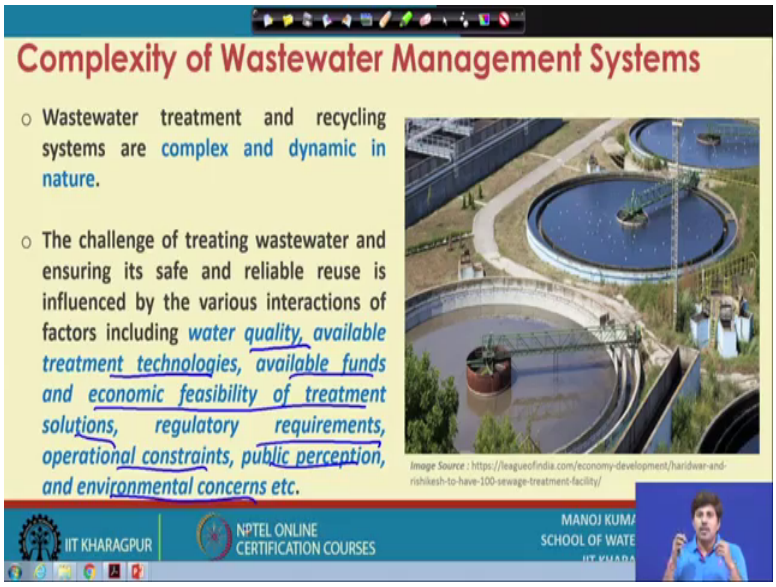
Wastewater Treatment and Recycling
Prof. Manoj Kumar Tiwari
School of Water Resources
Indian Institute of Technology, Kharagpur

Lecture - 58
Decision Making in Wastewater Reuse and Recycling

Hello everyone and welcome back. So, we are in the second lecture of this last week where we will be talking about the Decision Making Systems in Wastewater Reuse and Recycling ok. So, for if we see the sector of the Wastewater Treatment and Recycling is quite complex.

(Refer Slide Time: 00:42)



So, there is a lot of complexity involved in the Wastewater Management System ok, these are quite dynamic in nature ok. So, if we see the challenges of treating wastewater and kind of ensuring it is safe and reliable reuse of the wastewater is influenced by the various interactions of factors, which include from say your water quality, to available treatment technologies.

So, what is the inflow water quality and what kind of affluent quality is needed, then what are the treatment technologies available, what are the funds available, what is the economic feasibility of the various treatment solutions, what are the regulatory requirements, what are the operational constraints, then the public perception the environmental concerns?

So, all these play some role in the kind of adopting a final treatment strategy for the wastewater management systems ok. So, low like if we are producing certain amount of wastewater with say with a certain quality. Now, there could be N number of options available to deal with it ok. We just treat it to minimum scale and let it go into the little disposed into some natural water bodies, we treat it to adequate scale and let it use for irrigation purpose, agricultural purpose, we treat it to higher scale and argument it with the say potable water supply is ok. We treat it to certain scale and use in the industrial processes.

So, all these different options could be there. So, for these different options the output water quality requirements are going to be the different. Then; obviously, when the inflow and outflow qualities we know so, we can actually think of deciding a treatment chain.

