INDIAN INSTITUTE OF TECHNOLOGY MADRAS

NPTEL
NPTEL ONLINE CERTIFICATION COURSES

ECOLOGY AND ENVIRONMENT

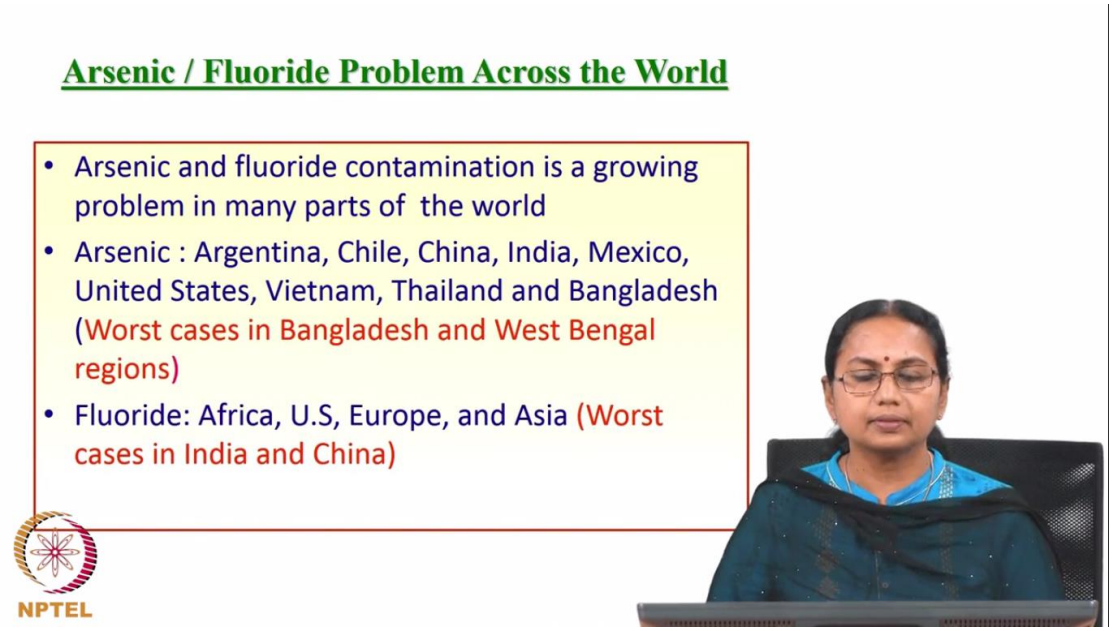
Water Treatment: Point of use filters.

Lecture 4

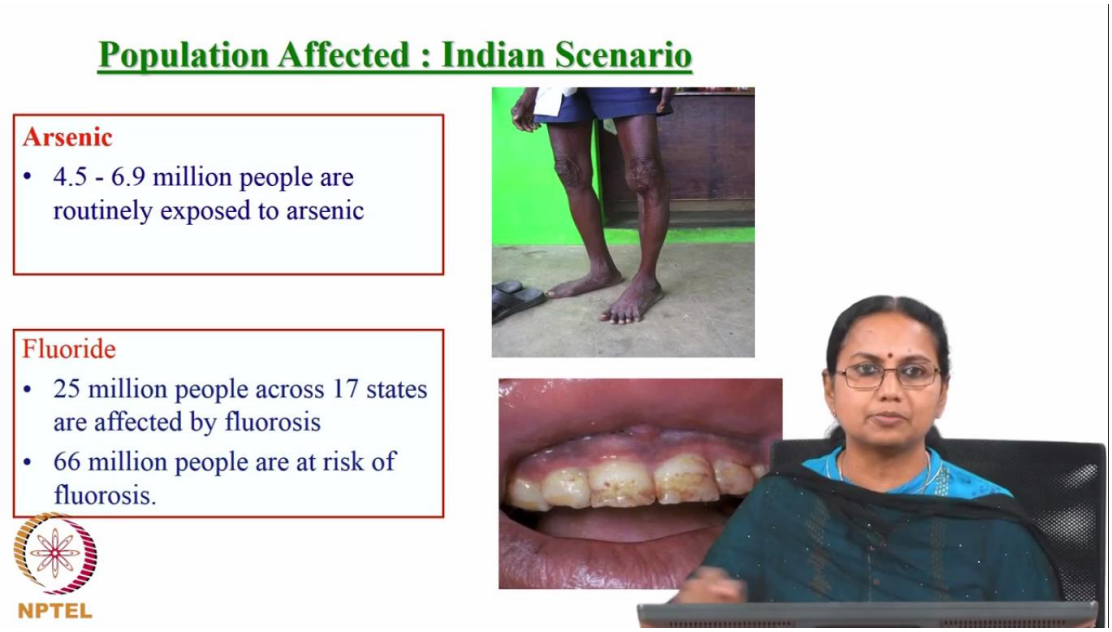
Prof. Ligy Philip

Department of Civil Engineering
IIT Madras

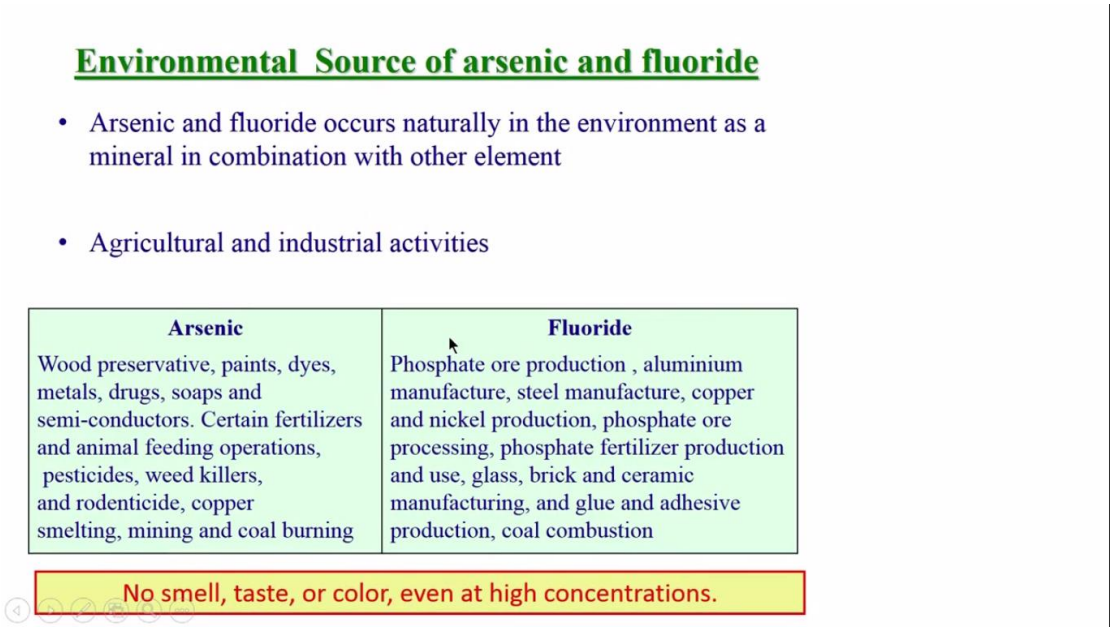
Welcome back. Last class, we discussed about water quality standards and the philosophy of water treatment and the general water treatment. Today, we will continue with water treatment, and I will be emphasizing on point of use filters and all because many of the people in India use this point of use filter. So, we will look into the treatment little more detail.



So, arsenic and fluoride problems exist across the world. Arsenic and fluoride contamination is a growing problem in many parts of the world. Argentina, Chile, China, India, Mexico, United States, Vietnam, Thailand, and Bangladesh is having arsenic problem, and worst case is in Bangladesh and West Bengal regions. And fluoride problems are also existing in many parts of the world, for example, Africa, U.S., Europe, and Asia. Worst case is in India and China.



