Wastewater Treatment and Recycling
Prof. Manoj Kumar Tiwari
School of Water Resources
Indian Institute of Technology, Kharagpur

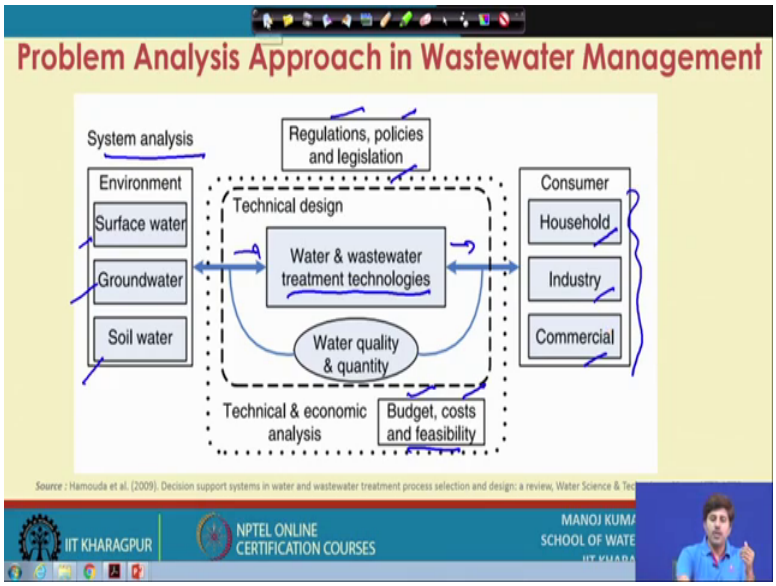
Lecture - 57
Wastewater Reuse and Recycling: Challenges, Risks and Research Trends

Hello everyone and warm welcome to this last week of this course. So, we have our journey has come towards an end. We are into the last leg of our discussions. So, the course Wastewater Treatment and Recycling was initiated, where we started discussing about the basic attributes of wastewater generation, its quantifications, quality characteristic, then its natural attenuation, the different treatment options. And then some of the advanced treatment option: including sludge management, then the setting up the treatment plants and since last week we have been talking about, primarily discussing about, the reuse and recycling aspects with the wastewater.

So, last week we did talk about various attributes of wastewater reuse and recycling, why it is important, how it can be achieved. So, this particular week, we are going to extend those discussions involving few more aspects on the decision making, and of course, the public perception because that is a very important aspect in the wastewater treatment, and recycling projects.

So, will discuss that in a later phase of this week, but what we are going to begin with, is the what are the basic challenges, risks and the various research trends which are being kind of people are being following in the recent times in the field of wastewater reuse, and recycling.

(Refer Slide Time: 01:53)



So, to begin with, if we see the problem analysis approach in the wastewater management system is again a multidisciplinary ok. We have to analyze once we are talking about risk, and challenges. So, of course, what problem are being faced will needs to be analyzed first, and this analysis is done based on a multi dimensional approach.

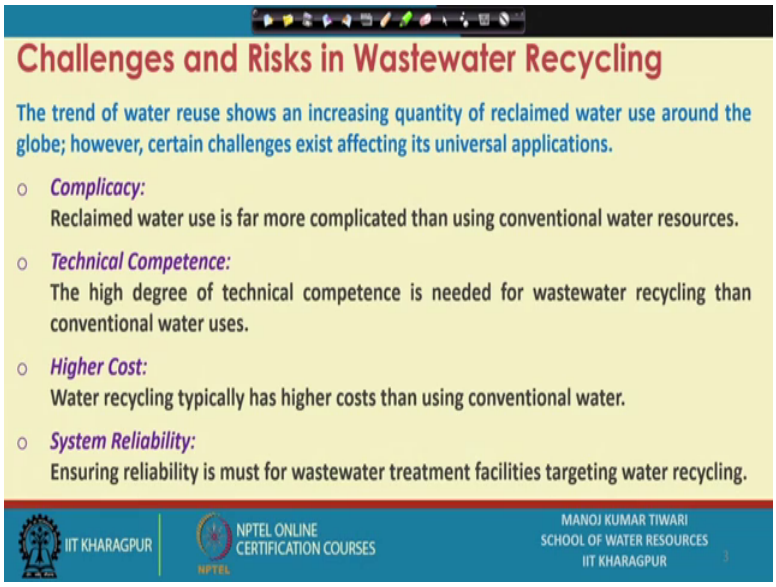
So, whether, like what particular domain we are in? What kind of analysis approach we are taking in matters a lot for this. So, for say there is a system analysis approach, where we are looking the system as a whole. So, our environment as a whole; then there are surface water, ground waters, and soil water. We have kind of regulators analysis approach, where what are the regulations what are the policies what are the legislations ok that there is a technical and economic analysis.

