Chemical Process Utilities
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Lecture - 17
Water Quality standards-II

Hello, friends. Let us discuss the water quality standards under the aegis of chemical process utilities. In the previous lectures, we have covered the different types of water properties. We briefly introduced why these properties are essential, maybe if we use the water for industrial or household purposes. Then we discussed the quality parameters especially applicable for the drinking waters like BOD, COD, pH coloring compound, total solids, total dissolved solids, etc.

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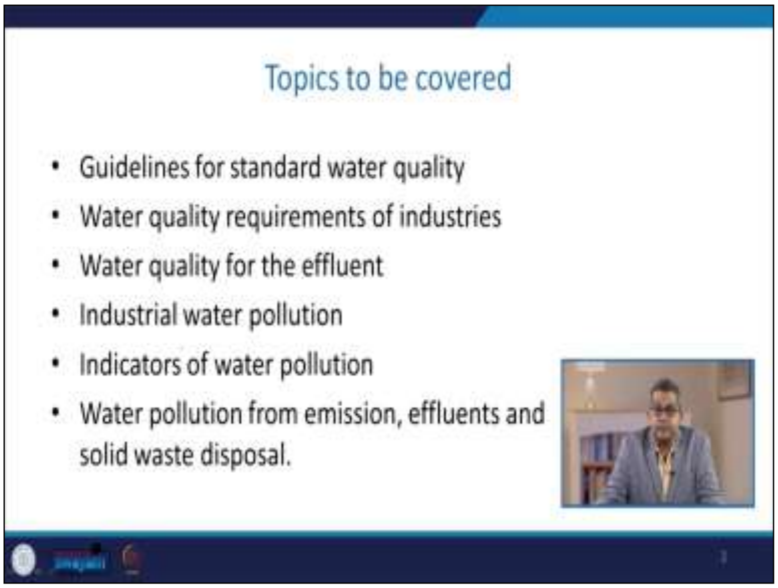

In this particular chapter, we are going to discuss the various guidelines for standard water quality. We are going to discuss the water quality requirements for industries. We will discuss the water quality for various kinds of effluents, especially industrial water pollution. Then we will discuss the indicators of water pollution. We will discuss the water pollution from emission effluents and solid waste disposal.

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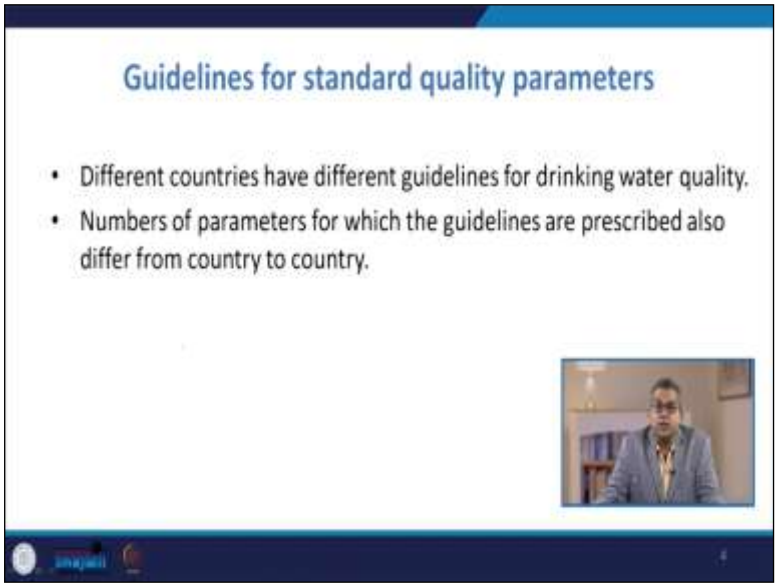

Now let us talk about the guidelines for standard quality parameters. Now the different countries have different guidelines for drinking water quality. So, especially when we talk about the availability and a requirement. Then every country or even every state has various guidelines for drinking water quality. So, a number of parameters may be needed. The number of parameters for which the guidelines are prescribed differs from country to country, state to state region to region.

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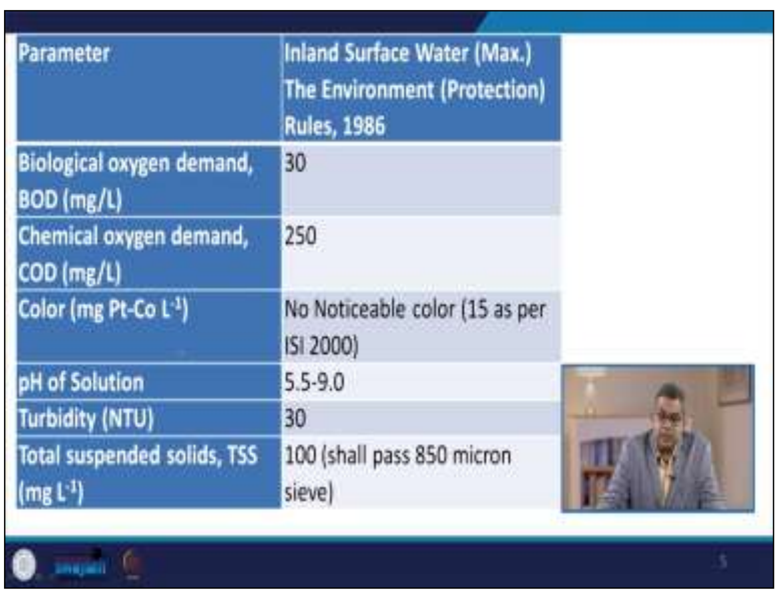

Parameter	Inland Surface Water (Max.) The Environment (Protection) Rules, 1986
Biological oxygen demand, BOD (mg/L)	30
Chemical oxygen demand, COD (mg/L)	250
Color (mg Pt-Co L^{-1})	No Noticeable color (15 as per ISI 2000)
pH of Solution	5.5-9.0
Turbidity (NTU)	30
Total suspended solids, TSS (mg L^{-1})	100 (shall pass 850 micron sieve)

Now here you see that in this table, we have discussed the various parameters and the inland surface water or the in the environment protection rules 1986. The biological oxygen demand BOD is referred to as 30 milligrams per liter. Similarly, the chemical oxygen demand it is referred as

250 milligrams per liter. Then coloring compound must not have any noticeable colors 15 as per BIS code, ISI 2000.

Then the pH of the solution must be maintained between 5.5 to 9, the turbidity should be 30, and TASS or total suspended solids should be 100, which means they shall pass the 850-micron sieve.

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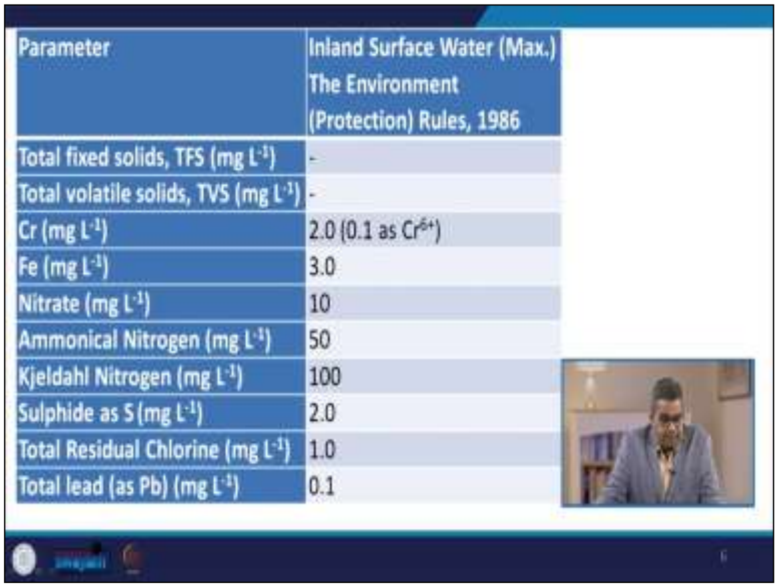

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Turbidity (NTU)	30
Total suspended solids, TSS (mg L^{-1})	100 (shall pass 850 micron sieve)
Parameter	Inland Surface Water (Max.) The Environment (Protection) Rules, 1986
Total fixed solids, TFS (mg L-1)	-
Total volatile solids, TVS (mg L-1)	-
Cr (mg L-1)	2.0 (0.1 as Cr6+)

Fe (mg L-1)	3.0
Nitrate (mg L-1)	10
Ammonical Nitrogen (mg L-1)	50
Kjeldahl Nitrogen (mg L-1)	100
Sulphide as S (mg L-1)	2.0
Total Residual Chlorine (mg L-1)	1.0
Total lead (as Pb) (mg L-1)	0.1

Total fixed solid TFS should not be there, total volatile solid should not be there the chromium maybe 2.0 iron 3.0 nitrate 10 ammoniacal nitrogen, and that must be 50 milligrams per liter Kjeldahl nitrogen must be 100 milligrams per liter sulfide which represents the sulfur it should be 2.0 milligram per liter and TRS that is referred as total residual chlorine 0.1 milligrams per liter and total lead it should be I mean in a traceable amount that should be 0.1 milligrams per liter.

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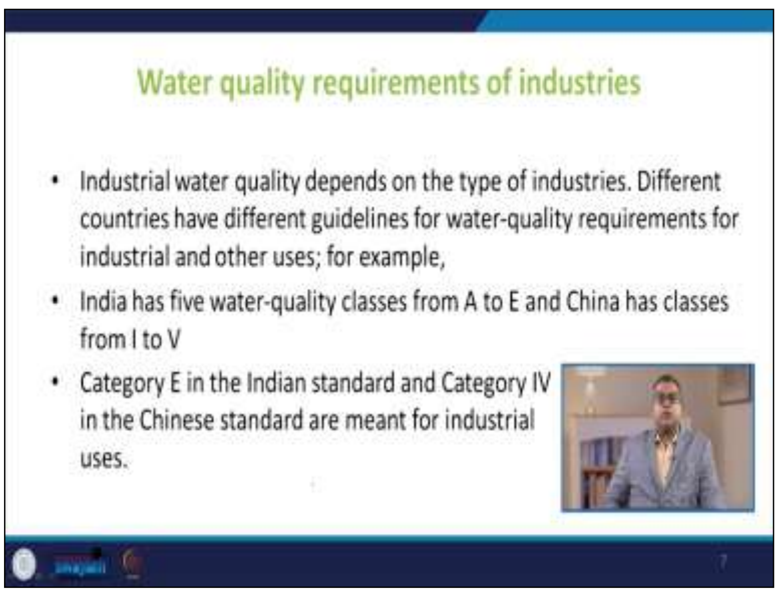

When we talk about the water quality requirement for industries, industrial water quality depends on the types of industries. Every industry may have a different type of water requirement different types of effluent that is purely based on the industry industrial owned specific use. So, different countries have different guidelines for water quality requirements, and as I discussed, this may differ from industry to industry and other uses.

