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

Lecture - 49
Wastewater Treatment Systems: Integrated Systems: Wetlands

Hi, every one. So, welcome back to the second lecture of this week. In the first one we did talk about the typical waste water systems and how there are various options available for the removal of different constituents or different type of pollutants present in the waste water. And, how we can actually pick different units unit processes or unit operations and then put them in a sequence of flow for getting the treatment from the stage of a raw waste water to the finally treated effluent.

So, the convection systems that are used we did have a kind of rephrase of the conventional activated sludge processes and conventional anaerobic system which is USB. Predominantly USB systems are used as conventional anaerobic treatment systems. So, we did have an kind of recap of those things in the previous class.

So, this class we are going to talk about again we are going to start the discussions on the approaches; newer approaches which derive the concept or removal mechanisms from the traditional physicochemical or biochemical principal and processes. But their assembly, their integration or their arrangements are different then the typical conventional systems.

So, these integrated systems we will be discussing from this class onwards throughout this week. And the first thing that we will be discussing in this particular lecture is the wetlands system. So, if we see the various treatment approaches as we were saying.

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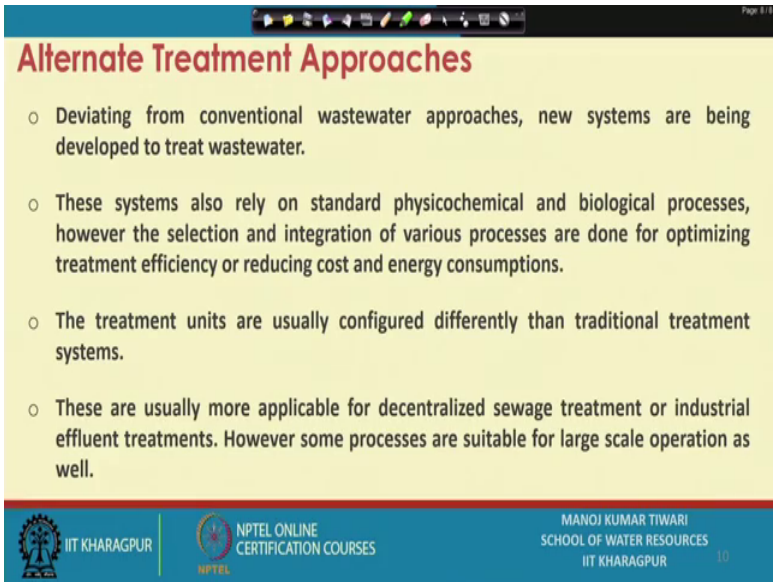

So, the conventional waste water treatment approaches that we have, we can have a deviations from those conventional treatment approaches which gives us some new assembly or new design or a new approach for treating the waste water. Now, the basic principle and processes are still going to remain same, the basic physical processes, chemical processes, biological processes will still be there. However, their selection and their integration in the system will be done in a different way from the conventional treatment systems. And, this is done with an idea of either optimizing treatment deficiency or reducing cost, reducing energy consumption reducing land requirement ok.

So, whatever our objective is or making the processes simpler reducing the technical expertise in operation and maintenance. So, whatever could be the objective it is done with those objectives and these treatment units are usefully configured differently then the traditional treatment systems ok. So, there are usually more these type of systems more applicable for decentralized sewage treatment. However, it is not always ok. We have systems which work for a large scale operation as well, but still the majority of systems are used for small scale municipal water treatment or industrial effluent treatment systems ok.

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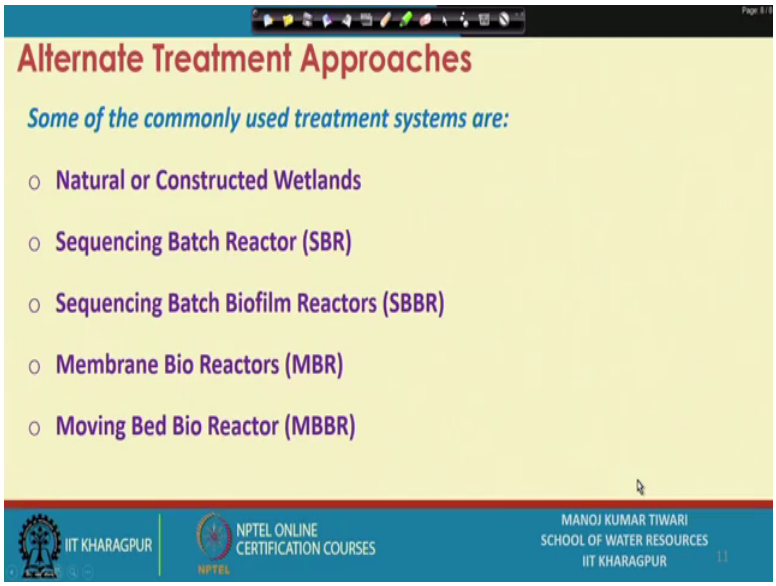

So, if we see some of these commonly used systems they are Natural or Constructed Wetlands mostly the Constructed Wetlands and then there are Sequencing Batch Reactors, Sequencing Batch Biofilm Reactors, Membrane Bio Reactors, Moving Bed Reactors. So, these are some of the popular systems of course, there are other configurations available.

And, in addition there is lot of research and development going on ok. So, with this like development of new and new technologies advent of newer technologies coming to the market we are having various alternate reactor configurations available. However, these are the popular ones which we will be discussing in this week.

