**Urban Utilities Planning: Water Supply, Sanitation and Drainage**
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**Module - 06**
**Water quality, testing, treatment**
**Lecture - 28**
**Water Treatment Part I**

Welcome back. In Lecture 28 we will start Water Treatment and this is 3-part lecture where this lecture is Part 1.

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The different concept covered in this lecture are basics of water treatment, the different treatment methods, sequence of treatment units, water treatment plant and screening.

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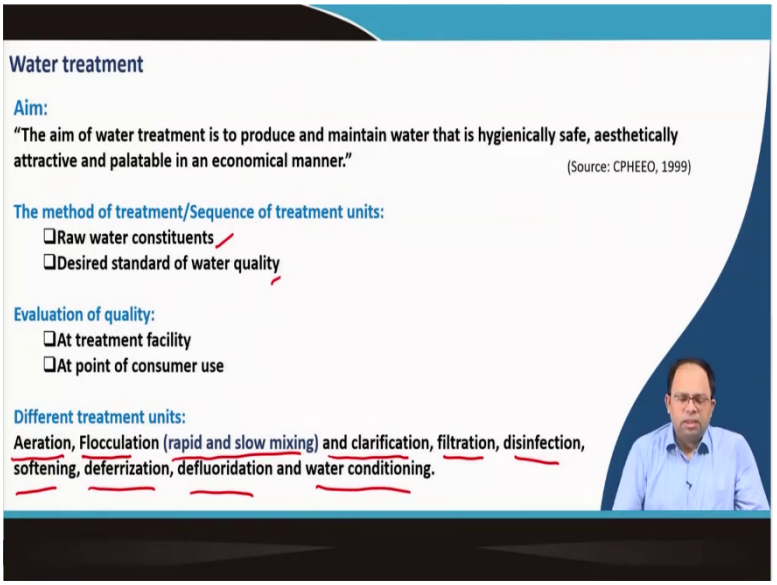


**Water treatment**

The basic aim of water treatment is to produce and maintain water that is hygienically safe, aesthetically attractive and palatable in an economic manner. The method and sequence of water treatment depends on the raw water constituents and the target standards needed to be attained.

In other words, to achieve a desired water quality, types of treatment and the corresponding units required in a particular sequence should be worked out. The treatment has to be done considering the cost of it and there are several technologies available and each technology comes with its own cost and own benefits.

Once the water is treated in a water treatment plant via series of treatment through some treatment units, the next stage is to check the quality of water that is coming out of the treatment plant. This is measured both at the treatment facility and also at the point of consumer use. The main difference is that once the water is sent from the treatment unit to the consumer within that pathway within that particular time, there may be contamination due to many reasons. There may be leakage, there may be mixing of sewage somewhere down in the pipeline; that means, the sewage line and water supply line going side by side which is pretty common in many cases.

The other reason could be because the water actually remains in the pipeline for a long time in certain sections and then the water quality deteriorates. So, that is why there is a need to measure the water quality at the point of consumer use as well.

The different treatments units commonly used in water treatment plant are aeration, flocculation and clarification, filtration, disinfection, water softening, water deferrization, defluoridation and water conditioning.

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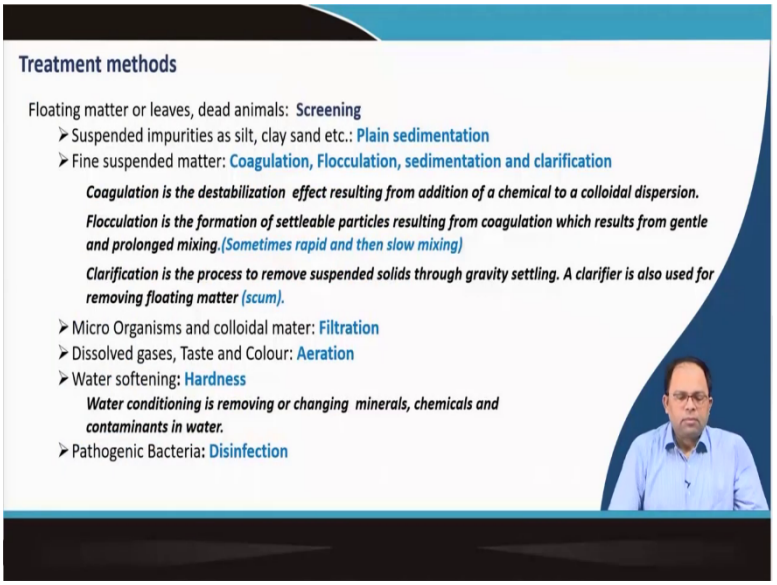


