Sustainable River Basin Management

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Module 3- 2

Lecture - 24

Part 04

Welcome everybody to Sustainable River Basin Management, module three-two, part four. Today, we will be speaking about water pollution.

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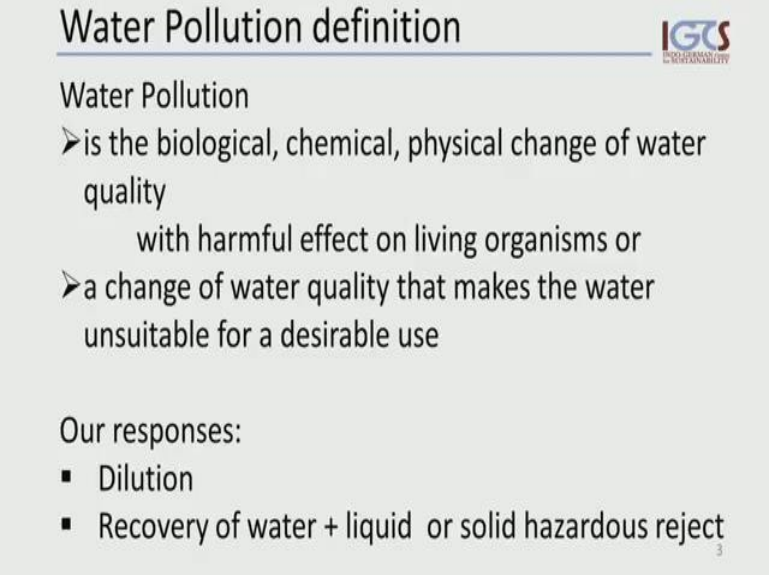

Let us first start with the definition of the term water pollution. Water pollution is the biological, chemical and physical change of water quality with harmful effect on living organisms or the change of water quality that makes the water unsuitable for a desirable use. It could be a change in color or a change in odour or similar.

What are responses to such water pollution? The responses are dilution or the recovery of water by treating the water and separating the water from hazardous reject. That reject could be in the form of solid or in the form of a liquid that we have to dispose or deal with.

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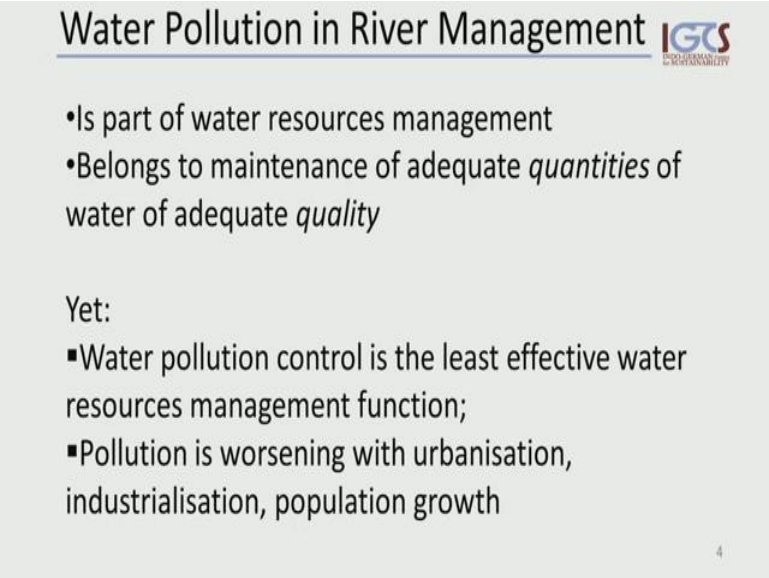

Let us look into water pollution in river management. It is part of the water resources management and it belongs to the maintenance of adequate quantities of water of adequate water quality. This is what the management function is. However, what we see very often in river management organizations is, that water pollution control is the least effective water resources management function and we also see, that pollution is worsening with the urbanization, with the industrialization, as well as, with the population growth.

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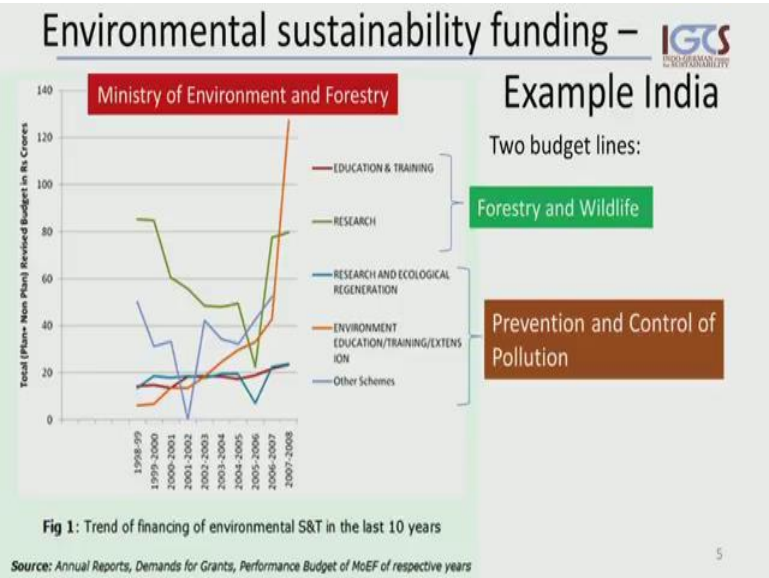

Now, let us just take an example of the funding aspects the environmental sustainability funding and this is an example from India. The ministry of environment and forestry has two major budget lines and departments, forestry and wildlife, and the prevention control of pollution, which includes the water pollution component. And this is a chart showing us the trend of the financing of environmental science and technology in the last 10 years. This starts here with, in the year 1989, '99 to 2008 and here we have the amounts in, cost, rupees. And what we can see here are the different funding lines, education and research under the forestry and wildlife, whereas research and ecological regeneration, environment education, training, extension and other schemes not specified here, funded under prevention control of pollution. And what we can see is, that some of those budgets have not changed a lot or do they as a general upward trend towards receiving more funds.