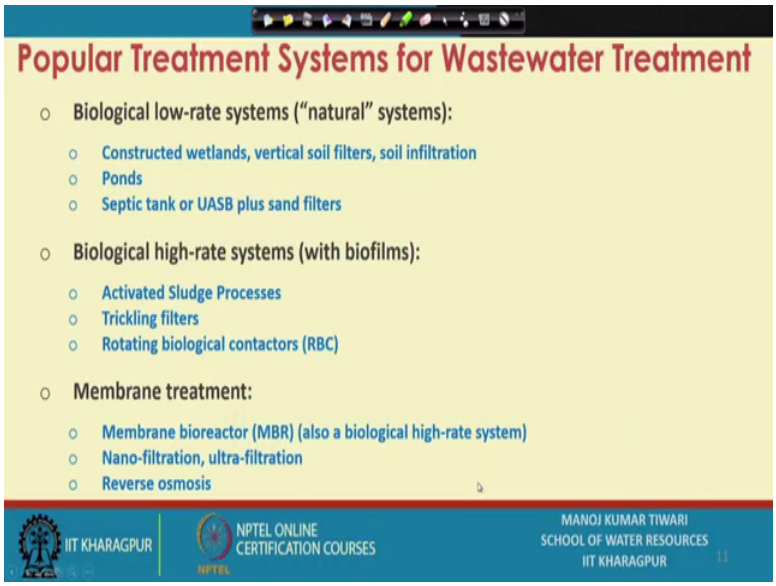
Now, this treatment chain could be different based on the different objectives based on the different final effluent water quality needed ok, then there is constraint of the fund. So, how much funds is available, if there is not adequate funds are not available. So, you need the best quality of treatment and you that you can get safer by using an R O system, but if your funds are not allowing you to go for a R O system, then you will have to look for alternates aspect alternates available.

So, that are the kind of thing then what are the regulatory requirements. If you want to reuse it so, there is some regulatory criteria that you have to produce or meet these regulate these criterias ok. So, what are then of course, how easy is the operation and maintenance, whether there are skilled people available to do that or not ok. You cannot install ion exchange or R O system those kind of thing in a rural scale, where there is no one is ready to operate that system ok.

So, those kind of constraint will also be there then the public perception particularly in the reuse projects ok. So, what are the public accepted reuse options and environmental concerns? So, these kind of dynamic interactions of these various parameters, these various factors, make the basically the entire wastewater management system and particularly if you are targeting a recycling.

So, this wastewater treatment and recycling system quite complex and complicated.

(Refer Slide Time: 04:26)

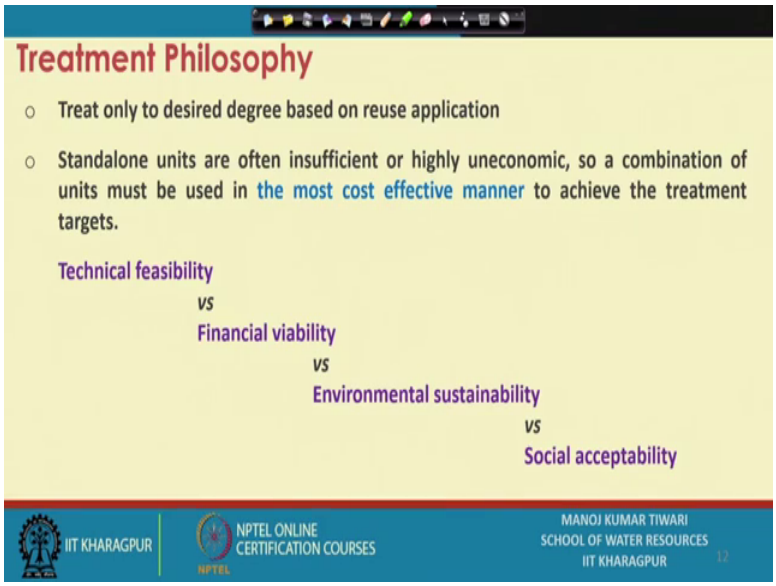


So, then what we can do with that, we have to look for what are the alternates available. So, as we say that we will go for seeing there are variety of treatment options available. Now, the some of the popular treatment options we have already discussed, but if you see the biological low rate system or natural system what we call is the constructed wetland, the vertical soil filters, soil infield filtration systems, pond septic tanks or USB kind of systems. Then biological high rate systems are there in the form of activated sludge process trickling filter, rotating biological contactor ok. Of course, we discussed the popular treatment in the form of kind of hybrid treatment systems as well.

So, there are membrane bioreactors which are also a biological high rate system apart from that sequential batch reactors, then the MBB are moving by obed reactors. So, those are the kind of systems which are available and which people tend to use it, then there are specific membrane process, high end membrane process, like Nano filtration ultra-filtration or reverse osmosis kind of thing is also options which are available, for the treatment purpose.