**Treatment methods**

Before even we start the treatment, we have to remove floating matters such as leaves or even dead animals by the process of screening. This helps in preventing the floating matter to get inside the water treatment plant. The next process is plain sedimentation where suspended impurities such as silt clay sand or the ones which are heavier are separated.

This is followed by coagulation, flocculation, sedimentation and clarification altogether. The combination of these processes deals with suspended matter.

The heavier suspended particles gradually settle down automatically due to its weight. For finer suspended matter, coagulants are used which has a destabilizing effect resulting from the addition of it into that particular water and this results in a colloidal dispersion.

For this purpose, we mix a separate chemical into the water which reacts with those fine suspended matter and they form a bigger mass which is heavier in size and then gradually it falls down.

In order to make this chemical mix with the water, we need to mix it properly by a process known as the flocculation. So, flocculation is the formation of settleable particles resulting from coagulation which results from gentle and prolonged mixing. So, sometimes it is rapid and sometimes it is slow mixing or it is a mix of both rapid and slow mixing i.e., little bit of rapid and then slow mixing.

So, usually this is where we just make sure that the chemicals mix with the fine suspended matter properly and once that happens then coagulants form which is heavier in size and it starts falling down and then we require the process of sedimentation.

Next, we require clarification which is the process to remove suspended solids through gravity settling and a clarifier is also used for removing the floating matter or scum; that means, once the sedimentation starts happening, it gets accumulated at the bottom of the that particular tank. And then we need to gather it that process is known as clarification and the clarification process is conducted using a clarifier. The clarifier is not only able to remove the settled solids or sludge, but also the scum that floats up.

Next steps can be called the second stage. This however, depends on what sequence of treatment is chosen and the kind of water that is being dealt with. But, this is only possible after plain sedimentation. Then to remove micro-organisms and some other colloidal matter we use the process of filtration. We pass it through a filter so that all the matter which is suspended in the liquid, all the micro-organism, gets trapped in the pores of that particular filter or acted upon by the bacteria which is present in that filter. This can also be followed by the process of aeration. Aeration sometimes can be done even at the beginning that is where we remove dissolved gases taste and color. So, that is why we mix air with water and that actually results in removal of other gases and taste and to some extent odor as well.

Then water softening and conditioning is done which is removal or changing of minerals, chemicals and contaminants in water. So, we can also change certain mineral constituents of the water or certain chemicals through water conditioning and finally, we remove or we kill

pathogenic bacteria through the process of disinfection. So, these are the different treatment processes that are usually undertaken and usually this is conducted in a sequence. The sequence of these treatments depend on what kind of water or what quality of water we are actually treating.

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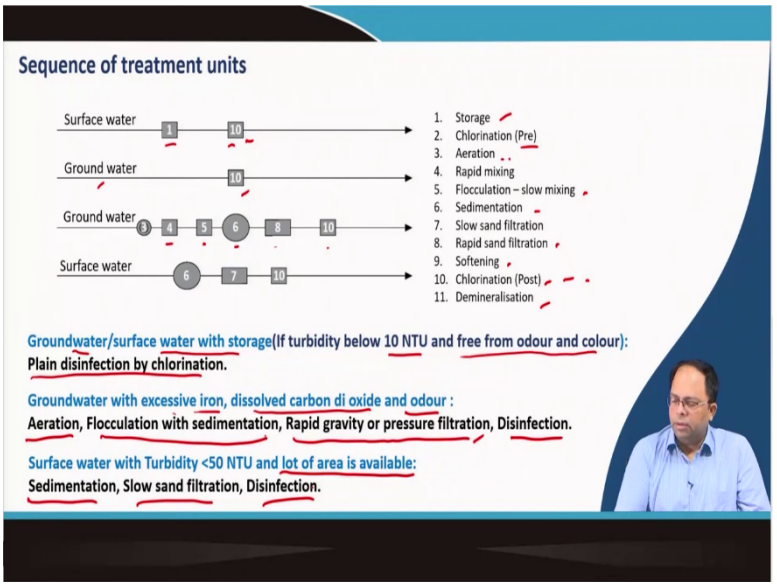


