INDIAN INSTITUTE OF TECHNOLOGY MADRAS

NPTEL
NPTEL ONLINE CERTIFICATION COURSES

ECOLOGY AND ENVIRONMENT

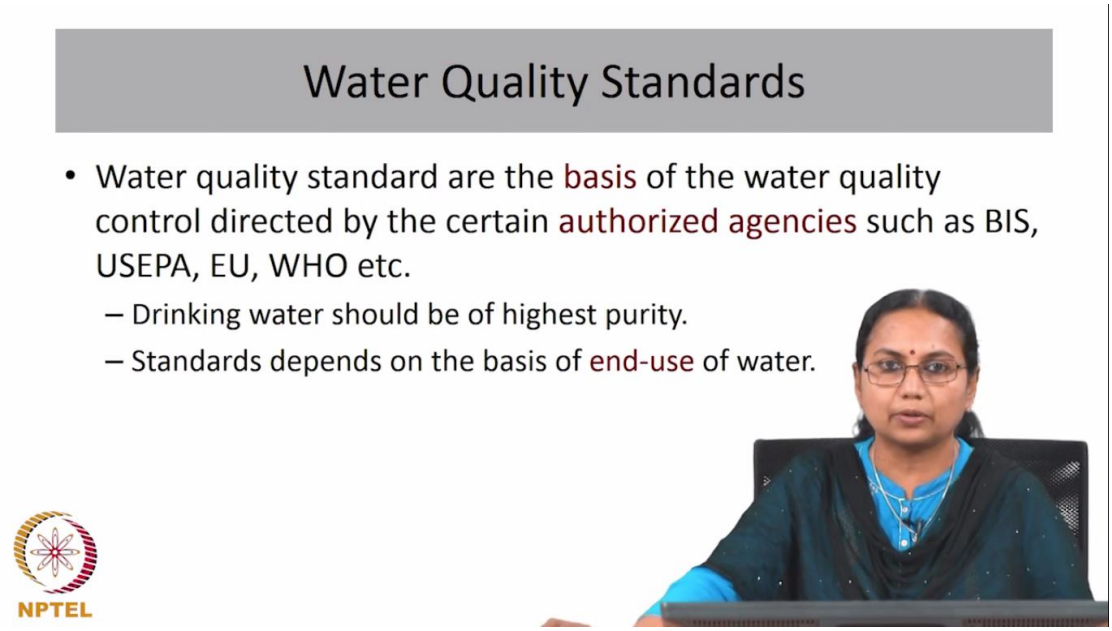
Water quality standards and philosophy of water treatment

Lecture 3

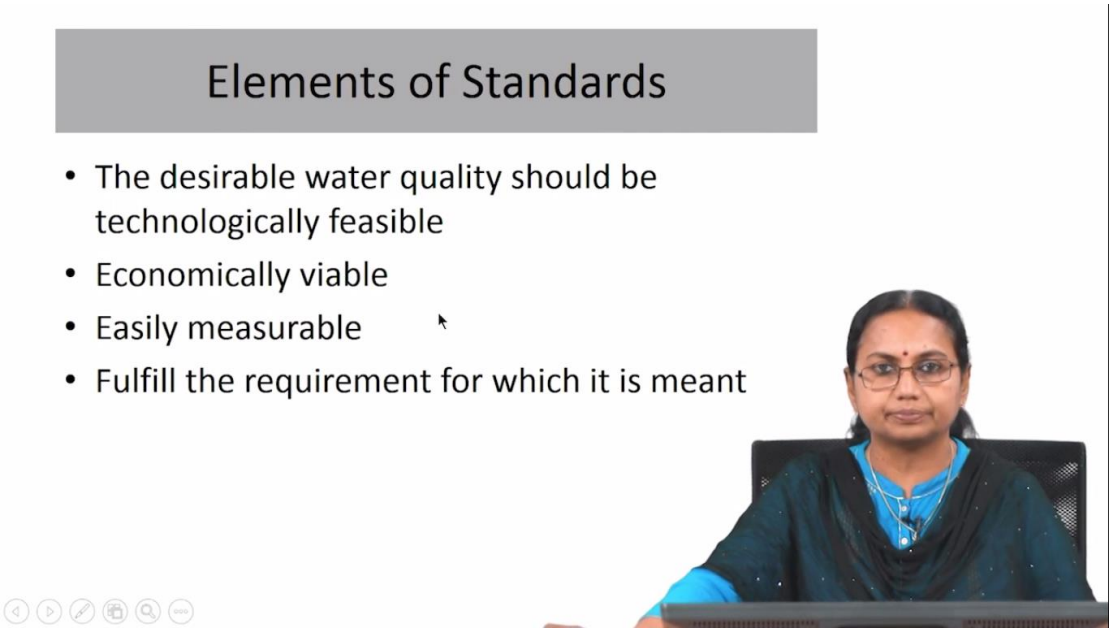
Prof. Ligy Philip

Department of Civil Engineering
IIT Madras

Good morning. Today we will discuss about water quality standards and philosophy of water treatment. The last lectures we have seen about what is the quality requirement, what is the quantity required and all the things. So, if you want to make sure that the quality is achieved there should be some standards so that legally somebody can question that one.



So, what is this water quality standards? Water quality standards are the basis of the water quality control directly by the certain authorized agencies such as Bureau of Indian Standards, U.S. Environmental Protection Agency, EU, WHO, etc. So, there are different standards, something will be more stringent, and other things will be less stringent, etc. And drinking water should be of the highest purity and standards depends on the basis of end-use of water. So, don't think that the quality required for drinking water, washing water, bathing water, etc. are the same. The standards is based upon the end-use of the water. And of course, drinking water should need the better, best quality.

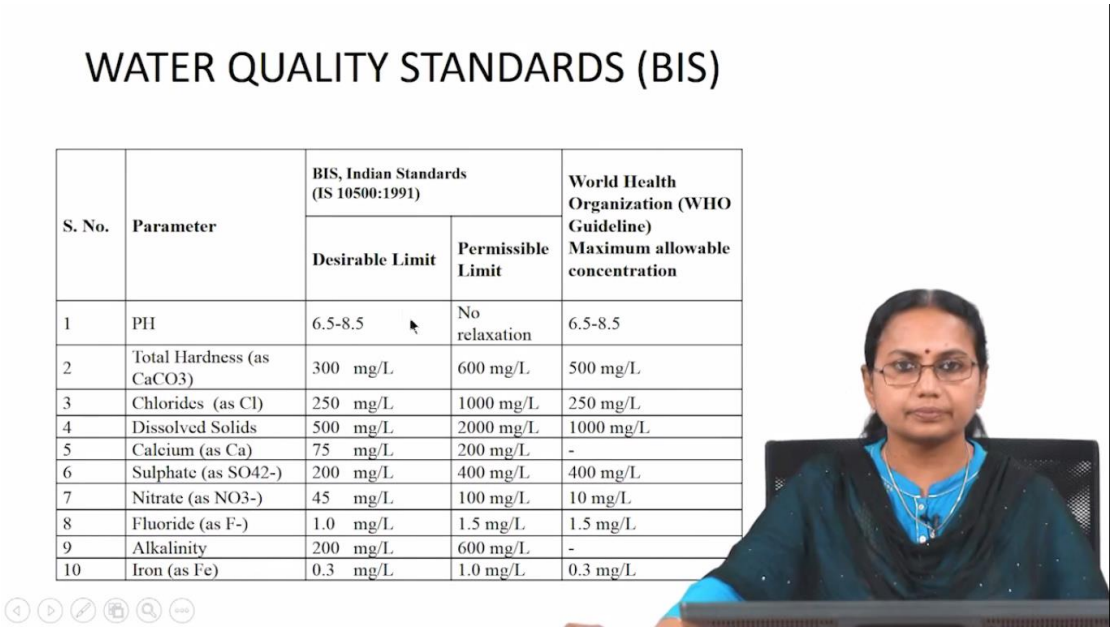


And when we talk about the elements of standards, the desirable water quality should be technologically feasible, and it should be economically viable and easily measurable, and it should full

fill the requirement for which it is meant. I will explain this one little detailed. If you put a standard, for example, we have some pollutant, and we tell that the concentration should be less than 0.0001 milligrams per liter and there is no technology available to achieve that one. Then no point in putting up a standard because even if you put up the standard nobody will be able to achieve that one.

