NPTEL
NPTEL ONLINE COURSE
ECOLOGY AND ENVIRONMENT
Sustainability and Case Studies
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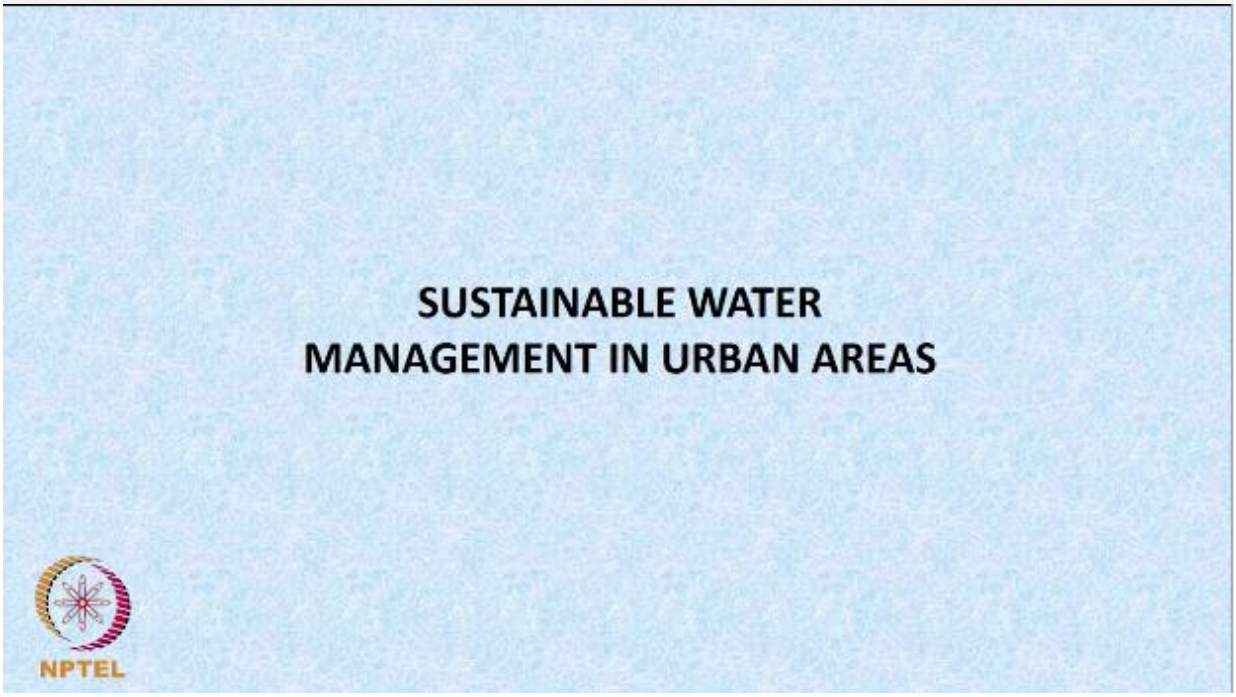
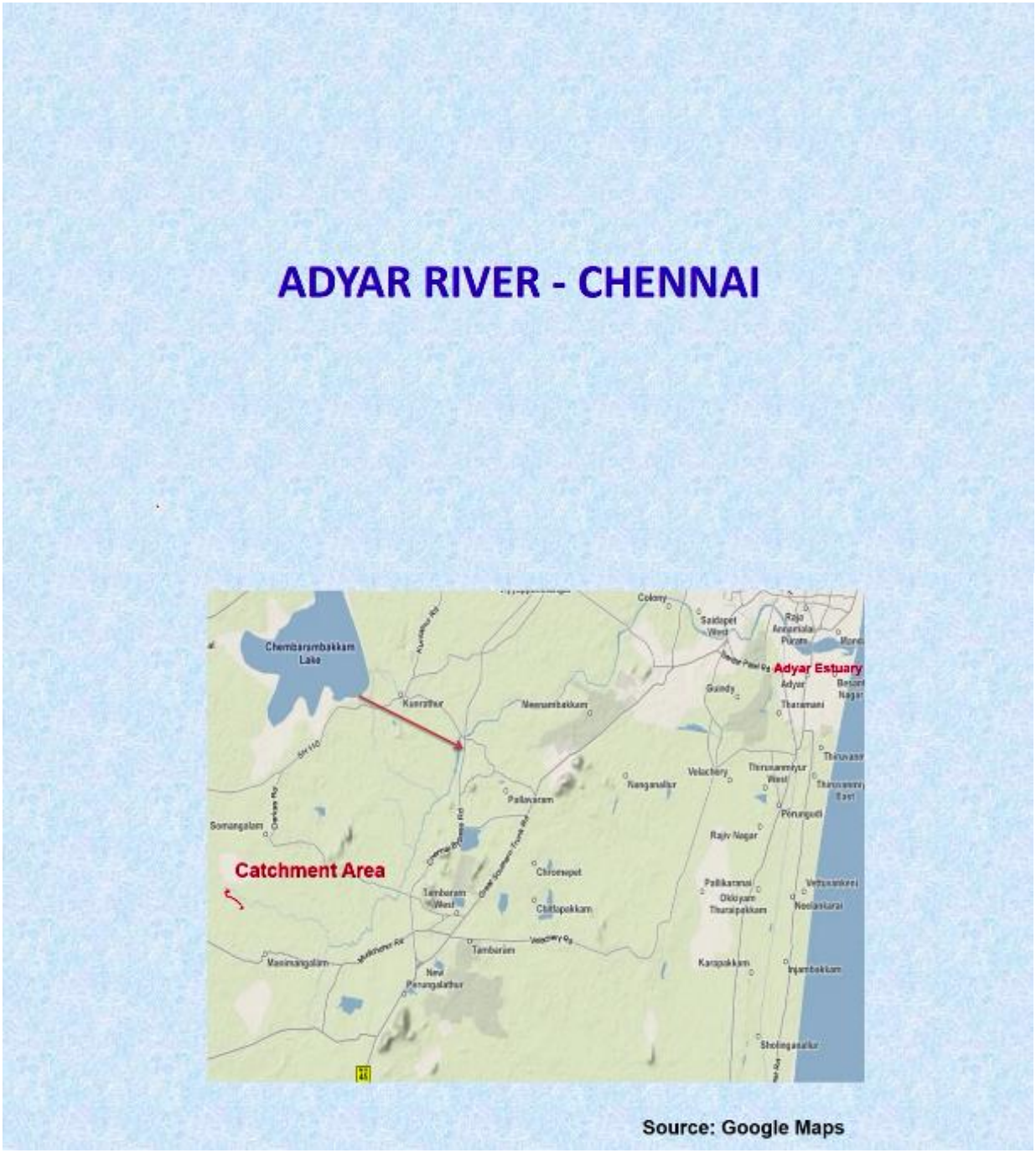
SUSTAINABLE WATER
MANAGEMENT IN URBAN AREAS



We will continue on the discussion on sustainable water management in urban areas. I would like to take the example of the Adyar River in Chennai which is close to my home.