**Sequence of treatment units**

The sequence of treatment units can be varied, as you can see in this particular figure, beginning one is storage, second is chlorination this is pre chlorination. Chlorination can be done both at the beginning as well as the end the end one is for disinfection, the beginning one is to prevent further growth of micro-organisms.

So, sequence can be storage, chlorination, aeration, rapid mixing, flocculation with both rapid and slow mixing, sedimentation, sand filtration (either slow or rapid), softening, chlorination and demineralization, which is water conditioning. Chlorination is disinfection and softening is removal of hardness and filtration can be both slow and rapid.

In the figure you can see that, for surface water, only storage and post chlorination is mentioned. That means, we are doing no kind of treatment directly we are putting chlorine in the water and then using it. So, ground water or surface water with storage in case if turbidity

is below 10 NTU and free from odour and colour and we can do plain disinfection by chlorine.

So, either whenever we are using ground water or surface water at a higher-level reservoir where it is free from any kind of contamination then we can directly use chlorination and use it. Water under storage means, if there were some sediments these have settled.

Then, in the case of ground water, we can directly go for chlorination and we can use it.

The next one is also ground water but here you see lot of treatment sequence are being mentioned such as aeration, rapid mixing, flocculation, sedimentation, rapid sand filtration and chlorination. In this case, ground water is with excessive iron, dissolved carbon dioxide and odour which is why these kinds of treatment are provided. First aeration is done which helps in removal of gases like carbon dioxide and odour. Next is flocculation with sedimentation; that means, we add chemicals which leads to sedimentation and flocculation as well as sedimentation and clarification and then rapid gravity or pressure filtration is done. The treated water might still have suspended particles and maybe some number of micro-organisms which needs to be removed through filtration. Then finally, once filtration is done, we have relatively clear water when we go for disinfection.

If you do not have enough area, you cannot go for processes like sedimentation because that requires larger tanks where the water is first kept for certain time and that actually leads to basic sedimentation of heavier particles. That means, in case adequate area is not available, we can directly go for flocculation with sedimentation.

So, that is how we decide on what sort of treatment units and treatment we should provide. It depends on amount of land area and water quality.

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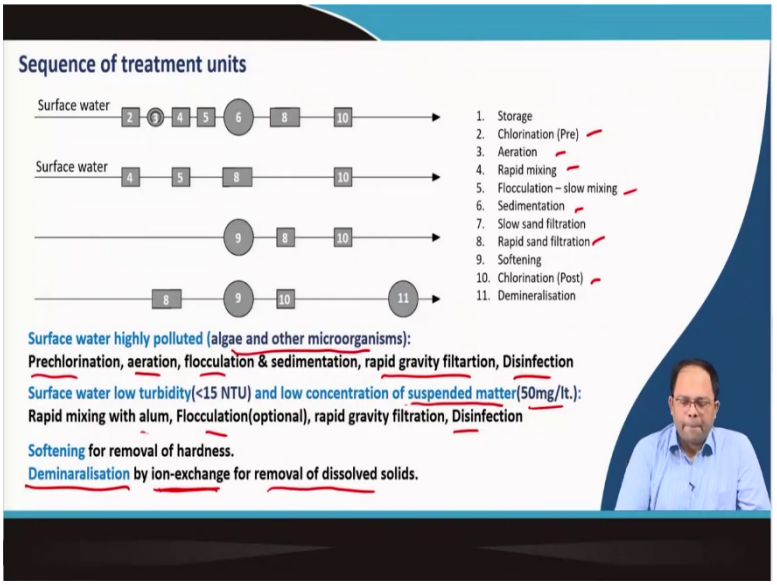


Similarly, we can look at other sequences. In case of surface water, we have a long sequence including pre chlorination, aeration, rapid mixing, flocculation, sedimentation, rapid sand filtration and chlorination. Surface water is highly polluted with algae and other micro-organisms. Therefore, we carry out pre chlorination to prevent their further growth since the water is in storage. Then there is aeration, flocculation and sedimentation, rapid gravity filtration and disinfection. For surface water with low turbidity lesser than 15 NTU and low concentration of suspended matter (50 milligram per liter), rapid mixing with alum, flocculation and then rapid gravity filtration and disinfection.

