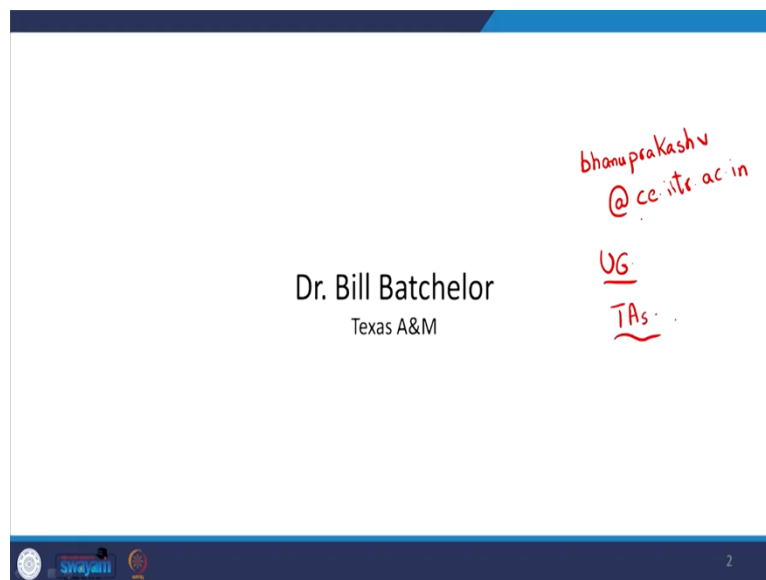


Water and Waste Water Treatment
Prof. Bhanu Prakash
Department of Civil Engineering
Indian Institute Technology – Roorkee

Lecture – 01
Importance of Water and Wastewater Treatment

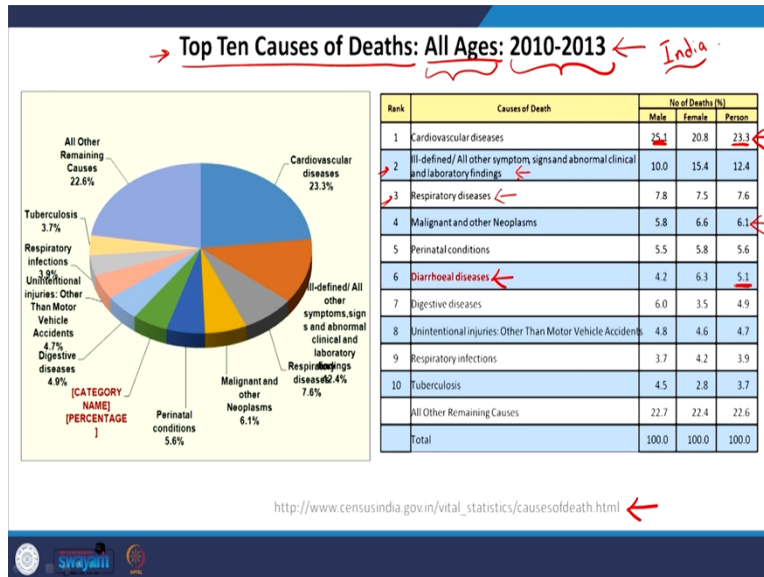
Hello everyone welcome to the first lecture session for the course water and wastewater treatment. It is a UG course. I am Bhanu Prakash from the Department of Civil Engineering at IIT Roorkee. Let us get this started without much delay.

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First aspect is I want to thank Dr. Bill Bachelor of Texas A and M who from whom I learned many aspects including this particular course too. First, I would like to do that.

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I would like to move on to the relevant aspects. But first why are we discussing this course? Or what is the relevance water and wastewater treatment? One answer is that it is typically mentioned as core course for UG civil engineering students and that is you need to take that but other than that why is it listed as a core course?

Let us look at some data here to understand why it is that we need to pay attention or understand the aspects that we are going to discuss in this course. In this slide I have top 10 causes of deaths here this is for all ages and this data was collected between 2010 and 2013. It goes without saying that here I am talking about India rates. And typically, I provide the relevant link or the source from which I gathered the data at the end of the slide are the lower portion of this slide.

But if I do not and you still required the data you can always email me. My email banupakashv@ce.iitr.ac.in you are going to have the TAs who are going to assist you and answer your queries in the discussion groups. But whenever you want to draw something to my attention on your response pronto you can email me. This is a 30 hours course.

