

Contamination of Storm Water and Pollution of water bodies



Dr. L N Thakural
Scientist
National Institute of Hydrology
Roorkee

STORM WATER MANAGEMENT IN URBAN AREAS
22-24 FEBRUARY, 2018

Why Clean Water is Important



Plants and Smaller Organisms



Fish



Waterfowl



Wildlife



Livestock

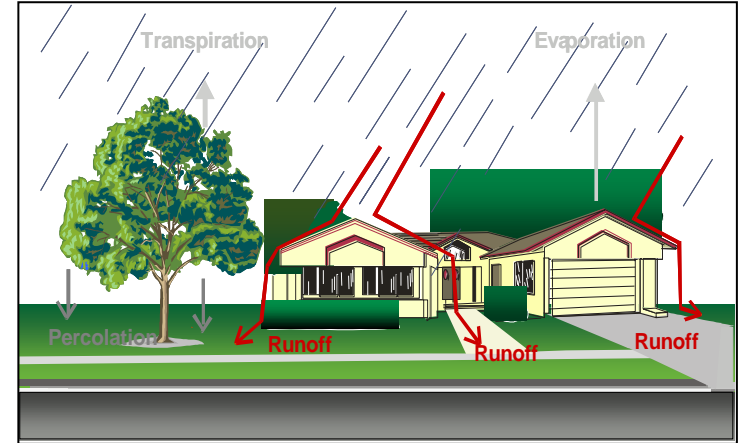


People

All these life forms depend on clean water for their existence

STORM WATER

- Stormwater: untreated water created from rain or melting snow that does not soak into the ground, but runs into nearby waterways.
- Storm water does not flow into a wastewater treatment system, it flows directly into our surface waters
- As the storm water flows on, it picks up and carries many substances that pollute it
- It affects our quality of life, our fisheries, and our recreation.



Storm Water (precipitation and Snow/ice melt)

soak into the soil
(infiltrate),

be held on the
surface and
evaporate

runoff and end
up in nearby
streams, rivers,
or other water
bodies

Natural landscapes



soil absorbs much of the stormwater
and plants help hold stormwater close
to where it falls

Developed Environment

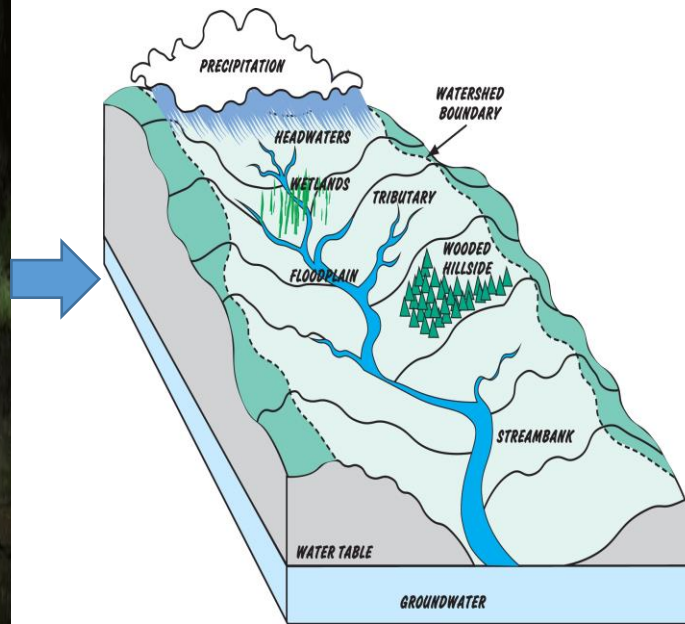


Major issues
Flooding and Water pollution

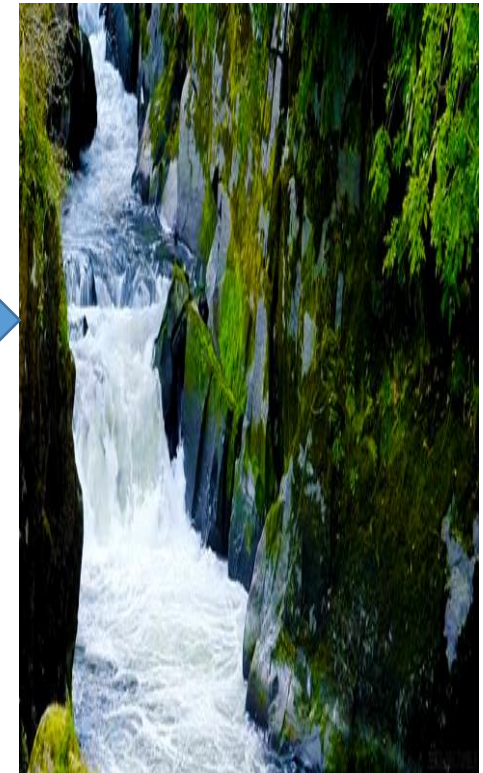
Rainfall-Runoff Modelling



Rainfall
(input variable)



Watershed as a hydrological system
(Physical, Chemical, Biological
processes)