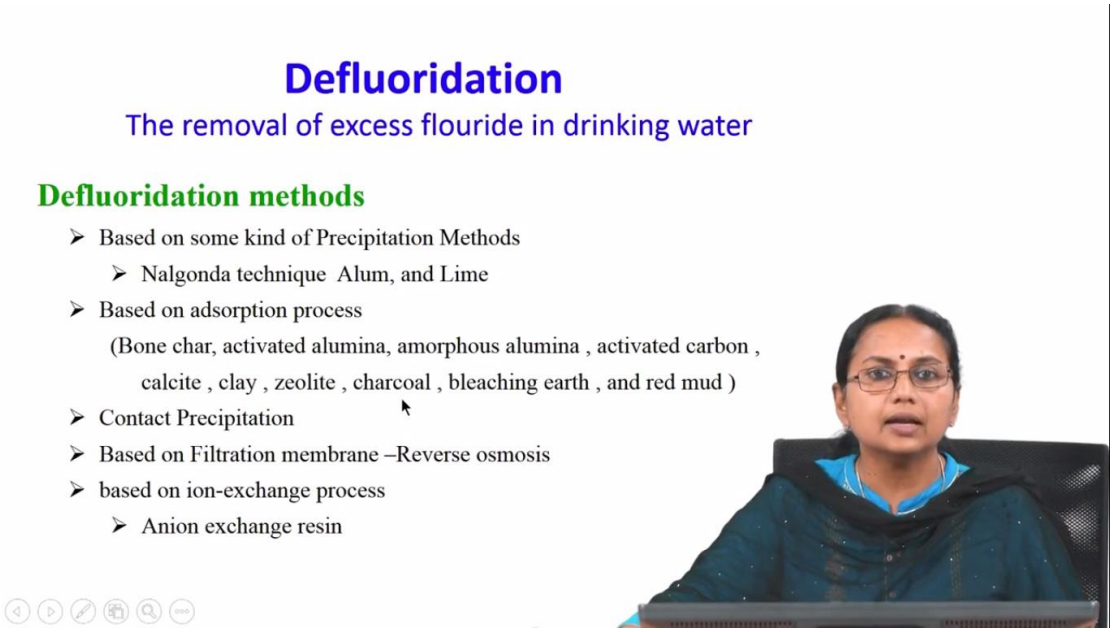
So, what I will do is, I will give some idea about how can we remove this one from the drinking water. So, population affected, if you see the arsenic, around 4.5 to 6.9 million people are routinely exposed to arsenic through drinking water. And when it comes to fluoride around 25 million people across 17 states are affected by fluorosis. Fluorosis is the state when you take fluoride for a long, high concentration of fluoride for a long period of time. 66 million people are at risk of fluorosis in India.



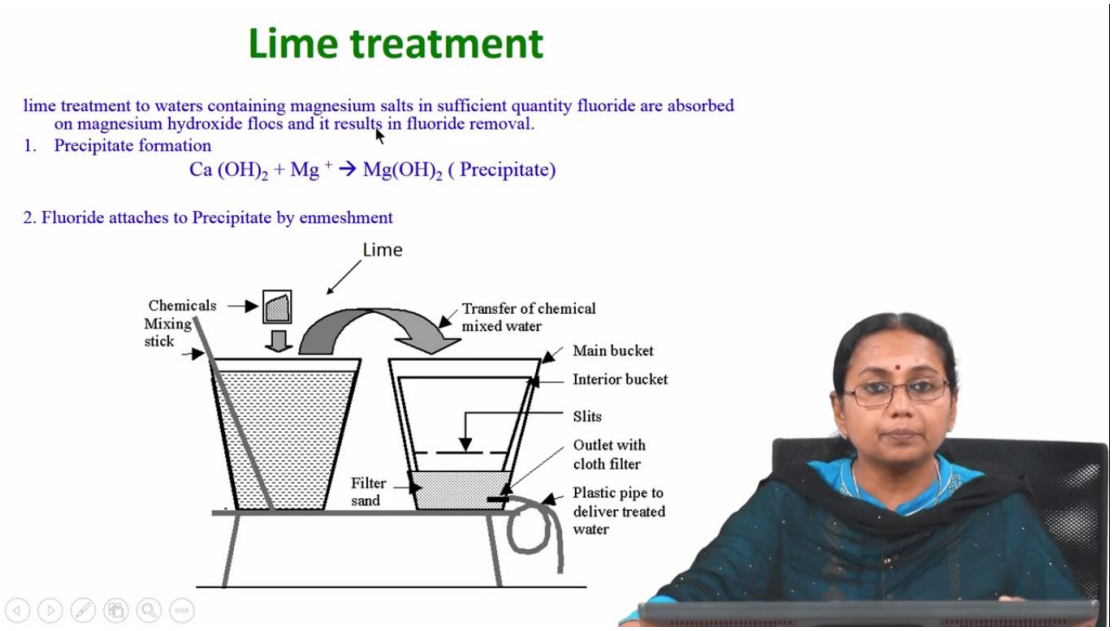
So, environmental sources of arsenic and fluoride, you may be thinking that it is because of industrial contamination, most of the cases it is not. Arsenic and fluoride occur naturally in the environment as a mineral in combination with other elements. So many times, it is the natural origin.

But agricultural and industrial activities also can contribute arsenic and fluoride. So, arsenic is present in wood preservative, paints, dyes, metals, drugs, soaps, and semi-conductors, certain fertilizers and animal feeding operations, pesticides, weed killers and rodenticide, copper smelting, mining, and coal burning. All these things are the industrial operations or anthropogenic operation which can, which gives arsenic, and naturally the waste coming, solid waste or liquid waste coming from that one will be containing arsenic. And when it comes to fluoride, phosphate ore production, aluminum manufacturing, steel manufacturing, etc. all these activities involve fluoride. So, the biggest problem because earlier I was telling you, the physical parameters we can see that one easily. But both arsenic and fluoride does not have any smell, taste, or color even at high concentration. So, what is happening is the analytical facilities are not available in all parts. So, what happens people are not

aware of the arsenic and fluoride presence in their water many times unless there is a frequent water quality monitoring. So, many people are getting exposed to this one.



So, we will see what are all the methods we can use for fluoride removal. Defluoridation is the word used for removal of excess fluoride in drinking water. As per the Bureau of Indian Standards, the permissible fluoride concentration in water is 1 milligram per liter, and arsenic is around 0.01 milligram per liter, very very low concentration. So, defluoridation methods, there are different methods. One is based on some kind of precipitation. So, when we precipitate, the fluoride will be getting adsorbed to the precipitate. Another one is based upon adsorption process, you use different types of adsorbents like bone char, activated alumina, amorphous alumina, activated carbon, calcite, clay, zeolite, charcoal, bleaching earth and red mud all these things can be used as adsorbents. Then contact precipitation and improved method of precipitation. Then based upon membrane processes. Many times, the reverse osmosis process is used to remove fluoride. It will be removing fluoride to a great extent. Then based on ion-exchange process, you use ion-exchangers, there the fluoride is getting exchanged with other ions and the fluoride will be getting removed. So, if you want to remove fluoride, you have to use anion exchange resins, and for arsenic removal also most of these methods can be used.

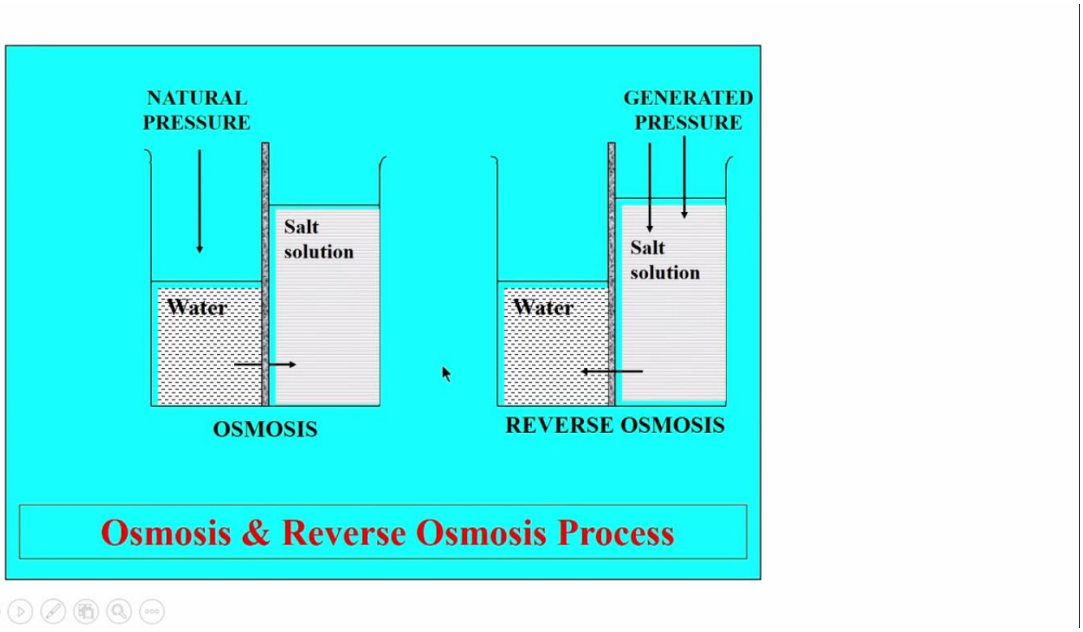


So, the precipitation method one is lime treatment. So, what we do calcium hydro-oxide and magnesium you will be getting magnesium hydroxide precipitate. Fluoride is getting attaches to the precipitate by enmeshment. So, what you have to do take a bucket full of water, add the chemicals, allow it to settle and you take the supernatant, most of the time the fluoride concentration will be coming down within the permissible limit.

