Water and Wastewater Engineering
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Lecture - 2
Water and Wastewater Quality Enhancement

In the first class we have discussed about the importance of quality of water and enhancement of quality of wastewater. We also discussed the quality requirement for various beneficial users. The beneficial users are; domestic industrial, recreational and the fourth one is about agricultural use. These are the four important users and we discussed about the water quality criteria for those things. Then we said that there is a… we have also said that the water available to us in terms of quality is not able to satisfy the requirement of the water quality for these beneficial users and hence there is a need for treatment.

We said that a treatment is required and in order to achieve that treatment we have to have treatment plants. And these treatment plants have a life period life time or the design period. So these design periods are essential, important.

In fact if you want to, if you design a treatment plant today it should serve the population today as well as it should serve the population say 30 years from today or 50 years from today and hence there is a need for the population projection. So, forecasting the population is also required and also forecasting the water need is also required. That's what we have discussed till now. And in today's lecture I would like to say, the water and wastewater quality enhancement and a philosophy of treatment. So once we understand this particular thing we could go further on how exactly we could treat the water.

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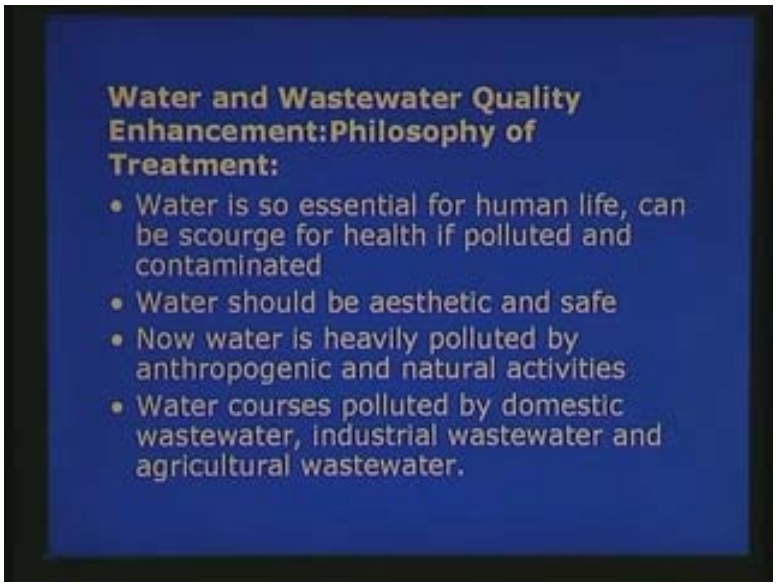

Water is so essential, very essential for human life and it can become scourge, scourge meaning dangerous or hazardous for health if water is polluted or contaminated. Here I would like to distinguish between the pollution and contamination. Pollution is normally, if I write it here pollution is normally by organic and inorganic material. Any foreign body which is organic or inorganic in nature, present in water we term it as pollution. So we should not have any foreign material of this origin.

Second thing is contamination; second term that we normally use is contamination. Contamination is presence of organisms that is pathogenic organisms in water. So the presence of organic pathogens in water is termed as contamination. If I say water is contaminated means it means most of the time the water is contaminated with the microorganisms which cause disease. That's the difference we can make between these two things; pollution and contamination. And water should be…….. Second point in the slide is, this is about the slide 1, I would like to state some of the explanations for the slides, I would like to take it.

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Second thing is, water should be aesthetic safe. So water should be aesthetic means aesthetic from the point of view of consumer. Consumer should have pleasing water and safe is from the point of view of the public health authority and civic authorities have a responsibility to supply the safe drinking water.

However, now water is heavily polluted by anthropogenic and natural activities. So again here the explanation is the water what we have now is not free of pollution it has got lot of pollution. The pollution of water or contamination of water could be from the anthropogenic activities.

What is anthropogenic activity?
Anthropogenic activity is a man made activity. That is, we are responsible for creating the pollution. So the anthropogenic activity can be again divided into several categories. Anthropogenic activities results in the pollution, causes the pollution and contamination of water

and this can be divided into the following categories: One is suspended load. I can call this anthropogenic activity causing the suspended load to the environment, suspended load it could be for water bodies in this case, we will take a water body, it could cause what is called a chemical load, it could introduce chemical load to the water bodies, it could introduce microbial load to the water bodies. So these are the three types of loads. These loads are the contamination or pollution from the suspended, from the chemical and microbiological.

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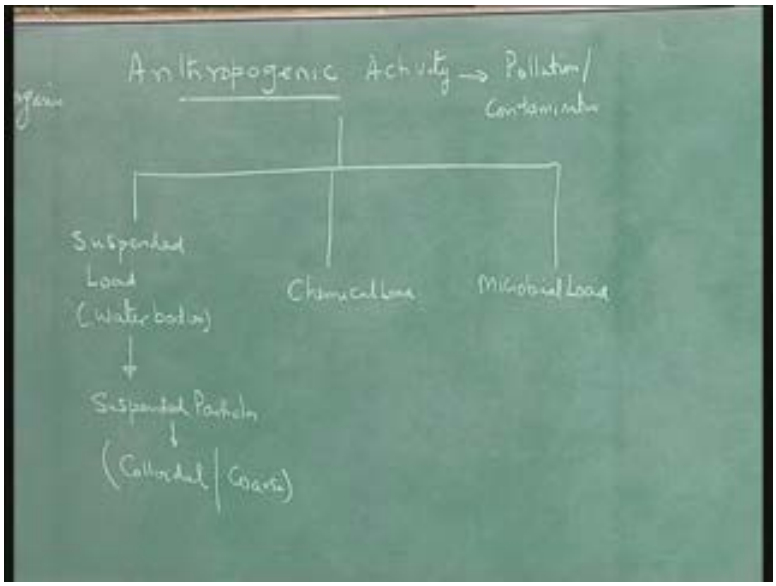

Suspended load is nothing but introduction of suspended particles in water. Suspended particles, they could be of colloidal nature, they could be colloidal or they could be coarse, these are types of particles that are introduced into the water which are not of the natural habitat, which are not natural components of water, these are foreign bodies.

Similarly, chemical load if you take the chemical load can be divided into two parts again sub parts. One is organic; another is inorganic, organic and inorganic loads. Organic loads can be further divided into two parts; one is what is called biodegradable and another is non-biodegradable. So, the organic matter is of two types; one is biodegradable and another is non-biodegradable.

For biodegradable organic matter example is presence of any organic matter which can be used by microorganisms. For example, domestic wastewater is biodegradable. So the examples could be any organic matter like domestic wastewater or industrial wastewater. For non-biodegradable, here if you look at non-biodegradable, non-biodegradable organic matter is also organic matter but cannot be attacked by microorganisms. These are like the phenols. One example could be phenol, another example could be plastic, that is a plastic bags etc we use nowadays or for several years we have been using this plastic is non-biodegradable type of plastic.

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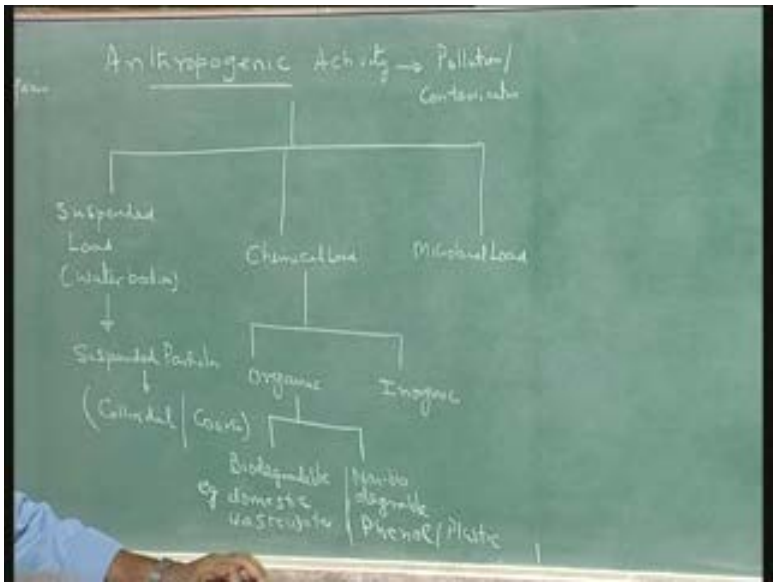

So, if you go to the another component that is inorganic component of the chemical load this could be of pesticides to kill the pest to kill the pest or insecticides to kill the insects and these are like DDT, BHC or the most common I mean modern thing is Endosulphon. These are the pesticides what we have and we have fertilizers. Some other examples are fertilizers, inorganic fertilizers, and organic fertilizers and so on and so forth come under this particular group.

The chemical load is the microorganisms that are the pathogenic microbes which we introduce in water due to the anthropogenic activity. These are the three types of categories just broadly we can divide at this moment of time.