So, in technical analysis of course, we need to see what are the most suitable treatment technologies ok? What is the inflow water quality, what is the outflow water quality which is being generated? How feasible it is for reuse purpose ok? So, all those things needs to be taken care, needs to be considered over here, and in the economic analysis part, then will have to see what is the budget? What is the cost? What is the feasibility of the economic, feasibility of the system that are being proposed?

And then, there is a consumer analysis prospects which could be, like consumer could be household, industry, commercial. So, they own will have their own prospects ok. So, like

prospect of a household user, prospect of industrial user, prospect of a commercial user, how they are willing to analyze the system? How they are willing to kind of weigh the various pros and cons of the system.

(Refer Slide Time: 04:01)



So, that way, since, we can actually do this analysis in multiple domain, multiple ways. So, will have to kind of look for the, what are the various risk that could come out of a wastewater treatment, or recycling projects. What are the various challenges that we are going to face in the field? So, if we talk about the various challenges and risk in the wastewater recycling aspects primarily.

So, we see, we can broadly categorize them into two major type of challenges, or issues. One is your financial based, or technical based challenge technical challenges, or financial challenges; which can be overcome because technologies are available, and if budgets adequate amount of budget, or adequate amount of funding is being made available. So, this is not a like, very difficult task; this can be a manageable task.

But we have, some other type of challenges as well, which are more so are related to the perception, related to the society, related to the governance, related to the politics involved and they are rather more difficult to deal with ok. So, the trained in the water reuse if we see; so, it shows a kind of increasing quantity of reclaimed water is being used around the world ok. However, there are certain challenges that affect this universal application of the wastewater treatment, and recycling system.

Now, what are these challenges? The first one is the complicacy. So, it is far more complicated to use a reclaimed water, then, simply abstract water from a resource and use it for the designated purpose. So, if say you want to use water for irrigation purpose ok, now, what people do? There are canals flowing in; they can channelize the water from the canal ok. They can make a kind of drain coming out of the canal and then use that, align that drain directly to their field, and when the gates in the gate gates in the canal are open the water through that drain will directly go into the field. Or if it is a groundwater supported system, so, they need to install a kind of well and through basically pump, they can actually pull that water, and directly put it into the field ok.

No treatment nothing needed. Now, if you want to use wastewater for that purpose or reclaimed wastewater for that purpose; just imagine what kind of infrastructure you will be needed it is far more complicated ok. You have to if let us say, the wastewater is being collected place so, you first thing you will have to provide a treatment, even for agricultural reuse it is not recommended to use like, the row see which in a irrigation purpose. So, you will have to provide some basic degree of treatment. So, there is a need of treatment process.

Now, again the selection of the treatment process it itself is a quite challenging task ok, and quite complicated task. We will discuss that in the next lecture, when we talk about the decision making systems, but still, like what kind of treatment hierarchy, what kind of treatment units you are going to pack in. Then the operation of the treatment system, maintenance of the treatment systems, then channelize it from there, bring it to the field level, reliability of the system, whether you are getting adequate amount of water or not. If it is not fulfilling it is not meeting the complete irrigation requirement.

So, still you need that additional facility either from a canal system, or from a groundwater system to meet and fulfil those demands. So, that requirement of that facility is still going to be there. So, you are going to basically install an additional feature, additional treatment plant, additional supplies, or distribution system and these are that way make this system a little more complicated than using just conventional water resources ok. Then there is a technical competence which is another big challenge ok; because, using just raw water from the available resources needs far less technical competence, needs far less technical expertise as opposed to the using recycled or water.

Why it is because the kind of, when adequate amount of treatment is to be ensured for the wastewater before it goes to the reuse and more so ever the wastewater the sources of the water for this treatment, if it is not just raw source water if it is a waste water; so, wastewater is known to harbour lot more pollutant, than the normal water. So, therefore, that there is a high degree of risk. So, they in order to kind of mitigate this risk, in order to ensure the protection, or safety, one needs to assure that these kind of the particularly, with the emerging contaminants.

So, if there are any emerging contaminants in the wastewater, they are taken care of well. So, how we are going to take care of emerging contaminant? You will have to go for that level of treatment which usually is not needed, when you are working with the just raw water system probably.