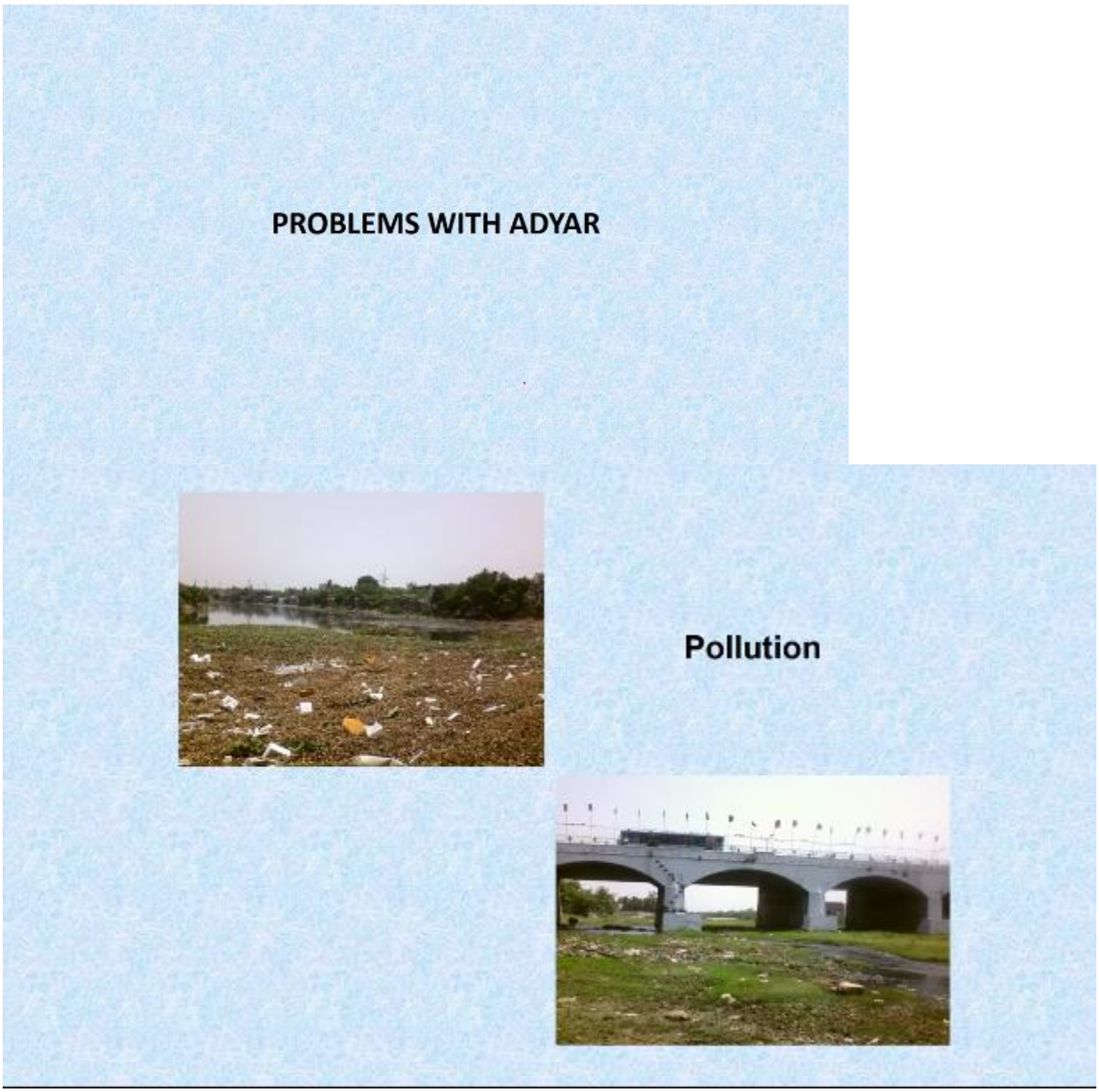
In the next slide, I will show you the catchment of the Adyar River and the surrounding areas. Adyar River starts somewhere here in this map and then it is going like this, this is the way it is flowing here, and then this is the catchment area I have, and then this entire thing is the catchment area. This is main where it is starting, and this is an Adyar Estuary an important point. And it also receives water, the excess water from this Chembarambakkam lake whatever

we can store this water in Chembarambakkam lake they store it for drinking water purpose, this water from this lake is treated and supplied to the entire Chennai city. If there is more water in this lake during the rainy season, then the surplus water also comes to Adyar River.