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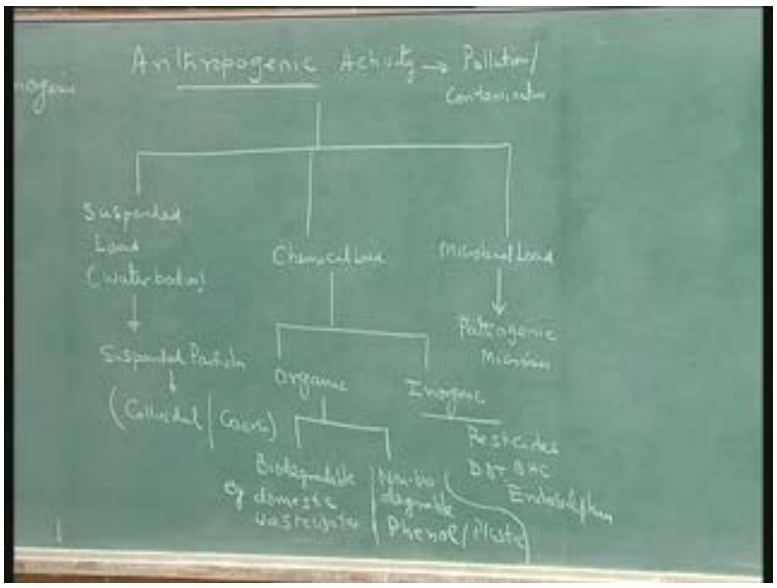

And also we have said that the water is heavily polluted with the anthropogenic activity as well as the natural activity. Nature also introduces the pollution. There is a lot of pollutant that are introduced by the nature into the water coarses.

Now another point I would like to say is that water coarses that is the rivers, lakes and any freshwater bodies are now polluted by the domestic wastewater, industrial wastewater and agricultural waste. Again here I would like to point out certain things. that is, domestic wastewater, it is just slide one only I am continuing, domestic wastewater and industrial wastewater, ww is the wastewater, it stands for wastewater, these are what is called point sources of pollution, these are called point sources of pollution. That means I can identify the point of entry of pollution from the domestic sector as well as industrial sector. These are point sources while the agricultural sector is a non-point source because the wastewater comes through the agricultural runoff. Agricultural runoff is a non-point source.

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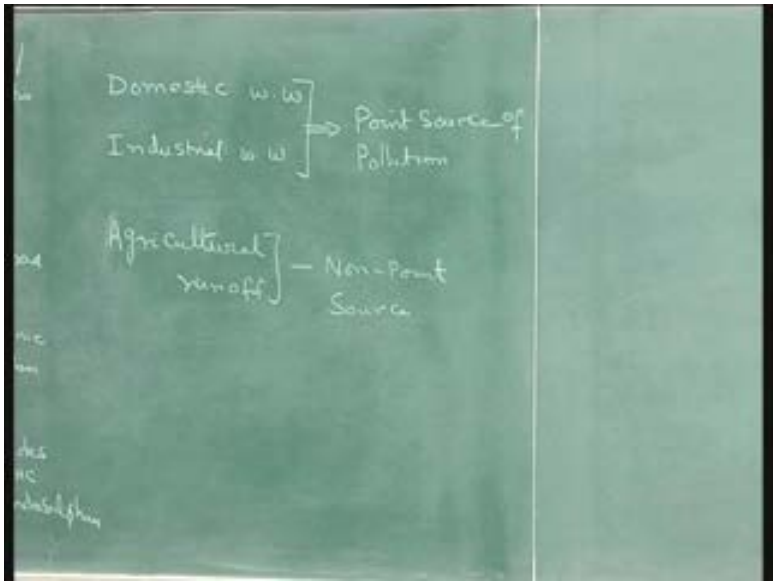

Therefore, if you have to deal with the pollution you should know whether it is a point source or non-point source. If it is a point source it is easier to identify where exactly the pollutant is entering into the river, if it is the non-point source it is difficult it can enter from several points and so on and so forth. So these are the some of the aspects that we could take, think about as the causes of pollution. Now I will go to the slide number two and try to explain things because that is essential for me to explain certain points here before we can go into the subject matter.

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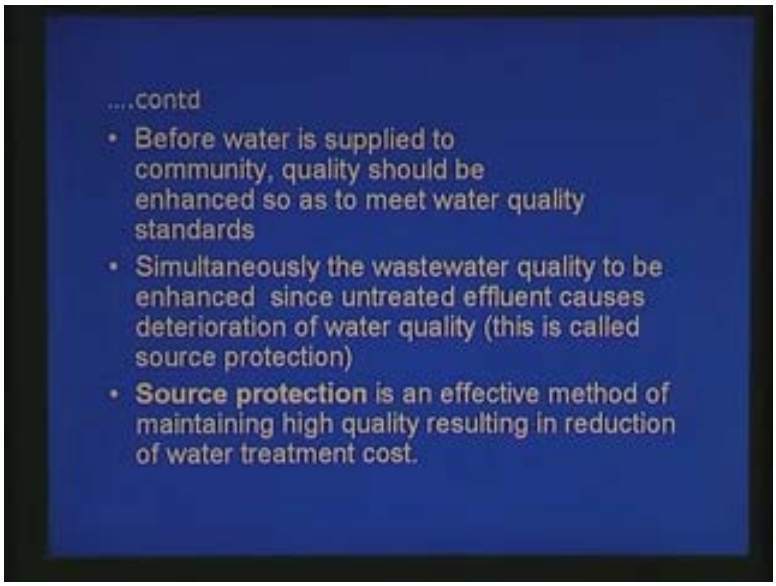

Before water is supplied to the community quality should be enhanced and that is very essential and we should meet the water quality standards. Water quality standard should be met. Who is setting these water quality standards? In fact water quality standards are set from the guidelines given by WHO. For example, we have got World Health Organization WHO guidelines for water quality. They are only guidelines they are not standards, they give guidelines only they are not standards.

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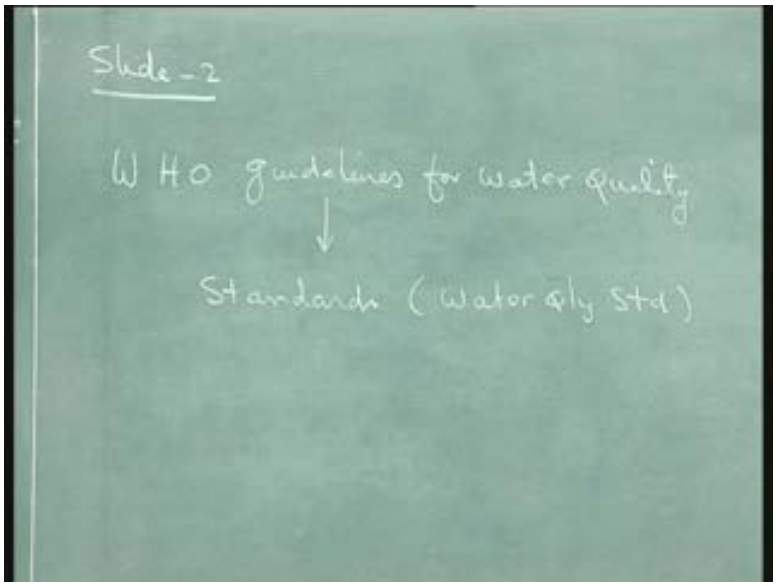

WHO guidelines for water quality, that is for domestic water quality, for the agricultural water quality is given by the world health organization. In fact you could get this information on the

water quality standards from the net. Go to the computer and then go to the website of world health organization and then through any search engine you can get this particular thing. These are merely guidelines. These guidelines are adopted for different countries by different countries and these guidelines become standards. These standards are known as water quality standards.

Each country has its own set of standards. Most of the standards are coming from the WHO guidelines. So these standards have authority vested in them. If the municipality does not supply the water confirming to the standard then there is going to be a problem for the municipality, they are supposed to supply the water.

Now we have to supply water confirming to the standards. That's what one thing. Second thing is that it is not just sufficient to supply the water confirming to the standards simultaneously at the same time we also have to do certain other things. We should enhance the wastewater quality also; wastewater quality has to be enhanced. Since if you discharge untreated wastewater into the rivers the river water quality will become poor, it will affect the river water quality. So it is essential that we should also treat the wastewater before it is disposed of into the rivers. That is one essential part of this particular thing what I would like to say. So, protecting the water from the polluted sources is very very essential so that is called a source protection. Source protection is an effective method for maintaining the high quality water high quality raw water which you take that raw water for treatment, for drinking purposes and then as a result of this protection of the source water the cost of treatment also will decrease.

Now let us see how exactly we can do that. So again continuing with the slide two I would like to elaborate the following aspect, how exactly we are going to integrate the water treatment and wastewater treatment.

