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ECOLOGY AND ENVIRONMENT

Wastewater Management in developing urban environments: Indian Scenario

Lecture 5

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WASTEWATER MANAGEMENT IN DEVELOPING URBAN ENVIRONMENTS: INDIAN SCENARIO

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Welcome back, today we will discuss little bit about Wastewater Management in Developing Urban Environments, especially Indian scenario we will discuss about.

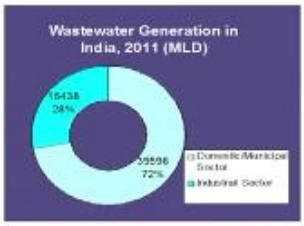
Wastewater Treatment Regulations in India

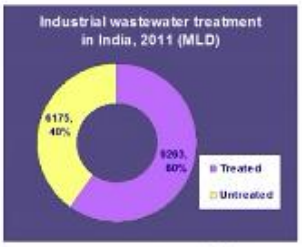
- Wastewater treatment: One of the most neglected services among all urban services
- Many cities with a population of more than 10 lakhs have some sort of collection system, catering to only part of the population.
- Coastal cities and cities located on the banks of rivers: discharge the untreated or partially treated wastewater into the nearby water bodies.
- Many places, Wastewater treatment : limited to septic tanks.
- Uncontrolled and unsupervised use of septic tanks has lead to severe groundwater contamination .

As all of you know, wastewater treatment is one of the most neglected services among all urban services. Many cities with a population of more than 10 lakhs have some sort of collection systems catering to only part of the population.

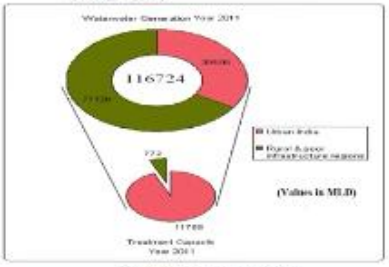
Coastal cities and cities located on the banks of rivers discharge the untreated or partially treated wastewater into the nearby water bodies. Many places wastewater treatment is limited to septic tanks. Uncontrolled and unsupervised use of septic tanks has led to severe groundwater contamination.

Wastewater Management Scenario in INDIA





Organized Sectors



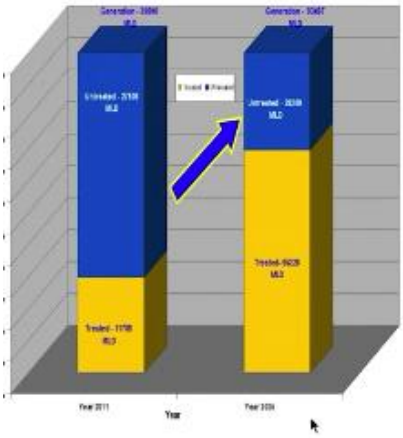
Domestic/ Municipal Sector

A. Inadequate treatment facilitiesa
- Only 26% domestic wastewater and 60% industrial wastewater is treated in India
- 423 Class I cities treat 29% and 499 Class II cities 4% of domestic wastewater is being treated

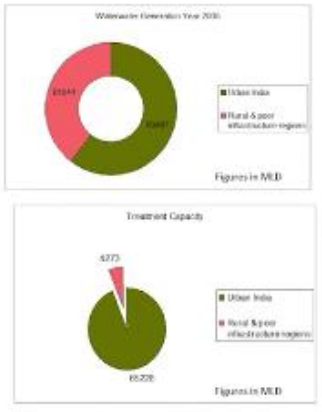
B. Inadequate infrastructure

And we can see the wastewater management scenario in India in these slides; this is 2011 data. In 2011, around 39 - 40,000 million liters of water per day is generated in the domestic sector, whereas around 15,000 plus in the industrial sector. Most of the time we think that industries are the most polluting sources, but the truth is the other way. Around 60 percentage of the industrial wastewater are getting completely treated as per the norms, only 40 percentage is getting discharged untreated. These are the small and micro level industries.

But when it comes to the domestic wastewater you can see here this is the domestic wastewater generated in Urban India and in Rural India. Urban India around 40,000 million liters per day is generated, and in Rural India around 77,000 plus is getting generated. And in Urban India, the treatment is, treatment capacity is only around 11,000 plus, and Rural India it is only 772, you can see that only very, very little part of the wastewater is getting treated. I have summarized here, only 26 percentage of the domestic wastewater and 60 percentage of the industrial wastewater is getting treated in India. And 423 class one cities treat around 29 percentage and 499 class two cities, around 4% of domestic wastewater is getting treated, the major reason is inadequate infrastructure.



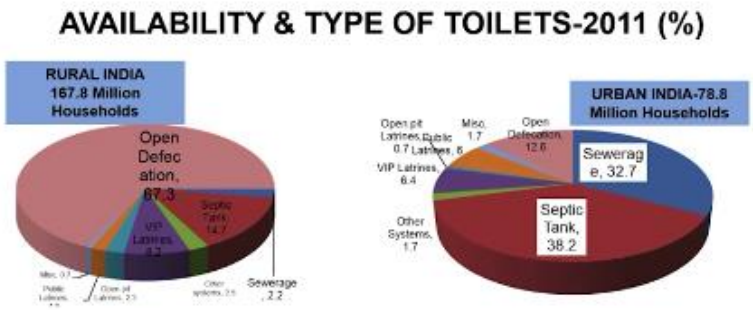
Current and project wastewater generation and treatment facilities in Urban India



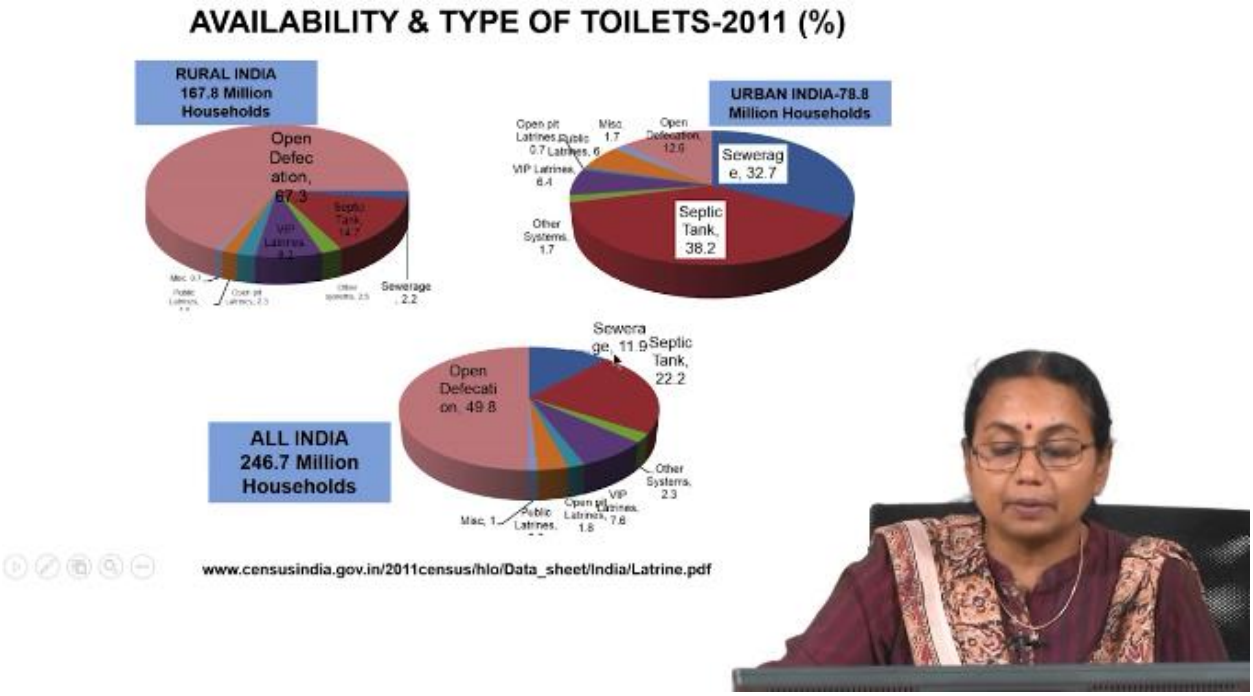
Urban and rural India domestic wastewater generation and treatment projections

So, now we know that a lot of emphases is given on Swatch Bharat and cleaning and wastewater management, wastewater treatment etcetera. So, if you go or if you create much more infrastructure, you see the condition here treated wastewater is around 11,788 million liters per day, and untreated is around 27,808 million liters per day. But in 2035 if you see definitely the treated wastewater quantity will be increasing significantly, it may go up to 65,2280 million liters per day, but you can see the untreated wastewater quantities also increasing, it become around 28,269, the reason is though infrastructure is developing, but it is not able to meet the quantity of wastewater getting generated in India. As the population is growing the amount will be getting, amount getting generated will be increasing significantly. So, this is the wastewater generation projected for the year 2035. This is rural and poor around 61,000 plus and Urban India around 93,000 plus. And rural treatment will be only 4,000 something and Urban India it will be around 65,228. So, that is why though the infrastructure develops, the pace at which it is

developing the coverage or the untreated wastewater getting into our rivers and water sources will be increasing day by day.



