Watershed Management

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Module No. # 07

Management of Water Quality

Lecture No. # 27

Surface Water Quality and Pollution Issues

[FL] and welcome back to the video course on Watershed Management. Today, we will start a new module, module number 7. In this module, there will be four lectures- lectures 27, 28, 29 and 30.

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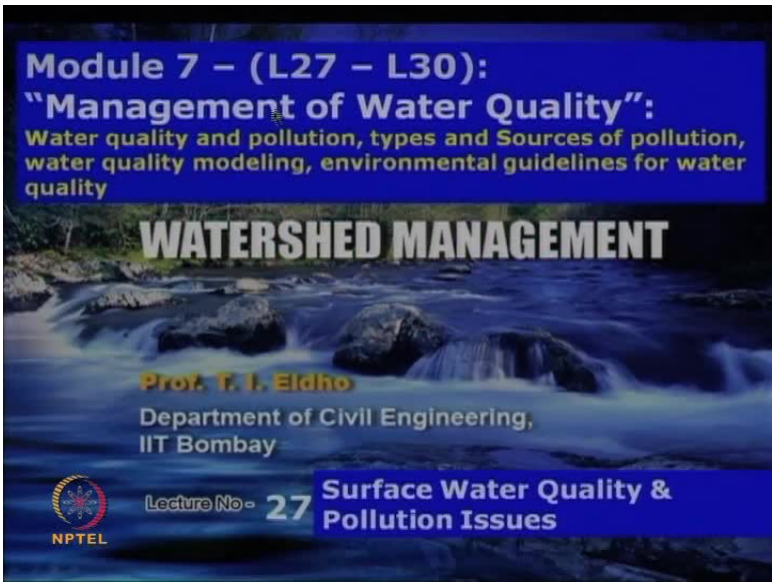

The title of this module is management of water quality. This is specific to the watershed related aspects. So, the topics covered in this module include water quality and pollution, types and sources of pollution, water quality modeling, environmental guidelines for water quality. So, today in lecture number 27, in this module number 7, we will discuss about surface water quality and pollution issues.

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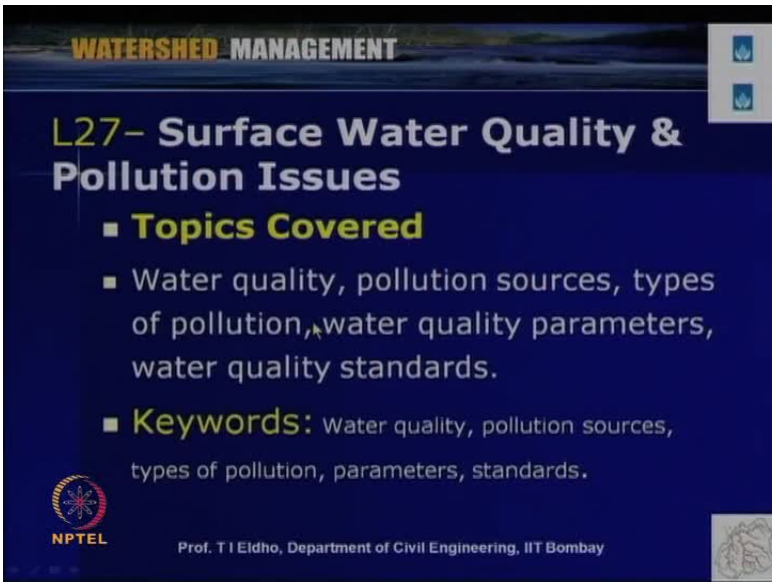

Some of the topics covered in today's lecture include water quality, pollution sources, types of pollution, water quality parameters, water quality standards. Some of the key words for today's lecture: water quality, pollution sources, types of pollution, parameters standards. So, as we discussed earlier, as far as watershed management is concerned; water as a resource, what we have to consider? We have to see the water availability, the quality of water is very important, but when we deal water as a resource, the quality of the water is also very important.

We have to see that the available water is protected, so that quality is good. While studying the quality of the available water, we have to see the whether there is any pollution has already taken place. If the pollution has taken place, what is the amount of pollution and what are the components of that pollution within the water? What are the sources of pollution, so that we can see that whether we can reduce the pollution or go for some remedial activities? When we discuss about watershed management, water quality is a very important issue.

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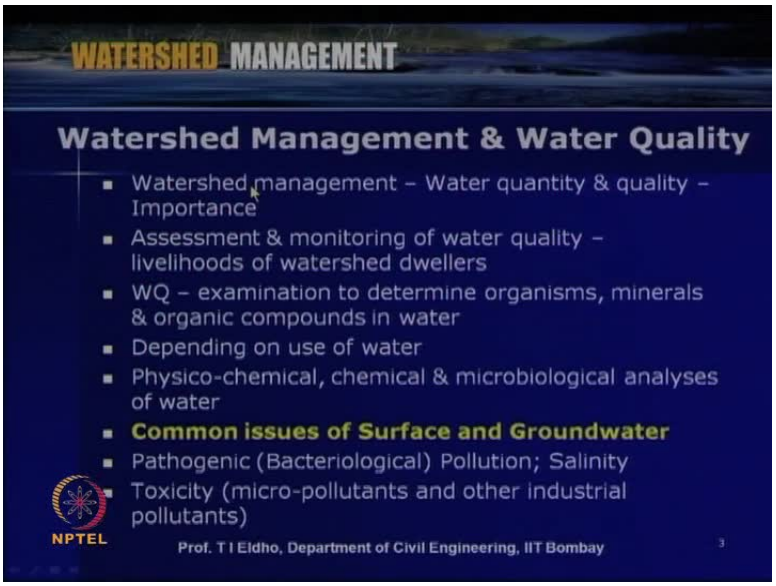

Let us look into various aspects of water quality as discussed in this slide. As I mentioned in water watershed management - water is the most important resource in watershed. So, both water quality and quantity are important, so not only the quantity, but quality also should be good. If more water is available, it does not mean anything, but quality also should be good for safe usage, for domestic, for drinking purpose or any other purposes.

Assessments and monitoring of water quality is very important. As we discussed, this is very important for the livelihoods of watershed dwellers, it means the people living there. It may be water used for domestic purpose, drinking purpose or irrigation purpose or whatever the purpose. It is very important that the quality is assessed properly and monitored, so that the safe water or good water is available to the people.

Water quality actually means that, we have to see whether water component is exceeding certain limits of whatever that is being considered. Water quality gives the examination or water quality is the examination to determine whether there is any organisms, minerals and the organic compounds within the water; whether it is exceeding certain standards. So that is what we are trying to do through water quality analysis.

As standards are concerned, the standards vary depending upon the use. So, for example, drinking purpose is concerned, we want best quality. For irrigation purpose or other

purposes, the quality will be different and for industrial purpose, the quality can be different. We have to assess the quality of the available water through physico-chemical examinations or chemical test and microbiological analysis. Various steps of analysis like physico-chemical chemical or microbiological analysis are very important.

When we consider the water available within a watershed, as we discussed the water can be either surface water just like what is available in a lake or in a river or it can be groundwater, which we are extracting from the aquifer systems through tube wells boreholes or the open wells. Some of the important issues, which generally we have to see that the water is not affected by bacteriological pollution or pathogenic pollutions. How much is the salinity or the dissolved solids within the water? Is there any toxicity in the water like micro pollutants and other industrial pollutants, which may percolate into the water resources like in a river lake or to the groundwater system?

These are some of the common issues, which we have to deal when we discuss about the water quality in surface water quality or groundwater quality. When we discuss, we have to see and analyze various samples and see that whether any pollution is there and then compare with the standards like World Health Organization standards or Indian standard institute standards or various types of various country standards. If it is not meeting, then we have to see what can be done. We have to discuss and we have to see as far as water quality is concerned on a watershed basis, when we deal with the watershed management.

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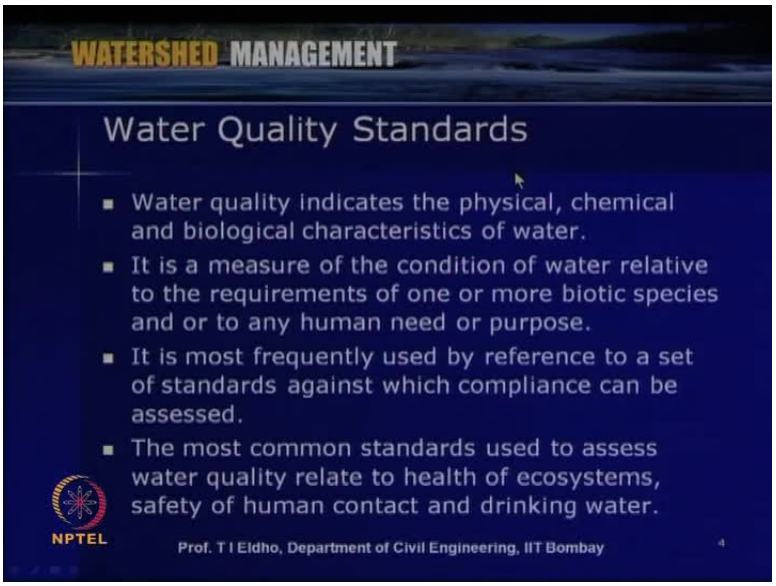

Let us see the important aspects related to water quality standards and water pollution etc. As I mentioned, water quality indicates the physical, chemical and biological characteristics of water. So, water quality indicates how the physical… like color, then what is the turbidity, what is the taste. Chemical like how much TDS is there, it is total dissolved solids or any heavy metals or any other chemical pollution is there.

Biological characteristics like any pathogens are there. So, as far as water quality standards are concerned, it is a measure of the condition of water relative to the requirement of one or more biotic species and or to any human need or purposes. As I mentioned earlier, whether it is for human consumption or whether it is other purposes like irrigation or industrial. According to the needs, we have to assess the quality of the water. So, it is most a frequently used by reference, I mean the water quality standards by reference to a set of standards like WHO or World Health Organization standards or Indian standard institute standard or VIS standards or US environmental protection agency standard.

Various standards are available, so we will be comparing with those standards with respect to the various test and then we will see that whether compliance is met as far as the particular samples or particular source is concerned. We have to see whether that particular usage is permitted or not. The most common standards used to assess water quality related to health of ecosystems, safety of human contact and drinking water is

generally the most common standards with respect to World Health Organization Standards. So, we have to go through various tests and see that the samples are complying with this standards. Accordingly, we can decide whether water can be used for domestic or industrial or agricultural or various other purposes.

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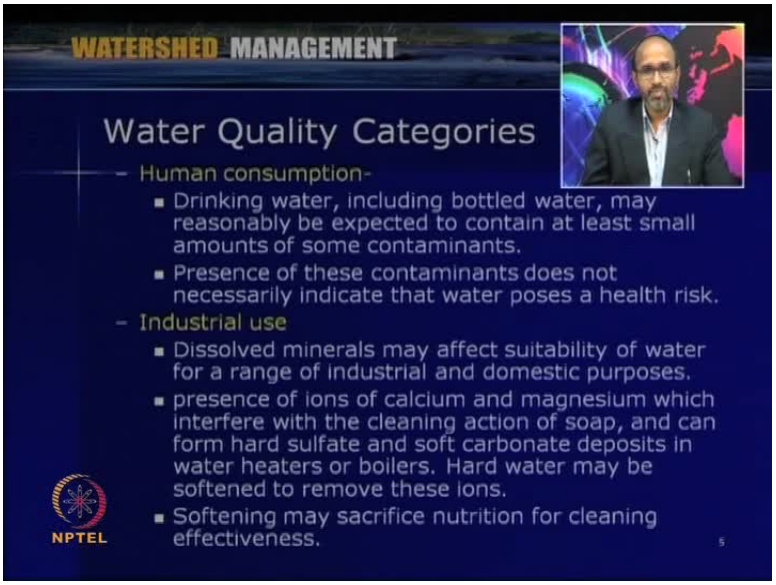

When we discussed about the water quality standards and categories, I mentioned that when we do this kinds of analysis, we could categorize into various category depending upon the usage of water. For example, when we are discussing about human consumption, we are using the water for drinking purpose including bottled water. In our cooking and other purposes, water is expected to contain at least small amounts of some contaminants. It may not be the purest form of the water just like the rain water or distilled water, but may be some total dissolved solids or some minerals etc will be there within the water.