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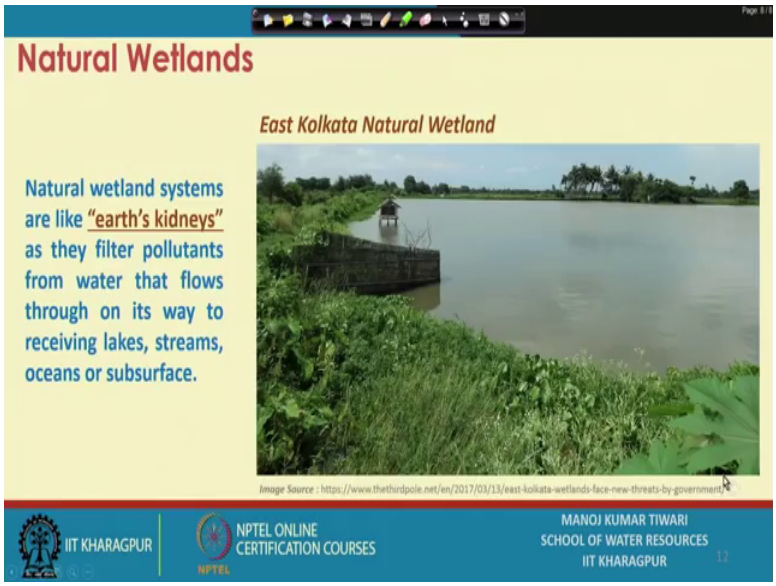

So, to begin with the wetland system is actually, we there are natural wetland systems and there are artificial wet land systems which is also known as constructed wetland systems or at times we call them engineered wetland systems or manmade wetland systems. So, essentially the natural wetland system like in the scientific community or many expert consider these like the kidneys of earth. So, we have our own kidney. What is role of the kidney in our body? The role of the kidney is to filter the various toxicants and pollutants that are entering that are they are present in our body ok. So, that is the role of our kidney.

So, similarly the wetlands may be considered as earths kidneys because they filter the pollutant, they filter the various pollutant from the water that actually flows its way to the receiving lakes, streams, oceans or subsurface ground waters those kind of places. So, this wetland do this part of the kind of filtration of the pollutants ok. And, that is why like many people mark them as kind of earths kidneys ok. So, what you see on a screen is it is a basically a East Kolkata Natural Wetland; one of the largest natural wetlands across the globe ok. And, is a like a significant part of the Kolkata's waste water is lined to the these wetlands, where there is a some degree of treatment takes place. And, this waste water is reused for the purpose of like fish culture or all those kind of thing ok; so, that is one of the examples of natural wetland systems.

However, these natural wetland systems will have a limited capacity because we are not doing any alteration, we have no control over the flow rate, we have no control over the other aspect and, when once we kind of allow the raw sewage to flow through this. So, there is lot of contaminant in the sewage and there will be an assimilation capacity of these natural systems because, we are not doing any intervention in this. So, there is the limited capacity of these systems and over a period of time we may see that those capacity is exhausted and as a result we may not see them doing this purification task or purification job. It is similar to like we discussed when we are discussing the natural attenuation of pollutants in the river or streams.

So, we add contaminate to the river it kind of a undergoes self purification, but again there is capacity of self purification as well. So, it is not that possible that the self purification can go to the infinite scale. So, that way the capacity of natural wetland systems are also kind of fixed and they cannot bear the excessive load of pollutants. For the purpose like taking this clue from the natural processes that happen in the natural wetland system, we can actually create an artificial wetlands what we what we also call as the constructed wetland system.

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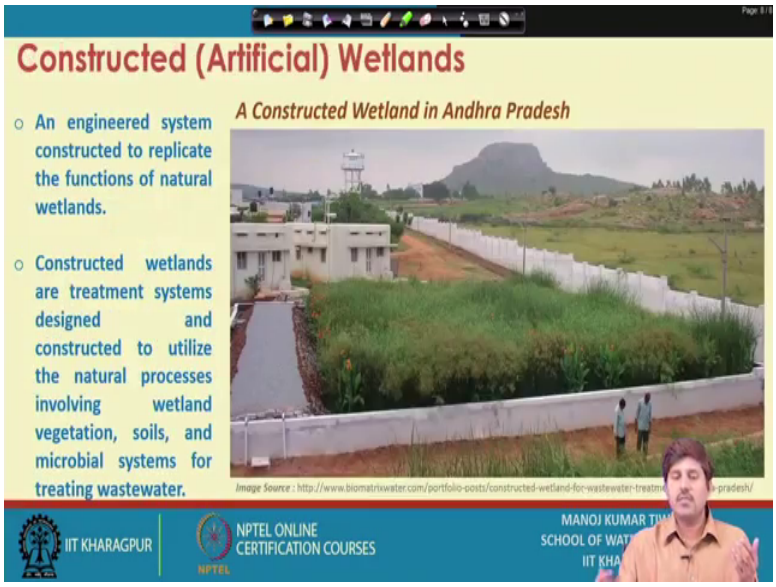

So, these are the essentially engineered system, which are constructed to replicate the processes or the functions that takes place in the natural wetland systems ok. So, whatever the processes that takes place in the natural wetland systems we can create, we

can kind of allocate some piece of land and let developing fashion like similar to the wetland. All those process which takes place a natural wetland could take place in this constructed wet land as well and probably with more control on that.

So, these constructed wetland that we are actually the treatment systems, which are designed and constructed for utilizing these natural processes which involves wetland vegetation, which involves soil, which involves microbial systems for the purpose of treating waste water ok. So, that is what happens in the artificial or constructed wetland which is a kind of system similar to the natural wetland system for the purpose of treating waste water.

