Applied Environmental Microbiology

Dr. Gargi Singh
Department of Civil Engineering
Indian Institute of Technology, Roorkee

Lecture – 41
Drinking Water Microbiology I

Dear students so far we have taken enough pains to understand the basics of microbiology, which are sufficient in all regards for you to move forward and start addressing our pressing environmental concerns. One of the when we talk about environmental problems; one of the first concern that we have as human beings is our essential need of safe drinking water. We cannot last more than few days without access to water to drink. And if that water is contaminated with microbes that are going to hurt us going to make us fall sick, we will fall sick and then it will be a burden to public health.

As such one of the first priorities for environmental engineers is to ensure access to clean water more than anybody else in India we are very acutely aware, that our surface water bodies are destroyed in terms that most of them are heavily contaminated with biological and chemical contaminants. It is quite, but natural when a country that has such high population density and high population and limited sub unlimited surface water resources, we will have our surface water contaminated. And as such it is even more important and imperative for environmental engineers such as you and me, that we step up and understand the basics of the microbiology of drinking water and how we can take steps to clean it?

So, today my dear students we are going to explore the drinking water microbiology and we are going to look at those pathogens that are very common in our country India and that which damage our health. So, let us start here with a general overview.

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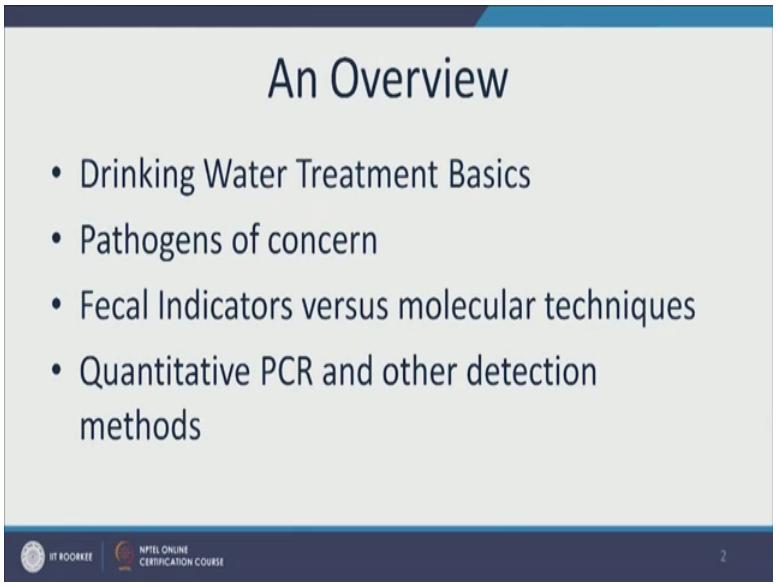

So, drinking what today we will cover the basics of drinking water treatment, pathogens that are of concerned, fecal indicators versus molecular techniques, and then as we move ahead we will talk about the different molecular biology and microbiology techniques that we have for detecting pathogens in water.

So, let us look at drinking water treatment. So, if you have ever seen a lake a pond or a river and you are aware of how clean or dirty it is? Imagine what would it take for you to convert that dirty water, into potable water that you can pour in a glass and drink up.

The first step would be definitely to get rid of the large particulate matter.

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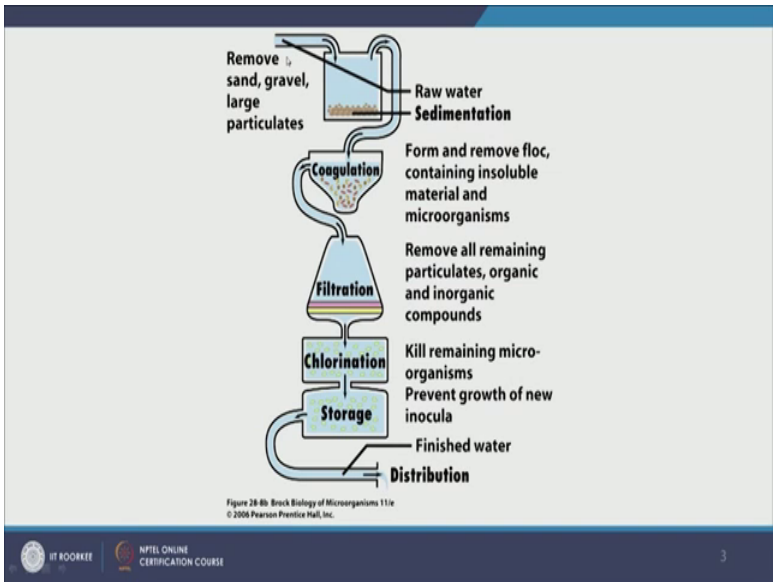

So, here first step is removing sand gravel and other large particulates. And once that has been done by sedimentation so, we allow these heavy particles to sediment, because they are heavy they sedimentary easily.