So, this shows the availability and type of toilets as per the 2011 census. Rural India in 2011, open defecation was very prevalent around 67.3 percentage; now it has reduced significantly because of the Swatch Bharat campaign and all the things and Urban India also was not that good around 12.6 percentage was practicing open defecation. And sewerage facilities available only 32.7 percentage in the Urban India and around 38.2 percentage is still depending upon a septic tanks and you can see that so many other options are also available or practiced in the Urban India. So, if you see all over India, open defecation is still there, but if you look into the sewerage coverage it is only 11.9 or around 12 percentage, and septic tank coverage is around 22.2 percentage.

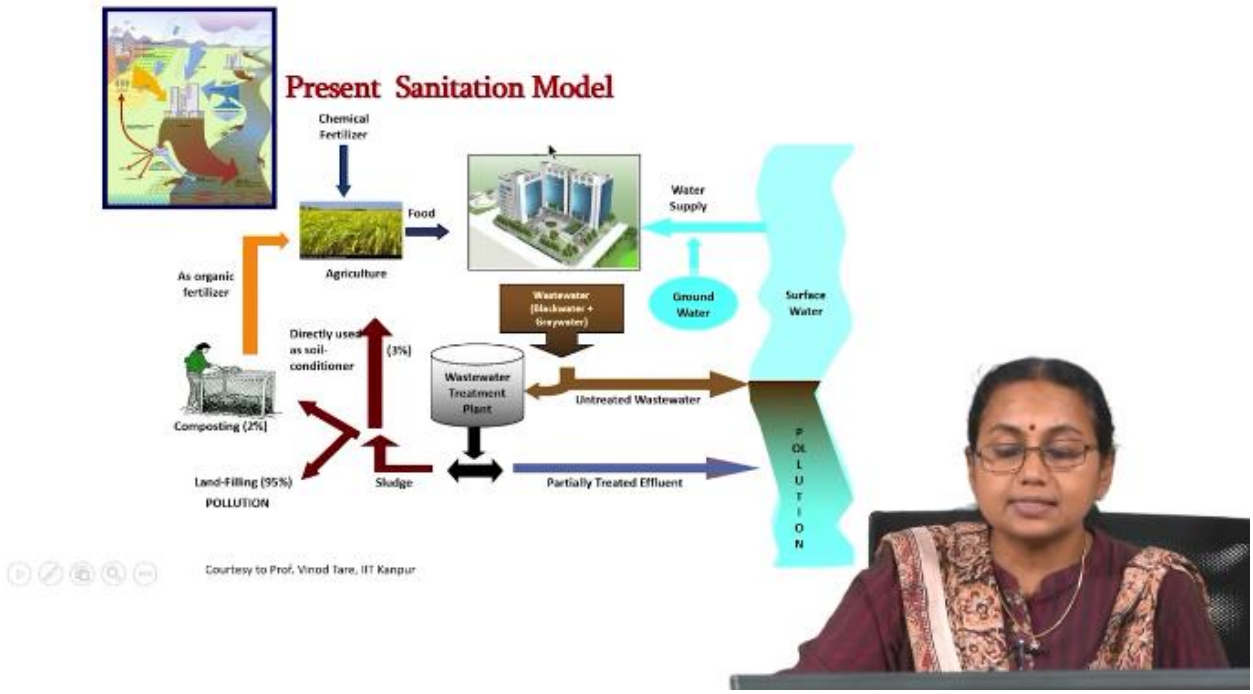


So, when we talk about the wastewater management, we have to realize the ground reality. Most of the time when we talk about the wastewater treatment, we think about a centralized treatment system and all the things, but that can be achieved, or that can happen only in the places where there is a sewerage coverage. So, when the wastewater is not treated and getting into the rivers, what will happen? All our rivers are highly populated.

So, you see anywhere, and everywhere we go the rivers are like this, so much of foams and other things, and all the garbage and other things are getting discharged into the rivers. A lot of weed growth inside the river and that is reducing the carrying capacity of the river and affecting the flora and fauna inside the river, and the DO level are coming down and all the things. So, this is

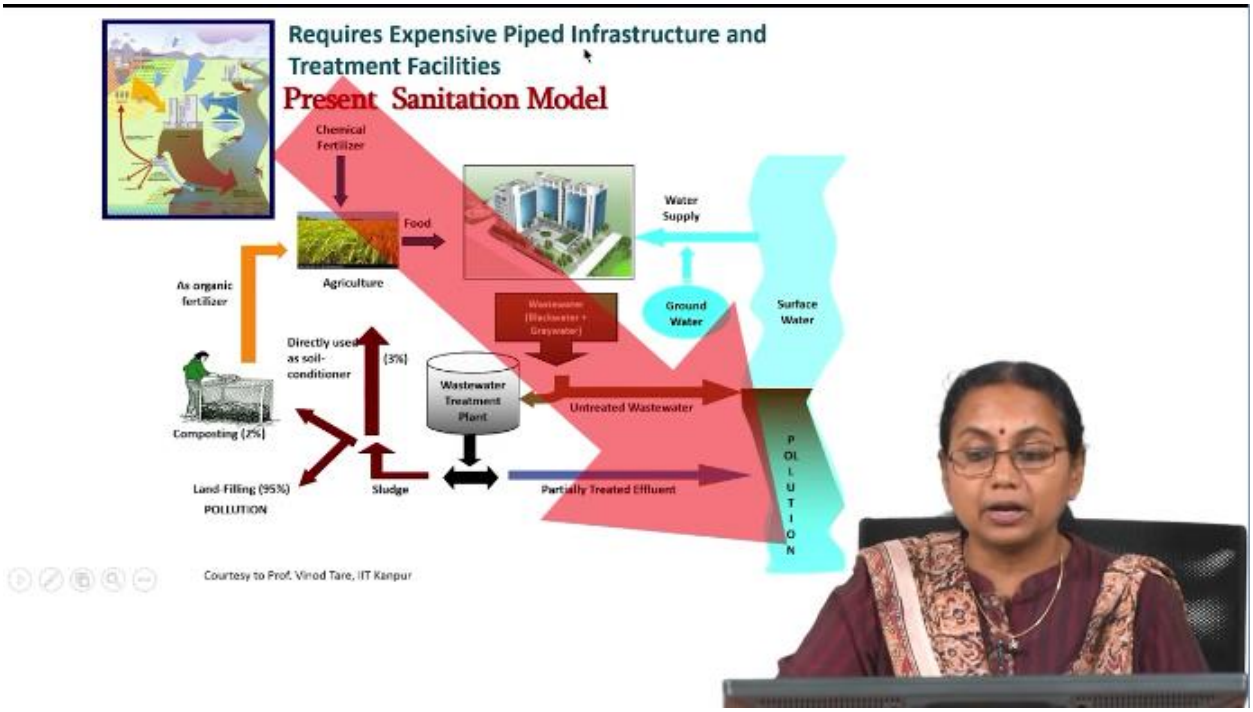
the status of the river, and the reason is untreated wastewater getting into the rivers; large quantities of untreated wastewater.