For example, India has five water quality classes, from A to E, and China has classes from 1 to 5. Category E in the Indian standard and four in the Chinese standard are meant for industrial uses.

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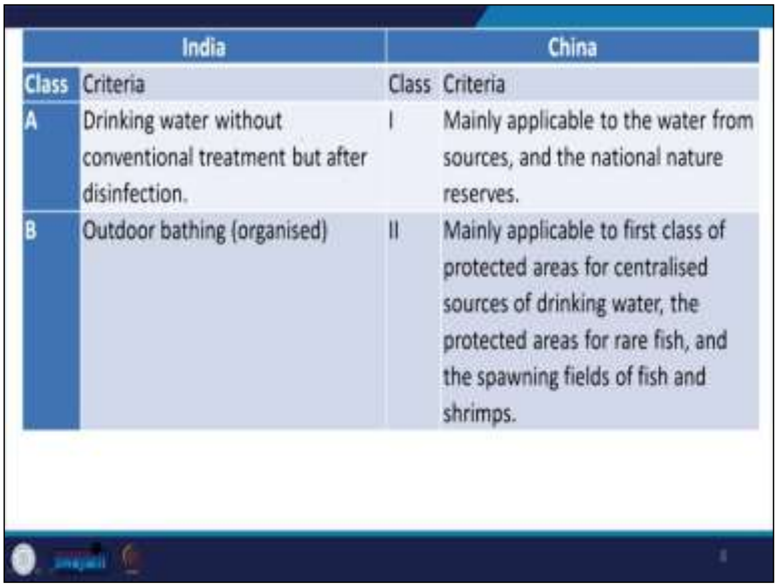

India		China	
Class	Criteria	Class	Criteria
A	Drinking water without conventional treatment but after disinfection.	I	Mainly applicable to the water from sources, and the national nature reserves.
B	Outdoor bathing (organised)	II	Mainly applicable to first class of protected areas for centralised sources of drinking water, the protected areas for rare fish, and the spawning fields of fish and shrimps.

Now here you see a class different we have depicted and compared with China. Class A, referred to as class 1 in Chinese criteria, is the drinking water without conventional treatment but after disinfection. The Chinese aspect is mainly applicable to the water from sources and the national nature reserves. If we talk about class N in the Indian context and the counterpart is class 2 in China context.

Now in Indian criteria, outdoor bathing in the organized sector and the Chinese context is mainly applicable to the first class of protected areas of centralized drinking water sources. The protected areas for rare fish and the spawning fields are fish and shrimp.

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India		China	
Class	Criteria	Class	Criteria
C	Drinking water source after conventional treatment and disinfection	III	Mainly applicable to second class of protected areas for centralised sources of drinking water, protected areas for the common fish and swimming areas
D	Propagation of wildlife and Fisheries	IV	Mainly applicable for industrial use and entertainment which is not directly touched by human bodies.
E	Irrigation, industrial cooling, controlled waste disposal	V	Mainly applicable to the bodies of water for agricultural use and landscape requirement.
Below-E	Not meeting any of the A, B, C, D and E criteria	Nil	-

Then class C is the drinking water source after conventional treatment and disinfection. Now, let's talk about the counterpart in the Chinese context. This is mainly applicable to the second class of protected areas for centralized sources of drinking water protected areas for the common fish and swimming areas. In the Indian context, if we talk about class D, the propagation of wildlife and fisheries, and class 4 of Chinese criteria, mainly applicable for industrial use and entertainment, which is not directly touched by human bodies.

And in the Indian context, we have class E attributed to industrial irrigation cooling controlled waste disposals, and in the Chinese context, the only applicable to the bodies of water for agricultural use and landscape requirement. Below E in the Indian context does not meet any of the A, B, C, and D criteria, and there are no criteria available for Chinese classification.

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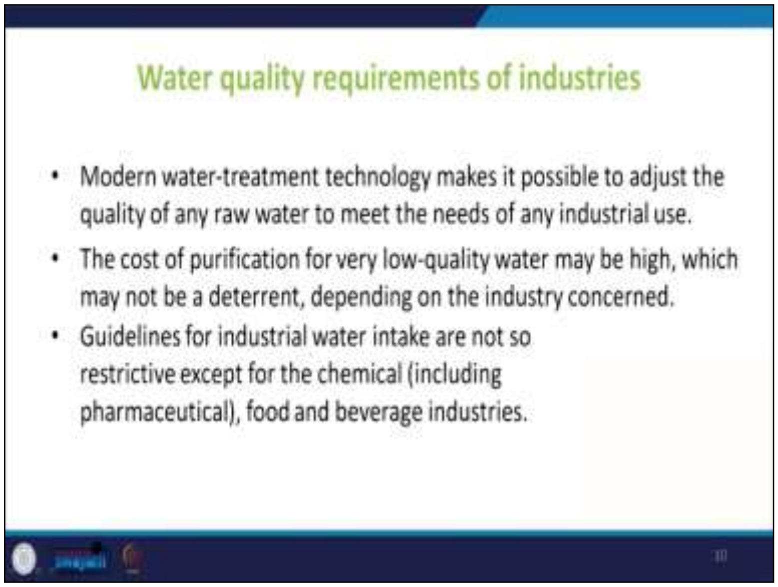

Now, modern water treatment technology makes it possible to adjust the quality of any raw water to meet the needs of any industrial use. The cost of purification for very low quality water may be high, which may not be a deterrent depending on the industry concerned. Guidelines for industrial water intake are not restrictive except for the chemical, pharmaceutical, and food beverage industries.

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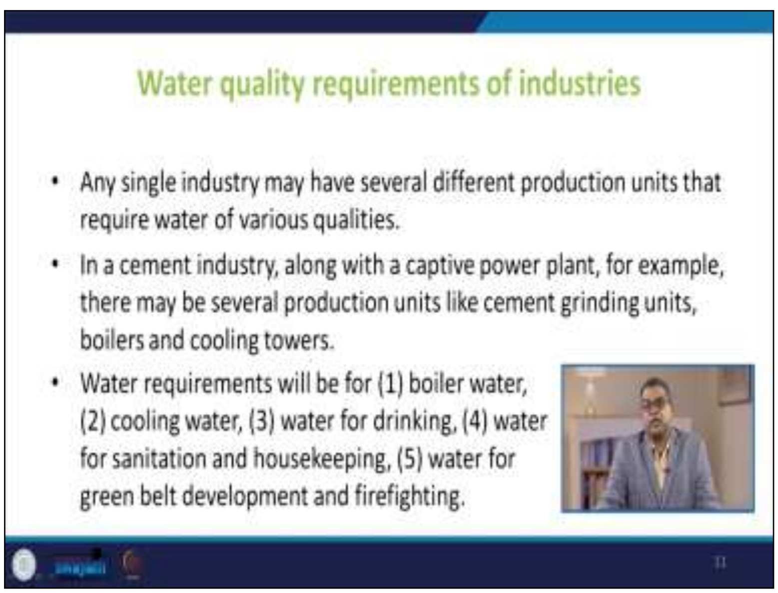

Now any single industry may have several different production units that require water for various qualities, including housekeeping, etc. In the cement industry, for example, along with the captive power plant, there may be several production units like cement grinding units, boilers, cooling towers, and water requirements will be for say, boiler water, cooling water, water for drinking water for sanitation and housekeeping water for green belt development and fire fighting.

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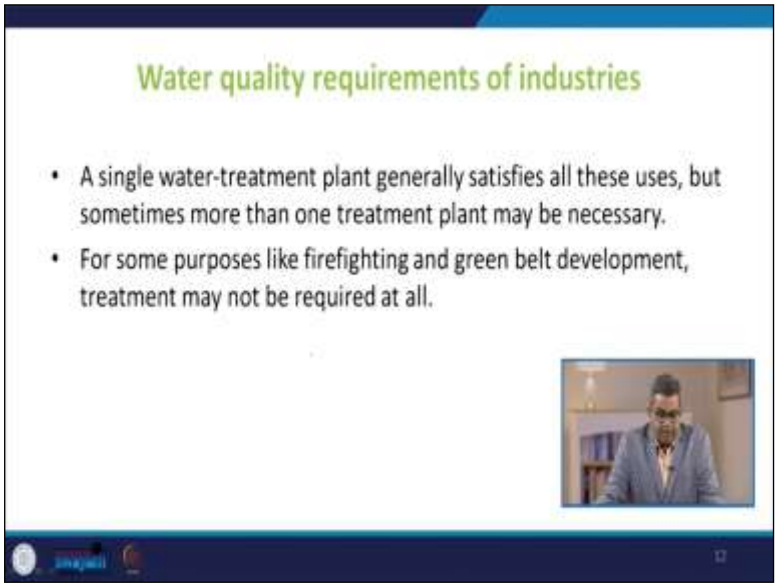

A single water treatment plant generally satisfies all these uses, but sometimes more than one treatment plant may be necessary. For some purpose, like if you say the fire fighting green belt development, the treatment may not be required at all and or if required. Then up to a very minute step steps.

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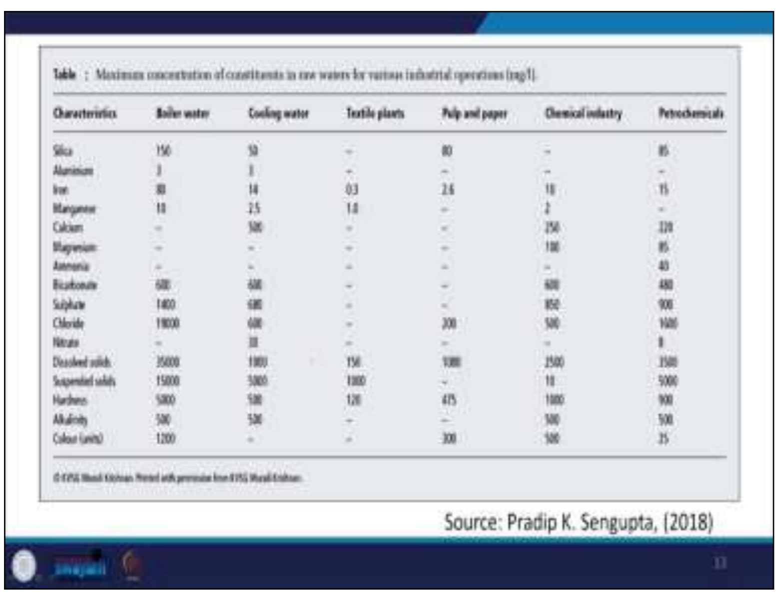

Table : Maximum concentration of constituents in raw waters for various industrial operations (mg/l).

