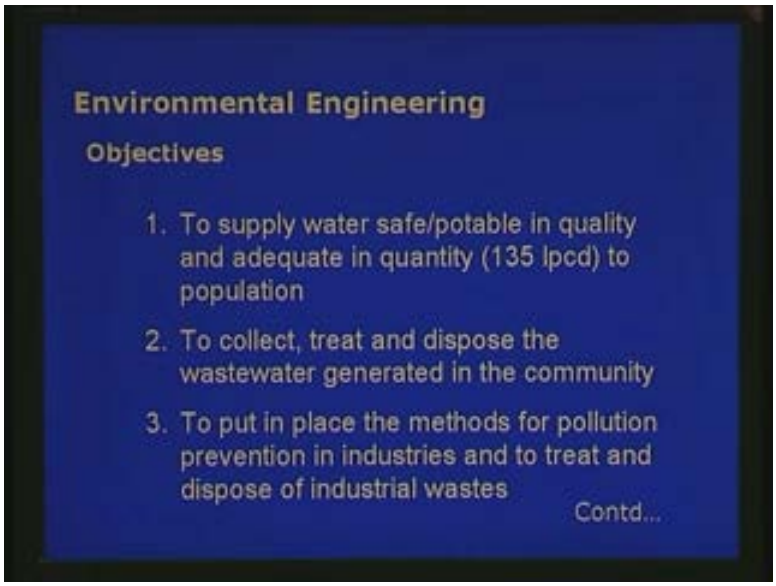
Water and Wastewater Engineering
Prof .C. Venkobachar
Department of Civil Engineering
Indian Institute of Technology, Madras
Lecture - 1
Introduction to Water and Wastewater Engineering

Good day, air, water and food are very essential for human existence. These materials which are so important for human existence if they are polluted they can create problems.

For example, if air is polluted there will be respiratory diseases. If the water is contaminated it can cause waterborne diseases. If food is contaminated then it could cause food poisoning. These three components which are so essential for foreman human existence can also become scourge, can also become harmful for the human life that's why it is very essential for us to see that these are not polluted.

In fact I would like to start the course on wastewater engineering with a proverb which goes like this: Many lived without love but none without water. The water is so much essential for our existence. So this particular thing I invite you, with this I invite you to the video courses in environmental engineering. But this particular course we concentrate on wastewater engineering. Let us see the objectives of environmental engineering in general. I would like to state the objectives.

(Refer Slide Time: 02:35)



The objectives of environmental engineering are to supply water which is safe in quality and also adequate in quantity. Two things are important here; the quality as well as quantity. The quality is important. If the water quality is not good, if water is polluted, if water contains harmful bacteria then waterborne diseases will be there, the diseases like typhoid, cholera will be there. So with this particular thing what would happen is that the productivity of the nation will decrease.

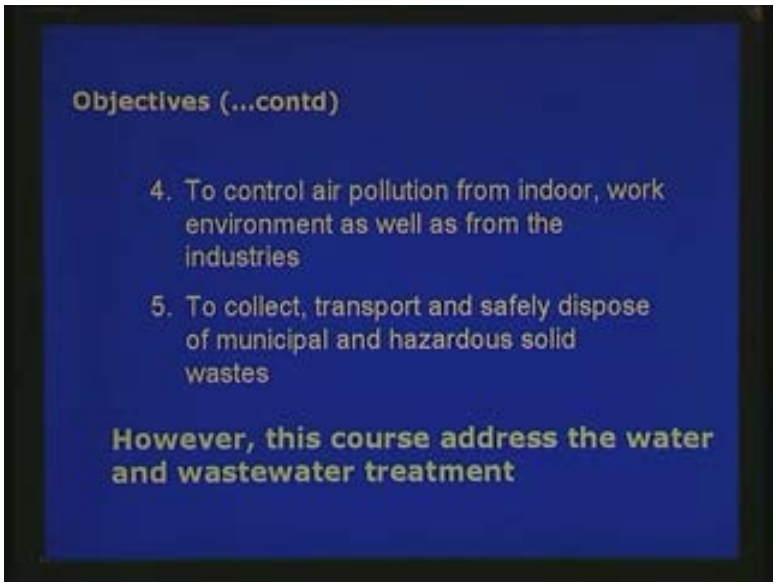
Secondly, if I do not supply water adequate in quantity, Government of India has suggested that we need to supply about 135 per capita per day, per head 135 liters of water is required. So, if this water is not……this water is supplied to keep the personal hygiene and to meet all water demands. If we do not supply this amount of water then what would happen is that people would like to get the water from the sources which may not be safe so that is a big problem. So quality and quantity are both important.

Secondly, second objective of this particular environmental engineering is to collect, treat and dispose of the wastewater generated by the people in the community. So we have to dispose of the wastewater in an environmentally friendly manner. In fact 60 percent of pollution that is caused in India may be due to the domestic wastewater. Now we have to have development. In order to have that development we have got many industries, these industries produce pollutants of gaseous in nature, gaseous pollutants, they produce liquid waste, they also produce a solid waste and solid waste which may be hazardous.

All these pollutants like gaseous waste, liquid waste and solid waste are to be treated before they are discharged into the environment. This is the responsibility of the industry and government has a responsibility to see that the industries do treat their waste properly. So, as environmental engineering is a field which deals with the methodology of preventing the waste creation in the industries and also to treat the waste if it is generated……. always prevention is better than cure that's what we try to see.

The fourth objective of environmental engineering is about the air pollution. We have to keep the good air quality so that the respiratory diseases, pulmonary TB etc are not transmitted through air. We have to keep up the indoor air quality, we have to keep up the work environment air quality, we have to keep up the air quality in the industries. So we deal with the air pollution from these sectors.