And finally, softening could be done for removal of hardness and demineralization by ion exchange for removal of dissolved solids. So, demineralization or water conditioning could be done via the process of ion exchange by addition of certain other chemicals.

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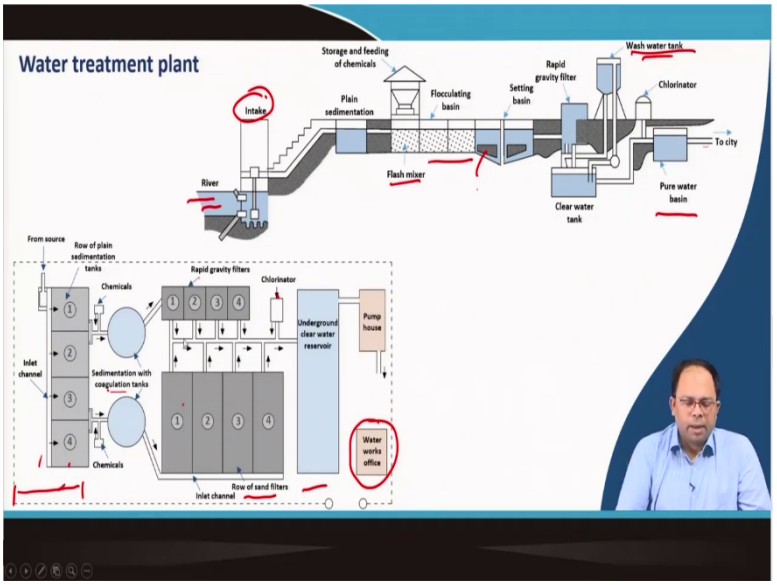
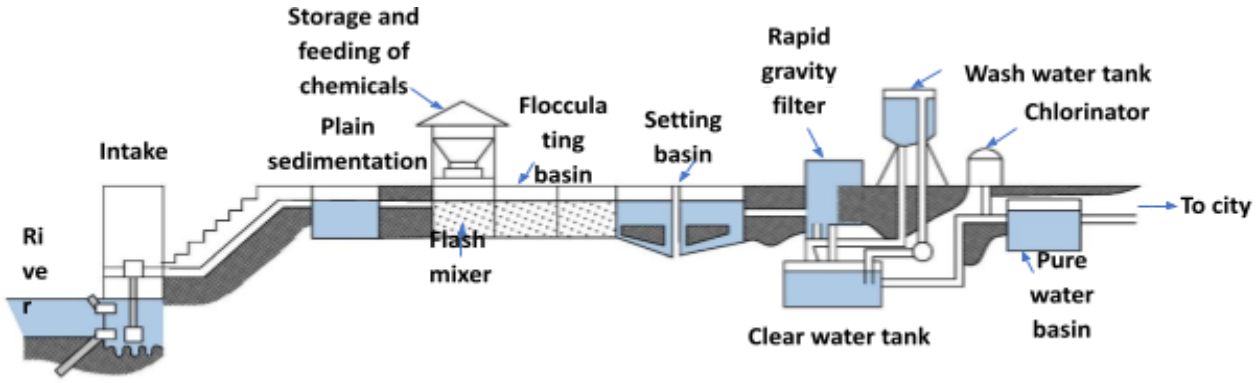



**Water treatment plant**




This image actually shows you the basic schematics of a surface water treatment plant. We have the river over here and from here we are drawing the water. So, this is our intake we have learnt about the different kind of intake structures earlier. Then we have a pump which is a low lift pump that actually lifts the water to the sedimentation tanks or it could be a high lift pump where it sends it far away to a reservoir or sedimentation tanks where the water is allowed to settle for some amount of time. Next from sedimentation tank water is drawn where we first mix the chemicals using a flash mixer. There is a flocculation basin that is where the mixing takes place and then there is a settling basin and this is where the clarifier actually scrapes the sludge that settles. Next, clean water goes into the next step which is a rapid gravity filter and from there once it is cleaned the water goes into the clear water tank from there the water goes into a chlorinator where chlorine is mixed and then it goes into

another reservoir which is a pure water basin from where it is pumped to the city. A a high lift pump is used to send water to the overhead tank.