So, you of course, need higher degree of treatment and higher degree of assurance because you need the regular monitoring of those contaminants regular label check up then whether they are within the regulatory framework, or not all those things need to be seen. So, since your degree or scale of treatment is increasing so; obviously, the need of technical expertise, or need of the technical competence is also going to increase with the reclaimed water system as opposed to the raw water system. And it is not just about the reuse purpose.

So, if you want to just dispose of that water again the disposal norms are far lenient as opposed to reuse norms. So, for reuse purpose because norms are more stringent particularly, if it is targeted for some industrial reuse or domestic municipal reuse, then norms are far more stringent and one needs to kind of make the treatment process to that level; in order to ensure the safety from that. There is a higher cost.

So, water recycling typically will higher cost than, conventional water system because of additional collection systems, additional treatment facilities ok. Your conventional water system you pump it bring it to a treatment plant, provide the regular or conventional treatment and supply it. It is done, but with your wastewater, you will have to provide higher degree of treatment.

So, that treatment and collection and storage part makes it more costly. So, generally the cost of recycled water, processing cost of recycled water is going to be higher than the processing cost of conventional water. We are not saying just overall cost because if you

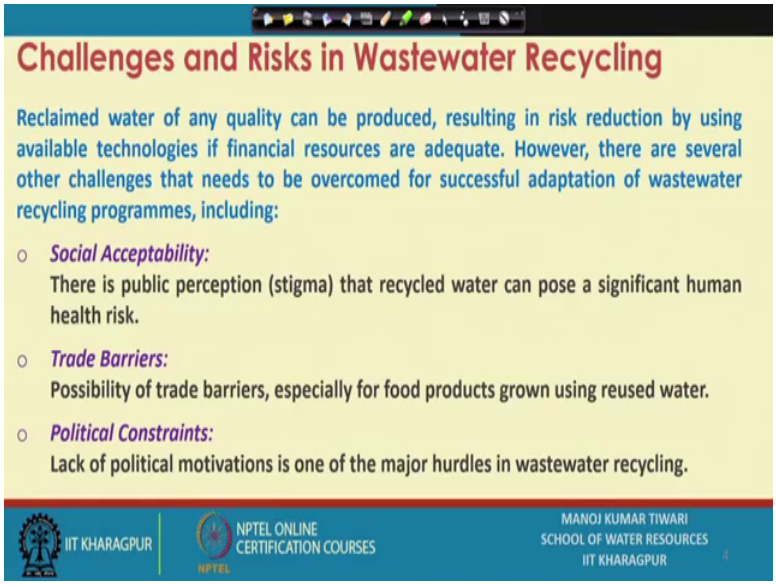
see; the there is a kind of opportunity cost with the water which is existing in the resources ok, then there is a disposal cost of the waste water how much environmental pollution it is going to create?

So, there are various kind of offset cost as well. So, if we include all of them then probably, we may see that recycled water is preferential over to the natural abstraction; however, just processing cost in simple terms if we see. So, you abstract the water from a natural resource, or a surface water, or ground water and then process it. So, the processing cost of that water is going to be far less as opposed to the processing cost of the wastewater because of obviously, higher degree of contamination or higher degree of pollution in the wastewater systems.

Then there is a system reliability ok. So, it is ensuring reliability is must for wastewater facilities ok; which is targeting water recycling. Why it is must? Because we know that source water is highly contaminated and if your system is not reliable so, the there is always going to be a risk of the human health like deterioration or those kind of thing.

So, in order to prevent that, it is important that your systems are actually reliable. It the level of reliability required with, again conventional water system is low because even if you are pumping groundwater; even if your treatment system is not that effective, your simple groundwater may not be that like that great degree of a threat as a waste water without treatment, or with lesser degree of treatment.

(Refer Slide Time: 13:08)



Now, these are the challenges the one that we discussed so far are something which, can be kind of dealt with. So, what happens that the, if we know that these days; we have adequate amount of technologies available, we have kind of RO system available which can treat almost everything. So, if we install a good system, it will ensure that your like the degree of, proper degree of treatment is being provided; it will ensure that your system reliability is good enough; it will ensure that the technical competencies required are being met. So, your system is technically sound, technically reliable, giving due or adequate degree of performances. Of course, the cost is higher right.