The second one is economical viability. If the standard specifies some value and if you want to achieve that value and if the cost involved is very very high then the standard is not a good standard, or we cannot put that one. And another thing is the quality whatever we are putting as a standard it should be easily measurable because the standard is a legally bound thing, so, if you want to enforce the standard somebody have to measure it easily. So, the standards whatever we are putting it should be easily measurable. The last one is fulfill the requirement for which it is meant. Most of the standards are based upon the health and wellbeing of the human being. So, whether your standard is meeting the requirement. For example, if you are looking into technological availability, economical viability, etc. and we are putting a standard, for example, we take the case of arsenic and we put a standard of 1 milligram per liter, it is not going to help because 1 milligram per liter is very high concentration, and it will be affecting the health of the people.

So, when we put up a standard, all these things has to be looked into. So, this is one of the reasons why there are different standards across the countries and all the things.



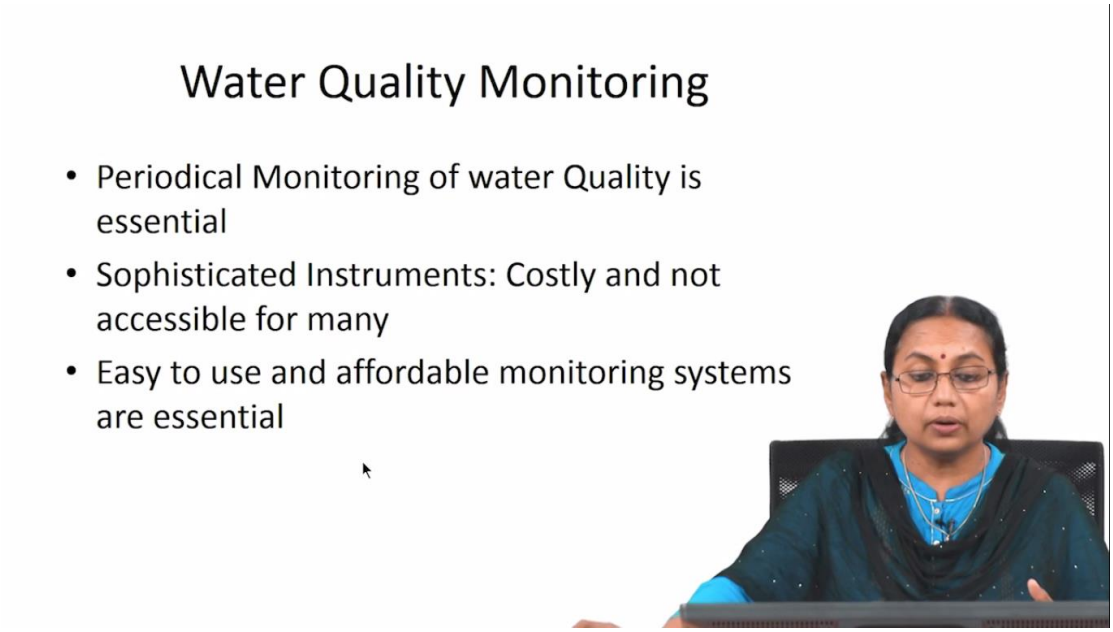
S. No.	Parameter	BIS, Indian Standards (IS 10500:1991)		World Health Organization (WHO Guideline) Maximum allowable concentration
		Desirable Limit	Permissible Limit	
1	PH	6.5-8.5	No relaxation	6.5-8.5
2	Total Hardness (as CaCO3)	300 mg/L	600 mg/L	500 mg/L
3	Chlorides (as Cl)	250 mg/L	1000 mg/L	250 mg/L
4	Dissolved Solids	500 mg/L	2000 mg/L	1000 mg/L
5	Calcium (as Ca)	75 mg/L	200 mg/L	-
6	Sulphate (as SO42-)	200 mg/L	400 mg/L	400 mg/L
7	Nitrate (as NO3-)	45 mg/L	100 mg/L	10 mg/L
8	Fluoride (as F-)	1.0 mg/L	1.5 mg/L	1.5 mg/L
9	Alkalinity	200 mg/L	600 mg/L	-
10	Iron (as Fe)	0.3 mg/L	1.0 mg/L	0.3 mg/L

So, I am giving a table. It is hard to read. Water quality standards provided by the Bureau of Indian Standards. Here you can see around 10 parameters including pH, total hardness, chlorides, dissolved solids, calcium, sulphate, nitrate, fluoride, alkalinity, iron, etc. and I told you bacteriological quality is the most important water quality parameter and it is measured in terms of most probable number and for drinking water most probable number should be less than 1.8 or zero for 100 mL of sample.

BIS Standard for Drinking Water: IS 10500

S. N	parametrs	Requirement desirable limit	Remarks
1	Color	5	May be extended upto 50 if toxic compounds is suspected
2	Turbidity	10	May be relaxed upto in the absence of alternative
3	pH	6.5 to 8.5	May be relaxd upto 9.2 in the absence of alternative
4	Total hardnes	300	May be extended upto 600
5	Calcium	75	May be extended upto 200
6	Magnisium	30	May be extended upto 100
7	Copper	0.05	May be relaxed upto 1.5
8	Iron	0.3	May be relaxed upto 1
9	manganese	0.1	May be relaxed upto 0.5
10	Chloride	250	May be extended upto 1000
11	Sulfate	150	May be extended upto 400
12	Nitrate	45	No relaxation
13	Fluride	0.6 to 1.2	May be extended upto 1.5
14	Phenols	0.001	May be extended upto 0.002
15	Mercury	0.001	No relaxation
16	Cadmium	0.01	No relaxation
17	Selenium	0.01	No relaxation
18	Arsenic	0.05	No relaxation
19	Cyanide	0.05	No relaxation
20	Lead	0.1	No relaxation
21	Zink	5	May be extended upto 10
22	Arsenic detergents	0.2	May be relaxed upto 1
23	Cr6+	0.05	No relaxation
24	Mineral oil	0.01	May be relaxed upto 0.03
25	Residual free Chlorine	0.2	Applicable only if water is chlorinated
26	Pesticides	Absent	No relaxation