Now, it is kind of when we go for making a decision towards a treatment system.

(Refer Slide Time: 05:44)



So, the water should be treated only to the desired degree based on the reuse application ok. Now, standalone units are often insufficient or highly uneconomic ok. So, a combination of units is used as we discussed earlier in a most cost effective manner to achieve the treatment targets. And, the treatment targets are the technical feasibility, financial viability, environmental sustainability, social acceptability, for the reuse purpose. And, many times we have to trade-off between these targets. Something which is technically feasible may not be financially viable let us say RO system which is the best technology available is not financially viable ok, because of the lack of funds for say.

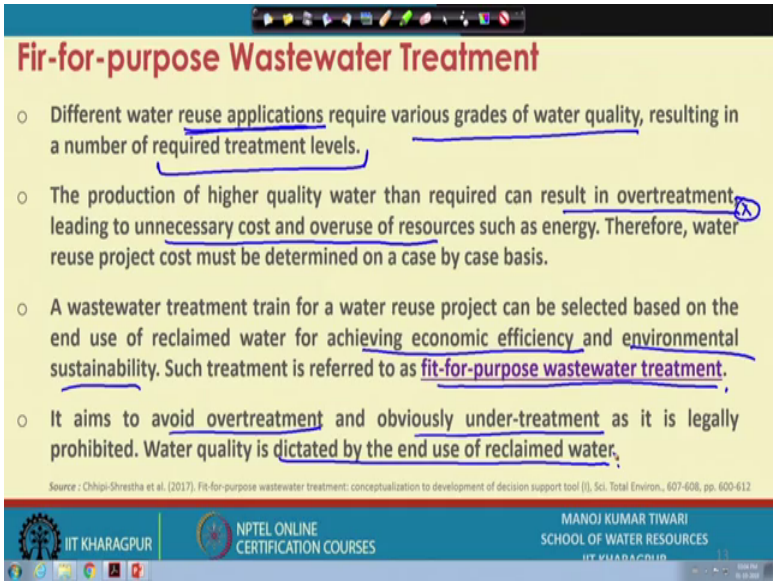
So, then will have to kind of trade off these like within our budget we cannot go for r o systems let us go for a ultra-flirtation or let us go for membrane bioreactor. So, instead of going for RO system you end up treating with a membrane bioreactor kind of thing ok. So, that way there is a trade-off between kind of in order to meet the financial viability criteria you go on to the compromise in the technical feasibility criteria or technical excellence criteria.

Then there is an environmental sustainability many times plays a vital role something which is environmentally sustainable may not meet you, may not technically give you the desired output ok. So, for so, R O system may not be environmentally sustainable because of it is high energy footprints or because of the reject water that it produces, but

if your requirement, if your technical requirements suggest that no you have to use it you have to treat it to that level.

So, probably you will compromise on environmental sustainability criteria instead of going for a natural system low treatment natural system, you will go for a high treatment kind of maybe a little lesser environmentally sustainable system ok. Then, again the social acceptability which kind of treatment is being accepted socially or those kind of things needs to be kind of seen.

(Refer Slide Time: 08:10)



So, this brings us to the kind of concept, which is called fit for purpose wastewater treatment, we just talked about this in the earlier lecture as well.

So, the fit for purpose water treatment is something which is kind of conceptualized, because the different water reuse applications require various grades of water quality. So, we need not to get R O treated water for irrigation purpose. We may need a R O treated water or our own like wastewater to get a R O level treated for potable water supplies. If you want to give it for a potable water, but we definitely do not need it for a irrigation purpose.

So that way the kind of number of required treatment levels would be different based on the reuse application. What is our reuse application will eventually guide, what is the required treatment level, or what is the required degree of treatment ok. The production

of higher water quality, then required is actually can result in over treatment. So, if we end up providing over treatment as just we are saying that if we end up providing say R O level treatment for agricultural application or irrigation application so; that means, we are leading to unnecessary cost and overuse of the resources like energy.