Presence of these contaminants does not necessarily indicate that water poses a health risk. So, for human consumption we are not looking for purest form of water just like a distilled water, but there can be some type of contaminants or minerals within the water. As far as industrial use is concerned, the dissolved minerals may affect suitability of water for a range of industrial and domestic purposes. So, depending upon the industrial use, for example - the hardness of the water, if calcium and manganese, which interfere with the cleaning action of soap can form hard sulphate and soft carbonate deposits in

water heaters or boilers. So, hard water may be softened to remove these type of ions. Wherever the water is hard, we have to make it soft depending upon the industrial purpose, so that we have to do some chemical treatment. Similarly for human consumption, we have to make it palatable and we have to purify it through filtration process or chlorination like that depending upon the requirement.

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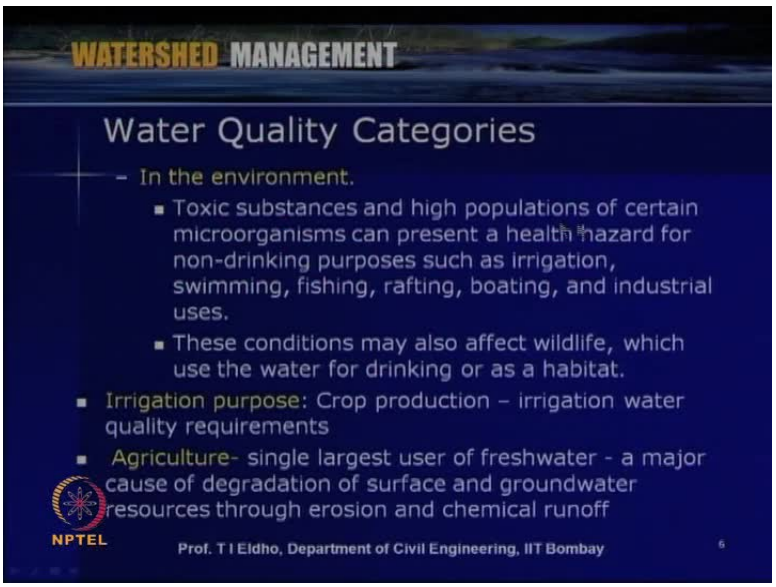

As far as the environment is concerned, it is like ecological use for the agricultural uses or whatever the uses. In the environment, the toxic substances and high populations of certain microorganism can present a health hazard for non-drinking purposes such as irrigation, swimming, fishing, rafting, boating and industrial uses. As far as these types of uses are concerned, we classify this as environmental use for plants or ecosystems or fish or that kind of purposes. Here, the standards will be different, conditions may also affect wildlife, which use water for drinking or as habitat. For example, some of the components can be higher, since we are not strictly following whatever is there for human consumption, so that way it will be standards and they will be different.

For irrigation purpose, we can see that overall in the world, about 70 percent of the water usage for irrigation or crop requirement. In India, it is especially going to be 80 to 85 percent, so that irrigation water quality requirements will be different. So, we do not have to go through these kinds of treatment, but of course some of the components like

salinity and other parameters are very important, otherwise the crop will be affected or crop growth will be affected.

Agriculture is a single largest user of freshwater. It is a major cause of degradation of surface and groundwater. It can also be coming from the agricultural usage like when we are putting fertilizers or herbicides or pesticides that may leech into surface water or groundwater. Agricultural can be also be a source, but for irrigation purpose, for crop use purpose and the standards will be different, so that way water quality categories like human consumption or the industrial use or the ecological purpose or irrigation purpose and various standards are available. Accordingly, we can decide the available water that is suitable for that particular use or not.

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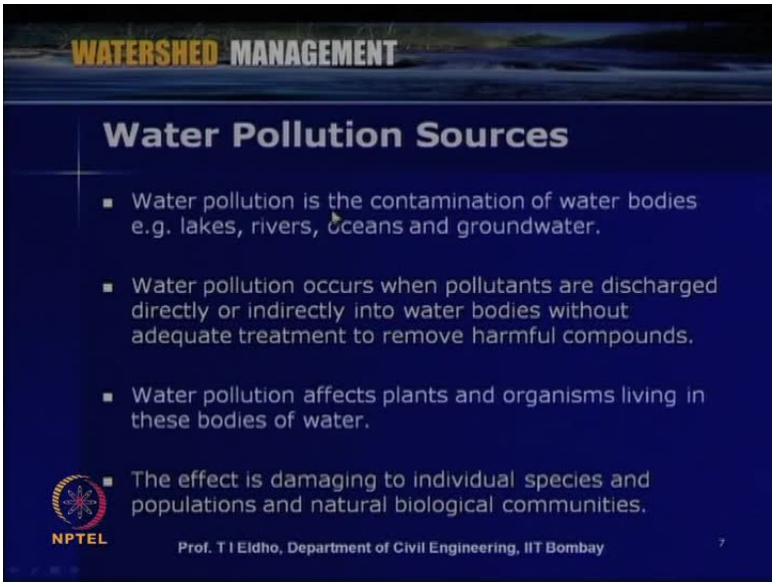

Now, let us discuss what the important sources of these types of pollutions are. When we consider a watershed or a river basin, what are the various sources of pollutions. As I mentioned, water pollution is the contamination of water bodies, so either water in lakes, rivers, oceans or groundwater. Whenever certain components are exceeding certain limits, we call it as contamination.

Water pollution occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds, for example, if an industrial effluent is coming through a large number processes within the industry;

certain components may be much more higher than expected with respect to certain standards. If we do not treat the industrial effluent to the acceptable limit, then that become a source of pollution.

This water pollution affects plants and organisms living in these bodies of water. The living plants or aquatic life will be affected due to this pollution or the water, which is utilized by the plants for irrigation or other purpose will also be affected. So, the effect is damaging to individual species, populations and natural biological communities, so that way we have to see that the water available is of good quality for the intended use.

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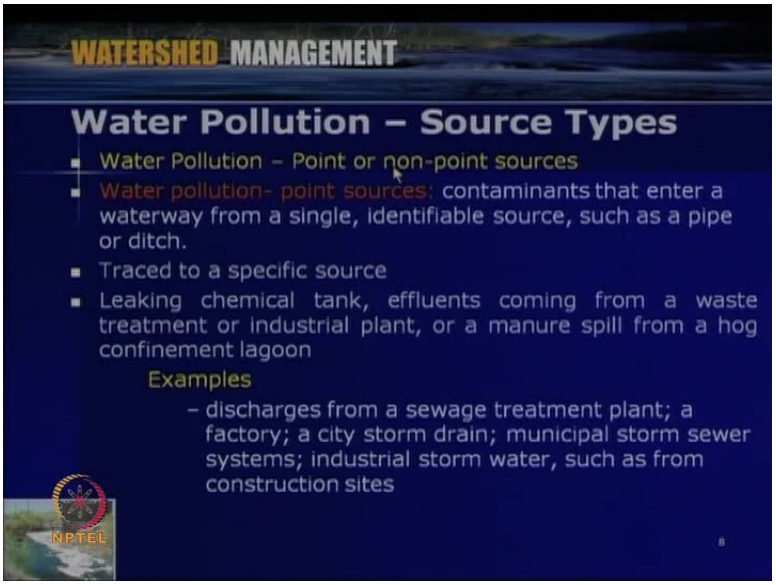

Now, as far as water pollution source is concerned, we can generally classify into two types. One is so called point source and another one is called non-point source. Depending upon what is coming and what is polluting, according to that classification is done. First one is water pollution point sources. So, point sources means contaminants that enter a waterway from a single identifiable source such as a pipe or ditch. For example, the effluent coming from an industry is directly put into to a lake or put into the ocean or put into the river. That is coming as a point source or the effluent that is coming from the effluent treatment plant or the drainage systems, so that we can consider it as point source.

This point source can be traced to a specific source. So, it can be leaking chemical tank, effluents coming from a waste treatment or industrial plant or a manure spill from a hog confinement lagoon etc. So, number of examples like discharge from a sewage treatment plant, a factory, a city storm drain, municipal storm sewer systems, industrial storm water from construction sites etc, so there are number of examples. This point source is a major source of pollution especially in urban areas. So, in urban areas, the appropriate treatment is not given for industrial effluent or the effluent or the sewage. So, this become a major source of pollution to the water sources like lakes, rivers or even to the groundwater.

This point source is easy to identify, since we can easily chase exactly from where it is coming from. We can also go for remediation that means by putting curtail to the that source or by enforcing agencies to treat that effluent coming from industry or coming from the sewage treatment plan. We can go for remediation or go for controlling this type of point source of pollution, so point source pollution is easier to deal as far as water quality is concerned. We can try to control through various means easily and other one is called non-point source of pollution.

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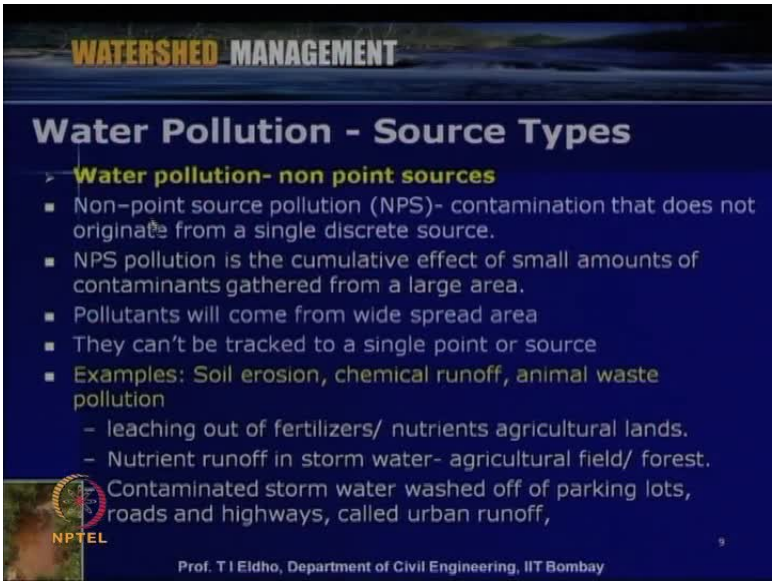

Here, the non-point source of pollution or NPS is the contamination that does not originate from a single discrete source. So, we cannot easily identify whether it is coming from one particular industry or like that. It is generally from the agricultural

lands or the sedimentation that are coming from the watersheds etc. NPS or Non-Point Source is the cumulative effect of small amounts of contaminants gathered from a large area. So, this is coming from an overland flow or the paddy fields or the irrigation water or the crop water, which we provide. When we put fertilizers or manures or herbicides or pesticides and all these will be leaching to the groundwater system or directly joining to the streams or rivers. So, this pollutant will come from wide spread area and as I mentioned, they cannot be tracked to a single point or source like soil erosion, chemical runoff, animal waste, pollution etc.

