is not sufficient for any kind of reuse if the water is totally polluted then we have to go for further treatment but if it is simple say, water coming from a kitchen or like that then even after primary treatment we can reuse the recycled water for say, gardening or irrigation purpose

Then from the primary treatment the water going to secondary treatment so there we can go for various treatments like biological oxidation or disinfection kind of treatment

So, actually after secondary treatment we can use the recycled water for various purposes like surface irrigation say, for example non-food crop then say, restricted landscape so we can use the water for say, to irrigate grass or the landscaping then it can be put to wet lands where further kinds of treatment will be taking place and then wildlife habitat then stream augmentation then say, depending upon the quality of the water we can go for industrial cooling so like that so this is about the secondary treatment

So, after the secondary treatment the water can be sent to the tertiary or advanced treatment there we will be giving detailed treatment with respect to the chemical say, like chemical coagulation filtration disinfection like that

So, actually the water coming from after this treatment is somewhat pure water to certain extent so this water we can use for say, landscape golf course irrigation then toilet flushing vehicle washing food crop irrigation unrestricted recreational impoundment so like that we can use this water for various purposes

And then if you are going to use the recycled water for say, drinking or portable purposes then we can have some more treatment like say, reverse osmosis kinds of treatment or the ultraviolet disinfection treatment and this water say, instead of directly say, using for portable we can use for ground water recharge and then surface water reservoir augmentation like that

So, like this when we are looking to the waste water say, as far as water recycling is concerned we have to go through a say, systematic treatment depending upon the nature of the waste water and depending upon the use for which we are going to put this recycled water so accordingly appropriate treatment will be given and will be reused

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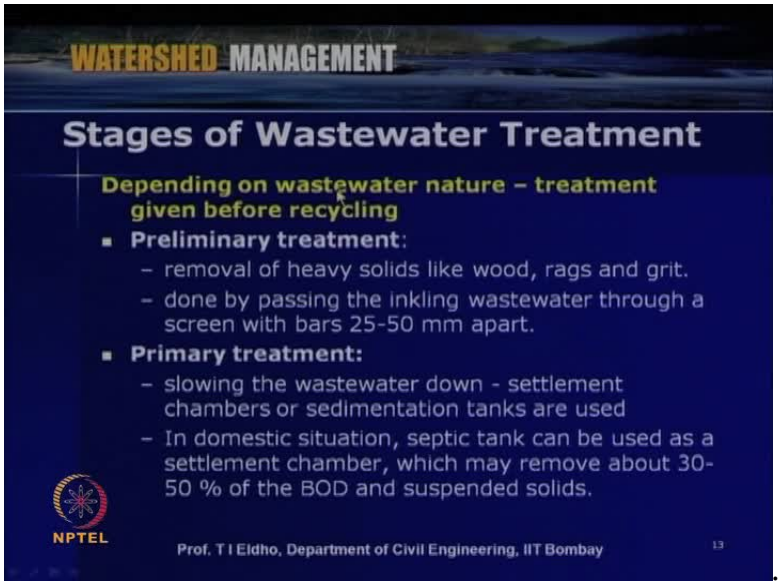

Now, further let us discuss somewhat in detail about this various stages of waste water treatment say, for recycling purposes so as I mentioned earlier depending upon the waste water nature we can give appropriate treatment before recycling

So, first one is the preliminary treatment so there say, we can remove the heavy solids like wood rags and grit etcetera so this we can put the waste water we can pass in the water inkling waste water through a screen with bars of twenty to fifty mm apart so that all the woods rags etcetera will be captured so that is so called preliminary treatment

Then the water will be sent to primary treatment so here we slow the waste water the flow rate and settlement chambers or sedimentation tanks we can use so in domestic situation septic tank can be used as a settlement chamber then which may remove about thirty to fifty percent of the BOD and suspended solid so primary treatment to certain extent we can remove say, most of the floating materials sediments and all those kinds of things and even some of the BOD also we can remove through primary treatment

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Then next one is the secondary treatment so here we can go for various kinds of treatments like a biological treatment say, for example to remove the microorganisms and removes the remaining BOD and suspended solids so here during later stages of secondary treatment the nitrification processes like when ammonia present in waste water is transformed into nitrate

So, like that we can go for a series of secondary treatment and as we have seen in the previous slide this after secondary treatment the water may be used for purposes like irrigation or say, golf course irrigation or landscaping like that

Then tertiary treatment is actually this involves taking the waste water through a further biological physical or chemical step so here further we try to remove the BOD suspended solids nitrogen phosphorus and pathogens in the tertiary treatment

So, we can also provide say, like in natural systems like wet lands or ponds and lagoons and then where say, if land is available so that will be say, the water will be detained for long time and then either aerobic or anaerobic kinds of say, treatment will be taking place in this kinds of system so that is about the tertiary treatment

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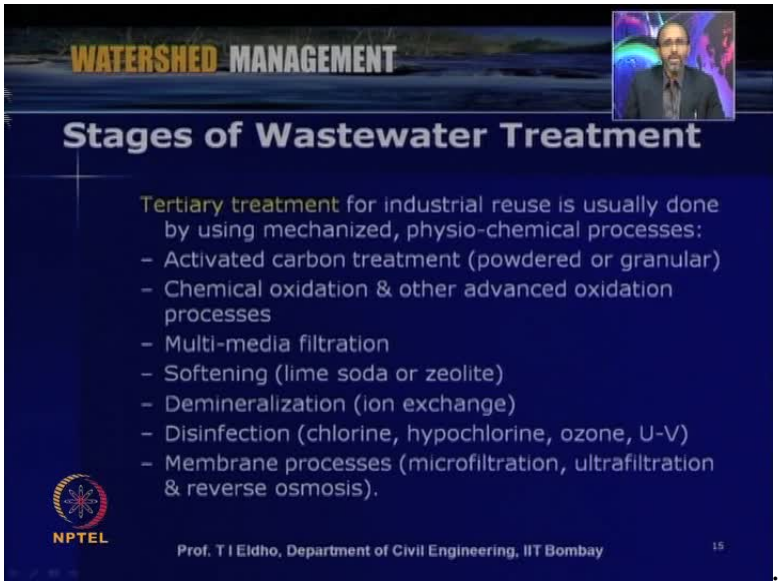

So, when we look into tertiary treatment actually say, when we look into the waste water so the tertiary truth after the tertiary treatment the water can be used for various purposes in say, reuse is concerned or recycle after the recycling through the tertiary treatment we can directly utilize like for irrigation then say, toilet flushing or direct industrial purpose like that