There is one steep change, political change in direction towards environmental awareness, environmental education at large scale, which has received a huge budget chunk under prevention and control of pollution, whereas in the part of ecological regeneration research in that part, not so much have been happening, has been very much also going up and down the blue line, that you can see here; this blue line here. Now, this is one example and this is not to judge what is going on. This is simply to show how also prevention and control of pollution water pollution as such is driven by priorities given by the respective countries.

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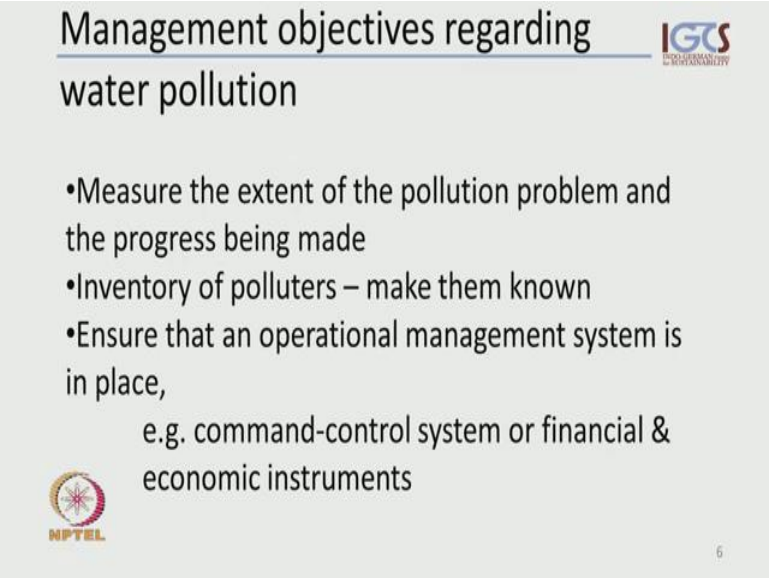

Now, let us look into the management objectives regarding water pollution. We are looking into what do river basin management organizations are doing and what are the objectives regarding pollution. This is to measure the extent of pollution, of the pollution problem to understand it and to measure or monitor the progresses made in dealing with the problem. It also includes an inventory of the polluters they should be known, they should be record on who is working using water in our river basin and who is the polluter. We should also ensure, that operational management system is in place, which could be either based on command control system or a financial and economic instruments system or a combination of both in, to achieve the water pollution management.

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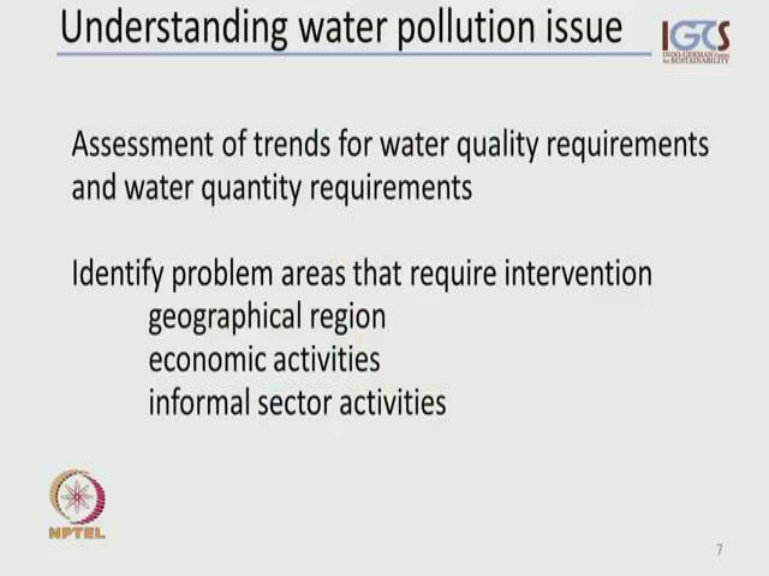

Now, let us try to understand the issues around water pollution. And this comes along with an assessment of trends for water quality requirements and also water quantity requirements, both in combination, which has to be conducted and also incorporated into the management plan. We have to identify problem areas that require intervention and this in terms of geographical region, in terms of economic activities including informal sector activities.

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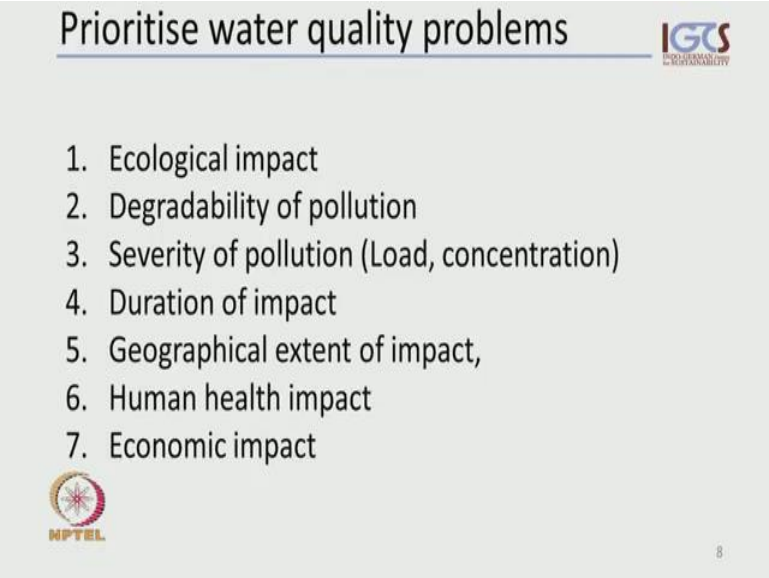

Now, this alone is not sufficient as problems are usually overwhelming. We have to prioritize our water quality problems and those in the order that is proposed here, but not always all of these points may be applicable. We have to prioritize by ecological impact, by environmental impact, by the degradability of pollution or by the severity of the pollution in terms of load, in terms of concentration, the duration of impact, has it been for just a short time or has it going on, has it been going on over months or years. The graphical extent of the impact human health impacts and economic impacts. Note, that the economic impacts have come last in this list.