After this we can either undergo a coagulation process, where this is a typical drinking water treatment training by the way. So, we undergo coagulation process where there are chemicals that coagulate the smaller particles that did not settle in the primary settling tank.

So, what coagulant does is it neutralizes the charge of the flock and makes the flock to aggregate with each other. And I search they become bigger particles and they settle let us look at coagulation process.

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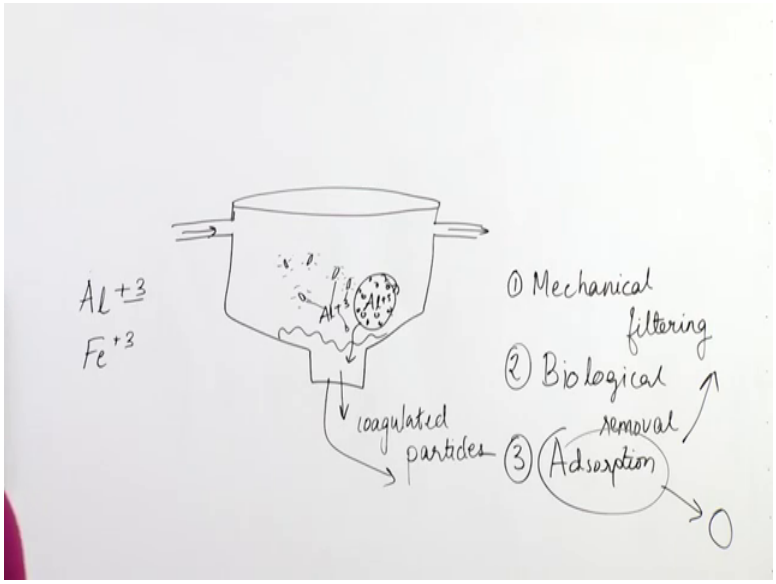

So, a typical coagulant is a salt of aluminum with triple electrons that it has given away and ferric, which is called alum this is a typical coagulant that has that is used in most laboratory and many drinking water and water treatment systems, where we use the coagulation process to get rid of smaller particles.

Now the heavier particles we have already allowed them to settle via gravity in the first sedimentation time, but then these lighter particles as they want to move down first they encounter like all other particles friction force, which some people refer to as drag which is proportional to the velocity square. And then they have the force of buoyancy, which is pushing them up and the only thing calling them down towards the earth is gravity and for smaller particles settling will take tremendously amount of tremendously large amount of time, something which we cannot afford because we have a thirsty population that we need to provide clean water to.

So, as we want to accelerate this process this process of the particle settling down. And the simple idea behind coagulation processes, if we can take these small particles get them to aggregate with each other and form large particles, then they will automatically settle down. To give you an idea if you take mud and you put it in water you will notice after some time and you mix it really well ok.

So, after some time you will notice that the sand, stone, and the grit. Have settled down towards the bucket, where you had the water in the mud, but then still there is some

turbidity in the water the water is not perfectly clear. So, the large particulate matter have settled down, but the smaller particulate mud matter are still floating and perhaps will remain in suspension for a very very long time a time that we cannot afford. So, we undergo coagulation where we use a typical of coagulant like Aluminium, oxide ferric oxide, and this is alum by the way now these are positively charged.

Most of these flocks are negatively charged on their surface. And this is the reason why they are so, stable. So, these negatively charged particles they repel each other which is quite understandable is not it. So, because like repel each other. So, when this element let us say a l plus 3.

Now remember a l plus 3 has lost 3 electrons and thus it seriously the electron defecent deficient. So, when a l plus 3 comes here it neutralizes these charges attracts these particles to it and what we see is a flock that forms with these particles aggregated around aluminum. And as they get neutralized they are they permit themselves to aggregate and form a big particle. So, this is a big particle now and this particle easily settles and then is removed as sludge.

