# Urban Hydrology

ES-206 seminar


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# Hydrology

Hydrology is the science that encompasses the occurrence, distribution, movement and properties of waters of the earth and their relationship with the environment within each phase of hydrologic cycle.

# Urban hydrology

- Is the scientific application of hydrologic principles and knowledge to the planning and management of urban areas and their surroundings.
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- It embraces all aspects of the interactions of man and water in occupancy of land.

- It includes special hydrologic studies needed to accomplish these ends and deals with *minimizing* the adverse effects of man's use of land and water and with *maximizing* the effective use of the available water resources.

# Urban Hydrology, Need of India

- As per the United Nations report in the year 2025 more than three fifth of the world population will live in urban areas (United Nations 1993). India is urbanizing at an unprecedented rate.

- Typically level of urbanization in India increased from 27.81% in 2001 to 31.16% in 2011 (Census India, 2011).

- Urban population growth is much faster compared to rural population growth; on the other hand, rural population growth is declining compared to urban population growth and the challenges of urbanization are increasing day by day.

# Increasing population and its effects on water systems

- In Indian cities and towns, large habitations are coming up in the low-lying areas, often encroaching over drainage channels. In some cases, houses are constructed even on top of nullahs and drains.

- In the absence of a proper sewerage system, most of the habitations discharge their sewage into the existing channels. The net result has been that the width of the natural drainage channels has become inadequate and the capacity for draining the rainwater has been greatly reduced.

- Moreover, urbanization leads to increase in impervious an area which, in turn, significantly increases the rate of runoff, resulting in overwhelming of designed capacity of the storm water drainage system. As a result of all these happenings, even small amounts of rainfall can cause urban flooding.

# Statistical analysis of Urban Hydrology

- All planning and development of urban areas, design of man-made structures and all water management activities in cities should take into account local climatological and hydrological conditions and possible interactions with rural areas around the city. Thus, gathering of reliable and adequate hydrological data is an import task for urban hydrological studies.

- Lack of spatial and temporal rainfall data over urban areas on a real-time basis is a very critical gap in India. Therefore, establishment of local networks for real-time rainfall data has to be accorded the highest priority.

# Statistical analysis of Urban Hydrology

- This will be immensely useful for much improved early warning, resulting in better response and management of urban flooding. Such rainfall data will also enable robust designing of urban drainage infrastructure in future.

- In UK, the recommended rain gauge density for urban areas is 1 ARG per 4 sq km while in Malaysia, it is 1 ARG per sq km. However, the area covered by all 2325 class I, II and III cities in India is about 54274.59 sq km and also total no. of rain gauge stations required to cover all these cities/towns on the basis of 1 per 4 sq km will be about 13569.

# Flooding

- In recent decades increasing trend of urban flooding in India is also demonstrates the need of urban hydrological studies. There has been an increasing trend of urban flood disasters in India over the past several years whereby major cities in India have been severely affected.

- A measure to prevent or reduce the loss of life and property on urbanized parts of flood plains thus becomes an important part of urbanized territory which may be covered in urban hydrological studies. The choice of measures to accomplish this includes structural measures, such as levees, dikes, channel improvement and upstream storage, and non-structural measures such as zoning and building regulations.

# Factors affecting flooding

1. **Meteorological factors**

- Extreme rainfall events
- Cyclonic storms
- Climate change

# Factors affecting flooding

## 2. Hydrological factors

- High tide impending drainage
- Absence of drain network
- Channel cross sectional shape and roughness
- Culverts
- Siltation in drain
- Dam overflows

# Factors affecting flooding

## 3. HUMAN FACTORS

- Land use change increase in runoff
- Construction in floodplain
- Siltation and inadequate nalla cleaning
- Blockage of nalla waterway
- Sudden release of water from dams
- Inadequate inlet arrangement for road side drain
- Inadequate inlet arrange of adjoining drain into nalla

# Flooding

- **Coastal Cities**:As land development increases, runoff discharges to surface water bodies more quickly and for a longer period of time. Because of this change in volume, rate and duration, surface water bodies may be unable to convey the increased flow downstream, which may lead to flooding of nearby areas. In addition, increased flow rates and velocities in water bodies may lead to erosion of stream channels and increased pollution entering water bodies.