The wash water tank is used for back washing of the filter; that means, whenever a filter has got pores where all these particles move down and then gradually the pores are filled. So, we need to clean the filter, now it is done by a via automatic process by back washing. We send the water in a opposite direction loosening up all these particles which gets into the pores and then remove that. So, that is why there is a wash water tank. So, this is more or less a standard sequence of units in a water treatment plant.

Now how are they organized area wise? We see at the beginning there is a source. So, this is the channel inlet and these are the row of 4 plain sedimentation tank. So, based on the area of the sedimentation tank or their organization or the sequence in which you are putting them you have to determine the area of these tanks. So, this area is first reserved for a water treatment plant. The second is the chain of flocculation and clarification tanks where sedimentation with coagulation takes place.

We mostly try to use gravity for the movement of water from one unit to another unit, but sometimes pumps are also involved. So, from here we will pump the water into this coagulation tanks and then we mix the chemicals and after the process we then move on to the rapid gravity filters. There are rows of sand filters and once the water is cleaned via this rapid gravity filters it is a chlorinated. And finally, we have the underground clear reservoir from where via a pump we pump the water to overhead tanks. Then there is the water works office as well. So, this is the space required for setting up a water treatment plant.

So, for each individual unit, the different techniques and technology involved and also their standard unit sizes are determined. Then we can determine the approximate area required for a treatment unit and space for future expansion.

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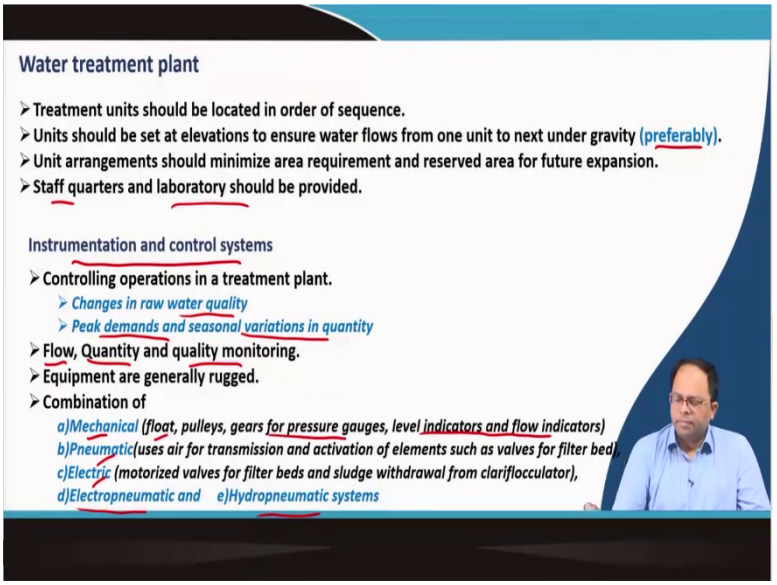


So, when we talk about water treatment plants, treatment units should be located in some order of sequence which have to be determined based on the kind of treatment that you want. These unitS should be set at elevations to ensure water flows from one unit to next under gravity preferably. However, sometimes it is not possible in flat terrain since sedimentation tanks are of large sizes and cannot be raised. So, it is better to have sedimentation tank as open water bodies and then from there we pump the water to the next unit which is a little bit raised from where it goes down. Then again rapid gravity filters are usually raised units.

So, unit arrangement should minimize area requirement and reserved area for future expansion. Staff quarters and laboratory should be provided. We need to test for water quality not only at the treatment unit, but also in the network.

So, there may be office set up, a laboratory set up to test both the water at the treatment plant as well as may be from outside from the distribution network. Since water treatment plants have different units carrying out different processes, it requires instrumentation and control system. So, these are all part of the water treatment unit.