The second step in drinking water treatment then is to filter the water. So, once we have coagulated the water and remove the sludge from here, they have clear water on the top that needs to be filtered. Why do we want to filter water, because we want to get rid of the remaining particulate matters, there is still some particulate matters, but for some reason let us say their surface chemistry and their charges were such that the coagulant did not impact did not encourage them to aggregate. Then we want to filter these particles and there are different kinds of filtration processes that we have most common in India are rapid sand and slow sand filters. Now these filters when the water passes through passes through these filters they are at least 3 different phenomena that are at work which contribute to water becoming more clear.

So, the first phenomena and I did want you to remember this. The first phenomenon; obviously, is mechanical filtering. The second phenomena I want you to take a guess at it, the second phenomena is that as water filters there are microbial communities in within the filter there develop biofilms and these biofilms attract cannot attract per say, but they capture the nutrients thus they create a nutrient rich environment in otherwise nutrient sparse drinking water.

So, we have biological removal of particulate matter. Now the simple question is what kind of particulate matter with biological agents remove, because they are life agents the only reason for them to interact with their surrounding in terms of consuming a particulate matter and destroying or getting rid of it is food or electron.

So, if a particular particulate can act as an electron donor or let us say in some cases electron acceptor or carbon source, then they will definitely consumer. So, lot of organic material and certain electron acceptors and donors are removed, because of biological phenomenon. And the third is adsorption at least in the initial phases of filtration, when we have a new filtering unit and we run water through it, but adsorption plays important role.

So, usually the printer material whatever it is surface area is it will have niches, where particulate matter can come and form a hydrogen or some other weak bond and get adsorbed. So, there at least 3 phenomena in filtering that is happening over the long run; however, adsorption plays little rule, because most of the spaces on which the particulate matter could adsorb are already taken away. And biological removals importance becomes small as biological agents or the microbial communities become stronger and more robust over time.

Mechanical filtering as mechanical filtering has really good efficiency, but then after a while the filter gets clogged and needs to be washed, most rapid sand filters and slow sand filters have a very neat mechanism for back washing and clearing away the particulate matter that are clogging the way for mechanical filtering.

So, after filtration we have chlorination in this diagram basically this is disinfection, in India this is the most common way of (Refer Time: 11:02) facting we add some kind of chlorine molecule, in which the chlorine has opportunity to oxidize cellular membranes and destroys the cell components. And we use bleaching powder we use chlorine gas primarily in India and in certain parts of other countries like U S people use chloramines as well. This is the purpose of disinfection step is to ensure that microorganisms we have got rid of particulate matter. So, water looks clean and probably does not have toxic chemicals in it.

We hope so, it does not have toxic chemicals in it. And then we have disinfection where we get rid of microbes. So, microbes who are not removed during the process of settling, coagulant, and filtration will now be removed in the process of disinfection.

So, that is the first objective of disinfection the second objective is that there is some amount of disinfectant must stay in the water. So, that when this water goes to distribution system or water supply system, nothing can grow in the pipes because a disinfectant is still present, and if by chance there is corrosion or there is some breakage and losing integrity of the water system, if pathogens intrude into the drinking water supply system this disinfectant will ensure that the microbes will die and by the time water reaches the top of the consumer it will still be portable.

So, after chlorination we have storage. So, we store them in water storage tanks and then we supply in a distribution system this is a finished water. Now notice here and this is I believe a highly and high under estimation of the actual number of typhoid cases, but the idea for you to understand is that when filtration was discovered just the basic filtration.

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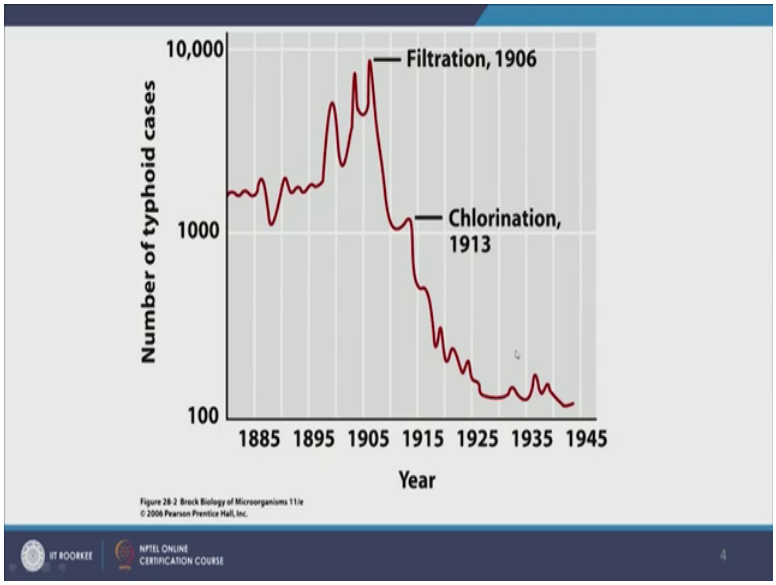