Characteristics	Boiler water	Cooling water	Textile plants	Pulp and paper	Chemical industry	Petrochemicals
Silica	150	50	–	80	–	85
Aluminium	3	3	–	–	–	–
Iron	80	14	0.3	2.6	10	15
Manganese	10	2.5	1.0	–	2	–
Calcium	–	500	–	–	250	220
Magnesium	–	–	–	–	100	85
Ammonia	–	–	–	–	–	40
Bicarbonate	600	600	–	–	600	480
Sulphate	1400	680	–	–	850	900
Chloride	19000	600	–	200	500	1600
Nitrate	–	30	–	–	–	8
Dissolved solids	35000	1000	150	1080	2500	3500
Suspended solids	15000	5000	1000	–	10	5000
Hardness	5000	500	120	475	1000	900
Alkalinity	500	500	–	–	500	500
Colour (units)	1200	–	–	300	500	25

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Source: Pradip K. Sengupta, (2018)

Now here you see that this particular table depicts the maximum concentration of constituents in raw water for various industrial operations. Now, if you see, there are various characteristics listed in column one: silica aluminum iron, manganese calcium magnesium ammonia, bicarbonate sulfate chloride nitrate, etc. Now here you see that in the first row, different types of industries enlisted or different types of operation enlisted like boiling water, boilers water, cooling water textile plant pulp and paper chemical industries petrochemical.

Table 6.8 Maximum concentration of constituents in raw waters for various industrial operations (mg/l).

Characteristics	Boiler water	Cooling water	Textile plants	Pulp and paper	Chemical industry	Petrochemicals
Silica	150	50	–	80	–	85
Aluminium	3	3	–	–	–	–
Iron	80	14	0.3	2.6	10	15
Manganese	10	2.5	1.0	–	2	–
Calcium	–	500	–	–	250	220
Magnesium	–	–	–	–	100	85
Ammonia	–	–	–	–	–	40
Bicarbonate	600	600	–	–	600	480
Sulphate	1400	680	–	–	850	900
Chloride	19000	600	–	200	500	1600
Nitrate	–	30	–	–	–	8
Dissolved solids	35000	1000	150	1080	2500	3500
Suspended solids	15000	5000	1000	–	10	5000
Hardness	5000	500	120	475	1000	900
Alkalinity	500	500	–	–	500	500
Colour (units)	1200	–	–	300	500	25

And you see that if we take one example that in silica the maximum concentration attributed for the boiler water is 150 and a cooler cooling water 50 and other, they do not require apart from the pulp and paper. Similarly, the aluminum and iron for boiler water should be the maximum level of say 80, and for cooling water, it should be 14, and the textile plant's very minimum quantity is 0.3.

Similarly, pulp and paper 2.6, 10, and 15. So, all these are the various maximum concentration of constituents for different operations. Now, if you see, take the example of bicarbonate for boiling boiler water. It should be 600 milligrams per liter, and cooling water should be 600 milligrams per liter. So, all these industries have different maximum concentrations based on their use based on their treatment protocols.

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As we mentioned in the previous table, raw water is not usable unless properly treated to achieve the required quality of specific use. The water quality requirement for point use in different industries is very specific.

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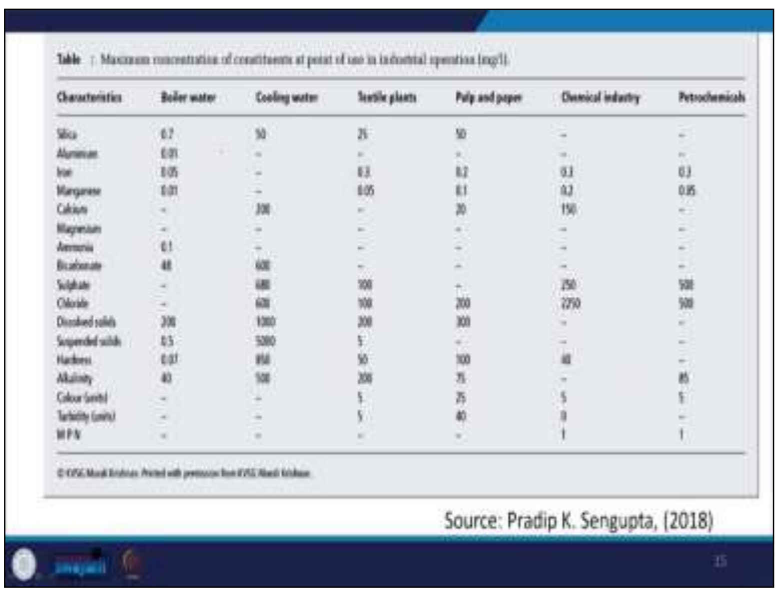

Table 1 Maximum concentration of constituents at point of use in industrial operation (mg/l).

Characteristics	Boiler water	Cooling water	Textile plants	Pulp and paper	Chemical industry	Petrochemicals
Silica	0.7	50	25	50	–	–
Aluminium	0.01	–	–	–	–	–
Iron	0.05	–	0.3	0.2	0.1	0.1
Manganese	0.01	–	0.05	0.1	0.2	0.05
Calcium	–	200	–	20	150	–
Magnesium	–	–	–	–	–	–
Ammonia	0.1	–	–	–	–	–
Bicarbonate	48	600	–	–	–	–
Sulphate	–	680	100	–	250	500
Chloride	–	600	100	200	2250	500
Dissolved solids	200	1000	200	300	–	–
Suspended solids	0.5	5000	5	–	–	–
Hardness	0.07	850	50	100	40	–
Alkalinity	40	500	200	75	–	85
Colour (units)	–	–	5	25	5	5
Turbidity (units)	–	–	5	40	0	–
MPN	–	–	–	–	1	1

Now, here you see again when we talk about the maximum concentration of constituents at the point of use in the industrial operation. Now, if you see that in silica, if we talk about the silica in the boiler water, it should not be more than 0.7 milligrams per liter, and similarly, if you talk about the textile plant, it should be 25 milligrams per liter. Similarly, if randomly we pick the bicarbonate in the boiler water, the maximum desirable concentration is 48 milligrams per liter, whereas, in cooling water, you can have 600 milligrams per liter.

Similarly, let's take the alkalinity of 40 milligrams per liter in the boiler water. 500 maximum concentration of 500 milligrams per liter for the cooling water and similarly for the textile plant, it is 200 pulp and paper 75, and if you take the petrochemical plant, it is 85.

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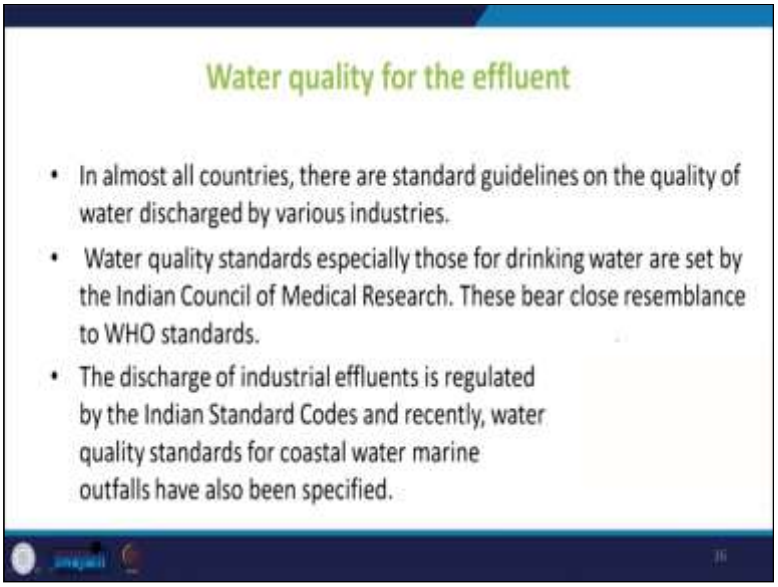

When we are talking about the water quality for effluent in almost all countries, there are standard guidelines on the quality of water discharge by the various industries, and effluent is a very addressable aspect for all states, countries, and industries. So, water quality standards, especially those for drinking water, are set by the Indian medical research council, which closely resembles world health organization standards.

The Indian standard codes regulate the discharge of industrial effluent, and recently the water quality standards for coastal water marine outfall have also been specified.

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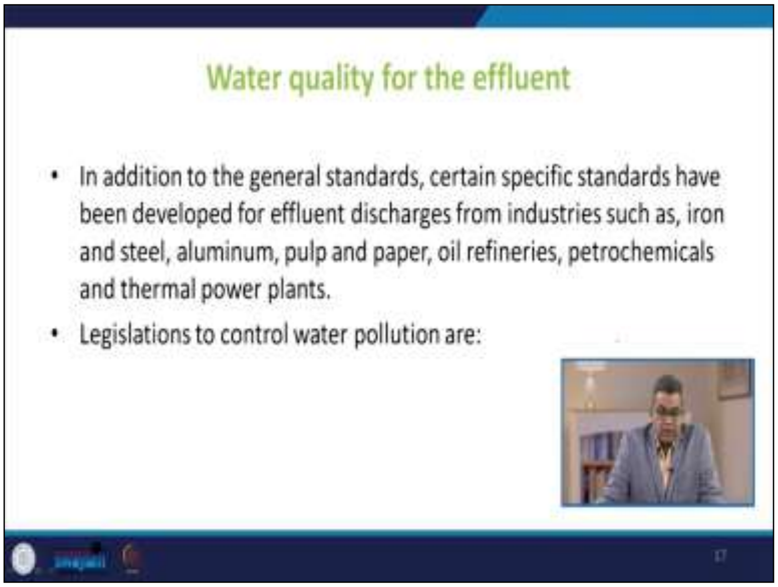

In addition to the general standards, certain specific standards have been developed for effluent discharges from industries such as iron, steel, aluminum, pulp, and paper oil refineries, petrochemicals, and thermal power plants. Various legislation has been attributed to the control of water pollution, and some of them are like water prevention and control of pollution act 1974.