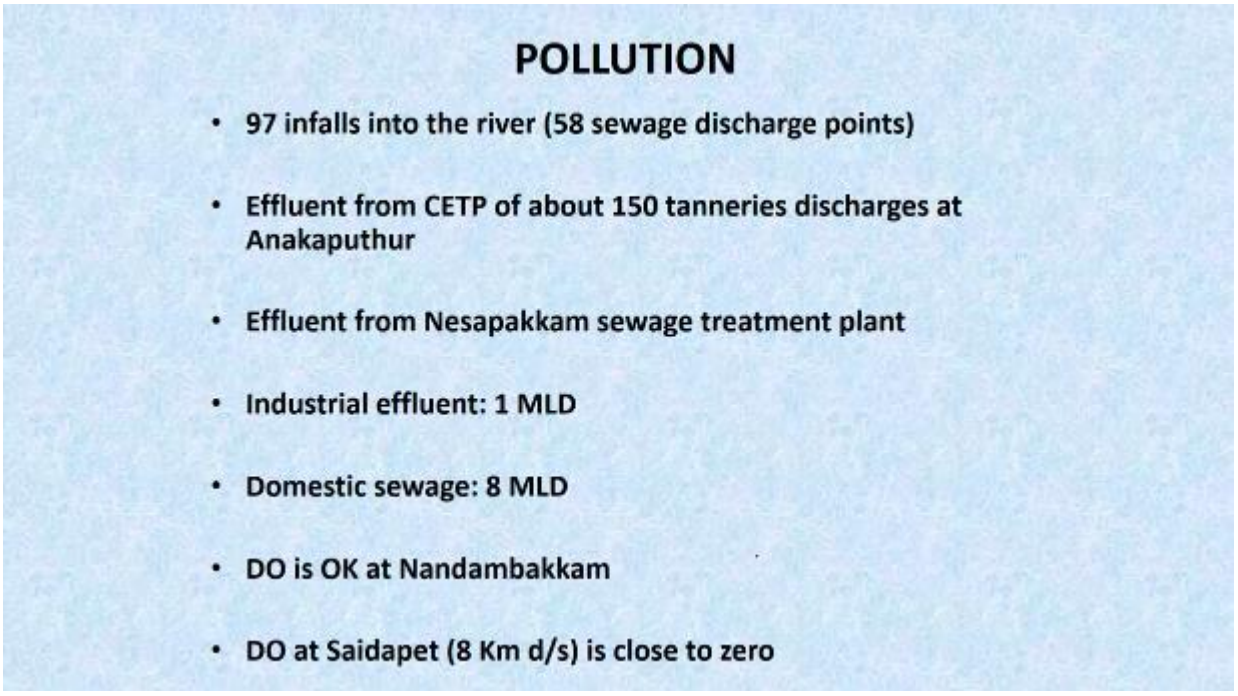
Here you can see the Adyar River catchment, this area, this entire area is highly urbanized, in fact this area is also urbanized, whereas the upstream portions, this is what we call the Peri-Urban area, it is getting urbanized now and then probably in few years time this place also will be having a lot of habitation, okay.

- **Origin:** **Kancheepuram** (Pillaipakkam and Kavanur Tank Groups)
- **Catchment Area:** **860 Km²**
- **Total Length:** **42.5 Km**
- **Length in City:** **15 Km**
- **Length in CMA:** **24 Km**
- **Width:** **10 to 200 m**
- **Average Discharge:** **89.4 MCM/Year**
- **Backwater:** **Up to 4 Km inland**

And this Adyar River actually origin is in Kancheepuram district, Pillaipakkam and Kavanur tank groups, the total catchment area of the river is 860 kilometer square, and total length is 42.5 kilometers, and the length within the city is 15 kilometers. Now, length in Chennai metropolitan area is 24 kilometers, the width of the river ranges from 10 meters in certain locations to 200 meters at other locations. The average discharge per year is 89.4 million cubic meters, and this is a tidal river. So, you have a backwater effect from the Bay of Bengal due to tidal fluctuations. During high tide, the backwater effect is felt up to 4 kilometers in land.

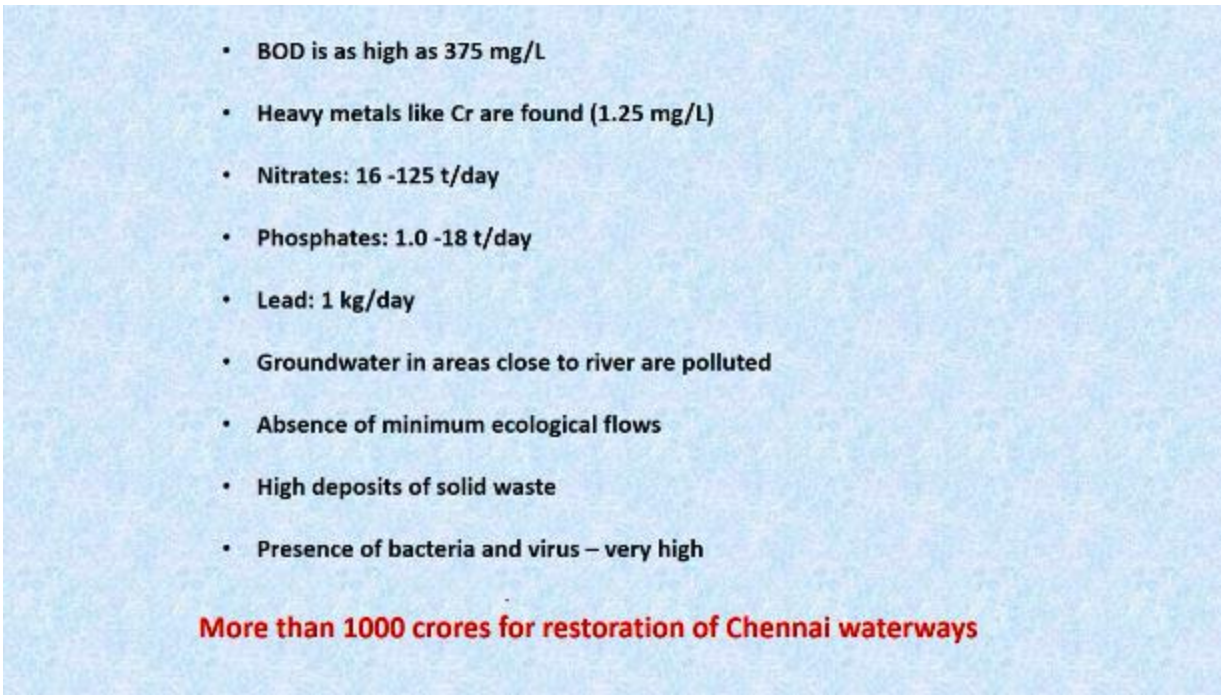


Now, what are the problems with Adyar River? First pollution, you can see how much of solid waste is there and how polluted the river is at certain and many of the locations. The scenery is like this.