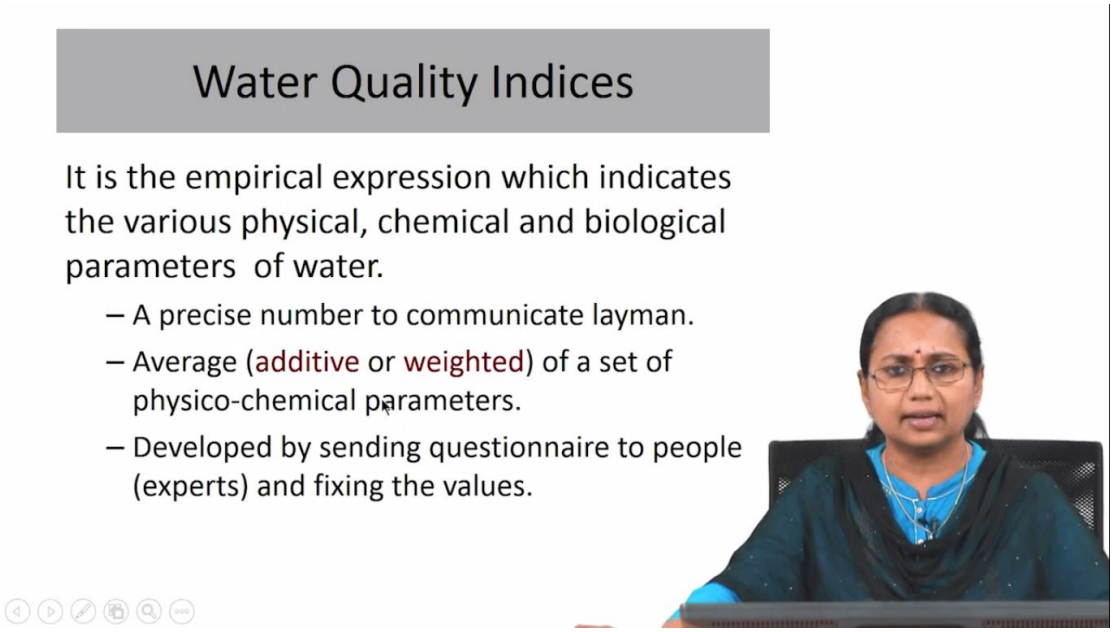
And recently BIS have included many other toxic chemicals in the standards. Those include, you can see here many of the heavy metals, mineral oil, residual free chlorine, pesticides, etc. are also included in the standards. That means if somebody is supplying water as drinking water, then it should meet all these conditions or the concentrations of the pollutants present or contaminants present in the water should be below this level.



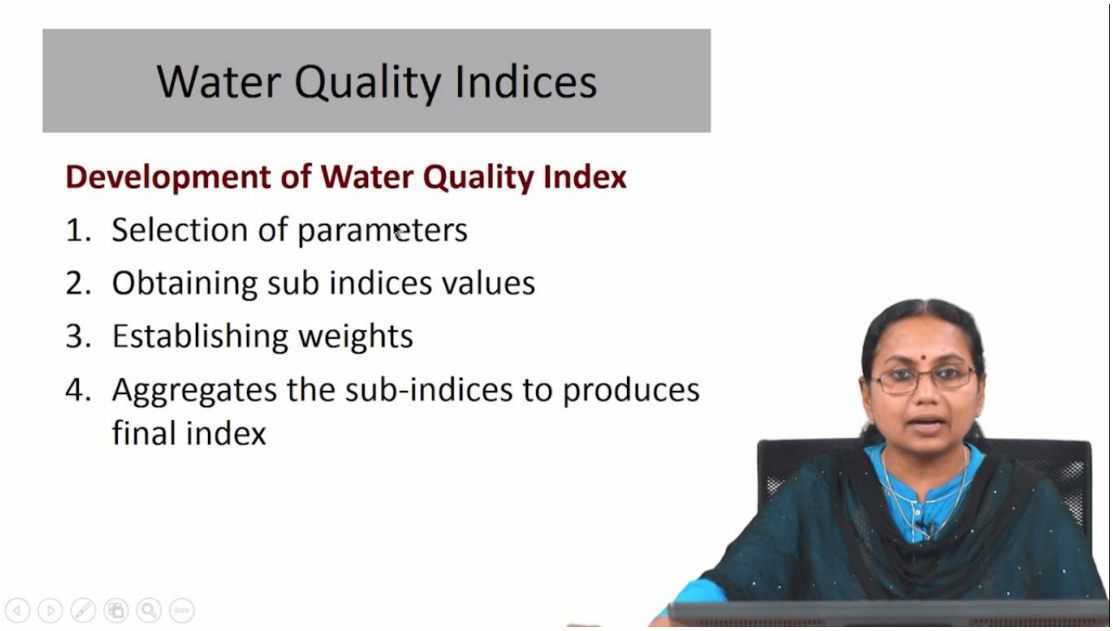
So, we have seen that the water quality is very very important. So, water quality monitoring is very very essential. So periodic monitoring of water quality is essential, and whenever you are identifying a new source of water supply, so, you have to take the sample and analyze for all the parameters specified in the Bureau of Indian Standards or if it in some other country then the standards prevailing

in that country. We have to do it. And many times sophisticated instruments are needed for the analysis and they are costly and not accessible for many.

So, many places easy to use and affordable monitoring systems are being used, and it is very very essential. Because for a village if the people wanted to check the water quality, taking the water and going to a high-end lab, one is time-consuming and another one is it is very very costly. So, it is very important to have easy to use and affordable monitoring systems to ensure water quality and well-being of the people.

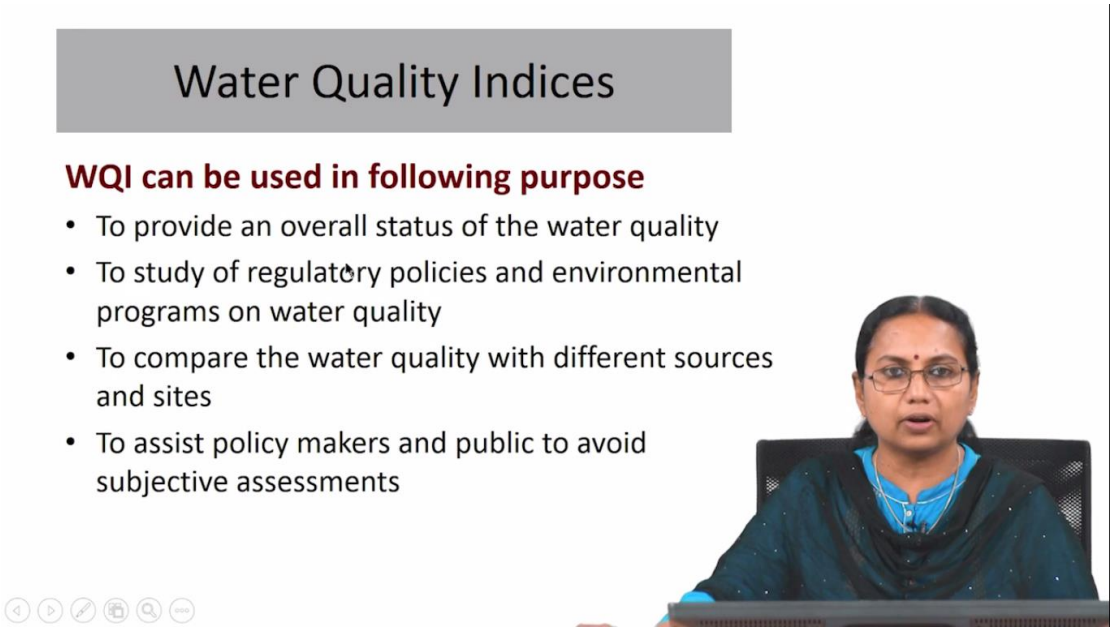


So, now we have seen that in the earlier tables there are some 43 parameters which is specified in the water quality. And when layman wanted to understand whether the water available for him or her is of good quality and they will not be understanding the chemistry or physics of this one. So, how can we communicate this one, the quality of the water available for them for drinking purpose? So, for that purpose, people are using water quality indices. So, here what is happening is the entire water quality say 43 parameters or 100 parameters, entire thing we are converting it into a single number which will be easily understood by the common people. So, what is the water quality indices? It is the empirical expression which indicates the various physical, chemical and biological parameters of water. This is a precise number to communicate to the layman, an average of a set of physio-chemical and biological parameters and there are various types. It can be additive type or weighted average type or multiplicative type depending upon what you are looking for etc. and developed by sending a questionnaire to people and fixing the values. So, for example, if you take the bacteriological quality, I told it is the most important thing. So, you have water which is looking very clean, and chemicals are not present, but many pathogens are present in the water. So, what is the number you have to give? So if you take all the standards and add it up and give a number, then it may be misleading. So, the weight for it, each parameter is assigned based upon a questionnaire send to people who is working in this area and who is knowledgeable in that one. Based upon this one some weights and the numbers have come up, and usually, these water quality indices vary from 0 to 100. Zero the least and 100 is the highest. So, if something is 90 and above we can tell that water is relatively good.