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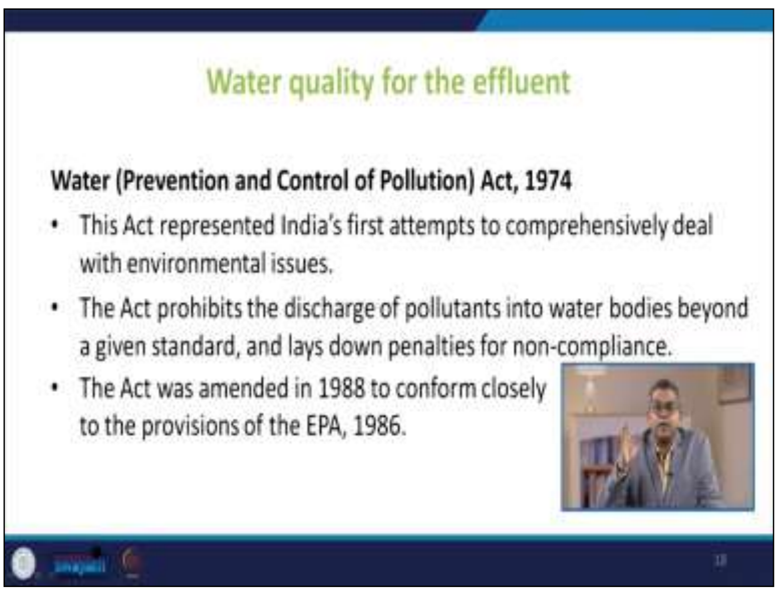

This act represented India's first attempt to deal with environmental issues comprehensively. The act prohibits the discharge of pollutants into water bodies beyond a given standard and lays down the penalties for non-compliance. Later on, after 14 years, this act was amended in 1988 to conform closely to the provision of EPA 1986. Now, this also set up the CPCB, the central pollution control board that lays down the standard for preventing and controlling water pollution.

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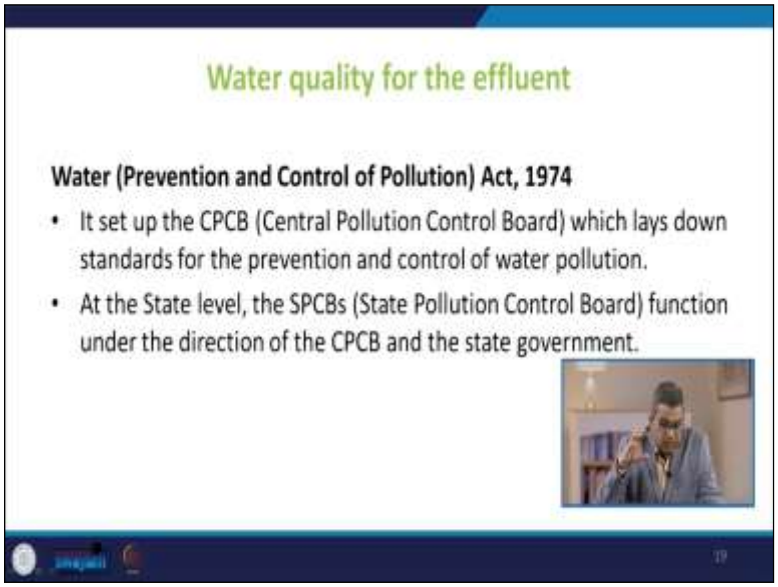

Similarly, all the state level, the state pollution control boards function jointly under the direction of CPCB and the state government. Then another act is water prevention and control of pollution, says acted in 1977. Now, this act provides levy or cess and collection of cess on water consumed by the industry and local authorities. This was introduced to see the water table's depletion or lowering.

So, it aims at augmenting the resources of the central and state boards for the prevention and control of pure water pollution.

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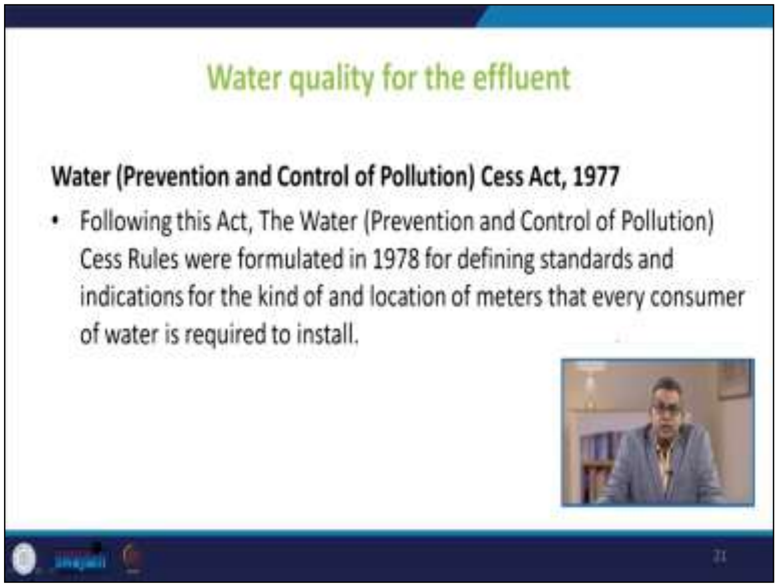

Following this act, the water prevention and control pollution says the rule was formulated in 1978 to define the standards and indications for the kind of and location of meters that every consumer of water is required to install.

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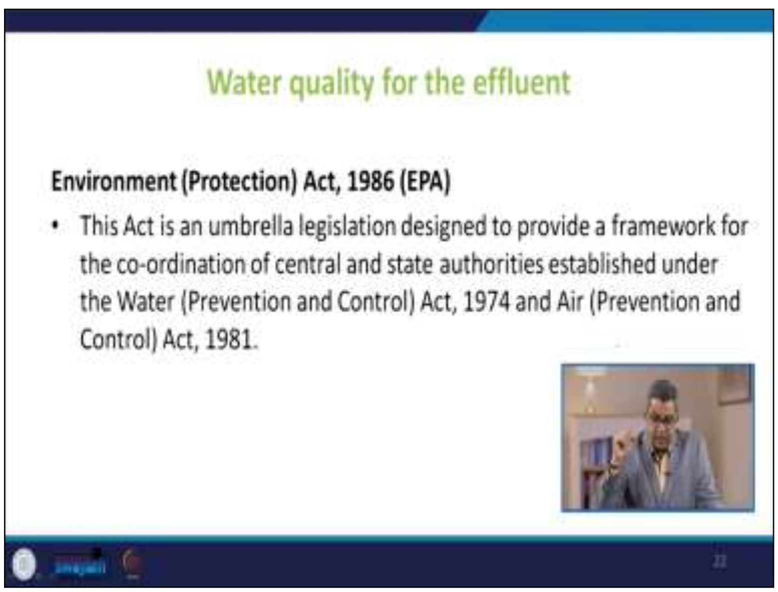

Then environment protection act 1986 is sometimes referred to as EPA 1986. This act is an umbrella legislation designed to provide a framework for coordinating central and state authorities established under the Water Prevention and Control Act 1974 and Air Prevention And Control Act 1981.

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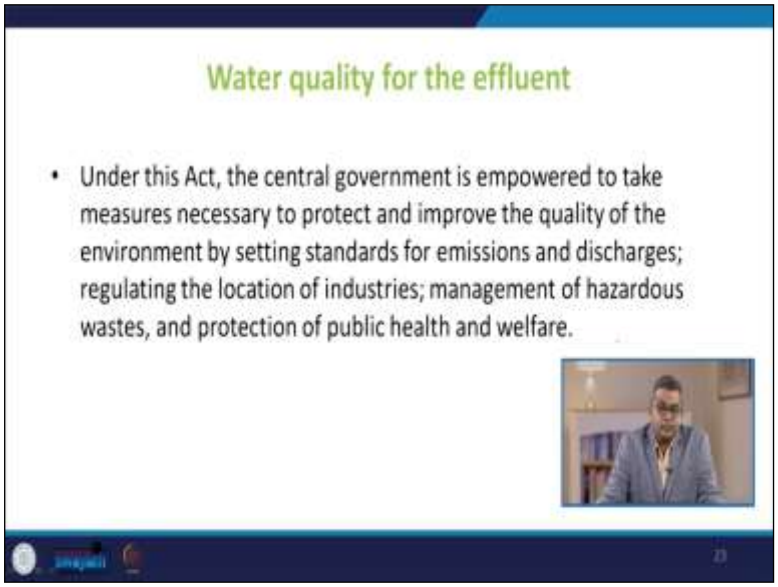

So, under this act, the central government is empowered to take measures necessary to protect and improve the quality of the environment by setting standards for emission and discharge, regulating the location of industries' management of hazardous waste, and protecting public health and welfare.

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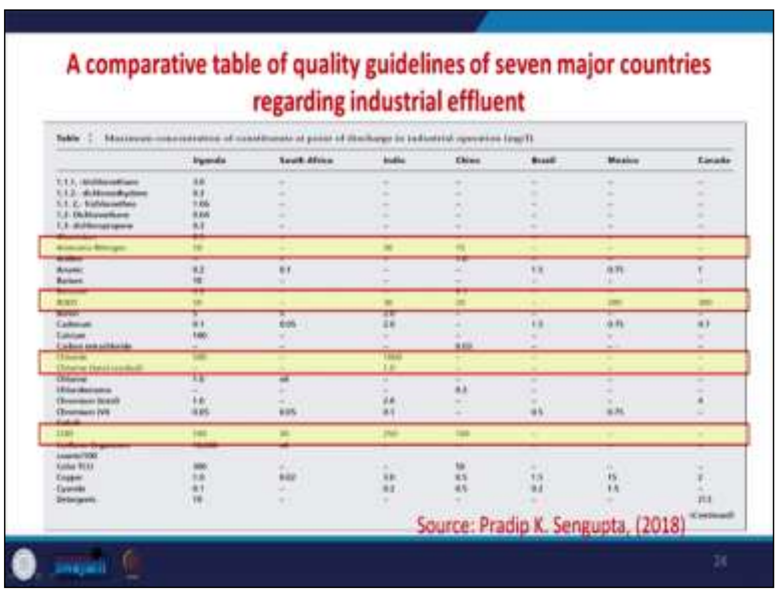

Here, we have given a comparative table of quality guidelines of seven major countries regarding industrial affluence. And we have taken the countries in question Uganda, South Africa, India, China, Brazil, Mexico, and Canada. So, if you see the maximum concentration of constituents at the point of discharge in industrial operation. Now, if you see that first for the sake of example, if you take ammonium nitrogen, ammonia nitrogen in Uganda is 10 milligram per liter. In contrast, in India, it is 50 milligram per liter, and a China, it is 15 milligram per liter.

If you take about the BOD 5, 5 days BOD in Uganda, 50 milligrams per liter. In the Indian context, it is 30 milligrams per liter, and in China, it is 20 milligrams. If you take Mexico and Canada, these Canada is a developed country, so 200 and 300 milligrams per liter, respectively. Similarly, suppose you take the chloride or chlorine. In that case, the total residual is 500 in Uganda 1000 if we talk about the chloride in the Indian context, 1000 milligram per liter, and 1 milligram per liter if we talk about the chlorine or the total residue.