Examples like leaching out of fertilizers, nutrients from agricultural lands, nutrient runoff in storm water - agricultural field or forest, contaminated storm water washed off from parking lots roads and highways, called urban runoff. So, these are some of the examples as far as the non-point source of pollution is concerned. Even though we can identify how much is the pollution by taking samples from the particular sources, but it is not so easy to identify these sources. Controlling the sources is also very difficult and that way the remediation has also become difficult.

If you consider the overall water quality issues or water pollution sources throughout the world, non-point source of pollution is a major source of pollution compared to point source. For point source, we can easily identify from where this contamination is coming from industries or sewage treatment plant or whatever it is. The non-point source of pollution it is very difficult to identify and the controlling also is much more difficult.

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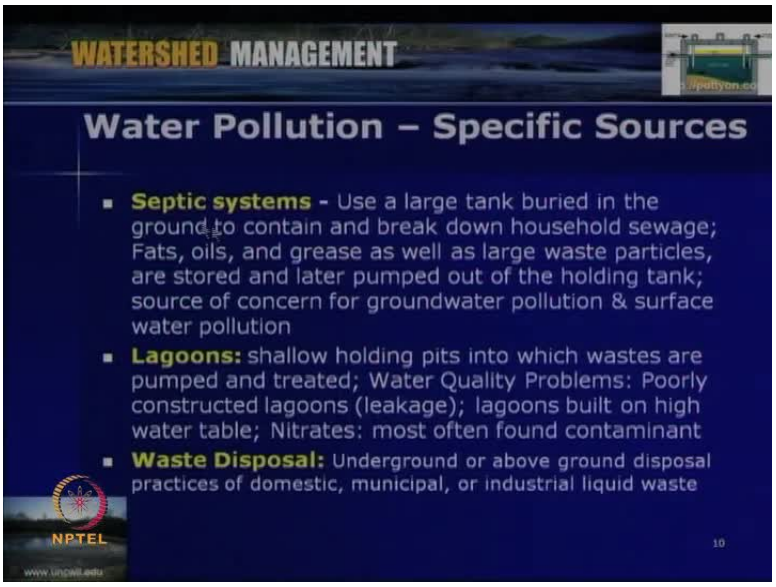

Now, let us discuss within this context, especially point source. What are the specific sources as far as water pollution is concerned? Here, I have listed some of the specific sources like septic systems, where we use a large tank buried in the ground to contain and breakdown household sewage; fats, oils and grease as well as large waste particles are stored and later pumped out of the holding tank after keeping some time, so that some stabilization to takes place.

Septic tanks are source of pollution concerned to groundwater. If there is any direct leakage in the inlet to the septic tank, then we keep it for some time and some of the things settle down. If they set a breakage for these system or overflow takes place, then it become the source of pollution either to groundwater system or the surface water systems. Sources like lagoons, where in shallow holding pits, wastes are pumped and treated in cities, when we go for sewage treatment plans and we put this waste water into lagoons.

Water quality problems like poorly constructed lagoons, leakage can take place from these lagoons. Lagoons built on high water tables can penetrate to the aquifer systems and from here, nitrates and various other heavy metals can takes place. Waste disposal plans like underground or above ground disposal practice or domestic municipal or industrial liquid waste, so how we are treating the waste disposal? Waste disposals especially in industries or cities are concerned; it is the major problem. If these wastes,

especially wastewater is not collected properly and treated through various systems, then this water will be joining the lakes, rivers or oceans. It will be seeping down to the aquifer system, so that become a major source of pollution. So, waste disposal or wastewater is one of the major source of water pollution to the surface water as well as to the groundwater.

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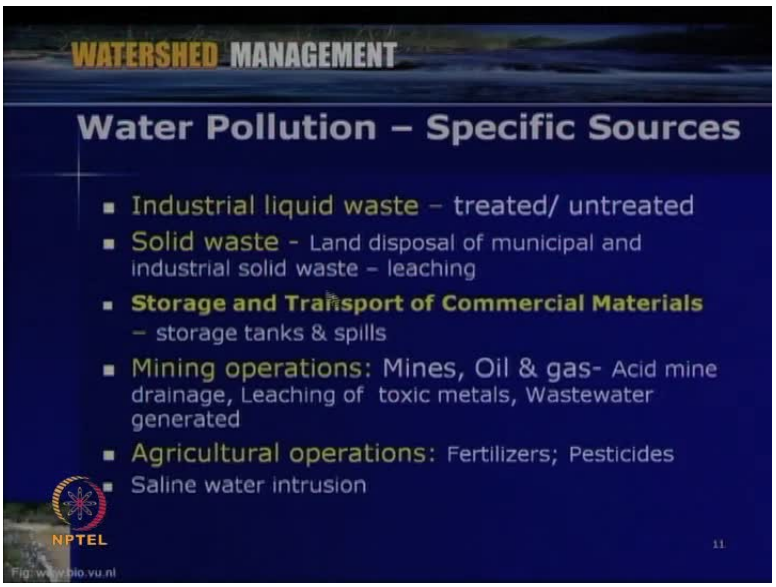

Some other specific sources have been listed here like industrial liquid waste; as I mentioned, treated or untreated. Then solid waste especially, in cities we do land disposal; landfills will be constructed either scientific land fill or unscientific. In India, for example, unscientific landfills - Landfill in a particular zone, say when it comes with rainfall or rainwater, a leach will be produced and this will be leaching down to the to the aquifer systems or it will or flow through the system to the nearby surface water sources, so that is from the solid wastes.

Storage and transport of commercial materials - if any tanks or the spilling takes place or the breaking of tanks takes place, then that will be source of pollution. We can see that in ocean also, due to the breakage or the tanker spilling in ships can be also source of pollution. Another source of pollution can be mining operations. Mines use a lot of water for various purposes and that wastewater will become a source of pollution. Oil and gas - acid mine drainage, leaching of toxic metals and all these have become source of pollution.

As I mentioned earlier, agricultural operations as non-point source of pollution. Whenever we put fertilizers, pesticides, it becomes a major source of pollution. So whatever fertilizers or manures we put, some parts will only be used by the plants and major portions of these will be coming to the surface water or to the groundwater and that become a source of pollution as far as the water is concerned.

Another source of pollution can be in coastal regions, when the sea water is increasing to the river water or the aquifer system. The sea water intrusion takes place in the aquifer system, so that also becomes a source of pollution. Various reasons can be there for these kinds of pollution due to the sea water intrusion. These are some of the specific sources as far as water pollution is concerned.

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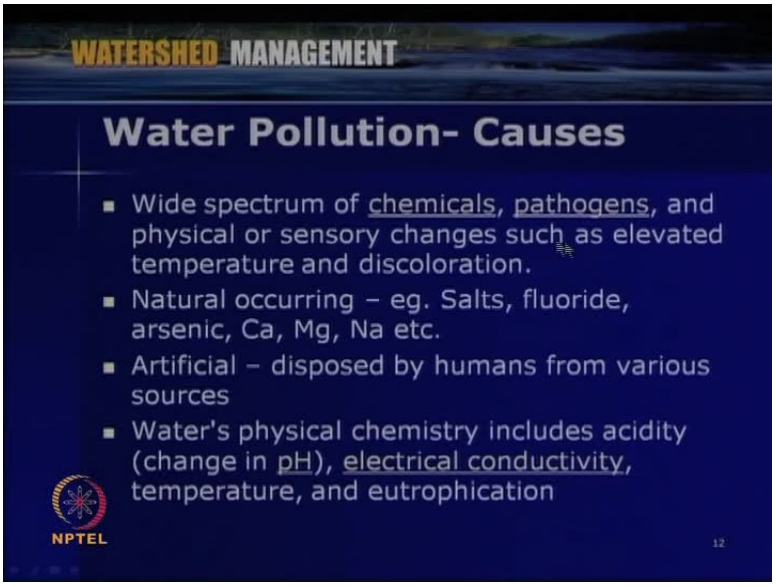

Now, let us look into what are the important causes as far as water pollution is concerned. In this slide, wide spectrum of chemicals, pathogens and physical or sensory changes such as an elevated temperature and discoloration and all these can be causes as far as water pollution is concerned. So, when some chemical components exceed certain limits or when pathogens are introduced within the water, it becomes the causes of pollution. Nowadays, huge amount of water is used for cooling purposes in a thermal power plant, so the temperature becomes another source of pollution.

Natural occurring causes can be like salts, fluorides, arsenic, calcium, magnesium, sodium etc. This will be due to rainfall or water passes over these kinds of salts that dissolve and become a source of pollution and manmade or artificial like disposed by humans from various sources from industrial or sewage or other kinds of things. Water's physical chemistry includes acidity like change in pH, electrical conductivity, temperature and eutrophication. So, all these indicates the type of pollution that is taking place. Physical examinations like the temperature, eutrophication or color or smell and from that also we can identify what is cause of water pollution. It also gives initial assessment and some of the samples can be collected and assessed to see that what kind of pollutions are there and accordingly we can look into the various aspects of the water pollution.

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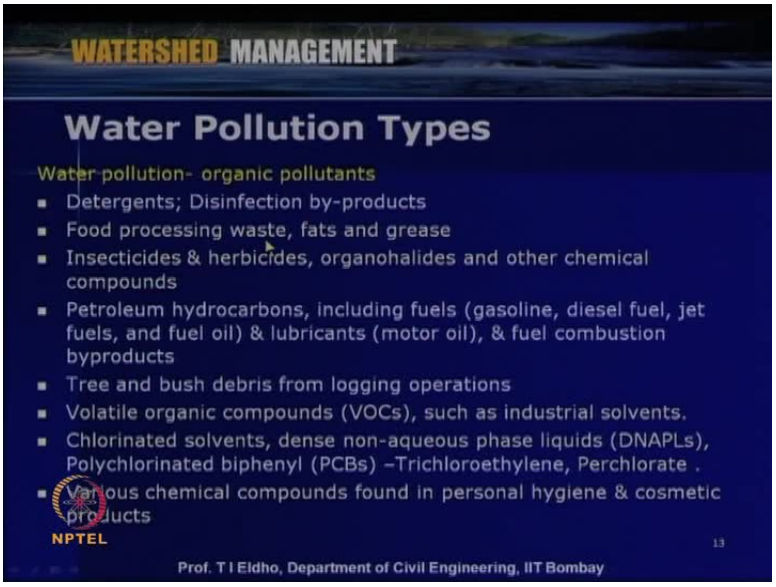

Now, let us look into the different types of pollutions like water pollution. As I mentioned, the pollutants can be that I have mentioned. Some of the components are more or less depending upon on the water, which is particular for the specific use. So, the pollution type can be organic pollutants like detergents, disinfection by by-products, food processing, wastes, fats and grease.

Next, we have insecticides and herbicides, organohalides and other chemical components. Petroleum hydrocarbons including fuel, lubricants, fuel combustion by-products, tree and bush debris from logging operations, volatile organic contaminants

such as industrial solvents, chlorinated solvents, such as DNAPL, polychlorinated biphenyl, trichloroethylene or perchlorate and various chemical compounds found in personal hygiene and cosmetic products. The water pollution type can be organic pollutants or inorganic pollutants. Organic pollutants are given in the slide, so it can be coming from detergents, petroleum products, volatile organic compounds or various things that we use for various cosmetic products or personal hygiene products. So, these type of pollution can be organic.