Controlling operations in a treatment involves the monitoring of change in raw water quality, peak demand and the seasonal variations and accordingly we have to adjust the processes, the amount of chemical that we are going to mix etc. We have to monitor the flow that is the

amount of water coming in the quantity of water and the quality of the water all have to be monitored.

The equipment as you can understand is a very rugged equipment and it has to run without failure and it has to be less complicated as well. It cannot be very complex units. So, it is usually combination of different kind of systems such as mechanical system, pneumatic systems, electric systems, electropneumatic and hydropneumatic systems.

Now, mechanical systems consist of floats. Floats are devices which float on a particular liquid and via that we can measure the level of water or a chemical and so on. Then, gears for pressure gauges, level indicators and flow indicators are all part of mechanical equipment.

Pneumatic equipment uses air transmission and activation of elements such as valves or for filter beds so; that means, we use air to control valves and so on. Electric equipment include motorized valves for filter bed and sludge withdrawal from clariflocculator; that means, at certain time periods the valve opens in a clariflocculator and the sludge is sucked out. So, this can be only controlled through electric means. Electropneumatic and hydropneumatic system are combinations of this kind of systems.

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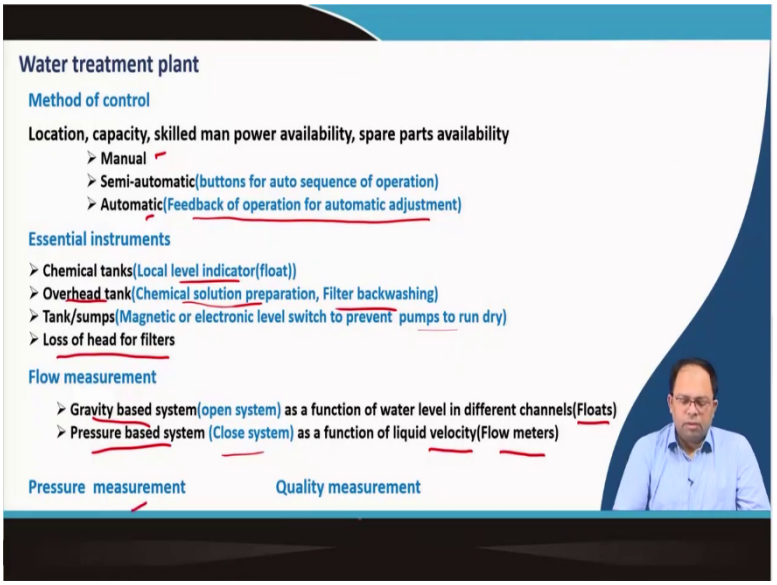

So, the method of control also varies depending on the location, the capacity of the workforce, the skilled manpower availability, spare parts availability and so on. So, usually we have manual treatment units, semi-automatic units or automatic units.

In semi-automatic, we have buttons for auto sequence of operations so that once we press those buttons things operate and fully automatic systems involve feedback of operation, for automatic adjustment. Some of the basic essential elements we find in a treatment unit are chemical tanks and these have local level indicators via floats and so on. We have overhead tanks for chlorine, coagulants and then filter back washing. Then tank and sumps with magnetic or electronic level switch to prevent pumps to run dry. And loss of head for filters when the water passes through may lead to disruption in the process, which is also monitored. Flow measurement for gravity-based(open) system i.e., we can measure the level of water in different channels through which it flows via floats or it could be a pressure-based system or a closed system using liquid velocity flow meters.

So, water flows from one unit to another and we need to monitor the flow rate because each unit has got different rate of loading; that means, how much water you can send to the unit depend on the surface area of the unit as well on the size of the unit.

Terms like surface loading dictates how much meter cube of water you can put for every meter square of that particular unit for a particular time period and similarly the detention time is also important which dictates how long you want to retain water in that.

So, for that we need to understand at what rate water is flowing from one unit to another unit. We have gravity-based system where we measure that level of water via float from there we can understand the amount of water that is flowing from one part to another or it could be pressure-based system where using meters we can measure the flow of water from one unit to another. So, pressure and quality measurement both are conducted.