We saw there is a river. So let me say that this is a river may be I can extend this river here so this is a river and this is flow is in this direction this is flowing in this direction (Refer Slide Time: 16:38) and I take the water draw the water for the water supply I would like to take the water and this is upstream side of the river and this is the downstream side of the river because the flow of river is in this direction so I have an intake structure so this could be called as intake structure which takes the water from the river and then the water is taken through a pipeline which is called as a transmission line, this is called a transmission line, I take the water through the transmission line through a water treatment plant, so this is my water treatment plant and in water treatment plant there are several units and these several units would enhance the quality of water.

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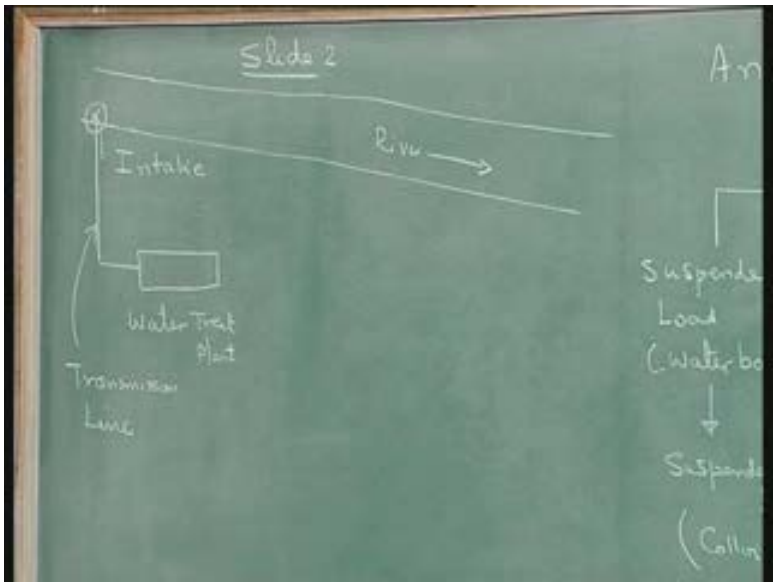

We will see later on, what are the different units in a water treatment plant. So water treatment plant produces water as per the standards. It produces water as per the standards and this treated water is supplied to the community through what is called a distribution system. Let's say that this is a distribution system. I am supplying the water to the consumer through the distribution system. This is the treated water, I am supplying this to the community and the consumers use this water and produce wastewater that is the spent water. So, that water from this consumer from these points are taken through a pipe, network of pipelines, these are all network of pipelines just schematically I am representing and all of them will join and then go to a wastewater treatment plant. So this particular thing; the distribution system is supplying water to the community and this is the sewerage system.

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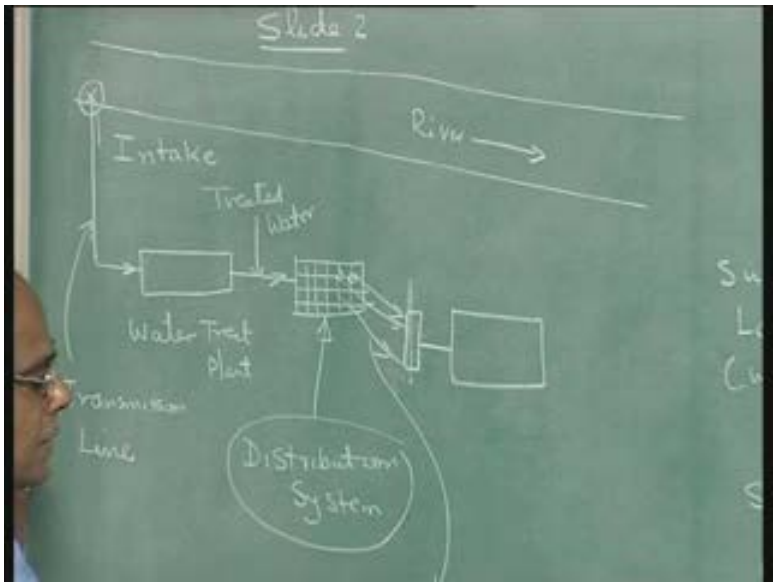

Sewerage system is the network of pipelines which collect the wastewater from the houses and take that wastewater to a wastewater treatment plant. This is a wastewater treatment plant (Refer Slide Time: 19:13). From this wastewater, I mean, the input to the wastewater treatment plant is the wastewater and the output coming out of this particular unit is the treated effluent. So, in fact again the wastewater treatment plant is not one unit there are several units in them. We will see what are the units and how exactly we need to design that afterwards. So, this treated effluent what we call normally goes into the river back, is discharged into the river, it goes into the river.

So in other words this is the intake, the river is the source for the water and also for the sink. It is the source and it is a sink. It is source here and sink over the other side, the downstream side of this.

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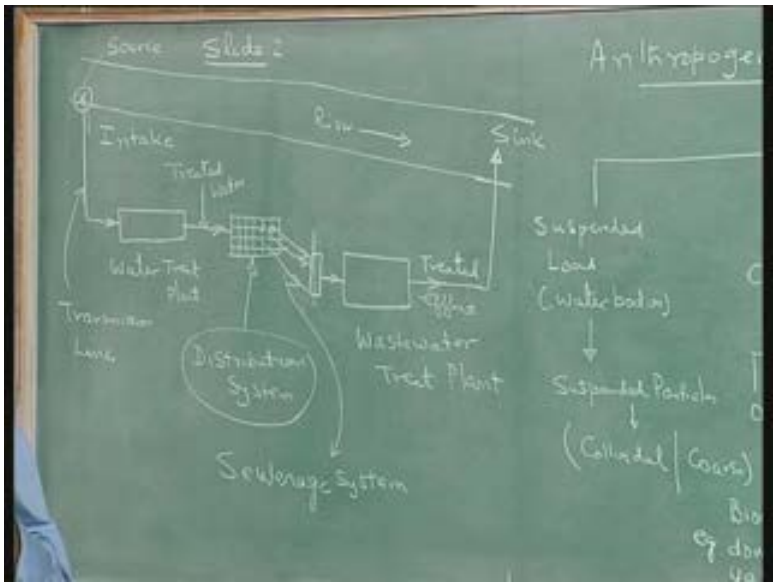

So what I have done is that I have drawn the water from the river, treated it, supplied it to the people, people consumed that water and produced the wastewater and this wastewater is collected through a network of pipelines and then that wastewater goes into a wastewater treatment plant, gets treated and then the treated effluent is going back into the river. That means I am taking the water from the river and putting back the treated effluent into the river. That's what we are trying to do in this. That means both these things are essential. If I did not do the wastewater treatment then what would happen is if I just discharge the wastewater from here untreated effluent, untreated wastewater if I discharge here the quality of the river water will suffer. And any user downstream side any town downstream side of this particular river will get bad quality water. That means all the more important is that we have to protect the source. Source of water should be protected. That's what now the highlight is of all international organizations and stressing the protection of the water sources.

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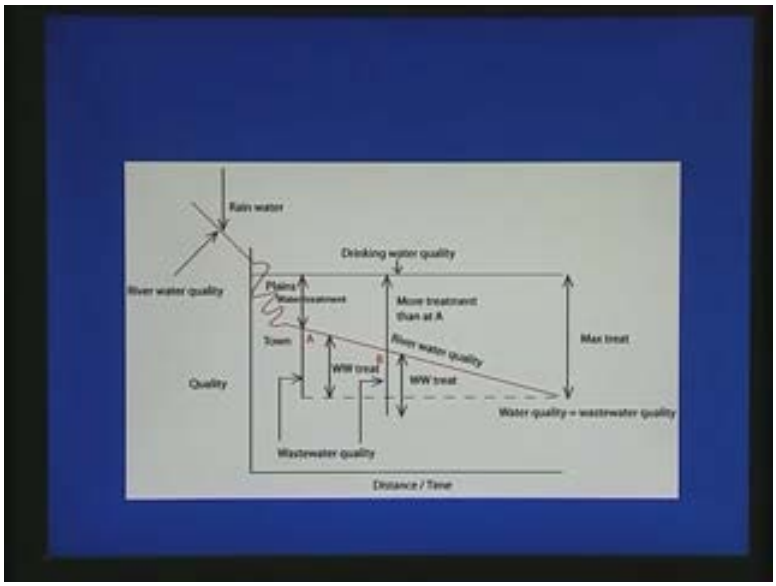

Now I would like to go to this particular slide that is slide number 3 which is indicative of various aspects. We can see here rain water is coming down, rain is falling and the rain water is coming down and the rain water quality is pretty good. As the rain water flows though the atmosphere it gets contaminated or it gets polluted whatever you want to say. Pollution is because of the gases that get dissolved into the water, atmospheric gases dissolve in water and then the water gets polluted. If there is air pollution in the area and if the rain falls there that rain water will have the pollutants because of the air pollution.