That is going to be relevant for 4 credit if I am not wrong at least that is the system in IIT roorkee. You should check what it is what the credit equal and credits are for your particular curriculum. That is and as I mentioned this is an UG course. You will have TAs who will assist you and will

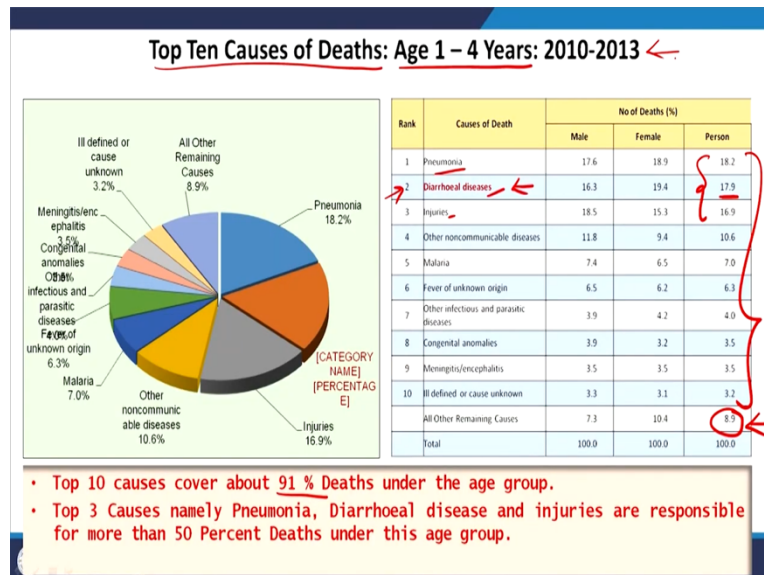
have home works. And one other aspect that I wanted to mention here is that you have to register via the NPTEL portal.

And if you want to take the exam, register for the exam. I mentioned this as some students here they enrolled or took permission from IIT roorkee website to enroll in the NPTEL course without actually enrolling at the NPTEL website. They were caught between IIT Roorkee and NPTEL once the deadline passed. Let us move on here, we are talking about top 10 causes of deaths all ages.

India has sedentary lifestyles with high carbohydrate and fat rich diet. Cardiovascular diseases are prime cause 23% relatively more in males. We will find symptoms respiratory diseases related to air pollution typically some this aspect too is also related to pollution increasing numbers of malignant tumors. But one aspect that I want to mention that is relevant to this course is the diarrheal diseases.

We see that even when we consider all age groups not just the relatively more susceptible age. People are the part of the population we see that diarrhoeal diseases leading to death of 5% of our population. But if we look at the relatively more susceptible

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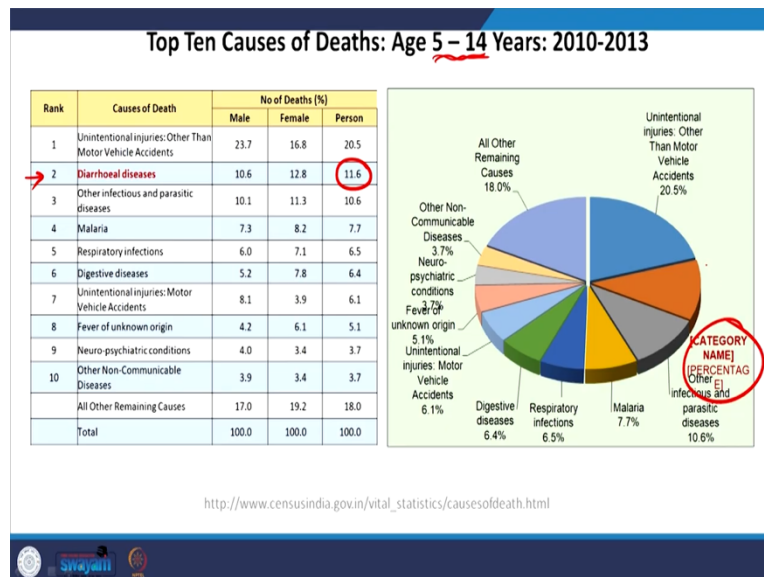


Fraction or parts of the population? What do we have here? The data that we have is top 10 cause of death but from for the ages 1 to 4. Here you see that diarrheal diseases contribute to almost 18% deaths. We have other diseases too but we are going to look at diarrhoeal diseases in greater detail.