Another one is adsorption. The most commonly used adsorbent for fluoride removal is activated alumina. So, this is the picture of a hand pump attached to the attachable defluoridation unit, so what is - this is the activated alumina. So, this is the hand-pump, the water is coming here, and it is passing through the filter made up of activated carbon, activated alumina. Here this activated alumina is acting as the adsorbent, so the fluoride will be getting adsorbed on the activated alumina. So pure water will be coming here, and that can be used for the drinking purpose.

So here what happens when we use the adsorption process with respect to time, in the adsorption capacity of the adsorbent will be getting reduced. So, in between, you have to take it and regenerate it for further removal. So, this is one of the method. This is the hand-pump attached unit. And there are many household filters available for the arsenic removal.

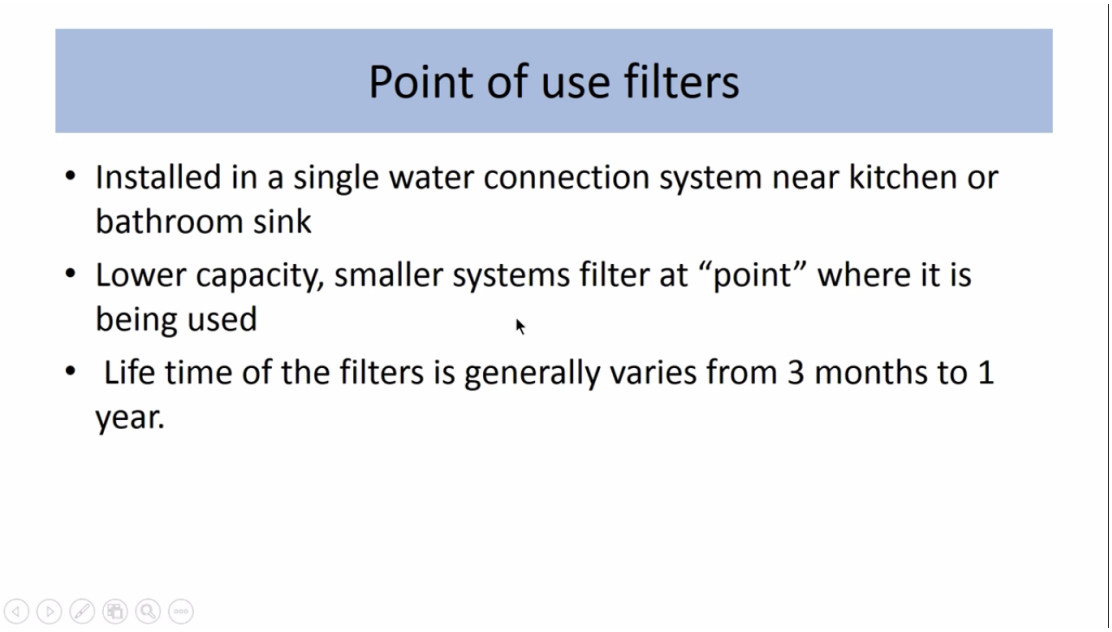
So here, this is a Candle filter type of a thing, and there are some filters, it is filled with activated alumina, and you can pour the water, and you will be getting the treated water in the bottom.



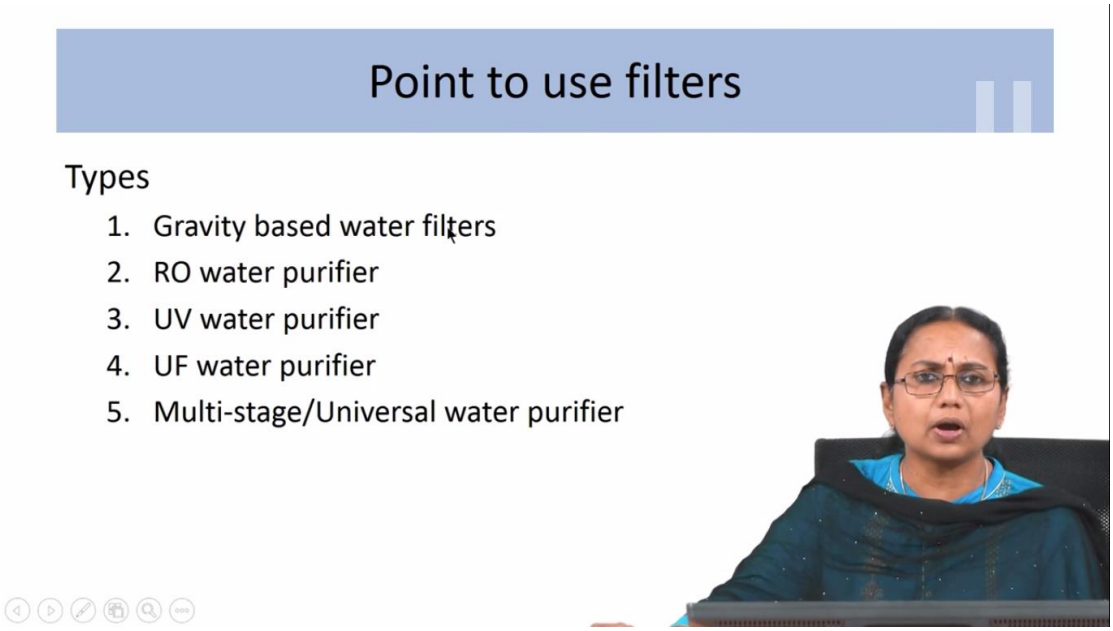
And another method is I told you reverse osmosis. What is osmosis? If you have a salt solution and clean water separated by a membrane, so what will happen? The clean water will be passing through the membrane to the salt solution until the osmotic pressure of both the solutions become almost identical.

In reverse osmosis, what we are doing we are exerting pressure here in salt solution so that the clean water from the salt will be passing through the membrane and you will

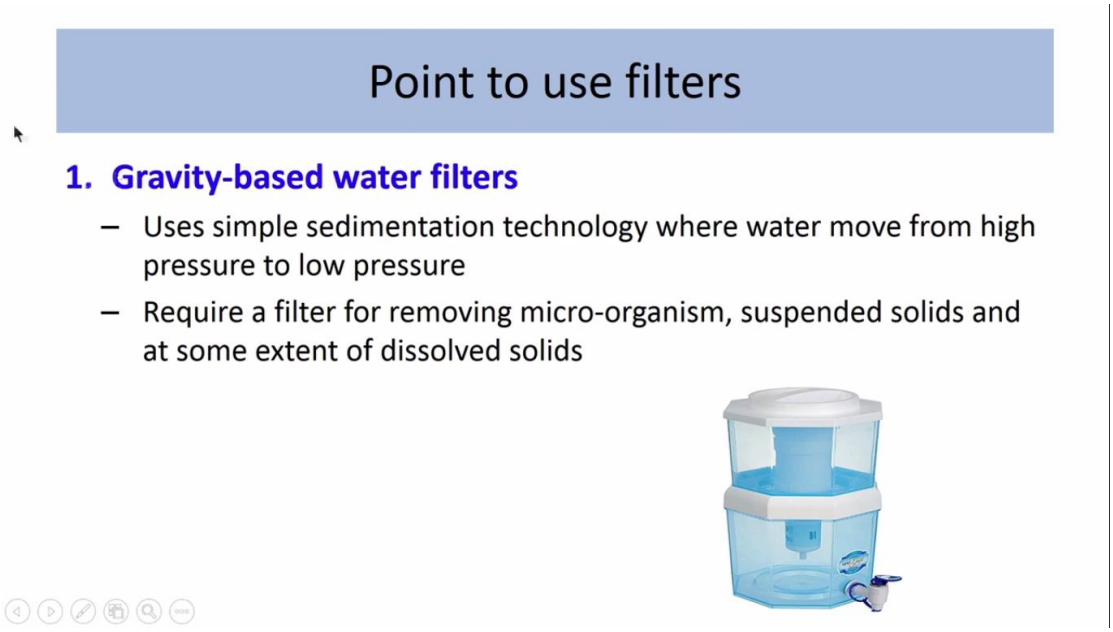
be getting the clean water. So that is why this is getting the name reverse osmosis. It is the just opposite to the osmosis process.