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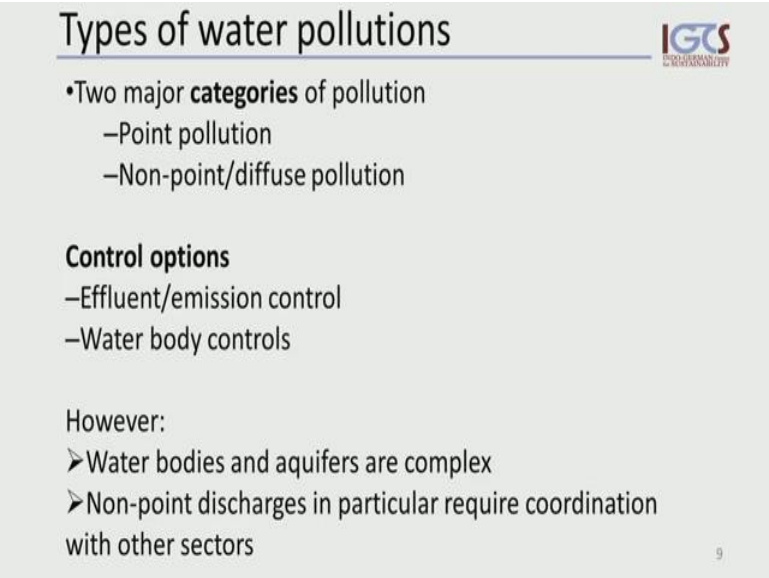

Now, let us look into the types of water pollutions. There are two major categories of pollution, one is point pollution and the other is the non-point or diffuse pollution. Now, our control options on both of them are quite limited. We can conduct effluent or emission controls and we can conduct controls on water bodies or aquifers and this applies to both, point pollution and non-point pollution. And we have to keep in mind that water bodies and aquifers are very often very complex so that even the way we control or monitor our water bodies may not really show us or keep us a tool sufficient to identify water pollution fast enough in time to avoid the worst to happen.

In non-point discharges especially, require coordination with other sectors. What is a non-point discharge? It usually is being associated with agriculture production where we have large areas been sprayed or irrigated in combination with fertilizers, pesticides, ((Refer Time: 09:21)), etcetera. And small quantities of these chemicals are washed out and back into our water systems, into out streams, into our aquifers, into the lakes. And it cannot be attached to one specific application, one farmer or one, upon application because of the temporary scale. The range of how fast some of these are slowed, some of these elements and compounds are moving and showing up again and convert in while moving through the soil, moving through the water bodies, convert into some other chemical compounds and show up again in our water bodies, now, and are detected eventually. That is the big problem and it is one example.

The other example comes from air pollution in the deposition of those pollutants, like on our earth surface, which also will be washed out and deposited back in our aquatic environment, eventually. Those are also non-point pollution where we cannot trace it exactly back to the course, to the single polluter in one region.

It is much easier to control point pollution because it is a, it is a, it is a localized source of pollution, often also very typical for specific industries or for the categories of sources of pollutants like domestic waste, domestic sewage. Such point pollution could be from an industry, could also be from a garbage dump site. It could be from an individual, from a leakage from a pipeline and those can be detected fairly well if appropriate monitoring is taking place.

So, some of those could be incidents or accidents or some of them could be purposely and some of them may not take place throughout the entire day or every day. They may

just occur once at a time when we may least expected to happen as part of the discharge of policy of some of the discharge ((Refer Time: 12:01)), discharge of pollutants, is conducted by some industries.

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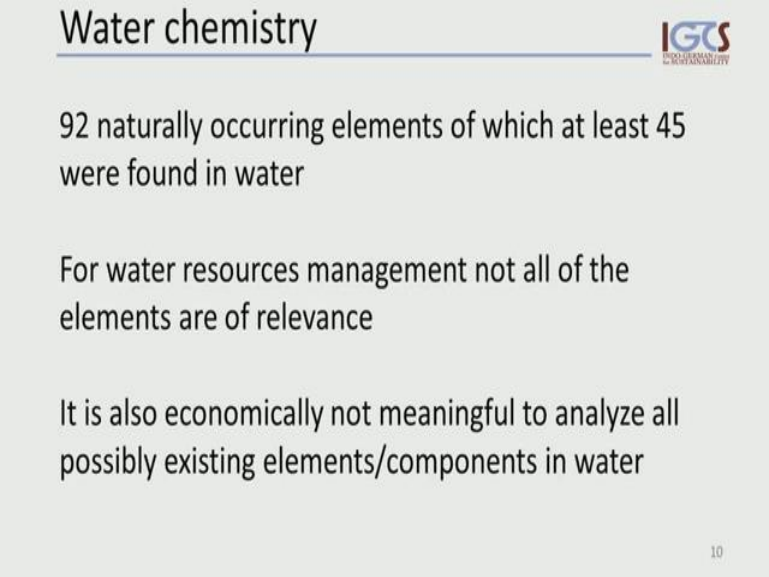

Now, let us zoom out a little bit and look into the water chemistry. Now, for a short while, there are about 92 naturally occurring elements of which at least 45 were found in water. They may naturally occur in water. For water resources management, not all of those elements are of relevance of course, and also it may economically not be meaningful or possible to analyze all of these possibly existing elements or compounds in water.