(Refer Slide Time: 05:33)



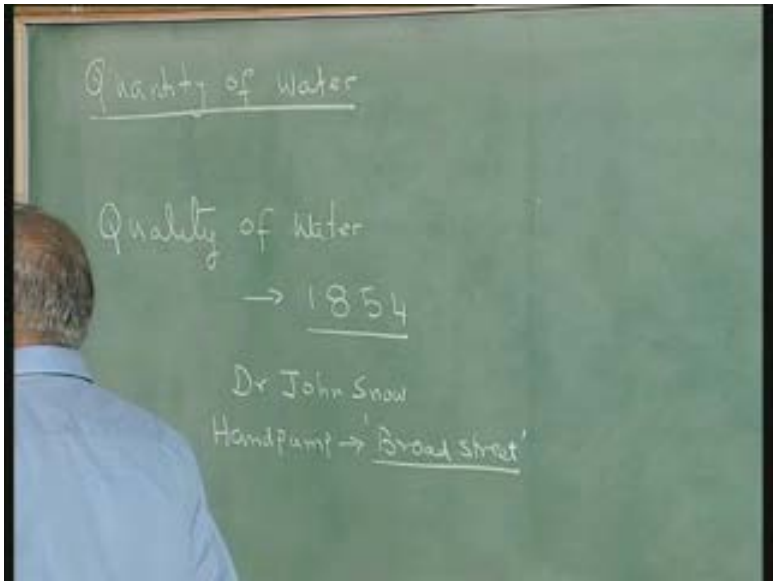
Finally environmental engineering also deals with collecting the…. collect transport and dispose of the solid waste generated by the community as well as the industries. So this is very important. We look around any city in India we have so much of solid waste to be treated with. And there are several courses which deal with each aspect of this. In this particular course we are going to deal with the first two aspects. This course addresses with the water and wastewater treatment.

Now I would like to say…… I have taken two attributes that is the quantity and quality of water. So the quantity of water People have realized in the earlier days itself the need for the quantity of water. If you see the human settlements the [foeman] race has settled along the river banks and these foeman settlements have become a great civilization. For example, Indus valley civilization has developed on industry ware and Ganga River is supposed to be the cradle for Indian civilization and we have great Indian civilization because of the Ganges River and we have got similarly other Greek civilization so on and so forth. So, all civilizations are developed on the banks of the river.

I would like to state that people realized the importance of quantity much much earlier. However, the quality aspect quality of water aspect was rather slowly realized. It was not realized at a faster pace like quantity. So the quality was in fact there no recorded incidents of quality aspects. However, in Indian literature, Indians scriptures if you see the water was kept in copper vessels and copper vessels keep the quality very well. In fact copper dissolves in water and imparting a bactericidal property to water, the bacteria would be killed if water is kept in copper vessels. So that was there in our scriptures. However, recorded incidences were not there. Recorded incidences like in a western world was there only in 1845 or so 1854 rather is a first recorded history about the quality of water. In this, what happened, in Central London there was a health worker by name John Snow, Doctor John Snow, he was a public health worker, he was the first person to correlate the spreading of the disease with the quality consumption of water. He said that if people consume the contaminated water there was a disease. So there was

also…… I mean he dealt with one hand pump hand pump in the broad street; it's called a Broad Street hand pump. Broad Street hand pump…. In the neighborhood of this Broad Street hand pump the cholera disease was rampant around this period and the water got contaminated, the water table was shallow and water got contaminated and people consuming this water had the disease.

(Refer Slide Time: 10:10)



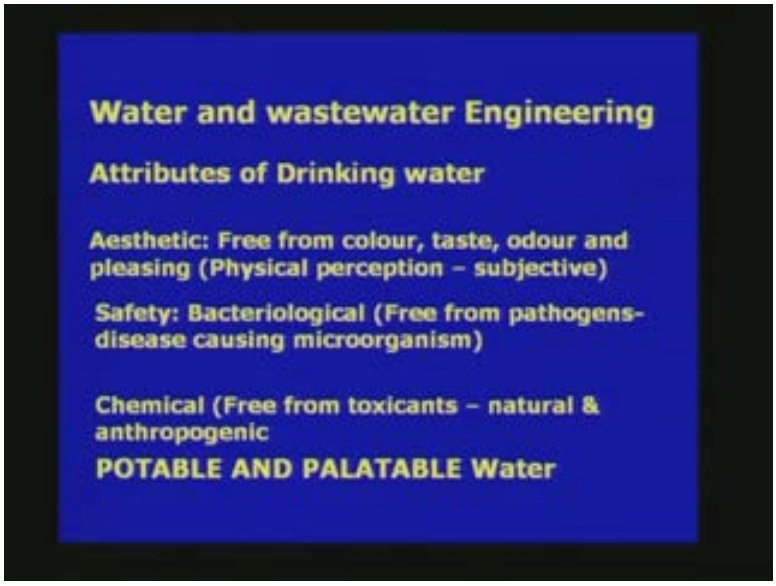
So then what happened was, he was the first person to correlate these two things consumption of water with the disease. At the time interestingly germ theory was not known. We were not knowing that microorganisms caused the disease. It was only in 1900 it was established that cholera is caused by organism called vibrio comma which is a bacterium so that was established only in 1900 and much before that he was able to establish the relationship between drinking the water and the disease production.

Then what happened, he wanted to see that the people do not drink the water from that hand pump. For that what he did was he removed the handle of the hand pump so that people could not take the water. Of course for doing that offence he was punished without knowing the actual real reason by the authorities. Anyway these are the two aspects quantity and quality most important. And history of quantity and quality is like this (Refer Slide Time: 11:38) and still I would like to say that this quality is remaining a challenge to the environmental engineers to environmental scientist even today. With the invention of modern equipment, most sophisticated equipment like AAS, HPLC and so on we are able to detect trace concentrations, concentration of pollutants in nano concentrations, nanograms, micrograms and milligrams, very very low concentration can be detected.

For example, pesticide may be twenty years back or fifteen years back we were unable to detect in water. But now, yes, we can detect the presence of pesticides in water. So this particular thing, the quality aspect is going to be a challenging task for the engineers and scientists in future also. Because as we keep on improving our equipments we are going to detect more and more

pollutants and more and more new pollutants which we were unable to detect in the earlier days even though they were present. So that's what is the importance of this quantity and quality,

(Refer Slide Time: 12:49)