And many community and central treatment units are available, but in India, many people are using point of use filters, installed at single water connection system near kitchen or bathroom or sink. So, so we will discuss about what are the different types of point of use filters available in India. So, again point of use filters are the filters installed in a single water connection system near kitchen or bathroom and its capacity is low, smaller systems filter at “point” where it is being used. Life time of the filter generally varies from three months to one year. Many times, we have to remove the media or the membrane depending upon what type of filter, point of use filters you are using.

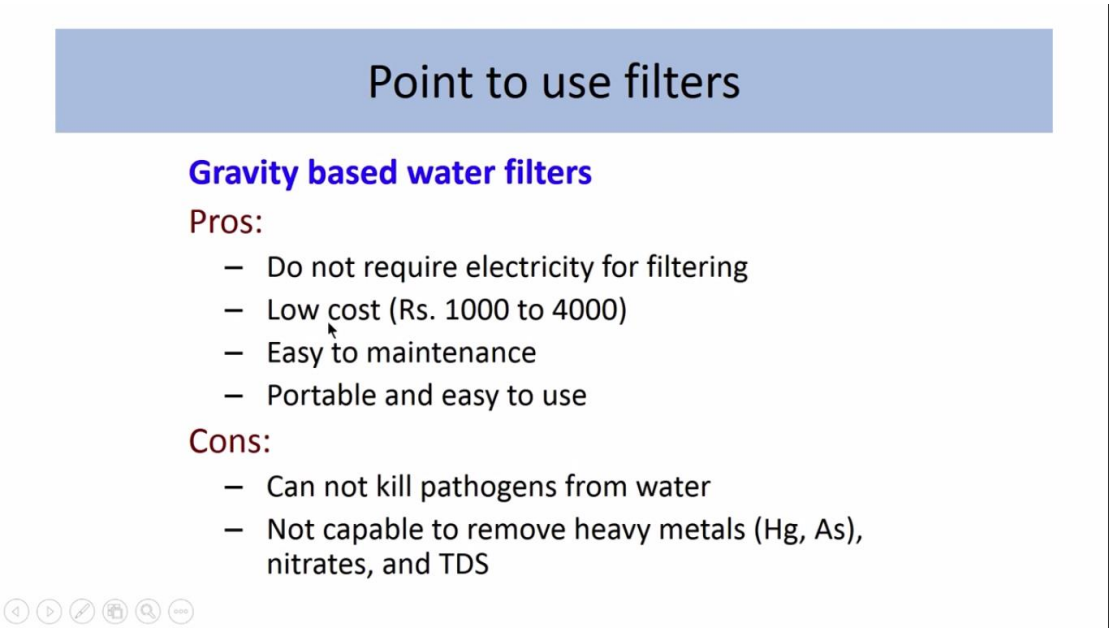


So, when we talk about this point of use filters, there are different varieties. When you use the centralized treatment system also all these technologies are available, but nowadays it is made to point of use filters. So, gravity-based water purifiers, reverse osmosis based water purifiers, UV based water purifiers, ultrafiltration based water purifiers, multi-stage universal water purifier. That means there are combination of many of these things. So, we will see one by one in detail.



Point of use filters, gravity-based water filters uses simple sedimentation technology where water moves from high pressure to the low pressure. Require a filter for removing micro-organism, suspended solids and some extent of dissolved solids. The most commonly used gravity filter consists of two layers, sand, and activated carbon. The sand will be acting as a filter media, so, it will be removing turbidity and some amount of microorganisms and all. And the activated carbon will be removing the organic matter and the taste and odor-causing compounds.

So, once the filtration is over, whatever the water is coming out you can collect it and disinfect using chlorine or any other methods and use it. This water will be very safe, and many times this gravity-based filter are economically very cheap, and the most commonly used gravity-based filters are the bio-sand filters. There very slow flow rate is employed, and the water is getting filtered through that one. And those filters will be having a thin bacterial layer in the top of the filter so that one will be taking care of the organic matter also.



So, we will see the pros and cons. Do not require electricity for filtering. Low cost. I told you 1000 to 4000, even if you go for a smaller size the cost can be still lower. And easy to maintain. Portable and easy to use.

Cons. Cannot kill pathogens from water, that is what I was mentioning. After this one, you have to give disinfection. Not capable to remove heavy metals if your water is contaminated with industrial effluents and all, this filter will not be sufficient to meet the water quality parameters. Mercury, arsenic, fluoride, nitrate, TDS cannot be removed by gravity based filters.

Point to use filters

2. RO water purifier

- Based on reverse osmosis technique
- Most commonly used filters in household and companies
- Can remove heavy metals like Arsenic, mercury, nitrate and fluoride.

Now, we will see RO water purifier. Most of the people are familiar with this one. This is based on reverse osmosis technique. Most commonly used filters in household and companies, can remove heavy metal, arsenic, mercury, nitrate, fluoride, etc. The problem is reverse osmosis filters will be removing all the dissolved minerals in the water. So, the water will be free of all the minerals. So that such a water may not be good for our health. So, remineralization of the RO treated water is very very essential. So many times, it is not being used, done. So, if you continuously drink this water, there may be health effects.

Point to use filters

RO water purifier

Pros:

- Can be used for treating high TDS 500–2000 mg/L
- Can treat salty water, hard water or bore water

Cons:

Require electricity

Require high maintenance cost

Wastage of water

Can not kill pathogens

So, what are the advantages? Can be used for treating high TDS water and can treat salty water, hard water, or borewell water. What are the disadvantages? Requires electricity, require high maintenance cost around 50% of the water is getting wasted and cannot kill pathogens. After the RO filtration also it is advisable to have a disinfection system.

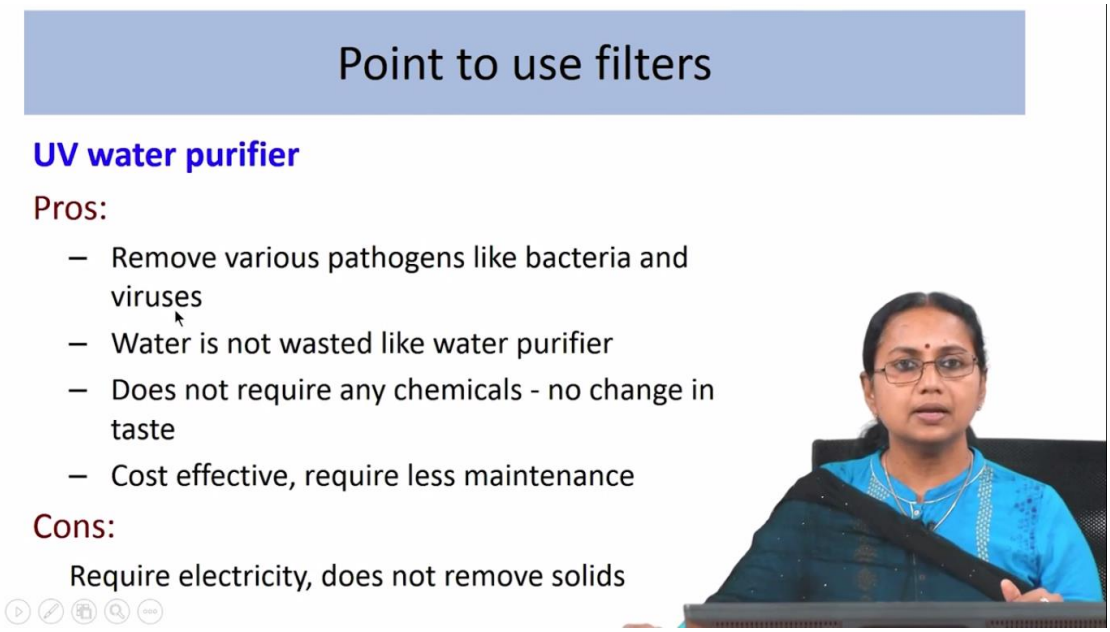
Point to use filters

3. UV water purifier

- Uses ultra violet radiation to kill pathogens
- They do not remove dissolved solids
- Does not cause corrosion of water unlike RO

So, now coming to UV water purifier. So, UV water purifier is only meant to do the disinfection. It will not be able to remove your heavy metals or any other things. So,

here what we are - what it does is, uses Ultra Violet radiation to kill pathogens. They do not remove dissolved solids, does not cause corrosion of water. So most of the time if you are going for UV water purifier, you have to have some pre-treatment to remove your turbidity and other contaminants present in the things.