So, these like if there are adequate financial resources are made available. So, there are technologies, there are systems available; which can kind of ensure the no risk or very risk free reclaimed water available for reuse or recycling purpose. But apart from that, there are several other challenges that needs to be overcome for successful adaptation of wastewater recycling programs.

So, if we want to kind of go for, successful recycling programs; of course, the one that we discussed will be there, and as we said that with adequate financial allocations those can be taken care of, but there are a few other challenges which also needs to be kind of see which also needs to be seen taken care of. Which are rather more difficult or we need a different approach; it is not just the financial application or technical technological application can are going to solve those problems. So, what are these problems? These problems are the social acceptability. So, if because the public perception the stigma, of the like, the reclaimed water or the recycled water has a significant human health risk, is something which needs to be kind of dealt with in the recycling projects. So, the public perception of the recycled water is not that great in developing countries, as well as in most of the developed world as well ok.

So, only there are a few places where as we have discussed earlier also; there are very limited places where the recycled water is being used for the say, drinking water supplies ok. Otherwise there is a huge reservation from public side to kind of use the treated sewage or treated wastewater for the potable purpose. So, that public perception one needs to overcome that public perception in order to successfully implement the recycling projects and this is one of the major challenges ok.

So we will talk about these again in one of the later lectures when we go about, when we discuss about the kind of social aspects of the recycling projects in great detail. Then there are trade barriers ok. So, there is a possibility of the trade barriers especially with the food products. So, many countries generally, means many countries may refuse to import the food materials, which are grown on the recycled sewage or recycled wastewater. So, what happens when we are going for recycling wastewater at growing food products on that so, if your treatment system is not reliable ok; if you do not have that reputation of yes your product is safe.

So, then the particularly, in the developed world many of the developed countries have these trade barriers that say, fruits grown on the recycled water cannot be imported ok. Or the other foodstuff grown on the recycled water and the grains, the those things cannot be imported. So, those trade barriers again, it is kind of a challenge to overcome with for the successful implementation of the recycling program. Then there are political constraints.

So, there is lack of political motivation, which is one of the another major hurdle for the waste water recycling programs, and at least in some places, some nation, some countries and there are various other political attributes in fact. So, if you are making what are free; so, then or particularly say the water resources you are if you are if the politicians are not valuing water resources; they are making adequate water amount available to the end consumers.

So, as we discussed, due to the higher technological needs or due to higher cost, no one is going to go for the recycled water if this source water or the conventional water sources are readily available. So, there has to be some sort of constraints applied on the abstraction from these waters, then only the recycling water can appear as an alternate source and that constraints we need good amount of political motivation for those constraints ok and that is another challenge in the wastewater recycling aspects.

(Refer Slide Time: 19:01)

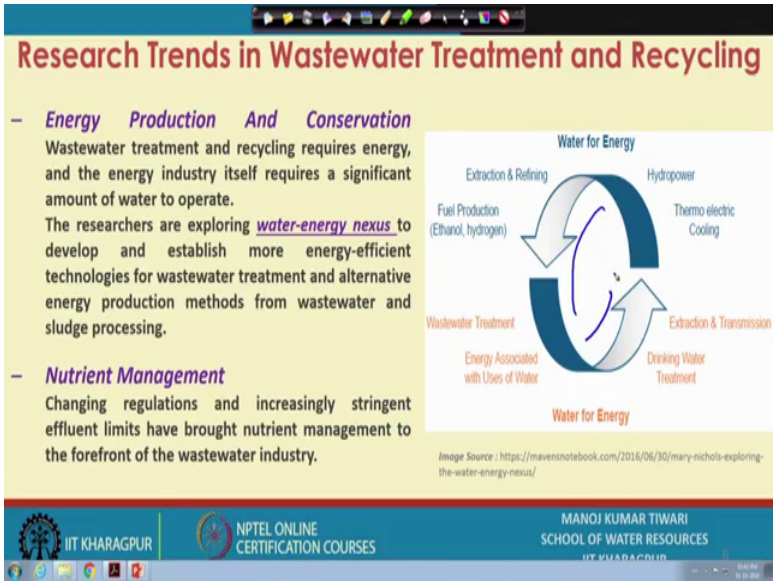
Now, if we see the various research trends in the wastewater treatment and recycling which is being observed. So, if we see the wastewater reclamation and reuse is one of the major area of research in the water domain, in the water sector these days ok. There is an intensive research going on; which focus on reusing this treated wastewater influent, and this research is targeting not just, like non contact uses it is for industrial application, for agricultural applications, and as well as for drinking applications including the direct potable reuse, and indirect potable reuse ok. Then there are fit for purpose; water reuse is also one area of research which is getting more popular ok.