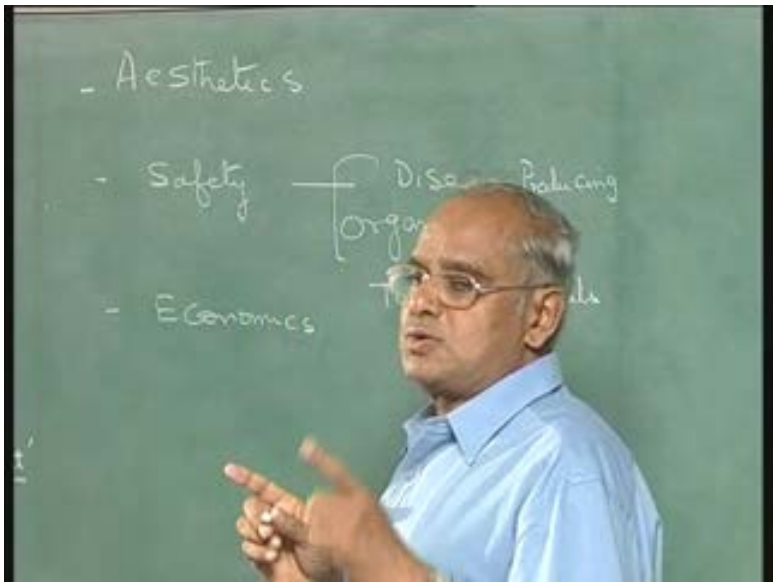


Now, if you want to see the attributes of the drinking water, attributes are some qualities of water whether the water confirms to the particular standards. So first of all there are three attributes I can say before I go to the standards; one is the aesthetics, second is the safety third is the economics. So there are three attributes I would like to write here; aesthetics, safety and economics. So any water you produce should be able to meet these three attributes, qualities.

Aesthetics is for physical perception. The water which we drink or water which I supply to the people should be colorless, tasteless, odorless and pleasing. These are the basic qualities of water. If water contains some turbid particles, suspended particles people will refuse to drink that water. If water contains some color, yes, we don't want to drink that water so that is the aesthetic. And this is a physical perception like our eyes, nose, tongue or instruments to detect these things. Since it is a physical perception it is a subjective test it varies from person to person. Consumer himself is an instrument to measure the aesthetics of water.

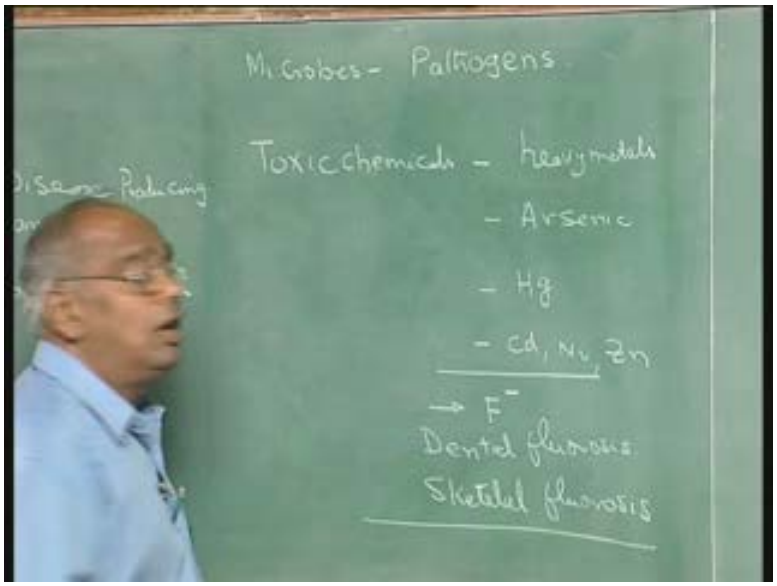
Second thing is the safety. Consumer is not the instrument; safety is the instrument probably is that we have to use analytical instruments equipments have to be used. Safety from the microorganisms, disease producing organisms I want to have safety from this I also want to have safety from the toxic chemicals. So the safety is from two things; one is the microorganisms. So these microorganisms can cause microbes that can be called as a pathogens, the one which produces a disease, the diseases are like; typhoid, cholera, dysentery, dysentery can be caused by bacterial cells as well as the amoeba, entamoeba histolytica can also cause the amoebic dysentery and infectious hepatitis. So these are some of the diseases caused by the microorganisms. Some of them are bacteria, some of them are protozoa, some of them are viruses so all those things come under this.

(Refer Slide Time: 15:06)



Therefore, as far as the toxic chemicals are concerned I would like to have water which should not have toxic chemicals like heavy metals; no heavy metals should be present in water. Unfortunately due to the anthropogenic activity that is man made activities some of the heavy metals are present in water and nature also contributes some of the heavy metals to water.

(Refer Slide Time: 17:45)



Example of nature's contribution towards heavy metal is arsenic in water. Arsenic is present in water because of the geological formation and this arsenic is present in the west Bengal ground waters of west Bengal and also in Bangladesh that is why arsenic is present as a heavy metal in water. Similarly, the mercury poisoning, mercury is present in water. In fact most of the fish

have got mercury in them; through food also they are getting the mercury that is the heavy metals like; mercury, cadmium, nickel, zinc and so on. These are some of the heavy metals which should not be present in water and they are all coming due to the anthropogenic activities the activities of man.

Another naturally occurring pollutant is fluoride F minus, fluoride. Fluoride also should not also be present in water and there is a limit for fluoride if it is excess than that is required than present it causes dental fluorosis or it causes what is skeletal fluorosis. Dental and skeletal fluorosis is caused by the presence of fluoride in water beyond certain limit. If dental fluorosis is there then what would happen is it would discolorize the teeth, teeth will be ugly, particularly for ladies and girls this is a problem. That is the cosmetic effect.

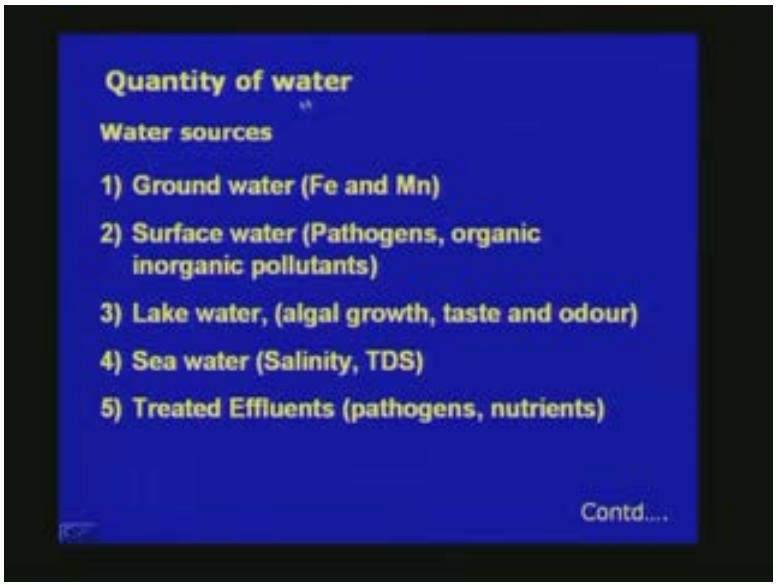
Second thing is skeletal fluorosis, the bones become weak they develop a stoop so on and so forth. So, if water contains the nitrates above permissible limits then it causes what is called a blue baby syndrome that's all we study in the books blue baby syndrome. These chemical should not be present in the water. So the consumer cannot know that whether these chemicals are present or not because we cannot see them so you have to depend on the equipment.