And one aspect to note is that the top 10 causes covered 91% deaths under this age group as you see all of the remaining calls it is just almost 9%. Top 10 cause itself lead to what is it now 90% deaths and that is something to note. And we also see that top 3 causes meaning pneumonia diarrhoeal injuries diarrhoeal diseases and injuries are responsible for more than 50% deaths.

And the reason that I keep reiterating this particular aspect about diarrhoeal diseases is that they are typically waterborne diseases. It is easy to tackle and save the lives of lakhs of children every year. We will come back to that but one aspect as you see is infants who are relatively more susceptible are dying in great numbers certainly due to diarrhoeal disease.

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But once the relevant time and once the body has developed and has gotten used to the surroundings or the environment, let us see where we are with respect to diarrheal disease. We still see that diarrhoeal disease occupies a place of infamy and it is still around 12%. Earlier it was around 18%, and now it is around 12%. Even in children that are not just in infants we see that the diarrheal diseases contribute 12% so that is considerably higher.

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Infant Mortality

- Three infants die every two minutes on an average in India due to lack of access to water, sanitation, proper nutrition or basic health services, according to a report by the United Nations Inter-agency Group for Child Mortality Estimation (UNIGME). ←
- About 8,02,000 infant deaths were reported in India in 2017, the lowest in five years, but the infant death numbers still remained the highest in the world, according to the report.
- Infant deaths were reported highest in the world in India, followed by Nigeria at → 4,66,000, Pakistan 3,30,000 and Democratic Republic of Congo 2,33,000 (DRC), the report said. ↗ ↗
- India continues to show impressive decline in child deaths, with its share of global under-five deaths for the first time equalling its share of childbirths," Yasmin Ali Haque, Representative, UNICEF India, said. ←



Let us look at some other data before we move on. 3 infants die every 2 minutes in India. Why is that? Lack of access to clean water? I should have mentioned clean water sanitation and nutrition and other aspects. But that is outside the scope of our course. 8 lakh infant deaths were reported in India keep in mind that they are reported.

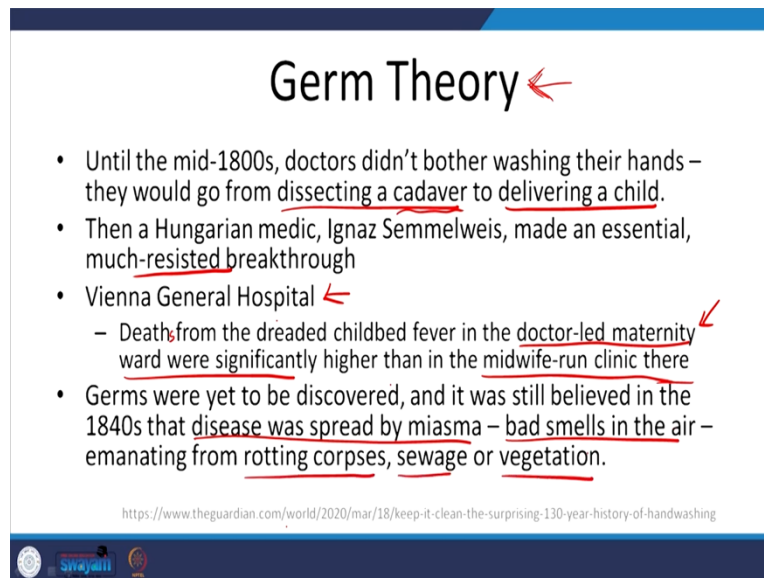
We are still a developing country, even our government machinery is yet to capture all the relevant aspects and cover all areas. I would think that we might probably be under reporting these deaths but to what extent? One good aspect is that is decreasing. But the infant death numbers are still the highest in the world.

That is something for you to look at. Just to look at where we are whom we can compare ourselves with. Not that this is the highest in the world but this is not normalized as this is not per 1 lakh population, this is for the total population. We are accompanied by Nigeria 4,66,000 and then Pakistan and Congo.