So, tertiary treatment for industrial reuse is usually done by using mechanized or physico-chemical processes such as say, some of the important tertiary treatments I have listed here like activated carbon treatment so we can pass through the secondary treated waste water through activated carbon so that most of the contaminants will be removed then chemical oxidation and other advanced oxidation processes then multimedia filtration and softening like lime soda adding lime soda or passing through zeolite so this is actually mainly for industrial purpose

Then demineralization say, like ion exchange processes then disinfection like by adding chlorine hypo chlorine ozone or ultraviolet systems or then we can put the waste water through for membrane processes like a microfiltration ultra-filtration and then the latest is the reverse osmosis

So, depending upon the type of use so we can choose particular type of tertiary treatment and then directly from that treatment we can use the water or we can recycle the water

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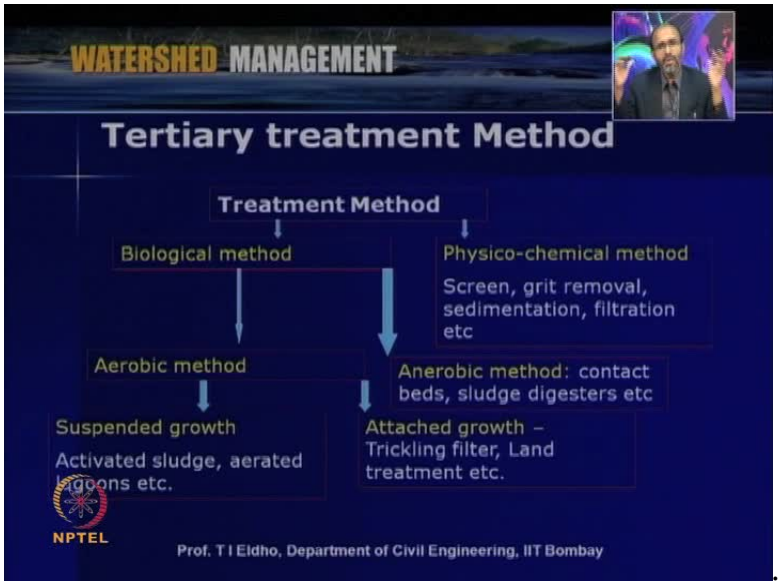

So, that way when we look into the tertiary treatments so we can classify the treatment method into the biological methods and physico-chemical method as far as physico-chemical method is concerned like a screen grit removal sedimentation filtration etcetera so these are all physico-chemical methods

Then biological method is concerned we can consider the treatment within the presence of with the presence of oxygen or so called aerobic method and then anaerobic method so say, without oxygen so that way some of the anaerobic methods include contact beds sludge digesters etcetera

Then aerobic methods say, we can again classify into suspended growth or attached growth so suspended growth say, systems like activated sledges aerated lagoons etcetera we can utilize. Then say, the attached growth is concerned we can go for trickling filter land treatments etcetera

So, when we discuss the tertiary treatment we have a series of treatment methodologies number of methodologies are available so depending upon the type of waste water or depending upon the quality of the components of the waste water we choose particular type of treatments and then that also depends upon the intended reuse

So, what kind of whether we are going to use the recycled water for say, domestic purposes or industrial purposes or agricultural purposes accordingly we can choose

particular type of treatment system so that say, we have to see that the economics also I mean the benefit cost ratio also we have to see when we say, put the waste water through such treatment

Now, let us look into some of the important methods of treating the waste water so the waste water treatment is concerned we can classify into conventional way of treating waste water and then modern techniques as far as waste water treatment is concerned

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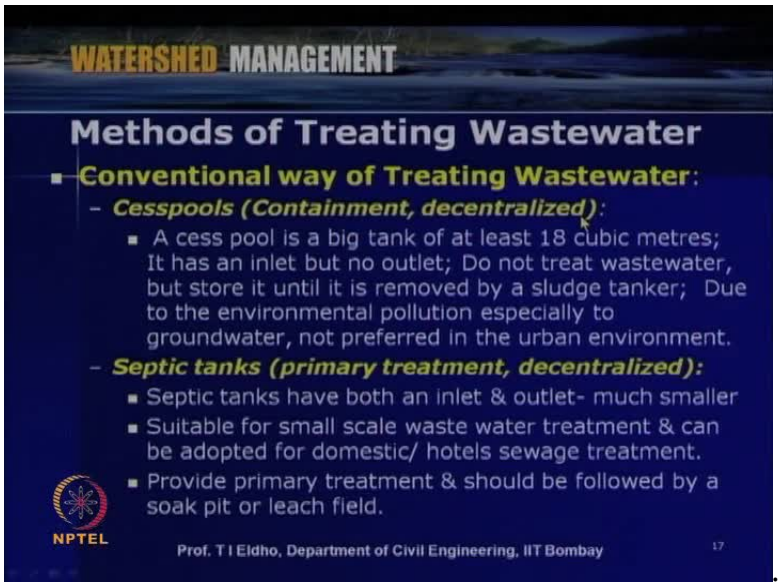

So, some of the treatment techniques are briefly mentioned here

First one is say, cesspools so this is mainly we are using for containment say, it is generally decentralized way of treatment so a cesspool is a big tank of at least 18 cubic meter size it has an inlet but no outlet so we do not treat waste water here but store it until it is removed by a sludge tanker so that it will be taken for further treatment some other location so it is a temporary storage.

So, due to the environment pollution especially to ground water so the it is not preferred in the urban environment so say, we should keep the waste water in a very good container otherwise if it is leaked into the soil then the ground water will be affected.

Then, second one is septic tanks so actually this is a primary treatment and it can be also decentralized so septic tanks have both an inlet and outlet and this is much smaller and

suitable for small scale waste water treatment and that can be adopted for domestic say, like household purpose or the housing societies or hotels like that. This provides primary treatment and should be followed by a soak pit or leach field so that one more treatment is required so septic tank is also a conventional way of treating the waste water.