So, we knew how to do coagulation and we knew how to filter the water, there was a remarkable decrease in number of typhoid cases. And when chlorination or disinfection was discovered there was even more remarkable decrease in number of typhoid cases, but typhoid by the way it is a disease, that is that people acquire by drinking contaminated water and eating contaminated food. So, when we started cleaning our

water we had at least a 10 to power to reduction in typhoid cases. So, this is showing you the power of a simple technique such as water treatment. Now because we environmental engineers know how to do it we play a big role in contributing to good public health.

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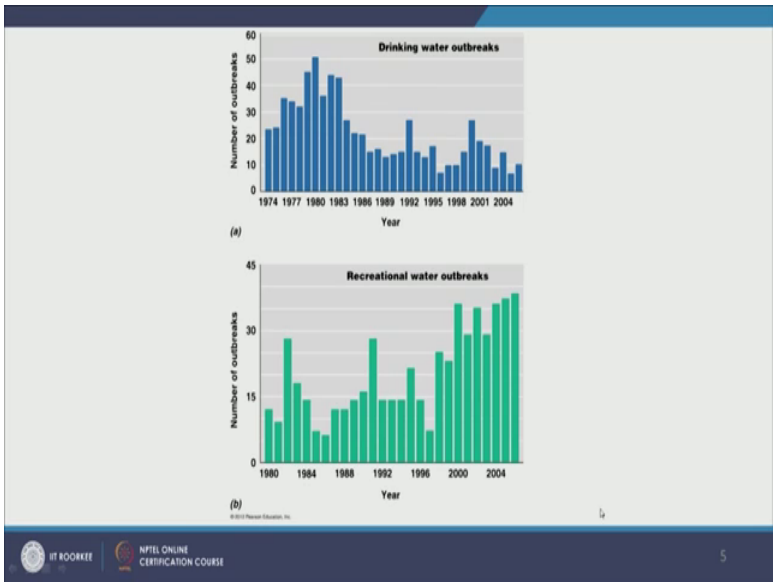

However this is data from U S by the way; however, we still know that every now and then even in developed nations will have drinking water outbreaks will have recreational water outbreaks. So, this is the water you drink this is the water you get exposed to interestingly recreational water outbreaks in the U S have increased in last decade last 2 decades.

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Transmission mechanism	Description	Examples of diseases
Water borne	Oral ingestion of pathogens in water contaminated by urine or feces	Cholera, typhoid, bacillary, trachoma,
Water-washed	Disease spread because of the scarcity of water making **cleanliness** difficult	Trachoma, dysentery
Water -based	Water provides **habitat for intermediate organism**, transmission to human through water contact	Schistosomiasis
Water Related	Insect vectors (mosquitoes) rely on water for habitat, human water contact not needed	Malaria, yellow fever, dengue

So, when we talk about diseases and I mentioned that there are 2 kinds of water that we are interested in drinking water and recreational water it implies that not just by drinking water, but there are other ways to get diseases through water. So, let us look at the 4 different kinds of diseases that are associated with water first we have waterborne diseases now these are most of the diseases that we are very very interested in India.

So, if the water has the contaminant if the water has a pathogen or the microbe that will make us fall sick, then if we drink this water and we fall sick then this kind of disease is waterborne disease. Examples are cholera typhoid and other bacillary disease that bacillary dysentery and trachoma.

Now, let us talk about cholera cholera and typhoid all these diseases are often fecal oral they have a fecal oral transmission route, which implies is that somebody somewhere pooped and the feces if that person that person was perhaps a sick person and because of that sick patient, pooping in a place in an environment where these microbes in the pathogens in his poop could go and contaminate the drinking water and then people who drank their drinking water fell sick.

Now water wash diseases these are diseases that spread mainly because we do not have enough water to maintain hygiene. You must have heard and if you have not I provide links anyway. So, you I encourage you to go through those links and take a look and if you have any chance at internet please look into water dot ORG it is an organization that

is insuring people have sufficient water and clean water. So, get rid of water wash diseases as well as waterborne diseases.