The numbers should not be used to draw petty or simplistic conclusions. But one aspect to note that is that still we are pretty high in this particular category. And one other aspect is that Nigeria and certainly Pakistan and Congo they are ravaged by war or interdesign conflict within the country, and that is why the numbers are high.

But in our case as you saw we have pneumonia and diarrheal diseases contributing to a majority of the deaths. With respect to India, we see that it continues to show impressive decline in child deaths. And we see that its share of global under 5 deaths for the first time is equaling its share of childbirth. That is something to note we are getting better compared to where we are, but still we have a long way to go.

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Germ Theory ←

- Until the mid-1800s, doctors didn't bother washing their hands – they would go from dissecting a cadaver to delivering a child.
- Then a Hungarian medic, Ignaz Semmelweis, made an essential, much-resisted breakthrough
- Vienna General Hospital ←
 - Death, from the dreaded childbed fever in the doctor-led maternity ward were significantly higher than in the midwife-run clinic there
- Germs were yet to be discovered, and it was still believed in the 1840s that disease was spread by miasma – bad smells in the air – emanating from rotting corpses, sewage or vegetation.

<https://www.theguardian.com/world/2020/mar/18/keep-it-clean-the-surprising-130-year-history-of-handwashing>

Germ Theory: one aspect to know is that what is causing these deaths. Now we know that it is germs pathogens, microorganisms which can get into our body and cause and lead to death or mortality in some cases. But earlier people did not know that; people used to think that it was a bad smell that used to cause deaths and they used to close their windows and think that that was good enough to keep them safe from diseases.

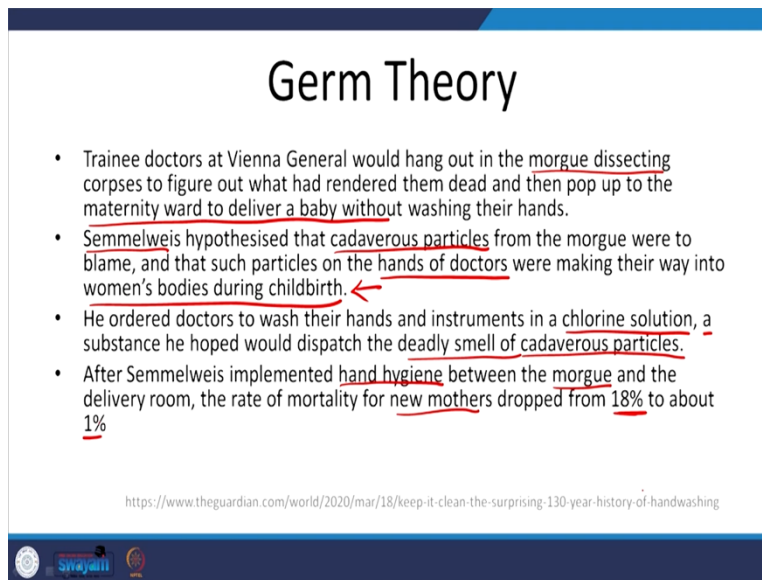
And typically, germs are pathogens which were not known. At that time, it was supposed to be prevalent only among the dirty population. Typically, when we say dirty when we are talking about society based on class. It is based on income levels. But germ theory here it is one aspect that here is one aspect I would like to point out to you until the mid 1800s doctors did not bother washing their hands.

They would go dissecting a cadaver, cadaver meaning a dead body which they used to investigate because at that time science was not as developed as it is now. We were still learning about the

human body. Doctors would go directly from dissecting or dissecting a cadaver to delivering a child, without washing their hands. Then Hungarian medic, Ignaz made an essential much resisted breakthrough.

He was working in the Vienna General Hospital. He observed that the deaths from the dreaded child fever child bed fever in the doctor led maternity ward were significantly higher than the midwife run clinic in the same hospital. In one in the same hospital, you have 2 clinics and one doctor led and the other midwife led and the number of deaths in this particular doctor led ward was much higher. Please note that germs were yet to be discovered. I mentioned earlier people believed that disease was spread by bad smells in the air which came from copses, sewage or vegetation.