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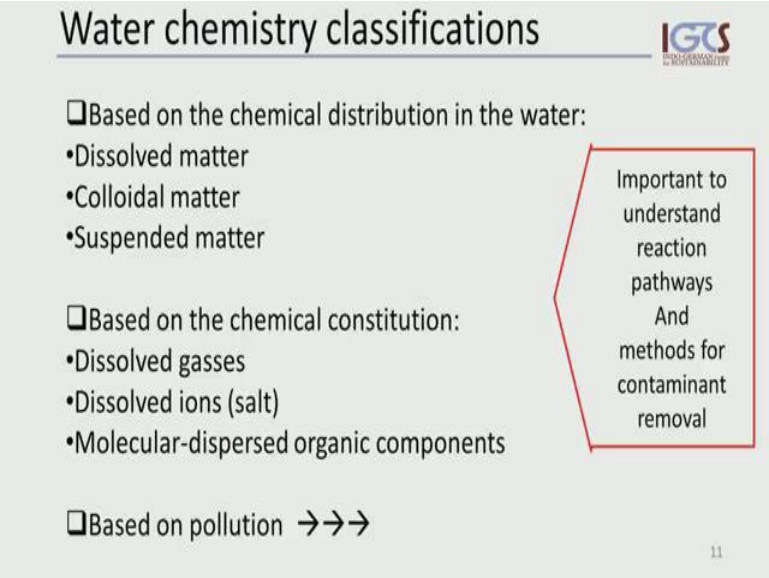

Now, this takes us to the point of trying to classify the chemical components in water. We can do this based on the chemical distribution in water, which might be either dissolved in the form of dissolved matter, it might be in the form of colloidal matter or it might be in the form of suspended matter. We could also classify this based on the chemical constitution and those components could occur in water in the form of dissolved gases. They could also occur in the form of dissolved ions or they may occur in the form of molecular dispersed organic components or they, we could classify this according to pollution and this is what we are going to discuss in a moment. However, the other classifications are relevant, that is why I am presenting it here because it is important they help us to understand reaction pathways and they help us appropriate methods for contaminant removal.

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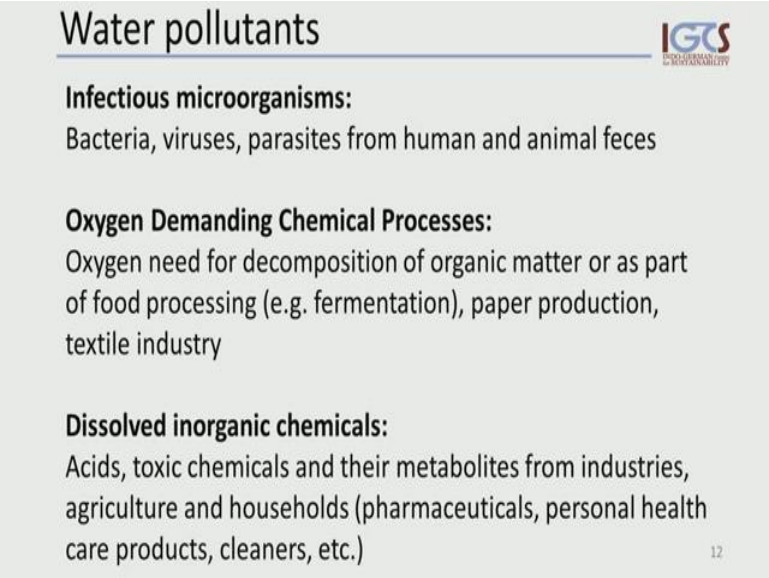

Now, let us look into the classification of water pollutants and one of the categories are infectious microorganisms. Those are bacteria, they could be viruses, parasites, which they in, majority of the cases are from human and animal feces if they occur in water. The second pollutant is, we can categorize as oxygen demanding chemical processes. Remember, that oxygen is needed for the decomposition of most of the organic matter and as well as a part of the general food processing, just remember of fermentation process, is very important. They are also important in, for instance, paper production, also quite important in textile industry, just as examples.

The third group of water pollutant is, are dissolved inorganic chemicals. Those are, for instance, acids; those, for instance, toxic chemicals and there are metabolites usually coming from industries and also from agriculture and households; just remember of the pharmaceuticals, the personal health care products, cleaners and so on. We have touched upon earlier already.

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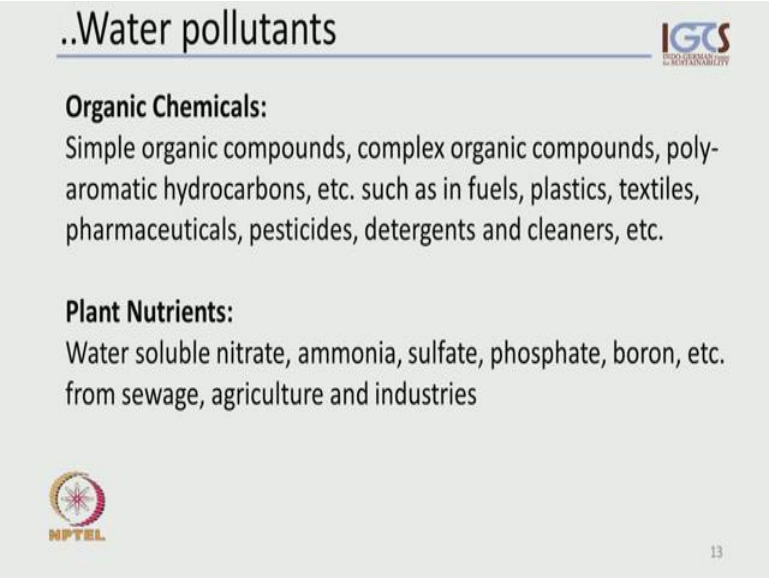

Now, let us continue in this list, it is long. Another group of water pollutants are organic chemicals and they may be simple organic compounds and they may be complex organic compounds or they may be poly-aromatic hydrocarbons and so on. And some of them occur naturally in our environment, some are completely artificial, human made and some of them, you know, I am, this, I am, just for writing a few examples of fuels, the plastics, ((Refer Time: 16:06)) of the textiles depending on organic chemicals, pharmaceuticals again, pesticides, detergents cleaners and many others.