One important thing is that acid rain. Acid rain is because if the water contains the acid mist, I mean if the if that air contains the acid mist when the rain is falling that acid is washed on and it comes to the surface so that is one of the things we have. The rain water quality is pretty good before it enters the atmosphere as soon as it enters the atmosphere it gets polluted with the gases that are present in the atmosphere. And afterwards when the water comes to the surface, again I would like to go to the slide number three and explains it an aspects of this slide number three.

As soon as the water comes to the…, touches the surface, if you put slide number three as soon as the water touches the surface of the ground then the suspended load will be introduced into the water that is suspended particles will be introduced into the water. As soon as water comes into contact with the straighter then chemical load also is reduced. As a result of which, if I were to plot a graph between the quality, this is the quality, the parameters of quality I am not defining here yet, I am not defining but I am just saying quality. How I am measuring the quality I am not telling you now. We will discuss about that particular thing afterwards.

And then here we have time or distance as the river is flowing. So this is the rain water, rain water has got the high quality that's what we said so you connect with this particular slide so we have, this is the river water quality so say that this is the river water quality, (Refer Slide Time: 24:34) this is the river water quality. You can see here very clearly that as the river flows down into the plains as it is flowing down the quality of water is decreasing. The slope of the graph

will tell you the decrease in the quality, deterioration in the quality of water, because of natural pollution or man made pollution it is decreasing.

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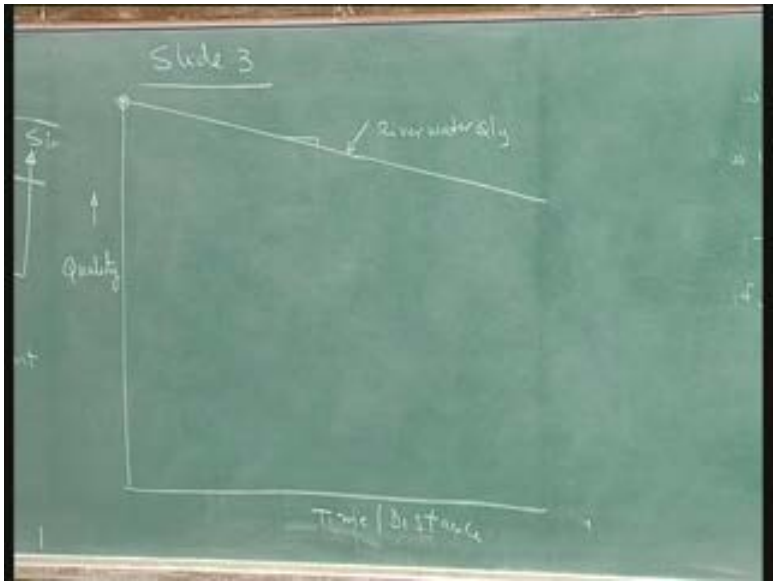

Now what I do is that I will draw the water, let's say that there is a town A here on the river and I draw the water from this river and I have to supply the water for drinking purposes. Let me say that, let me explain this particular thing, I say that this particular line represents drinking water quality. This line represents drinking water quality (Refer Slide Time: 25:30). That means I have to supply the water wherever you are along the course of the river you have to supply the water to this particular level quality should be to this particular level. So a town A is drawing the water and supplying the water to the people.

If it has to supply the water to the people what should it do is it has to…. May be I will remove this one (Refer Slide Time: 25:54) you have understood, this is slide three so this is the treatment that should be provided. So, enhancement of quality of water is to this extent that is water treatment I should provide at this stage. I think it is clear. I am drawing the water from the river; the quality of river water is not so good so I have to meet the standards. Standard is at this level, this is the same sketch quality standard so this much of the treatment I mean to this extent I have to give the treatment. This defines the extent of treatment I should give the water at this particular A. A is a point, A is the town which is drawing the water.

The same town also produces the wastewater. It utilizes the water and produces the wastewater and if I look at the wastewater quality may be that wastewater quality is something like this; so this is the quality of wastewater (Refer Slide Time: 26:55) ww is wastewater; this is qly quality I will put it here because anyway this vertical axis is quality, wastewater quality. Wastewater quality has gone down, wastewater quality is low.

So, in order to, what I should do now, if I put this same wastewater into the river then the quality of water is going to decrease, river water quality will decrease. What I do is I can treat the

wastewater. That means I will do a treatment. let's say that this is the treatment wastewater treatment I do, treatment of wastewater and then put back the water into the river that's what I showed here; the source and sink relationship, so I put the wastewater into the river then there is no problem at all. I am maintaining the river water quality. I have put the treated effluents and hence there is no problem.

Suppose if I don't do this, what's going to happen?
Most of the times it is not done to the extent that is required. Many towns do not follow the standards, they don't confirm to the effluent standards, as a result of which what would happen is that, let me say that I don't have wastewater treatment now. If I did not have wastewater treatment and if I have got the domestic wastewater, these are all domestic wastewater so what would happen is that the quality of the water will go down to this extent may be to this extent and then it would also increase and may come back to this particular level, will come back to this particular level.

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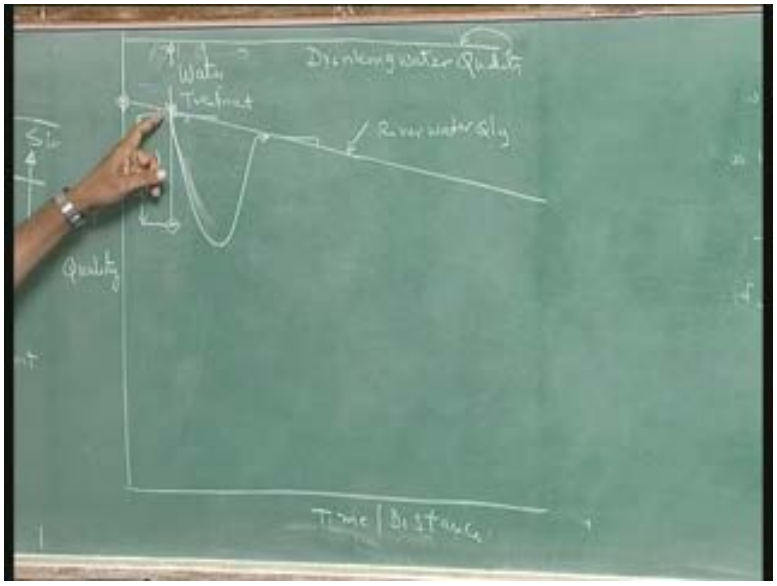

Quality goes down, these are all the quality scale, quality goes down and quality will increase. So this particular process by means of which the river sort of purifies itself is called self purification capacity. So, due to the self purification capacity purification capacity the river waters get purified provided the pollutant that is put in to the river is biodegradable, if it is non-biodegradable then it will keep on accumulating but if the pollutant is conservative it will remain in the river for long time.

You can see here what will happen, the river eventually reaches the same quantity but there is some quality deterioration during this particular period. So, for this particular period water quality in the river is poor. Water quality in the river is poor during this particular stretch of the river. So during this time period during this distance it is poor. Now that is the only problem if you do not treat the wastewater. If you treat the wastewater then this problem can be taken care of otherwise there will be some quality deterioration in the river that's what we are trying to say.

Now let us take…….. there is another town B here, this is the B town and B town is drawing the water from the river and then the extent of treatment is equal to this water treatment. And you can see very clearly that this scale is bigger than this scale, extent of water treatment is more if the river water quality is poor. If the river water quality is less then the extent of treatment has to be more because I anyhow have to meet these standards water quality standards.

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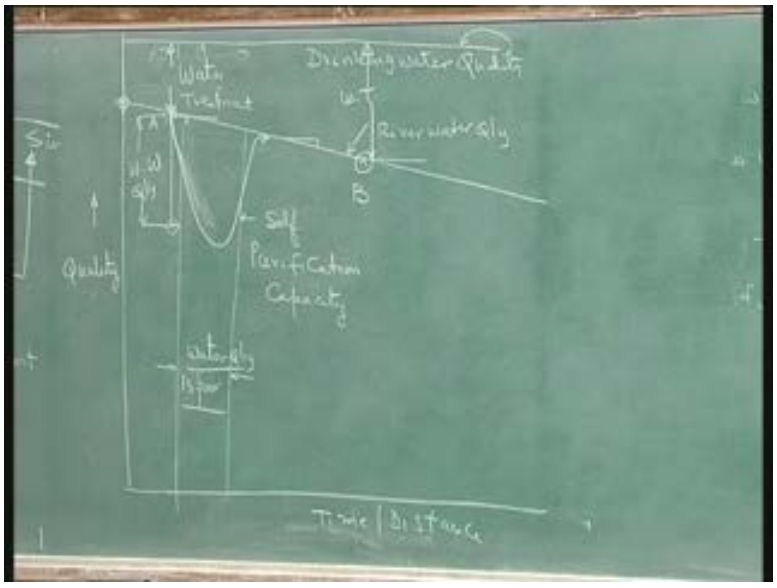

Similarly, you have wastewater that is produced here. B is the producer of wastewater and may be this is the quality of wastewater (Refer Slide Time: 31:07) wastewater quality. So this is the quality of wastewater at this stage. And again the extent of treatment to be given is more. You have to give the extent of treatment. If you don't give any treatment again this natural purification things will take place and as a result of which you may have this graph like this (Refer Slide Time: 31:37) repetition of this one and the poor water quality will be there in this distance. So this goes on continuously till the river reaches the ocean.