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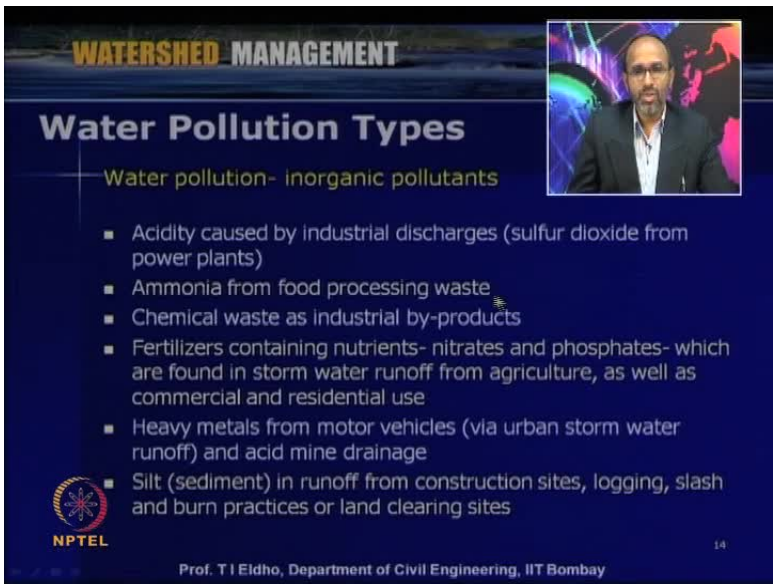

Another type is the inorganic pollutants. Here, I have listed some of the inorganic pollutants like acidity caused by industrial discharges like sulphur dioxide from power plants, ammonia from food processing wastes, chemical wastes as industrial by-products. Fertilizers containing nutrients-nitrates and phosphates, heavy metals from motor vehicles, silt or sediment in runoff from construction sites, logging, slash and burn practices or land clearing sites etc. All these introduce inorganic pollutants to the water. So, the pollutants can be classified into two types and one is organic pollutants and second one is the inorganic pollutants.

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Once we assess the water samples through various lab tests, we can assess that whether it is organic or inorganic and accordingly we can suggest typical type of treatment for the water, which we are trying to use for specific purposes. The pollution also can be macroscopic or microscopic pollutants. In this slide, macroscopic means it is a large visible item polluting the water. This may be termed as floatables in an urban storm water context or marine debris found on the ocean or open seas.

Trash or garbages, dumping of rubbish, nurdles, small ubiquitous waterborne plastic pellets, shipwrecks etc are all under the category of macroscopic pollutants. Microscopic pollutants like microorganisms within the water, dissolved or dispersed pollutants, which cannot be easily visualize. These kinds of pollutants are macroscopic type of pollutants; we can visualize and do the necessary treatment, but microscopic pollutants are concerned. We may have to go for various tests to identify what is the real pollution within the water. The pollutants can either be macroscopic or microscopic and then as I mentioned, nowadays due to lot of water used for power generation and then cooling, we use huge quantity of water, so thermal pollution is a major source of pollution.

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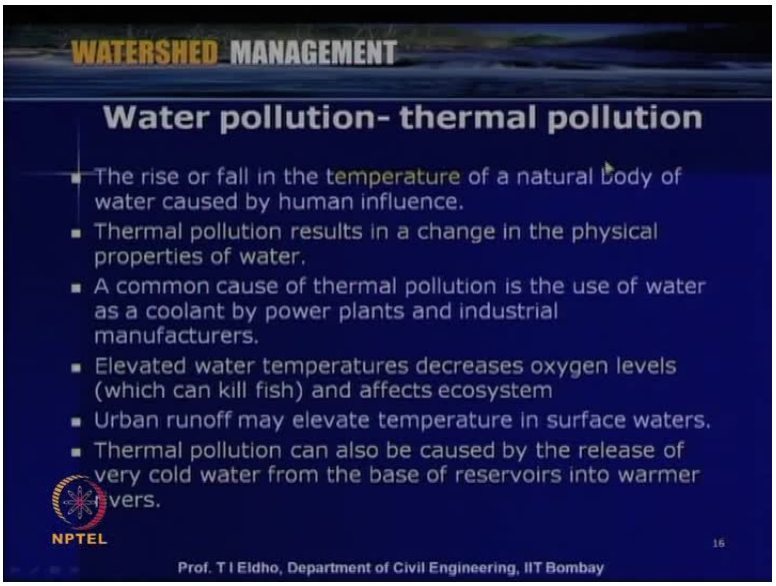

Let us look into the slide, where some of the important aspects of thermal pollution is discussed. So, the rise or fall in the temperature of a natural body of water is caused by human influence, so this is the thermal pollution. Thermal pollution results change in the physical properties of water. A common cause of thermal pollution is the use of water as a coolant by power plants and industrial manufacturers.

Elevated water temperature decreases oxygen levels, so this is the side effect; with the temperature rise, the oxygen content reduces, so that can kill the fish and affects the aquatic system or ecosystems. Urban runoff may elevate temperature in the surface waters like lakes or rivers or to the ocean and thermal pollution can also be caused by the release of cold water from the base of reservoirs into warmer rivers. So, both ways the pollutions are possible like cold water mixing with the warmer water and that way is also possible.

Thermal pollution is also a major source of pollution in many of the aquatic systems, so that also we have to consider. So, whatever we discussed so far is the sources of pollution, causes, types of pollutions and then the macroscopic or thermal type of pollutions. Now, what are the important parameters and water qualities.

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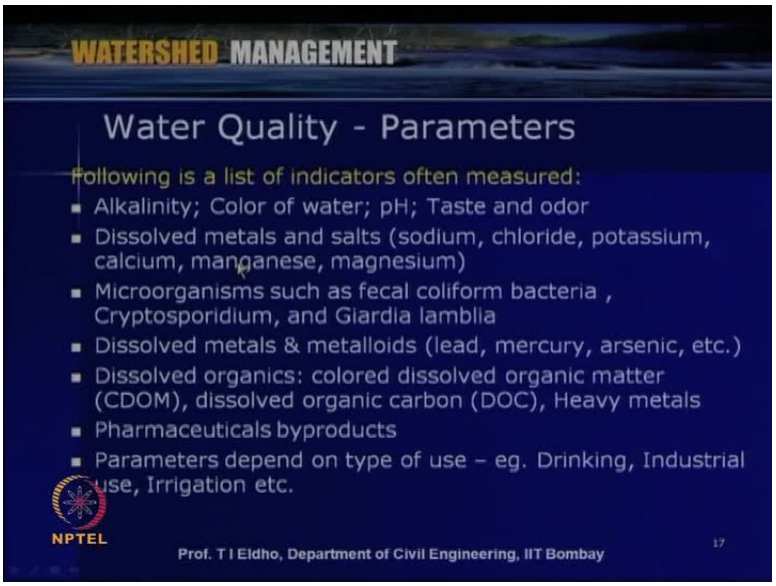

Let us discuss the water quality, so what are the important parameters which we have to consider, when we when we try to assess the given sample water is good or bad or what is the condition of the water. The parameters are very important and the following list of indicators are often measured when we are going for lab test or water type of particular test. The parameters are very important. The following are list of indicators that are often measured when we are going for lab test or water type of particular test. First one is the alkalinity; whether water is acidic or alkaline and actually the pH indicates whether it is alkaline or acidic, colour of water, taste and odour. Dissolved metals and salts are sodium, chloride, potassium, calcium, manganese, magnesium etc.

Microorganism such as fecal coliform bacteria, cryptosporidium and giardia lamblia. Dissolved metals and metalloids like lead, mercury, arsenic etc and then dissolved organics like colored dissolved organic matter, dissolved organic carbon, heavy metals etc, pharmaceutical byproducts. Parameters are of this type and when we are trying to assess typical particular samples of water, we are trying to see various parameters as how it is? What is the range of these parameters within the water sample?

As I mentioned already, we have to see the range and then depending upon what kind of use; whether we use specific water for drinking or industrial or irrigation purpose and accordingly, the usage or the treatment we go for that varies. These are some of the important parameters, which we have to consider as far as the water quality is concerned.

As far as water quality is concerned, we have to consider certain environmental indicators.

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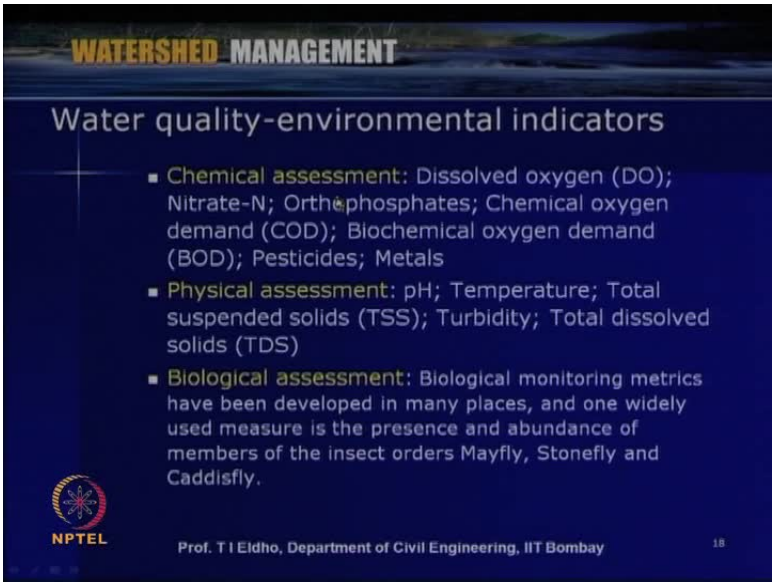

We have the environmental indicators. We can classify into three categories, first one is the chemical assessment, second one is a physical assessment, third one is the biological assessment. In chemical assessment, it is generally related to dissolved oxygen, nitrate, orthophosphates, chemical oxygen demand as COD, bio chemical oxygen demand, pesticides metal etc. So, these are some of the assessment which we will be trying to do as far as the chemical assessment is concerned.

Physical assessment is another important environmental indicator. We will be trying to see the water sample, whether it is acidic or alkaline. This pH indicates that whether it is acidic. When it is less than 7, it is acidic and above 7, it is alkaline. What is the temperature range as far as physical assessment is concerned? How much suspended solids are there, then turbidity of the water, total dissolved solids. So, these are some of the major environmental indicators as far as physical assessment is concerned.

The biological assessment - biological monitoring metrics can be developed depending upon the requirement. In many places, these metrics are used and one widely used measure is the presence and abundance of members of insect orders like Mayfly, Stonefly and Caddisfly etc. Presence of microorganisms like bacteria and protozoa or

other kinds of organisms is within the water, so that way the environment indicators are concerned; it can be chemical assessment, chemical related physical assessment or the biological assessment.

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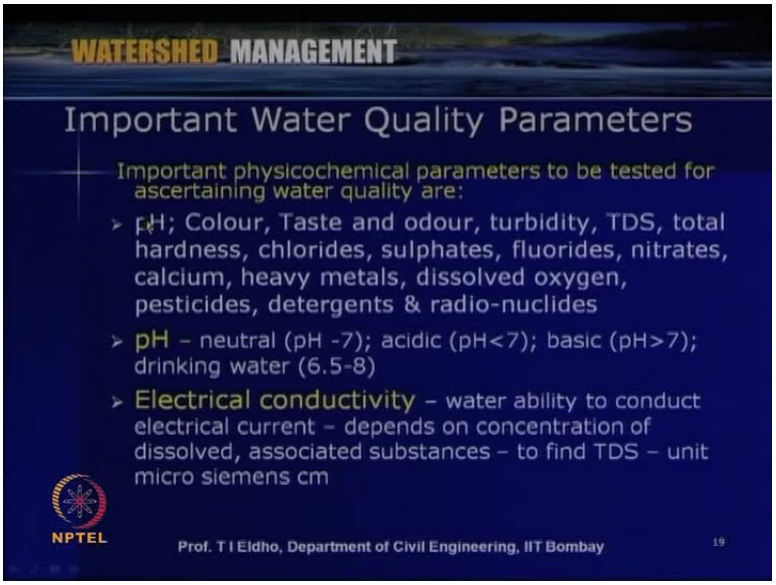

Now, let us look into some of the important physical chemical parameters as far as water quality is concerned, which we test as to assess the suitability of water for the specified use. As I already mentioned, it can be pH, which indicate whether water is acidic or alkaline, colour of the water, taste, odour, turbidity, TDS - Total Dissolved Solids, total hardness, chlorides, sulphates, fluorides, nitrates, calcium, heavy metals, dissolved oxygen, pesticides, detergents and radio-nuclides. So, these are some of the important physicochemical parameters, which we have to test and see how much is there for the particular samples, so that we can specify whether the particular source of water is suitable for drinking or suitable for the irrigation purpose or suitable for industrial purpose.