As we have discussed in the earlier lecture, all these rivers the waste load or pollution load is much, much, much higher than the carrying capacity of the river; the river is not able to take care of any of these pollutants. So, why should we bother about the pollution? Economic losses due to improper sanitation is huge around 73 million working days are lost due to water-borne diseases. We have seen what waterborne diseases is, and around 600 million dollars are lost because of this one per year, and around 6.4 percentage of Indian GDP is lost due to improper sanitation and economic loss in tourism industry in India is around 448 million US dollars per year. Because people wanted to go to a very clean and pristine area for tourism, not a river like this, where it is highly contaminated with all domestic and industrial waste and solid waste etcetera. So, definitely, if you are not doing the waste management properly it is having a significant economic loss.

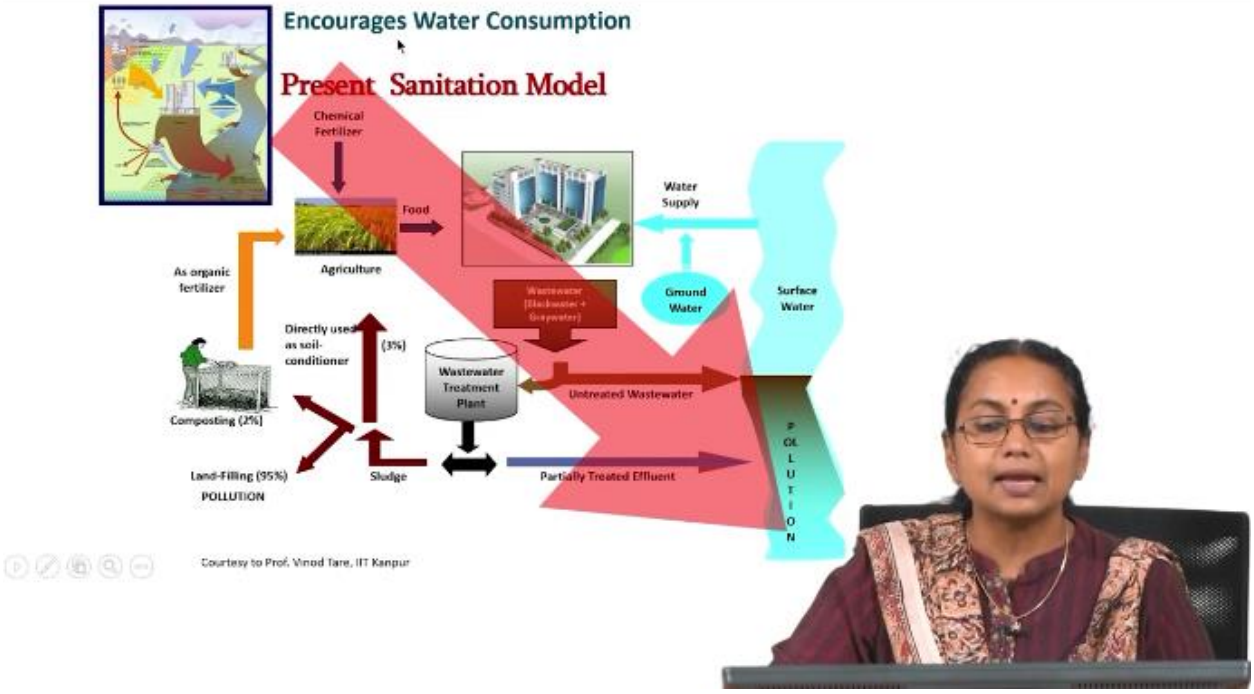


So now, we will see what is the present sanitation model. So, this is what is happening, we have cities, the food is coming from the agriculture fields, agriculture fields we are using the chemical fertilizers, and the food is supplied to the city and water is coming from the river and river water may not be sufficient, on many places we are taking a lot of groundwater to supply the water to the city. And the treated wastewater, wastewater whatever is generated, the black water that means the wastewater coming from the toilets and the gray water, wastewater coming from bathrooms and washbasins and all. All the things are getting mixed up and going to the wastewater treatment plant. Here you can see that only a part is going to the wastewater treatment plant, we have seen that around 26 percentage or 28 percentage, and remaining is going directly to the rivers without any treatment, and in the wastewater treatment also, we are not bothered much about the nutrient removal and all. So, partially treated effluent is again getting back to the rivers, and wastewater treatment plants will be generating sludge, the sludge is dumped in the lands fills around 95 percentage of the sludge is getting dumped in the landfills, not landfills, okay, just disposed it off and only less than 2 percentage is going for composting.

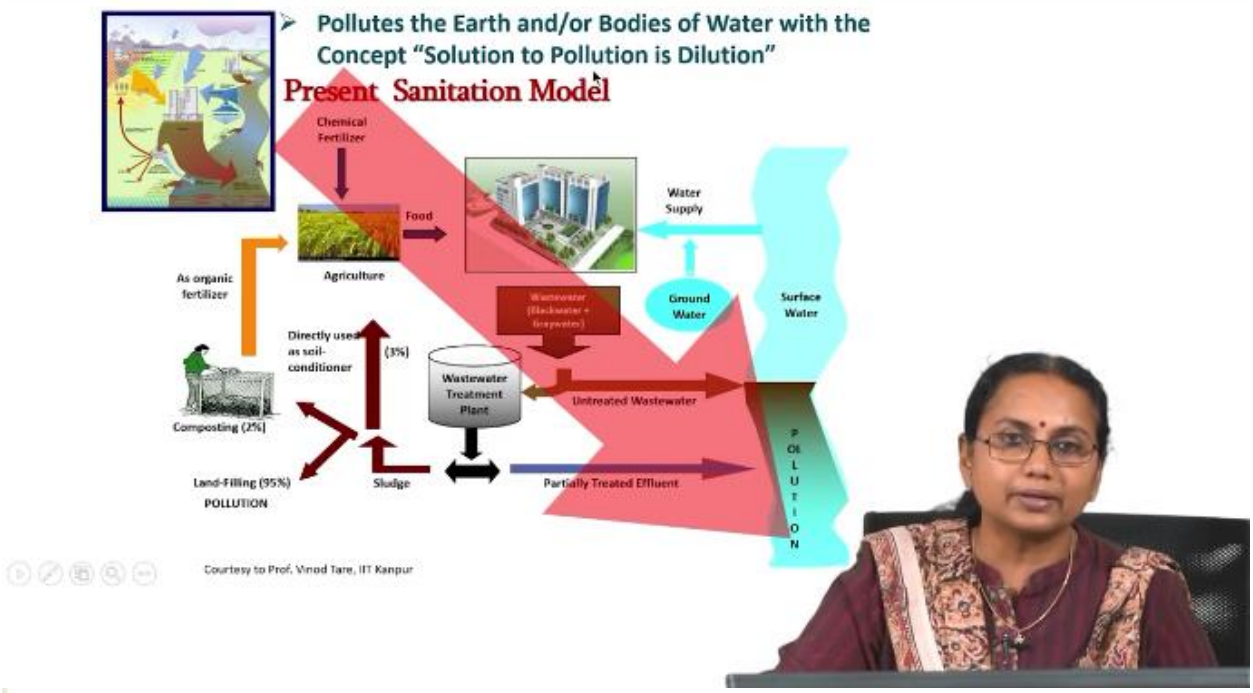
And around three percentage is used directly as a soil conditioner and whatever is used for composting is going for the agricultural fields and all. So, this is what is happening, so all these things the chemicals, the wastewater untreated, partially treated everything is going to the river. So, and this river water is being used by the cities which is staying in the downstream of the river, so indirectly all of us are drinking the other persons wastewater without much hesitation. So, when we talk about wastewater can be treated and reused for various purposes, people have the psychological inhibition, but every day we are doing that doing that without our knowledge. So, today the wastewater management is based upon centralized wastewater treatment systems, that means the water or the wastewater generated in the city is collected through pipeline, we call it as sewers, the sewer lines, so if you want to carry the waste through the sewer, we have to have large quantity of water, because otherwise the solid will be getting deposited there.