If we talk about the COD in the Indian context, it is 250 milligrams per liter. In contrast, if you talk Uganda, it is 100 milligrams per liter, and in South Africa, it is 30 milligrams per liter, and in Chinese, it is 100 milligrams per liter. Similarly, if we talk about the dissolved oxygen in South Africa, it is 75. Now if you take the lead in Uganda 0.1, South Africa, 0.1 Indian context point one whereas in Brazil 1.5 and Mexico 1.5 and Canada 1. If we take oil and grease, it is 10 milligram per liter in Uganda, and Indian context, it is 10 milligram per liter.

If you talk about mercury, it is 0.01 milligram per liter in Uganda, South Africa. They have 0.02 milligram per liter, and in the Indian context, it is 0.01 milligram per liter. In Brazil, it is 1.5 milligram per liter, but if you talk about Mexico and Canada, it is 0.015 milligram per liter and 0.01 milligram per liter, respectively. If you talk about the pH, it is 6 to 8 in Uganda, 5.5 to 9 in South Africa, 5.5 to 9 in the Indian context China 6 to 9, Brazil 6 to 10, and Mexico 5.5 to 210.

And if we talk about sulfate, it is 500 milligrams per liter in Uganda, and the Indian context says it is 1000 milligrams per liter.

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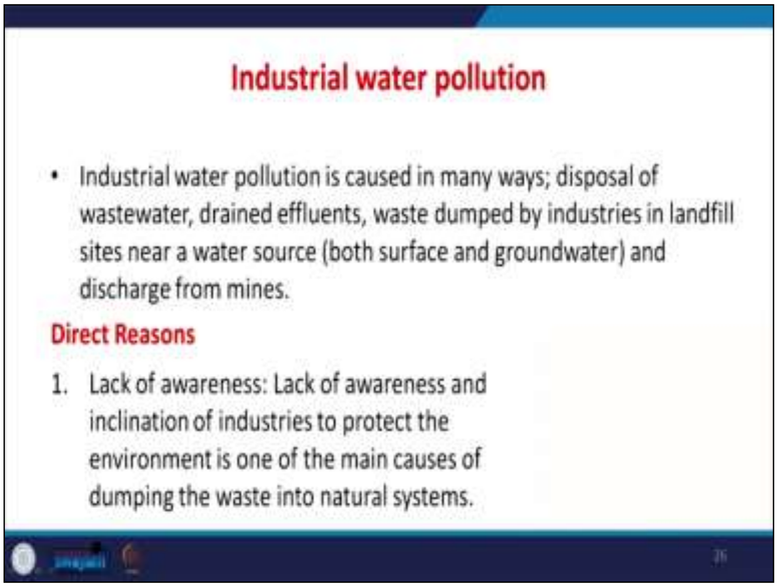

So, when we talk about industrial water pollution, this is caused in different ways like disposal of wastewater drains, diffuse waste dumped by the industries in landfill sites near a water source, both surface and groundwater, and discharge from mines. Now there may be certain reasons. One is the direct reason, is the lack of our awareness. Lack of awareness and inclination of industries to protect the environment is one of the main causes of dumping waste into the natural system.

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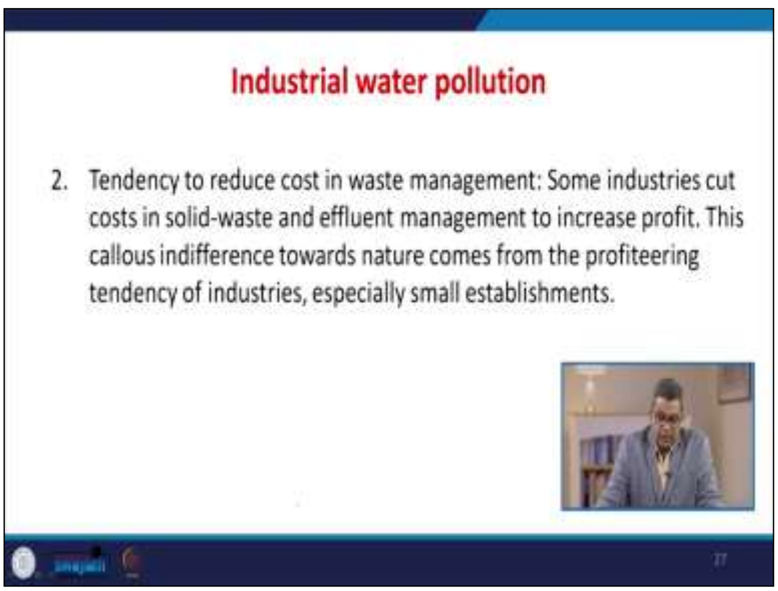

The tendency to reduce costs in waste management, and sometimes the industries cut costs in solid waste and effluent management to increase profit. Now this calls us the indifference towards nature comes from the profiteering tendency of industries, especially small establishments because they cannot bear the cost of influent treatment.

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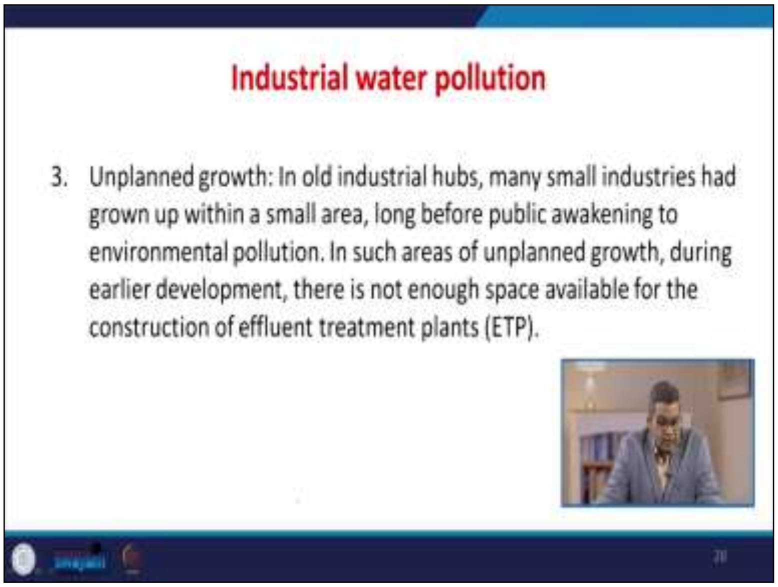

Another thing important thing is that unplanned growth. In old industrial hubs, many small industries had grown up within a small area long before the public awakening or public awareness of environmental pollution. In such an area of unplanned growth during the earlier development, there is not enough space available to construct an effluent treatment plant. So, they have to bear it either to discharge it to the common effluent treatment plants or to discharge it to the sewage.

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Then technological drawback the technological drawback industries neither upgrade their old and energy-intensive production machinery nor their old and inefficient ETP installation, thus contributing heavily to environmental pollution. Then lack of maintenance. Proper maintenance of water treatment plants and ETP pipelines and conduits results in increased discharge pollution into the environment.

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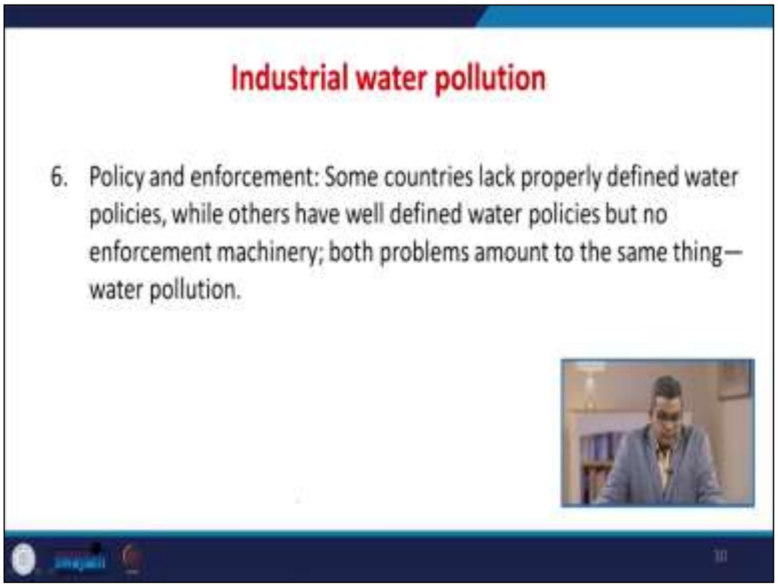

Then policy and enforcement, some countries lack properly defined water policies while others have well-defined water policies but no enforcement machinery. Both are problematic. Both problems amount to the same thing that is called water pollution.

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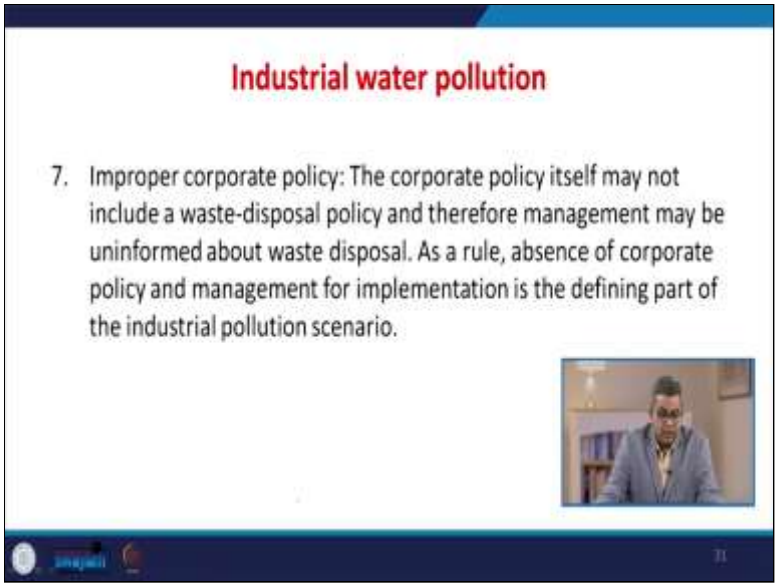

Then we are some industries, companies, or countries with improper corporate policies. The corporate policy itself may not include a waste disposal policy, and therefore, management may be uninformed about waste disposal. As a rule, the absence of corporate policy and management for implementation defines part of the industrial pollution scenario.