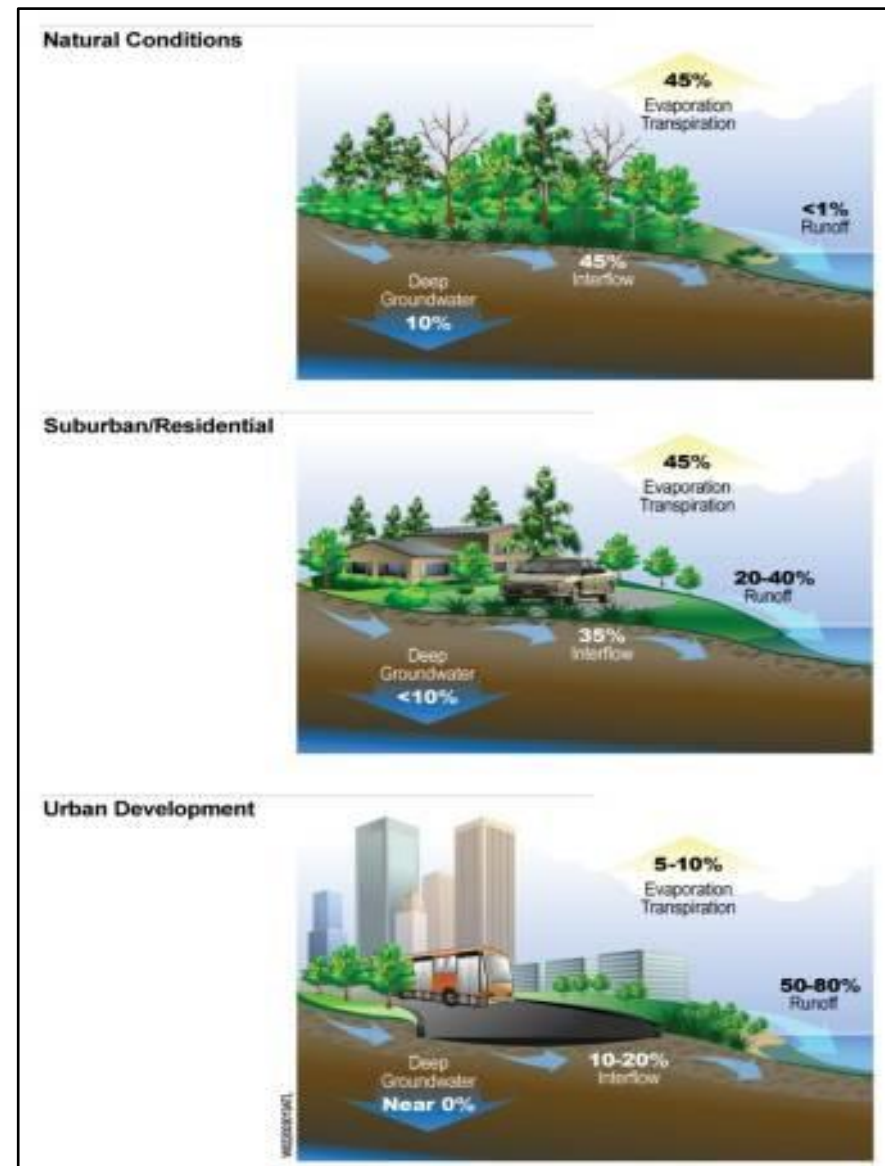


Streamflow
(Output Variable

Developed Environment: Urbanization

As land is developed:

- Ground is compacted - less water can naturally infiltrate
- Less trees and less evapotranspiration
- MORE stormwater runs off