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Germ Theory

- Trainee doctors at Vienna General would hang out in the morgue dissecting corpses to figure out what had rendered them dead and then pop up to the maternity ward to deliver a baby without washing their hands.
- Semmelweis hypothesised that cadaverous particles from the morgue were to blame, and that such particles on the hands of doctors were making their way into women's bodies during childbirth. ←
- He ordered doctors to wash their hands and instruments in a chlorine solution, a substance he hoped would dispatch the deadly smell of cadaverous particles.
- After Semmelweis implemented hand hygiene between the morgue and the delivery room, the rate of mortality for new mothers dropped from 18% to about 1%

<https://www.theguardian.com/world/2020/mar/18/keep-it-clean-the-surprising-130-year-history-of-handwashing>

Swajani

Trainee doctors at Vienna General what would they typically do? They would dissect corpses and morgue to find out the reason or cause for disease and then without washing their hands or such go to the maternity ward to deliver a baby. Ignaz hypothesized that cadaverous particles he did not know what yet; had something to do with. Cadavers from the morgue were to blame and that such particles on the hand, so the carrier was not in the air or such.

But something that was being carried by the doctor supposedly these noble people based on the professional work themselves the carriers of for death from one place to the other. Such particles

are in the hands of doctors which are making their way into the woman's bodies during death leading to death of the woman.

He ordered the doctors to wash their hands and instruments in a chlorine solution. Why chlorine? Now we know that it is a good oxidizing agent. But at that time the reasoning was unclear but it was a substance he hoped would dispatch the deadly smell of the cadaverous particles. (Note that chlorine has a pungent smell.) After this particular implementation of hand hygiene habits between the morgue and the delivery room the rate of mortality for new mothers dropped drastically from 18% to 1%.

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GERM THEORY

- The majority of doctors in Vienna at this time were from middle- or upper-class families, and they thought of themselves as very clean people compared with the working-class poor.
- Doctors were offended by the suggestion that they could be causing infections.
- Semmelweis's idea faced great resistance, and met a tragic end. He lost his job, and is thought to have had a breakdown. He died in a psychiatric institution, "a very despondent person at the untimely age of 47".
- Germ theory: Theory that certain diseases are caused by the invasion of the body by microorganisms, organisms too small to be seen except through a microscope. The French chemist and microbiologist Louis Pasteur, the English surgeon Joseph Lister, and the German physician Robert Koch are given much of the credit for development and acceptance of the theory.
(<https://www.britannica.com/science/germ-theory>)

<https://www.theguardian.com/world/2020/mar/18/keep-it-clean-the-surprising-130-year-history-of-handwashing>

But do people did people accept him or appreciate his findings or contributions? Note that people are typically not driven by science. We are not in a society over where people have a scientific temper, typically emotions ego come into play. When Ignaz Morales suggested that doctors this noble people called are acting as carriers of disease he was ridiculed .

Majority of the doctors in this time were from middle or upper class. And they thought of themselves as very clean people compared with the working class poor. Doctors were offended that they could cause infections. He met a tragic end, Dr. Ignaz face great resistance and met a tragic when he first lost his job and had a mental breakdown.


And he died at a relatively younger age of 47. In a psychiatric institution this always happens in society when you are trying to preach something radically new; either with respect to science but at that time even Europe or the relatively more developed countries or western countries to have did not have scientific temper. But now the situation improved there. Here I am talking about acceptance of an idea based on the scientific data or the reasoning.

That is what was lacking at that time, and he was ridiculed. But much later people started accepting the germ theory. What is this theory about? It is that certain diseases are caused by the invasion of the body by microorganisms these which are too small to be seen except through a microscope. The people Louis pasteurization of milk.

Joseph Lister the surgeon who more or less looked at disinfection all of the relevant surgical tools they got the credit for this particular theory. But this is what we observe that is in society. And I wanted to put that out there the source you can look that up.

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Pandemics and prejudice:
→ Typhoid, healthy carriers Oct 2020




Vilified as: 'Typhoid Mary' ←

Quarantined for 26 years, next to the Riverside Hospital on North Brother Island, where she finally died in 1938

Public Domain, <https://commons.wikimedia.org/w/index.php?curid=689801> ←

<https://www.thehindu.com/society/pandemics-and-prejudice-when-there-is-an-epidemic-social-prejudices-resurface/article31246102.ece> ←

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And one other aspect is how people think and act during pandemics and how prejudices play a role. Even during Corona, we had people from particular community being targeted due to various reasons. And then the poor who had no recourse to either good medical facilities or could not or those who could not fall back on bank deposits or such to live what we say hermit like life. They

were thrown out of most people's homes people they were not given their monthly wage and they suffered a lot.