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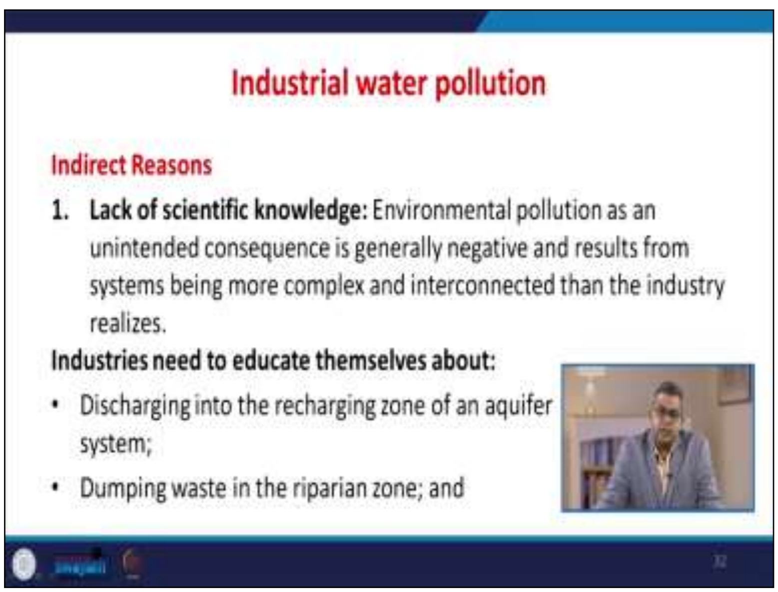

There may be certain indirect reasons. Are one reason is the lack of scientific knowledge. Environmental pollution as an unintended consequence is generally negative and results from the system being more complex and interconnected than the industry realizes. The industry needs to educate itself about the discharging into the recharging zone of an aquifer system dumping waste in the riparian zone.

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And landfills in an unconfined groundwater system can reach out to the groundwater system because of the toxic component. Another aspect is the natural disaster and system breakdown. Natural disasters like earthquakes or tsunamis can cause widespread water pollution by destroying plants and factories.

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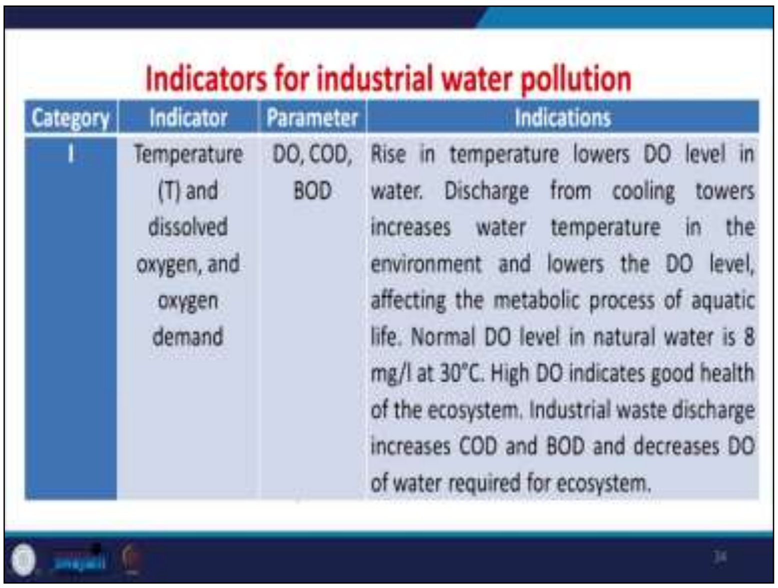
Indicators for industrial water pollution

Category	Indicator	Parameter	Indications
I	Temperature (T) and dissolved oxygen, and oxygen demand	DO, COD, BOD	Rise in temperature lowers DO level in water. Discharge from cooling towers increases water temperature in the environment and lowers the DO level, affecting the metabolic process of aquatic life. Normal DO level in natural water is 8 mg/l at 30°C. High DO indicates good health of the ecosystem. Industrial waste discharge increases COD and BOD and decreases DO of water required for ecosystem.

Here are various indicators for industrial water pollution like category 1, the temperature and dissolved oxygen, and oxygen demand. The parameters are DO, COD, and BOD. The indicators are that a rise in temperature lowers the DO level of dissolved oxygen in the water. Discharge from the cooling tower increases the water temperature because that is it. They are at a relatively high temperature. So, the temperature in the environment increases and lowers the dissolved oxygen level, affecting aquatic life's metabolic process.

The normal dissolved oxygen label in natural water is around 8 milligram per liter at 30 degrees Celsius. A high dissolved oxygen level indicates good health for the ecosystem. Industrial waste discharge increases COD and BOD and decreases the dissolved oxygen of water required for the ecosystem.

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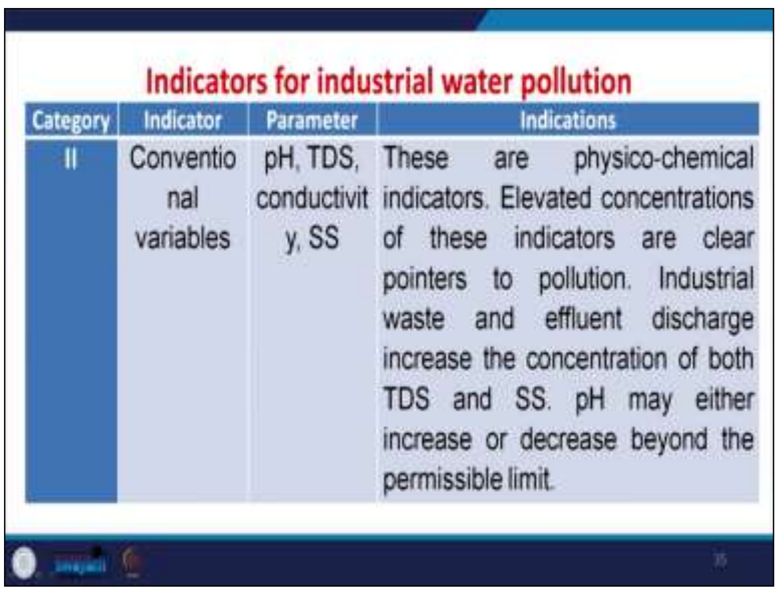

Now the second category is the conventional variables. The various parameters attributed to this are the pH, TDS conductivity, and solid system. These are the physiochemical indicators; elevated concentrations of these indicators are clear pointers to pollution. Industrial waste and efficient discharge increase TDS concentration in the total dissolved solids and solid suspended solids. PH may either increase or decrease beyond the permissible limit. The third one is the nutrients, and the indicators are nitrogen and phosphorus.

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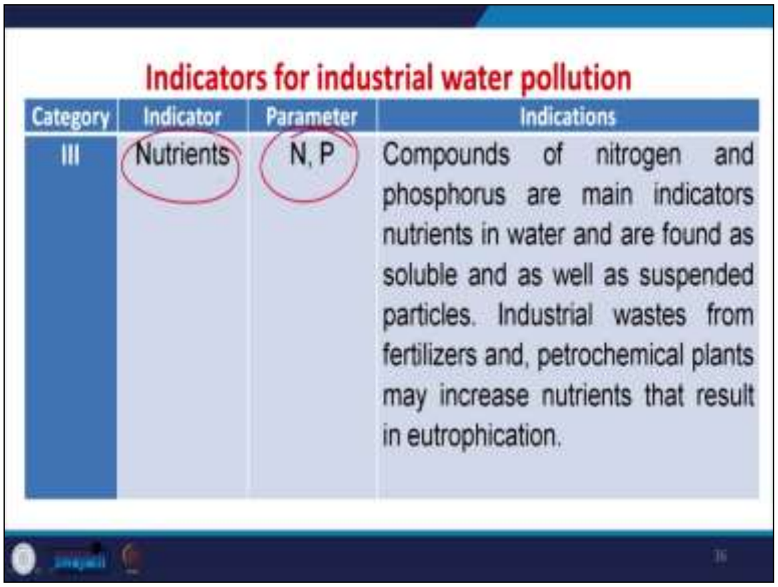

The compounds of nitrogen and phosphorus are the main indicator of the nutrients in the water and are found as soluble and suspended particles. Industrial waste from the fertilizer and petrochemical plants may increase nutrients that result in eutrophication.

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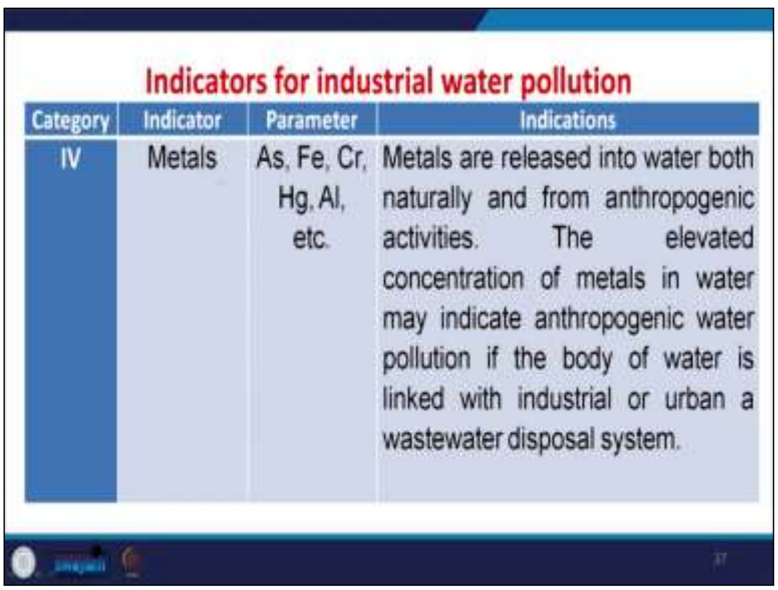

The fourth category is attributed to the metals like arsenic, iron, chromium, mercury, aluminum, etc. Now that metals are released into the water naturally. From anthropogenic activities, the elevated metal concentration in water may indicate anthropogenic water pollution now if the body of water is linked with the industrial or urban wastewater disposal system.

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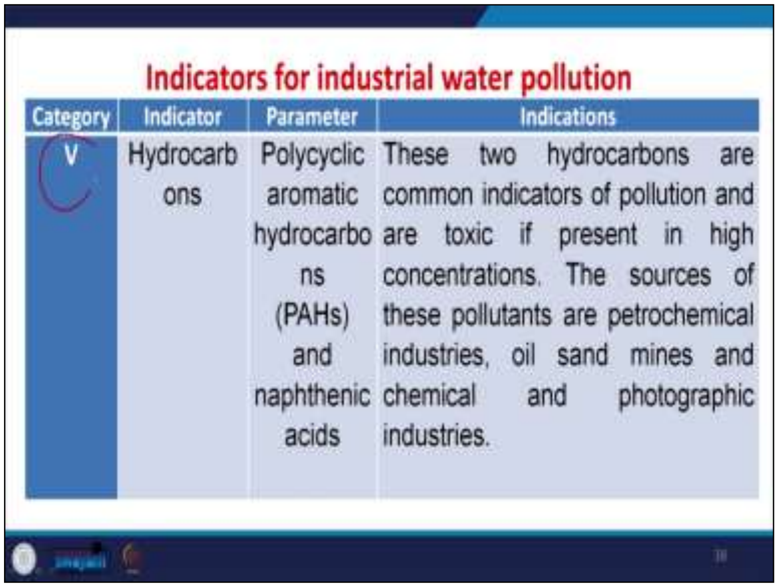

Indicators for industrial water pollution

Category	Indicator	Parameter	Indications
V	Hydrocarbons	Polycyclic aromatic hydrocarbons (PAHs) and naphthenic acids	These two hydrocarbons are common indicators of pollution and are toxic if present in high concentrations. The sources of these pollutants are petrochemical industries, oil sand mines and chemical and photographic industries.