Another plant, another water pollutant are plant nutrients, which we apply on our fields to improve harvest. Those are water soluble nitrates, we talked about it, ammonia, sulfate, phosphate, but also boron and many other nutrients we touched upon earlier. And those occur in sewage, in agriculture, also in industries and come back into sewage again.

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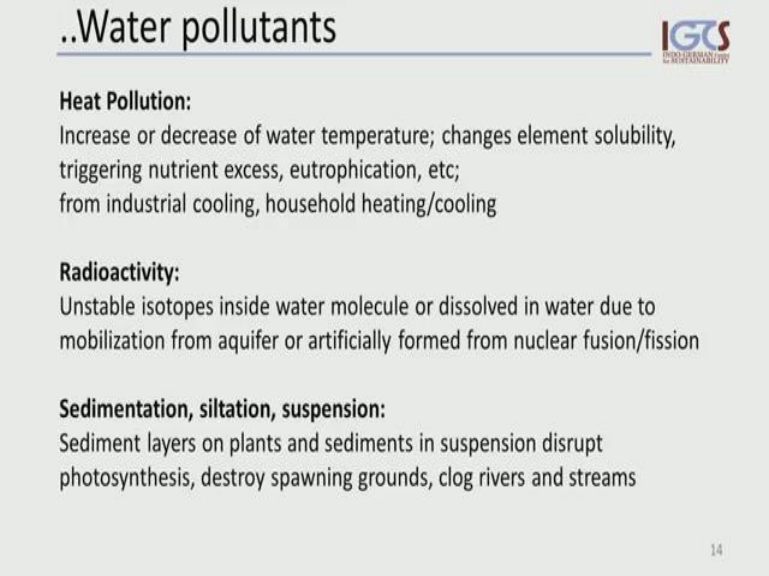

This list is still not ended, ending. What also comes under the group of water pollutants is heat pollution. We may easily forget about it, but it is very important. It means, the increase or decrease of water temperature, which as a consequence changes element solubility in water, which triggers in that way water nutrient excess and processes like eutrophication. And this can come, has its source from industrial cooling processes, but also from household heating and household cooling again. And think of the urbanization, the footprint of urban areas is exactly very high in terms of heat pollution.

Another water pollutant is radioactivity. What is radioactivity? It is, it is has its origin in unstable isotopes and so called radioisotopes, which occur naturally inside water molecules. Just remember of Titum, one of the elements making up a water molecule or they may be, occur in dissolved in water, which may have its reason in mobilization of these radioactive isotopes from the aquifer, from the rock environment in which water occurs or it may be artificially formed from nuclear processes like fusion or fission from our industries, from our energy, power generation industries or from our military applications.

Finally, we have as on the list of water pollutants, sedimentation, siltation and suspension. This is to say, that sediments form are deposited, they form layers on plants and also sediments may occur in the form of dust and they also may occur in the form of suspension in water, and by both, in both of the ways deposition on plants and

occurrence in suspension. They disrupt photosynthesis, they also destroy spawning grounds in aquatic environment, they clog rivers, they can clog streams, they clog the interaction between groundwater and surface water, they recharge discharge processes taking place in our rivers.

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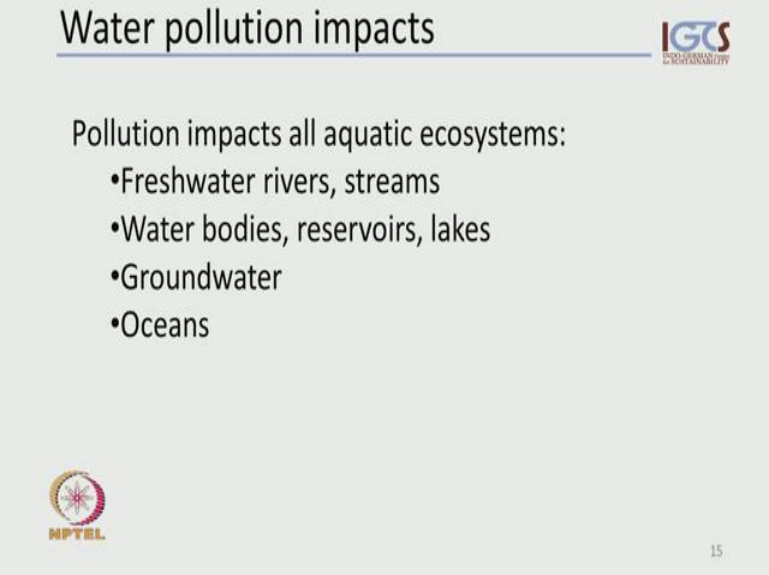

Let us look into the water pollution impacts now. Pollution impacts, essentially, all our aquatic ecosystems. Since we focus on water pollution right now, this means, our fresh water rivers, our streams, our water bodies, reservoirs, lakes, also our groundwater, also our oceans.