So, therefore, the water reuse project cost must be determined based on the case to case ok. So, if our ultimate project objective is for irrigation purpose, what level of treatment we should provide if our ultimate objective is say industrial reuse, what level of treatment we should provide and if our ultimate objective is say the potable water supply. So, what degree of treatment we should provide ok. Then wastewater treatment train or wastewater treatment scheme if you can say that.

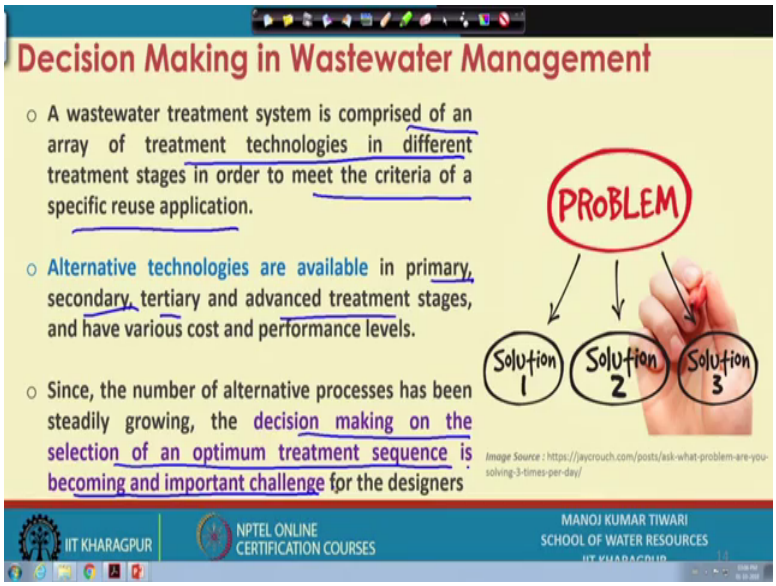
For a water reuse project will be selected based on the use of the reclaimed water ok, for achieving economic efficiency and environmental sustainability. So, how we can produce an environmentally sustainable reclaimed water at the economically efficient fashion will basically guide, what kind of wastewater treatment scheme we are adopting, or what kind of unit processes or combination of units, and arrangement of units we are adopting for the purpose.

So, this kind of treatment is called fit-for-purpose water treatment. So, this is what is fit for purpose water treatment, which drives that the water is to be treated only fit for the reuse purpose not beyond that ok. So, because beyond that will result in the over treatment and this over treatment is not advisable, because that is going to lead unnecessary cost and unnecessary consumption of the resources like energy.

So, that is why the fit for purpose water treatment usually aims to avoid this over treatment and; obviously, under-treatment, also like one cannot say that it should be under treated because there are legal requirements, or there are regulatory requirements to treat up to that level. So, under treated water is; obviously, not going to be accepted, but it also avoid the over treatment.

And the water quality is that way dictated by the end use of the reclaimed water. So, what is the end use, what is the target and use that is what will decide, that is what will dictate, what kind of treatment we should provide ok?

(Refer Slide Time: 12:11)



So, this is basically what is the concept of fit for purpose water uses and this for the purpose it is used. So, this brings us to the decision making, because we are at if we see. So, a wastewater treatment system is comprising array of technologies as we are saying that there for the fit for purpose water treatment, based on the output level will have to select a treatment train or will have to select a treatment scheme.