Let us look into some of these important parameters. What are those parameters and then what is the range of these parameters? So, this pH is one of the important parameter, which shows whether the water is acidic or basic. The water is said to be neutral, when pH is 7, it is acidic when pH is less than 7, it is basic or alkaline when pH is greater than 7. For example, as far as drinking water is concerned, pH should vary from 6.5 to 8. So, this is the range which is expected as far as drinking water is concerned and for irrigation

purpose. It is not good whether acidic or alkaline type water, so this is almost the same range that we generally prescribe as far as irrigation is concerned.

Another thing is that the dissolved solids or the salts are there within the water samples or water source. We can identify through electrical conductivity measurement and the electrical conductivity measurement shows water ability to conduct electrical current. So, this depends on concentration of dissolved substances like sodium chloride or potassium or various other kinds of dissolved solids, TDS. The presence is indicated by electrical conductivity and to find the TDS, we can do test and the unit is generally micro siemens centimeter.

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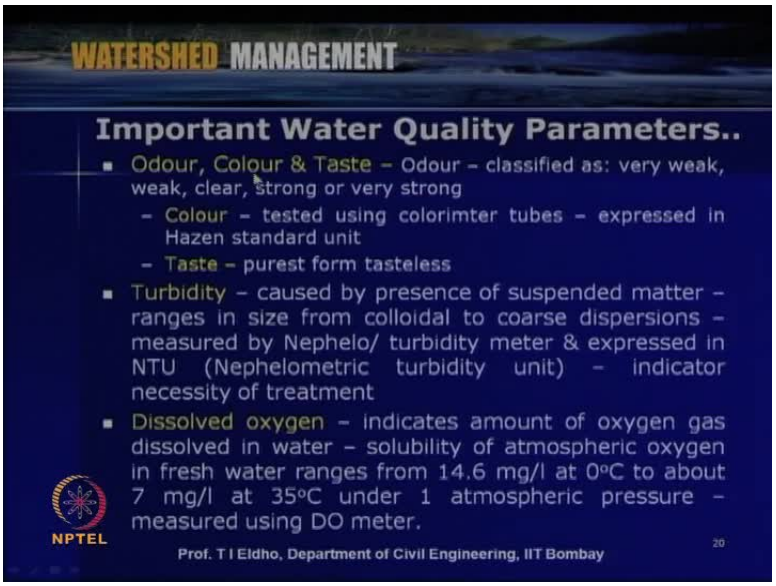

Some of the other important water quality parameters are odour, colour and taste. We can classify odour as very weak, clear, strong or very strong. So, we can do this our self. Odour of the water, colour and we can test using colorimeter tubes. So, this is expressed in Hazen standard unit. Generally for drinking water purpose, the water should be clear and no colour should be there. As far as taste is concerned, the purest form of water like the distilled water is tasteless, but most of the drinking water has some kinds of salts or some total dissolved solids will be there.

Some taste will be there and the taste will be called as palatable water depending upon the drinking purpose. Another important component is turbidity, so this turbidity is

caused by presence of suspended matter and it ranges in size from colloidal to coarse measured by Nephelo or turbidity meter and expressed in NTU - Nephelometric turbidity unit and this indicates whether we have to treat the water. For example, when we take water from rivers or lakes for municipal supply and depending upon the rainfall conditions, the water become turbid. We have to go for specific type of treatment like settlements or sedimentation or various processes for that type of water. This turbidity is an important parameter, which we have to assess for drinking water purposes.

Dissolved oxygen is another important parameter, which we have to assess and dissolved oxygen indicates amount of oxygen gas dissolved in water. Solubility of atmospheric oxygen in fresh water may range from 14.6 milligram per liter at 0 degree centigrade to about 7 milligram per liter at 35 degree centigrade under 1 atmospheric pressure. We can measure this using dissolved oxygen meter and we can see how much is dissolved oxygen. So, this dissolved oxygen is very important as far as aquatic life is concerned and various other uses like human use is concerned. We have to measure and see how much is available within the particular source of water.

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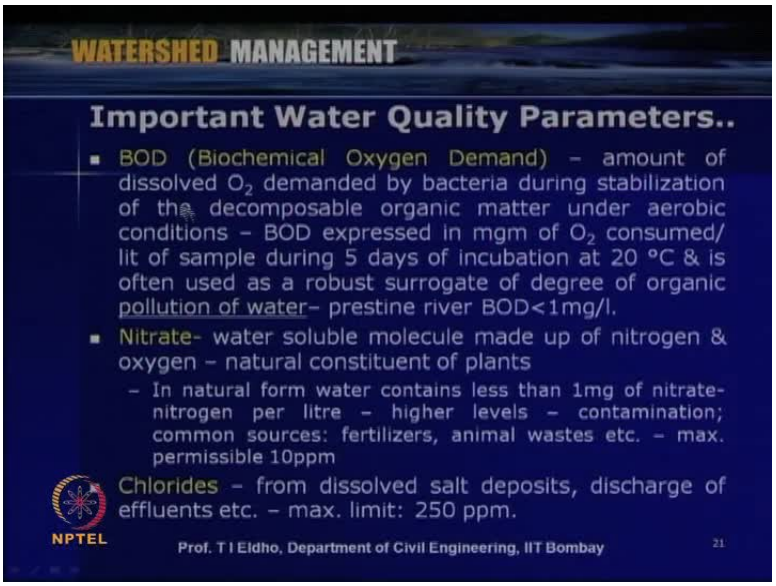

Other parameters like biochemical oxygen demand. This is another important water quality parameter, which we have to test. Here, the amount of dissolved oxygen demanded by bacteria during stabilization of the decomposable organic matter under aerobic conditions. This is what the BOD or biochemical oxygen demand indicates and

BOD is expressed in milligram of oxygen consumed per liter of sample during five days of incubation at 20 degree centigrade. It is often used as a robust surrogate of degree of organic pollution of water, for example, pristine river water in the BOD should be less than 1 milligram per liter.

BOD is one important aspect, which we have to measure and see whether the water resource is safe for drinking or other kinds of purposes. Some of the other important parameters like nitrate, so the water soluble molecules are made up of nitrogen and oxygen - natural constituents of plants. In natural form, water contains less than 1 milligram of nitrate - nitrogen per liter - higher levels – contamination. Common sources are generally like fertilizers, animal wastes like manures. Maximum permissible is 10 parts per million or 10 ppm of the nitrates. Another important water quality parameter is chlorides. Chlorides can come from dissolved salt deposit, discharge of effluents etc. Generally, maximum permissible limit is 250 parts per million or 250 ppm.

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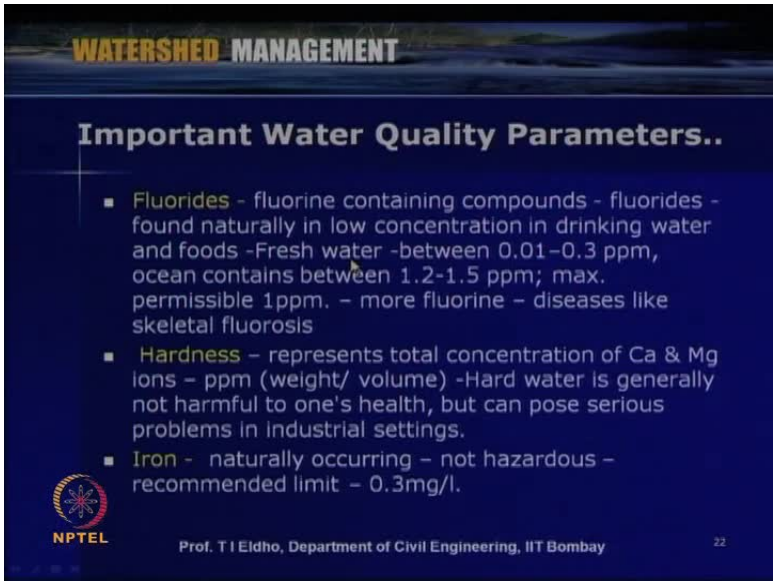

Some of the other important parameters like fluorides. A fluoride is in groundwater or some of the other water sources. It is the fluorine containing compounds then found naturally in low concentration drinking water and foods. Fresh water can be between 0.01 to 0.3 ppm, ocean water contents between 1.2 to 1.5 ppm and maximum permissible limit for drinking water is 1 ppm.

If fluoride exceeds certain limits, then there can be problems like skeletal fluorosis. If it is not there also like to a certain extent 0.5 ppm or like that should be available within the water or it can be upto 0.3 should be available within the water, otherwise there can be problems related to teeth and other related issues. If fluoride is less, it is a problem and also more types of problems can come like skeletal fluorosis.

Another important parameter is hardness. This hardness represents total concentration of calcium and magnesium ions. These salts are mentioned in ppm weight per volume and hard water is generally not harmful to one's health, but can pose serious problems in industrial settings like boilers, precipitations. Various problems can be there when we use hardness of water in the industry. So, we may have to make it soft depending upon the specific use of the water. Another important parameter is iron. It is naturally occurring and this is generally not hazardous, but recommended limit is 0.3 milligram per liter, so this also comes naturally to the water.

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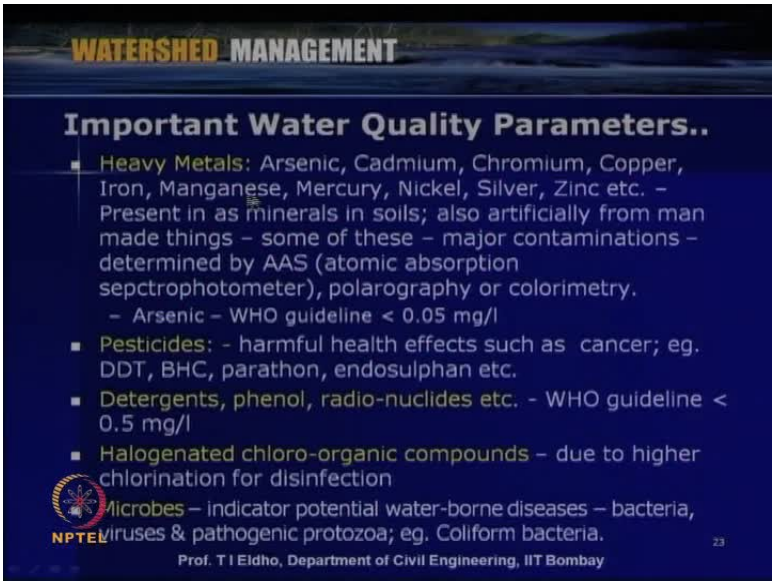

Some of the other important parameters like heavy metals. Heavy metals can be arsenic, cadmium, chromium, copper, iron, manganese, mercury, nickel, silver, zinc etc. It is present in as minerals in soils; this can be leached with the rainwater or the surface water, also artificially from man made things and sometimes from heavy metals. Major contaminations like arsenic or mercury or lead and these are all some of the major contamination as far as water is concerned. These are generally determined by atomic

absorption spectrophotometers, AAS or polarography or colorimetry. These are some of the testing methods as far as the heavy metals are concerned. For example, arsenic is a major issues in states like West Bengal and this is due to over draft on the groundwater and the especially that kind of arsenic related minerals are there that leaches into the groundwater. Generally, as per World Health Organization guidelines, it should be less than 0.5 milligram per liter.