Now, water wash diseases are those diseases where people cannot maintain their cleanliness. So, they have dirty hands they go up children are playing around and they touch mud, which has fecal droppings of humans and other animals they pick up on diseases and then they do not have soap and water to clean hand. So, they eat right away or they do not have awareness about it. So, mostly because they do not have enough water to ensure complete hygiene, these diseases are called water washed some examples are general dysentery and trachoma again. So, notice there is little difference between waterborne and water wash diseases. So, a waterborne disease would look like this we have contaminated environment.

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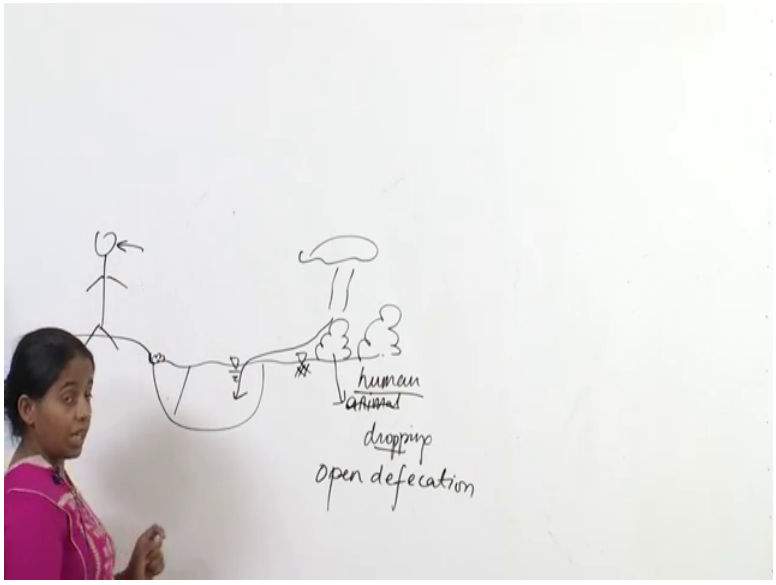

Now, this could be your liquid environment like a pond. So, this is liquid environment this is soil.

So, there could be animal droppings on this soil animal or human dropping and because most of us live in environments where human population is much more than animals. So, it is mostly human dropping mostly human dropping. So, human droppings are here because of open defecation a very unhealthy practice, open defecation is a very unhealthy practice if we are living in highly populated communities. Because our fecal matter does not have enough time to degrade and to ensure that all pathogens die before

another human is exposed to it all right. And then they have contaminated water, because let us say somebody food and in the water or the rain fell and the water brought the pathogens here. Now there is an environmental factor here in waterborne diseases.

Now, if a human being comes and drinks this water or a child comes in place with this soil. And then the child in all the human being ingests it the ingests in their mouth then this disease is called water borne disease, because this is a there is a big role of environment.

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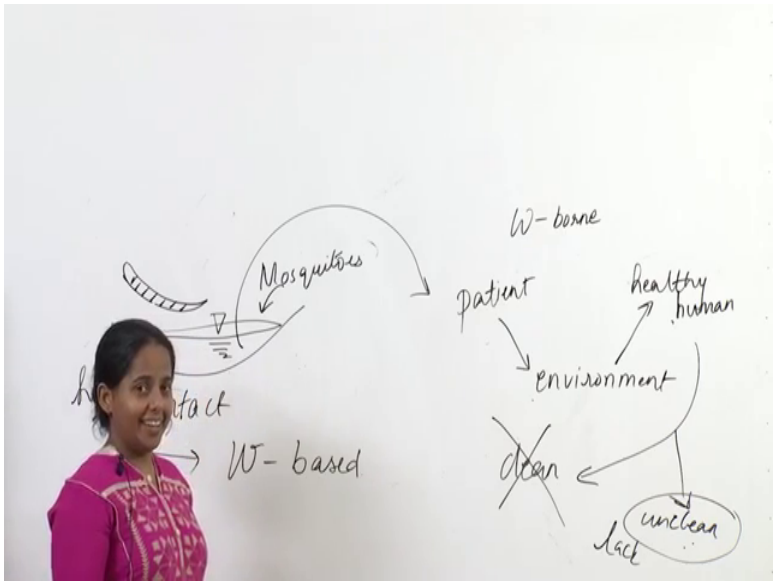

Thus we can say in case of waterborne diseases in case of waterborne diseases, we have environment so, there is a sick outpatient that releases microbes in environment and then there is a healthy individual that picks it up ok. So, these are water bond diseases instead in case of water wash diseases, what we will have is let us say this patient has dropped their fecal matter in environment and this healthy human who was playing around or and I got exposed to this pathogens.