What we have to do is that we should supplement the self purification capacity with treatment. I should treat it and also utilize to some extent the self purification capacity of the river. So that is going to be better than without any treatment. This is what goes on as far as the water quality and wastewater quality is concerned. So what all I want to stress again is that it is essential that we treat the water but it is also essential equally important that we also treat the wastewater. If we treat the wastewater or water resources are good and of better quality hence we will have better quality water. Let us go to the slide number 4.

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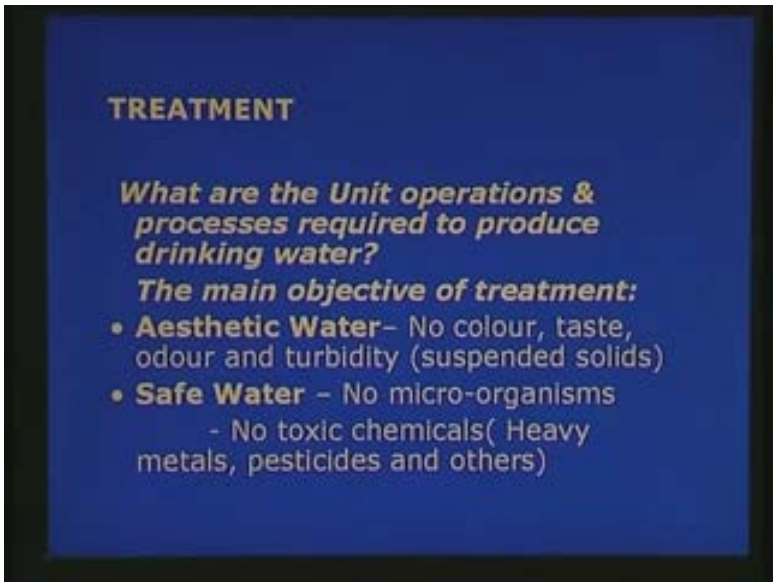

For this particular thing I am bringing an issue now here that I want to supplement the self purification capacity of river, for that I require treatment. In order to do the treatment I employ in the water treatment plant here (Refer Slide Time: 32:55) as well as the wastewater treatment plant here certain units which are unit operations and some of them are unit processes. So we are going to introduce certain unit operations and unit processes. What are these unit operations, what are these unit processes, we should incorporate, we should we should introduce particularly in the water treatment plants, and afterwards we will see the wastewater treatment plants also in the water treatment plants…… is to make the water, is to confirm it to the standards of drinking water quality. For that the main objective of treatment is water treatment in this case. I want to produce aesthetic water, water which is aesthetic that is water should not contain any color, taste, odour or turbidity so these are the things.

Turbidity is the presence of suspended solids. Turbidity interferes with the passage of light. If the water is turbid you cannot see the other side of the water clearly. If you put it in a glass you know you cannot see it so that particular thing which obstructs the passage of light is the turbidity. And we also have to produce water safe, safe from the point of view of the microorganisms and safe from the point of view of the absence of toxic chemicals. So toxic chemicals are like heavy metals and insecticides, pesticides and so on so forth so these things should not be present in water. So my main objective is to produce water which is aesthetic, pleasing and it also should be safe these are the two objectives. So for that let us move to the next slide that is slide number 5.

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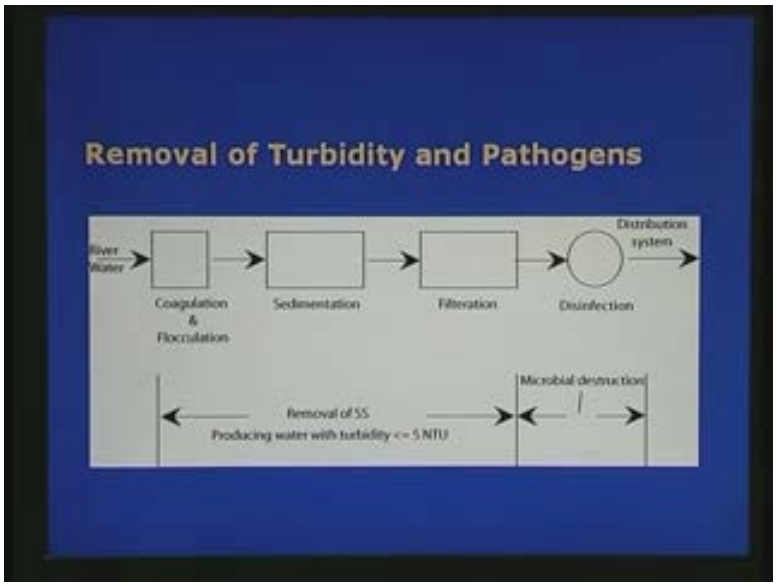

So the water treatment plant again I will take. The objective or the philosophy of the water treatment plant if I take it that is slide number 5 gives me a flow sheet. And in water treatment plant what are the different units that we should have in order to produce water which is aesthetic and which is safe. That's what we are trying to do.

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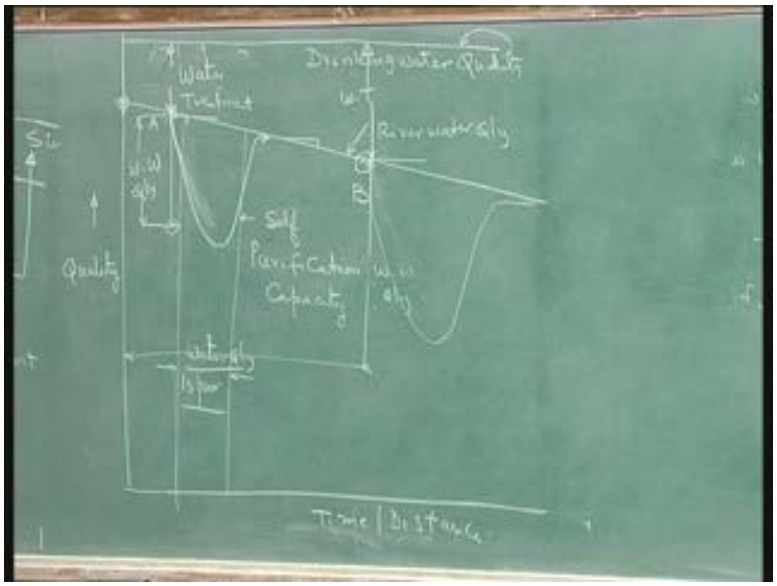

So the major objective of any water treatment plant for that matter is removal of turbidity that is slide number five removal of turbidity. That is, making the water pleasing. So, removal of turbidity is a very important thing which includes removal of color, taste, odour etc. removal of turbidity here itself I will write color, taste, odour, producing components I should remove that is

a very important thing. So this will make water aesthetic and people will drink that water without any hesitation.

Second thing is that I have to make water safe so the second objective is safety. The safety from the microorganisms is what I said, safety from pathogens that means no microbes should be present, no pathogens should be present in the water and no toxic chemicals should be present in water. You should not have any toxic chemical also; the toxic chemicals like I told you the pesticides, insecticides so on and so forth. Now let us see the flow diagram which has been projected here.

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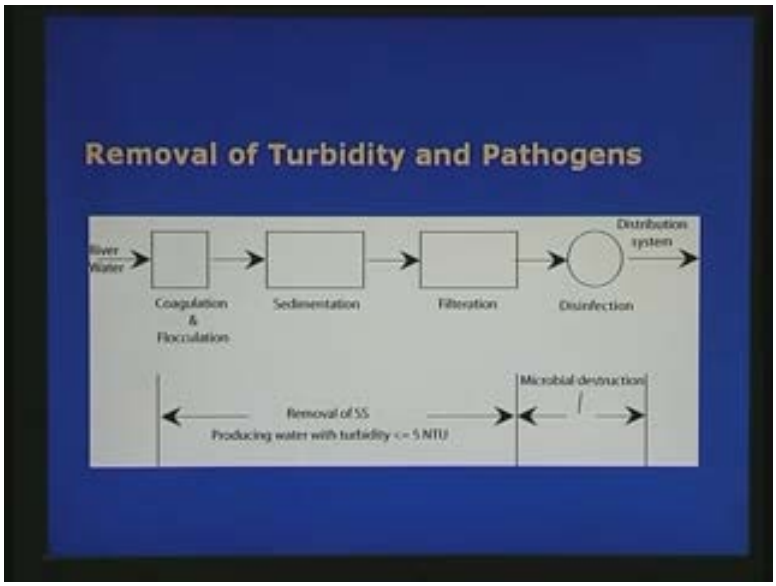

I take the river water, river water is the source of water that is through intake structures and transmission line and I am bringing the water to the water treatment plant. Once I bring the water to the water treatment plant what I should do is I have to look at various……. we should do the water quality analysis. I know what is the turbidity present, whether the color is present, whether the taste and odour causing organics are present so we should try to find out the physical parameters, chemical parameters and so on. So now what we do is that when water comes here from the river water, this is the raw water and river water and river water if you see river water has definitely suspended load, it has got what is called suspended load that's what we said. So river water has suspended load. That means suspended solids are present in the river water and I need to remove these suspended solids before I supply the water to the people otherwise people will not drink that particular water.