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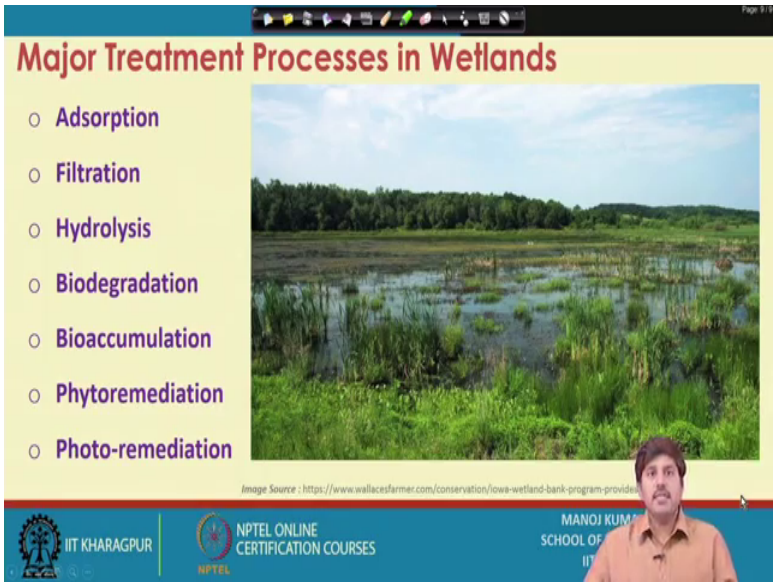

So, what are the various processes that takes place in a wetland system? Well, there will there is actually there will be first thing there will be adsorption. So, it is a wetland system there is valve through which water is passing or there could be a media in constructed wetland system through which water is passing so there will be adsorption takes place. So, on the soil minerals or all the kind of clay particles whatsoever, is there or the media that we are putting through will adsorb some the contaminants present in the water there will be filtration taking place.

So, normal straining it has to pass through the various pore sizes available in the soil. The water has to pass the if the contaminant or particularly the suspended impurities are of size larger than the pore sizes they will get detained they will get strained and water

pass through. So, that way the suspended impurities can be removed through the process of filtration. There will be hydrolysis which can take place. So, there is water there are microbial (Refer Time: 09:46) also present micro organisms present in the soil to biotic or abiotic hydrolysis also a possibility in this wet land system there are biodegradation that takes place. So, waste water will have organic and soil will have its inherit micro organisms. So, those system biological systems will actually will go for the decomposition and degradation of the organic method presenting the waste water.

So, there will be biodegradation there is possibility of bio accumulation. So, what happens that the plant is another essential component of the wetland systems. We can go for some specific species of plants or grass those kind of things are there. So, we can pick those plants which have a higher capacity of bio accumulation. So, various metals present in the water or various other things can actually be up taken by the plants and can be stored in the their roots or stems. So, that is what is actually the bio accumulation it leaves the water phase and get accumulated in these plant systems there is phytoremediation.

So, degradation with the plant or these species and there is possibility of photo remediation as well because if it is exposed to the atmosphere. So, there is sunlight coming in and those constituents which are susceptible to photo degradation will actually undergo. So, and that is how we can have some degree of photo remediation as well. So, all these are the processes which could possibly take place it is not that that these will defiantly take place, but there is possibility of this process happening to variable degree; some may be dominant, some may have very little contribution. Apart from these also there is possibility of few more processes that could happen depending on the conditions of the wetland.

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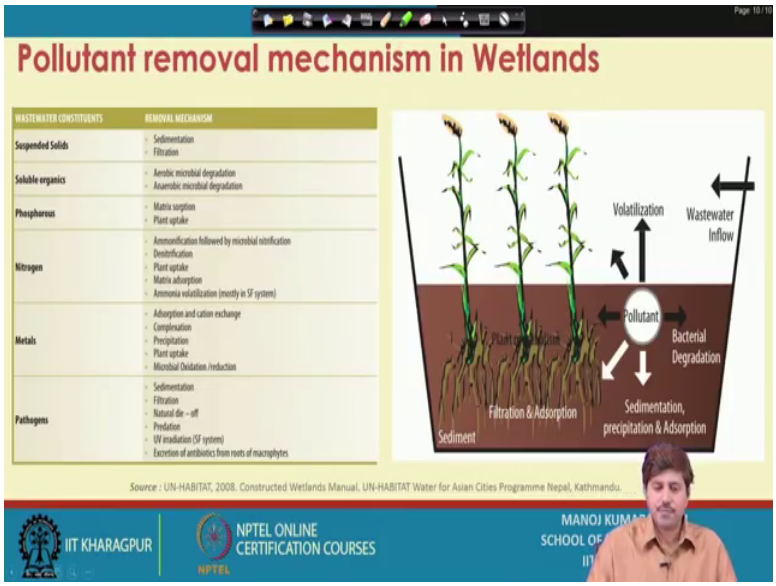

So, if we see the various pollutant removal mechanisms in the wet land ok. So, what happens that as the water will pass through there will be filtration and adsorption, as we were discussing ok. On the sediments particularly there is possibility of volatilization the waste water let us say if it is coming. So, there is possibility of some pollutant may get volatize as they get exposed to the nature ok. There is plant metabolism ok, that can also take place. So, the plant can metabolize what we are calling the phytoremendation that can also takes place the metabolism through the plant or those kind of thing there is a possibility of bacterial degradation, there is the possibility of sedimentation, precipitation, adsorption.