The fifth category is attributed to the hydrocarbons Polycyclic aromatic hydrocarbons and naphthenic acids. These two hydrocarbons are common pollution indicators, and they are toxic if present in high concentrations. These pollutants are petrochemical industries, oil sand mines, and chemical and photographic industries.

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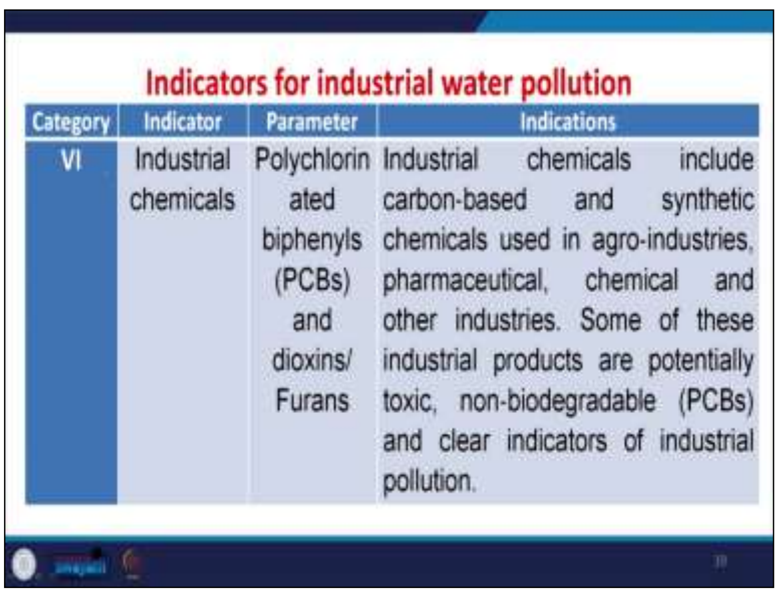

Indicators for industrial water pollution

Category	Indicator	Parameter	Indications
VI	Industrial chemicals	Polychlorinated biphenyls (PCBs) and dioxins/ Furans	Industrial chemicals include carbon-based and synthetic chemicals used in agro-industries, pharmaceutical, chemical and other industries. Some of these industrial products are potentially toxic, non-biodegradable (PCBs) and clear indicators of industrial pollution.

The sixth category is the; industrial chemicals polychlorinated biphenyl PCBs and dioxins furnace. Now industrial chemicals include carbon-based and synthetic chemicals used in agro industries pharmaceuticals chemicals other industries. Some of these industrial products are potentially toxic and are non-biodegradable. And they are clear indicators of industrial pollution.

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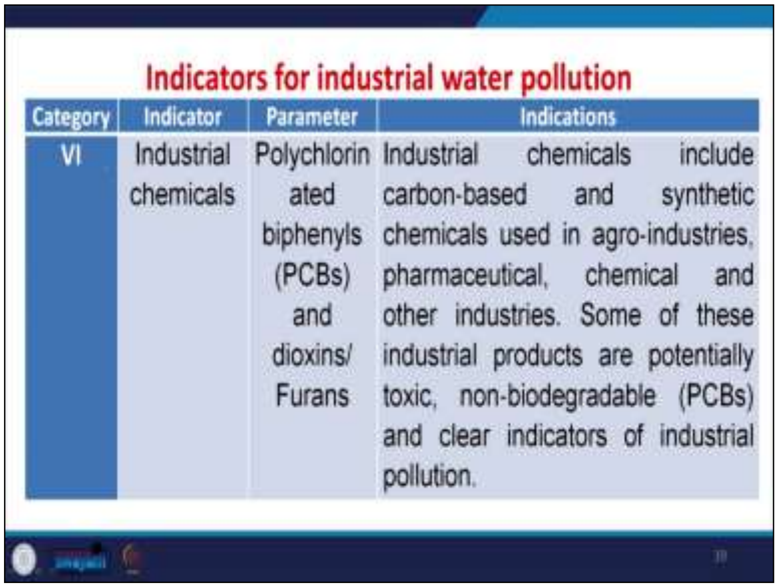

Indicators for industrial water pollution

Category	Indicator	Parameter	Indications
VI	Industrial chemicals	Polychlorinated biphenyls (PCBs) and dioxins/ Furans	Industrial chemicals include carbon-based and synthetic chemicals used in agro-industries, pharmaceutical, chemical and other industries. Some of these industrial products are potentially toxic, non-biodegradable (PCBs) and clear indicators of industrial pollution.

Now, apart from this, there are certain biological indicators. The biological indicators are direct measurements of population and the health of fauna and chlorine body of water or aquifer. The commonly used biological indicators are macroinvertebrates, fish diversity, benthic algal growth, and benthic oxygen demand. The industry emits particulate matters that go into the atmosphere and come down with rain.

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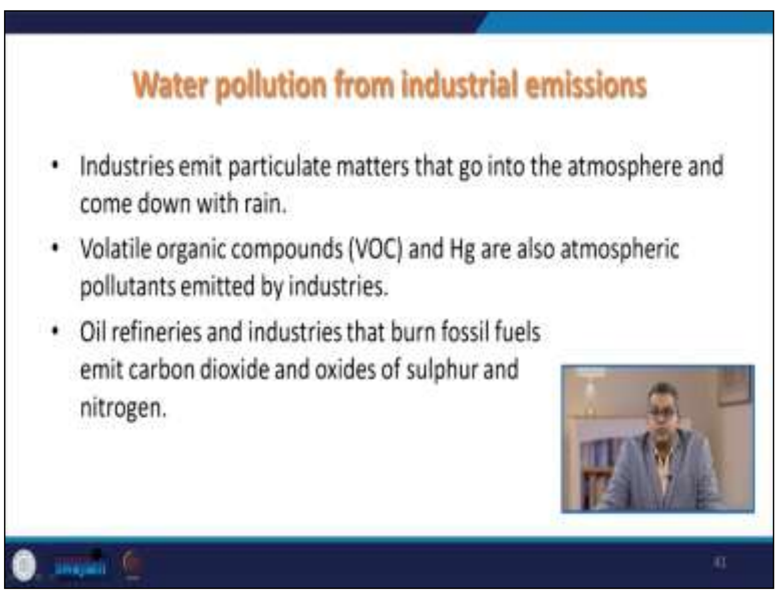

The volatile organic compounds, sometimes called VOCs and mercury, are also atmospheric pollutants, and the industries emit them. Oil refineries and industries burning fossil fuels emit carbon dioxide, sulfur, and nitrogen oxides.

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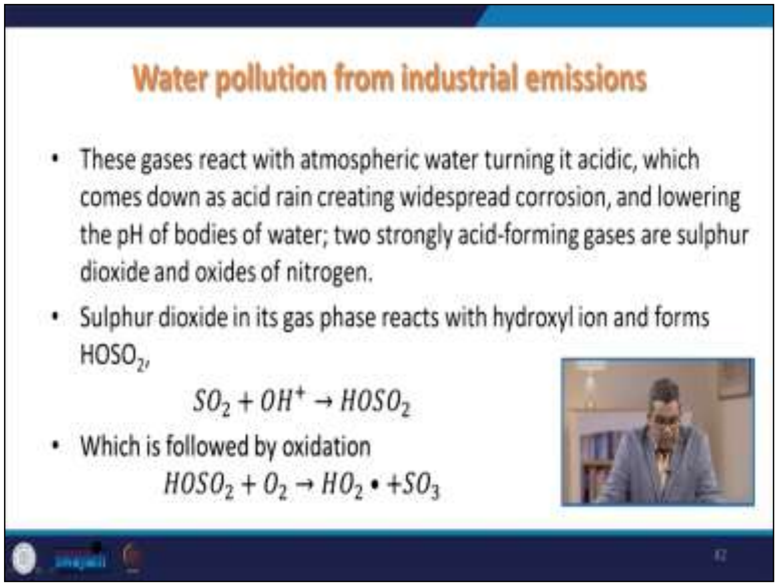

Now, these gases react with the atmospheric water turning it acidic, which comes down as acid rain creating widespread corrosion and lowering the pH of bodies of water. The two strongly acid-forming gases are sulfur dioxide and oxides of nitrogen. Now sulfate dioxide in the gas phase reacts with the hydroxyl ion and forms

$$SO_2 + OH^+ \rightarrow HOSO_2$$

• Which is followed by oxidation

$$HOSO_2 + O_2 \rightarrow HO_2 \bullet + SO_3$$

Sulfur Trioxide in the presence of water form sulphuric acid

$$SO_3 + H_2O \rightarrow H_2SO_4$$

Similarly,

Nitric oxide reacts with water to form Nitric acid

$$NO_2 + OH \rightarrow HNO_3$$

These two chemicals are the predominant reason for acid rain.

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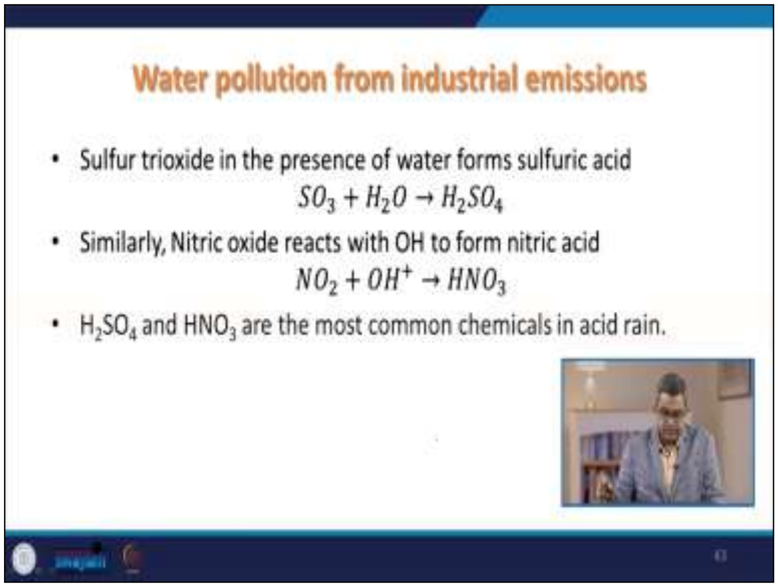

Now sulfur trioxide in the presence of water forms sulphuric acid. So, SO_2 plus H_2O becomes the H_2SO_4. Similarly, we can see that the nitric oxide can react with the o h and form nitric acid like NO_2 + OH and $NHNO_3$.