So, how to develop the water quality index. First, we have to do the selection of parameters because when you have 50 parameters or 100 parameters which all are the most important parameters we have to select. For example, definitely we have to include bacteriological quality. But whether we have to include taste, whether we have to include other parameters which is not that problematic with respect to the health of the being. So that is why the selection of the parameter is very important and obtaining sub-indices values. For example, if the bacteriological quality, zero pathogen is there, one pathogen is there, or 100 pathogens is there, is it a linear relationship or is it varying, okay, zero, okay, you will be having maximum value one onwards it will be coming to zero. That means the water is having zero pathogens then you will be getting 100 marks and if it is more than one – more than zero or more than one, then the value will come down to zero. So, these are debatable things. So, we have to get appropriate sub-indices.

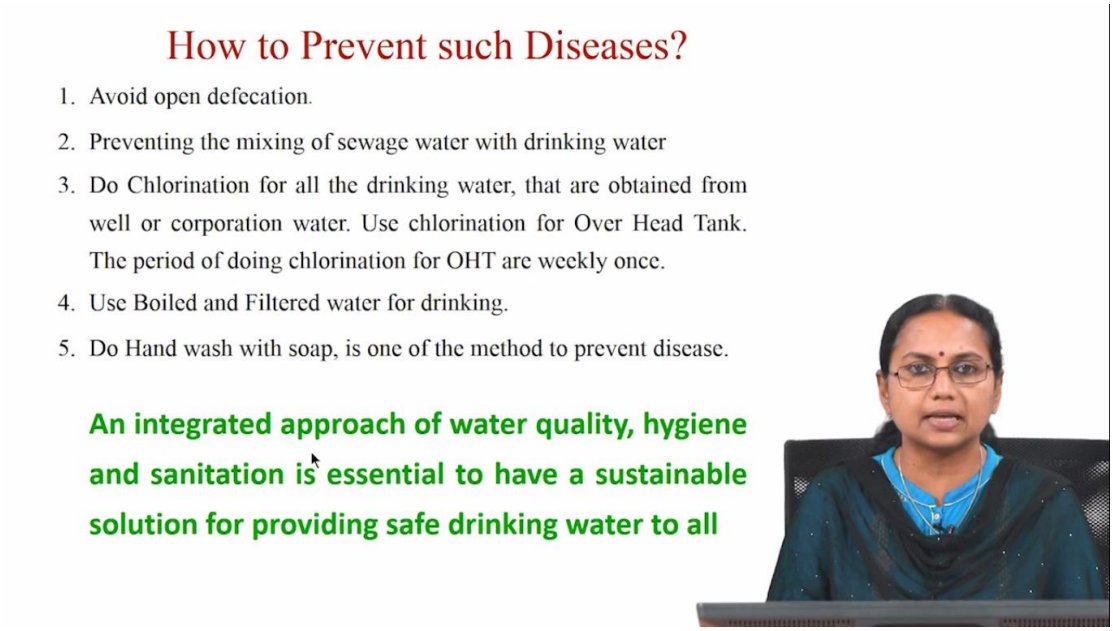
Then establishing weights. Which parameter should have maximum weight, which should have less weight, etc. this also has to be established. And aggregates the sub-indices to produce the final index. And all these things are done through questionnaires and a lot of discussions with the people working in this area and experts in this area and all the things. So, please understand there is a term known as water quality indices – index, it will tell average or whether the water is good or not with a single number.



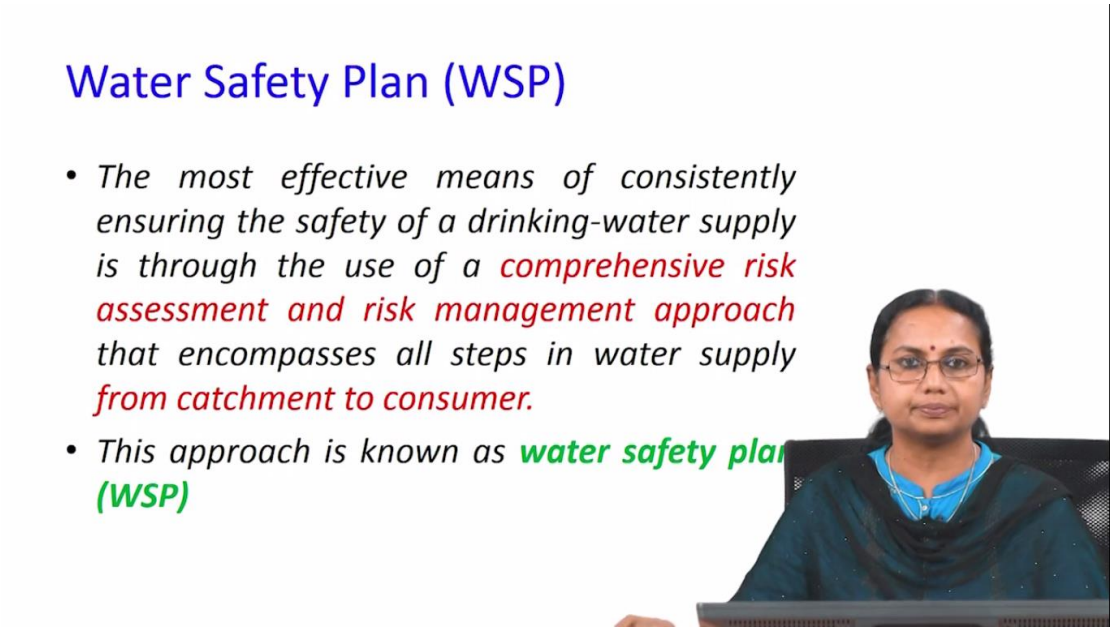
And water quality index can be used in the following purposes to provide an overall status of the water quality. It may not be giving you the details, but it will give an overall status of the water quality. And to study the regulatory policies on environmental programs on water quality because many regulatory policies may be coming and the environmental protection progress may be coming into effect. So, if you want to understand how it is affecting the water quality, then these numbers can be used different places and look into the water quality index and see whether it is having a positive impact or negative impact, etc. And this also can be used to compare the water quality with reference to with different sources and sites. A comparison because you have 50 parameters then comparing what to what, we have to compare. So, if you have a single number the comparison of water quality with different sources and site is easy.

And the last one is to assist policy makers and public to avoid subjective assessments. Many times, what happens if you have a water one water sample maybe looking very clean to our eyes and it does not have any smell or anything and other water sample which may be having slight color because of iron or something like that, but other chemical and biological parameters are well within the limit. Because of this color and all people will get a feeling that the colored water is not suitable for drinking purpose whereas the clean water is suitable for the drinking purpose. But, the clean water which looks to be clean maybe containing many chemicals beyond the permissible limit and the bacteriological contamination may also be there.

So, this water quality index can be used to assist the policy makers and the public to avoid subjective assessments. So, these are the importance or uses of water quality index.