As far as the public health authorities are concerned like us, we have to make sure that the water does not contain these chemicals; no harmful chemicals should be present. Third aspect is water should be produced economically. There is no point in producing water which is very expensive. You have to have very reasonable cost of production of water if you want to supply to the people. So these are the three important attributes.

The next thing let us say; as a result of all these things we are producing potable and palatable water. Next part if you see, how much quantity of water is available to us for supplying to the public for industrial use, for agricultural use, for recreational use, if you want to see that particular thing, water that is available for us can be divided into different categories, the ground water……..

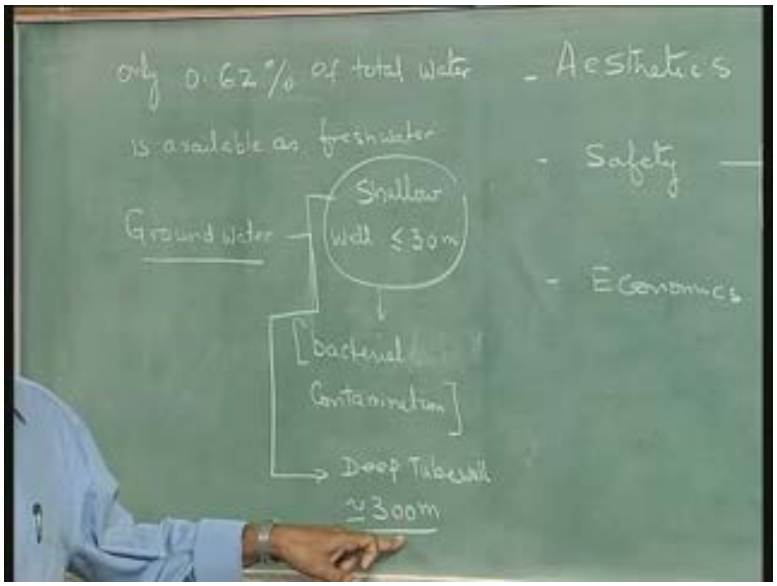
Number 1 is ground water, number 2 is surface water, number 3 is the lake water, number 3 is the lake water, number 4 is the sea water, number 5 is the treated effluent. These are the five categories I have divided. And we see first of all that the three fourths of earth surface is filled with water. Most of the water is locked up in the ice tabs and glaciers and only 0.62 percent of water is available as freshwater which can be used for the supply purposes. So we have very little water that is available. So 0.62 percent of the total water available 0.62percent of total water is available as freshwater for supplies and these waters are present as ground water.

(Refer Slide Time: 19:36)



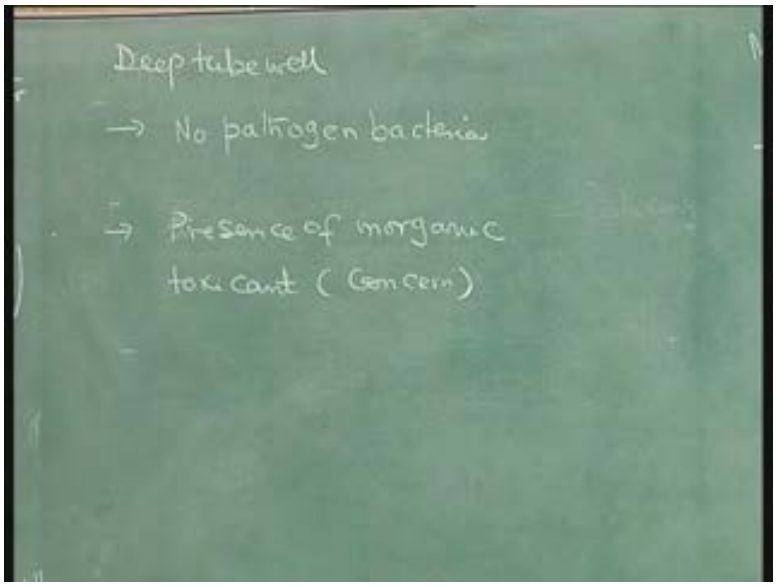
So let us take the ground water first. Ground water: the aquifers under the ground bear the water, the water bearing aquifers are present under the ground (underground) so these water if you are drawing from the aquifers which are less than 30 m deep that is they are called shallow wells, shallow wells draw the water from the aquifers which are less than or equal to 30 m and these shallow wells…… there could be shallow tube wells, this is a dug well, may be you have got water in 10 m, some places in the northern zone in the Gangetic Plain you get water just as you go by 4 to 5 m you get water those water are all from shallow wells, shallow tube wells we have. There is a problem with this water. These problems, these waters are prone for bacteriological contamination. The bacteria may be present in this water, pathogenic bacteria may be present. So the shallow well waters may have a problem of bacterial contamination. This water contamination I will write it here they are prone for bacterial contamination, these water may be free of turbidity, there is no turbidity present but they have bacteria, they can cause disease so we have to be very careful about those shallow wells.

(Refer Slide Time: 23:24)



Now, if I want to draw water from a deep source we have a deep tube well whose depth is around 300 m. That means I can draw water from a well which is 300 m deep. This if I draw the water from 300 m deep well it is called a deep tube well. So this water definitely does not have bacteria. Thus, in the deep tube wells I don't have bacteria, deep tube wells no pathogenic bacteria. Why there are no pathogenic bacteria? The pathogenic bacteria are filtered when the pollution is entering into the river; they are all filtered that's what no bacteria may be present.

(Refer Slide Time: 24:29)



However, the water may contain some inorganic……. presence of inorganic pollutants, inorganic toxicants I will put it here, toxicants may be of concern to us, this is the concern, this is a happy

news, no pathogens but it may contain in some of the inorganic contaminants or inorganic toxicants. Example, deep tube wells may have the fluorides, deep tube wells may have arsenic so we are solving one problem but getting another problem. That's what it is going to be.