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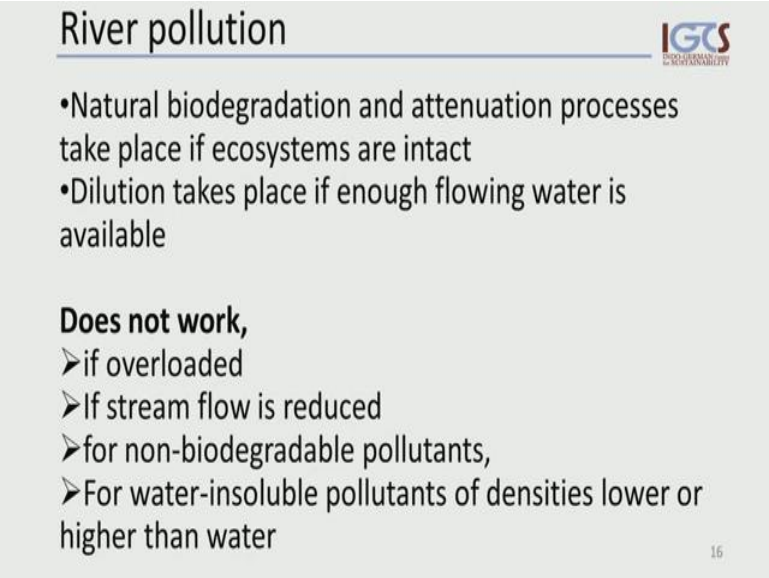

Now, let us look into each of those individually. First of all river pollution. There are natural biodegradation and attenuation processes taking place in rivers as long as the ecosystems functions are intact. This is important to keep in mind and dilution takes place whenever there is enough flowing water available, which also reduces the impact of pollution and removes pollutants from one end and carries other way, to some other downstream location, which can help reduce impacts in one place, but eventually will impact other place.

So, those are two processes naturally taking place, which we may use. We can also foster by our intervention such as the river restoration, but it does not work as a limit to it if this overloaded, if the stream flow is reduced or absent at all and it does not work for non-biodegradable pollutants. It does not work also for water insoluble pollutants, which may come in densities, which are lower or higher than water. So, they, just think of oil, which may be flooding on top of water, water surface or sink to the bottom of the water body and such ((Refer Slide Time: 22:13)) system water and also not be available to any aquatic organisms to eventually remove that pollutant or break it down into some other nutrients.

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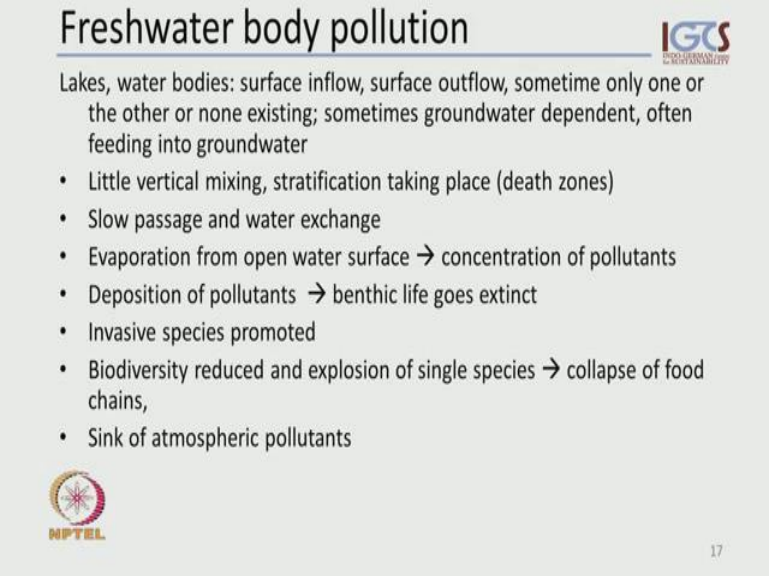

Now, let us look into the fresh water bodies and the pollution of those. What we mean by the fresh water bodies are lakes, water bodies and remember, that lakes and artificial water bodies usually have surface inflow and several surface inflows and usually one outlet or may be in rare cases also, several outlets. Sometimes they do not have an inflow and they may not have a single inflow, they may just have a sheet inflow, which carries water from the surface directly into that water body, into this reservoir and sometimes they also do not have an outflow, a surface outflow.

So, that means, that some of those look occasions, that these water bodies are groundwater dependent. Often, they feed also into the ground water, they recharge our groundwater or they may discharge recharged from the groundwater. So, this makes it

very sophisticated in terms of water supply and also in terms of nutrient balances and pollutant, in pollutants coming into such a water body. It has little vertical mixing taking place, which often leads to a stratification in such almost stagnant water bodies, which causes, for instance, so called death zones.

There is usually a very slow passage or very slow water exchange taking place from imaging water molecule entering the reservoir and leaving the reservoir and evaporation takes place from the open water surface, and is very important as one of the ways of removing water from the system, not just in terms of surface flows, but also evaporation has very, very important from open water surfaces, which means, that pollutants get concentrated nutrients and pollutants are concentrated in the remaining water.

What we also see is that pollutants may be deposited in, at the bottom of such a lake, which may lead to do extinction of benthic lives. We also very often see this water pollution of lakes and increase in invasive species, that promotes the development and growth of invasive species and it also comes along with a biodiversity reduction, the explosion of certain species. And this results in a collapse of our food chains, this affects at the end also our fisheries, for instance, and all those industries, which depend on the water, the lake water.

Finally, our fresh water bodies act as sinks of atmospheric pollutants. This open water surface as our surface or terrestrial land surface receives constantly atmospheric pollutants. They are settling, depositing on these surfaces and the lakes are sinks for those because either those pollutants are deposited straight into the water body on the water surface or they may be washed from the surrounding areas into the lake.

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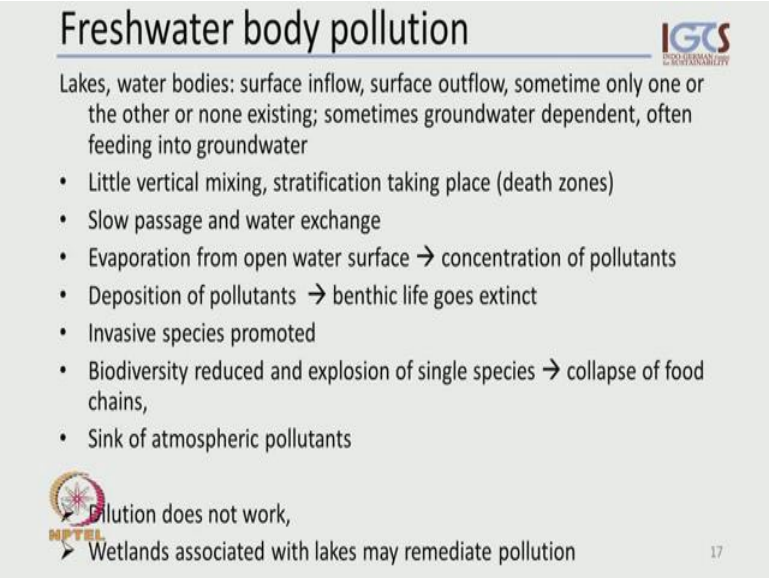