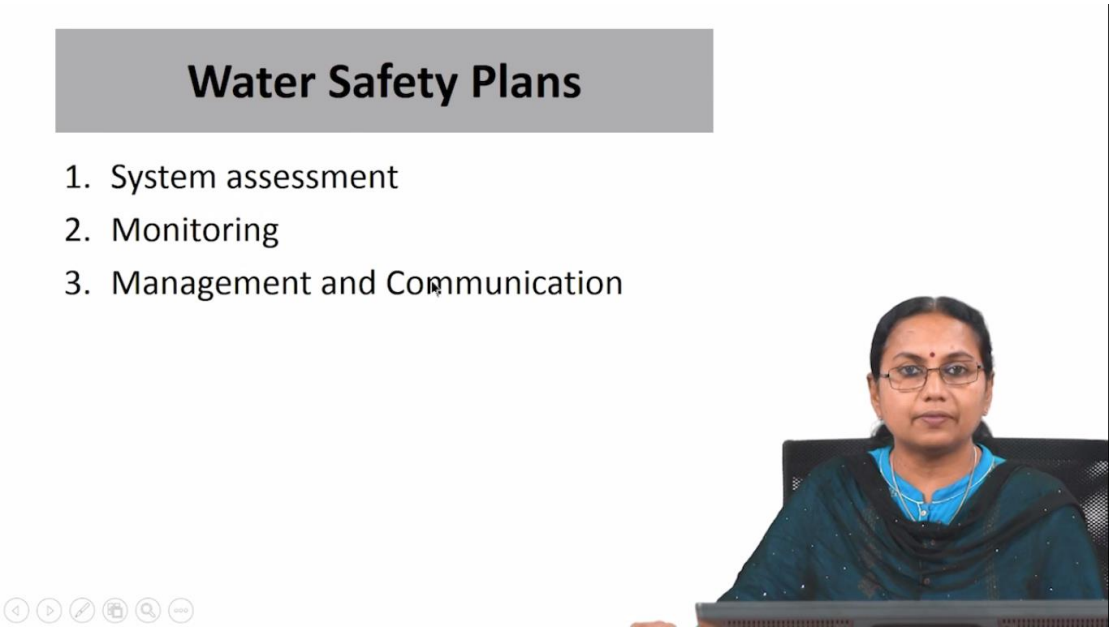


So, now we will see last class we were discussing about different types of disease which is spread through water and all the things. So, how to prevent such disease. One is avoid open defecation because that is the one which will which causes most of the bacteriological contamination. Then preventing the mixing of sewage water with drinking water that is another thing. Do chlorination or other disinfection for all the drinking water that are obtained from well or corporation water. Use chlorination for the overhead tank. The period of doing chlorination for OHT are weekly once, this is not correct, this is what most of the time we imply. We have to chlorinate the water on whenever we are supplying fresh water to the tank, you have to chlorinate otherwise you will be getting undisinfected water, or the water which is not disinfected that may cause diseases. Use boiled and filtered water for drinking purpose especially when there is some diseases spreading in the area. Do hand wash with soap, is one of the methods to prevent diseases. And the most important thing is an integrated approach of water quality, hygiene and sanitation is essential to have a sustainable solution for providing safe drinking water to all. Because if you are taking care of only the drinking water and we are completely neglecting the wastewater and the other waste generated in the surrounding, so you will not be able to provide good quality water because always there is a chance of the water getting contaminated. It may not be through the distribution system, at the point of use it can get contaminated.



So now, a new concept has come in water safety plan. So, why should we contaminate the water and treat it and measure the quality and all the things? So, the better approach is prevent the contamination of the water. So that is the basis of a water safety plan. The most effective means of consistently ensuring the safety of a drinking water supply is through the use of a comprehensive risk assessment and risk management approach. This is a comprehensive risk assessment and risk management approach that encompasses all the step in water supply from catchment to consumer because the earlier lectures we have seen what are the components of a water supply system from the source, then collection system, then treatment, then distribution system, then the point of use.

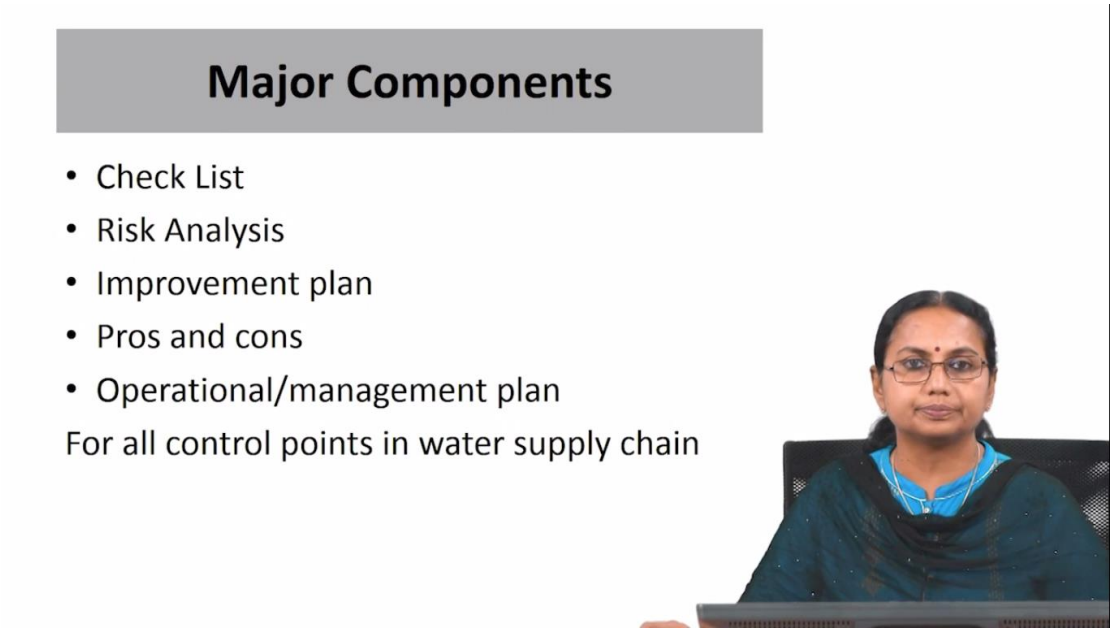
So, this risk assessment is encompassing all these components. So, this approach is known as water safety plan, that means see that the water is not getting contaminated in any source.



So, how can we do the water safety plan? First one is, system assessment, the second one is monitoring, the third one is management and communication. So, all these three components are very very important in water safety plan.

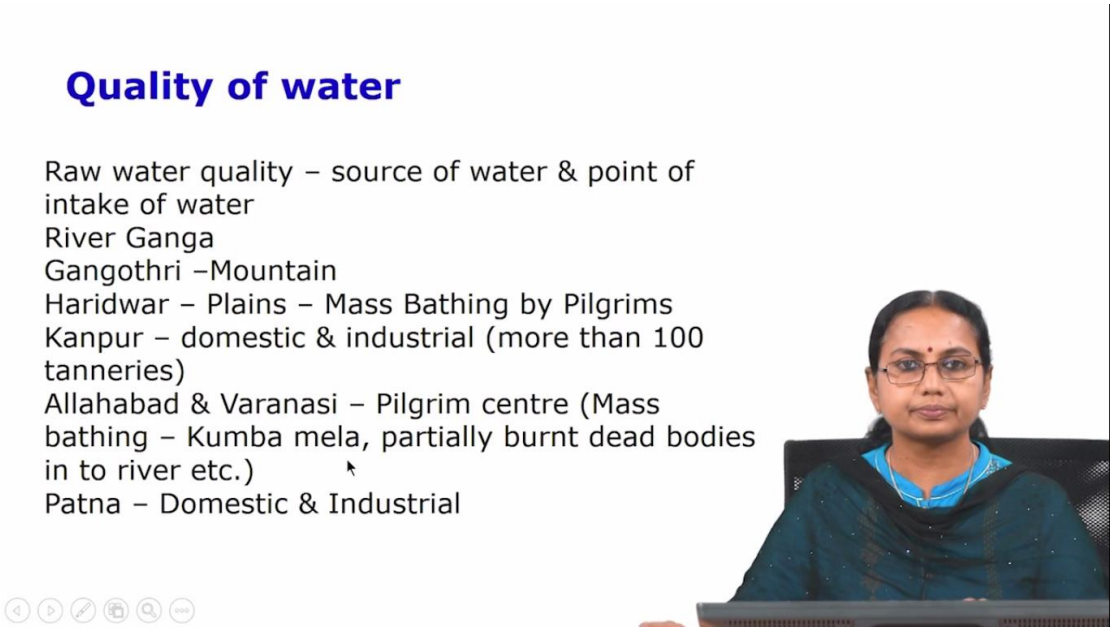
So, water safety plan, it ensures water quality consistently at the point of use. This is the objective. Ensure water quality consistently at the point of use. And it is a risk management approach. We have seen that one. So, assess the water chain hazards and risk, identify and implement control measures and corrective measures. For example, you take a village; there you have an open well, so, you can identify

what is the catchment area for that open well. So, if you can keep the catchment area for that well clean, the chances of the well getting contaminated will be very very less. And what we can do is you keep monitoring the system and if anything happens, what is the method to control the risk and what corrective measures can be taken for future contamination, etc. will be explained herein water safety plan. Again, it emphasis on prevention and management than control. So, if you can prevent and manage, if anything can happen, identify that one in advance and manage that one. That one will be always better than contaminating the water and then treating and keep on measuring the things. The second option that means contaminated water treat and distribute and keep on monitoring that one will be very very costly compared to prevent the contamination and manage the system in such a way that there will not be any contamination.