# Flooding

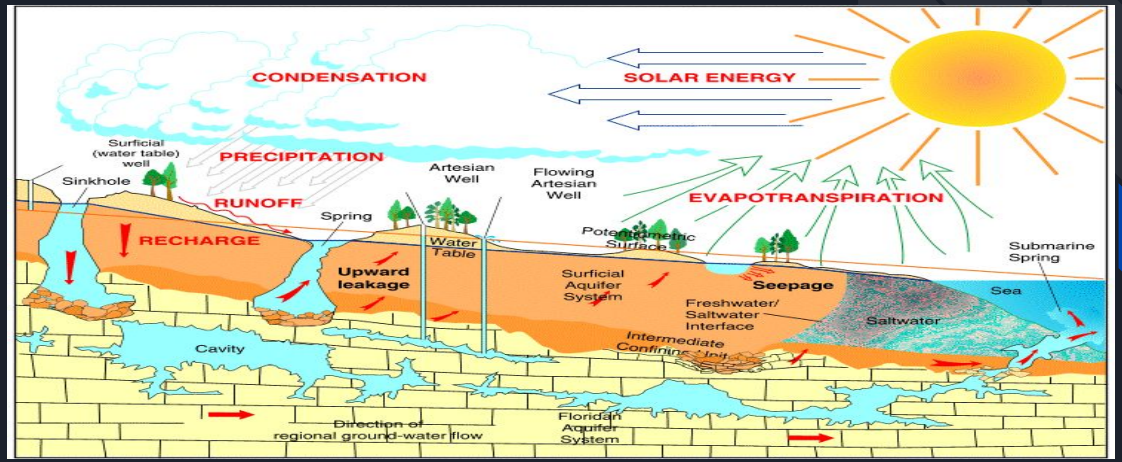
- **Cities near Dams/Reservoirs:** There are cities/towns which are located along a river, either downstream or upstream of dams/ reservoirs.
  Those located downstream of reservoirs can get flooded by release of water in excess quantities.
  Sometimes cities/towns located upstream of a dam/reservoir also get affected by rising level of back waters when release of water is sometimes withheld during the flood season.
  There have been instances when water was released suddenly without appropriate notice, causing severe loss of life and property.

# Flooding

- **Inland Cities:** Cities/towns located inland can experience floods largely because of localized heavy rainfall within the watershed due to overwhelming of the storm water drainage system capacity.

# Water to Feed Depleted Aquifers

In many locations of Indian urban areas groundwater resources are endangered due to over exploitation and polluted aquifers, therefore urban hydrology may be act for integrated and lasting solution of groundwater depletion problems not only to satisfy running municipal water needs but also to restore depleted groundwater levels. In large cities stormwater is usually an “untapped”' resource conveyed to the nearest surface water body. Instead, it can be used for restoration of groundwater levels. Wastewater can be, after adequate treatment, also used for this purpose.



# Stormwater Management

Storm water runoff is generated when precipitation from rain and snowmelt events flows over land or impervious surfaces and does not percolate into the ground.

As the runoff flows over the land or impervious surfaces (paved streets, parking lots, and building rooftops), it accumulates debris, chemicals, sediment or other pollutants that could adversely affect water quality if the runoff is discharged untreated.

# Stormwater Management

- A variety of new storm water handling and treatment methods have been developed in the world but still water is heavily polluted with domestic sewage, industrial effluents and solid wastes in most of urban parts of India. Only 209 of India's 3119 towns and cities have even partial sewage systems and treatment facilities.

- Consequently many urban rivers have steadily deteriorated in quality although on national scale ambitious projects have been started to reverse this trend.

# Wastewater Management

- Wastewater management is a serious problem in major cities of India.
- The amount of water, which gets into an urban center's system, finally empties out as sewage and drainage water. These pollute both surface and subsurface water resources in the region.
- A very huge quantities of solid waste is generated by the Indian cities and it is estimated that only 60% of it is collected.