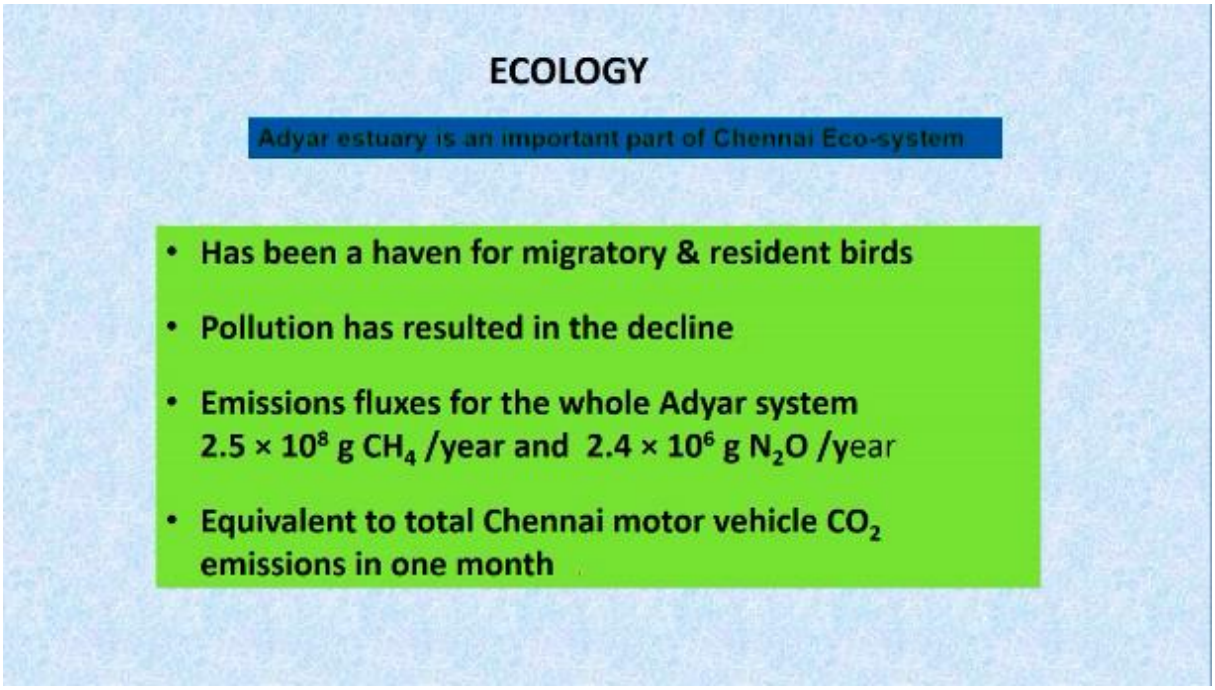
If you look at the pollution where it is coming from, the 97 infalls into the rive, basically 58 sewage discharge points, effluent from CETP of about 150 tanneries, this is CETP means common effluent treatment plant of about 150 tanneries discharges at Anakaputhur. Effluent from the Nesapakkam sewage treatment plant, this is a domestic wastewater treatment plant, Nesapakkam sewage treatment plant this is also discharged into the Adyar River.

The industrial effluents amount to 1 million liter per day, whereas domestic sewage that is discharged into the river is about 8 million liters per day. DO that is dissolved oxygen which is a good indicator of a general indicator of the health of the river because if the dissolved oxygen content is more than it supports fish life and other water life and then the plants, if DO is very low that means the river health is very bad, in general. DO is all right at Nandambakkam which is on the upstream side whereas dissolved oxygen content at Saidapet which is within the city, which is 8 kilometers downstream from Nandambakkam is close to zero. If you look at BOD, biochemical oxygen demand that gives an indicator of how polluted the river is, it is as high as 375 milligrams per liter.

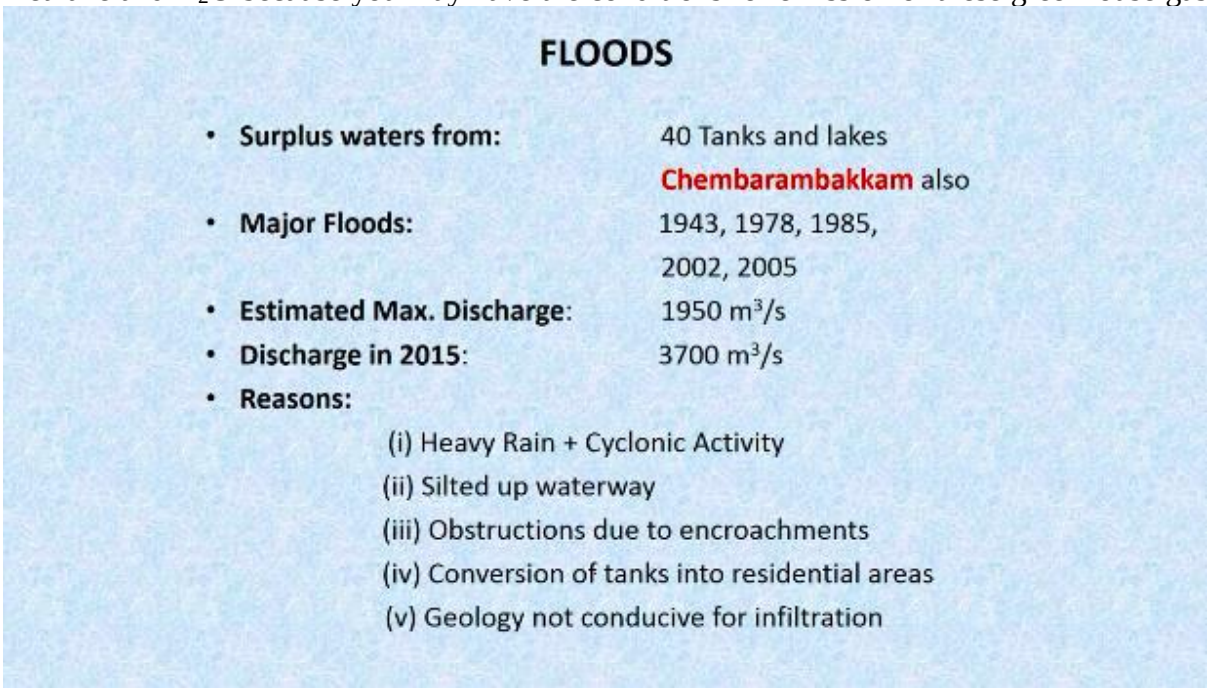


Now, there heavy metals like chromium are also found, and the concentration is around 1.25 milligrams per liter, nitrates the concentration is 16 to 125 tons per day, phosphates that are coming in 1 to 18 tons per day, and lead is coming 1 kg per day. Now, groundwater in areas close to the river are polluted, in fact, many wells which are in nearby to this river when they have taken the samples and they tested them, they were all found to be polluted. There is the absence of minimum ecological flows, high deposits of solid waste and there is the presence of bacteria and virus in these waters is very high. It is estimated that thousands of crores at least more than thousand crores of rupees is required for restoring all of Chennai waterways. There are other waterways other than Adyar, to all of the waterways in Chennai, more than a thousand crores are required to restore.