So, if I look at this what are the different types of suspended particles are there? there are colloidal particles, colloidal particles are present and colloidal particles have got two sizes; one is 1 nanometer, to say 500 nanometers and nanometer means 10 to the power of minus 9 of a meter. So the second group is that 500 nanometers to….. (roughly these are all rough estimates rough figures I am trying to give you here) about say 10 micrometers these are very fine colloids and these are the colloids and then there is a coarse suspension coarse particles, the particles which

have got a size greater than 10 micrometers. Particle size is greater than 10 micrometers. These are the rough estimates and some differences will be there. it doesn't matter at this stage the size of the particle but all what I want to say is that there are particles in this river water of these sizes; colloidal and coarse, this is the fine colloid and then this is a bigger colloid and these are the coarse particles (Refer Slide Time: 40:06).

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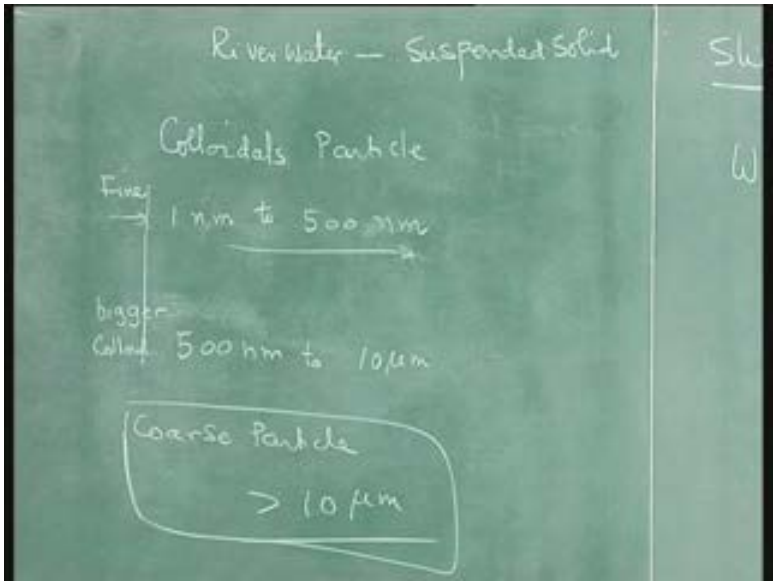

So, in order to make these colloidal particles to settle down in the tank by gravity we require certain chemicals. What we do is that we add certain chemicals to the treatment plant to the water, we add chemicals to the raw water in the treatment plant these chemicals are generally alum and lime. Mostly it is alum, sometimes a combination of alum and lime.

Sometimes there is a need of adding an electrolyte I mean some other coagulant aides. So all these things will go added and then there is a rapid mix here (Refer Slide Time: 40:53). Rapid mix is required to disperse the chemical into the water rapidly. very quickly I want to disperse the chemicals into the water and this particular thing after this rapid mix will go into what is called coagulation and flocculation unit. It goes into a coagulation and flocculation unit.

The purpose, what happens in the coagulation unit is that the small colloidal particles after getting neutralized by alum they get neutralized by alum and then the small colloidal particles combine together to form a flock. So, in coagulation and flocculation, in coagulation what will happen is that the flock formation or the neutralization or destabilization of colloidal particles will take place. I will use the technical term destabilization of colloids will take place. The colloids are destabilized, their property of being separated is removed, the property is destroyed, that property is destroyed so they are destabilized.

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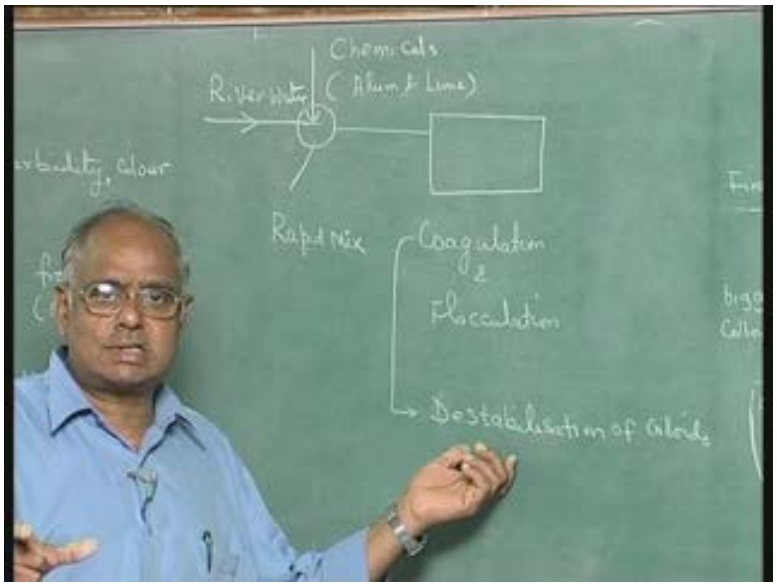

When they get destabilized then they come together and form a flock. So, in flocculation this is the process wherein the destabilized particles are flocculated so it is the flock of destabilized particles. Destabilized particles will occur, flock formation will take place. Flocculation is formation of a flock and coagulation is the destabilization of colloids. These are the two things essential. So these things; coagulation is brought about by the addition of chemicals and flocculation is brought about by induced slow mixing. So for the flocculation we use what is called a slow mixing. These things we will study in greater details when we take up the design aspects of these things. At this time I want to show a flow diagram of this.

Then after this coagulation and flocculation de flocks are formed here, the flocks are formed and these flocks are to be removed and the flocks are removed by what is called gravity sedimentation. So following this I have got a sedimentation tank. The purpose of sedimentation tank is to remove the flocks that are formed in the coagulation and flocculation. So the sedimentation removes the flocks.

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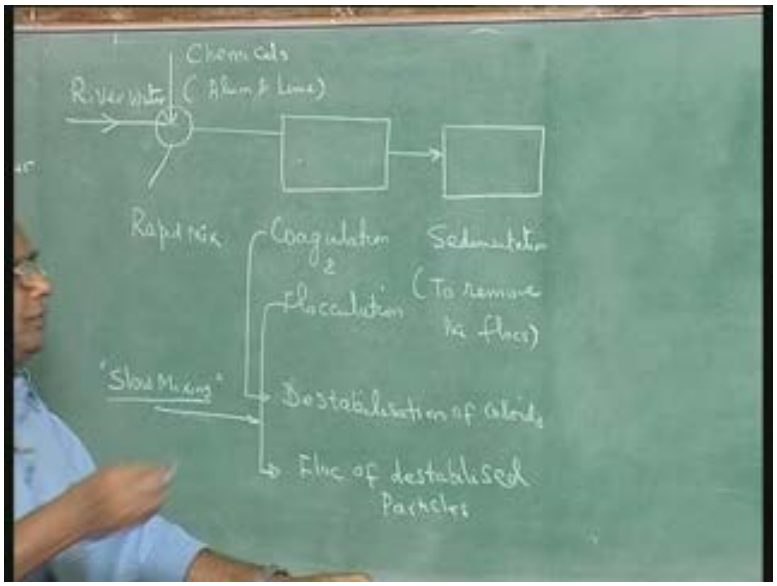

After this sedimentation we have….. from here I will take it here and then it will go to a unit called filtration. So what would happen in sedimentation is the flocks will be removed and the removal is not 100 percent some residual flocks will go out. That means in this water, this is the flow of water, some residual alum flocks, some residual alum flocks will escape in the water and still it causes turbidity. Its suspended solids are still present; very less suspended solids are present. In fact if you see the suspended solids it is about 20 NTU. The residual flocks will cause turbidity and this turbidity is about 10 to 15 NTU I could say. NTU is nephlometric turbidity units. So NTU NTU .this is the measure of the turbidity. They are still 10 to 15 NTU.