Now, what we have to recognize from this, that dilution does not work at all in lakes although those lakes may be flushed once a year with a rainy season, not all of them are flushed and stay. This is not dilution, usually it is evaporation driven, which means, pollutants are concentrated up and we have one positive effect in some of the cases where wetlands are associated with lakes. Some of the lakes themselves may be partially wetlands. They may extend their size during the rainy season and then shrink again and those wetlands systems are not only very important habitats, but they also have remediate pollution.

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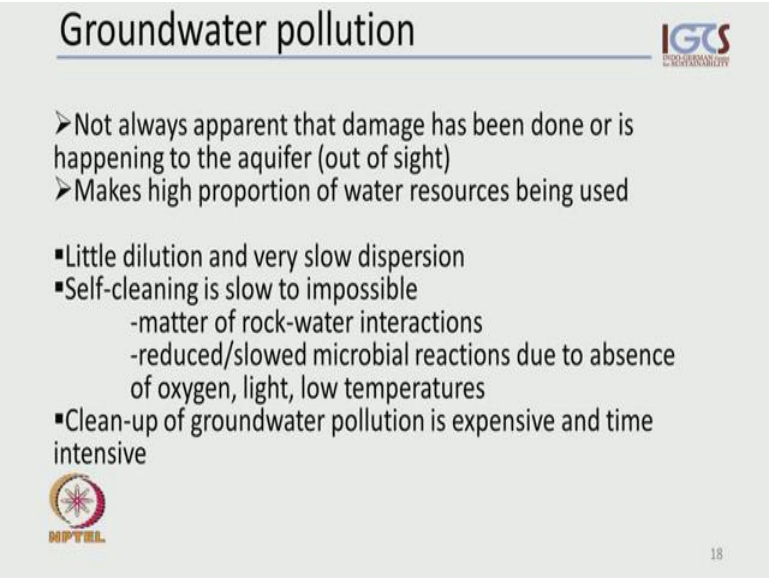

Now, let us stop on surface water bodies and look into the ground water pollution. It is a very difficult subject because not always it is apparent, that some damage to the groundwater has been done or that this is an ongoing process because our groundwater is out of sight to us and we believe that groundwater is being cleaned by moving through the soil or rock layers slowly. Now, we say you should keep in mind, that groundwater pollution is a serious issue because the groundwater itself makes this high, makes up a high proportion of water resources being utilized as water, drinking water supply to us to people.

What we, what happens in aquifers is, that there is very little dilution taking place as there is little recharge taking place and that this dispersion processes are very slow dispersion means, that particles including water molecules are moving very slowly from one location to another location very often in the form of ((refer Time: 28:59)) where the possibilities for self cleaning like in the sense are very slow, and in some of the cases even impossible and this is because the cleaning is a matter of the rock water interactions taking place. The type of rocks that we have in which water will move and those self cleaning is also very much slow down or inactive because the microbial reactions are either reduced or absent because of the lack of oxygen.

There is only very few types of microorganisms, that may be able to survive in such tough living conditions. There is no light that could accelerate microbial growth and the water temperatures in groundwater are usually fairly low, which also slow down microbial growth or chemical reactions in general. Now, the cleaning up of the ground water pollution, once it is being discovered is usually very expensive and also very time intensive and not often successful.

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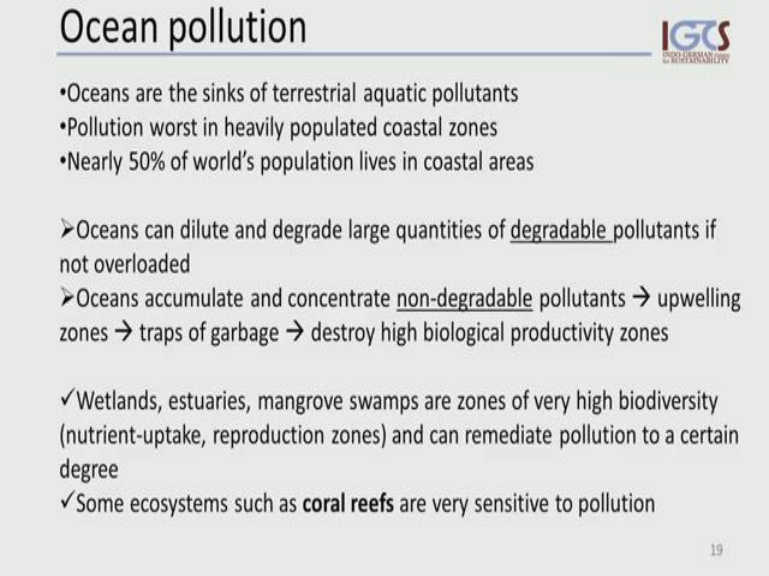

Now, let us move into the ocean pollution as the last of all points here. Remember, that oceans are the sinks of terrestrial aquatic pollutants. All of our rivers, all of our surface terrestrial surface water will eventually either evaporate or reach the oceans. So, those are natural sinks and the pollution observed is usually worst in heavily populated coastal zones. Why is this so?

Nearly 50 percent of our world population lives in coastal areas. Most of our mega cities are located in coastal areas. What are the processes possible to deal with water pollution in ocean, ocean? Dilute it is one of the major ways of getting rid of our ways of our pollutants. By diluting it in the ocean, and many of the components are degraded, are broken down into reusable components, which will be taken up by other organisms again or may move back into cycle back into atmosphere and eventually come back to our terrestrial zones. But this simply requires, that those are degradable pollutants and that we do not overload the oceans in a, in a global way.