And also the ground waters generally have iron and manganese. That's what I have written here. Iron and manganese is also present in the ground water. Iron is going to cause color problem, the water may be get colored if iron is present. Iron and manganese beyond a certain limit may cause stomach disorders, stomach disorders may also be caused but that is not very important. But the most important thing is that my clothes get stained and the laundry is affected because of the presence of iron and manganese.

Now let us go to the surface water. At this time as an introduction I would like to state these things. Let us go to the surface water. Surface waters are probably most polluted waters available, polluted water sources available. So we have in the surface water, surface water may be receiving the untreated effluents form the domestic sector, untreated effluents from the industrial sector, untreated effluents from any other source also like agricultural sector they may be receiving the wastewaters. When the wastewaters are received from the domestic, industrial, agricultural sectors then the water is highly contaminated. So, if you are taking this particular basically we have to deal with problems like pathogens, we have to deal with the problems like organic and inorganic pollutants. So we have lot more problems with surface waters.

Basically surface waters do have turbidity. Turbidity is also present in the surface waters. Besides turbidity we have got the pathogens and organic and inorganic pollutants.

Now let us go to the next thing the lake waters. If you see, the lake waters are present in big reservoirs and these lake waters have a natural sedimentation in the reservoirs. Since there is no turbulence in the lake waters what would happen is that algal growth will be more. Since the algae grows and the presence of algae itself produces some taste and odor problems to water. So, if you are taking water from the lake it would have some organics which cause taste and odor. These taste and odor problems have to be dealt with in our treatment. The cost of the treatment will increase because we have to deal with the taste and odor. However, the water will have very less amount of turbidity.

Now let us go to the sea water next. Sea water is available in plenty. However, the sea water suffers……if you want to use the sea water for the domestic use or for industrial use you have to remove the salinity first and also you have to remove the total dissolved solids. So, in order to make this sea water as the potable water we have to use desalination, desalination plants are there. In fact in Middle East we have many desalination plants. They remove the solids from the sea water and use that particular water. They use reverse osmosis that is the technique that is used for making the sea water into freshwater. And in fact we have this in Tamil Nadu and some other parts we have to use the sea water for making potable water.

I have an example, in Gujarat in Bhavnagar we have desalination plant which will convert the sea water into freshwater and there are cases in Tamil Nadu also where the sea water is converted into freshwater. However, there are several problems. In order to produce potable water from sea water we do require electricity, high energy so this energy has to come from solar

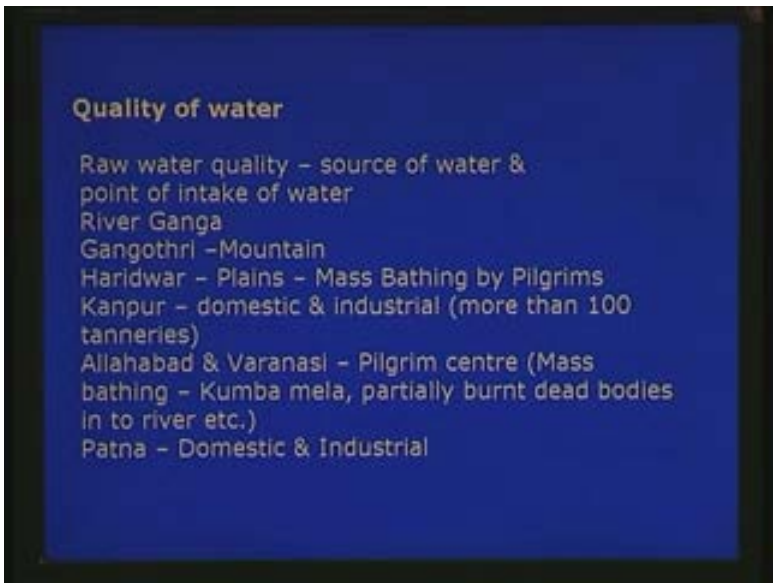
energy. If you are able to trace the solar energy then you can use the desalination very effectively.

Then fifth one is the treated effluent. You may be surprised how I could use a treated effluent as a source of water. Yes, you can use treated effluent as a source of water. The treated effluent could be used for some purposes.

Number 1; I can treat the affluent, that is I treat the wastewater and use it for gardening, I can use the water for the flushing, I can also use this water for the air conditioning. There are many industries which purchase the wastewater from the municipality and treat it. May be they even sometimes do the secondary treatment, the municipality has to do the secondary treatment, they do the tertiary treatment third degree treatment and use that water for air conditioning purposes. There are examples; that is Chennai Fertilizers or MRL that is Madras Fertilizers Limited uses this particular thing. And similarly the Chennai petrochemical limited also uses its treated effluents for water for air conditioning. So, high potential is there as far as the usage of treated effluents as water of sources.

In fact this is also called as the zero discharge that means I am not allowing any effluent going out of my premises so that is what is called a zero discharge. So next slide, let us see that after seeing the quantity we will go the quality. Quality of raw water depends upon the source of water and also the point of intake where from I am taking this particular water and also the source. Here I would like to take an example of Ganga River because that is a very important river and we have we have what is called Ganga Action Plan which gave rise to National River Action Plan strategy in India. We want to keep all our rivers clean.

(Refer Slide Time: 31:36)



So Ganga River started as spring in Himalayas at Gangothri and this spring traverses through the hills Himalayas and then comes to plain at a place called Haridwar and from there it travels on the plain, it travels on the land interior of India, it traverses for 2525 kilometers before it enters

into Gangasagar in West Bengal and it reaches the ocean there. So all along this particular river great cities have come up, great cities which are religious in nature, of religious importance, learning, scholarliness importance and also industrial. So, for example, Haridwar is a great religious center and Haridwar Ganges enters into the plains and before it enters into the plains the water is crystal clear, the water is very pure, excellent water we have, as soon as it comes to the Haridwar millions of people take bath in the Ganges River, we have got Melas, Kumbh Melas, Artha Kumbh Melas and solar eclipses, lunar eclipses, people dip themselves, want to purify themselves in Ganges River and transfer their sins to the Ganges River, definitely indeed they are transferring the pollution at least. That is Haridwar. After Haridwar the water goes to the river flows to Kanpur.