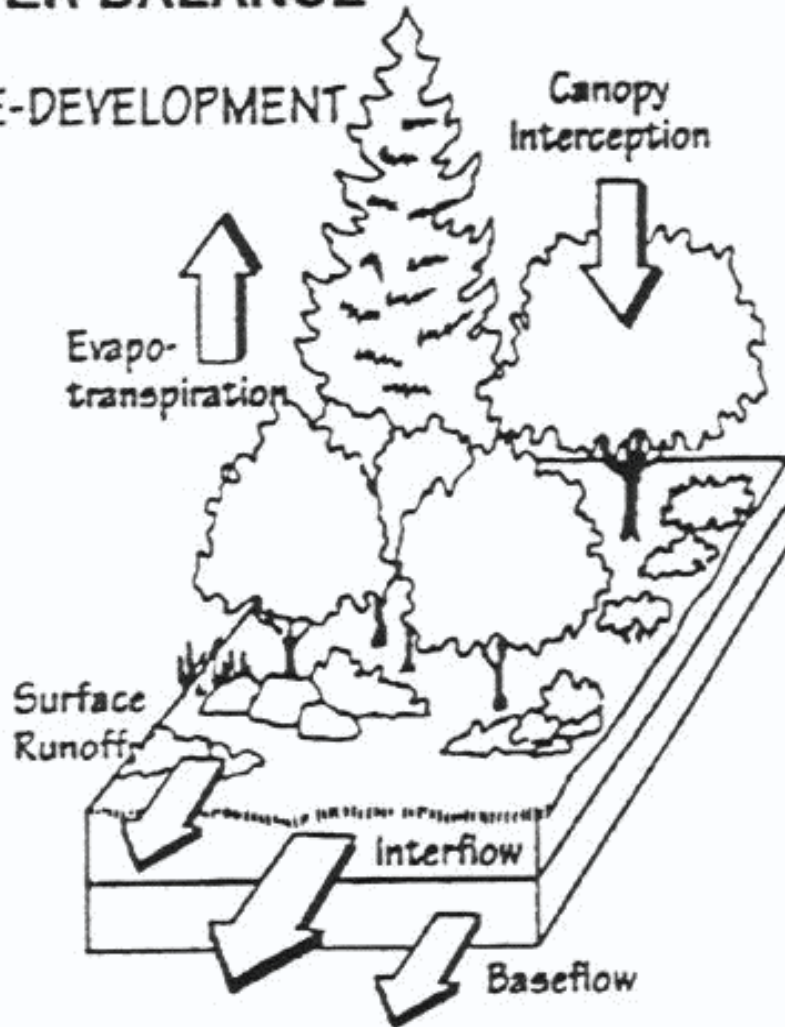


Hydrologic Impacts

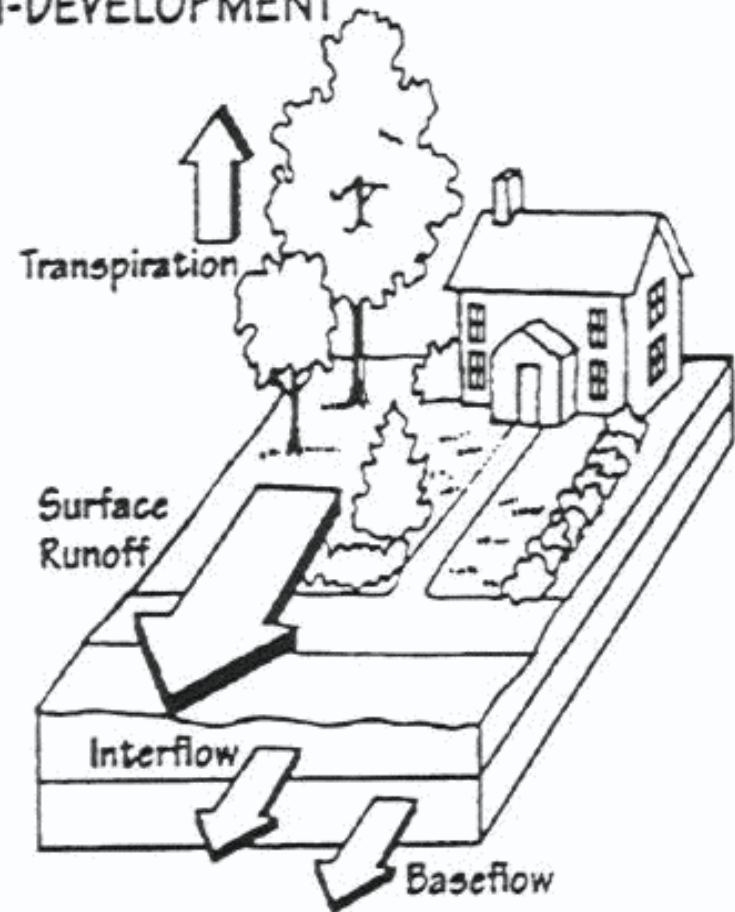
Rainfall / Runoff Relationship

WATER BALANCE

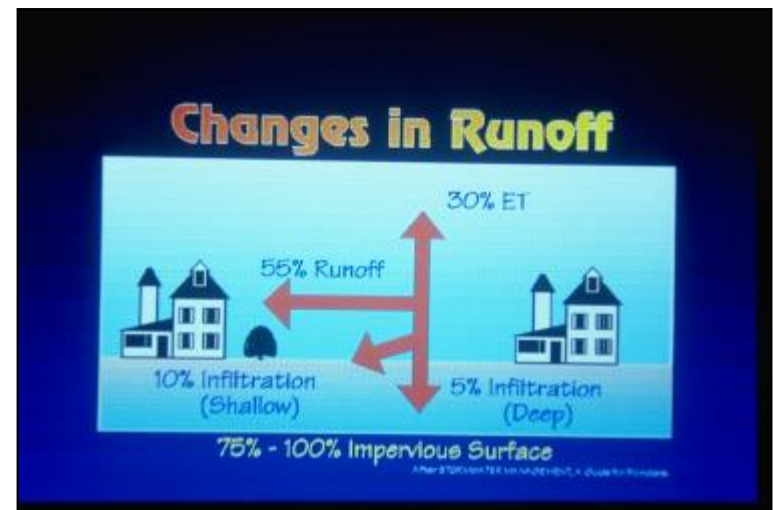
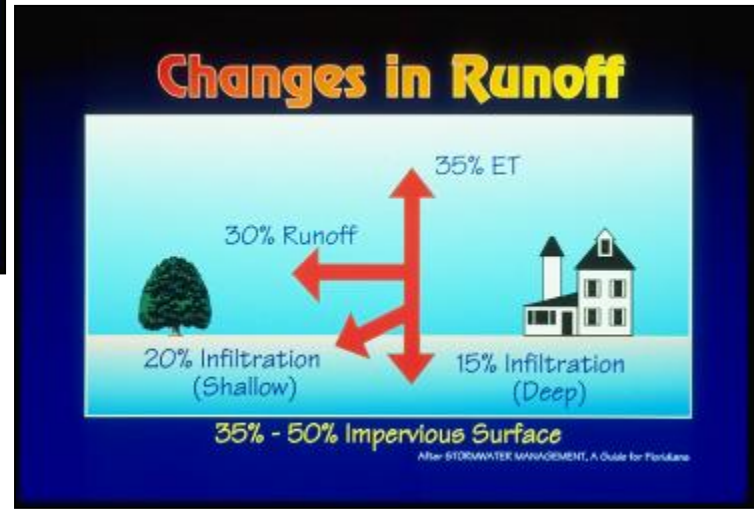
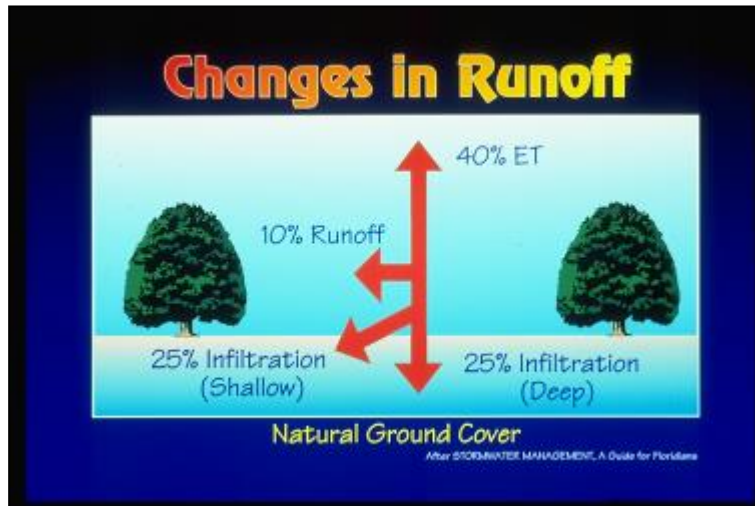
PRE-DEVELOPMENT