So, we will see what are the advantages of this system. Remove various pathogens like bacteria and viruses; water is not wasted like RO water purifier, does not require any chemicals nor change in taste, cost-effective, require less maintenance. Disadvantage is require electricity, does not remove solids.

And Ultrafiltration water purifier. So, this is another system. Ultrafiltration water purifier uses ultrafiltration membrane to purify water.

Point to use filters

4. UF water purifier

- UF water purifier uses ultrafiltration membrane to purify the water
- These purifiers remove pathogens like bacteria and suspended solids

This purifier removes pathogens like like bacteria and suspended solids. It will not be able to remove total dissolved solids.

Point to use filters

UF water purifier

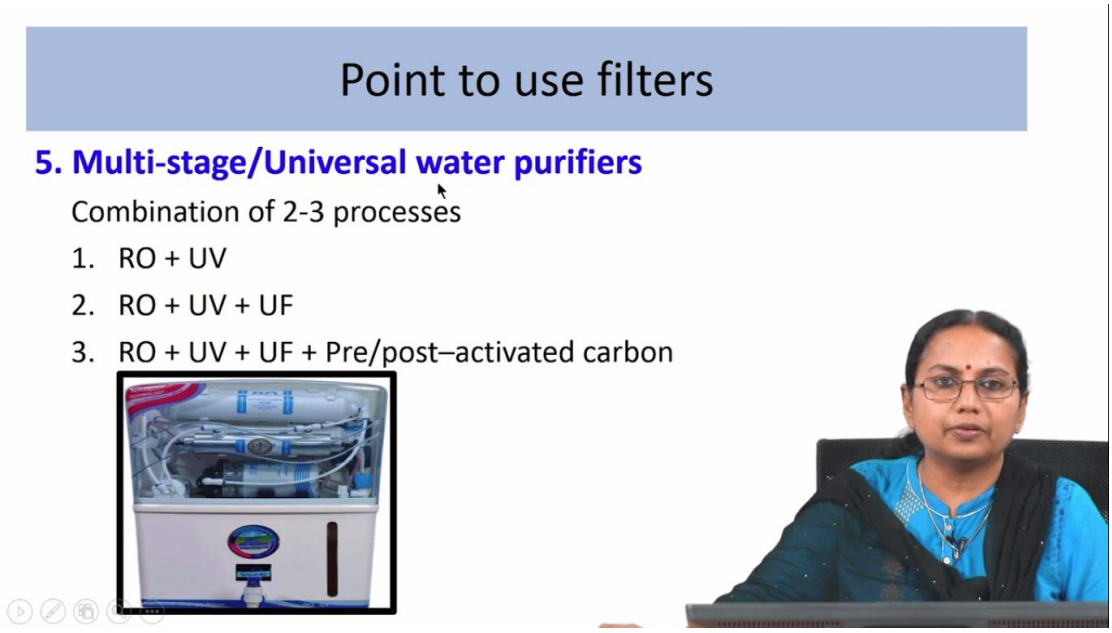
Pros:

- They require less quantity of electricity
- Can remove pathogens and suspended solids
- Long lasting and low in maintenance

Cons:

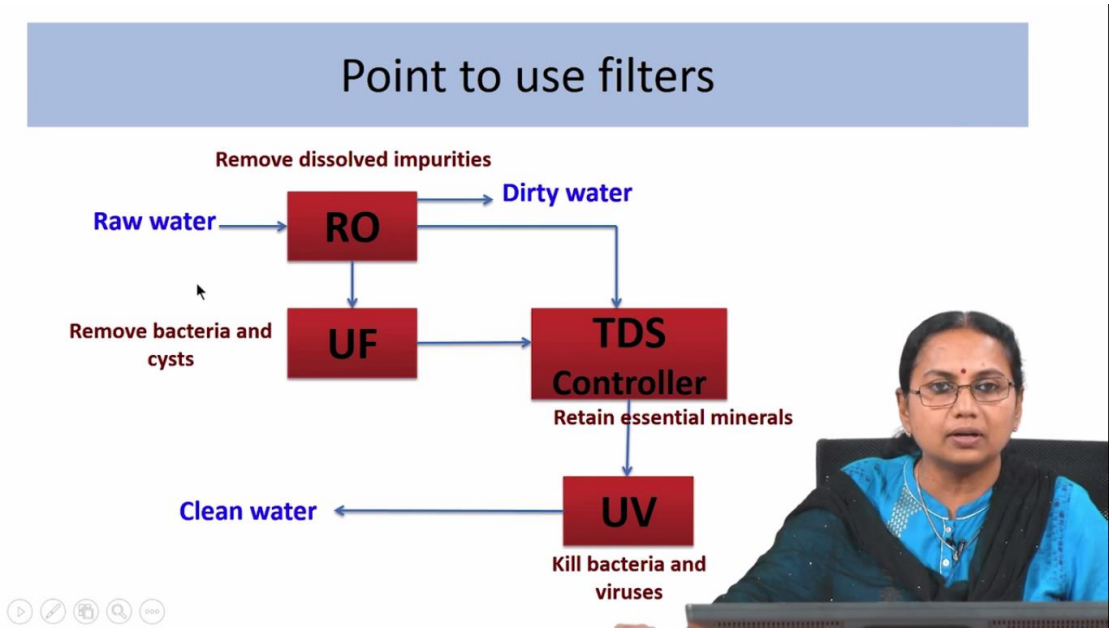
- Can not remove dissolved solids
- Can be used to remove water with low TDS, so can not remove toxic ions

So, we will see the advantages and disadvantage here. They require less quantity of electricity, can remove pathogens and suspended solids; may not be completely you have to go for disinfection if you want to be 100% safe, long lasting and low in maintenance. Disadvantages, cannot remove dissolved solids, can be used to remove water with low TDS and it cannot remove toxic ions, etc.

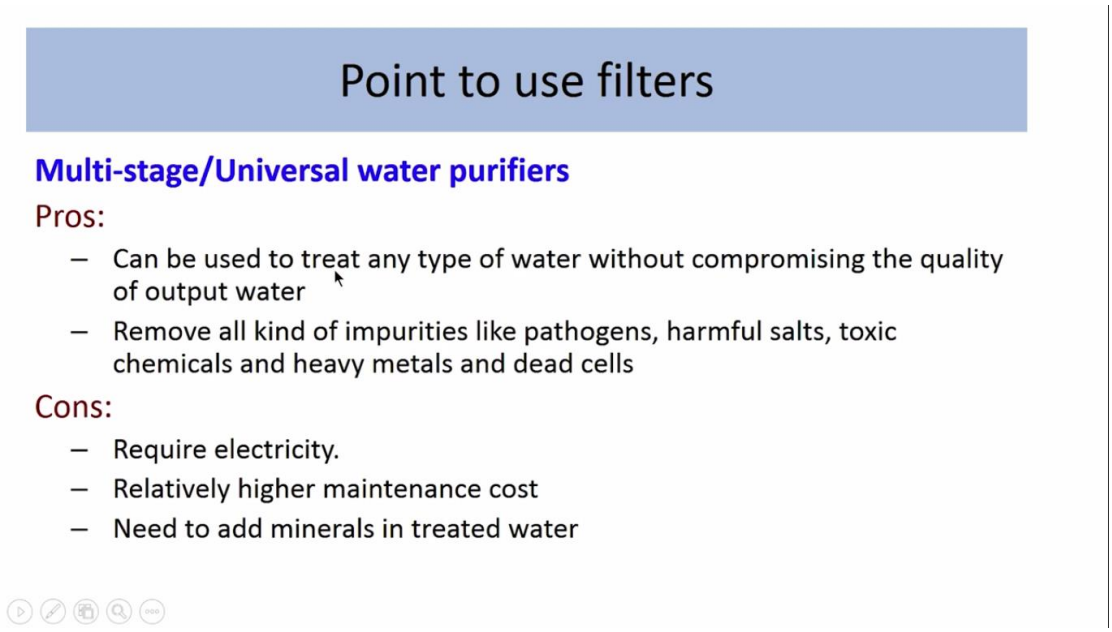


Then multi-stage universal water purifier. This is a combination of 2-3 processes whatever we have discussed. There are RO+UV available, RO+UV; Ultra Filtration+RO+UV, Pre-post activated carbon, Ultrafiltration RO and UV. So, all these combinations. Now, what I am trying to tell is you cannot tell that this is the treatment system we can adapt for any type of water. We have to look into the water quality, raw water quality and the water treatment system should be tailor-made because one raw water quality will be varying from the other. So, the treatment required will be entirely different.