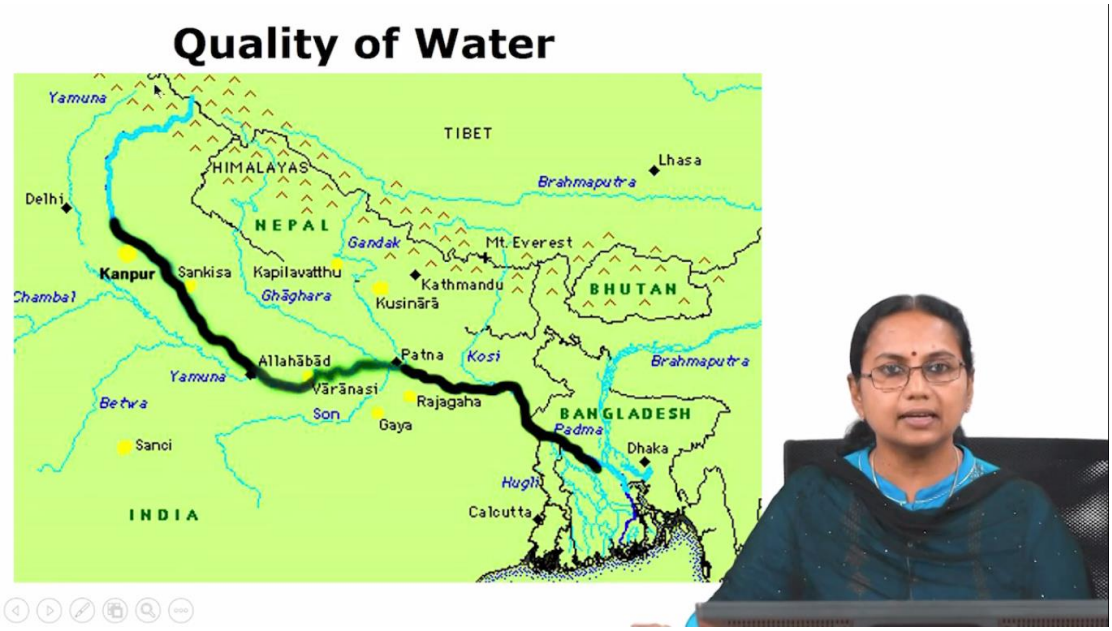
So, major components of this water safety plan is a checklist. So, you take a system, and what all are the components involved in that one, so you have to make the checklist, then you have to look into risk analysis, where all the risk can happen. For example, in a distribution system, you know that so many kilometers of pipeline will be there. So, one of the things is leakage. So, how can you find out where the leakage can happen. If the leakage is there the chances of contamination is there. So, you have to look into the pipeline health and all the things. So that is why the checklist, then risk analysis, what all are the risk involved in that one you have to look into, then come up with an improvement plan. So, what all are the ways you can improve the system, then different improvement plan will be there. You look into the pros and cons of each plan and identify which is the best option for that particular system. Then come up with an operation and management plan, and you have to stick to this one for all control points in the water supply all these things are needed. For example, for the source, you have to have a checklist of the chances of contamination and all, then risk analysis, then you come to the treatment system you have to have the things. The distribution system you should have the thing. Then point of use system, in the point of use itself the tap, until the tap if the clean water comes, even there the chances of contamination is there. If you are taking in a glass, if the glass is not clean definitely the water whatever you are consuming will be contaminated.

Similarly, if your hand is not clean and you are putting your fingers inside the glass, the chances of contamination is there. So that is why the control points, this has to be done for all control points in the water supply chain.

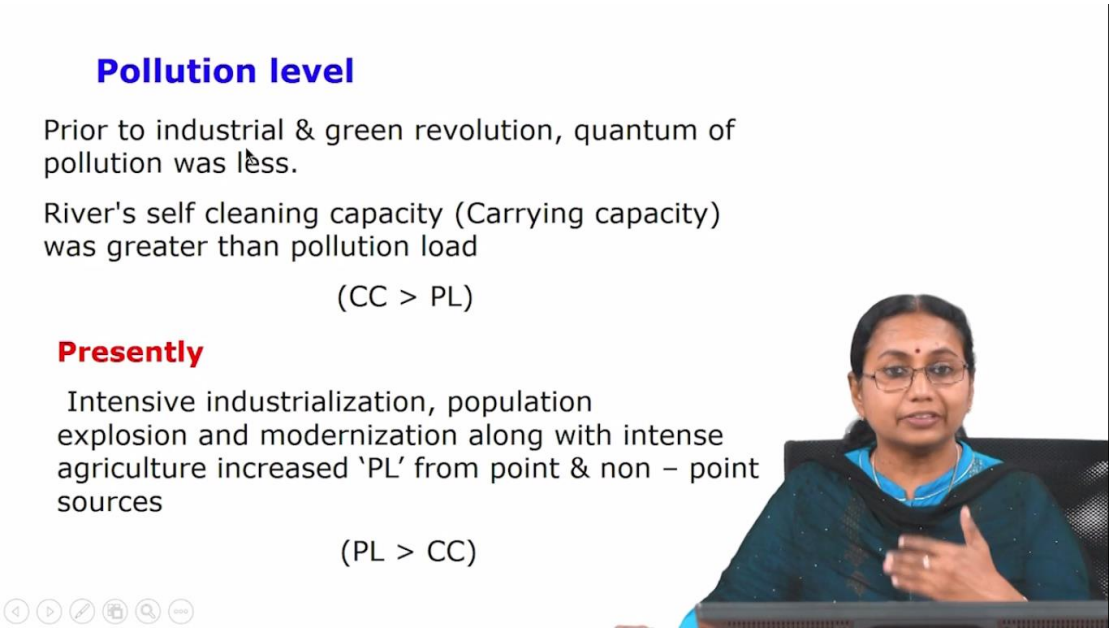


Now, we will see what is the philosophy of water treatment? So first we will see the water quality. For example, we will take a river. In many of the cities in India, we use some surface water source as the water supply source. So, we will take the case of Ganga river because Ganga river is the water supply source for many cities starting from Rishikesh, Haridwar, Kanpur, Allahabad, etc. So, it is the Ganga water. So, when we take the water from the Ganga river whether the quality of the water will be same all through the river or that treatment needed for drinking purpose is same all throughout the river that is what we are discussing here.

So, the raw water quality. So, the raw water, whatever we are going to supply to the people will be depending upon the source of water and point of intake of water because source of water we have discussed earlier because different sources will be having different types of pollutants and point of intake of water is also very important. So this I will explain through the case of Ganga river. So, Ganga river is originating from Gangotri, and it reaches the plains in Haridwar, and you know that Haridwar, mass bathing by pilgrims, etc. takes place and it flows down, reaches Kanpur, in Kanpur lot of domestic and industrial waste is getting mixed up with the Ganga river water, then Allahabad and Varanasi again pilgrim centers and partially burnt dead bodies in the river and lot of industrial waste again getting into the thing and domestic wastewater also and Patna again domestic and industrial waste.