Kanpur is a place where it has got several industries, several different types of industries I would like to say. There are textiles. In fact Kanpur was known as Manchester of India, there are textile industries, paper industries, tanneries and also allied chemical industries, several industries are there, and all the industries use the water and specially the tanneries. In some of the tanneries there are more than 100 nearly 200 tanneries. These tanneries use the water and produce the wastewater and dump into the river, I mean this was happening earlier at least not now. So this water with highly putrefied effluent was going into the river Ganges and depleting oxygen from the Ganges River and as a result of which there used to be fish scales, there used to be bad smell, unsightly river used to be there as far as Kanpur is concerned.

Then after Kanpur we have Allahabad and Varanasi. Allahabad and Varanasi as you know are very great pilgrim centers. Particularly in Allahabad three rivers meet that is Sangam, Ganga, Yamuna, Saraswathi three rivers meet and Saraswathi is a hidden river. And at that Sangam people take bath millions of people take bath during the Kumbh Melas, Artha Kmbh Melas and solar eclipse and on all types of eclipse they take bath and then pour lot of ghee, sugar, milk and flowers into the river which they offer as a part of the prayer. So because of this the Ganges gets highly polluted.

Then at Banaras besides this Pooja Samagri going into the river there are even dead bodies that is half burnt dead bodies are being thrown into the river with an idea that the dead soul will get the salvation that is a belief we cant help it. So because of all these things there is plenty of pollution in the Ganges River. The river flows to Patna; Patna has got the domestic and industrial wastewater dumped into it.

(Refer Slide Time: 35:41)

India the several states of India about 2525 kilometers and reaching the Bay of Bengal. And here you can see this is in blue color this is pretty good water (Refer Slide Time: 36:00) this is somewhere in Haridwar and at Haridwar the water quality is pretty good. Afterwards it comes to Kanpur, Kanpur water quality is bad and then you can see here after this the river revives to some extent and again from Allahabad to Varanasi the water is little better than what is there at Kanpur because Kanpur has industrial pollution and then afterwards it reaches Patna and from Patna again the color is changed to the bad quality water.

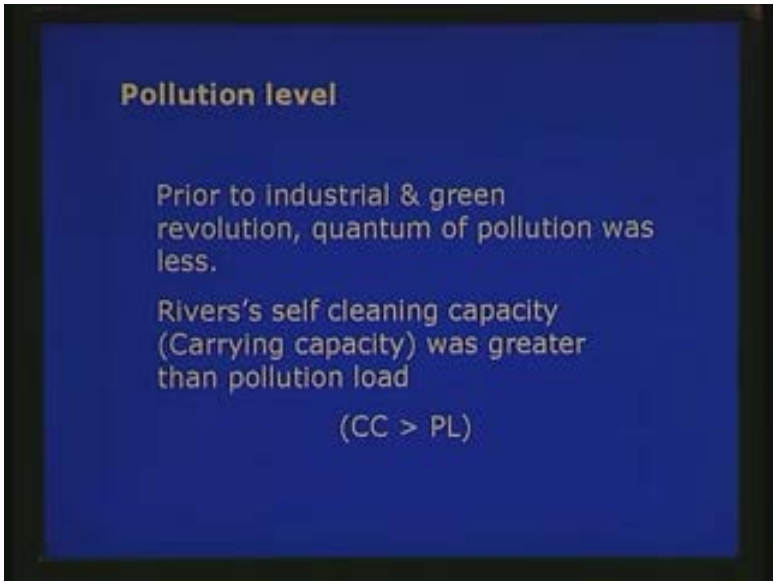
In fact the river reaches the Bangladesh as Padma River and a part of the river reaches the Gangasagar. By this slide I want to explain one more point. If you want to take water for supply, if you want to take this as a raw water for supply from……. see for example from here Haridwar we have very good water, the raw water quality is pretty good and hence the treatment that should be given will be less and the cost of treatment also will be less. As you pick up the heavily polluted water then the pollution is more and hence the treatment has to be more extensive and may be the cost of treatment will be more.

So, all along the river the cities like Kanpur, Allahabad, Varanasi, Patna etc the treatment has to be more extensive than that it can be given at Varanasi. So these are some of the aspects we would like to say on the quality of water when you look at the river. In fact Government of India has instituted a program called Ganga Action Plan. What they want to do is that specially at Kanpur they want to divert all the wastewater untreated wastewater going into the river they want to divert it, intercept it and divert it and then bring it to a treatment plant, treat the wastewater and then again put back the treated effluent in the Ganges River. This is what is called….. under Ganga Action Plan they were doing it.

Now, National River Action Plan has come wherein every river has this plan by means of which they are trying to treat the wastewater, the untreated wastewater going into the river is being

intercepted, diverted, treated and then discharged into the river. This is a progressive thing what is being is done now.

(Refer Slide Time: 38:29)



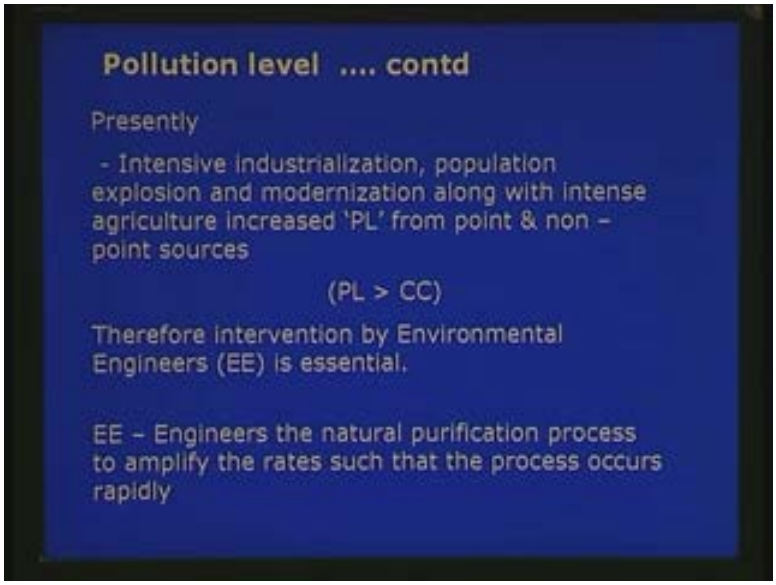
Now, if you take this, how exactly this pollution is happening and what is the capacity of the environment to take up the pollution then we will move to what is called pollution level. I want to introduce another term what is called pollution level and also introduce another term what is called carrying capacity. All rivers for that matter environment in general has got what is called carrying capacity.