The other problems, other than the pollution is encroachment. There are a lot of encroachment on the banks of this river and the slums and if you want to clean this river and then keep it clean after, I mean to keep it clean forever after you clean first time then you need to see how much of pollutant - pollution is coming from these encroachments. Whether we would like to have the encroachments there? Whether we can let them continue to live there? If we do not want to have these encroachments, in fact, the government has taken a decision that we would like to you know resettle these people who are living on the banks of the Adyar, who have encroached the space into the Adyar. Now, where do we move them? What are the issues while moving them? Because many of the people who are living in these slums or in these encroached areas are actually contributing to the economy of the surrounding area, many of them work in the industrial units which are located nearby. So, if you remove all of these people from here and then move them somewhere else how do they commute? What is the effect of this resettlement on the economy of this place? these are some of the questions which are important. Which we need to answer before we move them. Of course, we also need to find a space where we can resettle them.



Now as far as the ecology is concerned, we have looked at the pollution, we have looked at the encroachment problem, now if we look at the ecology, now Adyar estuary is an important part of Chennai eco-system. It has been a haven for migratory and resident birds. However, the population of migratory and resident birds has declined in recent years because of pollution. It has been estimated I mean emission fluxes for the whole Adyar system is around $2.5x10^8$ grams of methane per year and $2.4x10^6$ grams of N_2O, nitrous oxide per year, this is equivalent to total Chennai motor vehicle CO_2 emissions in one month. That is because this river receives lot of untreated and partially treated wastewater, and because of that, you have these emissions of methane and N_2O because you may have the conditions for emission of these greenhouse gases



The next and most talked about problem of the Adyar is the floods. As we have seen earlier surplus water from Chembarambakkam lake and not only Chembarambakkam lake about 40 tanks in lakes is discharged into Adyar River. We had major floods in the year 1943, 1978, 1985, 2002, 2005 and of course 2015 very recently we had major floods. Until about 2015 when they did analysis they found that estimated maximum discharge was 1950 meter cube per second, but the estimated discharge in 2015 was a huge 3700 meter cube per second, the reason for this floods is heavy rain plus cyclonic activity, and a lot of waterway is silted up. There are obstructions due to encroachments, there is a conversion of tanks in the catchment area into residential areas, and of course, geology is not that conducive for infiltration of rainwater.

Adyar in full flow: Floods in Adyar river on 28/11/2008 Date 28 November 2008
Source : L.vivian.richard

https://commons.wikimedia.org/w/index.php

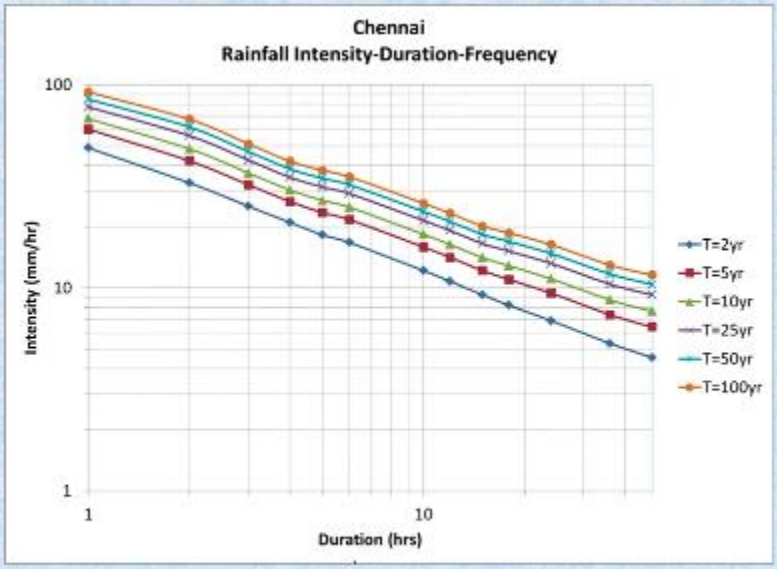
Showing some pictures of Adyar River in floods in 2008, 28th November 2008.

EFFECTS

- **Loss of Property**
- **Disruption of lives of slum dwellers**
  - (i) Displacement (50,000 persons)
  - (ii) Expenditure in relief
  - (iii) Loss of manpower
- **Health:**
  Malarial mosquitoes have returned in full measure

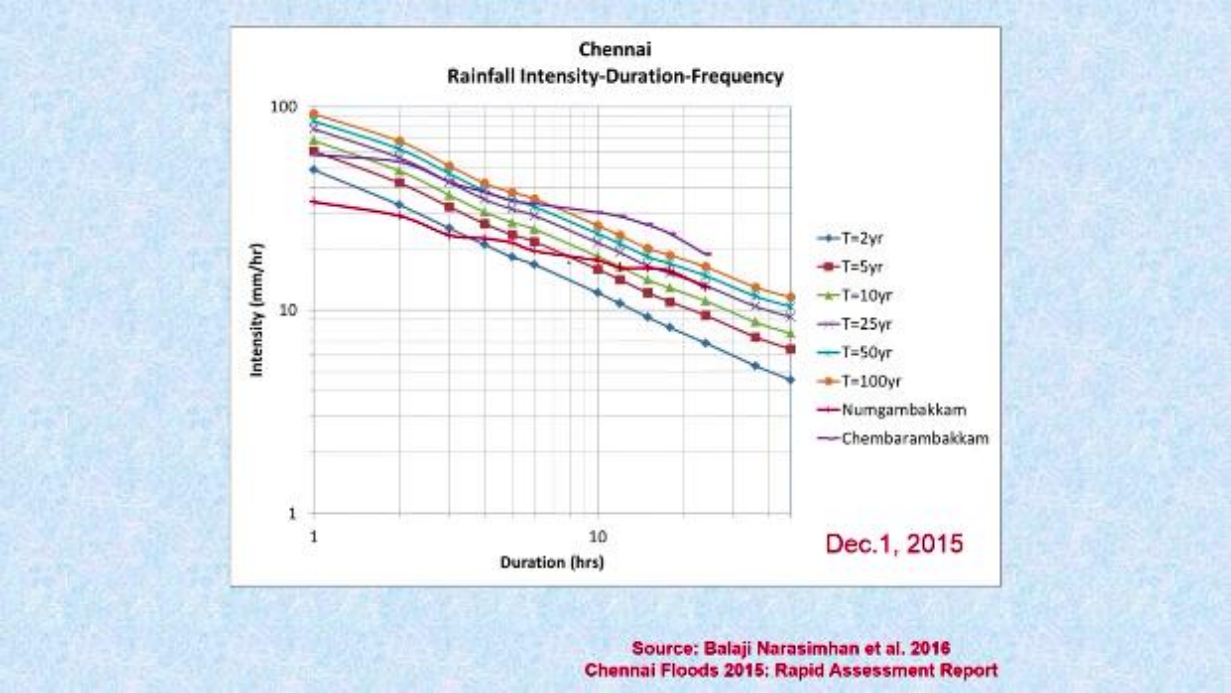
Crores of rupees every year for temporary measures !
(desilting)