Now these pathogens let us say are there in this healthy humans hands the human is still healthy, but the pathogens are in the hand.

Now, this healthy human has 2 options either to maintain a level of cleanliness or not maintain it not maintained and usually the option that they have the with the option they choose is not based upon their personal choice and awareness, but upon the necessity in a

country like India people do not have water to drink, let alone water to wash hand before eating meals every time.

In fact, dear students how many of you wash your hands every time before you eat see. So, most if this healthy human chooses not to practice hygienic practice is because of lack of water, then this healthy human falling sick is then when the healthy human falls sick, it is called as water wash disease. Now not all diseases that a water bond can become water washed this is important to remember, because we will then we talk about individual diseases I will give you example the next kind of disease we have is water based disease.

So, let us take a look at what base disease in water based disease the water will give a home or habitat for a part of the organism or type a life portion of the organism pathogenic organism to survive, and then a human being can be transferred transmitted the disease through contact with water.

So, for example, schistosomiasis and many other internal parasites what they do is they live a particular portion of their life in the aquatic system. So, again let us say I have worms or some patient has worms and they poop and the worms are washed into an aquatic system. Now these worms cancer need this aquatic system to fulfill a particular portion of their life cycle.

So, the eggs that are released they will mature they will grow in an aquatic system and when they are ready to be consumed if a human being consumes at that time then they will get fall sick such diseases are called water based disease.

Now, water related disease are a big menace all of these are big menace in our country in North India at during monsoon usually and near and after monsoon these are diseases that are caused, when there are puddles of water available because the insect that carries these diseases require this puddle of water to complete it is life cycle.

So, here we have insect vectors usually mosquitoes rely on water for habitats human water contact this not needed. Now there is a big difference between water based and water related diseases in both of the cases the pathogenic organism and in water related cases the vector for pathogenic organism, requires to live in water to complete a portion of their life cycle.

However, and water based diseases we need to come in touch with the water contact is an important; in water related diseases water contact is not important. For example, I mean never go swimming and I may never touch dirty waters and dirty soil you know be very careful prudent.

However a mosquito can still come and bite me. So, whereas, I can protect myself from what a base disease is this way I cannot protect myself from water related diseases. So, think of it this way now in our environment we have a puddle. So, this is puddle or some water body.

Now in this there are 2 kinds of organism that will be very happy to find a puddle one is a warm let us say and this worm need the eggs of this worm need this water puddle to fulfill a particular portion of their life cycle the other are mosquitoes, I do not want to draw mosquitoes so, the other mosquitoes who will lay eggs here and allow their eggs to turn into hatchlings.

So, in this case this when I and the human being comes and touches this water comes in contact is a very important term here, when they come in contact human comes in contact with contaminated waters then this disease can infect them. Such kind of infections are called as water based diseases. This is really cool because some worms you do not need to ingest you just touch it and it infiltrates through your skin. Now these mosquitoes who have laid eggs here and their hatchlings have started flying we do not need to come and touch these mosquitoes will come our home. So, this is kind of home delivery, the mosquitoes will find us and if they are carrying diseases like dengue malaria Japanese encephalitis and so on and so forth, then they will make us fall sick such diseases are called as water related diseases.

So, now, let us very quickly understand another kind of classification for pathogens we can also divide them on basis of the domain that they come from. So, virus is neither bacteria, because we do not even know a virus is alive or dead there is a debate in biological community regarding that. So, it is definitely not bacterial not are (Refer Time: 23:52) not eukaryote. So, there are some viral pathogens it is basically just a protein or RNA or DNS in co in k in encapsulated by the protein and then this DNA or RNA Can come and in fact, us and other organisms.