Carrying capacity is nothing but the environment can assimilate the pollution dumped on to it. It can assimilate and it can take care of the pollution put on to it. If the pollution were to be natural pollution, if the pollution is biodegradable pollution then the nature can take care of it very easily. If the pollution is not natural, if pollution is man made that is what is called anthropogenic pollution, pollutants are anthropogenic one simple I can give of anthropogenic pollutant is plastic, plastic covers which we use. These plastic can stay in the environment for years together for long time, even my great grand son can also see the plastic cover which I have used they are non-biodegradable organic matter. Now of course we are trying to manufacture biodegradable plastics.

So what I am trying to say that the environment has got what is called a carrying capacity and this carrying capacity is restricted to only natural pollutants not to the anthropogenic pollutants. For example, pesticides are there, pesticides are man made thing and environment does not have answer for it. These pollutants keep on accumulating in the environment and hence they are called as conservative pollutants. Conservative pollutant means they will not get destroyed. So the carrying capacity is not there for those pollutants. While for biodegradable things the environment has got what is called carrying capacity, rivers have got self cleansing capacity or self purification capacity that is what is called carrying capacity of the river.

Earlier when there was not much of industrialization in India and also not much of green revolution in India then what was happening is that the pollution level was less than the carrying capacity of the environment. In this case let us take the river, self purification capacity of the river. So it used to be that the carrying capacity was always greater than the pollution level and there was not much effect of pollution prior to this particular thing. However, we want to have industrialization. Definitely industrialization is required, we have to progress and we have to have green revolution and because of that we have got surplus food today. Green revolution is a must and in green revolution what we have used is we have got plenty of fertilizers, different types of fertilizers, we have used different types of pesticides, insecticides so that we can avoid the competition from these insects and pests that's why we have used insecticides.

(Refer Slide Time: 42:06)



So the green revolution has brought in the pesticides and insecticides and fertilizers into the arena of our chemicals. Population explosion is there, high population growth is there in the country and because of this domestic wastewater has increased and we have modernization, we would like to have air conditioning, we would like to have automobiles, we have got you know carbon monoxide, carbon dioxide, Nox, Sox, oxides of nitrogen, oxides of sulphur, hydrocarbons in the atmosphere so all those things are there because of intense modernization with respect to automobile industry and also we have the cfc's for the air conditioning. So because of this particular thing we have many many pollutants being introduced into the environment and environment does not have answers to these new anthropogenic pollutants and as a result of which the pollution level is greater than the carrying capacities of environment.

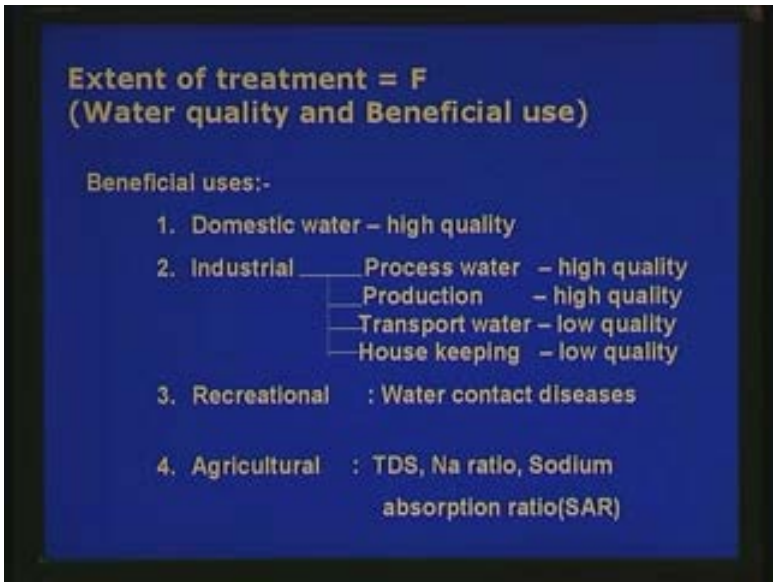
Therefore, when pollution level is more than the carrying capacity the problems have started, we have the problems. the problem is that we have skies laden with smoke, rivers having fish kills no oxygen depleted oxygen in that particular thing and everywhere the solid waste is around in the towns and in cities, this is the scenario now. I am not suggesting that we should not have sustainable development, we should have sustainable development. Sustainable development is how to develop with a concern for the environment, we should not destroy the environment

during the process of development. So at this moment of time there is a role for the environmental engineer. So, intervention by the environmental engineer is needed at this time to change this inequality, inequality is that is pollution level now should be less than carrying capacity that's what I want to do as an environmental engineer.

So what does an environmental engineer do is, environmental engineers what they do is they engineer the processes that are that are present in the nature. That is processes like self purification, they study those processes and increase the rate of reactions of those processes and make these processes to occur in a limited space or limited volume called a treatment plant that's what he does.

So, a reaction which is taking place in the river in 100 days. Now the environmental engineer can do the same reaction, can perform the same reaction, can allow the same reaction to take place in 10 days time or in 10 hours time or in 10 minutes time so that is his capability. Now that he is able to amplify the reaction rates in such a way that the reaction takes place in a limited amount of time within a short span of time. Nature also does the same thing but it does with a lot of time may be 100 days it takes. So that's what it does. He does that particular thing; he is trying to do only that particular thing that he learns from the nature.

(Refer Slide Time: 45:46)



Now let us take that I have introduced a treatment, treatment is required, treatment is done by the environmental engineer. Now you may ask me what is the extent of treatment to be done. Extent of treatment, if I take the water treatment, extent of treatment to be given depends upon the water quality and beneficial use of water. And the water quality depends upon at what point you are taking, am I taking water from Haridwar, am I taking water from Kanpur, am I taking water from Banaras or Varanasi it all depends, quality depends on the place at which I am taking the water. And beneficial uses are the following: One is the domestic use, industrial use, recreational use and agricultural use.

In the domestic use if I want to supply water to the domestic it has to be high quality, quality of water should be very very high. That means safety is most important thing for me. I want no pathogen to be present in water; I want no heavy metal to be present in water if I want to supply the water to the people. And from the consumer point also I should satisfy the water quality that is water should be pleasing, water should not have taste, water should not have color, water should not have suspended particles so a high quality water. And in industry water is required for various purposes. One purpose is processed water. Processed water is use of water in the process in the production of a produce.