What are the effects that these floods have? It is obvious there is a loss of property, there is disruption of lives of slum dwellers, about displacement of 50,000 persons. So, and we have to spend a lot of money for relief operations, and there is, of course, loss of manpower, and there are also health problems which are malarial mosquitos have returned in full measures after the floods. Crores of rupees is required to be spent every year if you go for temporary measures like desilting. You desilt the river and then probably it gets silted up again in another 4 or 5 years, so how many times you can go ahead and then do this desilting or can we find some kind of a permanent solution to this? These are the questions one should ponder.

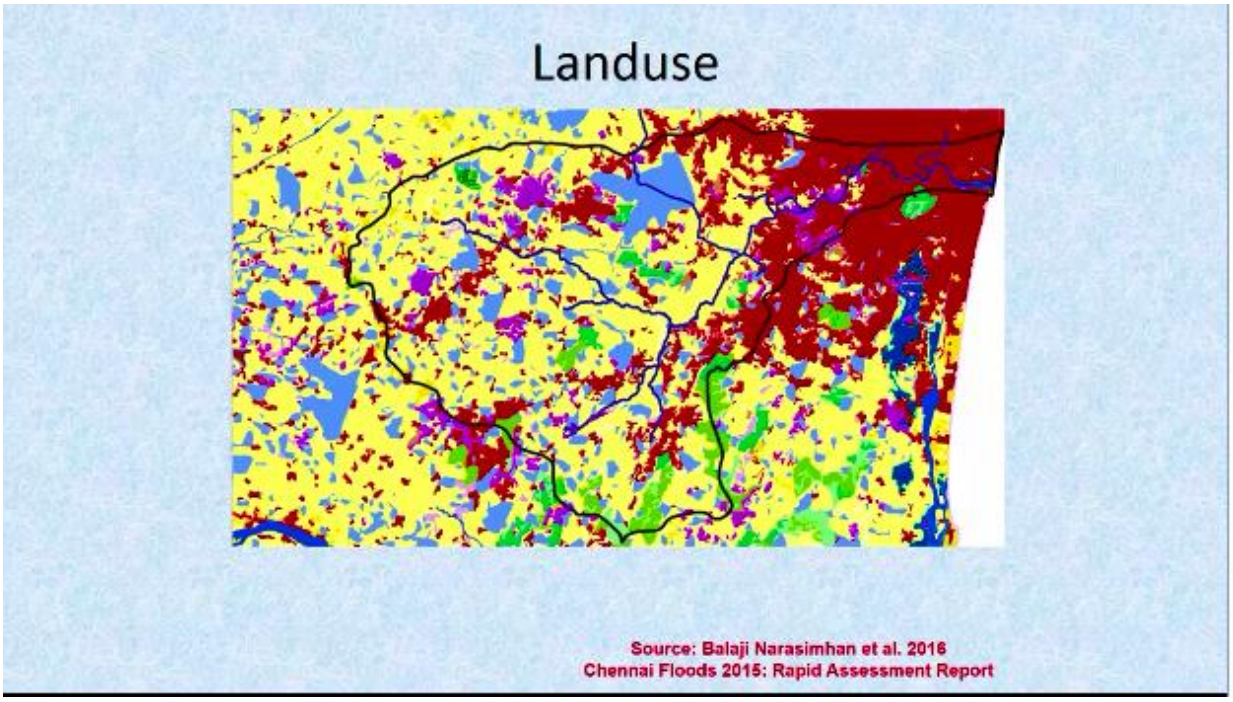


Source: Balaji Narasimhan et al. 2016
Chennai Floods 2015: Rapid Assessment Report

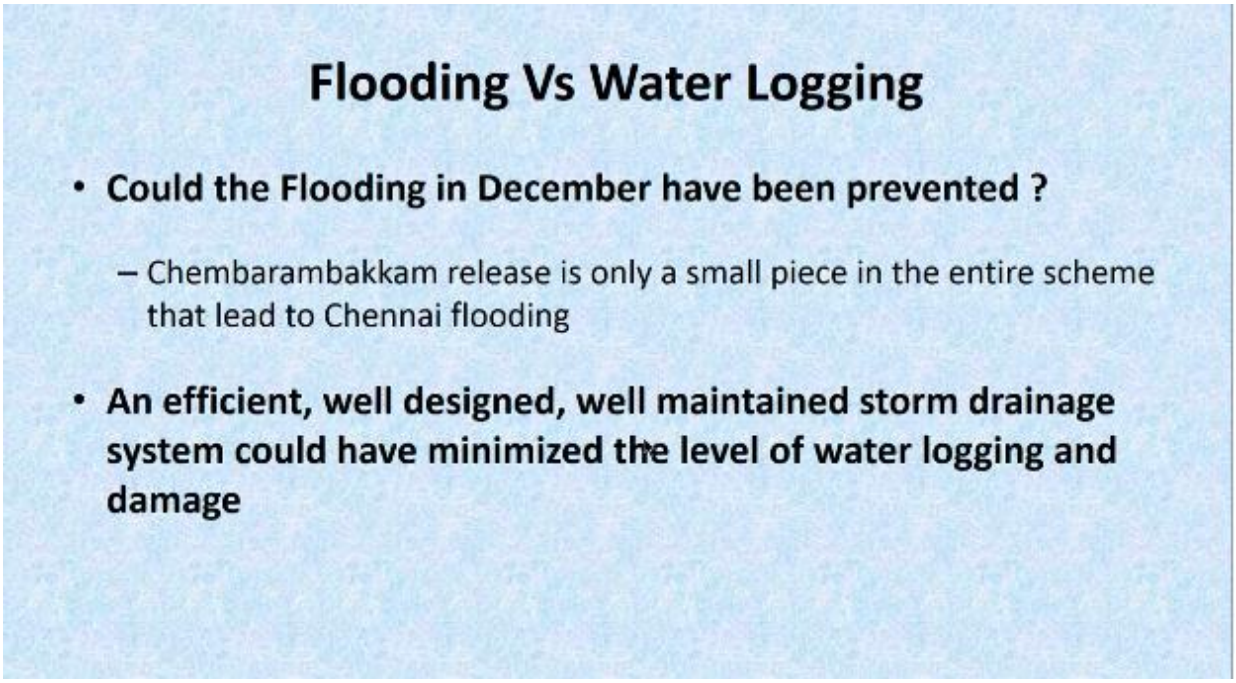
If you look at the floods, normally hydrologists would like to work in terms of what we call rainfall intensity duration frequency curves. Here is, I know at your level you may not be aware of what this rainfall intensity duration frequency curve is, so I will explain a little bit. What it shows here is, what kind of rainfall intensity normally have in a particular area depending upon what is the frequency of occurrence of that particular storm. So, here, if you say there is a 100 year rainfall that means the probability of occurrence of that kind of rainfall is one in 100 years. And then if you have a look at the duration that is how long the rainfall is going to last, that kind of a rainfall is going to last, and then you have what we call the intensity on the other side, this axis. One of my colleagues has done this hydrologic analysis for 2015 floods, in fact here done this rainfall analysis and from the measured rainfall, you find that the rainfall in Nungambakkam, this curve shows for Nungambakkam that is within the city.