POST-DEVELOPMENT

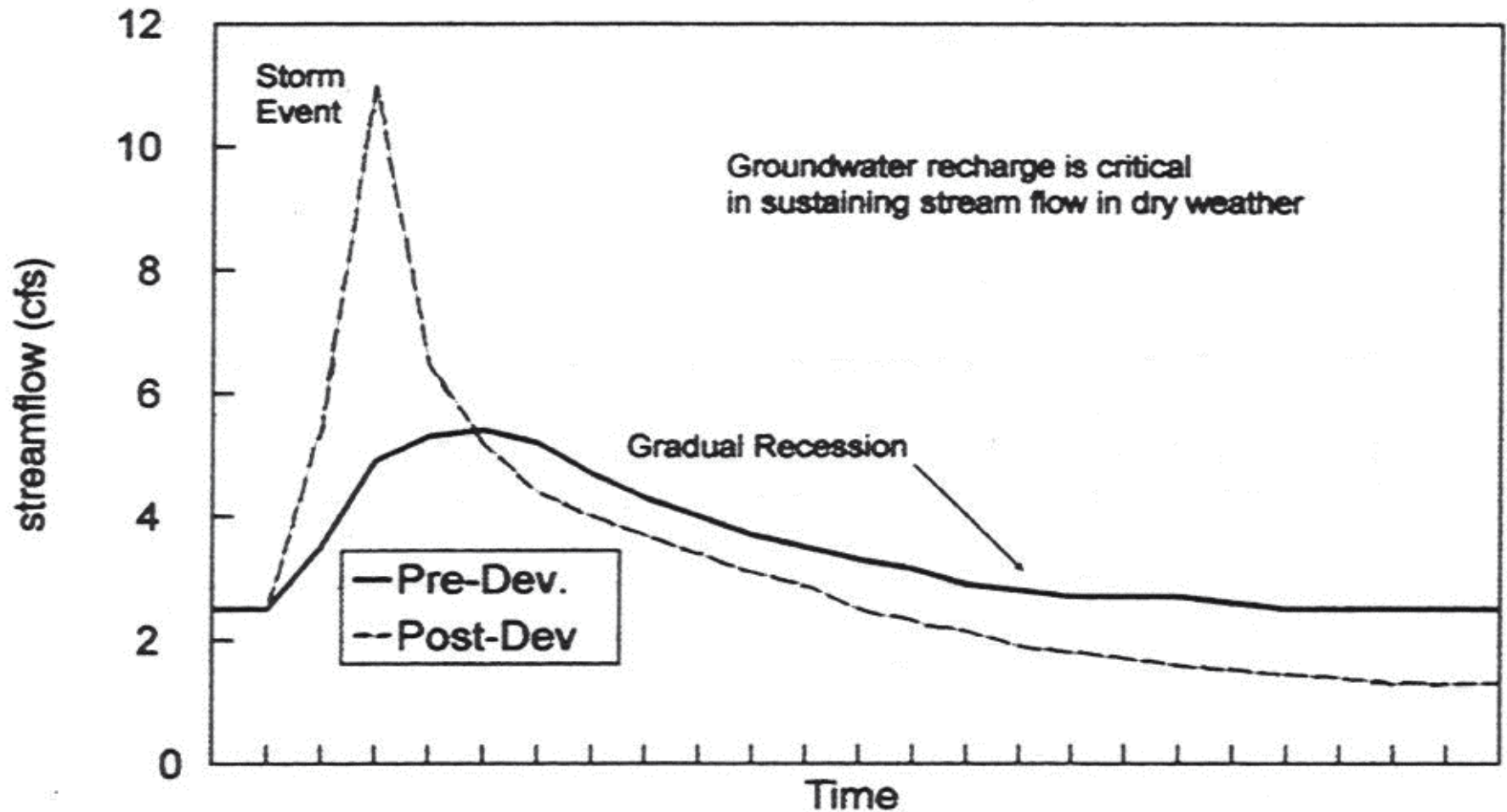


Effect of Imperviousness on Runoff and Infiltration



Arrow lengths indicate increase/decrease

Storm Hydrograph Variation



More Runoff generation : Two major issues



Increase in man-made impervious surfaces, such as roads, rooftops, and parking lots, the volume of stormwater runoff has drastically increased.

- **Flooding:** *Stormwater deposits sediment that decreases the depth of waterways, further increasing flooding.*
- **Pollution:** *runs off collects pollutants (Nutrients/Metals/others)*

Three main type of stormwater pollution

- *litter — cigarette butts, cans, food wrappers, plastic bags or paper*
- *‘natural’ pollution — leaves, garden clippings or animal faeces*
- *chemical pollution — fertilizers, oil or detergents.*

Urban Flood

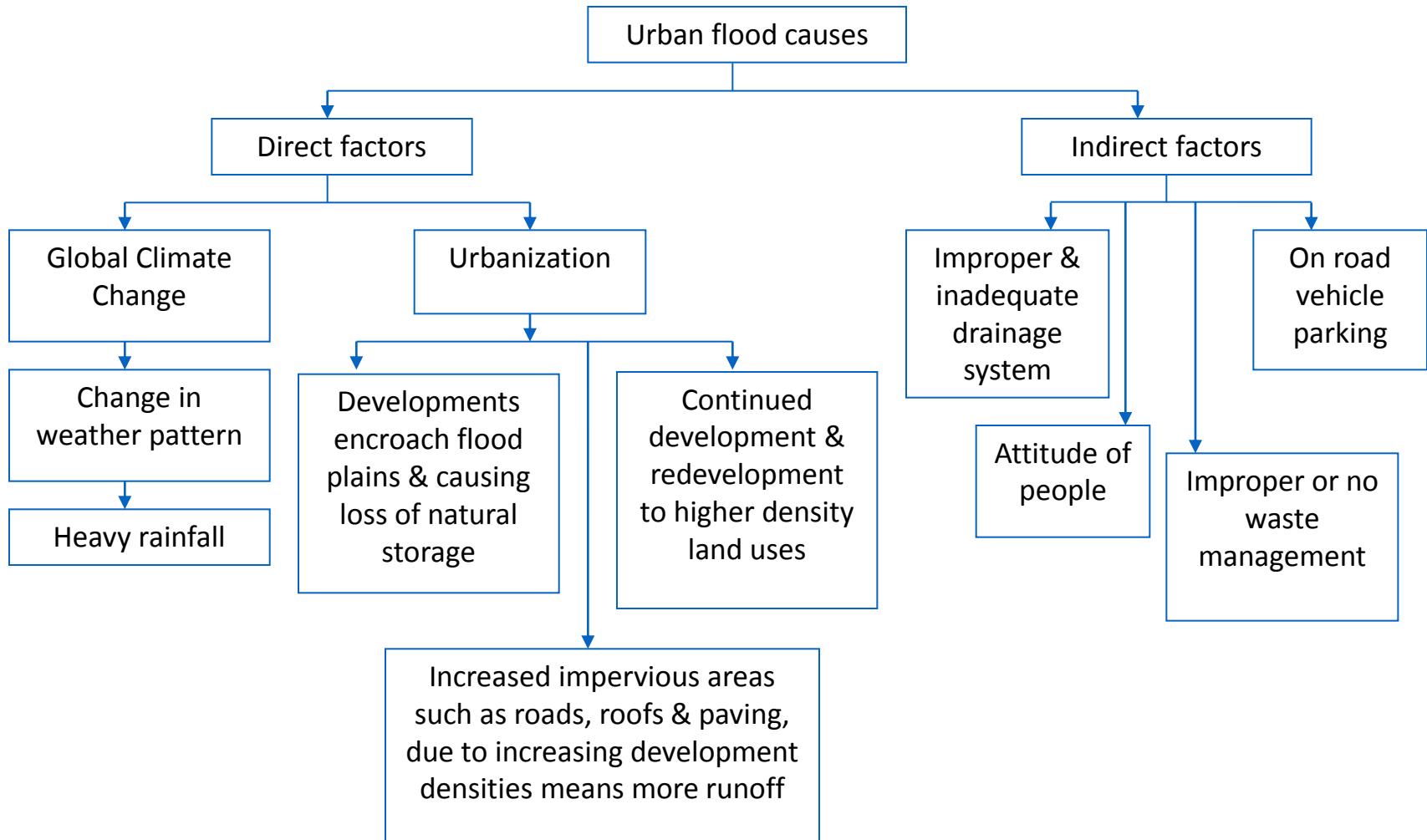
common & annual event in Indian cities

Reasons are

- Rapid urbanization and uncontrolled development
- encroachment of the flood areas
- Inadequate drainages
- absence of proper regulations & maintenance.