So, all those things will happen and if we see the different constitutes and how they remove. So, suspended solids will be removed either through sedimentation or filtration. So, either there will settle get sedimented in the bottom of the wet land or there will be filtered out the soluble organics through aerobics or anaerobic microbial degradation of course, phyto remediation and those kind of things will also could remove some of this; this phosphorus will be matrix option or plant uptake.

So, either they get adsorbed in this valve mineral matrix or the up taken by the plant nitrogen will be removed by the ammonification followed by the microbial, nitrification, denitrification, plant uptake, matrix adsorption or ammonia volatalization can also can take place the metals through adsorption in cation exchange systems. So, if we are

having let us say some minerals which can have the exchangeability. So, ion exchange can also actually be effective in this then complexation, precipitation, plant uptake and microbial oxidation or reduction and pathogens can be removed by sedimentation filtration natural die off. So, their natural decay process their predication UV radiation if you can have those kind of systems present. So, these are the variable various mechanisms through which we can get the removal of these contaminations from the wetland systems.

So, that way if you see these processes are essentially the same that we discussed, but they takes place in a kind of environment which is created differently which is packed in differently other than the typical convectional systems.

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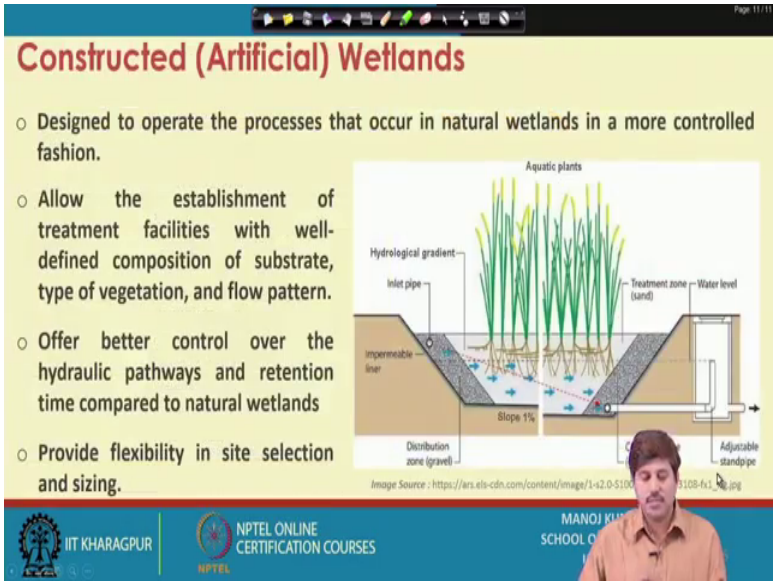

So, the artificial wetlands constructed wetlands if we see they are kind of designed to operate the processes that occur in natural wetland systems in a more controlled fashion. So, that is what is the idea or objective of putting through a constructed wetland system as we are saying that in natural wet lands systems we do not have too much of control over the processes which we can achieve in the constructed wetland system.

So, that is how the constructed wetland systems are more kind of popular for the waste water treatment this eventually allows the establishment of this treatment facility with well defined composition of substrate type of vegetation and flow pattern. So, substrate essential means media is not it does not like we usually when we are talking about

biodegradation we use substrate in terms of the BOD ok, but here in the wet land system the substrate we mean to say the media. So, what kind of media we have providing the BOD or the organic matter always be there present in the water waste water which is coming into the system.

So, we can have kind of fixed composition like what kind of aquatic plants we want, what kind of that what kind of vegetation we want, what kind of filter media or media we want, what kind of flow pattern we want, whether we want up flow, down flow or horizontal flow. So, all those things we can control we can control these hydraulic pathways and the retention time ok. So, for how long we want to the water to be retained in the system that is also importantly because if we are having working with the very high flow rate retention time is very low ok. So, probably we will not be able to get the desired removal in order to get the removal, we must ensure that the adequate amount the water is spending adequate amount of the time in this wetland.

So, that those processes of sedimentation process of degradation, decomposition and adsorption can take place effectively additional thing that does is actually the constructed wetlands also provide flexibility in site selection because natural wetlands have fixed sites where they exist they exist, but constructed wetlands you can create anywhere even in a urban setup you can create a constructed wetland. So, that way we get the flexibility in site selection where we want to create that this things and sizing also to what size we want to create ok. What are the dimension we want to keep depending on the land area requirement depending on the flow requirements we can actually setup the size and setup kind of identify the appropriate location for constructing these wetlands.

So, that is the advantages of kind of constructed or artificial wetlands which gives us much more flexibility in operation in design in construction in management and in processes control as well.

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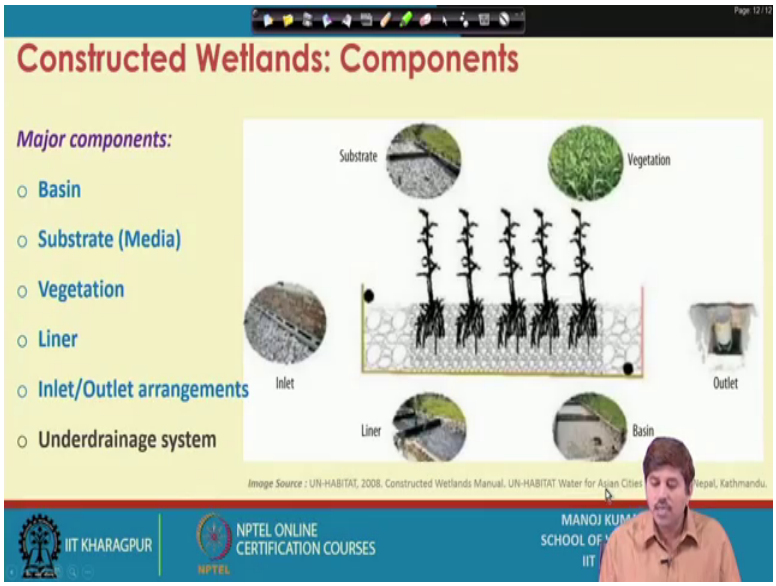

So, if we see the different components of constructed wet land ok. So, there are there are kind of various components there is substrate. Which is, as we said actually the media or what media we are putting at the bottom, so that is a substrate then there is a vegetation what type of vegetation you want to provide ok.