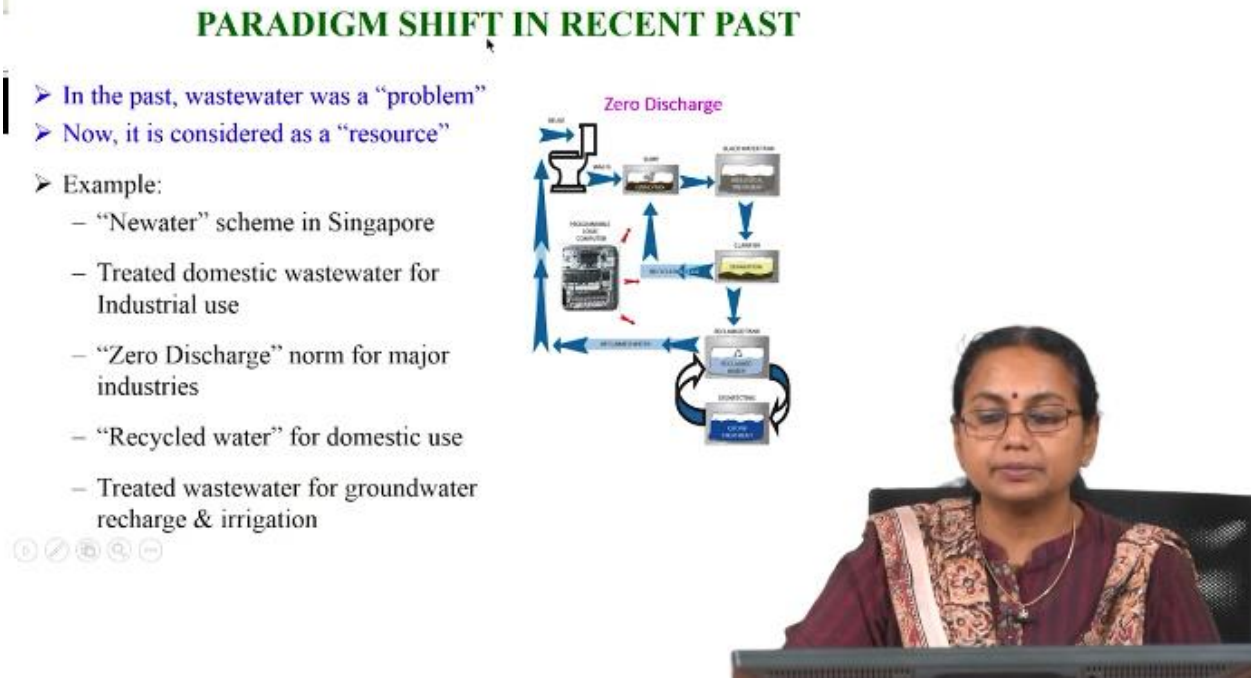


So, request expensive piped infrastructure and treatment facilities and encourage water consumption, because the pipe should have the minimum velocity, otherwise all the solid will be getting accumulated there, and it will be clogging the pipeline, so centralized systems will be centralized wastewater treatment systems, encourage water consumption and most of our treatment systems does not reduce nutrient pollution because the treatment systems are not designed for that one.



So, pollutes the earth and water bodies with the concept "solution to pollution is dilution", but our rivers are not having much water, so it is that, and our water bodies are getting contaminated. So, it is not sustainable.

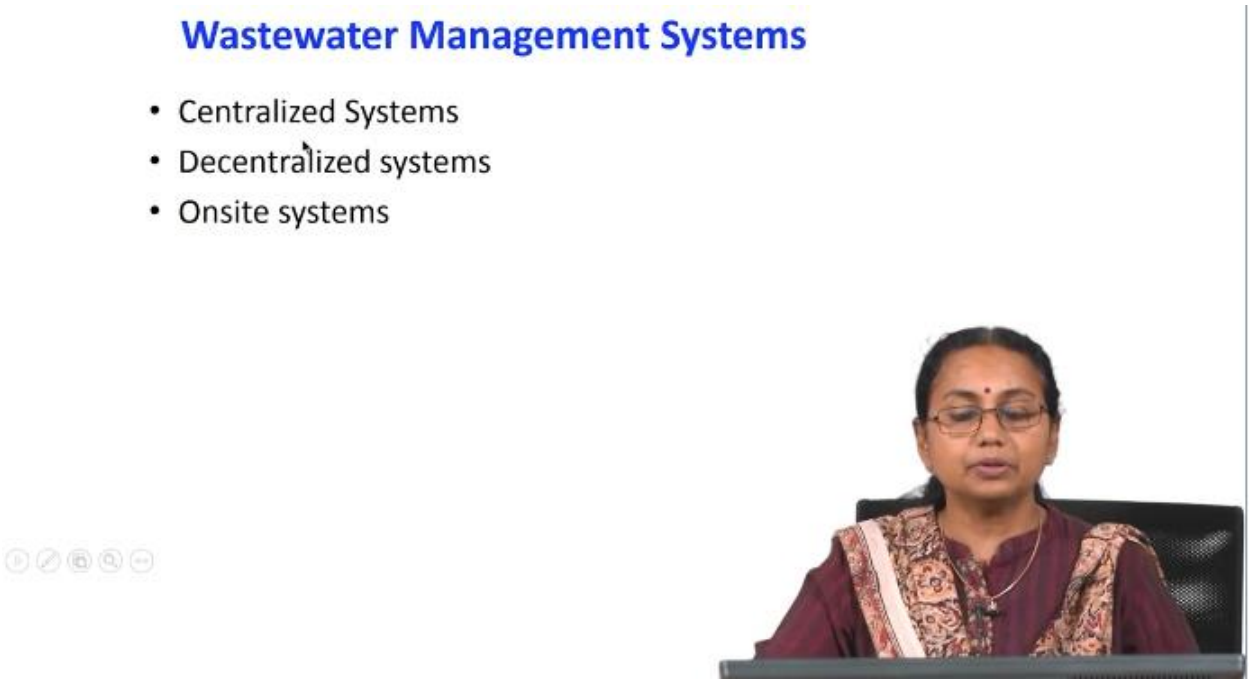




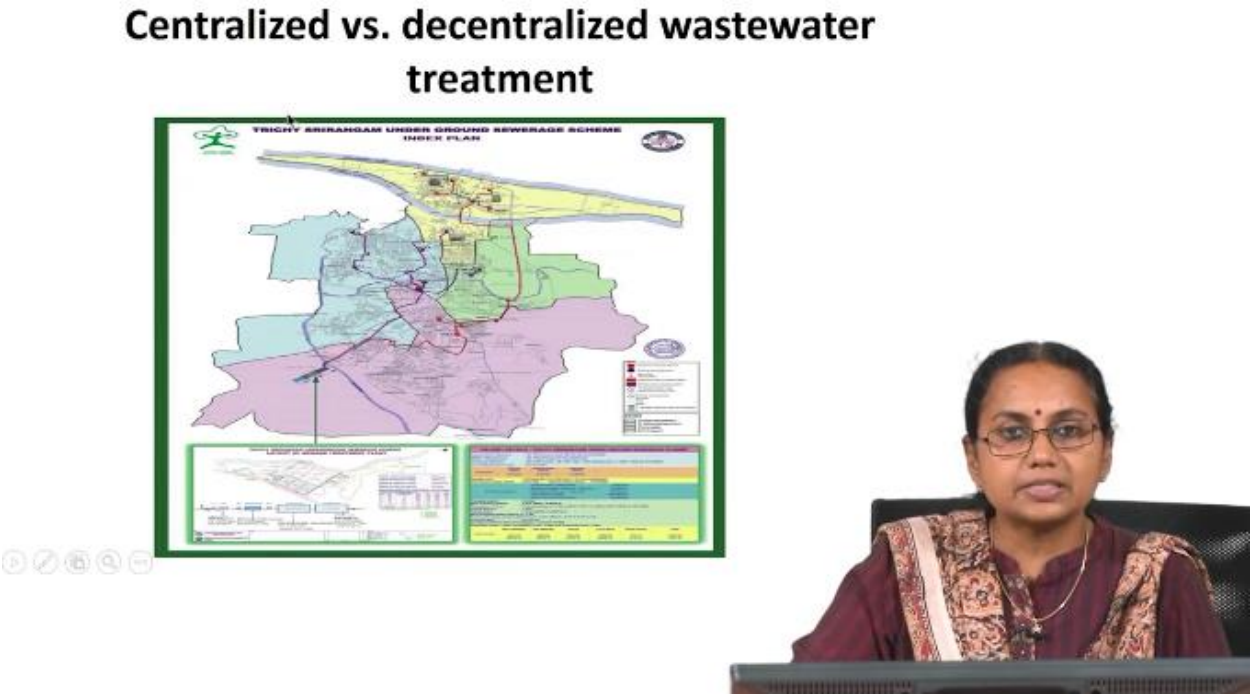
So, now there is a paradigm shift, in the recent past. In the past wastewater was a problem, or it is considered as the problem, now it is considered as a resource, that means many places zero liquid discharge is being practiced that means whatever the wastewater generated you treat it to the required level for the specified beneficial use and recycle within the community or within the facility completely. So, that is known as zero liquid discharge that means no liquid is getting discharged.