CAUSES OF FLOODS IN URBAN AREAS



Pollution



Oil spillage in a water body



Solid waste in a water body

Poor condition of a Pond near Roorkee



Deteriorated Quality of water



Sources of Pollution

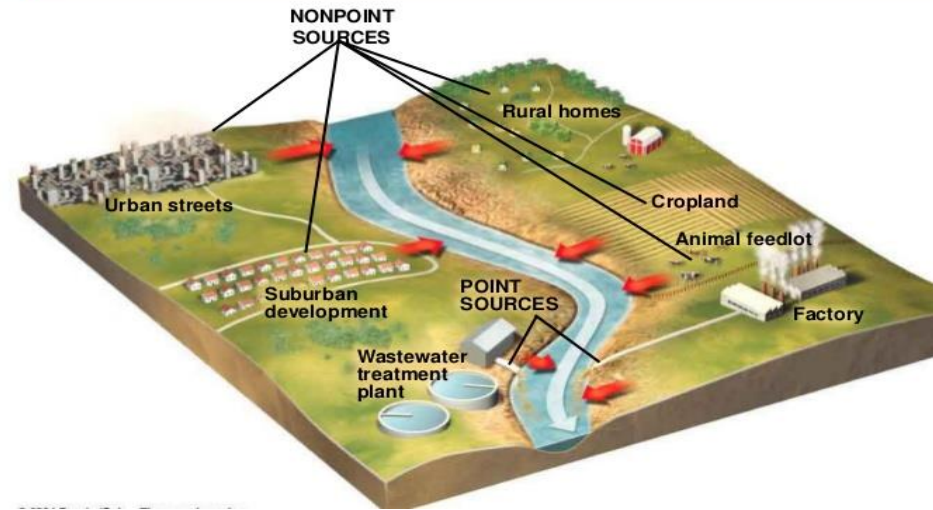
Point sources

- A point source is a single, identifiable source of [pollution](#) such as a pipe or a drain.
- Industrial wastes are commonly discharged to rivers and the sea in this way.
- High risk point source waste discharges are regulated by EPA

Nonpoint sources

- Non-point sources (diffuse pollution)
- occur over a wide area and are not easily attributed to a single source.
- They are often associated with particular land uses
- Urban land use: rainfall-runoff
- Agricultural land use: pesticides, fertilizers in runoff
- Forestry land use: sediment runoff

Sources of Water Pollution



Pollutants associated with urban runoff

Potentially harmful pollutants associated with urban runoff

- **Solids**
- **Oxygen-demanding substances:** Food waste and dead plant and animal tissue
- **Nitrogen and phosphorus:**
- **Pathogens**
- **Petroleum hydrocarbons**
- **Metals**
- **Synthetic organics**

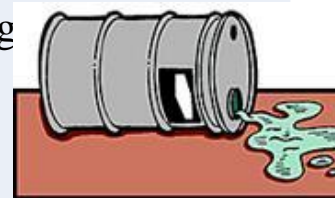
These Solids, Sediment and Floatables pollutants degrade water quality when exceeds standard criteria



Designated Best Use Classification of Surface Water

Designated Best Use	Quality Class	Primary Water Quality Criteria
Drinking water source without conventional treatment but with chlorination	A	Total coliform organisms (MPN*/100 ml) shall be 50 or less pH between 6.5 and 8.5 Dissolved Oxygen 6 mg/L or more, and Biochemical Oxygen Demand 2 mg/L or less
Outdoor bathing (organized)	B	Total coliform organisms (MPN/100 ml) shall be 500 or less pH between 6.5 and 8.5 Dissolved Oxygen 5 mg/L or more, and Biochemical Oxygen Demand 3 mg/L or less
Drinking water source with conventional treatment	C	Total coliform organisms (MPN/100 ml) shall be 5000 or less pH between 6 and 9 Dissolved Oxygen 4 mg/L or more, and Biochemical Oxygen Demand 3 mg/L or less
Propagation of wildlife and fisheries	D	pH between 6.5 and 8.5 Dissolved Oxygen 4 mg/L or more, and Free ammonia (as N) 1.2 mg/L or less
Irrigation, industrial cooling and controlled disposal	E	pH between 6.0 and 8.5 Electrical conductivity less than 2250 micro mhos/cm, Sodium Absorption Ratio less than 26, and Boron less than 2 mg/L

Contaminants in Urban Stormwater Runoff

Pollutant	Effect	Source
Toxic organics	Can poison living organisms or damage their life processes.	<ul style="list-style-type: none"> • Pesticides • Herbicides • Spillage, illegal discharge • Sewer overflows, septic tank leaks
Heavy metals	<p>Poison living organisms or damage their life processes in some other way.</p> <p>Persist in the environment for a long time.</p> <p>Eg: mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (Tl), and lead (Pb).</p>	<ul style="list-style-type: none"> • Atmospheric deposition • Vehicle wear • Sewer overflows, septic tank leaks • Weathering of buildings, structures • Spillage, illegal discharges
Gross pollutants (litter and debris)	<p>Unsightly.</p> <p>Animals can eat and choke on this material.</p>	<ul style="list-style-type: none"> • Pedestrians and vehicles • Waste collection systems • Leaf-fall from trees • Lawn clippings • Spills and accidents
Oils, detergents and shampoos (surfactants)	<ul style="list-style-type: none"> • Carcinogenic and toxic compounds in water that are sourced from asphalt runoff • Highly toxic to fish and other aquatic life. 	<ul style="list-style-type: none"> • Asphalt pavements • Spillage, illegal discharge • Leaks from vehicles • Car washing • Organic matter
Increased water temperature	<p>High temperatures are lethal to fish and other aquatic organisms.</p> <p>Increased water temperatures stimulate the</p>	<ul style="list-style-type: none"> • Run-off from impervious surfaces • Removal of riparian vegetation