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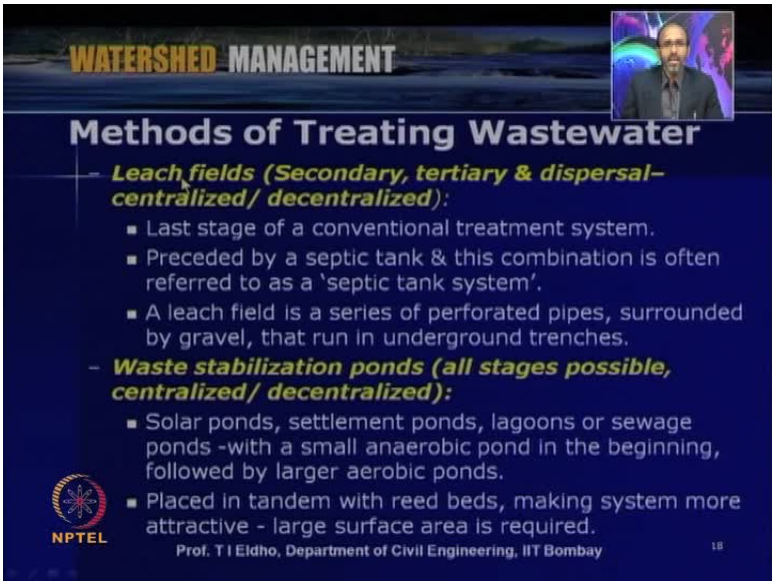

Then, third one is leach field or actually, this can be secondary or tertiary and dispersal or it can be also centralized system or decentralized system so here say, it is generally a last stage of a conventional treatment system so this is preceded by septic tank and this combination is often referred to as septic tank system. A leach field is a series of perforated pipes surrounded by gravity that run in underground trenches so through this say, we get somewhat treated waste water and then the next one is waste stabilization ponds so this can be all stages possible like secondary tertiary then it can be either centralized system or decentralized system.

So, like a solar ponds settlement ponds lagoons or sewage ponds with a small anaerobic ponds in the beginning followed by large aerobic ponds so the waste water go through a series of ponds and then finally we will be getting somewhat treated water.

So, this say, generally this kinds of stabilization pond we place in tandem with reed beds so that making system more attractive and large so in the one of the limitations we need large surface area to have this kinds of waste stabilization ponds.

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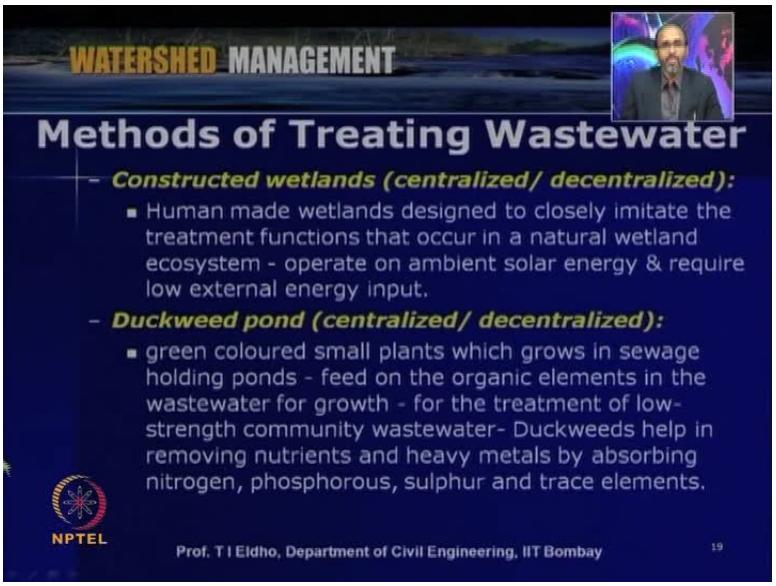

Then the other kinds of say, the conventional treatment include like constructed wetlands so this also can be centralized or decentralized systems so constructed wetlands actually this is a human made wetland designed to closely imitate the treatment functions that occur in a natural wetlands say, just like a what is happening within eco-system so there will be some specific types of plants will be there in the system that absorb many of the contamination contaminants within the waste water and then the water will be detained the waste water will be detained for some time and that will be going through a natural processes.

Then, this will be operating on in an ambient solar energy and require low external energy input so that way the waste water will be passing through the system for some time and then the we will be getting somewhat treated water. And, then other conventional techniques like duckweed pond so this can be also centralized or decentralized system so this is some green colored small plants which grows in sewage holding ponds so this plants will be absorbing all this some of the waste material within the water and then that become a field for the plants so this feed on the organic elements in the waste water for growth for the treatment of low strength community waste water this can be used and duckweeds help in removing nutrients and heavy metals by absorbing components like nitrogen phosphorus sulphur and tracer trace elements like that.

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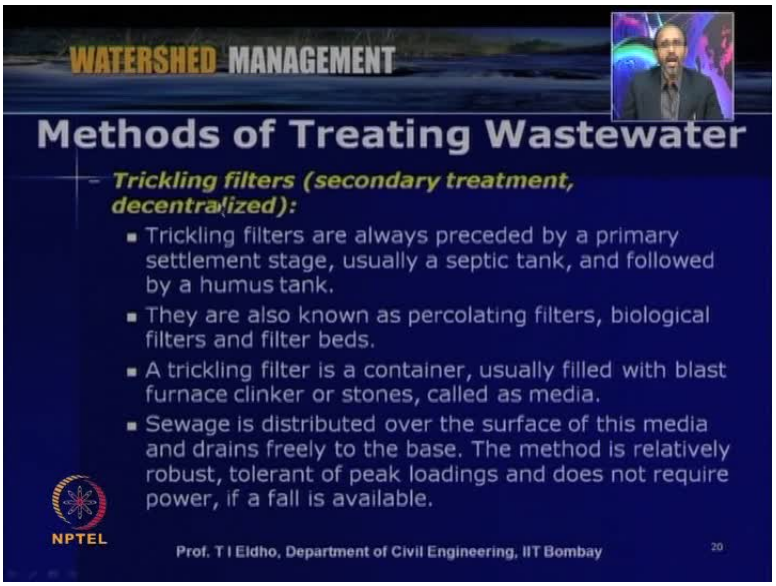

So, this is another conventional treatment technique say, as far as water recycling is concerned then another one is so called trickling filter so this is actually used for secondary or tertiary treatment so trickling filters are always preceded by a primary settlement storage usually a septic tank and followed by a humus tank and they are also kNow,n as percolating filters biological filter and filter beds then a trickling filter is a container usually filled with blast furnace clinker or stones called as media and then the waste water will be passing through that and then many of the waste material will be absorbed. Sewage is distributed over the surface of the media and drains freely to the base the method is relatively robust tolerant of peak loadings and does not require power if a fall is available.

So, that way this trickling filter is one of the best conventional way of treating the waste water and that treated waste water can be recycled or can be used as recycled water for say, various purposes like agricultural.