So, examples are many, new water scheme in Singapore, because Singapore and their water is getting treated and putting it in the rivers and lakes, and they are reusing it. Treated domestic wastewater for industrial use, even in Chennai many industries are practicing this one, zero discharge norms for major industries, and it is coming in a big way wherever water stress is there. And recycled water for domestic use may not be for drinking purpose, for all other secondary uses like toilet flushing, gardening, cleaning, etcetera. Treated wastewater for groundwater recharge and irrigation, here we have to be extremely careful, if you want to use the treated wastewater for groundwater recharge, the quality of the treated wastewater should be as good as the drinking water, otherwise what happens the groundwater will be getting contaminated, once the groundwater gets contaminated, treating that one will be very, very difficult.

So, when we talk about wastewater reuse, the treated wastewater can be reused for multiple purposes like recreational and environmental uses. We can do lakes and ponds, to rejuvenating that one; we can use the treated wastewater, properly treated wastewater, otherwise, it will be leading to much more problem. Marsh enhancement, stream flow augmentation because if the rivers are not having the environmental flow, so how can we get the water. You treat all the wastewater to the required quality and put it back to the river so that the stream flow augmentation can happen, then it can be used for fisheries and for wetlands.



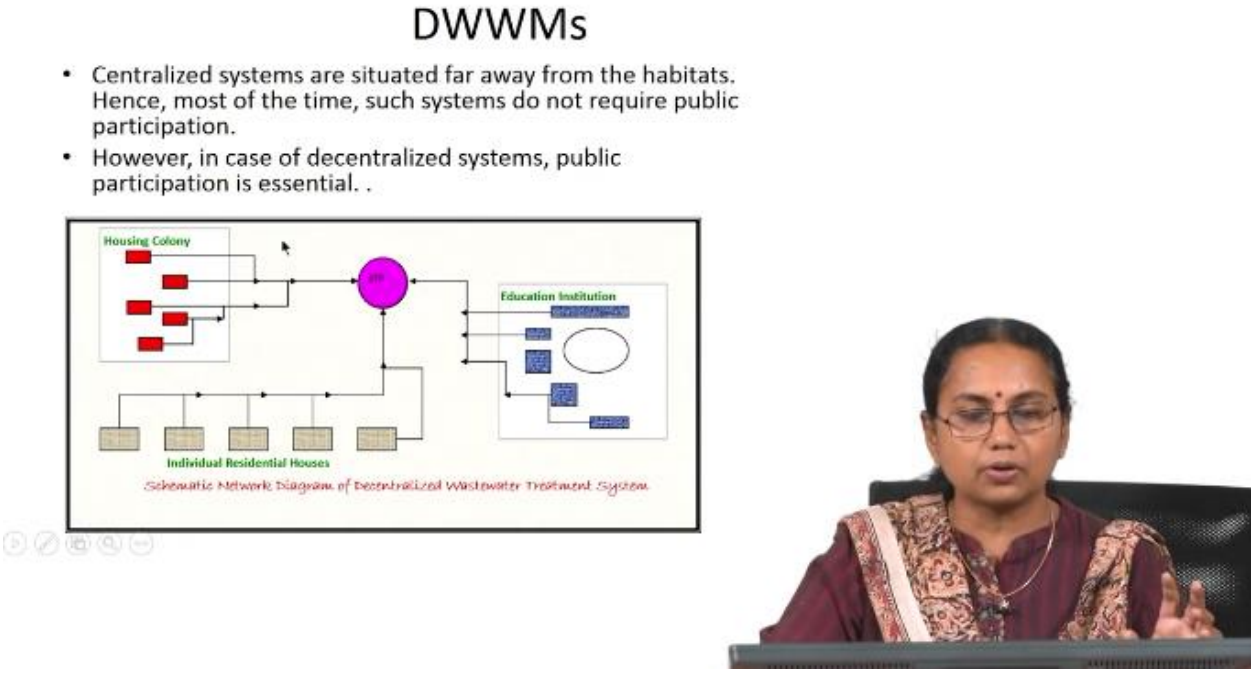
Then when we come to the wastewater management systems, usually that can be classified them into three categories one is centralized systems, next one is decentralized systems, and onsite systems. So, when we talk about a city or a town, if you want to achieve 100% wastewater management, it should be a combination of centralized systems, decentralized systems, and onsite treatment systems.



Now, we will see what are these centralized systems and decentralized systems. So, centralized wastewater treatment system means all the wastewater generated into city is, or city or town is collected through pipelines. This pipelines maybe 100 of kilometer long, and all the wastewater is getting collected and take and take it to the low-lying area in the outskirts of the city wherever

you have enough land, treat it there and discharge it. That is what the centralized treatment system, this is one of the towns in Tamil Nadu, Trichy. So, here you can see that this is an example of centralized sewage treatment system, so these are the pipelines, you can see that all the sewer lines and all the water, wastewater is getting collected and it is brought to an area here, and here it is getting treated, far away from the city, but here we have problems, some areas which are low lying compared to the major pipeline it is very difficult to connect to the existing sewer systems. The reason is if you want to get connect it, we have to have the pumping stations and all, so the operation and maintenance cost of such systems will be huge. So, it is advisable to have centralized system, and whichever is not, whichever area is not possible to connect to the centralized treatment system, centralized sewer system can have decentralized wastewater treatment system. That means for that location you provide a small treatment, and if you have some isolated houses and all, providing the sewer network will be very, very costly, in such cases you can go for onsite treatment system, that means only for a single house or a cluster of houses you can have a very small treatment system.

So, this is a centralized wastewater treatment system that means entire wastewater is getting collected through the sewer network and transported to a faraway place and getting treated and discharged there.



In the decentralized wastewater management system, what we are doing is wherever the wastewater is generated in that area itself it is getting collected and treating, this is a housing colony, some individual residences are there, some educational institute is there, everything is very close by, so what you do, you collect all this wastewater and treat it in a wastewater treatment plant here. So, this is an example of decentralized wastewater treatment system, so if you are thinking of reusing the treatment treated wastewater, it is always economical to go for decentralized wastewater treatment systems, because centralized wastewater treatment system we are taking all the wastewater to a faraway place than where it is getting generated.

Then if you want to reuse it, you have to pump it back to the place where it is required. So that piping cost, pumping cost everything will be very high. Here what is happening is we are treating the wastewater wherever it is getting generated, so reuse will be much, much easier.