Other parameters like pesticides, which are harmful for health effects, such as cancer, for example, presence of DDT, BHC, parathon, endosulphan etc. This endosulphan is a major source of pollution in Northern Kerala and Mangalore region. This has created lot of problems, which are used mainly for cashew nut crops that comes to the surface water sources or groundwater sources.

Other parameters like detergents, phenol, radio-nuclides. So, World Health Organization guidelines are there. In all these, it should be definitely less than 0.5 milligram per liter and then halogenated chloro-organic compounds. This can be due to higher chlorination for disinfection and we have to control these also. Microbes like pathogens or bacteria or viruses are all indicator of potential water-borne diseases and this also we have to control, for example, coliform bacteria. All these are some of the important water quality parameters, which we have to identify and then we have to test it. If it exceeds certain standards like World Health Organization standards or USEPS standards or Indian standards, we have to go for specific treatment and then only we can use the water for that particular usage.

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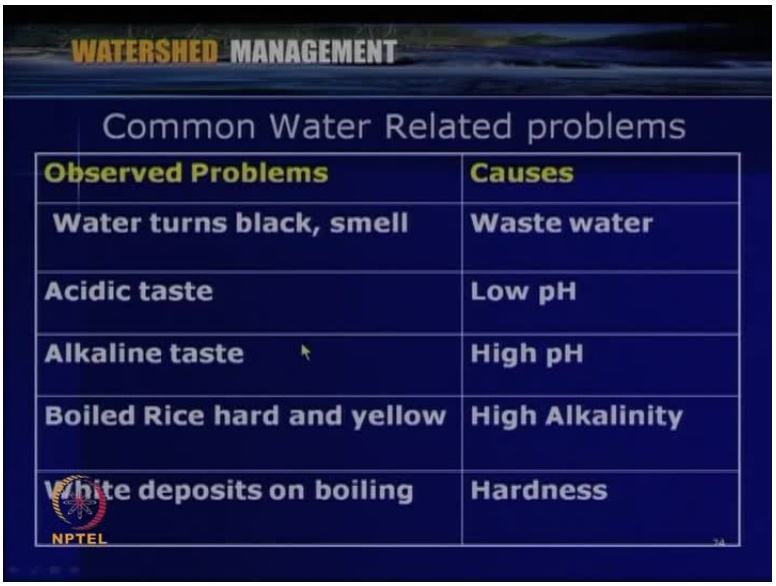

Now, let us look into what are the common water related problems and we can see that depending upon the presence of various contaminants or various pollutants within the water. Some of the effects can be directly observed within the water like taste or like colour or smell. All these things can be easily visualized or tasted, so that we can easily go for various measures or we can try to identify what are the sources of this type of pollutions.

For example, the water, which we are storing or which we are using for cooking or other purpose turns black or the smell is not good, then it can be that the source of water will be mixed with wastewater and we can try to identify. If any acidic taste is there for dull water, then that means the pH is low and alkaline means high pH. Depending upon the source of water, if it is acidic or alkaline, it is dangerous. Generally for drinking or cooking purpose, the pH this should be in between 6.5 to 8. While boiling rice, the rice become hard and yellow and they can presume the water is slightly alkaline. A white deposit on boiling means the water is hard.

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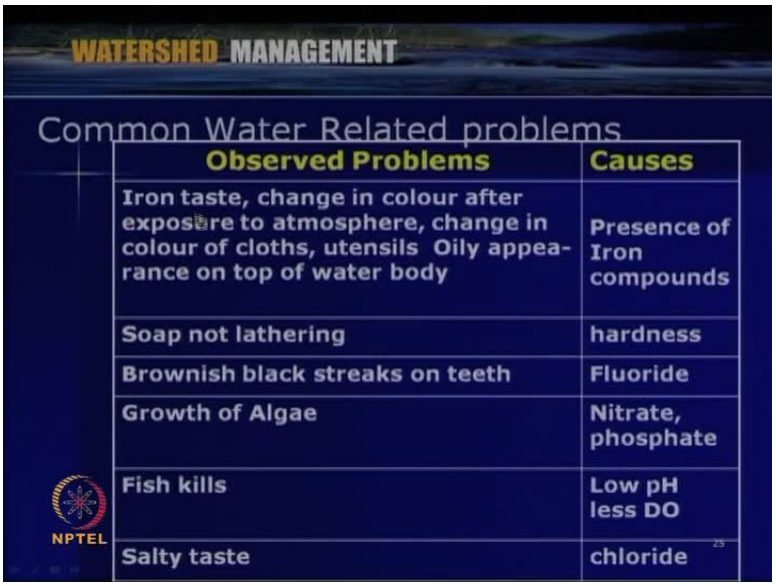

Iron taste, change in colour after exposure to atmosphere, change in colour of cloths, utensils and oily appearance on top of water. So, here that means the presence of iron compounds. Soap not lathering that means hardness, then brownish black streaks on teeth means fluoride or related issues. Growth of algae in the water source is due to presence of nitrates or phosphates. Within the water available, fish are killed that means the it can be due to less dissolve oxygen within the water or pH is less. If the taste is salty, then more chloride is present and like that we can easily identify the observed problems and we can try to identify the causes.

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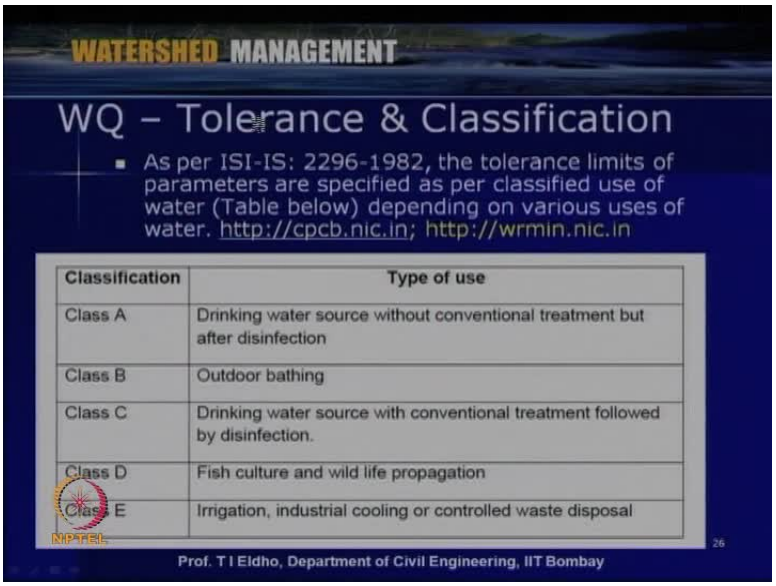

Now, let us look into water quality tolerance and classification. As per Indian standard institutes, IS 2296-1982, the tolerance limits of parameters are specified as per the classified use of water. Here, it is classified into class A to E, so types of use class A is drinking water source without conventional treatment, but after disinfection. Class B is outdoor bathing, class C is drinking water source with conventional treatment followed by disinfection, class D is fish culture and wild life propagation, class E is irrigation, industrial cooling or controlled waste disposal.

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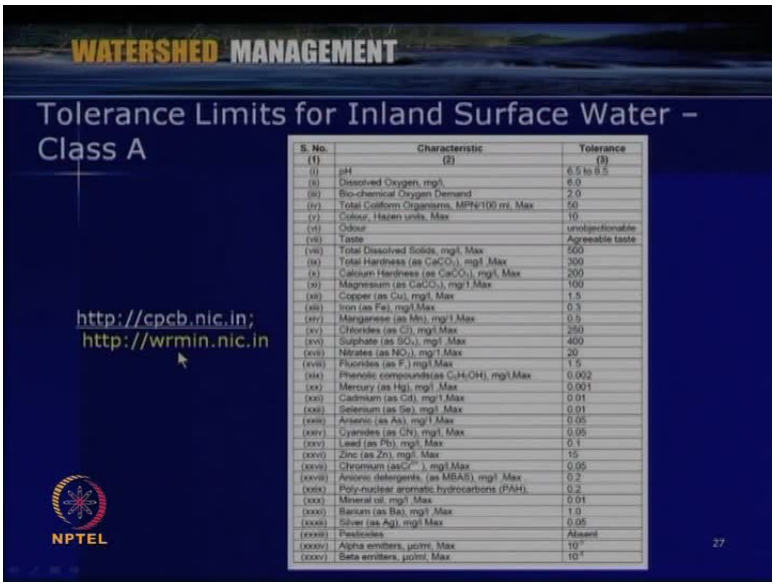

Let us look into these categories, for example, as given in the IS codes and reported in ministry of water resource or central pollution control board, government of India; some of the classifications are given. Now, pH should be 6.5 to 8.5 then dissolved oxygen should be the tolerance is 6.

BOD 2 and total coliform organisms is upto 50 colour Hazen units, odour should be unobjectionable, taste should be agreeable, TDS should be less than 500, total hardness should be less than 300, so like that various say tolerance limits are given for class A. Class A is for drinking water source without conventional treatment, but only after disinfection it can be used.

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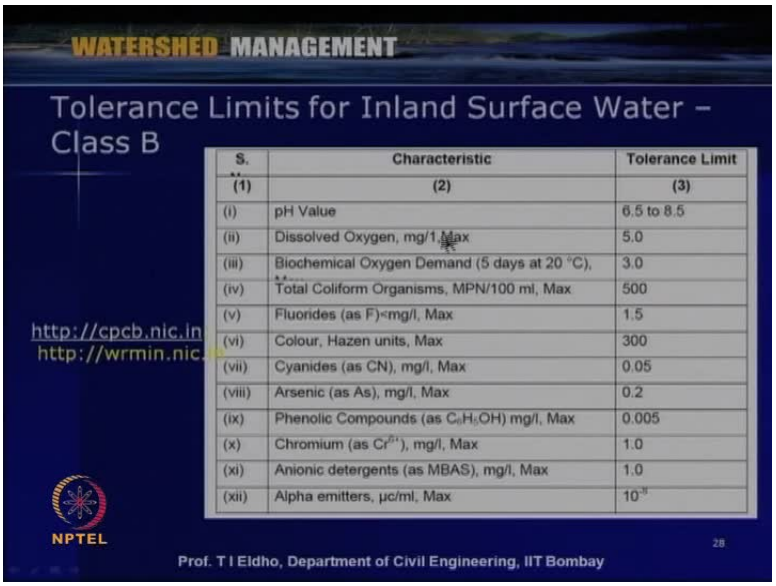

S.	Characteristic	Tolerance Limit
(1)	(2)	(3)
(i)	pH Value	6.5 to 8.5
(ii)	Dissolved Oxygen, mg/l, Max	5.0
(iii)	Biochemical Oxygen Demand (5 days at 20 °C),	3.0
(iv)	Total Coliform Organisms, MPN/100 ml, Max	500
(v)	Fluorides (as F)<mg/l, Max	1.5
(vi)	Colour, Hazen units, Max	300
(vii)	Cyanides (as CN), mg/l, Max	0.05
(viii)	Arsenic (as As), mg/l, Max	0.2
(ix)	Phenolic Compounds (as C_6H_5OH) mg/l, Max	0.005
(x)	Chromium (as Cr^{6+}), mg/l, Max	1.0
(xi)	Anionic detergents (as MBAS), mg/l, Max	1.0
(xii)	Alpha emitters, µc/ml, Max	10^{-9}

This table gives limits of inland surface water for class A, then class B, which we use for outdoor bathing and other purposes. Some of the tolerance limits like pH value should be between again 6.5 to 8.5, dissolved oxygen limit is 5, BOD is 3, total coliform organism is 500, fluorides is 1.5, colour Hazen units is 300, in a phenolic compound, it is less than 0.005 like that. This is for class B, which is for outdoor water usage like your swimming and other purposes.