Now, what happens to the non-degradable pollutants is, that they get accumulated and concentrate in our oceans. This is especially, and a major concern in our so called upwelling zones is where major ocean currents meet and any of the pollutants, solid or liquid, are trapped in those upwelling zones and accumulated there and eventually, destroy our highly important biologically productive zones.

There are many documentaries about this and you should probably go into search about those and watch some of these documentaries to get a better impression about the scale of the impact of these pollutants in our oceans. Now, there is an additional component to our ocean. We have wetlands and estuaries and mangrove swamps along the transition from terrestrial to aquatic zones, which are very highly diverse in organisms. They characterized by very high biodiversity, which comes along with the very high nutrient uptake taking place in these specific zones and they, the importance of these zones for reproduction of closing food chains. Also, some of these can actually remain the, remediate pollution to a certain degree because of this high, highly biodiverse, highly productive action or activities of biological lives.

Now, some of these ecosystems in oceans, for instance, coral reefs are very sensitive to pollution and they are the first who are affected and will completely die when pollutants occur even in quantities, that may not be visible to the bare, which may have to be detected in sophisticated analysis, but still our coral reefs show immediately respond to such pollutants. So, this is where we want to quickly go and talk about the detection of pollution and water quality. This is one way of using a living organism this is.

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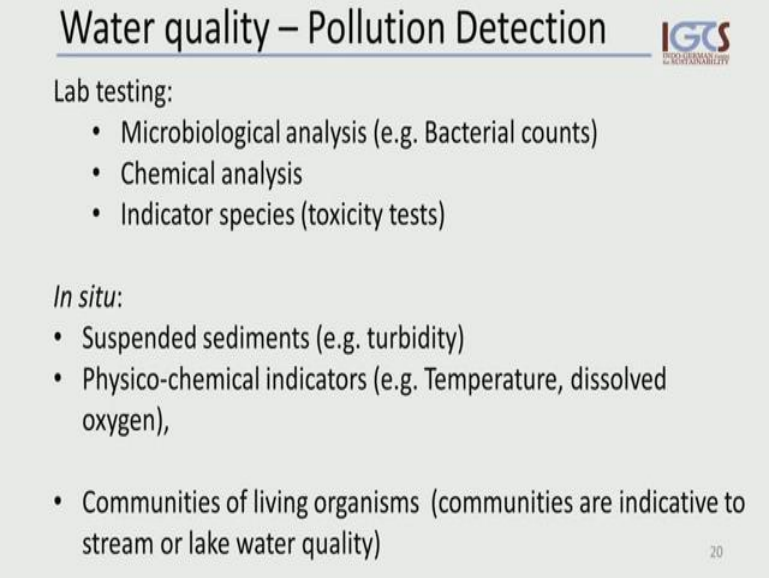

We can also remove such a species and take it into a laboratory and use this as an indicator species we call those also toxicity tests. And so, coral reefs are one way of, sort of not the best way, an unwanted way of conducting a toxicity test. Other lab tests are

microbiological analysis where we may go bacterial or microorganisms count or identify the species or we may conduct chemical analysis at various levels of complexity to detect pollution and to assess the water quality.

The other methods are in situ. This means, that we are removing the water from the location, but put our sensors into the bottom bodies. This is to, for instance, measure suspended sediments, for instance, in the way of turbidity or another way would be to measure clarity. We also measure in situ or physical chemical indicators such as temperatures or dissolved oxygen or others.

Or there is another way which is a biological mean of measuring pollution by monitoring communities of living organisms and there are communities, which are indicative to stream or lake water quality. And by knowing what type of species communities occur under certain conditions at a certain time, we know quite soon before we are able to detect any large, of large scale pollutants. Pollution, we can already identify, that something is wrong and something has to be done more profound to understand why the community compositions have been changed or as they are identified for a specific aquatic environment.

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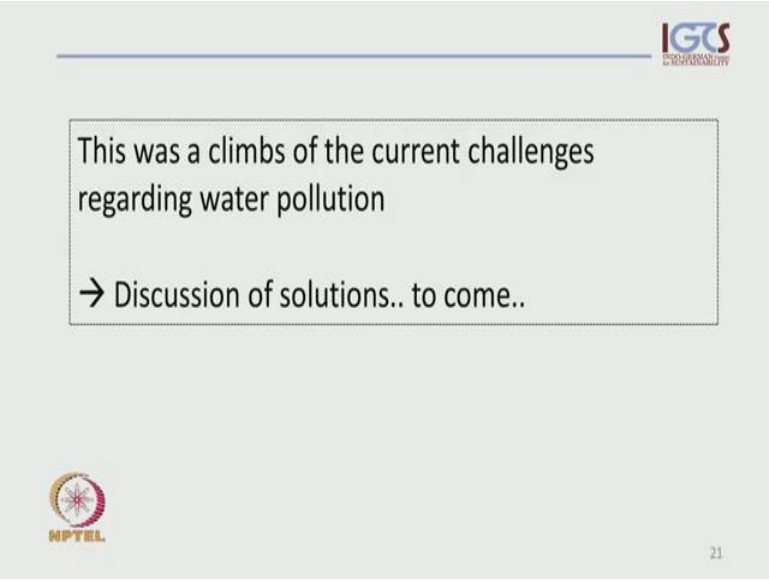

Now, this was just a very quick overview of the issue of water pollution. Remember, we are talking about the challenges. So, this is just open, it is up to you, you should search for more information. There is much more about this available in terms of

documentaries, in terms of scientific literature to each of these aquatic environments that I touched upon here and we will be discussing these solutions in our next module, which will start after, right after this one.

Thank you for this and I see you next time again.