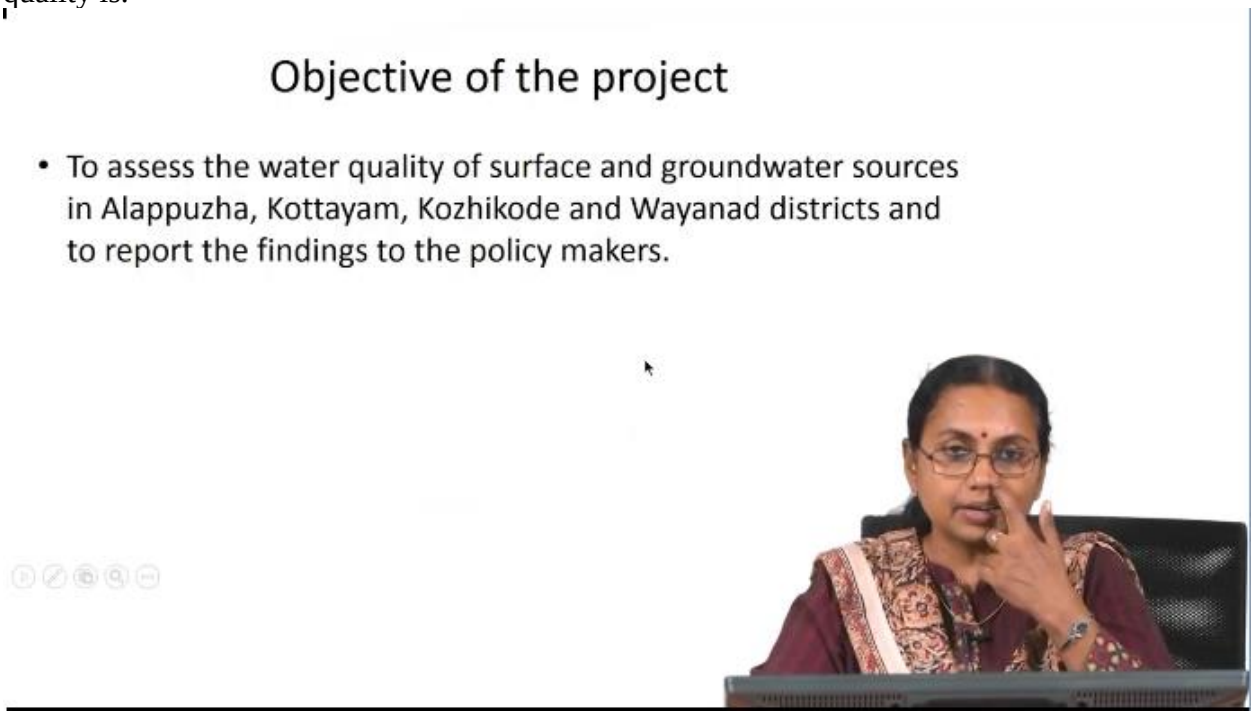
So, onsite treatment systems means for individual houses or a cluster of houses we are providing the wastewater treatment systems. And in India, the onsite treatment system mostly consists of septic tank, so these scenes are very common in India. This is a septic tank, and this is the gas vent pipe we can see that one, it is an underground watertight tank, only the effluent will be coming out. And you can see this is a clogged septic tank and this is the honey-sucker which comes and sucks the sludge from the or septage from the septic tank and many places this septage is going, getting discharged into wherever they see the place. So, those things can create much problem.

And if you want to see a proper septic tank, this is a cross-section of a proper septic tank, usually it will be having two chambers or some cases three chambers, and it should be a watertight tank and whatever the effluent coming out of the septic tank should be sent to a drain field, so that because in the septic tank around 50 to 60 percentage of organic matter removal is taking place, and the large number of pathogens will be coming out in the septic tank effluent. So, if you just discharge it into the open drains and all, there will be significant groundwater contamination, so here what we are doing is we are spreading it into a large area in the soil, so soil acts as the treatment medium, and the waste is getting treated. So, but because of the land constraints and all the things many places this drain field is not existing at all. So a properly designed drain field you can see like this house, septic tank, and a drain field, but many places this drain field is not existing. So, either the effluent is going to the drainage, or it is just entering into soak pit, and from there it is infiltrating into the groundwater if the groundwater table is very high.

So, problems of improper wastewater management. We have already discussed, contamination of surface water sources most of the rivers in India. We can talk about Ganga, Yamuna, Adyar, Coovum, any river you take it, many things are getting contaminated. And if you are not designing and operating the onsite treatment system properly, again contamination of groundwater can happen. I will talk to you about some example from Kerala. So, this is the case study from Kerala, we all know that Kerala, open defecation is almost nil, and all social development indices are very good.

And they have very nice rivers and all the things, and mostly the environment is clean and all the things, but what is the status of the groundwater. So, we have done a study just to monitor the

water quality, surface and groundwater quality in four districts of Kerala, just to find out how the quality is.



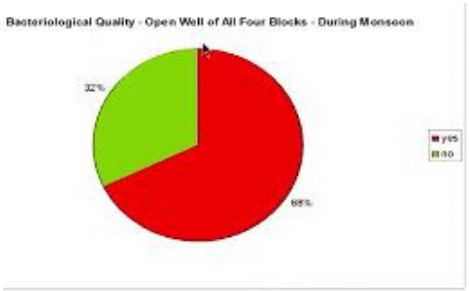
So, we have conducted, collected samples, around 309 samples from open wells, bore wells, and tap water. So, what I wanted to show you is, here the number of open wells, percentage of open wells, bore wells, and tap water I have shown.

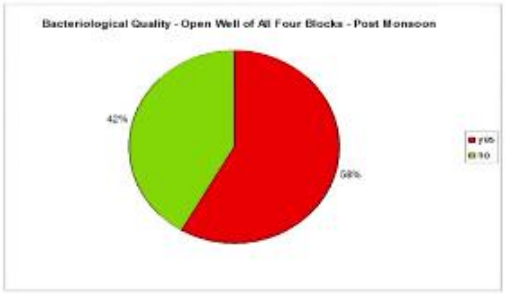
Percentage Contributed of Samples collected from Open Well, Bore Well and Tap Water from Each Block

Sl.no	Block Name	Total No of Samples Collected	Open Well	Bore Well	Tap Water
1	Ambalapuzha	77	55%	34%	12%
2	Ettumanoor	78	94%	0%	6%
3	Kalpetta	77	90%	5%	5%
4	Vadakara	77	90%	9%	1%
	Total	**309**	**82%**	**12%**	**6%**

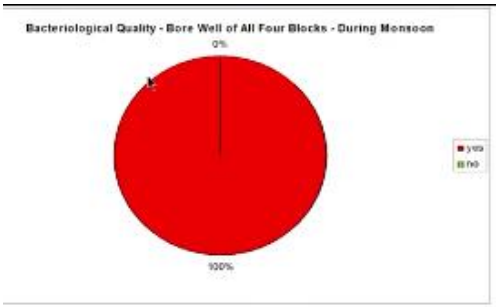
No of Samples collected from Open Well, Bore Well and Tap Water from Each Block

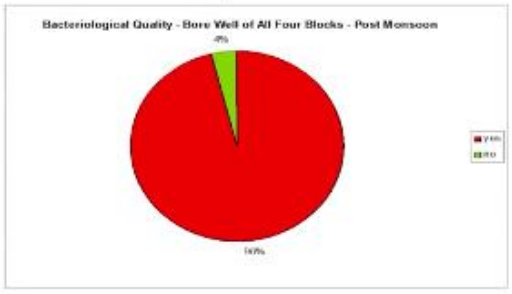
Sl.no	Block Name	Total No of Samples Collected	Open Well	Bore Well	Tap Water
1	Ambalapuzha	77	42	26	9
2	Ettumanoor	78	73	0	5
3	Kalpetta	77	69	4	4
4	Vadakara	77	69	7	1
	Total	309	253	37	19



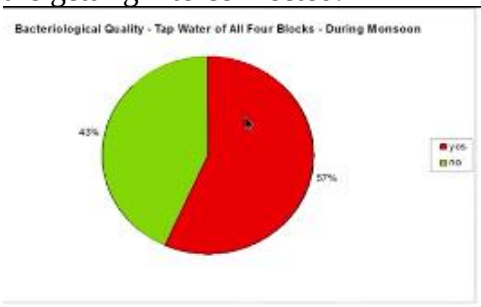


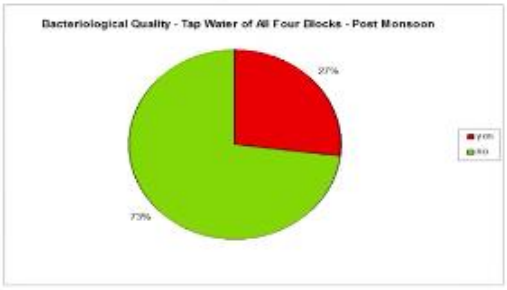
So, you can see that bacteriological quality in open wells in all the four blocks during monsoon, you can see that open wells around 68 percentage of the wells are having fecal contamination, and only 32 percentage wells are free from that one. This is after monsoon, around 58 percentage and 42 percentage. So, what I am trying to tell is, even if you have the onsite sanitation systems and all, if you are not managing it properly, your groundwater will be getting contaminated significantly. And this is the bore well in all the four blocks, almost all the bore wells are contaminated, this is after post monsoon.