So, that is another major component what type of plant you grow you are planning to grow these different plants have different characteristics there are certain plant species which can actually have higher nutrient uptake there are certain which do not need that much of nutrient to grow there are certain plants species which have ability to uptake various heavy metals in their root zones by accumulate them. So, if your idea is to removal of these kind of metals you must go for those plant species.

So, these the kind of vegetation will also give us an idea or will give kind of control over the performance of the entire wetland system ok. So, that is a very important component vegetation also then we have to have a kind of inlet and outlet arrangement ok. So, how do water is entering how the water is leaving from the system.

So, that also will govern the kind of flow pattern that we are generating ok. There has to be a liner that is another essential component. Because, we do not want our water to say percolate to this sub surface to this wetland treatment systems particularly the constructed wetland treatment systems because we want to get the treated water.

So, for that purpose we would and there are lot of pollutants also getting adsorbed in this and if the water leaks through that may actually get the like those pollutants can also leaks through. So, that for preventing that protecting that we provide a liner ok. So, the liner to kind of ensure that there is no flow from this wetland apart from the direction which is intended to outlet system ok.

So, the flow has to basically come through inlet and leave through outlet and should not go in any other direction. So, that is another idea of providing liner and as we said we will be inlet and outlet arrangement then we may need under drainage system. That is not an essential component depending on the design of wetland if we are having a say, if we want to collect the flow particularly a vertical flow system where we want to collect the flow at the bottom.

So, we should have an under drainage system which collects the flow well and put it through outlet system, but in a surface flow wetland or those kind of systems we will not need this under drainage system. So, that becomes an kind of optional step whether to like go for under drainage systems or whether there is a requirement of under drainage system in that wet land or not and overall these entire things has to be incased in a basin which actually gives you the boundary of wetland system ok.

So, that is another component this over all basin under which all this things are kind of packed or arranged in the appropriate fashion. So, that is what is the various components of wetland system. Again, the wetland could be of different type that depends on the flow regime depends on their kind of how they have been constructed.

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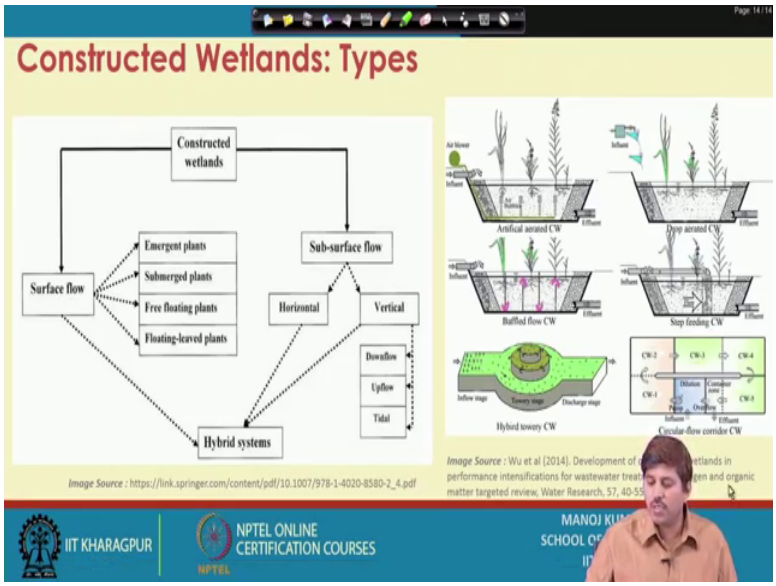

So, there are surface flow wetlands and there are subsurface flow wetland the surface flow wetland can be with emergent plant or submerged plants free floating plant floating leaved plant that way the sub surface flow wetlands can have horizontal subsurface flow or vertical subsurface flow then under vertical also we can have down flow, up flow, or tidal flow and we can have a hybrid systems where we can kind of mix more then one type of wetlands and in order to basically trying to extract the maximum feature of those things ok. So, if we see the again there like we may go for aerated wetlands artificially aerated wetlands or kind of drop aerated wetlands, there is a baffle flow wetlands were the flow is channelized in the baffle baffled fashion, there is a step feeding wetlands. So, it goes to first step then it goes to the second step the through flow it goes to the second step.

So, that way there is a hybrid wetland systems there is a circular flow corridor wetland system. So, it actually flows from one basin to another basin that way ok. So, there; there could be like variety of arrangements for kind of kind of conceptualizing the wetlands how we basically what kind of flow what kind of processes we want to take place in our wetland system the popular ones are the free surface wetlands were which is very close to a kind of naturally occurring wetland system or natural wetland systems typical (Refer Time: 22:33) or those kinds of so, kind things.