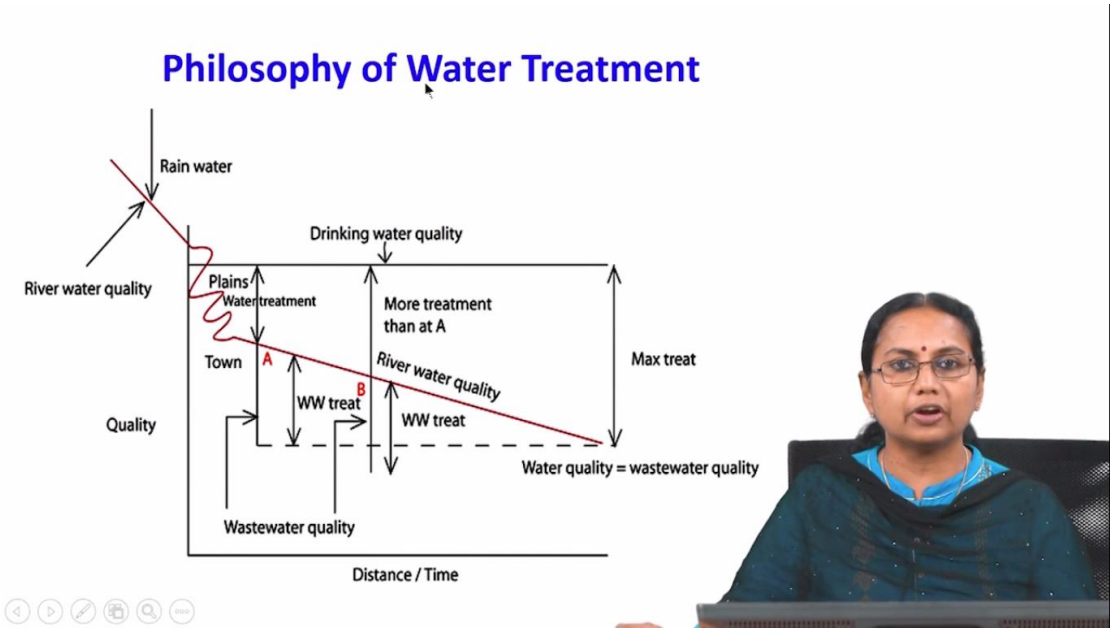


So, if you see the Ganga river, you see here from the starting point up to Haridwar, or so, the quality of the water is good. And as it flows the downstream say Kanpur and all the water quality will be getting deteriorated because more and more waste, treated or partially treated or untreated waste is getting into the river. As it flows, the quality is getting worse and worse. So that is what is happening, so and this Ganga river is acting as the source of water for many many cities. So, if you take the water in Haridwar, in Kanpur, in Patna or in Howrah whether the extent of treatment needed is the same? It will not be, because the quality of the water is different.

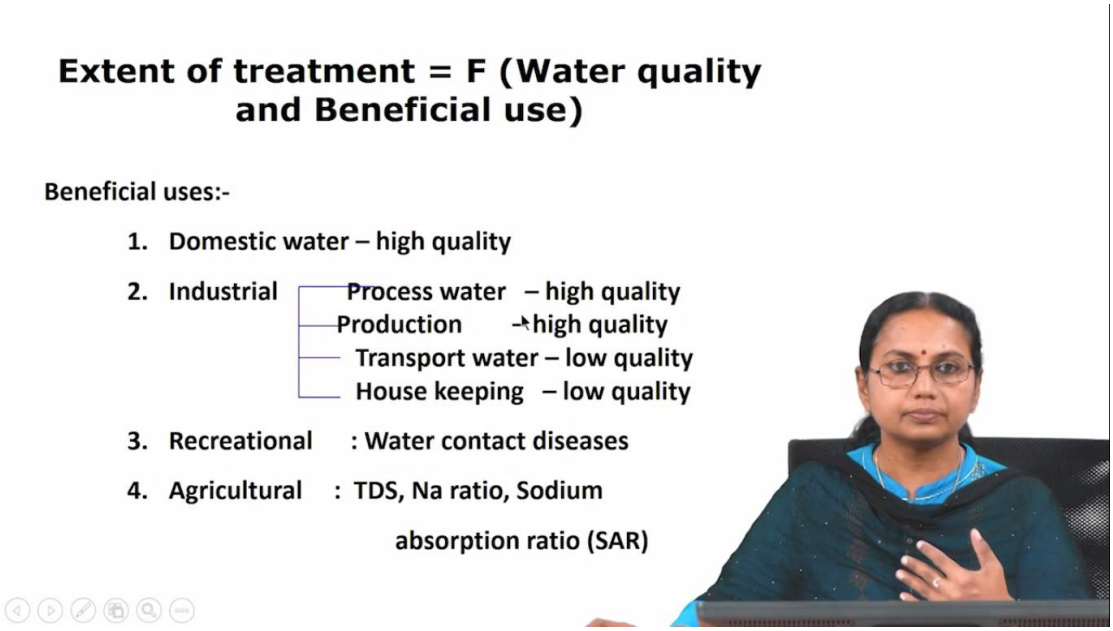


So, the pollution level of the river is changing. Prior to the industrial and green revolution, the quantum of pollution was less. So, rivers are having self-cleansing capacity, or it is known as the carrying

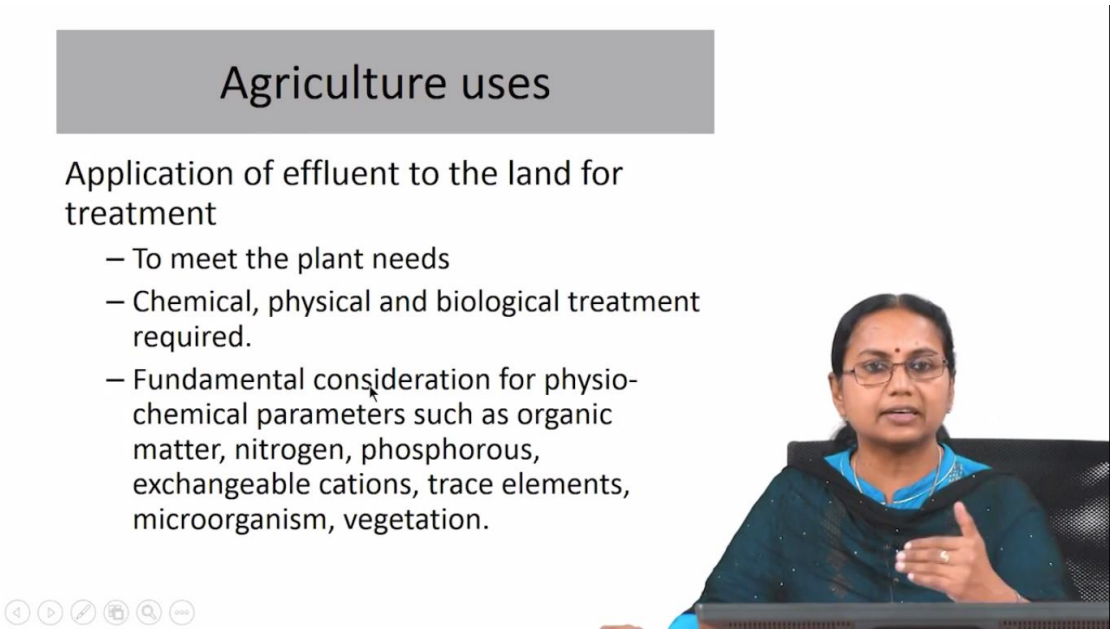
capacity. For example, you have a majestic river, and very little amount of waste is getting into the river. The river itself can clean the thing because there is oxygen transfer some microbes are present there and all the things. So, in earlier days the carrying capacity of the river was much greater than the pollution level or pollution load. But presently what is happening is intensive industrialization, population explosion, and modernization along with intense agriculture, increase the pollution load from the point and non-point sources. So, at present pollution load is much greater than carrying capacity. So, the river quality or river water quality is deteriorating as it flows.