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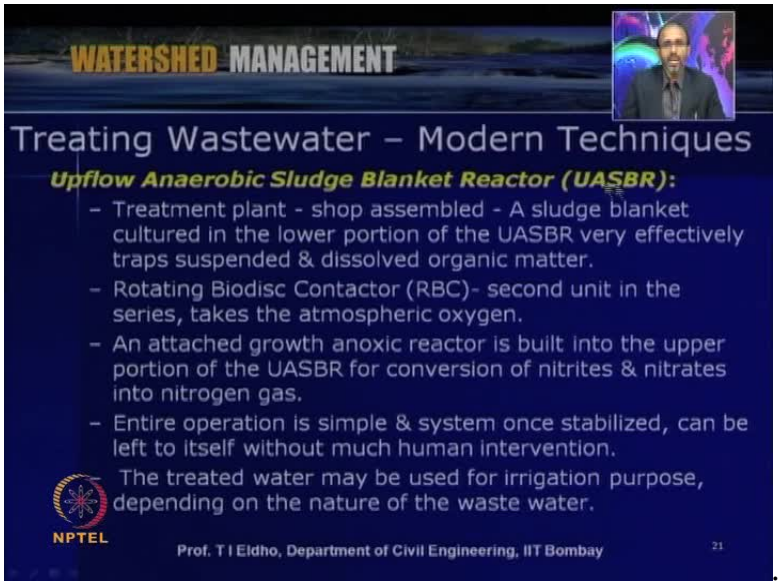

Then say, let us now look into some of the modern techniques used for treating the waste water so this is mainly say, we use as tertiary treatment so first one is the up flow anaerobic sludge blanket reactor or UASBR so here treatment plant say, we can would have say, actually as module it be available and directly it can be obtained from the shops and it can be assembled a sludge blanket cultured in the lower portion of the UASBR very effectively traps suspended and dissolved organic matter.

Then we can have rotating bio disc contactor say, second unit in the series and takes the atmospheric oxygen and then an attached growth anoxic reactor is built into the upper portion of the UASBR for conversion of nitrites and nitrates into nitrogen gas and then entire operation is operation is simple and system once stabilized can be left to itself without much human intervention. So, once it is stabilized we have to only pass the waste water through the system and then the system will be keep on working.

So, treated water may be used in a say, it will be somewhat good quality say, water so that can be used for irrigation purpose depending upon the nature of the waste water so that is about the UASBR.

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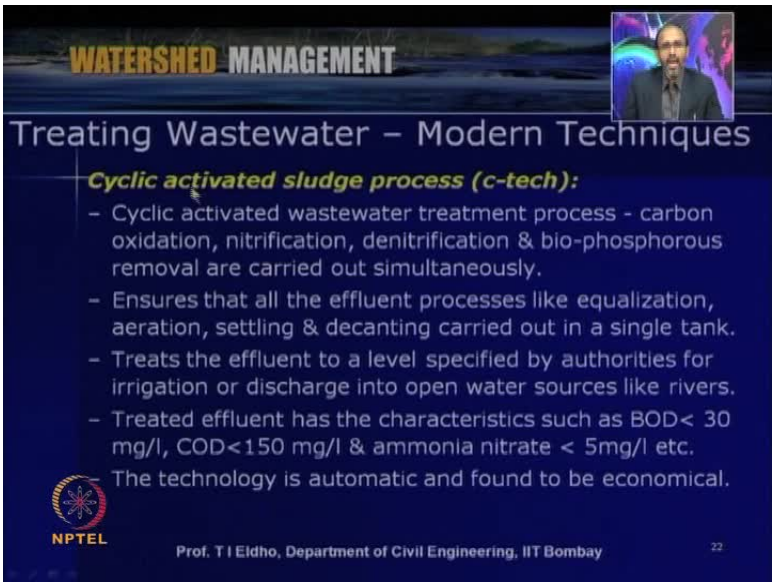

Then another one is another modern technique is called cyclic activated sludge process or c-tech so here say, this cyclic activated waste water treatment process actually we pass through the water through activated carbon so carbon oxidation nitrification de-nitrification bio-phosphorus removal all are carried out simultaneously as far as the c-tech is concerned. And this technique ensures that all the effluent processes like equalization aeration settling and decanting carried out in a single tank so this is very systematic modern system so where we can directly get better quality water.

Then, this treats the effluent to a level specified by authorities for irrigation or discharge into open water sources like rivers so through this cyclic activated carbon process we can achieve say, the BOD can be less than 30 milligram per liter COD can be less than 150 milligram per liter and ammonium nitrate can be less than 5 milligram per liter like that.

So, like that we can achieve say, better quality water through when the waste water is going through the c-tech technique so the technology is automatic and found to be very economical so for small scale industries this technique is very useful for the treatment of the waste water.

So, that way we can see that say, this either c-tech or the UASBR so like that this kinds of modern techniques are very effective and then it occupies much smaller space and then for a small industrial unit in an area we can directly they can buy it and put it in

operation mode. Then, as far as the modern techniques are concerned most important technique is so called membrane processes so here we will be passing the waste water through the membranes and then that will be capturing most of the contaminants within the waste water so that we get a better quality water.

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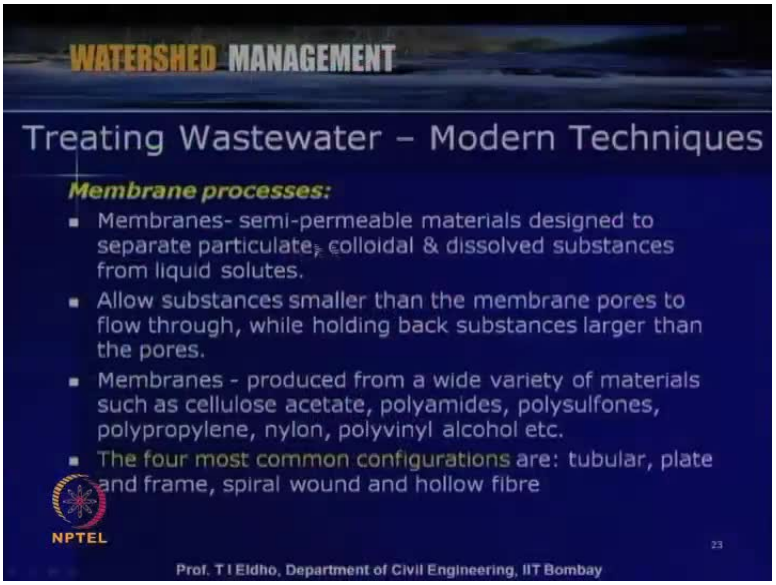

The membrane process actually the membranes are semi-permeable material designed to separate particulate colloidal and dissolved substances from liquid solutes or the waste water. Then, these membranes allows substances smaller than the membrane pores to flow through while holding back substances larger than the pores so depending upon the requirement we can have say, micro filters or Nano filters like that so membranes produced from a variety of materials we can use for such purposes like a cellulose acetate then polyamides then polysulfones then polypropylene nylon polyvinyl alcohol etcetera so various kinds of membranes are available now a days in market.