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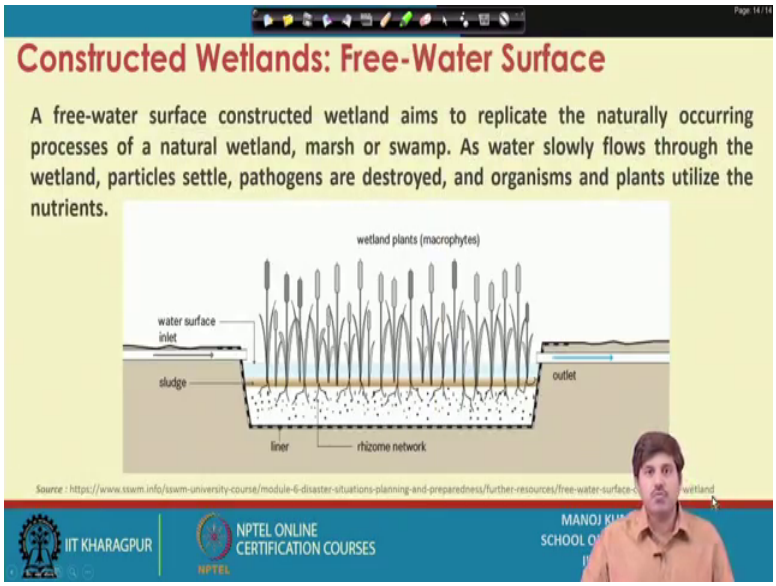

So, they replicate those cases only we will have the substrate of media over at the bottom ok. The water will be put through the top there is some sludge accumulation takes place through the settling and the major water flows through the top itself. So, that degree removal will not be too much in the free surface wetlands because this process of passing through the media is limited only remains optional. In fact, that times there will be plant uptake though.

So, these whatsoever plants those nutrients and those things can be taken off the settlements this kind of settling can takes place adsorption to some extent takes place, but again over all the removal efficiency will be lesser if it is just, if it is just free water surface or surface flow wetland systems ok. And, that is why these are generally not used for treating raw waste water as whole rather they are used for either primary or secondary treated waste water as a polishing unit or as a kind of next stage tertiary stage treatment also they may be used.

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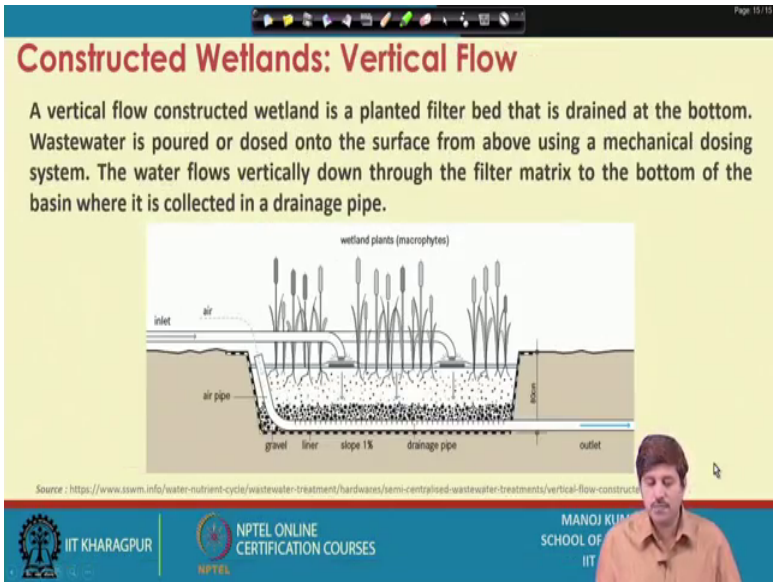

Then we have vertical flow wetland systems ok. So, these vertical flow wetland systems are we kind of as the name itself suggest the flow pattern of flow regime in the wetland is vertical. So, we will have influent coming in and they are released from the top and from there these flow takes place to the bottom in the bottom we have drainage pipe or under drainage system you can say that over under there is a gravel there is a media or substrate.

So, when the pass through the these their adsorption takes place then are roots which will be like plant uptake or phytodegradation then biodegradation will takes place here it goes to a gravel media. So, filtration adsorption all those process will take place and eventually they will collect it in the drain pipe and will come out of the system ok. So, that is what happens ok.

So, that is the idea of kind of vertical flow system were flow is the down flow. We have vertical flow up flow system also were things remains more or less similar only thing is that water released at the bottom and collected from the top. So, what happens then when you release the water the bottom so, the direction of flow is reversed in that case the direction of flow will be reversed in that case.

So, you are having a wetland of this kind. So, water is coming in here will being release from here and through this there is there will be basically plants over there and the media

these will be there. So, water eventually takes a path up flow and then it the over flow goes from this point forwards ok.