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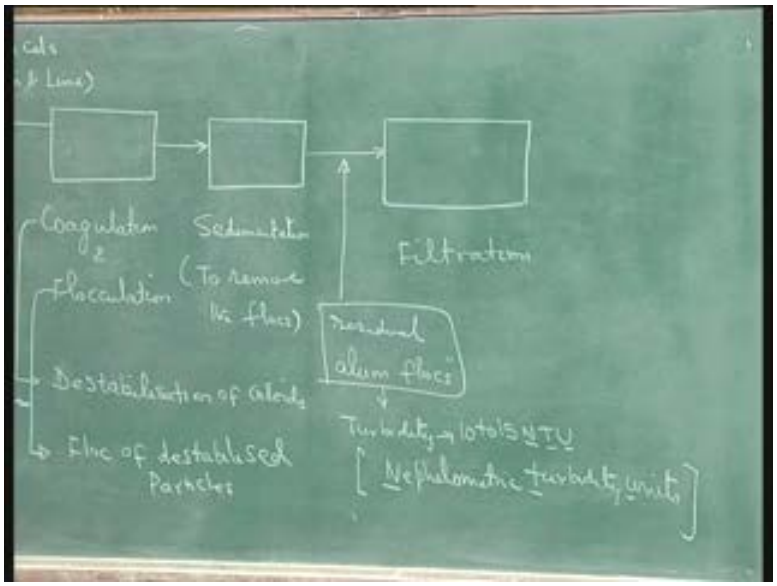

If you want to supply the water to the population the water should have less than 5. So still there is turbidity, I cannot supply this water and hence I have a filtration. The filtration is the unit in which this residual turbidity is removed. So I am producing the water here (Refer Slide Time: 45:57) with turbidity probably less than 5 NTU. Water has a turbidity of less than five NTU. That filtration is the unit which will remove the turbidity to this particular extent.

Here if you see this particular thing is what is called as pre-treatment up to here (Refer Slide Time: 46:16) whatever chemicals, addition and other things etc is pre-treatment and people call filtration to be treatment so this is treatment, and after filtration still the water has microorganisms, there is no unit.

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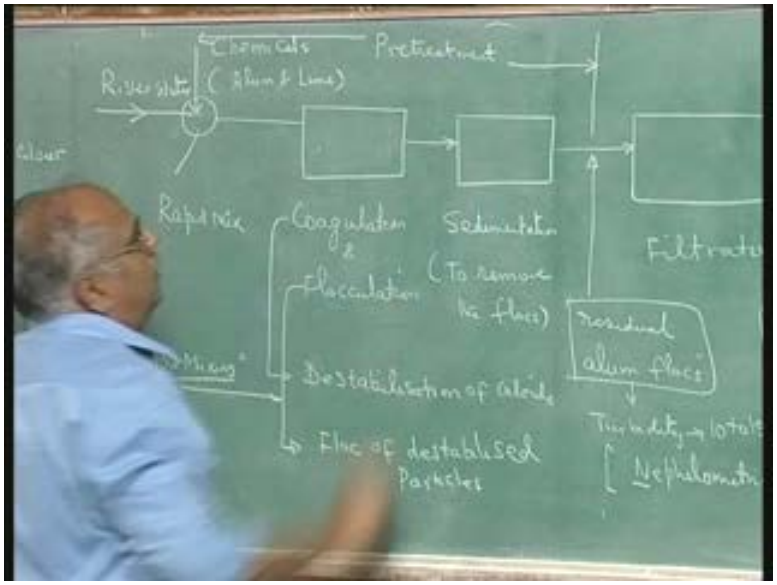

These are the units which are aimed at removal of suspended particles that is aimed at removal of turbidity. There will be some marginal removal of bacteria also, pathogenic bacteria also will be there, and removal of bacteria also will be there in this particular thing that is the marginal thing. This is the bonus what you are getting; removal of microorganisms. So in order to remove the microorganisms make the water fit for the drinking purposes we then have the disinfection unit. So the next unit is the disinfection (Refer Slide Time: 47:29) and disinfection is the unit which produces the water which is free of microorganisms. Microorganisms will not be there.

Suppose if I want to supply water for the community……. at this time I will tell the standard. For the microorganisms, there are two types of microorganisms which were counted: One is called total count total coliforms rather and another is the fecal coliforms. Fecal coliforms indicate the pollution from the fecal matter, this is the contaminated water, this is the most important parameter. So the fecal coliform should be equal to zero organisms per 100 ml, around zero organisms per 100 milliliters. There should not be any organisms. This normally we will say 3 to 5 total coliforms.

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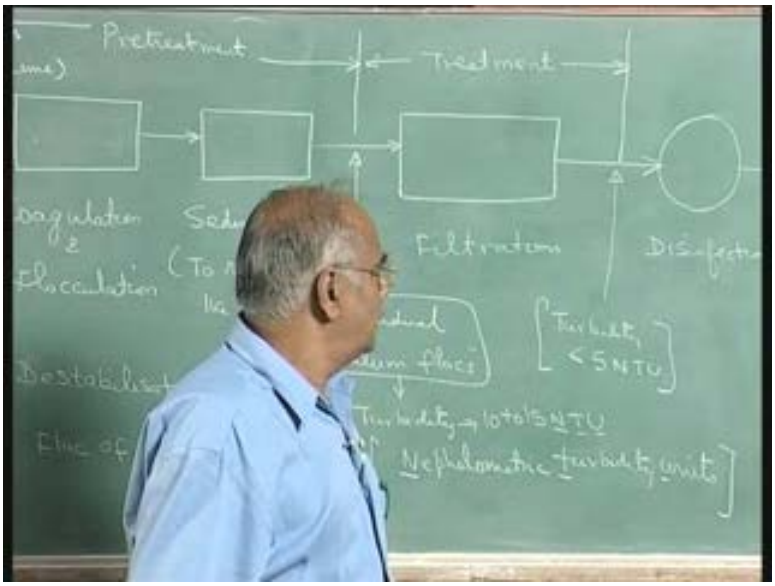

So what I have to do here is, in disinfection I am going to kill all microorganisms which are fecal type fecal organisms. So disinfection is then to kill the microorganisms present in the water number one and number two it also offers some sort of a protection. We would like to have some residual disinfectant here (Refer Slide Time: 49:14) we will have residual disinfectant which will ensure it will take care of any contamination that will take place in the distribution system. So that's what it is, residual disinfectant.

In fact the chlorination is done in our country by…….. I mean, the disinfection is done in our country by chlorination. In fact chlorination and disinfection are synonymous. If I say disinfection it means chlorination in our country. However, nowadays the chlorination has certain limitations, people have found out the limitations of chlorination and we may go for, I mean UV radiation. UV radiation is the other method of disinfecting the water and UV radiation is going to be expensive. The chlorination is the most inexpensive method of killing the microorganisms present in water and hence we go for chlorination.

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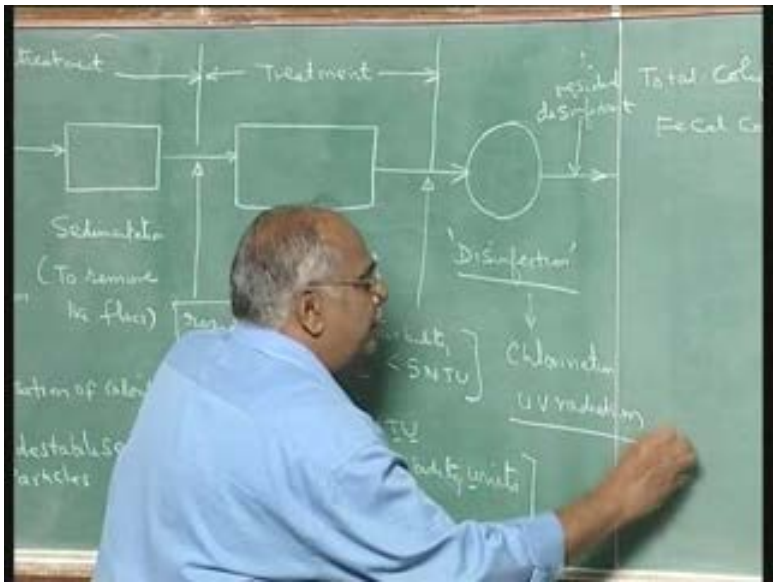

Chlorinate the water and maintain some residual chlorine in water to the extent of 0.5 mg per liter, will have a 0.5 mg per liter of residual chlorine, to the extent of approximately 0.5 mg per liter, this particular thing 0.5 mg per liter of residual chlorine will take care of contamination in distribution system, to take care of contamination in distribution system DS DS is the distribution system. That's how we try to do the water treatment. These are the various units.