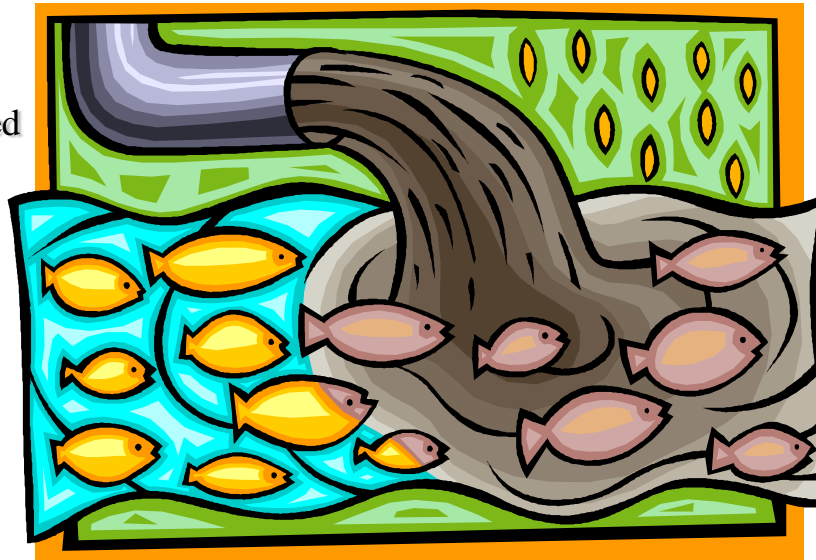


Pollutant	Effect	Source
Sediment	<p>Reduces the amount of light in the water available for plant growth, decreasing the supply of food for other organisms.</p> <p>Can clog and damage sensitive tissues such as the gills of fish.</p> <p>Can suffocate organisms that live on or in the bed of lakes and streams by forming thick deposits when the suspended material settles out.</p>	<ul style="list-style-type: none"> • Land surface erosion • Pavement and vehicle wear • Building and construction sites • Spillage, illegal discharge • Organic matter (for example, leaf litter, grass) • Car washing • Weathering of buildings/s • Atmospheric deposition 
Nutrients	<p>An increase of nutrients in water stimulates growth of aquatic plants. This causes excessive growth of aquatic weeds and algae that may choke lakes and streams and lead to dramatic daily fluctuations in dissolved oxygen levels.</p>	<ul style="list-style-type: none"> • Organic matter • Fertilizer • Sewer overflows, septic tank • Animal faeces • Detergents (car washing) • Atmospheric deposition • Spillage, illegal discharge 
Oxygen-demanding substances	<p>Oxygen is used up more quickly than it can diffuse into the water from the atmosphere. The resulting drop in oxygen levels may then kill fish and other aquatic organisms.</p> <p>If all oxygen in the water is used up, can cause unpleasant odours.</p>	<ul style="list-style-type: none"> • Organic matter decay • Atmospheric deposition • Sewer overflows, septic tank leaks • Animal faeces • Spillage, illegal discharges
pH (acidity)	<p>Increased acidity damages plants and animals</p>	<ul style="list-style-type: none"> • Atmospheric deposition • Spillage, illegal discharge • Organic matter decay • Erosion of roofing material
Micro-organisms	<p>Contain very high numbers of bacteria and viruses.</p> <p>Some of these organisms can cause illnesses, including hepatitis and gastroenteritis.</p>	<ul style="list-style-type: none"> • Animal faeces • Sewer overflows, septic tank leaks • Organic matter decay

Stormwater Management

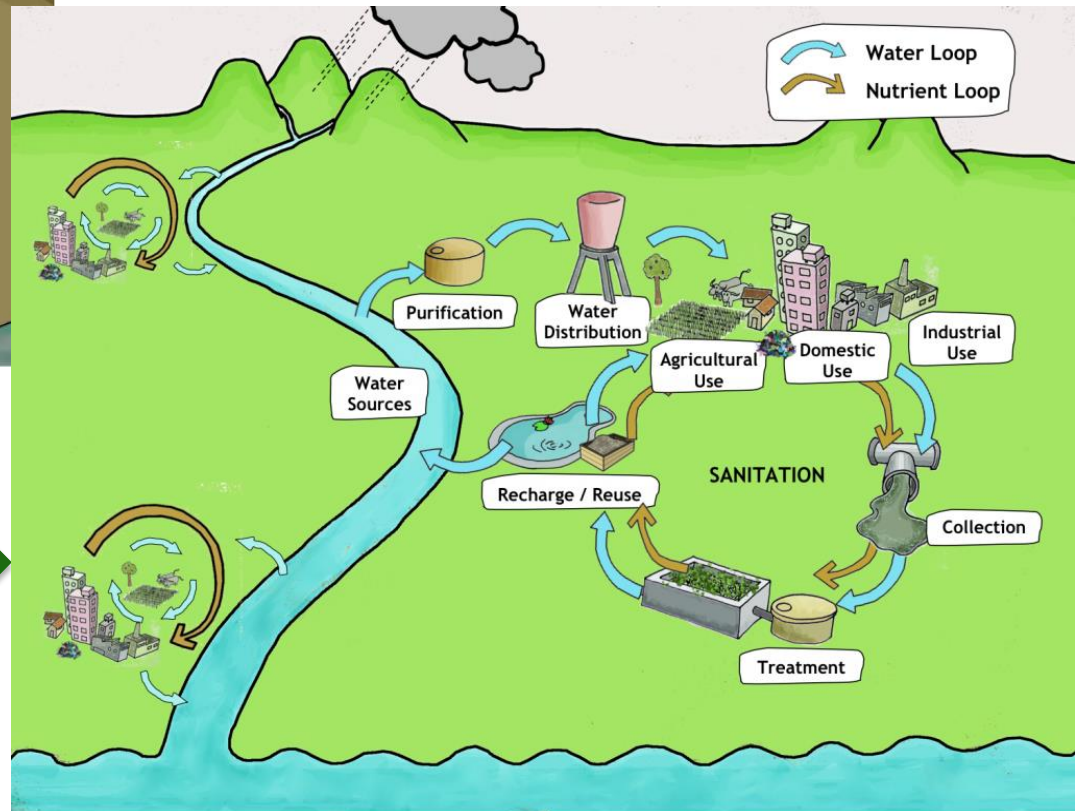
- Stormwater Quality – “how good”
- Stormwater Quantity – “how much”

Quantity is directly related
to ...



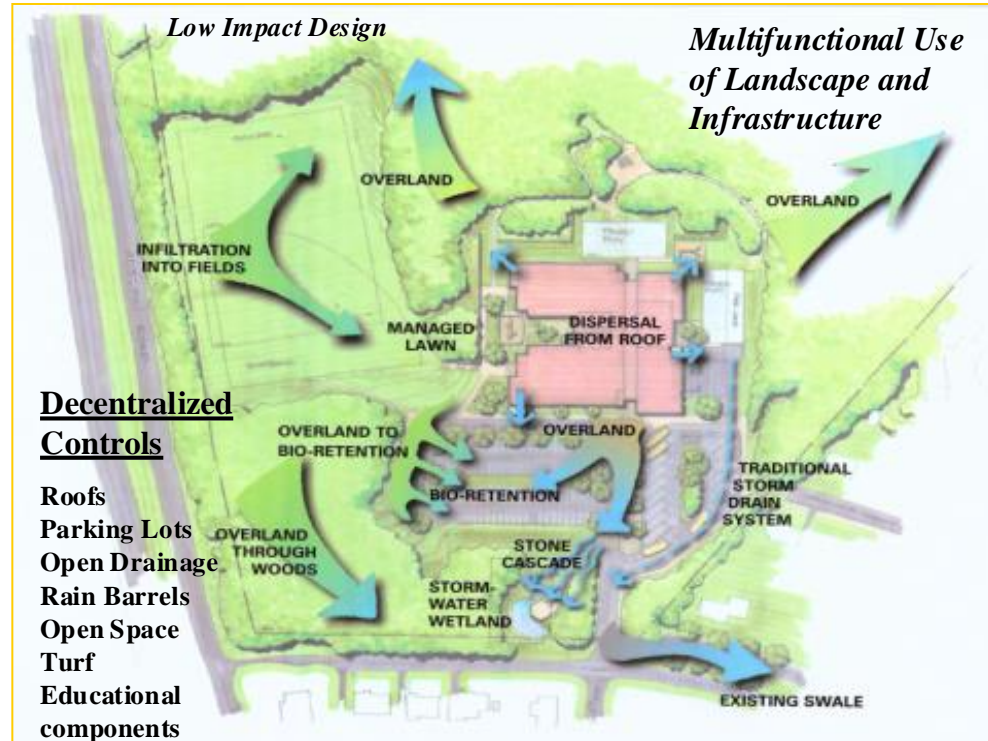
Quality

- Storm water Management helps to collect, treat and (re-) use runoff water; to avoid contamination and destruction; and to restore the disturbed urban water cycle!