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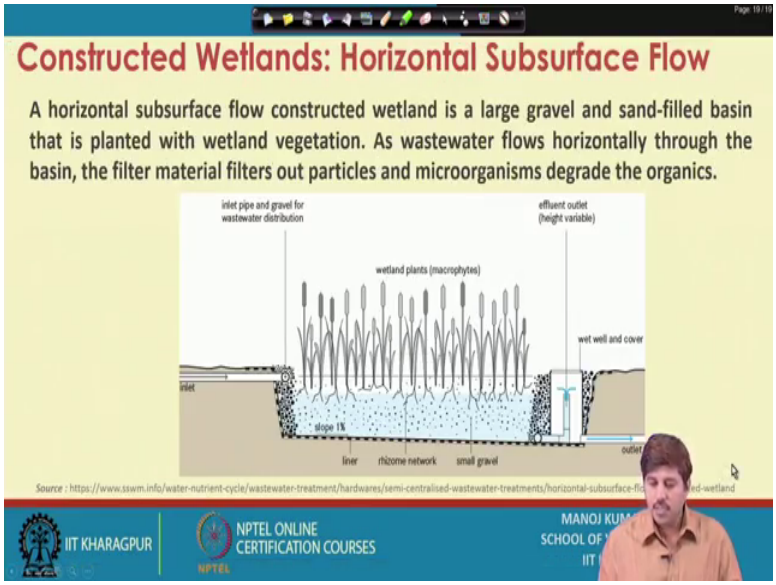

So, that is how the up flow wetland system will be there then we have another wetland which is the your horizontal sub surface flow wetland system. So, here as in the up flow and down flow we are making water move either up to down or down like from top to the bottom or bottom to the top, but in the horizontal sub surface system the inlet is released, here only and then there will be kind of substrate or media provided here and then there is again media here.

So, it flow there is some down radiant slope in order to ensure the movement of water. So, net direction of movement of water will be this it flows horizontally and then as it flows through this media. So, there would be kind of adsorption all those process will be taken taking place in this zone the plant uptake degradation decomposition again it passes through a filter media, and then it is collected in the form of out let ok. So, that is what happens in a horizontal subsurface flow wetland and then.

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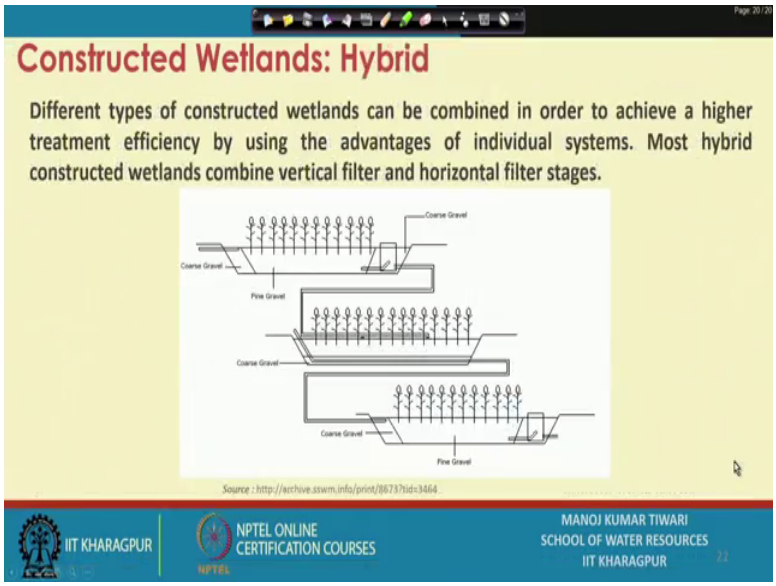

We have we can have hybrid wetland systems as well. So, the hybrid wetland systems as we are saying that is actually a mixture of these type wetland system. So, the different type of constructed wetland can be combined to achieve a higher treatment efficiency using the advantages of these different individual systems.

So, most hybrid constructed wetlands combined vertical filter and horizontal filter stages. So, they will be one stage vertical filtrations on stage horizontal filtration at least that will be there and we can have additional kind of setups or additional units as well.

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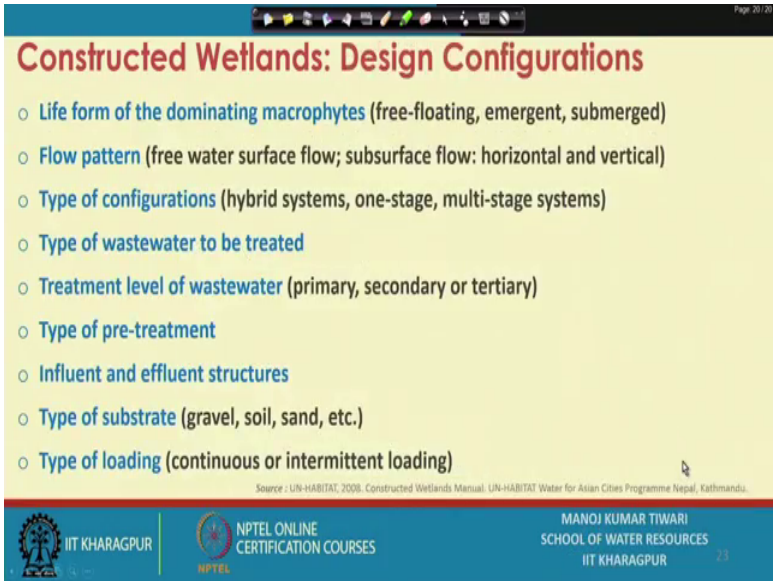

So, if we see the design configurations of these wetlands various wetlands systems so these for the purpose of design; we must think of the various live form of the dominating plant species which are there. So, microphytes whether they are free floating emergent and submerged kind of a microphytes we are using there are flow patterns.

So, free water surface flow or the subsurface flow or the horizontal flow, vertical flow what kind of flow it is there then the type of configurations; whether it is hybrid system, one stage system, multi stage systems. What kind of waste water is to be treated whether it is simple domestic sewage or some industrial sewage whether it is coming with the what level of the waste water it is treating whether it is treating primary level, secondary level or tertiary level waste water treatment are there any pre-treatment provided or not what are the influent and effluent structure final whether it is just dropped through a pipe or first it is being pass through a media. So, those kind of thing what are the types of substrate or types of the kind of media.