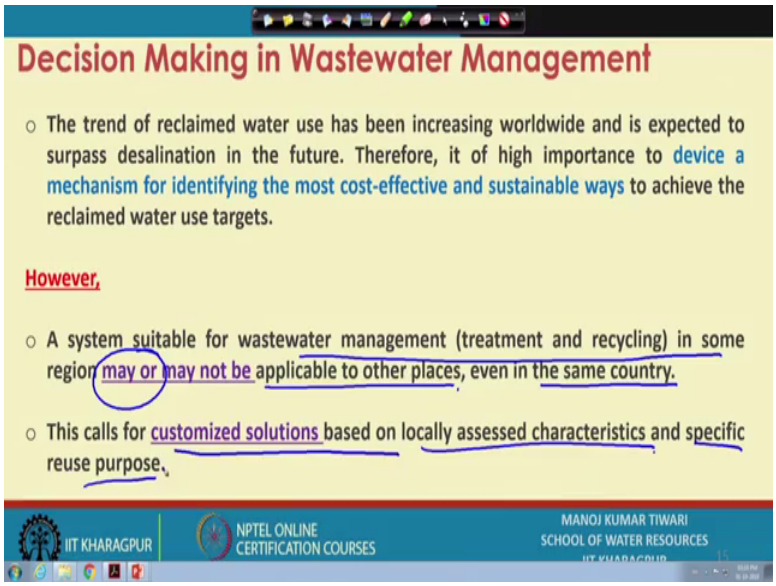
So, that, treatment scheme typically comprise of a various treatment technologies ok, in the different treatment stages and the idea is to meet the criteria of a specific reuse application. Now, these various alternative treatment technologies that are available and that they are available in a different levels primary level, secondary level, tertiary and advanced level treatments, they have various cost and performance levels. So, all of them will not perform to the similar level and they will have the different cost associated with that.

Now, since the number of the alternative processes has been kind of steadily growing there are more and more newer process are being developed like, if you see the advanced oxidation process there was just 3 4 methods. Now, we have some more than 10 different methods to generate O S radicals for advanced treatment options. So, that way there are like more technological advancement and technological developments are being taken place and as it is an active area of research. So, more new methods are being coming. So,

that way since these different methods are potentially available it becomes important to decide on to select on an optimum treatment sequence ok.

So, the decision making on the selection of this optimum frequent sequence is that way becoming more important ok. For people who are designing so, far engineers for the designers, what kind of treatment philosophy they want to select. If there is a say problem of removing something so, what are the solutions? There might be several alternate solutions, which solution is the best. How you are going to do that, we are going to do; that means, how we are going to select one that is what is called basically decision making. Because one has to make a decision that which one is select and this decision making is often made based on a decision support system, which derives informations from various aspects

(Refer Slide Time: 14:48)



So, if we see the trained off this reclaimed water has been increasing worldwide and is expected to surpass the desalination fraction in the future. So, right now the desalination is the contribution of desalination is higher in the water supplies as opposed to the wastewater recycling, but by 20 30 or so, people kind of estimate that the recycling will overtake the desalination option.

So, since there is huge potential since there is a huge demand there is a high importance to device and mechanism for identifying the most cost effective and sustainable way. To kind of achieve the reclaimed water use targets. So, if say we need this degree of

treatment for say certain reuse application, what mechanism we should choose, what way is to kind of identify the most cost effective treatment strategy?

Because, there are n number of options available. So, which one is the most cost effective how we are going to make that decision ok. So, for that we need a kind of system the other important aspect is that these decisions are always kind of very local decision they are not global.

So a system suitable for wastewater management in some reason may or may not be applicable to other places ok. So, we just out rightly cannot say that something that has worked in a Singapore is going to work in India or something which has worked in say Australia is going to work in India or Bangladesh ok or something safe or something which has worked in India nicely will work in a US or UK.

So, that way we cannot say ok. It may work or it may not work it is not necessarily, it is that it will never work it may work also. So, there are success replication stories as well, but there are failure replication stories as well where. The system adopted somewhere has given a kind of quite desired and good result, but same thing tried to replicate at other place has made the different results ok.