# Methods to Prevent Stormwater runoff pollution

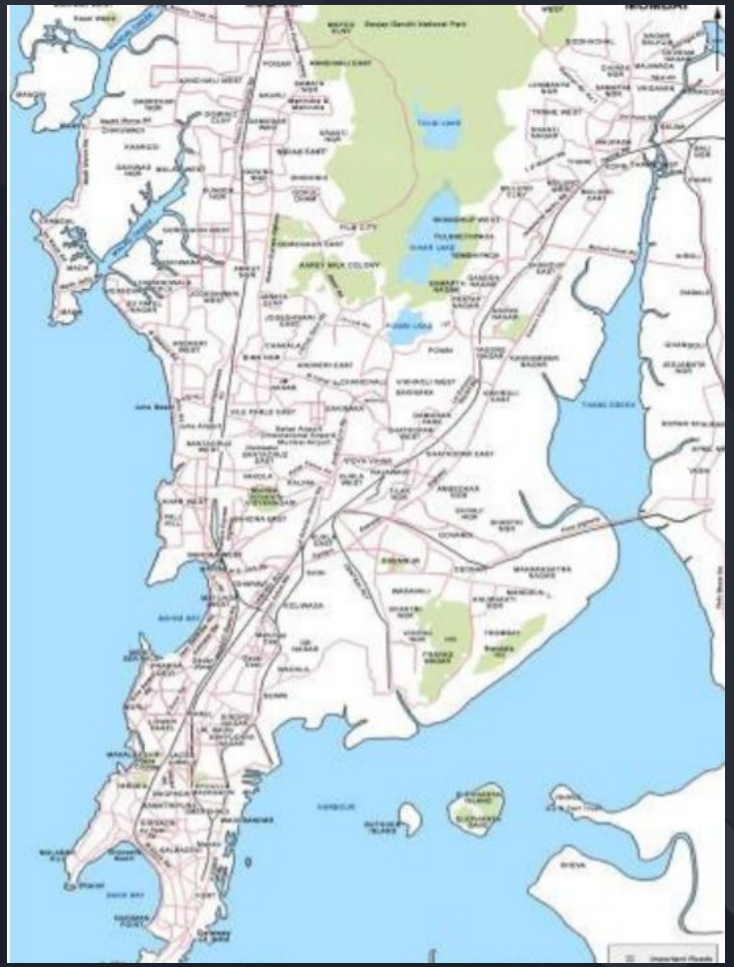
1) Never dump anything down a storm drain
2) Keeping cars tuned up
3) Recycling used oil
4) Avoid usage of pesticides
5) Avoid over watering yards
6) Having awareness of our surroundings
7) Never wash cars in driveway

# Example

# Mumbai Floods

# Mumbai Floods - A glimpse of complexity

- Mumbai - originally a group of 7 islands; many reclaimed areas are just 5 mtrs above low tide sea level
- Area- 437 Sq.Km; Population-12 Million (2001); Population density - 29000 per sq-km
- Mithi river dividing the city, the western & the eastern suburbs can cause floods
- The ratio of > 75 mm rainfall days to flooding days increased from 1:7 to 1.5:1 during the last sixty years
- Sea level rising by 3 mm every  year



# Measures taken to avoid Flooding

1. **Storm Water Drainage :**

a. Widening and deepening of existing water channels and causaways
b. Moderating the river course by replacing existing sharp bends with longer gentler bends

2. **Actions by MCGM:**

a. Operates a control room - the Main Centre of Communication
b. MCGM has installed 60 automatic rain gauges at 58 locations. These Gauges give an audible alarm if rainfall intensity exceeds 10 mm in 15min.

# Measures taken to avoid Flooding

3. **Actions by State Government:**
   a. Active traffic management / diversion when roads are waterlogged
   b. 288 retaining walls in 74 places have been undertaken by the Slum Improvement Board
4. **Actions by Government of India:**
   a. Hon'ble Prime Minister sanctioned a special grant of Rs. 1200 crores outside the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) as 100% subsidy
   b. The work involves widening of drains and construction of pumping stations

# Lessons Learnt from Mumbai Floods

- Sustainable and meticulously planned growth is key. Expert reports must be prepared for future planning
- Shift from conventional / reactive approach to strategic approach is necessary.
- Contour mapping of city required for better storm-water management
- Create public awareness about warnings, teach people how to react and ensure self help grooming; collaborate with NGOs
- Effective communication is key. It can make or break the response measures

# Conclusion

- One of the biggest problems of most of the urban areas of India is the unplanned urban expansions and land use patterns.Effective measure should be taken to minimize the population growth rate.

- Networks of monitoring stations equipped with rain gauges capable of measuring short-term rainfall and runoff gauging as well as water quality monitoring stations in all urban areas should be established and it may be operated by local body.

- Many developed and developing countries have adopted the option of recycling and reuse of wastewater for agricultural and non-potable purposes. Same practices must be encouraged and facilities for recycling of wastewater should be built to minimize the pressure on groundwater resources.