1-Site Planning and Design

- Minimize clearing, grading
- Save permeable soils
- Limit lot disturbance
- Soil Amendments
- Alternative Surfaces
- Reforestation
- Reduce pipes, curb and gutters
- Reduce impervious surfaces



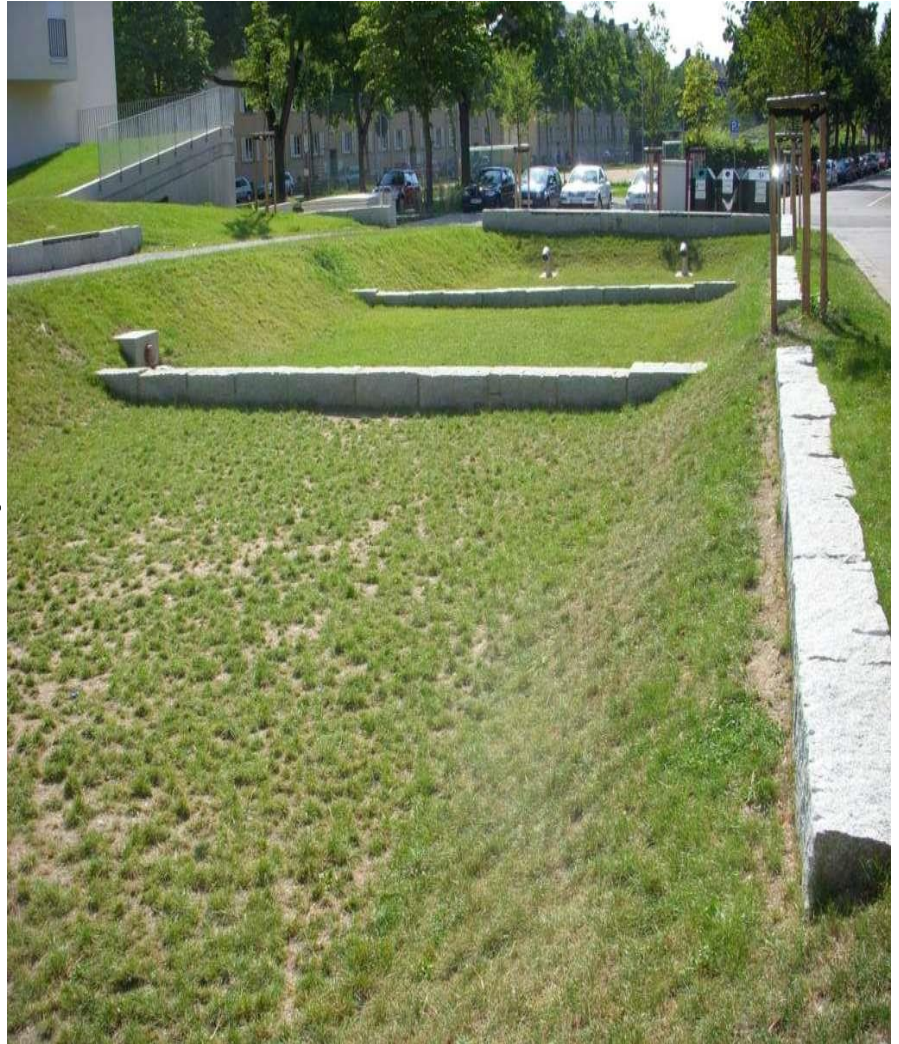
2 Constructed Wetlands

- Description - Constructed basins with a permanent pool of water. Among the most effective stormwater practices. Offer aesthetic value.
- Natural Processes - Settling and biological uptake.
- Applications – Larger scale storm water management facilities



3-Vegetated Swales

- Drainage conveyance facilities designed to slow storm water runoff and allow it to infiltrate into the subsurface
- Natural Process – Slow runoff velocities, infiltration, storage, filtration, biological treatment
- Applications – Drainage conveyance network



4-Bioretenention

- A conditioned planting soil bed and planting materials
- Natural Processes – Filtration, adsorption, biological treatment of runoff stored within a shallow depression
- Applications – Parking lots, streets, residential and commercial landscaping



5-Pervious Paving

- A load-bearing, durable surface with an underlying layered structure. Unobtrusive
- Natural Processes - Temporarily stores water prior to infiltration or drainage to a controlled outlet.
- Application - Residential, commercial and industrial applications are possible. Light vehicle loading in parking areas. . Spatially constrained areas.



Roof Runoff Controls

- Direct roof runoff away from paved areas and direct it to rain barrels, infiltration trenches, and planting areas.
- Natural Process – Storage, infiltration, filtration, biological treatment
- Applications – Residential and commercial roofs



Constructed Wetland Technique

इब्राहिमपुर तालाब का पुनरुद्धार

Design of wastewater treatment facility based on Natural Treatment System

(प्राकृतिक उपचार प्रणाली पर आधारित अपशिष्ट जल उपचार सुविधा का डिजाइन)



Sedimentation in Pond



Weeding Problem due to organic matter



Channelization of inflow



Constructed Wetland Technique



प्रयोगात्मक परियोजना: तालाब का नवीनीकरण (वर्ष 2017-18)
 मुख्य लाभार्थी : ग्राम-इब्राहिमपुर मसाही
 संस्था: राष्ट्रीय जलविज्ञान संस्थान, रुड़की
 (जल संसाधन, नदी विकास एवं गंगा संरक्षण मंत्रालय, भारत सरकार)

सहयोग: ग्राम पंचायत, इब्राहिमपुर मसाही; उप जिला अधिकारी भगवानपुर;
 तहसीलदार भगवानपुर (जिला हरिद्वार)

तालाब की स्थिति नवीनीकरण से पहले



प्रमुख कार्य

1. जलकुंभी एवं अन्य खरपतवारों की तालाब से निकासी एवं निस्तारण
2. तालाब से सिल्ट की निकासी
3. तालाब की बाउन्ड्री की मरम्मत एवं कटीले तारों द्वारा सूरक्षात्मक उपाय
4. गाँव के अपशिष्ट जल के शोधन के लिए कन्स्ट्रक्टेड वेटलैंड पद्धति पर आधारित प्राकृतिक उपचार तंत्र (नैचुरल ट्रीटमेंट सिस्टम) की स्थापना एवं फायटो-रेमेडीयसन बिधि का विकास

शोध कार्य (प्रस्तावित)