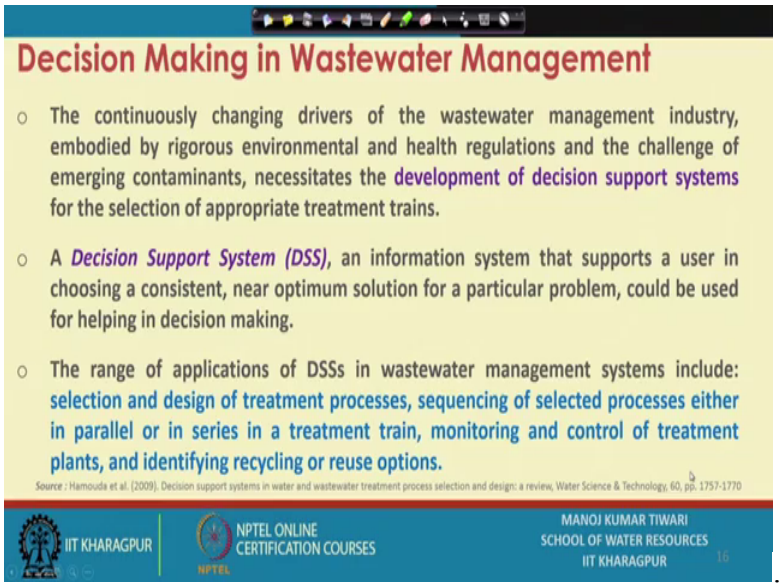
So, they that way they may or may not be replicable and they may not be actually replicable even in the same country particularly for the larger section. So, say something which is applicable in a state of West Bengal, may not be applicable in a state of Rajasthan because the different attributes. Something which is applicable in a southern state which is generally have warmer climates, may not be applicable to the northern reasons because of the climatic different climatic conditions.

So, you end up opting a biological process for say treatment purpose some fit for purpose treatment purpose in a in a southern state. And, you try to replicate that in another state in a northern state, where temperature go as low as 3 4 degrees who your biological process might be basically not that efficient to give you the desired degree of treatment. So, that way there is a possibility of failure of such system.

And that is why there has to be a customized solutions developed based on the locally assessed characteristics and specific reuse purpose. So, if we want to target that this is going to our reuse purpose and these are our local conditions. So, we have a system

which can guide us through which can guide us through basically opting for a efficient or the most cost effective treatment scheme, for local conditions based on the local characteristic and the reuse target.

(Refer Slide Time: 18:54)



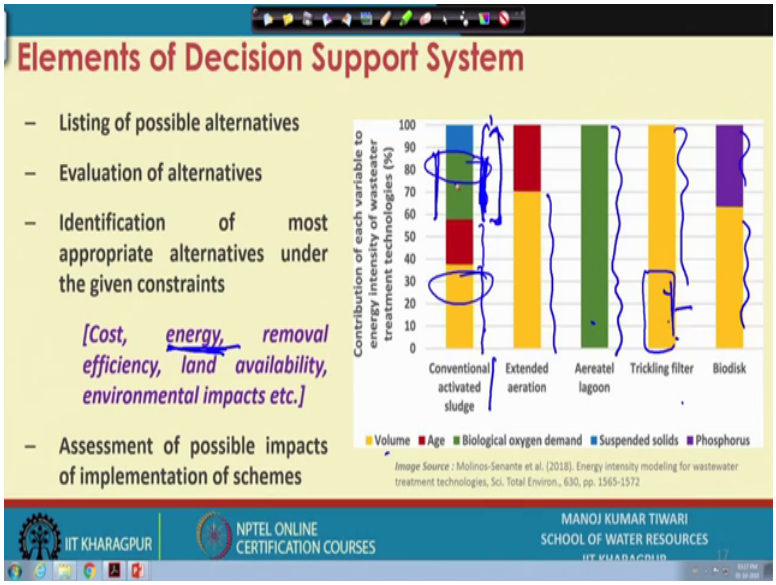
So, that is what is done through the decision support system ok. And, now if we see the kind of sector of wastewater management, it is a continuously changing drivers are there in the form of various embodied rigorous environmental and health regulation, then the challenges of emerging contaminants. Those things are there and these necessities the development of a decision support system for selection of the appropriate treatment trains or appropriate treatment schemes. So, this decision support system is basically a information system, that support users for choosing a consistent and near optimum solution for a particular problem.