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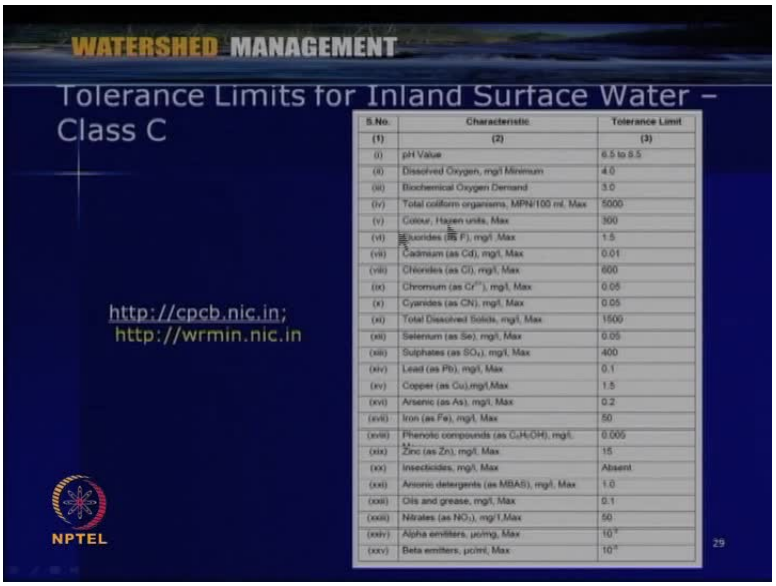

S.No.	Characteristic	Tolerance Limit
(1)	(2)	(3)
(i)	pH Value	6.5 to 8.5
(ii)	Dissolved Oxygen, mg/l Minimum	4.0
(iii)	Biochemical Oxygen Demand	3.0
(iv)	Total coliform organisms, MPN/100 ml, Max	5000
(v)	Colour, Hazen units, Max	300
(vi)	Fluorides (as F), mg/l ,Max	1.5
(vii)	Cadmium (as Cd), mg/l, Max	0.01
(viii)	Chlorides (as Cl), mg/l, Max	600
(ix)	Chromium (as Cr^{++}), mg/l, Max	0.05
(x)	Cyanides (as CN), mg/l, Max	0.05
(xi)	Total Dissolved Solids, mg/l, Max	1500
(xii)	Selenium (as Se), mg/l, Max	0.05
(xiii)	Sulphates (as SO_4), mg/l, Max	400
(xiv)	Lead (as Pb), mg/l, Max	0.1
(xv)	Copper (as Cu),mg/l,Max	1.5
(xvi)	Arsenic (as As), mg/l, Max	0.2
(xvii)	Iron (as Fe), mg/l, Max	50
(xviii)	Phenolic compounds (as C_6H_5OH), mg/l, Max	0.005
(xix)	Zinc (as Zn), mg/l, Max	15
(xx)	Insecticides, mg/l, Max	Absent
(xxi)	Anionic detergents (as MBAS), mg/l, Max	1.0
(xxii)	Oils and grease, mg/l, Max	0.1
(xxiii)	Nitrates (as NO_3), mg/l,Max	50
(xxiv)	Alpha emitters, µc/mg, Max	10^{-9}
(xxv)	Beta emitters, µc/ml, Max	10^{-8}

Class C is actually for drinking water source with conventional treatment followed by disinfection. This table again shows the pH value should be between 6.5 to 8.5, dissolved oxygen is 4, BOD is 3, total coliform is 5 per 100 ml to 5000, colour is 300, so like that these type of specifications.

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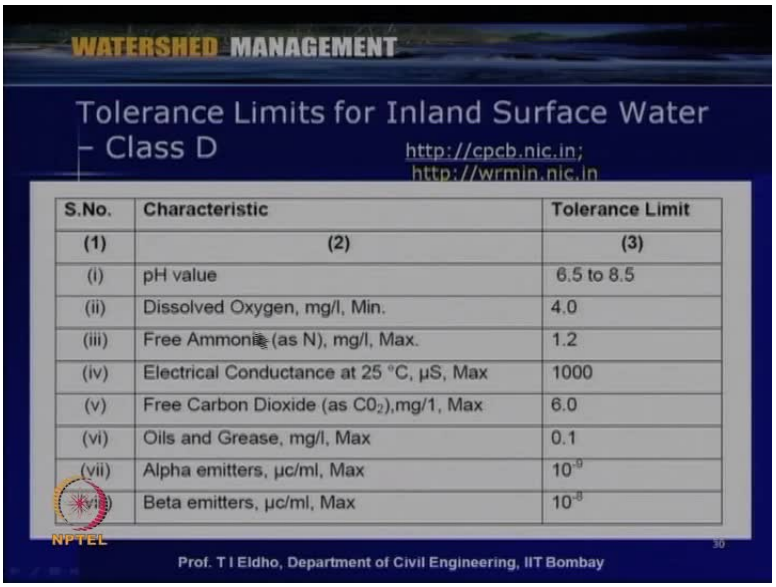

S.No.	Characteristic	Tolerance Limit
(1)	(2)	(3)
(i)	pH value	6.5 to 8.5
(ii)	Dissolved Oxygen, mg/l, Min.	4.0
(iii)	Free Ammonia (as N), mg/l, Max.	1.2
(iv)	Electrical Conductance at 25 °C, µS, Max	1000
(v)	Free Carbon Dioxide (as $C0_2$),mg/1, Max	6.0
(vi)	Oils and Grease, mg/l, Max	0.1
(vii)	Alpha emitters, µc/ml, Max	10^{-9}
(viii)	Beta emitters, µc/ml, Max	10^{-8}

Class D is considered is for fish culture and wild life propagation. Here, the pH value is again 6.5 to 8.5, dissolved oxygen is 4, free ammonia is 1.2, electrical conductance is 100, alpha emitters is 10 to the power minus 9, beta emitters is 10 to the power minus 8.

The last one is for the purpose of irrigation and industrial, so it can be the variation like electrical conductivity and it can be up to 2250, total dissolved solids can be 2100. Like this, we can see that various standards are available. What is the tolerance limit given as per highest standards? I have shown, according to WHO standards or USEPA standards or Indian standards, we can prescribe those standards and accordingly, we can see that available water is suitable.

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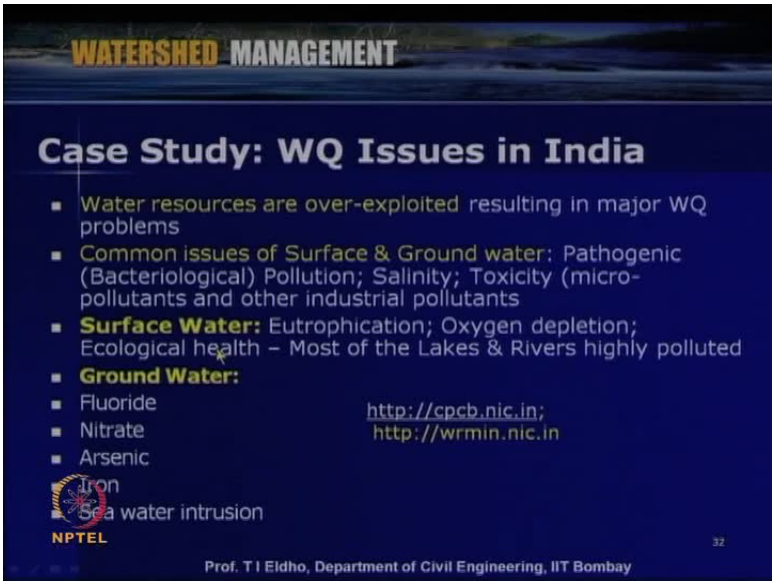

Now, before closing, let us briefly see a case study related to water quality issues in India. In India, water resource are over exploited resulting in major water quality problems, common issues like surface and groundwater. It includes pathogenic (bacteriological) pollution, salinity, toxicity and other industrial pollutants. Surface water especially has main issues like eutrophication, oxygen depletion, ecological health - most of the lakes and rivers highly polluted. So, these are some of the surface water pollution issues in India. Groundwater is concerned; presence of fluorides, nitrate, arsenic, iron or sea water intrusion. So, these are some of the main issues as far as the water quality in India is concerned.

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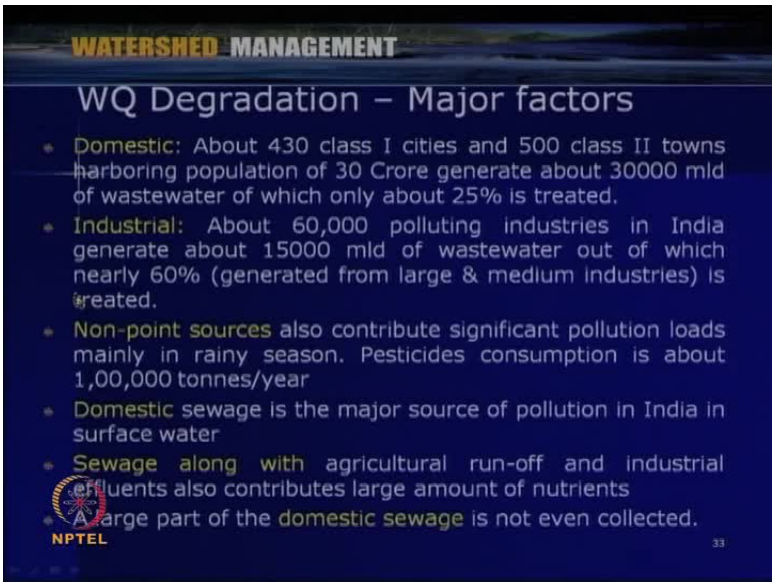

Some of the major factors which causes these kinds of degradation like domestic industrial or non-point source or domestic sewage or sewage along with agricultural run-off. Domestic - about 430 in class one cities and 500 in class two towns harboring population of 300 million generates about 30000 million liters of per day of wastewater and only about 25 percent is treated.

Industrial - about 60000 polluting industries in India generate about 15000 million liters per day, of which only 60 percent is treated. Non-point source of pollution contributes significant pollution load coming from overland and the agricultural sources. Domestic sewage is the main source of other type of pollution for surface water and sewage along with agricultural run-off and industrial. So, effluents also contribute to large amount of nutrients.