So, this basically talks about identifying the cost effective treatment ok; to what extent one should treat the water that is needed for fit for the purpose water reuse ok? So, the fit for the purpose what reuse is like if we are want to use water say for agricultural purpose, so, what is the requirement treatment requirement for agricultural purpose only; why we should go for a potable water wastewater treatment to produce a water with the potable level if our end use is agriculture? So, that is what is fit for purpose water reuse ok. We will talk about that in next class as well. Then there are integrated water management related research is going on, and particularly, moresoever even in the context of urban water management.

So, this calls for the various components of urban water cycle to be, kind of considered in an integrated fashion. So, there is all the alternate resource along with the storm water,

rainwater, then, there is usual surface and groundwater resources; along with these the wastewater should also be considered as a resource in this integrated urban water management cycle. So, how much optimum contribution can be taken from waste water can be taken from storm water. Or how much of water withdrawal minimum water withdrawal should be taken from our existing water resources conventional water resources. So, all those things needs to be kind of integrated in a framework to see, the optimum water uses from these different domains, and that way maximizing the water productivity. So, that is another area of research which is basically people are involved in, actively involved in.

(Refer Slide Time: 21:47)



Then there is another quite popular area is the water energy nexus where energy production and conservation is kind of evaluated. So, as we know that the wastewater treatment and recycling will require lot of energy and the energy industry itself requires a significant amount of water to operate. So, energy needs water, water needs energy ok.

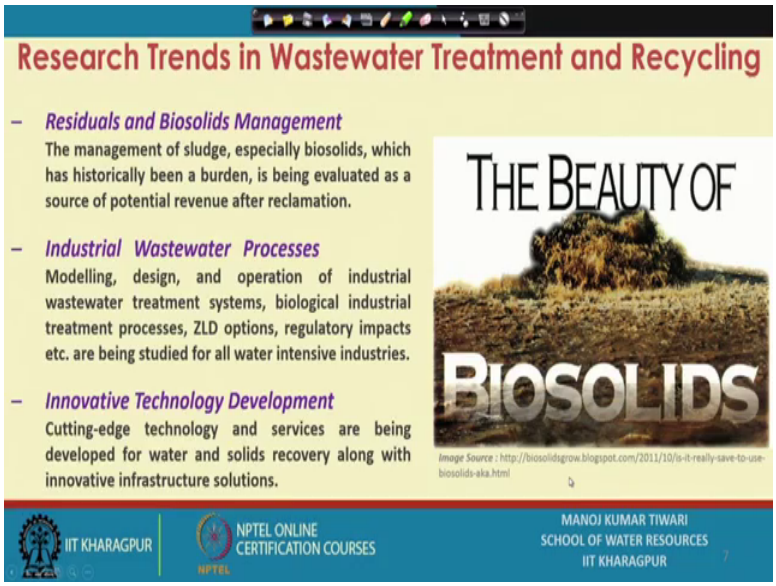
As we can see it here ok. So, there are researchers who are exploring this water energy nexus and moresoever, from the aspect of the water management ok; or what productivity. So, there they are trying to develop and establish more energy efficient technologies for wastewater treatment, and the alternate energy production methods from wastewater and sludge processing. So, how we can basically minimize the energy consumption in the wastewater treatment and how we can potentially if we can

potentially generate some amount of energy through these wastewater or sludge processing.

So, as we discuss the in aerobic digestion of sludge, or those kind of thing incineration, or fumigation those kind of things may produce certain amount of energy; the anaerobic treatment of wastewater may also produce certain amount of biogas which is a form of energy. So, there is the minimization of energy and input and maximization of energy output is another active area of research. Then there are nutrient management.

So, with eutrophication becoming a more wider phenomena worldwide ok; a more major environmental threat worldwide, people are actually trying to like due attention due focus is being paid on the nutrient management aspect ok. Where people are trying to see what are the optimum ways to manage the nutrients ok; if it is feasible to recover the nutrients or if it is feasible to let it be in the water and use it for some beneficial purpose. So, changing moresoever there are changing regulations ok, and which are becoming more and more stringent on the effluent mixed particularly in terms of nutrient. So, this like is bringing the nutrient management in the forefront in the wastewater industry, and that is why getting lot of attention in the research field as well.