And, this could be kind of helping in decision making. So, through the modeling of different choices through kind of choice modeling protocols if you are having say N number of different choices for a treatment. So, your decision support system will be able to evaluate all those choices and kind of recommend you a best choice based on the input parameters fading ok. Now, this there is no universal decision support system exists in the of wastewater management. So, even these decision support systems are being developed in bits and pieces.

So, something which is applicable here or something which is applicable there so, they kind of drive in the local factors and based on that come up with a decision support system. So, the, but their range of these decision support systems are quite wide ok. So, this includes the selection and design of the treatment processes, this includes sequencing of the selected processes, either in parallel or in series in a treatment plant.

So, if you are let us say going for 2 options or how you got how you are going to sequence them, whether you sequence them in a series process first with that and then with that or in a parallel. Then monitoring and control of the treatment plant and identifying the recycling or reuse option is also one of the kind of goals of these decision support systems.

(Refer Slide Time: 21:05)



So, if we see the various elements of a decision support system. So, your decision support system should ideally first list the possible alternatives.

So what are the different possible alternatives, then evaluate those alternatives ok. These evaluation is based on the several criteria's and then based on this evaluation on those criteria's on those constraints the decision support system should be able to identify the most appropriate alternative under the given constraints and criteria's which could include the cost. So, we can optimize the cost. So, we can choose for a most cost effective treatment scheme, we can choose a most energy effective treatment scheme, we

can choose a treatment scheme which is giving you the highest efficiency we can choose a scheme based on the land availability ok.

So, which can be achieved in a minimum land or land footprint could be reduced, it can be basically the environmental impact. So, the environmental impacts could be reduced. So, these could be the various criterias based on that we can actually evaluate the different choices and then come up with a sustainable solutions based on the different alternates available ok. And, this assessment of this possible then eventually it will help in assessing the possible impacts of the implementation of these schemes. So, based on decision support system we end up making a decision that ok.

We have say these 6 alternatives out of these 6 alternatives these are going to be the kind of cost these are going to be the performances, the environmental footprints, the energy requirement, the operation and maintenance cost of these systems. And, based on the constraints that we have for the project based on the kind of output required based on the treatment degree required, based on the funds available, this particular technology or this particular alternate is going to serve us the best, that is what something can be derived from this decision support system ok.

So, there could be like multiple aspects multiple evaluation ok. So, far say what is there on like this is a contribution of the various variable in energy intensity of wastewater treatment technologies. So, if your idea is to say instigate energy like, how we can optimize energy? So, you see that the conventional activated sludge process is have close to 40 percent of energy attributed to it is volume, then some energy attributed to it is age, then some energy attributed to it is BOD and some to suspended solids. Your extended aeration is primarily focused on the volume and age your agitated (Refer Time: 24:07) all the energy requirement is for the BOD purpose.

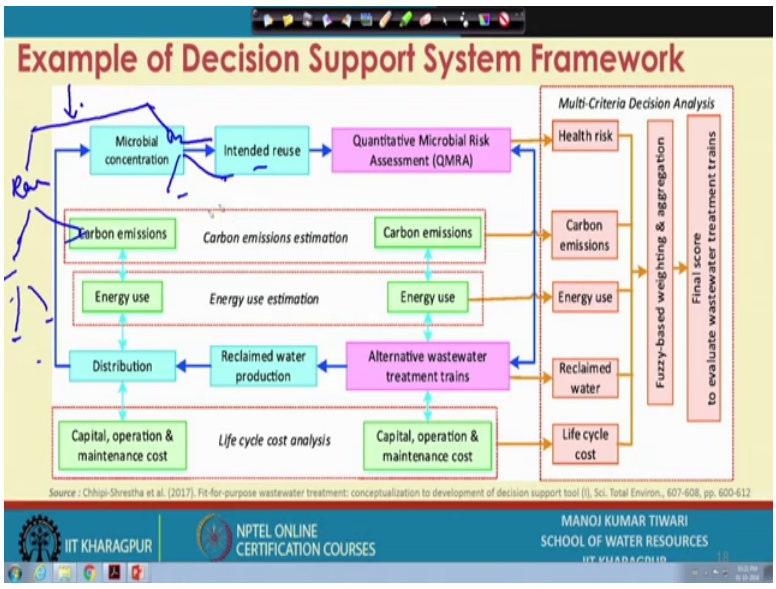
The volume or age does not matter that much for trickling filter it is all the basically volume ok. And, bio disc it is phosphorus or kind of volume of the system. So, for say, if you want to optimize energy and volume together so, you should choose a process with where the kind of like, you for a trickling filter a small volume trickling filter, you know that energy needs are going to be small as it does not depend on the BOD. So, you can have a high rate BOD system with a smaller volume with a lower energy on this thing, but if you want to go for activated sludge process it depends on the BOD as well.