But these prejudices always come into play during pandemics. Here I have one particular case with respect to typhoid. Until then the world did not know that healthy people could act as carriers. I am healthy I have no symptoms; visible symptoms are such if not visible no fever or any such symptoms. But people did not know that a person like me could be a carrier of a particular pathogen.

Here we have someone here who was vilified as typhoid Mary. And we I have the picture from here and the article from the Hindu outlet. She was a cook, and at that time there was an outbreak of what is it now typhoid related fevers and deaths. A private detective finally tried to solve the puzzle or rather was able to solve this puzzle and linked her and forcibly made her tested her for this pathogen that causes typhoid.

And then that was the first time people came to know that healthy people can act as a carrier but people do not take it that way. They quarantine her, thinking that she was an oddball or case they will find her as typhoid Mary. They quarantined her for 26 years. I am not going to draw the obvious. Comparisons with what is been happening in these couple of months? Please note that I am recording this lecture in 2020 October.

What is been happening with respect to the Coronavirus, how people have been prejudiced their own neighbors, people working with them or for them and so forth. More or less the root cause of such issues is that prejudice and lack of scientific temper but what happens slowly but surely science catches up.

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Reported Cases And Deaths By Water-Borne Diseases in India										
Disease	2013		2014		2015		2016		2017	
	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
Cholera	1130	5	844	5	913	4	718	3	385	3
Acute Diarrhoeal Diseases	11413610	1629	11748631	1137	12913606	1353	14166574	1555	9230572	840
Typhoid	1650145	387	1736687	425	1937413	452	2215805	511	1493050	286
Viral Hepatitis	110125	574	138554	400	140861	435	145970	451	98086	283

Source- Ministry of Health and family welfare

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Cholera epidemic in London

- In 1854 it was discovered a cholera epidemic spread through water in London.
- The outbreak seemed less severe in areas where sand filters were installed.
- British scientist John Snow found that the direct cause of the outbreak was water pump contamination by sewage water.
- He tried to disinfect the water with chlorine.
- Since the water in the pump had tasted and smelled normal, the conclusion was finally drawn that good taste and smell alone do not guarantee safe drinking water.
- This discovery led to governments starting to install municipal water filters (sand filters and chlorination).

Here I have an aspect I will come back to this. There was a cholera epidemic in London and it was discovered in 1854. Anyway, it was spreading through water in London. The outbreak seemed less severe in areas where sand filters were installed. And the scientist John Snow found that the direct cause of the outbreak was water pump contamination by sewage not sewage water. They had what was called a cesspit, meaning your septic tanks where sewage is collected and typically undergoes anaerobic degradation.

Cesspits were common at that time; they were believed the home and they were taken to the River Thames. In that particular location though the sewage or not the sewage faeces lead to

contamination of the drinking water but not that the water does not taste different does not smell different and the color too colorless mixes so visually or with the primary senses people were not able to distinguish it.

What is it that he tried to do looking at this particular data he tried to disinfect the water with chlorine. Since the water pump water in the pump tasted and smell normal. The conclusion was that good taste and smell alone do not guarantee safe drinking water and this was a deal breaker at that time. People did not accept the findings of Dr. Jon Snow at that time. But much later people started accepting sand filters and chlorination as a way to treat and disinfect drinking water. Keep in mind that this was in 1854, germ theory too came about later.

(Video Starts: 19:33)

For example, here I have a graphic from Wikipedia the source for which is given out here. From here you have the number of deaths with cholera as a cause this is London outbreak the one in 1854 that we are just talking about. You see that it is relatively more concentrated in this particular area, and this area as I mentioned the person who will pile up the statistics or the data. He observed he observed that this particular pump was caused.

Also, he observed that among the 2 water distribution or supply companies for those people who are taking water from a particular company were falling ill more often than to with respect to cholera, why is that? This particular company number one was taking water from that part of Thames River into which people used to dump their sewage.