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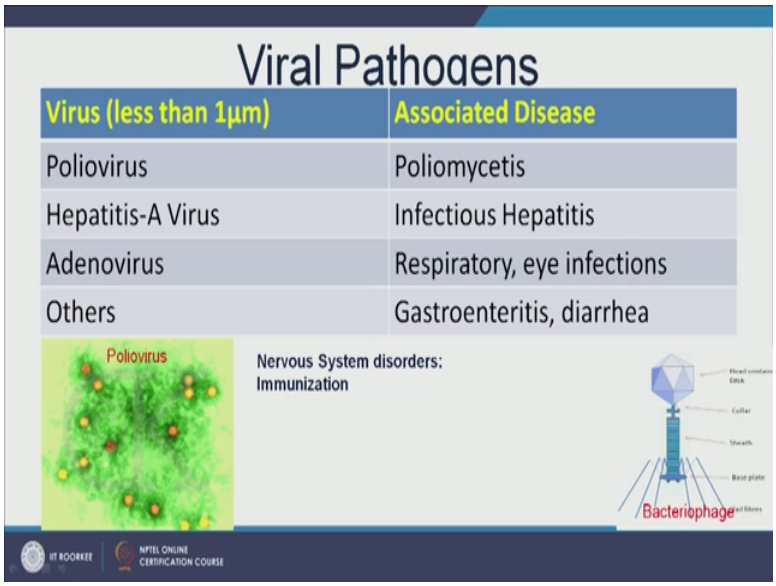

So, one is poliovirus we believe we have eliminated polio from our country completely, it causes poliomycetis which is a nervous system disorder then we have hepatitis a and e which causes jaundice adenovirus, which causes a respiratory, eye infections and then we have many other that causes some serious diarrhea.

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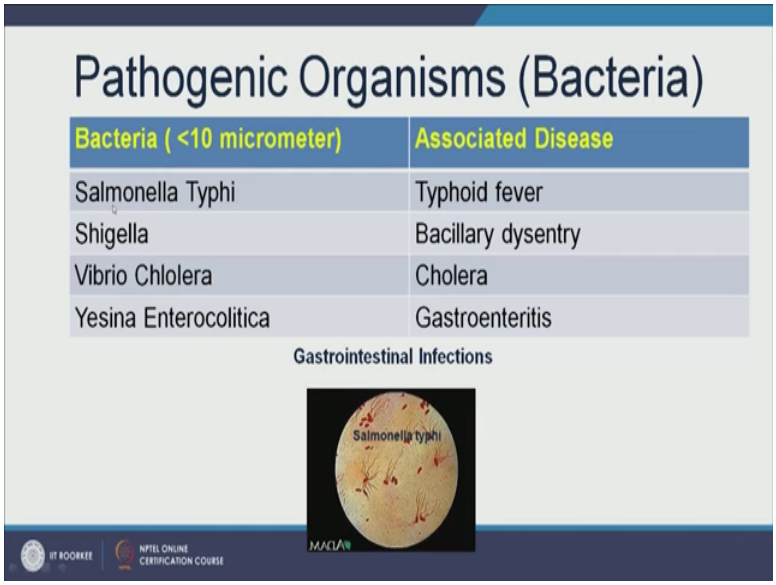

Then incomes welcomes to bacteria we have salmonella Typhi in famous microbe causing typhoid back typhoid fever, Shigella causes dysentery, Vibrio Chlolera as the name suggests causes chlolera, which is really severe diarrhea Yesina Enterocolitica

causes gastroenteritis, then we have protozoa Entamoeba entamoeba histolytica I am from UP many parts of UP and Uttarakhand by the way are endemic to this organism.

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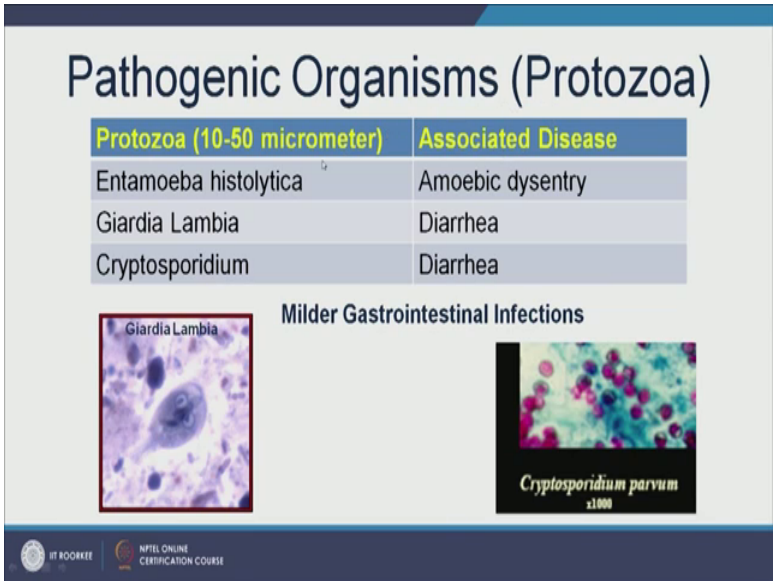

So, there are people in my hometown that get this disease and we picked this entry every 10 days every 5 days. Then we have giardia lambia causes giardia diarrhea cryptosporidium again causes a very severe diarrhea the cool thing with giardia and cryptosporidium is that very little amount of microorganisms are required to fall sick. So, whenever water is clear, but the only few of these protozoa present then we are in debts enough to make us fall sick.