Whereas this curve here, it shows the curve for Chembarambakkam. What it is saying here, this picture is there is lot more rainfall in Chembarambakkam area in the upstream areas than within the city. Okay, that means most of the water that has come into the river during the December 2015 floods is because of very high-intensity rainfall in the catchment areas rather than within the city, now that is very crucial for our discussion.



Here, I show a picture of the land use; the red areas show the areas which are highly urbanized which you can see which are in the downstream portions of the river where it is completely urbanized whereas from here this area is not yet urbanized as much as, as compared to the areas here. The land use pattern, the change in the land use pattern has a significant effect on the floods. It works this way, there are a lot of this little blue, blue bodies those are the tanks. So, when the rain comes down many of these tanks have to be filled first, and then they have to overflow before the water goes into the river and then gets carried to the downstream side. So, they are acting like springs to take the load of the rain. If there is urbanization, then all these water bodies would, I mean if there is bad urbanization or if we do not control how the urbanization is taking place, all these tanks would disappear. And if the tanks disappear then the spring effect onto the floods will also disappear and then definitely for the same amount of rainfall that you may get one in 30 years, you may have a worse floods in future because lot more water will come into the river. Not only that, when the urbanization takes place, a lot of area gets paved that means whatever the rainfall is falling on this area because it is paved and then it is impervious that rainfall will not go into the ground through infiltration process. So, you have more generation of overland flow or the runoff into the river, and that certainly will increase the frequency of flooding in the river. So, it is very crucial, this area how we allow the development. If we allow uncontrolled development in this area, and we allow the disappearance of these water bodies, then certainly the people here will find that there is an increase in flood frequency, the damage due to the floods will increase here, so whatever we do here we have to keep in mind what is its effect on the downstream side.



Now if you look at 2015 floods, one has to think about whether it is flood or whether it is waterlogging, that is flooding versus waterlogging. We can ask one question, could the flooding in December 2015 have been prevented? Definitely, we say that Chembarambakkam release, what I mean here, there has been a debate where they say a lot of water which has been released from the Chembarambakkam reservoir because that was getting full and one could not have kept the water in Chembarambakkam without breaching. So, a lot of water got released from the Chembarambakkam, so there is a feeling that the releases from Chembarambakkam could have caused this floods in 2015 December, as per our analysis we feel that Chembarambakkam release is only a small piece in the entire scheme that lead to Chennai flooding in 2015.

An efficient, well designed, well-maintained storm drainage system could have minimized the level of waterlogging and damage. A lot of flood, a lot of water that we have seen during that period may not have come from the Adyar River or overflowing of the Adyar River; it is more so because the rain water which has fallen in those areas could not be drained easily and so, there was a water logging.

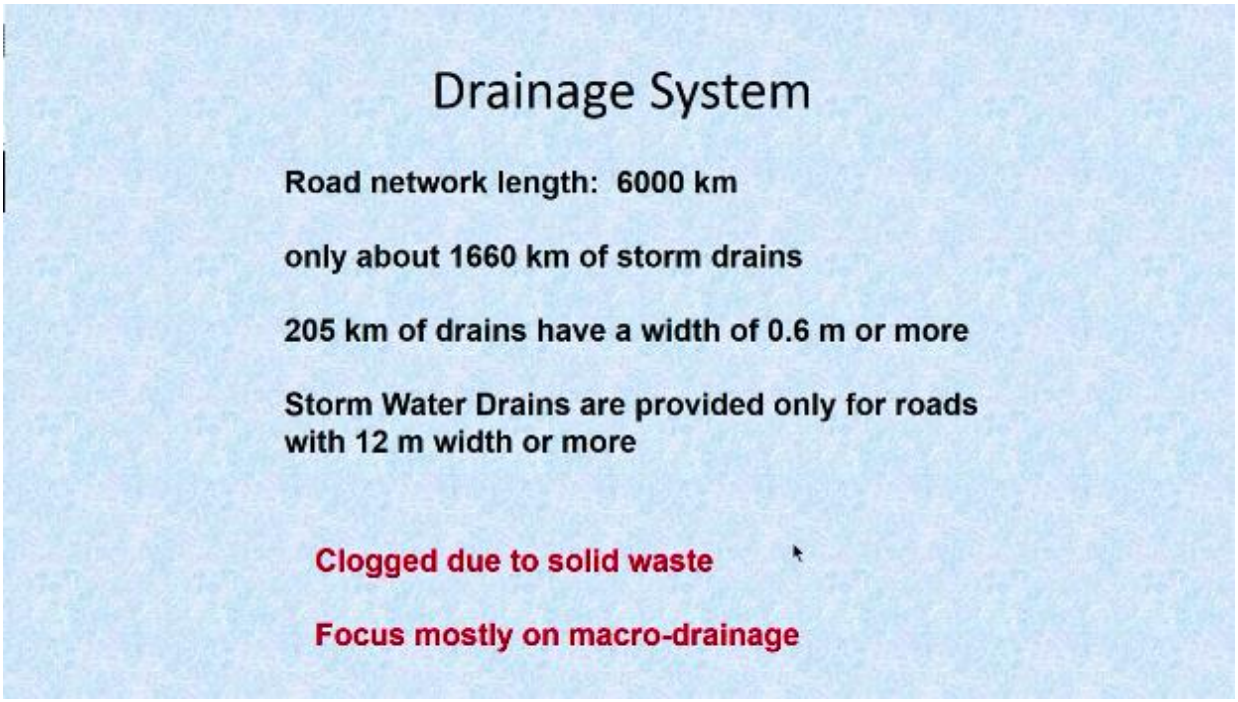
Source: Balaji Narasimhan et al. 2016
Chennai Floods 2015: Rapid Assessment Report