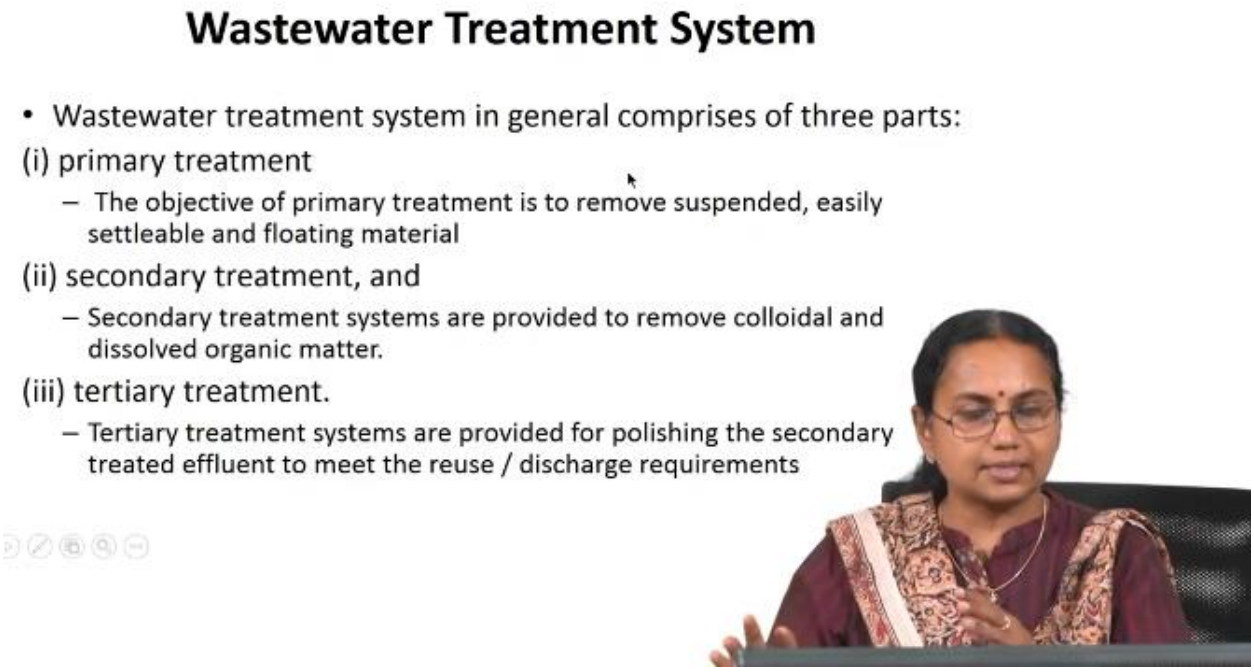


We usually think that open wells are prone to contamination and bore wells are not that prone to contamination. But why it is happening, because the groundwater table is very high, the things are getting into the groundwater and open well, many times they do the disinfection in the well itself, so many wells are getting cleaned. But bore well, since the bore is many times bore well is dug in the open well, so what is happening is the chlorination is not effective, and the aquifers are getting interconnected.

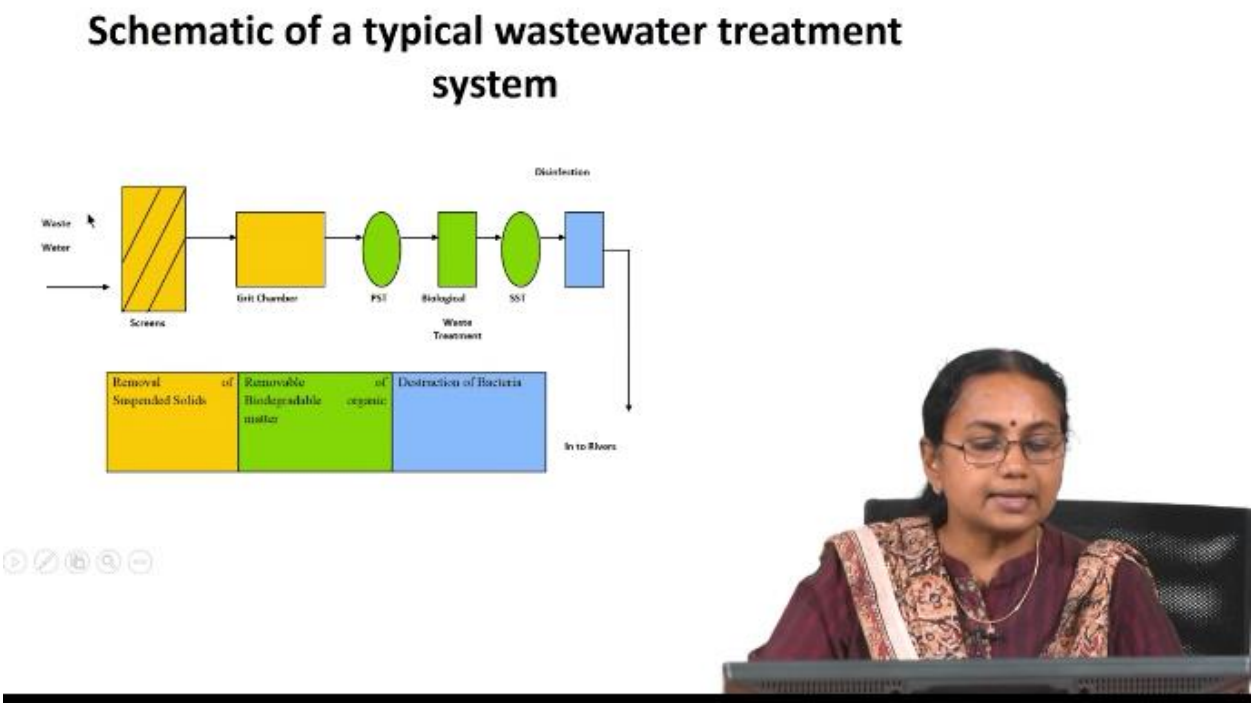




So, the bore well is contaminated, and that disinfection is not happening that is why the bore well is showing much more contamination, and tap water also we can see that it is getting contaminated or around 57 percentage of the tap water is also contaminated.
What I am trying to tell is even if you have toilets, if you are not managing the waste properly you can have severe groundwater contamination problem.



So now, we have seen the scenario of wastewater management in India. Now, we look into what are the wastewater treatment systems or how can we treat the wastewater. So, usually, the wastewater system generally comprises of 3 parts, we have a primary treatment, a secondary treatment, and a tertiary treatment. The objective of the primary treatment is to remove suspended, easily settleable and floating material, and secondary treatment are provided to remove colloidal and dissolved organic matter, and tertiary treatment systems are provided for polishing the secondary treated effluent to meet the reuse or discharge requirements. Because secondary will be removing most of the organic matter, but pathogens and some other contaminants and nutrients may be present, so if you want to remove that one we have to for tertiary treatment. So, this shows, the wastewater is entering.



First, you have screens, grit chamber, primary sedimentation tank, this is optional, some treatment system does not need this one, then you have biological wastewater treatment system, solid-liquid separation system, then disinfection.