So, the four most common configurations are like, we can keep that configuration tubular form plate and frame spiral wound and hollow fiber. So, like that depending upon what kind of design we are doing as far the membrane processes are concerned and depending upon the type of membrane we can have the particular system.

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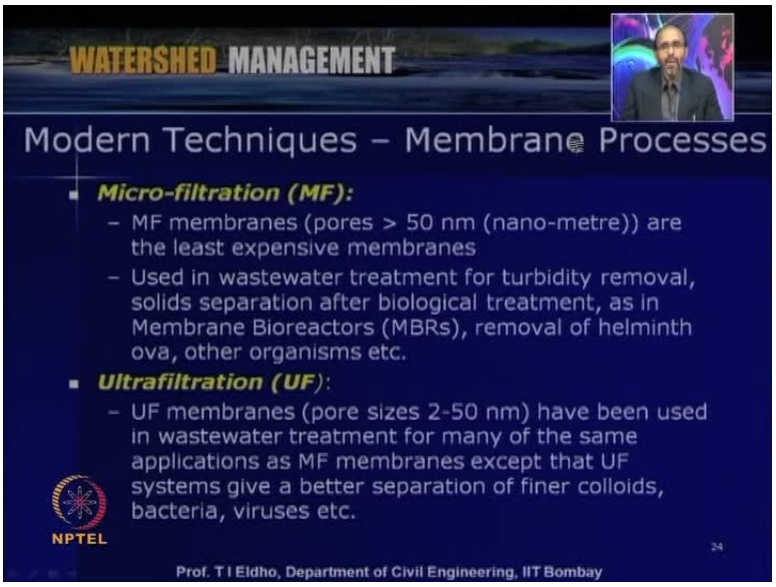

As far as the membrane processes are concerned, actually we can classify this into 4 categories first one is the micro-filtration so this categorization is according to the size of the membrane so microfiltration membranes so actually pores will be greater than 50 nanometers are the least expensive membranes and this we can use in waste water treatment for turbidity removal of solids separation after biological treatment and then this also can be we can use in membrane bioreactors and this can be used for removal of helminth ova other organisms etcetera from the waste water.

So, microfiltration when the pores the membrane pores are greater than for 50 nano meter so we that kind of membrane when we use that is called microfiltration. Second one is so called ultra-filtration means the ultra-filtration membranes the pore size will be varying from 2 to 50 Nano microns or nanometer 50 nanometer have been used in waste water treatment for many of the same applications as micro filter membranes except that ultra-filtration scheme systems give a better separation of finer colloids bacteria viruses etcetera.

when the waste water is passed through the ultra-filtration system so other than the colloids and the sediments all these things we can also remove the bacteria viruses, etcetera, from the waste water. So, this water available from the ultra-filtration will be much better than what is from the microfiltration.

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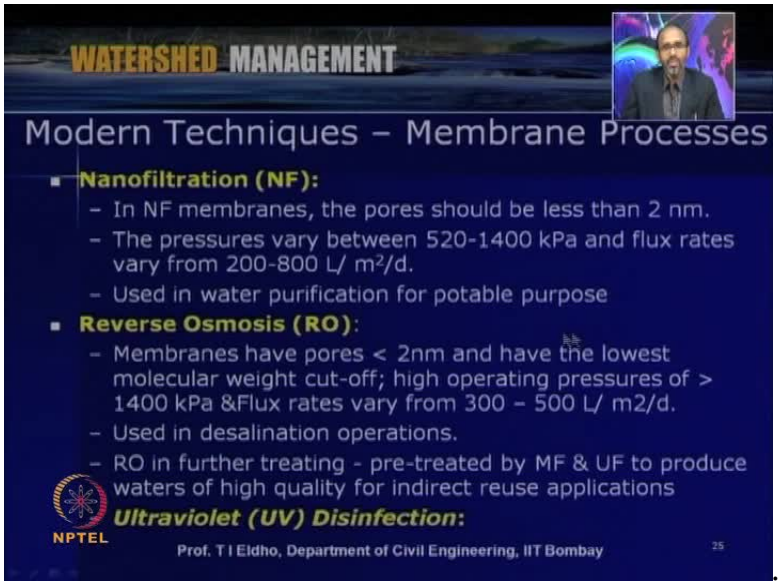

Third system is so called Nano filtration so here in Nano filtration membranes the pores should be less than 2 nanometers so the pressures vary between 500 and 20 to 1400 kilopascal and flux rates vary from 200 to 800 liters per meter square per day and this the water passing through the Nano filtration we can directly use for even for portable purposes like recharging or other kinds of purposes.

Then the ultimate say, filter technique is by using the technique is called reverse osmosis so here the membranes pores will be much smaller than 2 nanometer and have the lowest molecular weight cutoff and then high operating pressures of more than 1400 kilopascal and flux rates vary from 300 to 500 liters per meter square per day. So, this is say, actually when we are reverse osmosis is one of the commonly used technique say, as far as the desalination plants are concerned and the reverse osmosis in further treating pretreated say, from microfiltration or ultra-filtration to produce waters of high quality or indirect reuse applications.

So, even you say, for example if the water is not available in particular area we can the water passing through reverse osmosis systems we can directly even utilize or we can use for the recharge to the aquifer systems like that. One more say, modern techniques like ultraviolet disinfection, so where we can remove all the pathogens, hyper bacteria viruses, etcetera from the recycled water and then directly we can use for the intended use. So, like this we can see that say, depending upon the use what we are considering so

depending upon the quality of the waste water we go for particular type of say, treatment and then we can directly say, use for the intended use depending upon the treatment given.