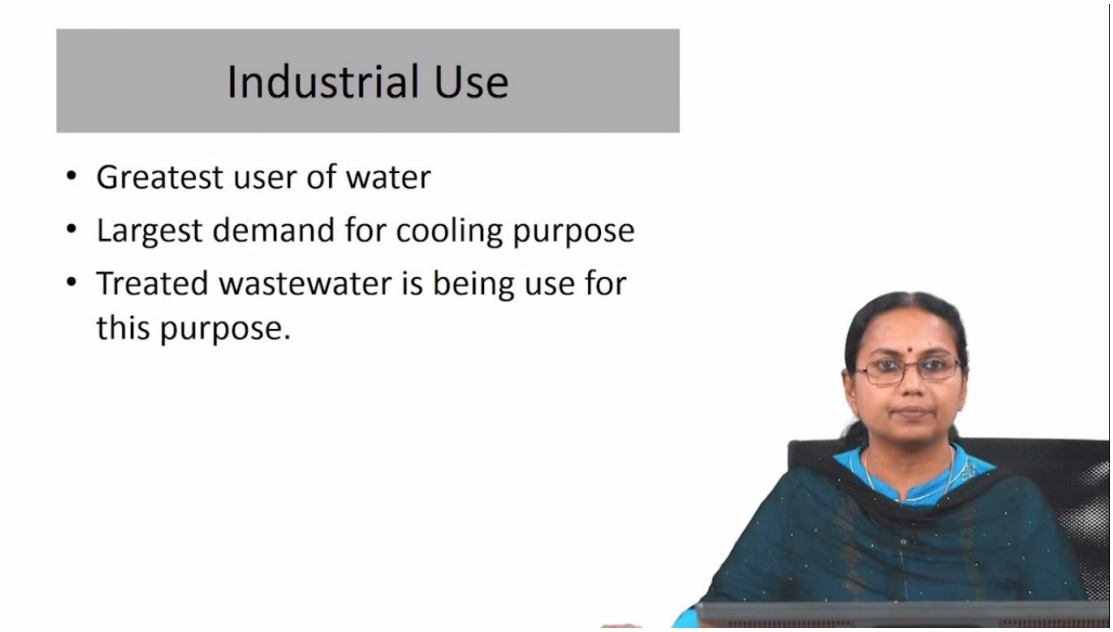
So, the philosophy of water treatment. So, what is the philosophy of water treatment? So, this picture shows it very clearly. So, this is the rainwater, I am showing there, and this is the rainwater quality. And I am marking this is the drinking water quality. So, some specific number or that is marked here. So, rainwater, the quality of rainwater, pure rainwater without any contamination, I am talking about that one. The quality is much higher than whatever is specified in the standard. So, what is happening, the rainwater quality is very good. So, you do not need any treatment because the drinking water standard or drinking water quality is somewhere here. So, and if you take the Ganga river in the initial stages, the quality is relatively good where it is originating and all the things. You may not need much treatment. As it passes what is happening? the quality is deteriorating. So, depending upon the source where we are taking the water. So, in the upstream, for example, Haridwar, the extent of treatment needed may be the gap between this black line and the red line. But when it comes to Kanpur, what will happen much more wastewater is getting into the thing, so the water quality of the river has come down significantly. So, you have to give much more treatment and as the pollution load increases the treatment needed for the river is very high. So, what is the philosophy of water treatment, when your raw water quality is lower than the required water quality - drinking water quality, what is the extent of treatment you have to provide to bring it to the drinking water quality. So, that is the thing. So, the water treatment will not be uniform all throughout. It will be varying based upon your raw water quality and what purpose you are using the water for.



So, the extent of treatment is a function of water quality and the beneficial use. So, if your raw water quality is bad you have to give more treatment and depending upon the beneficial uses also. So, we will see what are these beneficial uses. When we talk about domestic water, high quality is needed. Industrial process water, the water which is getting involved in the process, high quality and product water also high quality, but the water used for transport purpose and housekeeping low quality is sufficient. Recreational water, we have to see that water contact diseases are not spreading. We are not bothered much about the chemical parameters. Agriculture again we have to be careful about the total dissolved solids, sodium ratio, sodium absorption ratio, etc.

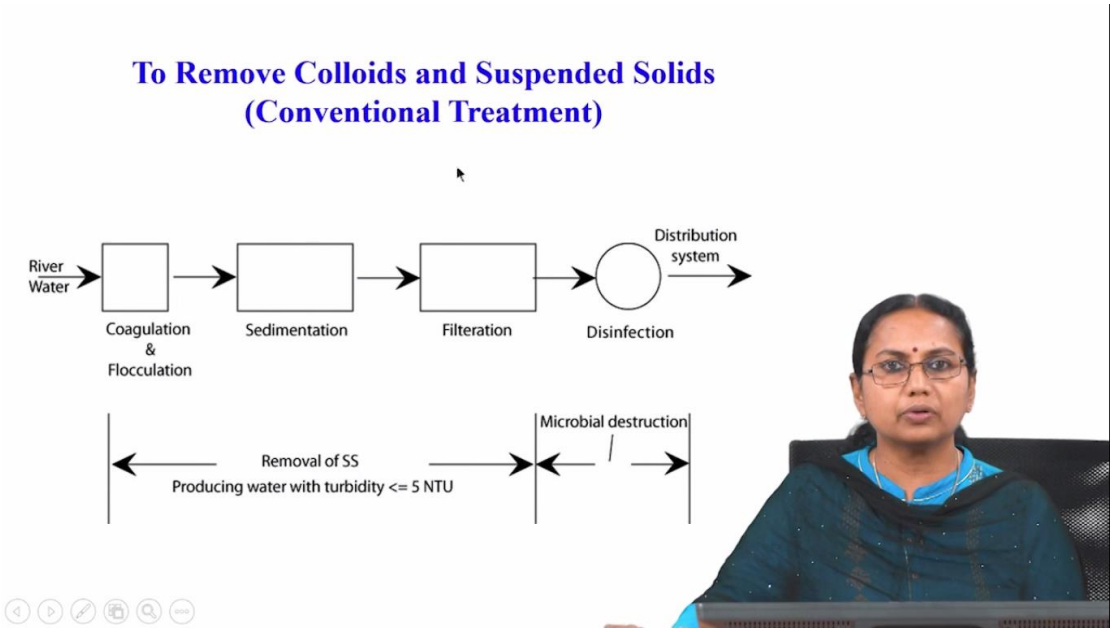


And agriculture use, application of effluent to the land for treatment, so we have to be careful. We cannot give a water with very high TDS. It will be affecting the soil characteristics and plant intake etc.



And industrial use, largest demand for cooling purpose, treated wastewater is being used for this purpose but depending upon the industry, different standards are needed. So, according to that one you have to give the treatment. What I am trying to tell is, the water treatment is not a uniform all throughout, depending upon the raw water quality and the beneficial use it will be varying.

In the case of industrial water if it is not treated there can be scaling, metallic corrosion, biological growth, fouling, etc. can happen.



So, to remove colloids and suspended solids, this is the conventional treatment system usually we employ. The river water if you take it, you give coagulation and flocculation, sometimes if the turbidity is very high before this one itself you give plain sedimentation. Then coagulation and flocculation and sedimentation, then we go to a filtration, then disinfection. So, this treatment systems will be removing all the suspended and colloidal particles, and your disinfection system will be removing the microbial contamination.

So, next class, we will discuss about the details of treatment.

Thank you.