So, if your system is having higher BOD or your organic loading rate is higher even with a smaller system because close to 40 percent contribution is coming from the BOD. So, even with a smaller system you will be able to save only little amount of energy and most will actually be a significant part of energy attributed to the your suspended solids, or the organic loading rate is eventually kind of like around more than 40 percent is from that this thing.

So, that way your energy reduction possibility is lesser over here ok. If, you want to tend to reduce the kind of volume so, that way also means as these kind of analysis can be used this is just an example. So, this kind of analysis can be used for identifying for kind of fixing up a system that ok, where from this similarly for the cost also you can see. So, the different cost of the, different components in the, different treatment system.

So, because in a decision support system, it is not necessarily the kind of picking up one particular treatment, it can suggest you that you use arietids you use activated sludge process with this modification ok. So, that way or you use this particular system with or you use a combination of this particular system. So, you get your treatment partly from here partly from here that weight is going to be most cost effective or most space effective almost energy effective. So, those things will basically be guided from a decision support system that way.

(Refer Slide Time: 26:44)



So, this is an example of decision support system framework ok. So, this example as you see like similarly we can develop the different frameworks, a typical decision support system will be like a flowchart that you start from one particular point and then ok. If, it is following this go to here, if not go to this rule ok, that way we can have. Now, this is kind of from a paper which is for fit for purpose wastewater treatment conceptualizing or decision support tool ok. So, they are there is a carbon emission, estimation. So, what are the various carbon emission, then energy use estimation, what is the different energy used then life cycle cost analysis.

And based on these they come up with a kind of what are the alternative wastewater treatment options available, what is the reclaimed water production, then it is distribution, then it is microbial concentrations, intended reuse, then quantitative microbial risk assessment, and from this we get the idea of health risk, from carbon emission we get the idea of carbon emission, from energy use sector energy use estimation we get the idea of energy use, from here we get the idea of reclaimed water and this total lifecycle cost. So, based on all this we can kind of (Refer Time: 28:07) away the contribution of all these systems and then give a final score to the different treatment system.

So, based on these multi criteria decision analysis, multi criteria involves, health risk, carbon emission, energy use, reclaimed water production, lifecycle cost. So, based on all these multi criteria decision analysis, we can reach to a final score for the different alternatives, and then the alternatives with the highest score or the most preferred score can be then selected.

So, that is how this decision support system works ok. Another approach for the typical decision support system is like that you have say for you have the water inflow, the volume is this again for these systems you will have an idea of what are the reuse options or if you do not then, you can have if your reuseoption is this reused option is this. So, again based on this the treatment options available this for his treatment options cost energy.

So, that way we can make a chain kind of thing and then starting from one point going from like following that words and we can come up with a system to evaluate the various available options, and then to kind of analyze pros and cons of these options and come

up with a preferred solution of these. So, that is how this decision support system or decision support framework helps, in decision making in taking a call on the best or the most suited treatment scheme, treatment hierarchy that could be adopted for the purpose of the wastewater treatment and recycling also.

So, will conclude this lecture here and in the next classes we will talk about some of the other features, in terms of the stakeholder participation or those things in sense of the wastewater recycling projects. So, see you then.

Thank you for joining.