So, for example, we have the steam water, steam generation. I want to generate the steam. Steam is generated by using the water and that water should have no hardness. You should not have minerals and hence I should have a treatment called demineralization. I should remove all minerals from water for boiler feed purposes.

Now, second is the production water. Production water is water becomes an integral part of the produce. Example; if I take the food processing industry, beverages or soft drinks the quality of water that is used in manufacturing the soft drink should confirm to the standards of drinking water. It should not have, it should not have pathogens, it should not have pesticides, it should not have any toxic chemicals that is what it is. If I am producing textiles I should not have iron, I should not have any components present in water which cause color to the textiles. Similarly, if I am producing paper it should not cause any color to the paper because I want to produce excellent paper, I want to produce excellent textile, not color textile and so on and so forth.

Then third water is transport water. Water is used for transporting the material within the industry may be lumber industry, timber etc they are all transported through water.

Another thing is house keeping. For house keeping purposes we could have low quality water. I don't have to have production water or processed water quality. And another important use of water is the cooling water. Cooling water is the water which picks up the heat from the equipment from heat exchanger and so on and so forth and the temperature of the cooling water increases. So the temperature is a pollutant there. That water quality can also be low.

Next we have got the recreational water, water that is used in the swimming pools. This water should have a quality of not having any organisms which is caused due to water contact. They should not produce water contact diseases. For example, the swimmers itch is caused by a fungus so water should not contain fungus. Also, another disease which is normally transmitted through swimming pools is the conjunctivitis that is red eyes that should not be present. Third thing is that water should not have excess chlorine. If swimming pool water has excess chlorine it will cause irritation to the eyes and mucous membranes.

The fourth beneficial use of water is agricultural water. This agricultural water is where large quantity of water used for agricultural purposes. The water quality for agriculture is of importance. For example, the water should not have high TDS, it should not have high sodium content, it should not have high SAR Sodium Absorption Ratio. If these quantities, these parameters are higher than the required quantities then what would happen is that they will have certain problems.

Number one; problem is the plant will not get enough calcium; calcium does not enter into the plants.
Second thing is that the sodium will form salinity to the soil. Salinity of the soil will increase and as a result of which the soil becomes non-fertile, fertility of the soil will decrease.

The third thing is SAR Sodium Absorption Ratio. If these things are high what would happen is that (all these things together I would not like to separate out) the soil becomes impervious. When soil becomes impervious oxygen transfer of atmosphere will not take place to the root zone it cannot go down, at that time we have to disturb this impervious soil which is called as tilling, you have to do tilling. So, when you do tilling the cost of agriculture is going to increase. That's what is the beneficial uses and that dictates the quality of water.

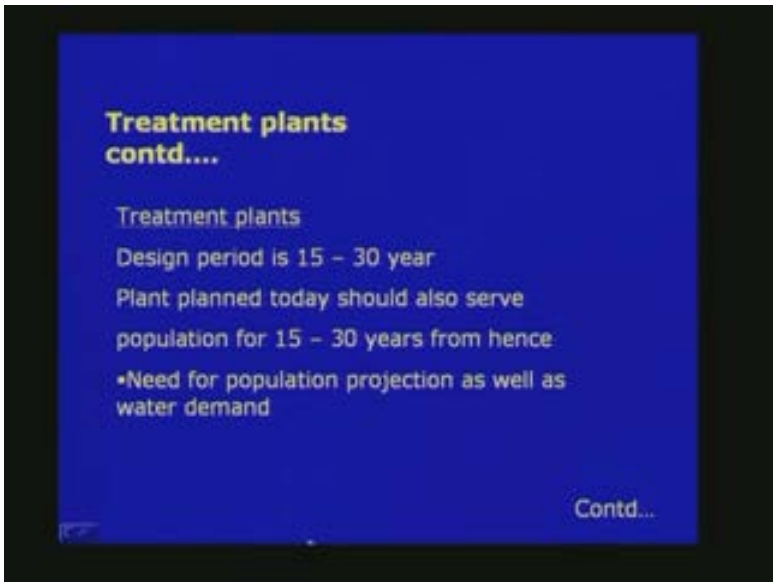
Next, in order to do this quality enhancement we require treatment plants. There are several treatments plants. In this I want to say that water is a continuum. This is a very important thing. This is a continuous phase, for example, the wastewater discharged at Haridwar becomes water at Kanpur. The wastewater discharged at Kanpur becomes water at Allahabad and so on and so forth. That means it is a continuous phase.

(Refer Slide Time: 52:17)

Therefore, in other words, water is a continuum, there is no difference between water and wastewater except in quality and wastewater is nothing but 99.99 percent water and remaining solids. But these solids are biodegradable solids and that is what we said. So the difference is in biodegradable organic matter. So what I would like to say is that whatever treatment technologies I employ for treating the water same technologies could be applied with modification to wastewater treatment. Principles; basic, physical, chemical, biological principles are being the same, only thing is the modifications are required. However, for treating the wastewater I require additional treatment units because I want to remove the biodegradable organic matter. So the selection of treatment now depends upon the nature of pollutants.

Depending on the nature of the pollutants we have the selection of treatment processes treatment technologies. If you see the nature of pollutants the pollutants can be divided into three types of categories; one is the pollutants in the molecular form, pollutants in the colloidal form, pollutants in the coarse form. All these three categories is based on the size of the particles.

(Refer Slide Time: 53:40)



For example, if the size of the particle is 1 nanometer or less, nanometer is 10 to the power of minus 9 m; if it is less than that particular thing then it is called a molecular form. For example, calcium, magnesium, sodium are in the molecular form. The colloidal form could be divided into two categories again. One is called ultra microscopic where the size is about 500 nanometers size is very less so you can see only with the ultra microscope like electron microscope. Another one is the microscopic. Microscopic can be seen with the help of a microscope.

Coarse one is the bigger particles, the size is about 20 micrometers. So, in order to remove these pollutants we do require treatment systems, we require a treatment system and in order to have a treatment system we have to design treatment plants, these treatment plants have got their design periods and most of the times the design period of a treatment plant is 15 to 30 years. That means if you design a treatment plant now it should be able to serve the population at this time and also should serve a population 30 years from today that's what should be the design treatment plant. In order to do that, we need to go for population projection methods because I should know the population after 30 years. In order to know that we have got the methods for population, projection and this will be taken in the next class.

(Refer Slide Time: 55:18)