(Refer Slide Time: 24:16)



Other things that one can see actually. So, there are research trends; also, kind of exploding the residual and biomass or bio solids management ok. So, this management of sludge or biomass or particularly the bio solids, which has historically been

considered as burden is being evaluated as a potential revenue resource after reclamation. So, if we can reclaim say, some mineral some these things out of that or we can use that as a source of energy. So, those things like that way we if it is possible to generate certain revenue of these residual or bio solids management is another aspect, another active area of research people are engaged in. Then of course, the industrial wastewater processes.

So, moresoever, with the kind of advent of the emerging contaminants coming in the industrial wastewater; the norms are getting more and more stringent. So, how we can meet those norms? These days the zero liquid discharge option has come in. So, how we can kind of meet these norms fulfil these regulatory requirements at a minimum cost is what is being explored; so, under this the modelling, the design, the operation of the industrial wastewater treatment systems more so over the biological industrial treatment process because they are considered more sustainable.

So, under these biological treatment processes, the more attention is being given to the anaerobic treatment systems because of their energy of lower energy footprints ok. So, these anaerobic treatment systems, or aerobic, or advanced oxidation processes that way ok. So, they are all being investigated ok. The zero liquid discharge option what are the various zero liquid discharge options, what are the various regulatory impacts it is being going to be create? So, these are being kind of studied for particularly, for the water intensive industries ok.

So that is being done on the industrial forefront. Then innovative technology development: so, the newer technology is being developed the cutting edge technology, and various services, or scheme, or treatment operations are being developed for water and solid recovery along with the various innovative infrastructure solutions. So, that is also another area of research that way. Then, the wastewater utility management as a whole.

(Refer Slide Time: 27:10)

So, the wastewater utilities or wastewater treatment systems, how they should be managed? How the troubleshooting should be ensured? The funds management, the meeting of the regulatory criterias ok; and most important aspect, one of the most important aspect in the form of public outreach: how we can like put the system put the information on the public domains and the public should also be aware with what is happening in that. So, all those aspects are also being investigated moresoever with the pressure from the international organizations, the United Nations, the World Health Organizations and the then some of the national or public domain institutions as well. Then there is another quite important aspect in the form of instrumentation control and automation.

So, with the technological advancement that we are in an age of this technological advancement. So, the instrumentation control and automation is basically rapidly intervening in all sectors and so, is in the wastewater treatment and recycling sectors. So, like the various operation of the treatment plants that we were seeing; so, the conventionally the systems were being operated manually, but nowadays there as there is like the automation is the control, or the instrumentation system has come up; so, that we can actually control these through remote locations through scada kind of systems ok. Supervisory automated supervisory control kind of systems.

So, these and the online monitoring system in the quality has also come into the picture, like the pollution control board official sitting in their office can track what is the effluent quality being generated say from different industries ok. So, with these like the technological advancement, technological development this online monitoring; control the automation of the processes. So, when to operate gate? How to operate channel? When to open? When to shut down the plant? How to operate pumping services?

So, all these can be done in an automated fashion. So, that is again, active area of research where people are kind of investing energy; in order to see that how efficiently we can take advantages of these automated systems, and get rid of these several operational issues with the wastewater management or wastewater treatment systems ok.

Then, there is the cost reduction aspect which will always be there ok. So, reducing the cost of the high end treatment processes, like processes such as membrane filters, advanced oxidation processes, then various ion exchange, adsorption system. So, how we can basically cut down onto the cost and make these processes, make these units more affordable for application to the wastewater treatment and recycling projects.

So, these are also like being investor like the system and there is a great deal of success. So, initially like you say the RO systems used to cost a lot and they used to kind of for treating 1 litter of water, they were wasting 3 litter of water that way. So, the reject percentage was kind of more than 2 third or up to 3 fourth of the total water inflow. Whereas, now we have moved on to the advanced stage or with proper adaptation of the mechanism, pre filters or those things we can reduce the reject component from the RO system. So, we can actually get say even up to 70 80 percent permit and only 10 to 30 percent going for the reject.

Further apart from that the cost has also being kind of bring people have engaged in bringing the cost down, developing different type of membranes, developing different type of configurations or doing different type of system analysis or arrangements in order to bring the cost down with not compromising on the performance aspects. So, these are the things that are being kind of investigated; these are the major research trends which are kind of going in the field of wastewater treatment and recycling. So, we will conclude the discussion in this class here and next class of this week, we are going to

talk about the decision making systems in the wastewater treatment and recycling. So, see you in the next class.

Thank you for joining.