So according to that treatment, the raw water quality, you have to identify what is the proper type of point of use treatment system you have to adopt.

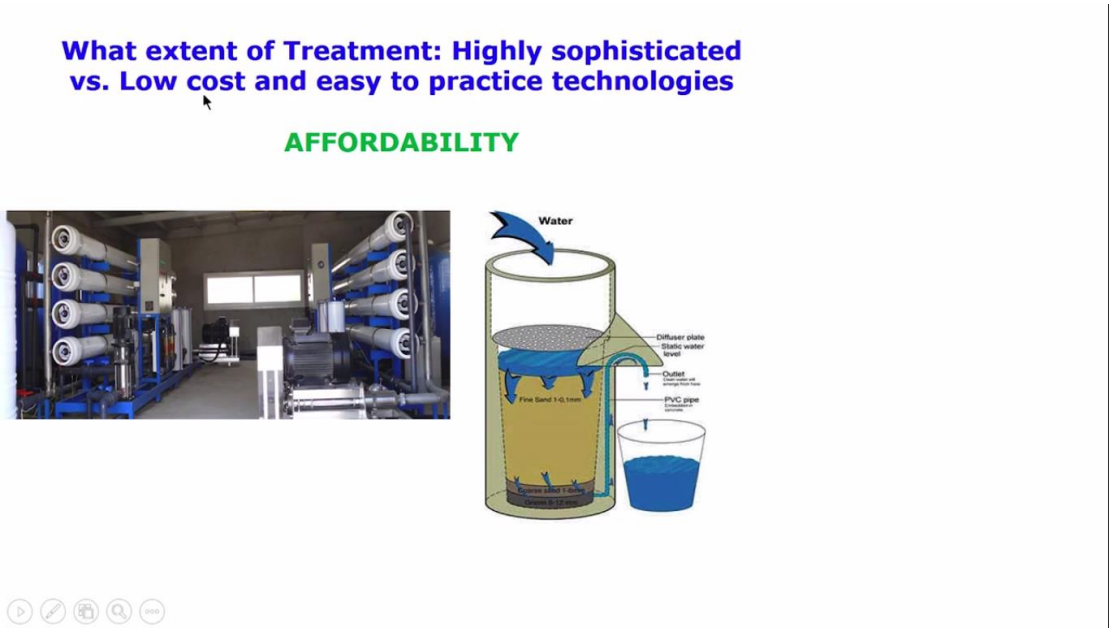


So, point of use, how it is working? So, this is raw water, it is not first RO. Raw water will be going to ultra-filtration, it will be removing the turbidity and all. Then it will go to RO, RO will be removing TDS. First, it will enter in the UF then RO then to UV. So that is the way you will be arranging the filter. So, this will be removing all the contaminants. UF will be removing your turbidity and to a certain extent the bacteria, etc. And RO will be removing your TDS and UV will be removing the remaining bacteria and viruses.



So, multi-stage universal water purifier what are the advantages? It can be used to treat any type of water without compromising the quality of output water. Remove all kinds of impurities like pathogens, harmful salts, toxic chemicals, and heavy metals and dead cells.

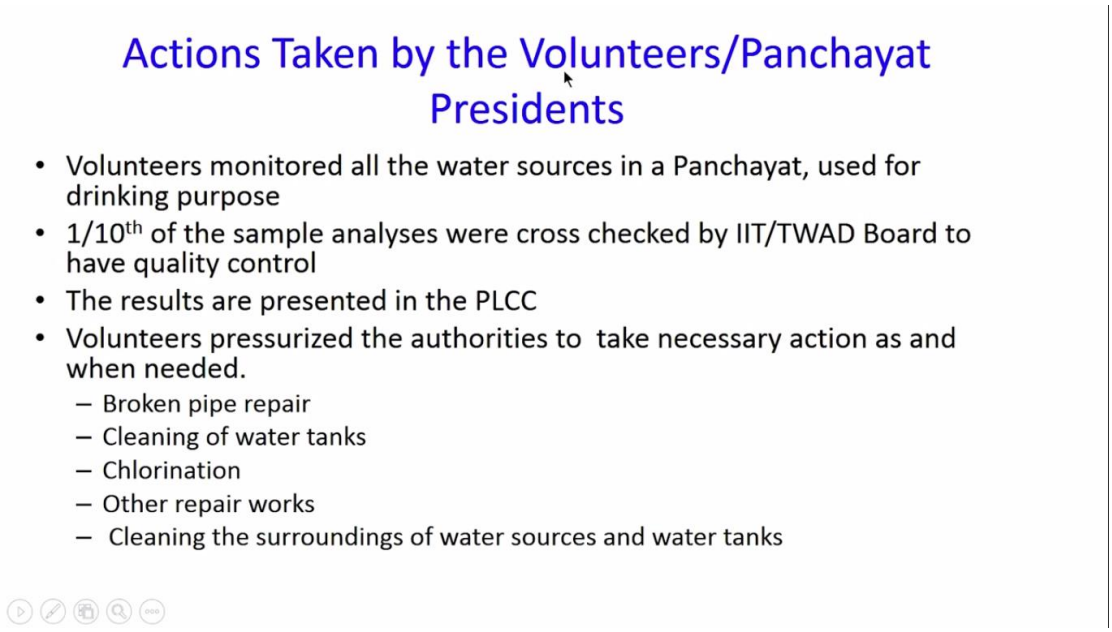
Disadvantages, require electricity, relatively higher maintenance cost, need to add minerals in the treated water and lot of wastage of water will be there because around 50% of the water will be wasted in the RO unit.



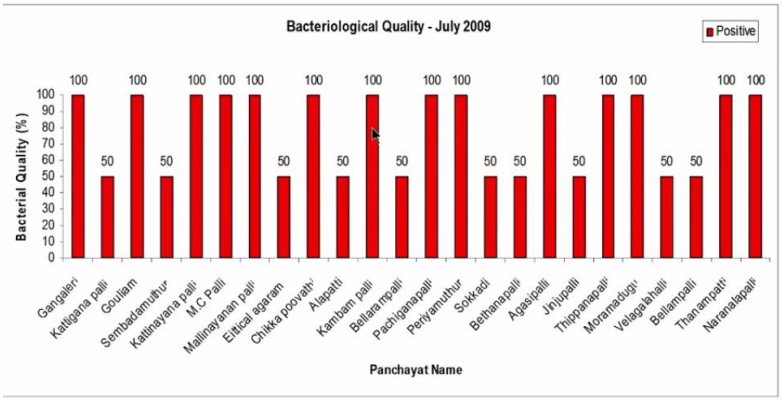
So, what extent of treatment, whether we can go for highly sophisticated or we can go for low cost and easy to practice technologies. So easy to practice technologies like this, this is the biosand filter. Most of the contaminants will be getting removed here if it is not having heavy metals and other toxic compounds. If you have only turbidity, some color, taste, etc. this type of a filter will be able to remove that one and what are all the treated water is coming you can disinfect and use. So, what I am trying to tell is blindly you do not have to go for RO and other treatment. Depending upon the water quality if necessary go for such treatment otherwise low-cost treatment systems are more than sufficient to meet the water quality.

I will show you some example. How can we give education and awareness to improve the water quality significantly? So, I told you water quality analysis is very very important but in many parts our country, the sophisticated labs are not accessible for many of the population. So, because they are very costly and very few numbers are available. So, easy to monitor water quality test kits if you can deploy them and give some sort of a training to the people, the awareness about the water quality, the diseases, etc. will be increasing and that alone can improve the water quality significantly.