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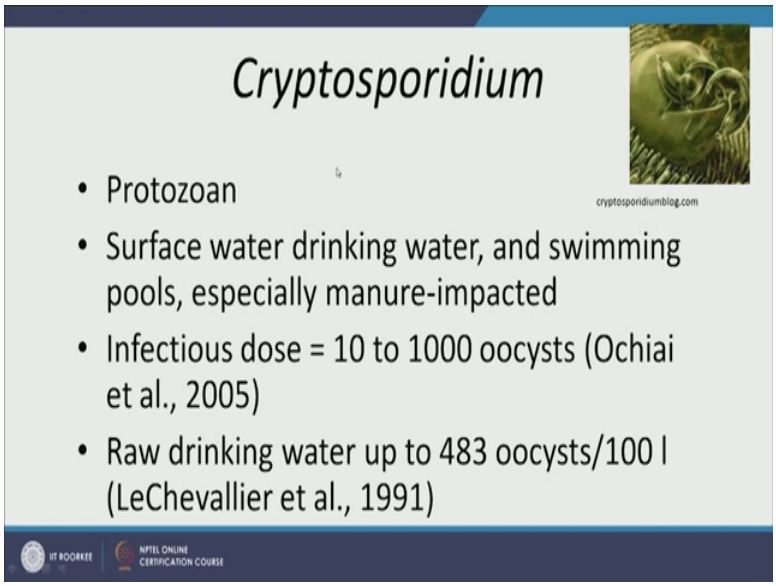

So, when I say about cryptosporidium let us just study about cryptosporidium for today. So, it is a protozoan that causes serious diarrhea and it is found in surface drinking water especially swimming pools that have been exposed to human feces or animal feces a 10 10 oocysts of cryptosporidium enough to make us fall sick.

And in raw drinking water people have found upto 483 oocysts for hundred meter which is very high and we cannot detect more than this bath away. So, I detect be limited by detection and this is crypto life cycle.

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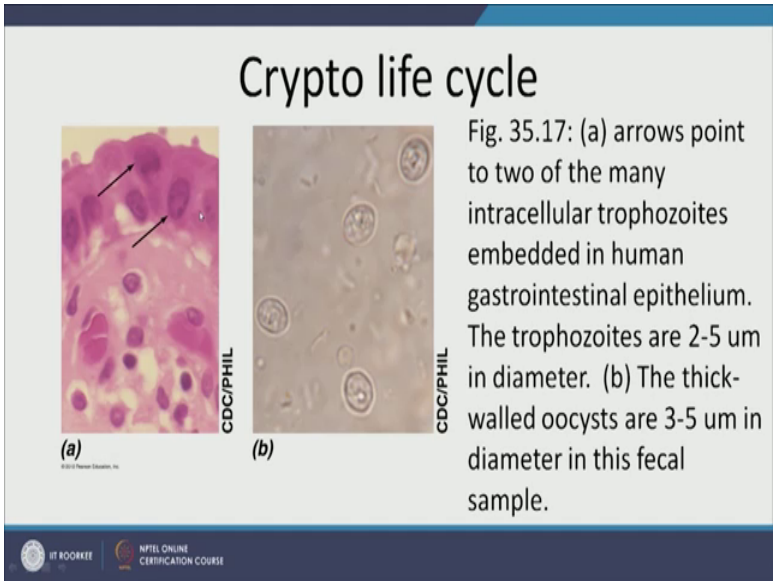

It enters our endothelium and intestines and it grows there the trophozoites in ignorance it is nourished and then the trophozoites, when they are ready then there is secreted out in fecal matter which is here. So, in this fecal matter you can see some really thick walled oocysts 4 of them, all right dear students this is all for today.

In the next lecture we will go ahead and talk about other pathogens and there is a long list of pathogens specially for a watered starved country like India and where we have such difficulty in maintaining our water to good drinking quality standards.

So, we will talk not only about bacterial viral and protozoa pathogens, but we will also talk about when these pathogens become super pathogens. So, that is all for today see you in next lecture.

Thank you.