People did not want to have the sewage piling up near their home. They used to dump it into the river, and at that time the thought process was that this is spread through the what is it air. People did not understand that clear water which tastes and smells fine can also or acts as a carrier of these pathogens. The company that was supplying this water the company or the people who are being supplied by the water from this company fell ill more often.

And the other company which was taking water from upstream upstream of the point of pollution.

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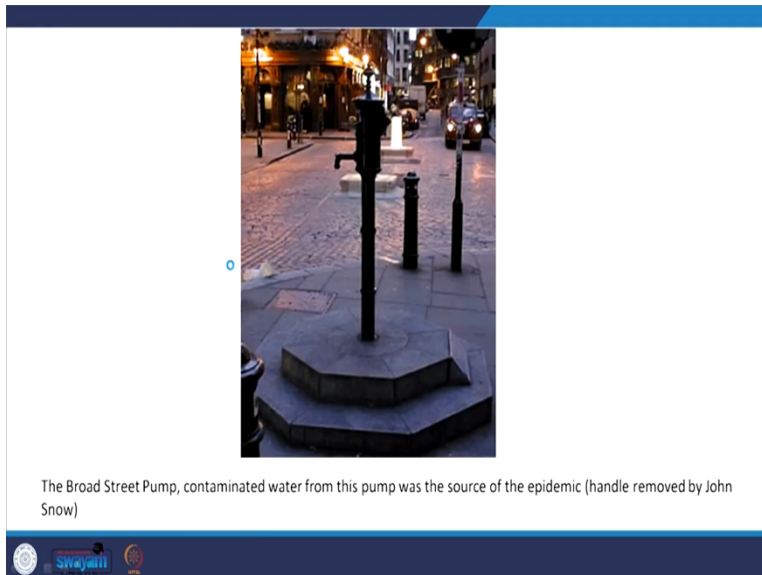
Or relatively clear or unpolluted source they people those people did not experience as many casualties or cases of cholera.

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This is one of the original data from Wikipedia. He stacked up such data in stacks original map by Jon Snow showing the clusters of cholera cases indicated by this tag rectangle. Here is the pump and you see that there is greater incidence of cholera in that particular region.

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Cholera-vibrio cholerae infection

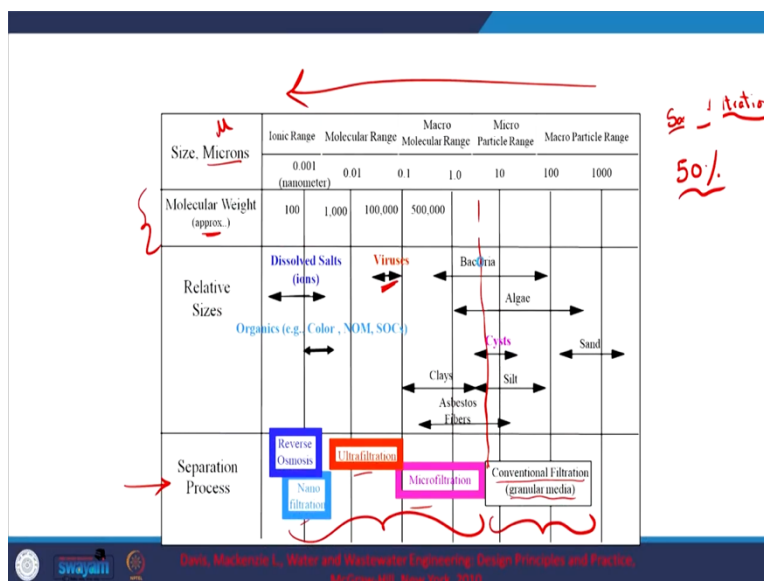


<https://www.cdc.gov/cholera/index.html>

What did he do? He took out that particular handle out there. That is something to keep in mind color what is that look like? It looks like comma shaped bacteria, vibrio cholera infection this is what we have now and slowly but surely though people started understanding. But slowly why is it because people are not typically very much ready to accept data that flies in the face of their assumptions or what we say wisdom passed down generations.

People typically think that whatever was told in the past is what we say the God given truth without typically applying logic or reasoning.

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Davis, Mackenzie L., *Water and Wastewater Engineering: Design Principles and Practice*, McGraw-Hill, New York, 2010.