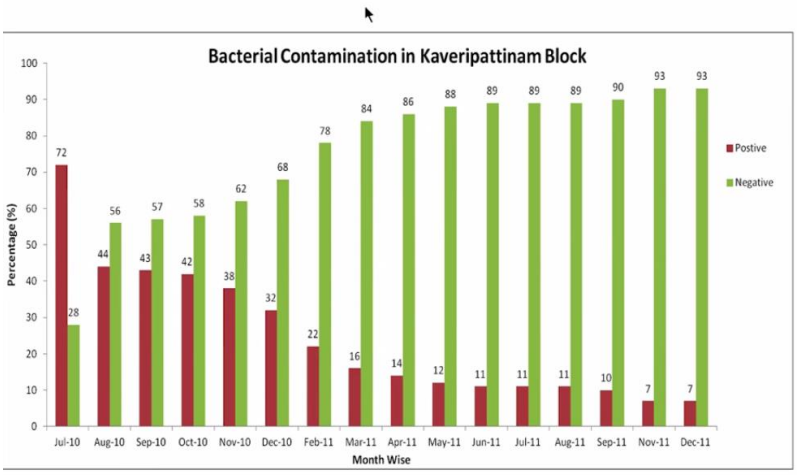
I will show one example. The project whatever we have done. So, IIT Madras has developed a water quality test kit with the help of financial support from UNICEF. So, what we have done is we have developed the water quality test kit and use this water quality test kit to give training to many Panchayats in two districts of Tamil Nadu. What we have done, we have done the training, given the training to Panchayat president, Panchayat secretary and three volunteers from each Panchayat. So, after the training what they were doing is they were going and taking all the drinking water samples from the from the villages from the where they are coming and the results they were reporting to the Panchayats.



So, this is the action taken by the volunteers, Panchayat Presidents. Volunteers monitored all the water sources in the Panchayat used for drinking purpose using the water quality test kit, and $1/10^{th}$ of the sample analyses were cross-checked by IIT or the water supply board or TWAD board to have quality control. The results are presented in the Panchayat level consultative committee. Volunteers pressurized the authorities to take necessary action as and when needed because they could see the water quality how it is changing and they know what is the quality need to be there. So, they were pressurizing the authorities if there is a broken pipe for repair, cleaning of the water tanks, wherever chlorination is not done, do the chlorination frequently. Then other repair works. Cleaning the surroundings of water sources and water tanks. Very simple community-based activities they have done.



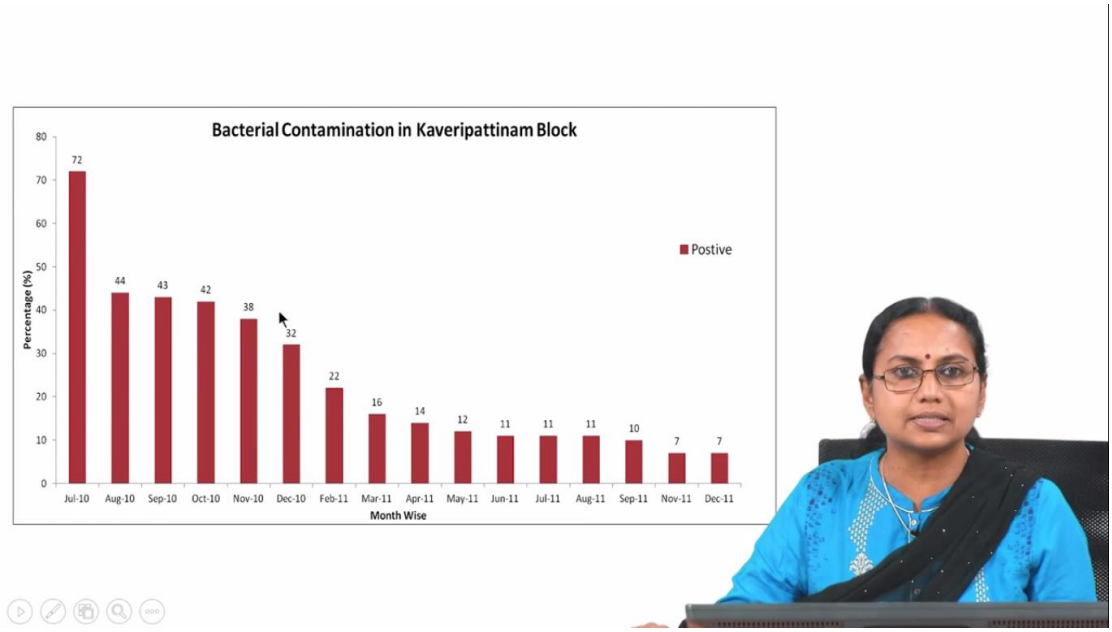
So, when we started the training. So, this is the presence, absence test we were doing. So, this is the water quality existed there. That means the majority of the water sources were contaminated by fecal coliforms. So, the water was contaminated.



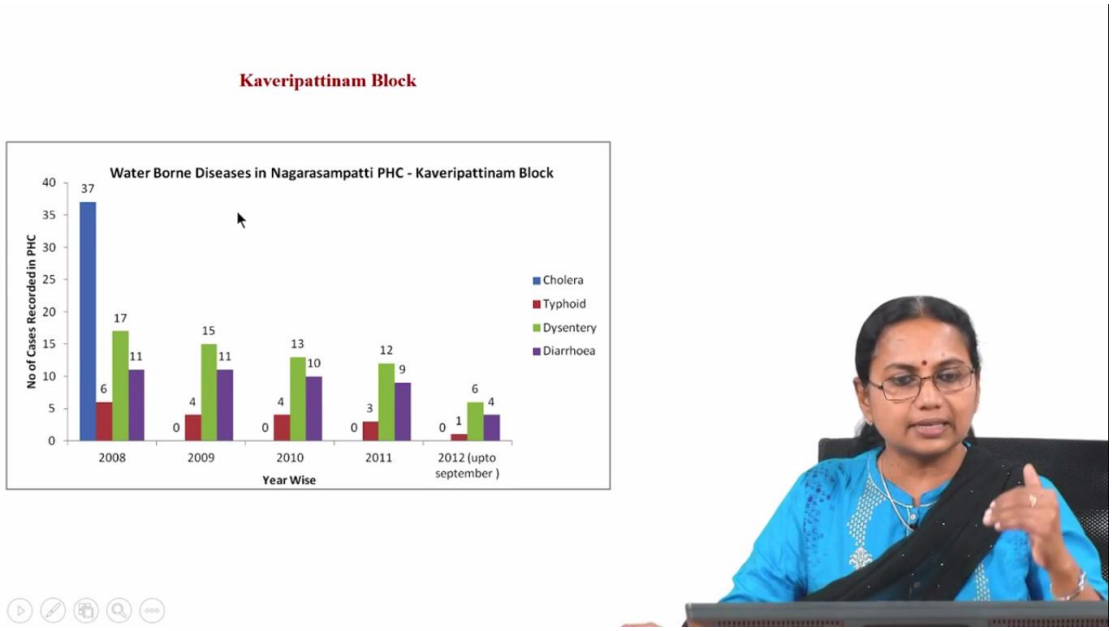
So, we started the – we have given the test and every by monthly we used to go there to test the - check the results and what is going on. So, you can see that during the training period this is July 10, about 72% of the water samples were contaminated. Then the people started checking the water quality and taking corrective measures.

Corrective measures means, only cleaning and repairing the things. No other infrastructural things. You can see that the contamination level is coming down from 72 to 44, 43, 42, 38. So, wherever they are seeing that the water quality is not good they go and take the action and again go back and check it. So, you can see that within one year or one and half years from 72% the bacteriological contamination has come down to 7% without any infrastructural thing. By just creating awareness among the people educating the people and providing them with easy to use water quality test kit which anybody can use.

So, what I am trying to tell is, just educating and creating awareness and give the people, the common people with some testing tools then the water quality whatever they are consuming on a daily basis can be improved significantly.