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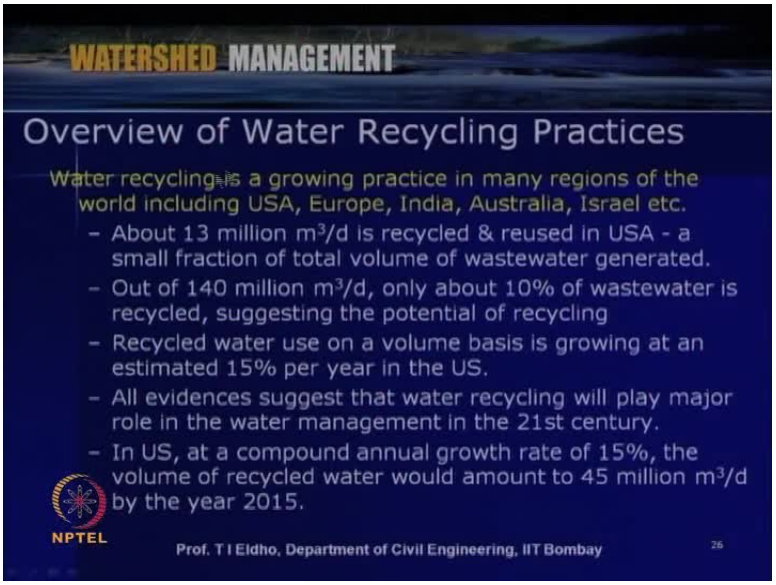

Before closing today's lecture let us say, have an overview of the water recycling practices so water recycling is a growing practice in many regions of the world including USA Europe India Australia Israel etcetera so especially in countries like Israel Australia where water scarcity is there it this water recycling is very common in many of the areas.

Say as far as US is concerned, about 13 million meter cube per day is recycled and reused and a small fraction of total volume waste water generated actually this is small fraction out of the 140 million meter cube per day only about 10 percent of waste water is recycled and suggesting the potential of recycling.

Recycled water use on a volume basis is growing at an estimated 15 percent per year in united states and all evidences suggest that water recycling will play major role in the water management in the twenty first century so this water recycling practices are increasing in many of the especially industry is concerned they are looking for 0 liquid discharge that means no waste water from the system so that way say, many of the industries are now adopting the water recycling.

In united stated for example at a compound annual growth rate of 15 percent volume of recycled water would be about 45 to 50 million meter cube per day in another 5 to 10 years; so like is that the system is growing and water recycling is becoming very common.

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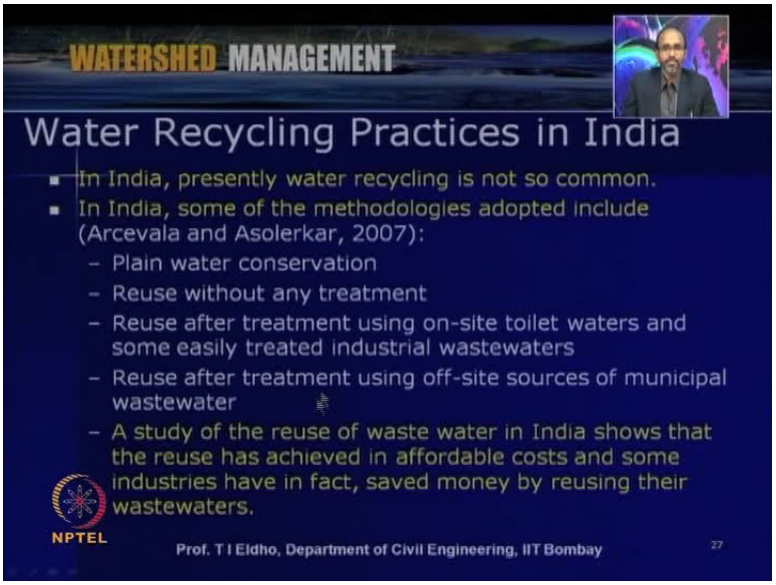

As far as water recycling India is concerned say, in India not much recycling is done. Now, industries are picking especially industrial sector the recycling is coming up like anything so in India some of the methodologies adopted as far as recycling is concerned water recycling is concerned like plain water conservation reuse without any treatments reuse after treatment using onsite toilet waters and some easily treated industrial waste waters then reuse after treatment using offsite sources of municipal waste water then say, study of the reuse of waste water India shows that reuse has achieved in affordable cost and some industries have in fact saved money by reusing their waste water.

Many examples are there say, where money is the whatever the money invested say, in waste water treatment or water recycling they have got back in few years time and then they are saving money as far as water recycling and reuse in concerned.

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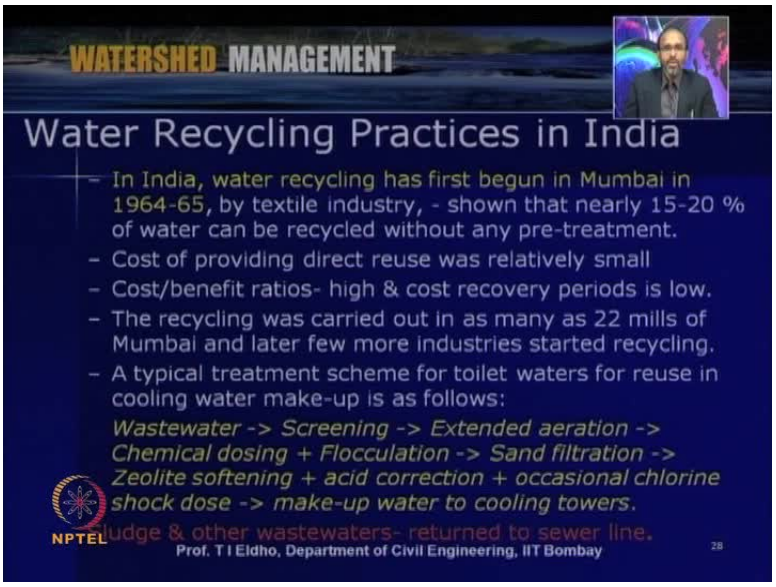

In India the water recycling has first begun say, in Mumbai say, in 1964 and 65 especially by textile industry and that time water availability was much less to Mumbai region so that way the textile industry started this showing that about 15 20 percent of water can be recycled without any pretreatment especially in textile industries and cost of providing direct reuse was relatively small then cost benefit ratio is high and cost recovery period is say, within 2 or 3 years then the recycling was carried out in as many as 22 mills in 70s and 80s in Mumbai and later a few more industries started recycling.

A typical treatment scheme say, for example say, if we consider toilet water is as follows the waste water so first will be screened then extended aeration will be given chemical dosing plus flocculation will be done then sand filtration then zeolite softening plus acid correction occasional chlorine shock dose then make-up water say, for example using for cooling towers so then remaining sludge and other waste water will be returned to sewer line.

So, like that it will be going through a systematic process depending upon the waste water and then depending upon the intended use. Now, before closing today's lecture let us see, let us discus 2 small cases where the water recycling is practiced for last few years in Mumbai.