So, they are gravel, soil, sand or any engineered media is also kept or mixed or amalgamated with that the type of loading whether it is a continues flow wetland or intermediate flow wetland it is basically continuously receiving the waste water or waste water is being loaded in the batches.

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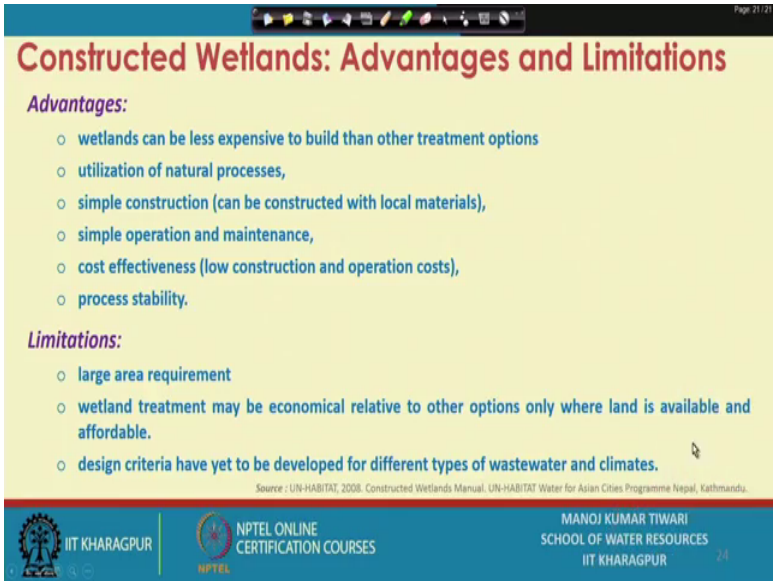

So, that all those things need to be kind of seen for the purpose of designing. So, if we see the advantage and disadvantages. So, wetlands can be less expensive to build then

other treatment options. So, they have cost is very low the major cost is of land only ok. So, that is the major component of the wetland cost otherwise the construction is simple the utilize is mostly the natural processes it can be constructed with various local materials the operation and maintenance is also quite simple not much control is needed that way and that wise means over all they are cost effective process and the process is also more or less stable. On the disadvantages all limitation in front there is a large area required.

So, that is why one of the major limitation of the wetland system particularly in the urban set ups were a huge amount of waste water is generated or industrial flow is generated the land costs are quite high and it is not possible to get a large land area which you can actually devote just for the purpose of wetland based waste water treatment. So, that will because you if you plant you just leave this large area for this purpose heart of a city or in a middle of say populated city that land cost itself is very high and that land can be utilized for much better resources or much better purpose. That is one of the disadvantages for small setups that like if there are smaller flows or rural area those kind of small towns it is easier to get area and you do not need in you do not that much of technical supervision available so these kind of systems could actually be ideal because they do not need those kind of technical expertise.

So, you can install these they will operate to define, but in a kind of urban setups managing that much of area becomes very difficult. So, it may be economical related to other treatment options, but only were land and is kind of available and affordable and the design criteria has to be developed for the different type of waste water and climates because climate also plays a role in the treatment processes, many of these are temperature dependent your adsorption process degradation process material growth. So, particularly in the low temperatures you may not get very good efficiency through these wetland systems.

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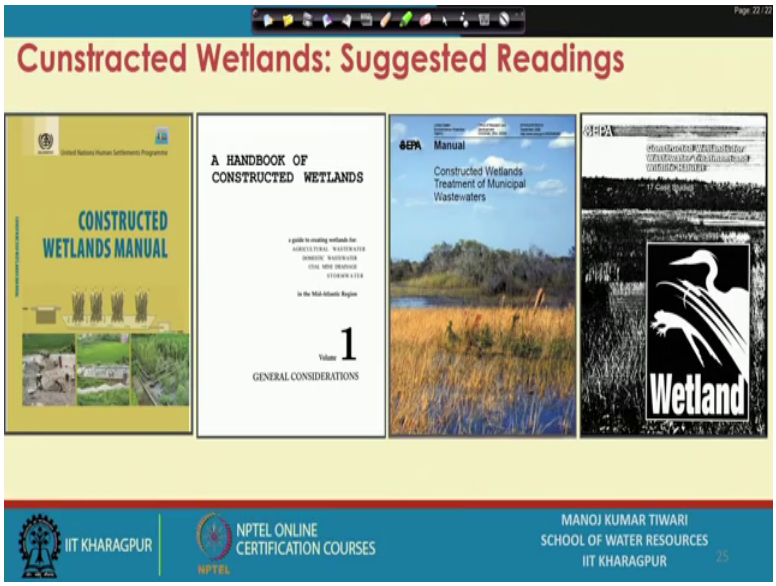

So, there are variety of wetlands like has been stalled across the globes all nations will have been India also there are quite a few a wetland systems are there; so further reading you can actually refer to these manuals and books ok. So, they are all available most of these are taken fact available online. So, there is a constructed wetland manual, there is a hand book of constructed wetland manual, these are EPA manual on the constructed wetland treatment of the municipal waste water.

This has various case studies combined so, some as I think some 6 17 case studies are listed here and there is lot of material available on the web on these wetlands. So, for further reading you can actually refer to this. So, we will conclude the lecture here and in the next class for this week we will be the other processes recent or will like the other waste water processes. So, next class we will talking about Sequential Batch Reactor SBR and its another modification has SBBR Sequential Batch Biofilm reactor.

So, thank you for being with us and then see you in next class.