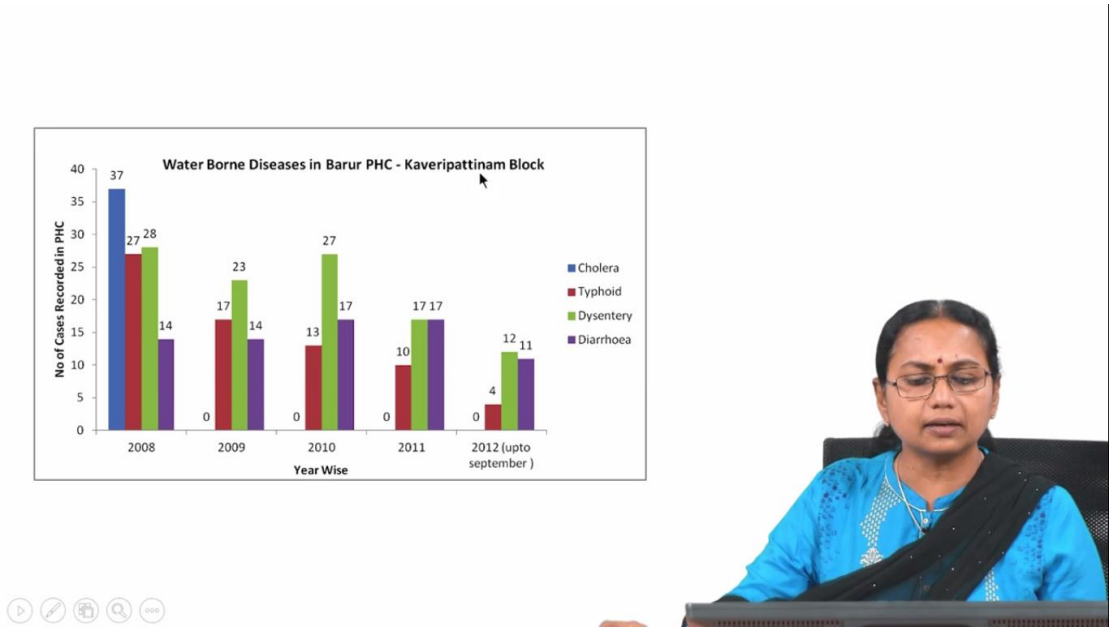


So, here you can see how the bacteriological quality is coming down.

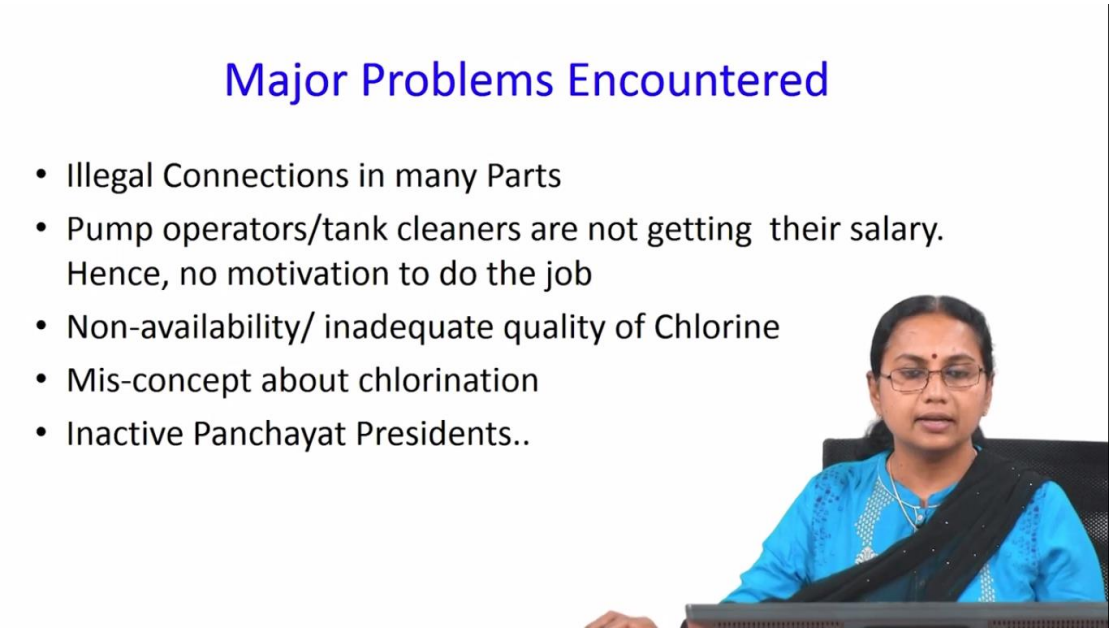


So, and after doing the studies we have gone to, I told you we have done the study in two different districts and around 190 Panchayats or something like that, and we have gone to the public health sector of this Panchayats, and we have looked into the disease history. We have given the training in 2010. You can see that before that one what was the disease occurrence, water-borne diseases and after the training you can see that the disease has come down. There is a decrease in the disease. This is the secondary data we have collected from the primary health centers, but it is very clear that the number of water-borne diseases has decreased in all these PHEs. We have done in many places. I am representing only one picture. So, we have looked into the incidents of Cholera, Typhoid, Dysentery, Diarrhea. All these things are – all these diseases are water-borne diseases. That means the diseases are occurred because of consuming contaminated water.

What I am trying to tell is by providing education, awareness and testing kits, we will be able to improve the water quality significantly.

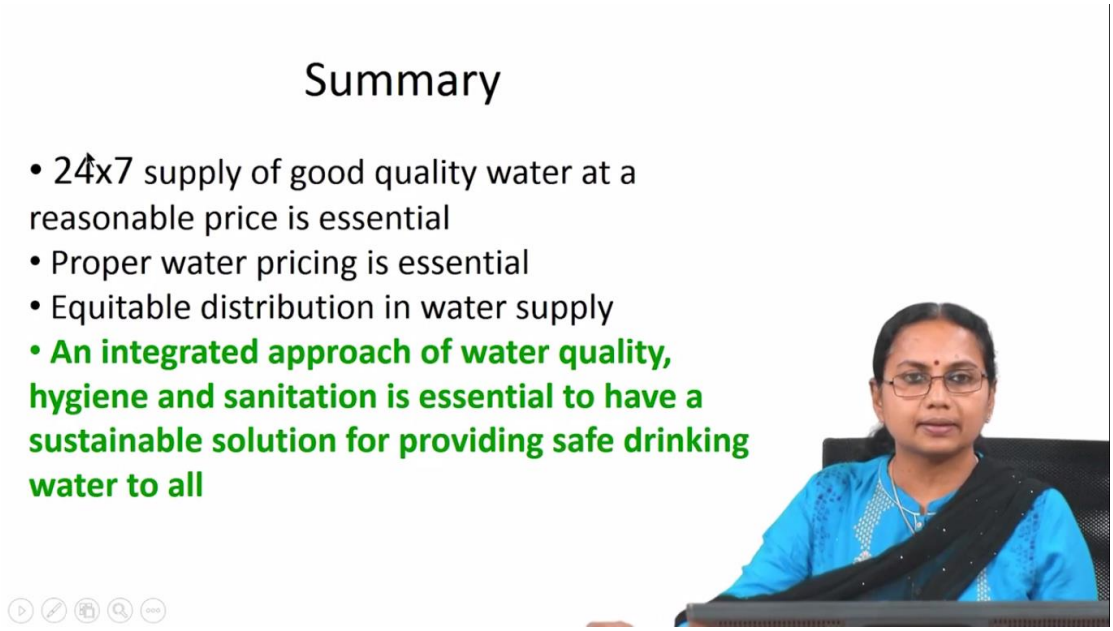


So, this is another block. Here also you can see the same trend. The number of waterborne diseases are decreasing significantly after the training. That means when the awareness is increased the things are improving significantly.



So, major problems encountered in the villages are illegal connections in many parts. Pump operators, tank cleaners are not getting their salary hence no motivation to do the job. So many places we have seen that the tanks are not cleaned for two years, three years, lot of slush was accumulated in this one. Non-availability or inadequate

quantity of chlorine. Mis-concept about chlorination, they are thinking that chlorination needs to be done only once in 15 days that is not the case. Whenever you are pumping fresh water to the tank you have to do the chlorination then only it will be getting disinfected. Many places we could see inactive Panchayat presidents.



So, summary about water supply, what we have to do? 24 by 7 supply of good quality water at a reasonable price is essential. Proper water pricing is essential then only the system will improve. Equitable distribution in water supply and again an integrated approach of water quality, hygiene and sanitation is essential to have a sustainable solution for providing safe drinking water to all. With this one, I am stopping my class.

Thank you.