1. प्राकृतिक उपचार तंत्र (नैचुरल ट्रीटमेंट सिस्टम) द्वारा अपशिष्ट जल शोधन के लिए विकसित फायटो-रेमेडीयसन बिधि की क्षमता का अध्ययन

तालाब की स्थिति नवीनीकरण के बाद



विशेष अनुरोध: कृपया तालाब में कूड़ा न फेंके और तालाब को स्वच्छ रखने में सहयोग करें।

Water Quality Aspects for Utilisation of Sagar Lake

Study Area

Sagar lake (MP)

- Location :latitude $23^{\circ} 50' N$ and longitude $78^{\circ} 45' E$.
- Catchment area of lake: 1817 ha
- Water spread area : 145 ha

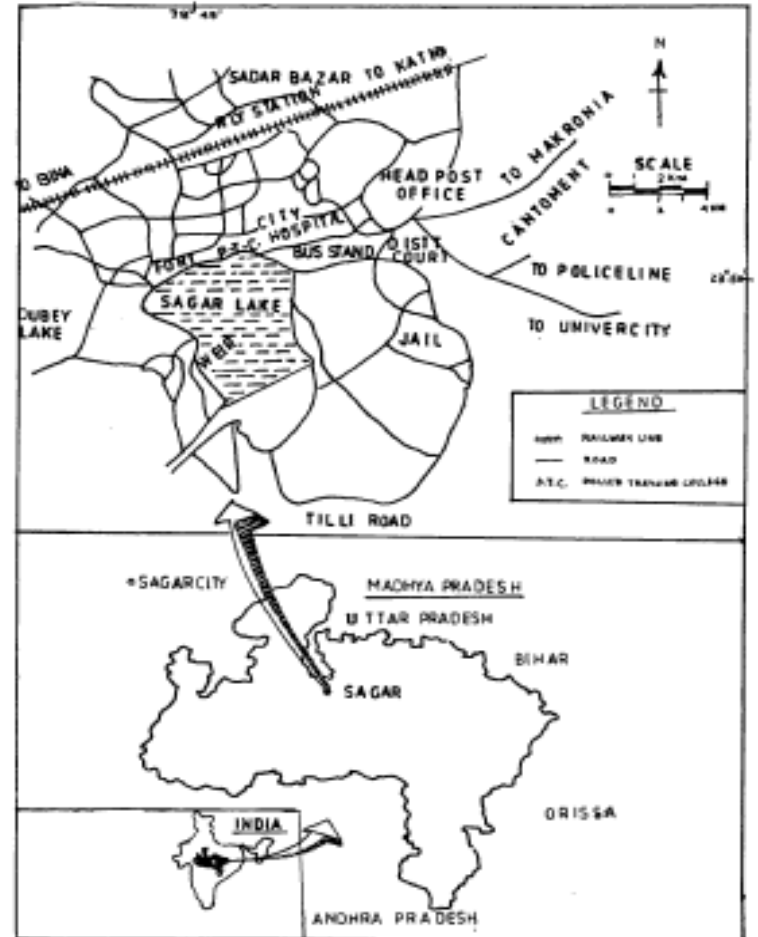


FIG. 1: INDEX MAP OF SAGAR LAKE

Physico-Chemical Properties of Sagar Lake and its significance

Sl. No.	Parameter	Observed Values	Desirable Limit as per standards	Remark
1	Water Temperature (°C)	18.3 – 26.3	--	--
2	Color	Light Green to Greenish	--	Indicates presence of plankton algae
3	Odour	Unpleasant	--	Not acceptable for drinking purposes
4	Total Hardness (mg/L)	115 – 199	< 300	Acceptable for drinking and other purposes
5	Total Dissolved Solids (mg/L)	164 –221	For drinking < 500 For irrigation < 700	Acceptable for drinking and other purposes
6	Chloride Content (mg/L)	26 – 75	< 200	Acceptable for drinking and other purposes
7	pH	7.7 - 9.6	Drinking & bathing - 6.5 to 8.5 Wildlife, Irrigation & waste disposal - 6 to 8.5	Not acceptable for drinking and any other purpose
8	Calcium Content (mg/L)	21-70	< 75	Acceptable for drinking and other purposes
9	Dissolved Oxygen (mg/L)	4.7-11	6 ≥	Not acceptable for drinking and any other purpose
10	Magnesium Content (mg/L)	11- 27	< 30	Acceptable for drinking and other purposes
11	Electrical Conductivity (µmho/cm)	369 – 647	< 750	Good for irrigation
12	BOD (mg/L)	8 – 12	≤ 2	Not Acceptable for drinking and any other purposes
13	Coliform Organism MPN/100 ml	1400-1600	For drinking ≤ 50 For bathing ≤ 500	Not Acceptable for drinking and bathing but can be acceptable for drinking purpose after conventional treatment and disinfect ion

Conclusions

- The color of the Sagar lake water was mostly light green to greenish and indicated the presence of Plankton Algae.
- The water temperature has been ranging between 26.3 °C in summer to 18.3 °C in winter.
- The lake water has always been alkaline due to high pH value.
- The values of BOD, Dissolved Oxygen has been observed beyond the permissible limit, which makes it unfit for drinking purposes.
- Lake water even observed unsuitable for outdoor bathing and wastewater effluent discharge.
- The Electrical Conductivity ranges from 369 to 647 $\mu\text{mho/cm}$, which is found well below the acceptable limit and may be used for irrigation purposes.
- The total Hardness, TDS, Chloride, Magnesium and Calcium contents was found within the acceptable limit. The physico-chemical features suggest a high organic pollution level in Sagar lake water making it unsuitable for potable use and can be utilised for irrigation with proper treatment.



DR. L N THAKURAL
NATIONAL INSTITUTE OF HYDROLOGY
thakuralln@gmail.com

THANK YOU



Water Quality	Level	Effect
Aquatic Weeds or Algae	decrease oxygen levels and increase pH	be harmful to fish, Decomposition of weeds and algae can also lead to oxygen depletion, clog navigable waters
Bacteria - E. coli (Escherichia coli)	bacteria and other organisms	human illnesses from typhoid and dysentery to minor respiratory and skin diseases
Chlorophyll	Elevated chlorophyll	levels indicate excessive inputs of nutrients.
Dissolved Oxygen		can result in severe oxygen depletion.
pH	acidic (pH too low) or alkaline waters (pH too high).	biological processes, such as everyday metabolism and reproduction
Sedimentation	fill in spaces in the gravel	Sediment may clog and damage fish gills
Temperature	temperature exceeds tolerance levels	difficulty obtaining enough oxygen specific conductivity and conductance, salinity, and the solubility of dissolved gases
Toxic Substances	toxic substances may be harmful	affect public health, aquatic life, or wildlife.
Turbidity	high turbidity	a large amount of suspended sediment in a stream.