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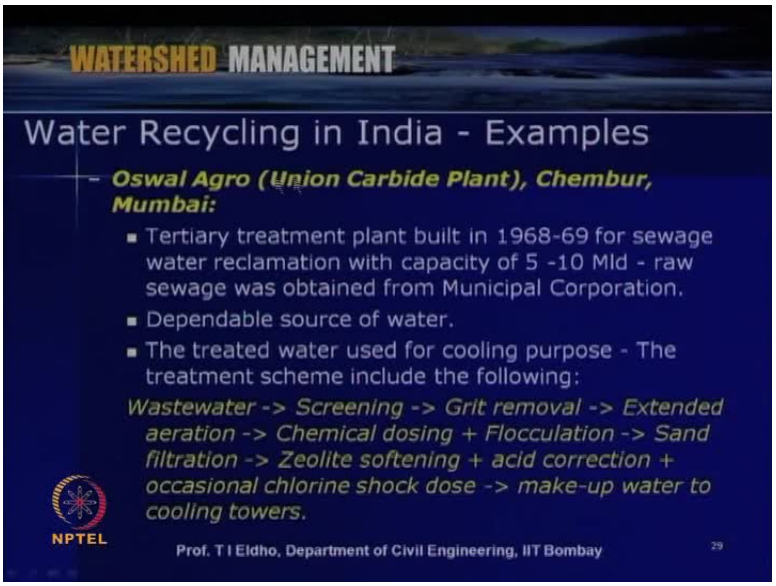

Say for example, first industry is Oswald agro union carbide plant Chembur, Mumbai so here they have given tertiary treatments which is built up it is actually a very old plant say, about 40 years say, actually this plant is there so for sewage treatment reclamation with capacity 5 to 10 million liters per day raw sewage was obtained from municipal corporation as far as this industry is concerned and so being using the waste water from municipal corporation which is a dependable source of water.

The treated water used for cooling say, used for cooling purposes and treatment scheme include say, the waste water coming from the municipal or sewage water then it will be passing through screening then grit removal will be done then extended aeration is given then chemical dosing plus flocculation so that all the sediment or the suspended solids will be removed then sand filtration is given. Then, zeolite will be passed through zeolite so that softening is done and plus acid correction and occasional chlorine shock dose are given and then this water is directly used for cooling purposes.

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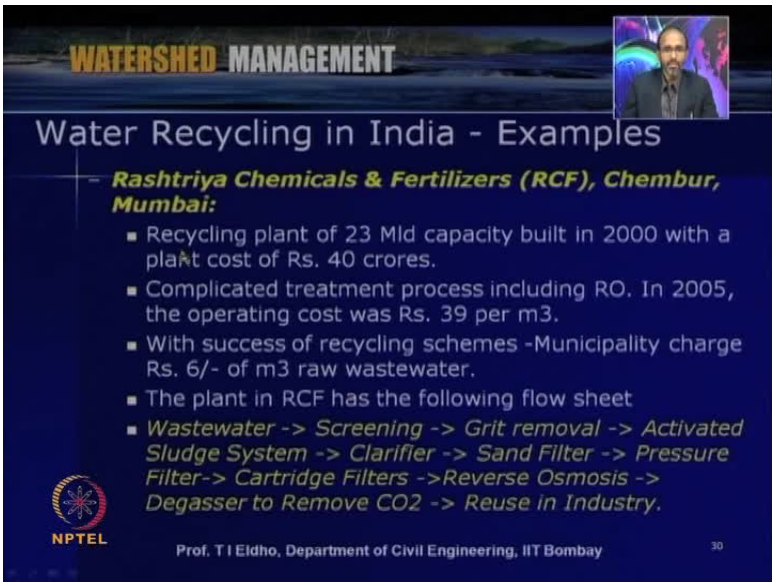

Then another example is Rashtriya Chemicals Fertilizers RCF, Chembur, Mumbai. Actually, this plant was installed in 2000 for recycling about 23 million liters per day and the investment was about 400 million rupees and a complicated treatment process including reverse osmosis is installed in the RCF plant 2005. The operating cost was about rupees 39 per meter cube with success of recycling scheme municipality also started to charge this waste water.

The waste water there RCF was taking from the municipal supply the plant in the RCF has the following flow sheet like waste water will be taken from municipal supply waste sewage then it will be put through screening then grit removal then activated sludge system clarifier then sand filter then pressure filter then cartridge filter; then, it will be passed through reverse osmosis and then, degasser to remove carbon dioxide finally this is used in in industry. So, that way RCF this last say, 10 - 15 years they are very effectively using this municipal sewage waste water or the sewage for their water supply in the RCF plant.

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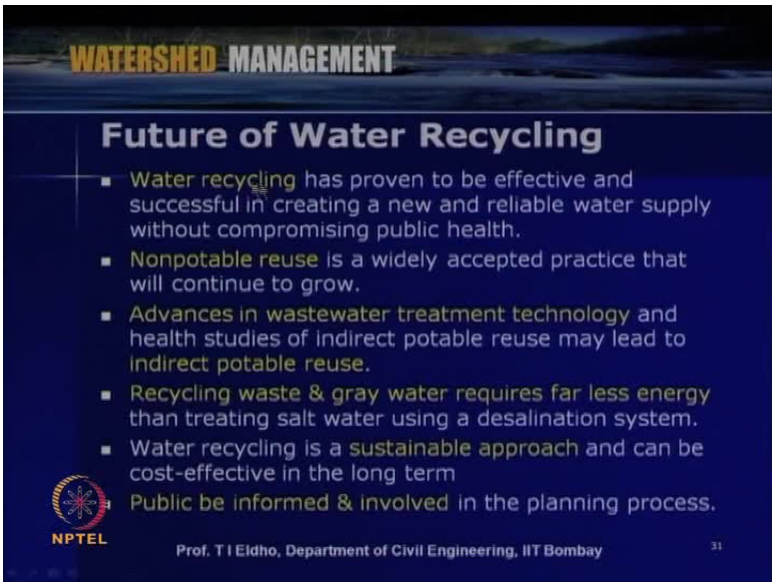

Now, before closing the lecture let us look into the future of water recycling. Water recycling has proven to be effective and successful in creating new and reliable water supply; then, non-portable reuse is widely accepted; then, advances in waste water treatment technology and helps studies say, may be for portable purposes also we can use recycling waste. Gray water requires less energy than treating salt water like desalination system; then water recycling is a sustainable approach and can be cost effective in the long time and public be informed and involved in the planning processes.