And the first thing this yellow color shows the treatment units used for removal of suspended solids, green systems removal of biodegradable organic matter, and blue for destruction of bacteria. And after that one, it is discharged to rivers. But if you want to reuse the thing, we have to give further treatment. So, we have to do recycle and treatment, raw wastewater, raw wastewater treatment. So, we can treat it in the better way and recycle within the system.

Sustainable Treatment Processes and Technology

- Several treatment options are available :Choose the most appropriate technology for the region under consideration
  - Waste stabilization ponds,
  - Constructed wetlands,
  - USAB (anaerobic digesters),
  - Moving bed biofilm reactor,
  - Activated sludge process,
  - Extended aeration process,
  - Sequencing batch reactor,
  - Membrane bioreactor.

So, what are the wastewater treatment processes and technology, there is no dearth of technologies, we have N number of technologies available for the treatment of wastewater. A few are waste stabilization ponds, constructed wetlands; these are engineered natural systems, cost-effective, and you do not need any electricity or mechanical devices, then USAB - Up flow anaerobic sludge blanket reactor, moving bed biofilm reactor, activated sludge process, extended aeration process, sequential batch reactor, membrane bioreactor like that we have all type of technologies available depending upon the treatment quality requirement and your space availability and all you can select appropriate treatment technologies.

Biological Wastewater Treatment: Process Description

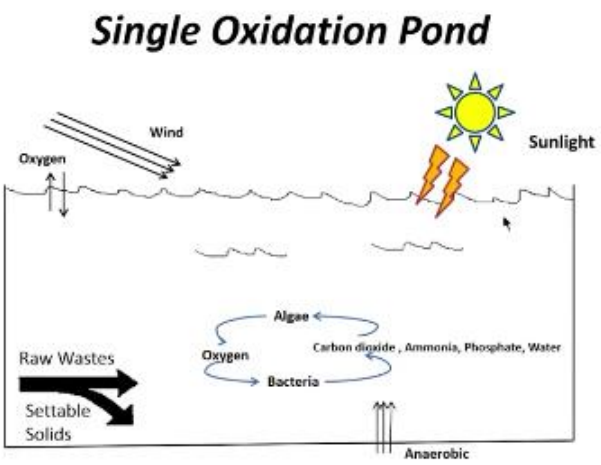
The aerobic conversion of the organic matter occurs in three steps:

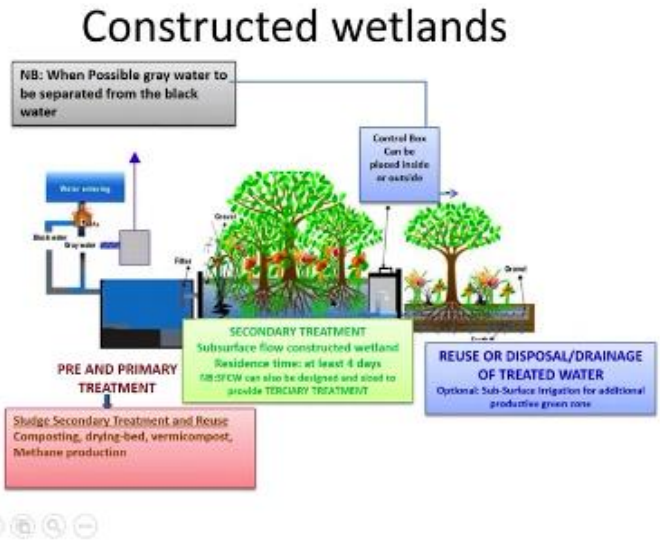
- **Oxidation**
- $COHNS + O_2 + BACTERIA \rightarrow CO_2 + NH_3 + END\ PRODUCTS + ENERGY$
  (Organic matter)
- **Synthesis of new cells**
- $COHNS + O_2 + BACTERIA + ENERGY \rightarrow C_5H_7NO_2$ (new cells)
- **Endogenous respiration**
- $C_5H_7NO_2 + 5O_2 \rightarrow 5\ CO_2 + NH_3 + 2H_2O + ENERGY$

And in wastewater, especially for domestic wastewater most of the time we go for biological process, the reason is the wastewater will be containing a lot of suspended, colloidal and dissolved organic matter which are highly biodegradable. So, instead of going for chemical processes we usually adopt a biological process.

In the aerobic process what happens, your organic matter in the presence of oxygen, bacteria or other microorganisms convert the organic matter to carbon dioxide, ammonia, and end products, some energy also will be generated. This energy will be utilized for the synthesis of new cells, the new cells synthesis is like this organic matter, oxygen, bacteria, that energy is generated, and it is giving new cells. And some days what will happen, if the organic matter content is less, the microorganism will use the existing microbes, and they will get the energy.

And low-cost options as I told you have oxidation pond, aerated lagoon, anaerobic ponds, facultative ponds, facultative lagoons, constructed wetlands. And this is a single oxidation pond, here you can see that a symbiotic action of algae and bacteria are happening and as a result, the treatment is happening, that is what is happening in an oxidation pond.





And this is a constructed wetland, here you have a watertight tank, and you will be having plants and the matrix on which the microorganisms also will be there. So, you have a combination of physical, chemical and biological action taking place and you will be getting that treated wastewater.

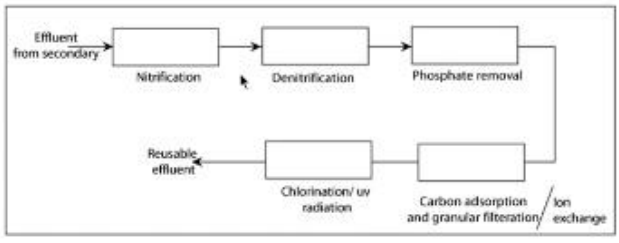
Stage III: Tertiary Treatment - Options and Norms

- Coagulation-flocculation-settling followed by filtration and disinfection is generally recommended.
- Other processes could be selected on the basis of land availability, cost considerations, O&M cost, reuse option, compatibility issues in case of up-gradation of existing plants, etc. However, disinfection operation should invariably be included.
- Where sewage flows are low and/or land can be spared without compromising on other developmental objectives or agriculture, waste stabilization ponds followed by constructed wetland can be adopted without coagulation-flocculation-settling.
- Expected effluent quality after tertiary treatment:
  - BOD < 10 mg/L
  - SS < 5 mg/L
  - Phosphate < 0.5 mg/L
  - MPN of fecal coliforms < 10/ 100 mL

And tertiary treatment as I explained already, you can, based upon that you use, the treated wastewater use you can select your tertiary treatment either you can go for coagulation, flocculation or other process. Most of the time for toilet flushing or other secondary uses the expected quality of tertiary treated water is BOD less than 10, suspended solid is less than 5, phosphate around 0.5, MPN less than 10 milligram per liter.

Tertiary Treatment

Aimed at removing nutrients and make effluent recyclable



And tertiary treatment can be nutrient removal, phosphorous removal, chlorination, carbon adsorption or dual media filter, ultrafiltration or even you can go for reverse osmosis and disinfection.

PRESENT SCENARIO

- Wherever wastewater is collected, mostly treatment plants are not there
- Places where treatment plants exists, enough wastewater is not collected
- Wholesome approach is missing, in many places
- City sanitation plan
- Under JnNURM, funds are provided only for asset creation

So, what is the present scenario? Wherever wastewater is collected, mostly treatment plants are not there. Places where treatment plants exist, enough wastewater is not collected. The wholesome approach is missing in many places, but now cities are coming up with city sanitation plans. Most of the time, the funds are provided for only asset creation, operation and maintenance is not available.

WAY FORWARD

- Integrated approach
  - Combination of centralized, decentralized, and onsite treatment systems
  - Recycling and Reuse
  - Combination of technologies according to the requirement
  - Tertiary treatment
- Policy changes to make the systems sustainable
- Proper Enforcement
- Capacity Building

So, what is the way forward? An integrated approach is needed; a combination of centralized, decentralized and onsite treatment systems, recycling and reuse has to be practiced, a combination of technologies according to the requirement, then we have to give tertiary

treatment also. Policy changes to make the system sustainable is essential. Proper enforcement and capacity building is also needed.

Thank you