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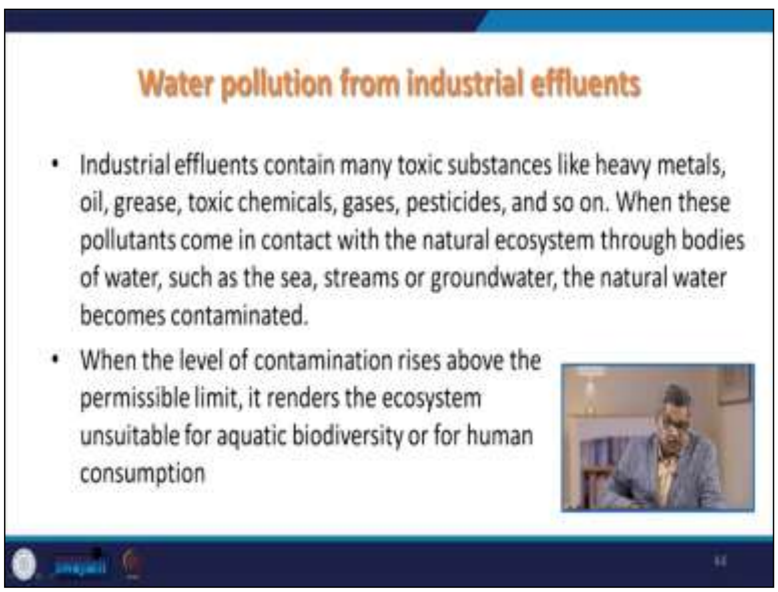

So, you see that various industrial effluents contain many toxic substances like heavy metals, oil greases toxic chemicals, gases, pesticides, etc. Now when these pollutants contact the natural ecosystem through the bodies of water such as sea streams or groundwater, the natural water becomes contaminated. Then water purification water conditioning is always required. So, when the level of contamination rises above the permissible limit, it renders the ecosystem unsuitable for aquatic biodiversity or human consumption.

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Table : Direct water pollution from industrial liquid wastes (effluent).

Sector	Cause	Pollutants
Iron and steel	Fugitive emission from handling, crushing, loading and unloading, and smelting. Major polluting processes are pig iron and steel manufacturing.	High organic carbon, suspended solids, dissolved solids; cyanide fluoride, COD, zinc, lead, chromium, cadmium, zinc, fluoride, and oil and grease.
Textile and leather	Polyvinyl chloride to size fabrics, chlorine bleach, benzidine and toluidine as dyeing agents, formaldehyde, lead and mercury (Rogers, 2016); Chromium for tanning.	BOD, solids, sulphates, chromium.
Pulp and paper	Pulping and bleaching are major sources of pollutants. Paper machine water flows, fibre and liquor spill.	Volatile organic compounds (VOCs) such as terpenes, alcohols, phenols, methanol, acetone, chloroform, methyl ethyl ketone; detergents and surfactants; dyes and pigments; acids; and alkaline solutions (Frost and Sullivan, 2006).
Petrochemicals and refineries	Process wastewater, tankage wastewater, cooling tower blow-down, ballast water tank flow.	Total suspended solids, heavy metals, NH_3, H_2S, trace organics, BOD5, COD, oil, phenolic compounds.
Chemical and pharmaceutical	Chemicals for washing and cleaning of floors and chemical by-products.	Pesticides, VOC, arsenic, cadmium, cyanide, mercury, chromium and lead, organic chemicals (Bahadori, 2004).

Source: Pradip K. Sengupta, (2018)

Here in this table, you see the direct water pollution from industrial liquid waste. Now, if you see that we have enlisted various sectors like iron steel texting leather pulp and paper petrochemical and refineries chemicals and fertilizers, if we talk about, say iron and steel, the cause for this industrial pollution may be the figurative emission from handling crushing loading unloading smelting, and major polluting processes are pig iron and steel manufacturing.

So, apart from this when these causes we are going to discuss. Then let us discuss the various pollutants. They are the high organic carbon suspended solid dissolved solids cyanide fluorides COD zinc-lead chromium cadmium zinc fluoride and oil and greases. If you talk about pulp and paper, the cause is pulping and bleaching. They are the major sources of pollutants. Now paper machine water flows fiber liquor spills etc.

And they can attribute to the volatile organic compound VOCs such as terpenes alcohols, phenol methanol acetone chloroform methyl ethyl ketone detergent surfactants dyes, pigments acids alkaline solutions, etc. Now petrochemical and refineries are the major contributors to the pollution and the process wastewater tankage wastewater cooling tower blowdown balanced water tank flow etc. Now they can increase the total suspended solids heavy metals ammonia as two as trace organics, BOD, COD, oil phenolic compounds, etc., if we take the chemicals and pharmaceuticals in general.

So, chemicals for washing the cleaning floors are chemical by-products they can attribute to the pesticides VOCs arsenic cadmium cyanide, mercury chromium lead organic chemicals, etc.

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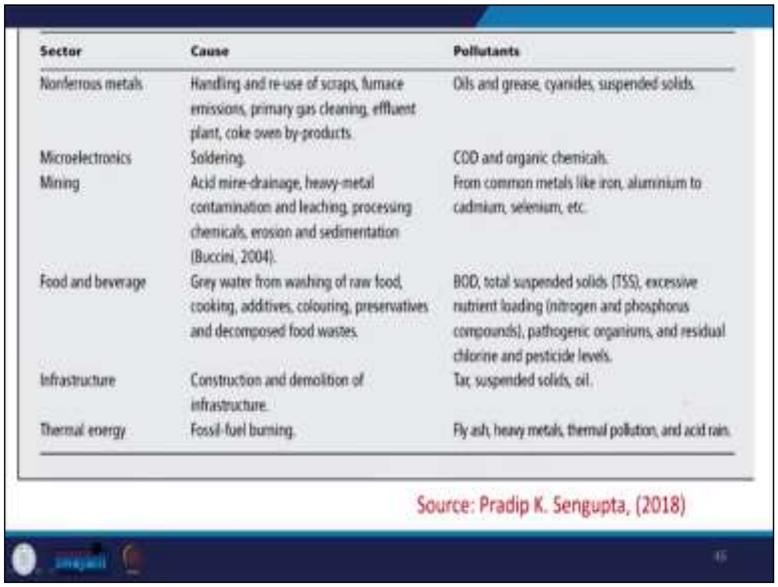

Sector	Cause	Pollutants
Nonferrous metals	Handling and re-use of scraps, furnace emissions, primary gas cleaning, effluent plant, coke oven by-products.	Oils and grease, cyanides, suspended solids.
Microelectronics	Soldering.	COD and organic chemicals.
Mining	Acid mine-drainage, heavy-metal contamination and leaching, processing chemicals, erosion and sedimentation (Buccini, 2004).	From common metals like iron, aluminium to cadmium, selenium, etc.
Food and beverage	Grey water from washing of raw food, cooking, additives, colouring, preservatives and decomposed food wastes.	BOD, total suspended solids (TSS), excessive nutrient loading (nitrogen and phosphorus compounds), pathogenic organisms, and residual chlorine and pesticide levels.
Infrastructure	Construction and demolition of infrastructure.	Tar, suspended solids, oil.
Thermal energy	Fossil-fuel burning.	Fly ash, heavy metals, thermal pollution, and acid rain.

Source: Pradip K. Sengupta, (2018)

Similarly, if we talk about, say, microelectronics mining. Here you see the various causes like acid mine drainage, heavy metal contamination, leaching processing of chemicals heroes, and sedimentations. And they may form the COD or organic chemicals from common metals like iron aluminum to cadmium, selenium, etc. Now, if you take the food and beverage industries again, it is an I can say the upcoming field concerning chemical engineering.

They cause greywater from washing raw food, cooking additives, coloring preservatives, decomposed food waste, etc. The pollutants may be BOD total suspended excessive solid nutrients loading nitrogen phosphorus compound pathogenic compounds pathogenic organism residual chlorine and pesticides level. Sometimes thermal energy is again the contributing sector attributed to the fossil fuel burning, and they may impart the fly ash heavy metals thermal pollution and acid rains.

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So, when we talk about water pollution from solid waste disposal, industrial solid waste is the waste in the solid form generated from industrial activities, including the manufacturing process providing services to the various establishment's maintenance, etc. Now, here you see that sometimes these industrial solid wastes are hazardous and non-hazardous.

So, suppose we club or classify these two streams as hazardous. In that case, it may include the medical waste paint residue fly ash sludge and waste is generally considered hazardous if it is harmful to humans or the environment. Now non-hazardous, it is attributed to construction materials like metal scraps, which can affect the drainage system and land use pattern. If it affects the drainage system again, the growth of micro microorganism and other decomposition may occur.

So, it may become a non-hazardous operation that will become hazardous. So, at last, in this particular lecture, we discussed the various aspects of water quality assessment. We discussed the various industries and common industries, and we have already discussed or performed the comparison between India and China. Apart from this, we discussed the common parameters among different countries in the different standards.

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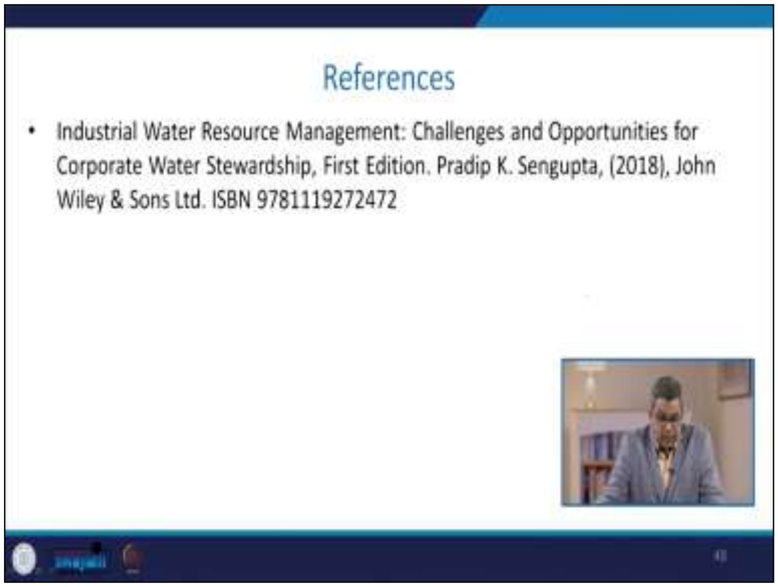

And for your convenience, we have enlisted the reference, and if you wish to have further reading, you can take the help of this particular reference, thank you very much.