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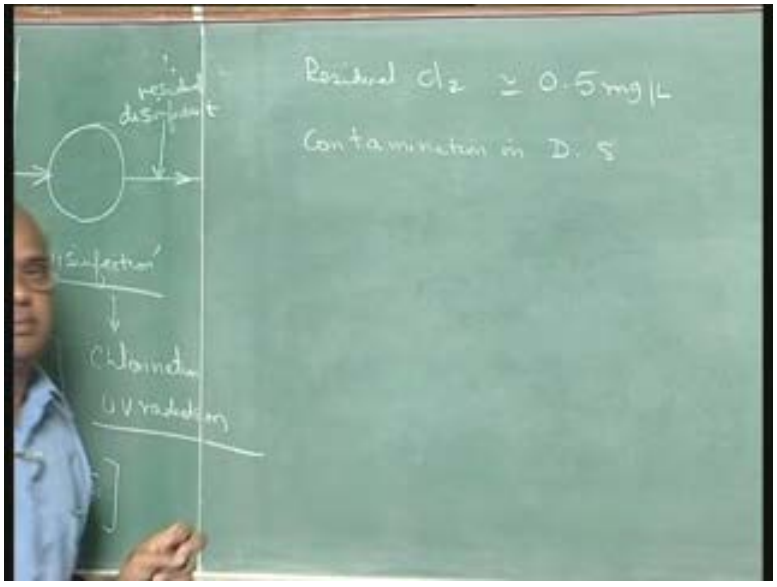

In fact as we proceed in the course we are going to discuss about the design aspect of all these units besides the theoretical aspects. We will not make these units as black boxes. We would like

to tell you what exactly happens in these particular units. Everything will be discussed in great details in that particular thing.

Now let us see one more thing I would like to say here; we have sedimentation. Sedimentation is the physical unit and we can apply physical unit process, we can apply what is called classical mechanics, we also have to do certain experiments to design it. Coagulation flocculation and disinfections are chemical in nature, chemical unit processes and filtration is physical and physico chemical. Just I want to make the distinction between these two things.

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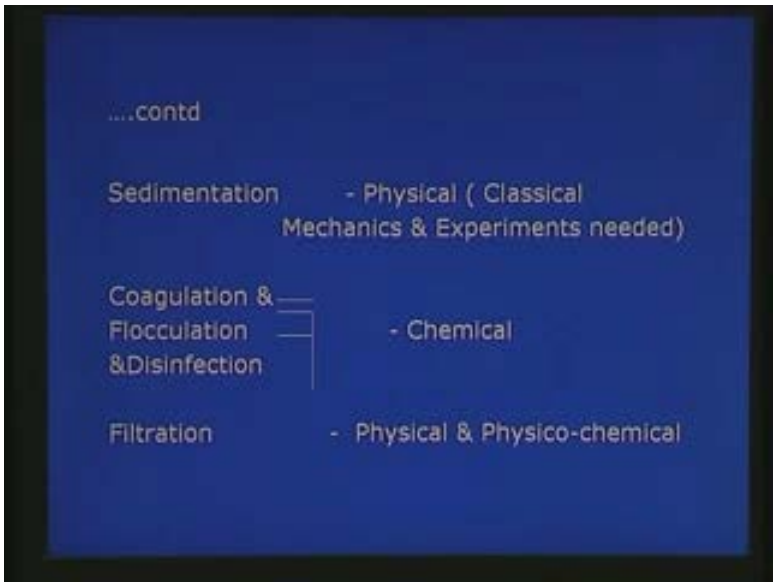

Some of these units are physical where physical principle applies; some of the units are chemical in nature so chemical principles have to be applied. So we should know some amount of chemistry and other subjects and third is the filtration so again physical and physico chemical. So, in other words this field of water treatment is going to be some sort of a mixture of chemical engineering, civil engineering, chemistry, mathematics, physics so on and so forth. So there is an interdisciplinary approach that is required for the design of these things.

Now let us see, I would like to take one more example before my time is off so that is ground water. Ground water is also a good source of water as far as some of the towns and some of the cities are concerned or a part of towns and part of cities are concerned. In fact there is what is called conjunctive use of ground water and surface water. You will get the water from the ground and also the river water; sometimes they are mixed and then used and so on and so forth.

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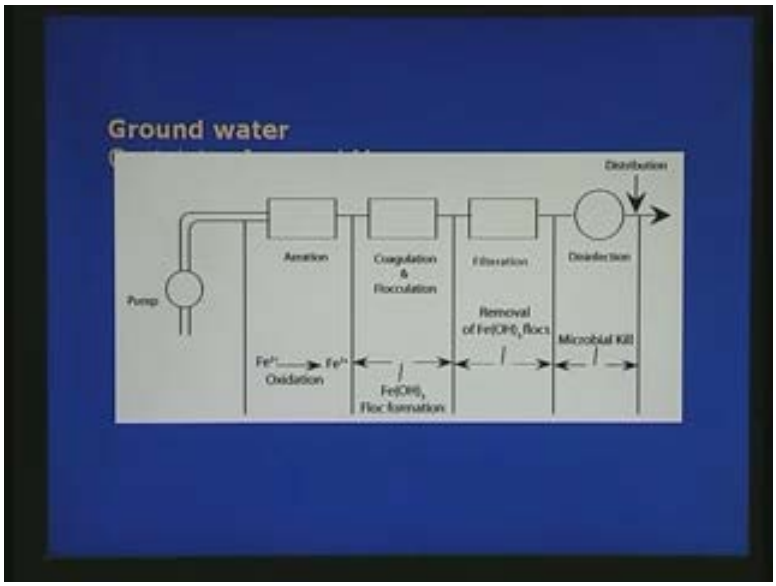

Now let us take the ground water. If you have a ground water, ground waters are generally free from microorganisms, generally free from microbes, pathogens. Of course this depends upon the depth of the tube well. If it is hollow tube well or the dug well or an open well there is a possibility of microorganisms being present. If it were to be deep tube well then the microorganisms will not be there. But often we have a problem with respect to presence of iron and manganese Fe and Mn both are twins, both of them stay together in ground waters.

In ground water Fe is present as ferrous that is in the reduced form. Similarly, manganese present is manganous that is also in the reduced form. So what we need to do is that in order to handle this, the standard says that iron should be less than or equal to 0.3 mg per liter and manganese should be less than or equal to 0.05 mg per liter these are the standards, as per the standards these are the two concentrations we have to achieve.

If water has higher concentrations than this then we need to go for the treatment. The treatment is, first of all I have to convert this iron which is in the reduced form into ferric ferrous to ferric. For that we will use aeration, that's what we have said, if you look at the slide you have aeration.

Aeration is the process by means of which oxidation is enhanced, ferrous to ferric. And after that we use what is called a coagulation and flocculation whatever we discussed earlier coagulation and flocculation can be used. And we use a alum as a coagulant, lime as an addition to the coagulation and the flocculation is done. So during this process what will happen, iron which is converted into ferric form is precipitated as ferric hydro oxide and that's what is happening. This ferric hydroxide is a very fine precipitate; this fine precipitate has to be removed. In order to remove this precipitate of ferric hydroxide we use filtration. After filtration we have to disinfect the water and supply the water to the people.

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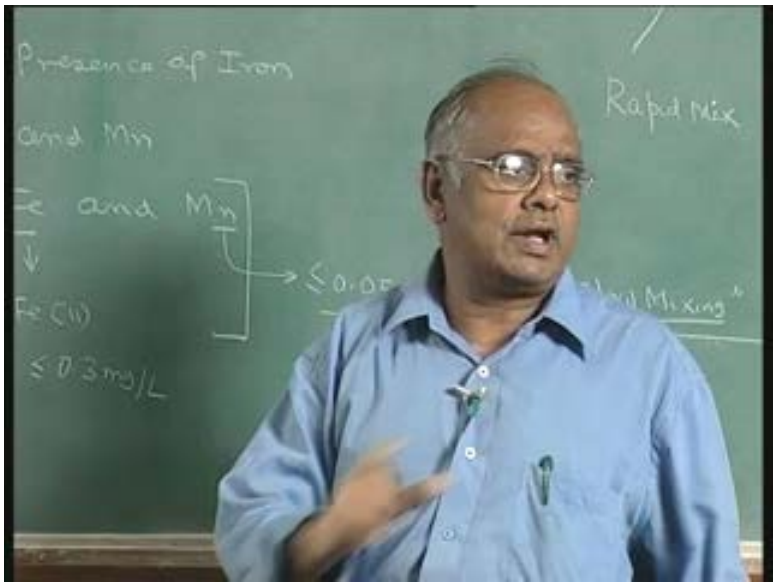

That's what we had to achieve if the ground water contains iron and manganese. Same thing will happen to manganese. Manganese, mangonous to manganese and that also precipitates as a MnOH4 that is hydroxide of manganese and then that will also be precipitating and then you will have the filtration and then disinfection. So there is a simultaneous removal of iron and manganese. This is just one example I have given as far as the ground water is concerned.

So today's lecture dealt with the philosophy of treatment philosophy of treatment so what all we did is, water treatment plant we took it and we tried to suggest what are the different units that are required for treating the water and before that we also have seen that how exactly the water quality varies as the river flows from one place to another place due to the anthropogenic activity as well as due to natural activities.