Drainage System

- Insufficient coverage with storm water drains
- Lack of Proper connectivity
  - **Linkage to major canals and waterways**
- Insufficient capacity
  - **Original design intensity of 31.39 mm/h**
    - 1hr storm duration and 2yr return period
    - Seems very less based on the IDF curve
      - **Should have been > 50 mm/h**
    - Revised to 68 mm/h in 2014 (new drains)

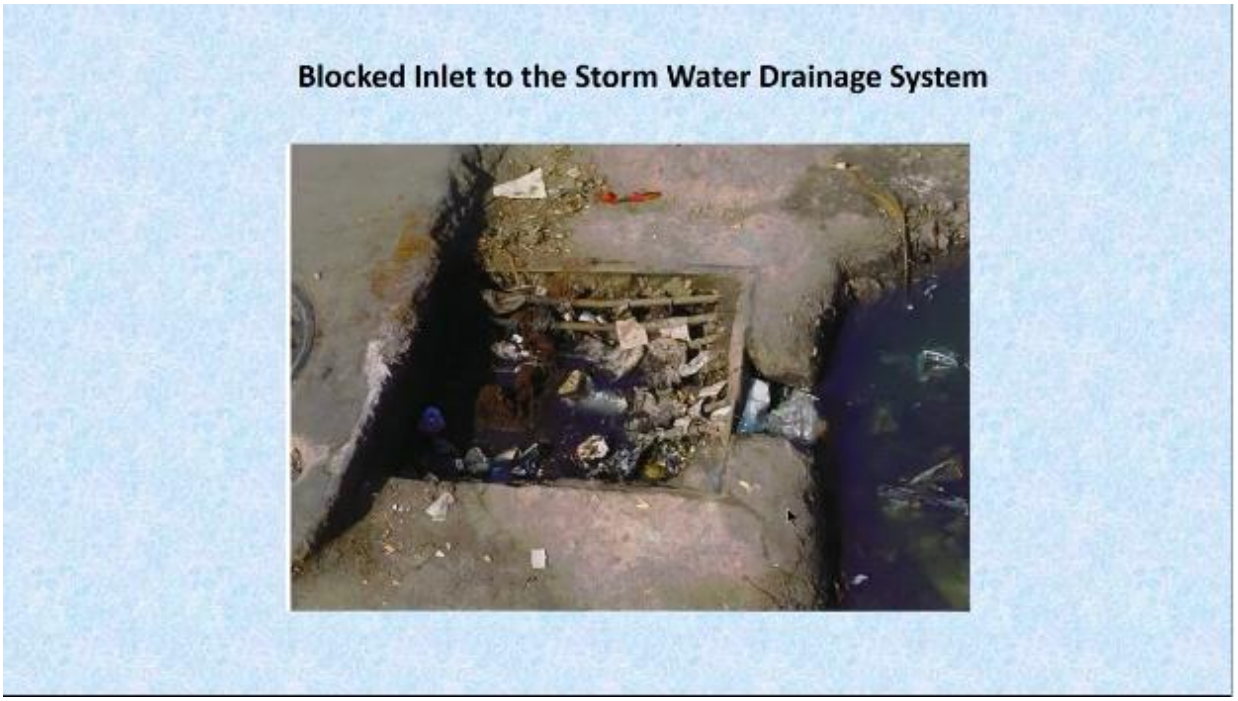
And we have here a picture of storm water drainage system that I am showing; we have an insufficient coverage with storm water drains in the city. There is lack of proper connectivity, there is, linkage to major canals and waterways from many areas is not existent. And many of these drainage channels, okay which are designed and constructed to drain the rainwater, there is storm water drainage system, their original design intensity I mean there they have to be designed for certain rainfall intensity, their original design intensity was only 31.39 millimeters per hour, and they have designed for 1 hour storm duration and 2 year return period. This seems

to be very less. Based on the analysis of intensity duration frequency curves, they should have been, of course, this have been designed quite a while ago, they should have been designed for more than 50mm per hour. In fact, in 2014 there has been a revision by the government, the government has revised the design intensity to 68 millimeters per hour but this is only meant for all the new drains, and the question arises what do we do with the old ones? How do we retrofit them?



Another thing road network length is about 6000 kilometers, but we have only 1660 kilometers of storm drains, there is 205 kilometers of drains have a width of 0.6 meters or more only 205 kilometers of drains. You look at this number 6000 kilometers here. We need 6000 kilometers whereas only about 1660, okay 1660 kilometers of storm drains are there and out of this only 205 kilometers of drains have a width of 0.6 meters or more. Now, stormwater drains are provided only for roads with 12-meter width or more, there is a focus mostly on the macro-drainage, there is not much attention paid to the micro drainage, and many of the drains are clogged due to solid waste.

I will show you some pictures. This is a feeder drain which is clogged with solid waste. Definitely this kind of a drain, this kind of canal or a channel will not be able to drain the area very easily and will lead to waterlogging.



This is another one, here you see this is an entry point to the drainage system, and this entry point to the drainage system again is clogged due to a lot of solid waste. So, how do we expect during the heavy, intense rainfall events, the rainwater will actually go through this into the

storm drainage system and then drain off. Which also brings to the point that it is not just the design and construction of this drains but the maintenance of this drains is very important. It is not only the maintenance of the drains is very important, but if we are trying to solve the drainage problem or the storm drainage problem of Chennai city, then we also need to solve the problem of the solid waste. Without solving the problem of solid waste or without having a proper solid waste management in practice, we will find ourselves in this kind of a situation again.

Thank you