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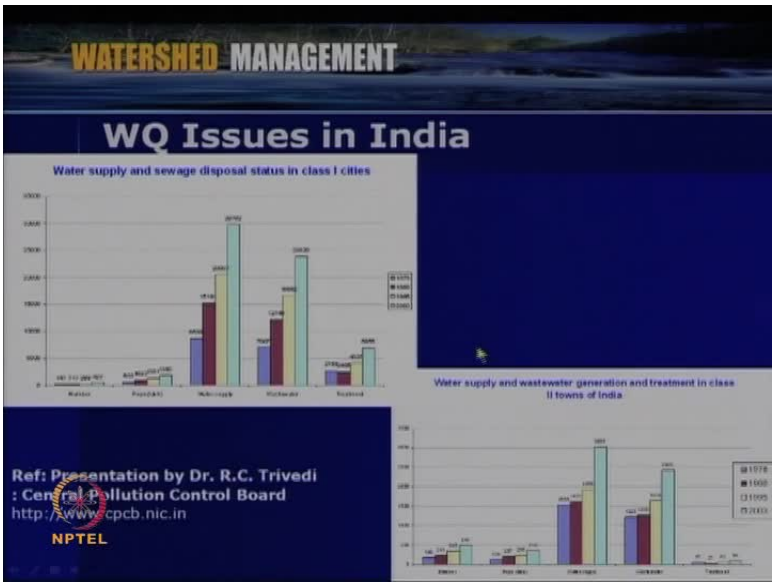

Some of the figures taken from this Central Pollution Control Board, you can see that the number of populations, water supplied, wastewater treatment. You can see that water is varying from 1978 to 2003, so this amount is going up, but the treatment is also not going to that level, so that is the major source of pollution. Water supply and sewage disposal status is in class one cities. Similarly, the similar trend can be seen in class two cities.

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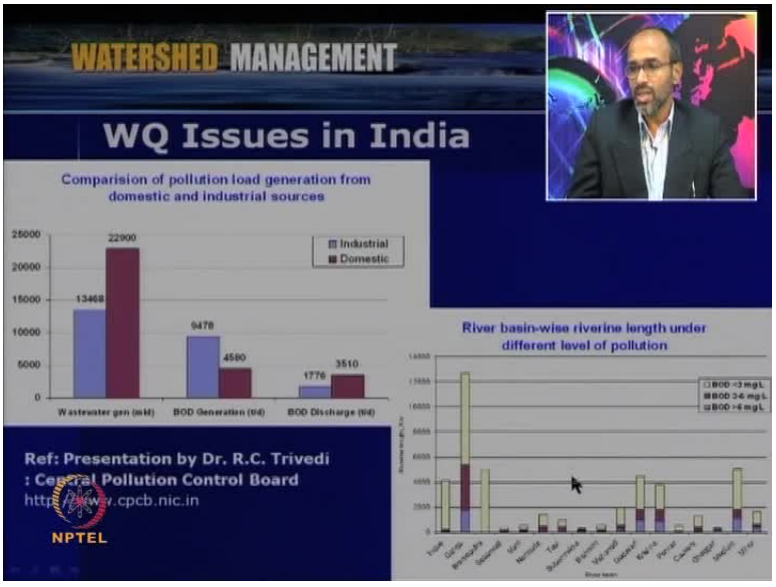

Comparison of pollution load generation from domestic and industrial sources. This red colour shows the domestic and this blue colour shows the industrial. It is again the BOD discharge or BOD generation and then waste treatment. These things are shown in these figures. Similarly, river basins are major rivers like Indus, Ganges, Brahmaputhra, Sabarmati etc.

This red colour shows where the BOD is in higher range. Blue colour more than 6 milligram per liter, then red colour is between 3 to 6 and blue colour less than 3. So, you can see that major stretch of the rivers is in problem. So that way, with the water qualities concerned, the major issues as far as India is concerned, especially surface water or river water or lake water. So, major pollution problems are there.

Through various agencies, government of India is trying to solve these problems like river Ganga action, plans to reduce the pollution ten loads, so that various state governments are also working this direction. Private public partnership or people should come together to deal these kinds of pollution problems as far as surface water or groundwater is concerned.

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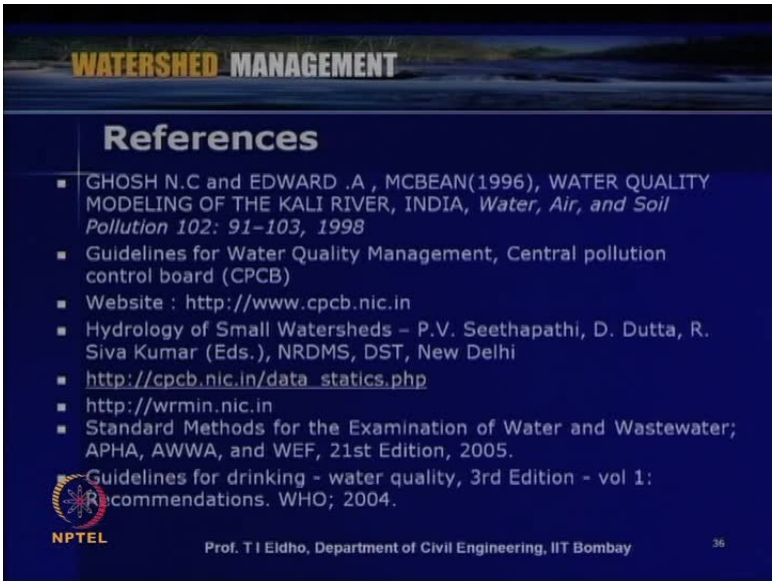

Some of the important references used in today's lecture.

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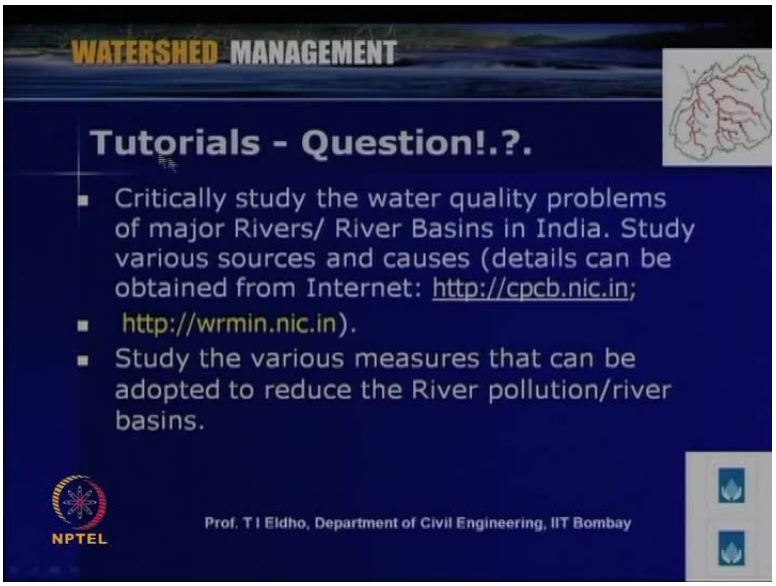

Before closing, some of the tutorial questions - critically study the water quality problems of major rivers basins in India. Study various sources and causes, whose details are given here and from this you can get. Study the various measures that can be adopted to reduce the river pollution or in river basins.

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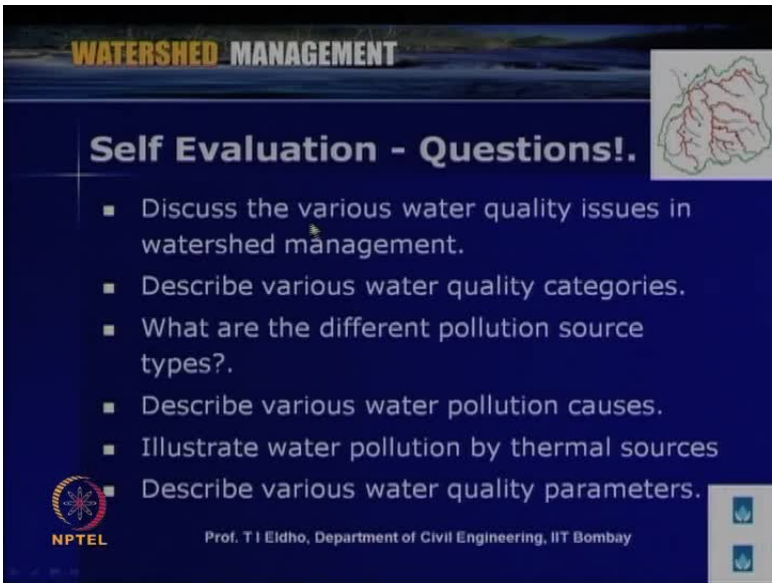

Some self-evaluation questions, discuss the various water quality issues in watershed management. Describe various water quality categories. What are the different pollution

sources types? Describe various water pollution causes. Illustrate water pollution by thermal sources. Describe various water quality parameters.

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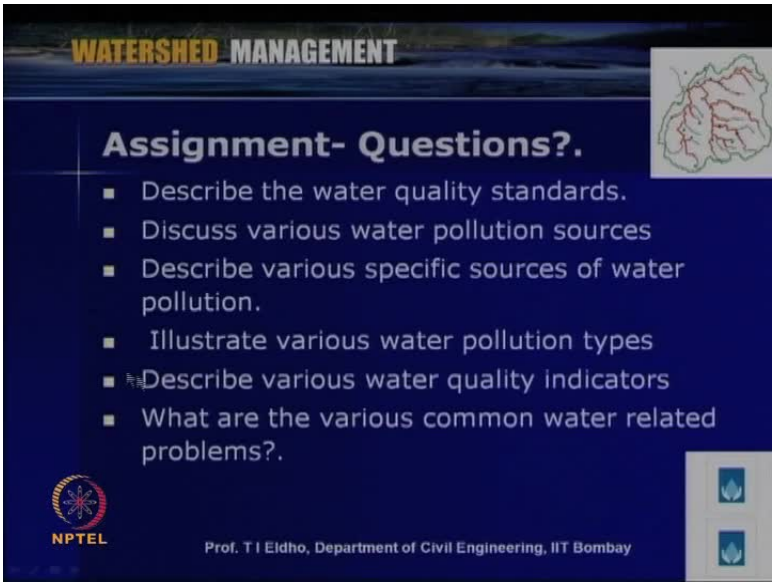

Few assignment questions - describe water quality standards. Discuss various water pollution sources. Describe various specific sources of water pollution. Illustrate various water pollution types. Describe various water quality indicators. What are the various common water related problems?

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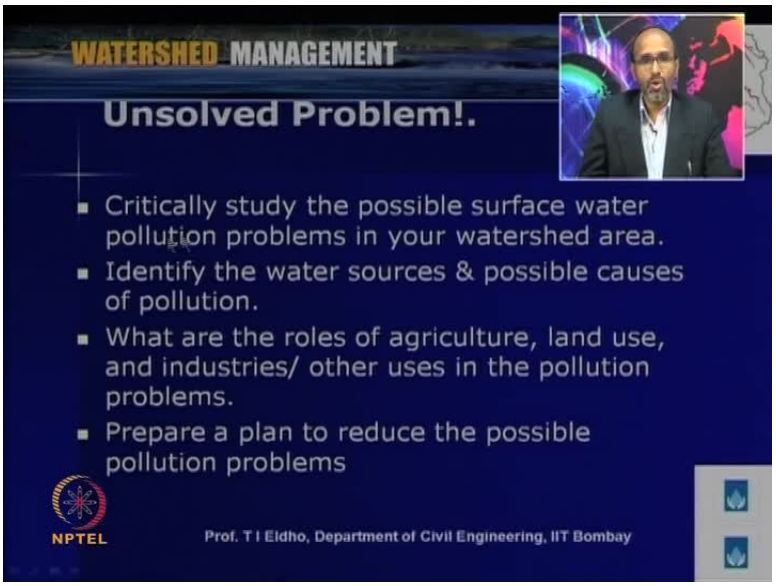

Finally, unsolved problem is critically study the possible surface water pollution problems in your watershed area. Identify the water sources and possible causes of pollution. What are the roles of agricultural, land use and industrial uses in the pollution problems? Prepare a plan to reduce the possible pollution problems. So, many of these questions like assignment or so self-evaluation questions can be answered by going through today's lecture and other details are given. Today, what we discussed is the water surface, water quality issues, water pollution sources and various parameters. Further, we will discuss this groundwater quality problems issues and water quality modeling. Thank you very much.