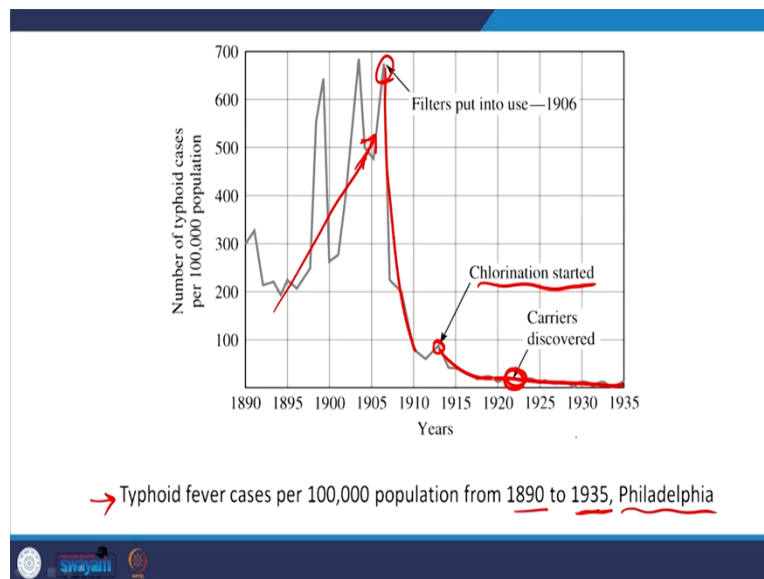
We looked at sand filtration. Typically, sand filtration alone brought down the number of cases of cholera by 50%. I have different process based on separation, separation process meaning at least in my childhood we used to have a cloth.

The cloth used to act as a filter, we are trying to remove those particles that are bigger in size than the pore size of this particular cloth or the filter size of that particular cloth. Here we have different separation process based on relatively similar principle; reverse osmosis. We have conventional filtration meaning with respect to activated carbon sand or such micro ultra nano these came much later but let us concern ourselves with conventional filtration.

And here we have the relative sizes of different salts or viruses or pathogens of concern and molecular weight is given. As the size decreases molecular weight approximately decreases and the size particle range also decreases. Here we have the size in micron slits and what we see out here sand particles can be removed by sand filtration.

And we see that a considerable fraction of bacteriology can be removed from sand filtration and that is what we see out here. The simple act of filtration will be able to remove a consumable fraction of bacteria but not viruses; that is something to keep in mind as virus are just RNA.

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We have typhoid fever cases per 1 lakh population from 1890 to 1935 in Philadelphia, and the case of this poor lady typhoid Mary. This was case in New York she was the poor lady who was quarantined for 26 years later on healthy carriers also were identified but she bore the brunt of people's pent up anger.

Typhoid fever cases per 1 lakh population from 1890 to 1935. What do we have here? Number of by typhoid cases they started going up relatively more densely packed societies or population densities. Greater sewage in that particular area sewage lifting to what we say transmission of disease into what we say the human beings water.

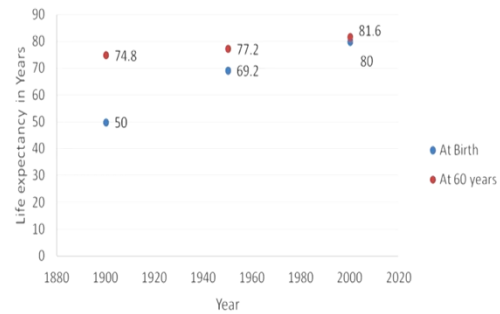
That is what we see increasing cases. But then people figured out that filters can be used, and you see a drastic decrease. Chlorination was discovered as a very effective way to disinfect. Then carriers were discovered and that this is why it is written into various journals that the greatest medical revolution of this previous century was not by doctors but by engineers.

That is the reason why we are going to look at this course in greater detail. In India we see that the cases due to diarrheal deaths are still remarkably high. We saw the case of the relatively more developed countries as in they went through the same phase but that was relatively earlier.

But now we have a different challenges, infrastructure is an issue. But with respect to dissemination of knowledge this is what we are trying to do. With such dissemination of knowledge the hope is that we are going to be able to have a better quality of life for our citizens and humanity in general.

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Life Expectancy: USA ←



How life expectancy in the USA is, but I am almost out of time. I will continue this in the next session. I thank you for your patience.