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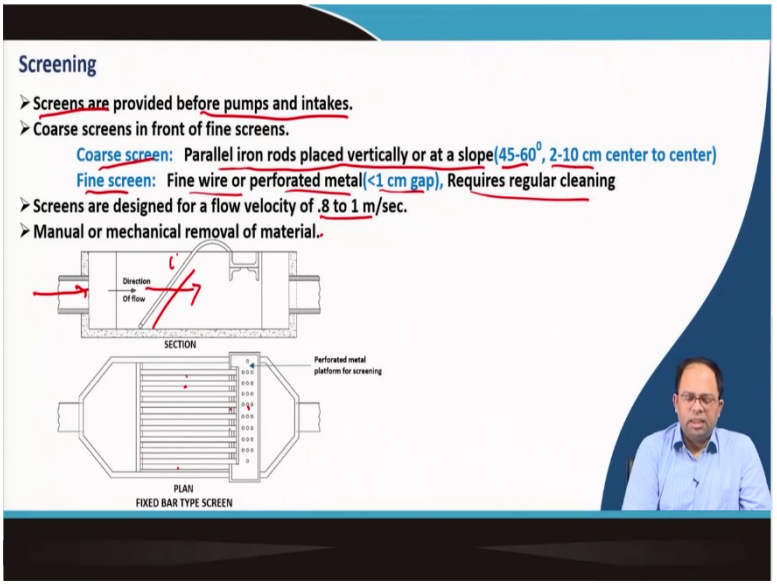


**Screening**

Screening is achieved by provision of screens before pumps and intakes; that means, before we start the treatment, we have to put screens and also before pumps for lifting we have to put screens.

There are two kinds of screens used for water; one is a coarse screen and another is a fine screen. Coarse screen is placed in to first trap the bigger material and once that is done, we have a fine screen which taps the smaller materials. So, a coarse screen could be developed using parallel iron rods placed vertically at a slope of 45 to 60 degrees and the gap between these rods are 2-to-10 centimeter center to center. Whereas, fine could be a fine wire or perforated metal of less than 1 centimeter gap and requires regular cleaning since the pores are very small and it will gradually get clogged.

Screens are designed for a flow velocity of 0.8 to 1 meter per second. Based on the flow velocity and the quantity of water or the size of those particular channels, we have to determine how many of these screens are required which will determine the area required for setting up these screens.

Manual or mechanical removal of material.

First, a coarse screen is provided at an angle which leads to the stoppage of the bigger particles and then the perforated metal screen are placed which is the fine screen.

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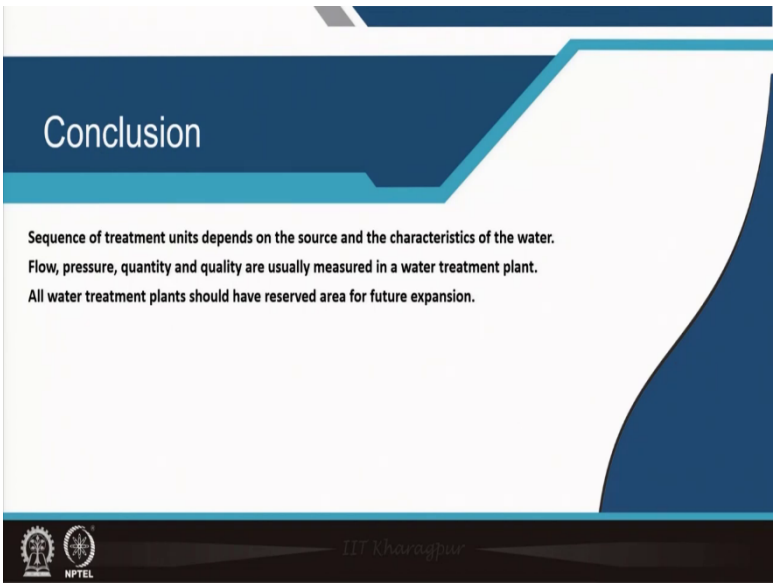


So, to conclude, sequence of treatment units depend on the source and the characteristics of the water. Flow, pressure, quantity and quality and are usually measured in a water treatment plant and all water treatment plant should have reserved area for future expansion.

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So, these are the references you can study.

Thank you.