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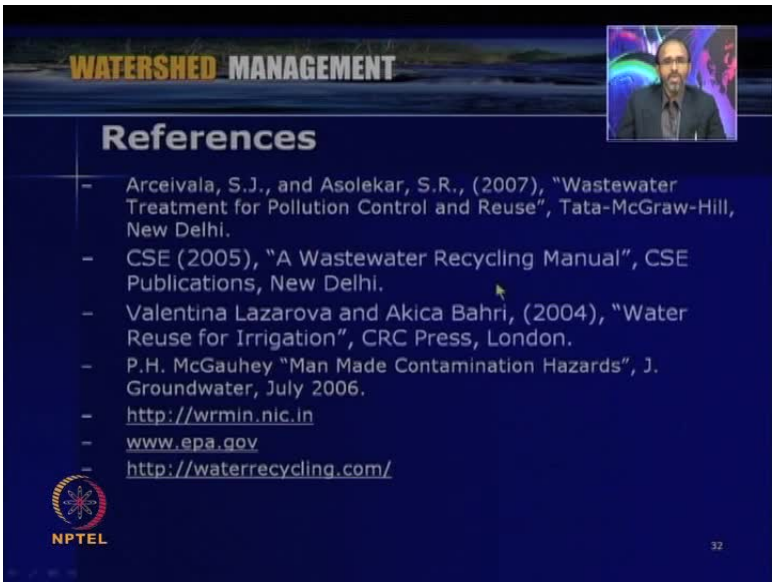

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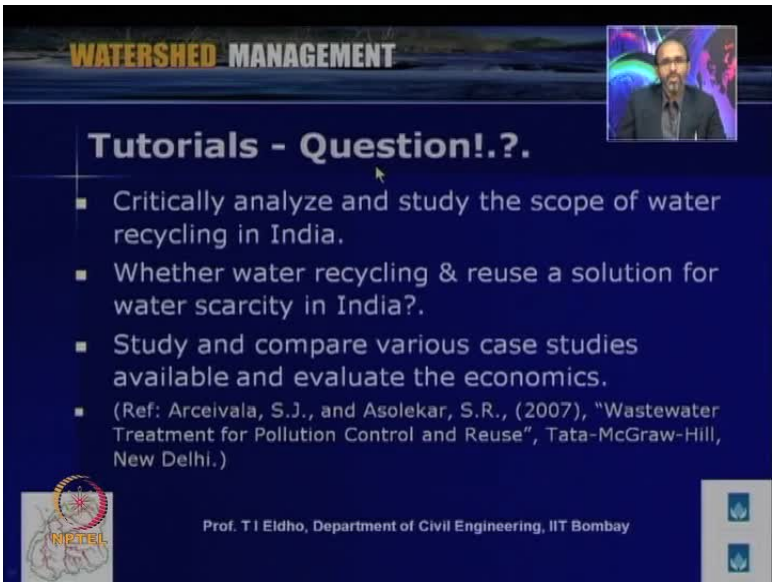

Before closing today's lecture, these are some of the references used for today's lecture then few questions, tutorial questions, critically analyze and study the scope of water recycling in India. Whether water recycling and reuse a solution for water scarcity in India study and compare various case studies available and evaluate the economics.

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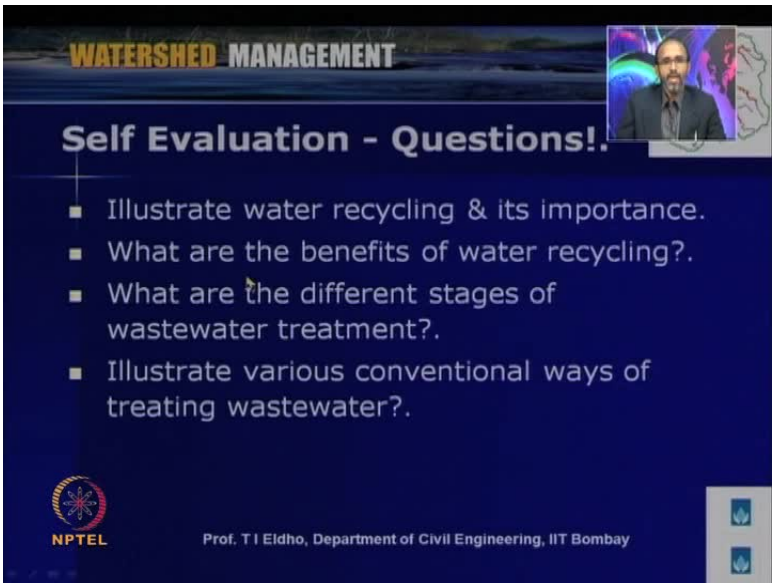

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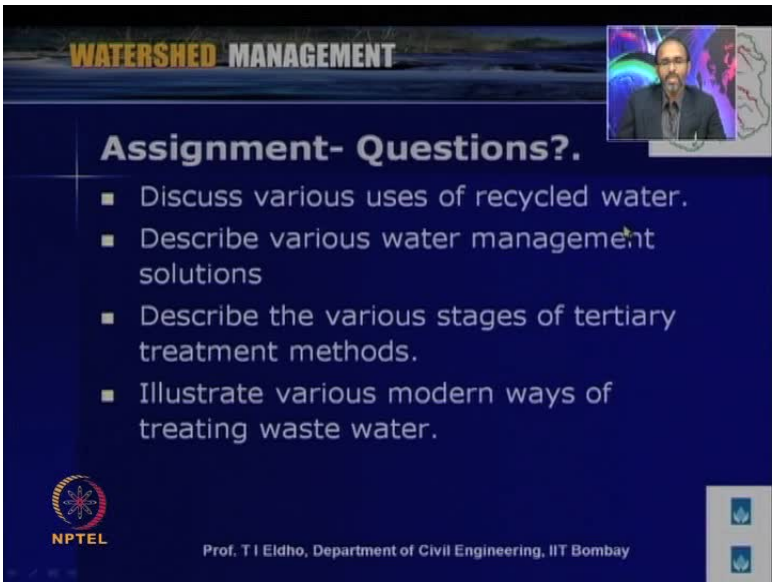

Then, self-evaluation questions illustrate water recycling and its importance. What are the benefits of water recycling and what are the different stages of waste water treatment? Illustrate various conventional ways of treating the waste water. Then, few assignment questions like discuss various uses of recycled water describe various water management solutions describe the various stages of tertiary treatment methods illustrate various modern ways of treating waste water.

Today, we were discussing about the water recycling; so we were discussing about how we can use the waste water for various purposes by giving appropriate treatment. Depending upon the waste water nature of the waste part, we have to give appropriate treatment for the indented use. So, in the last lecture, in the next lecture we will be discussing about water reuse and further reclamation and further topics in this module; thank you.