



Module 7 – (L27 – L30):

“Management of Water Quality”:

Water quality and pollution, types and Sources of pollution, water quality modeling, environmental guidelines for water quality

WATERSHED MANAGEMENT

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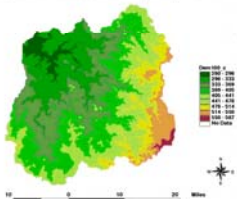
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Lecture No - **27** **Surface Water Quality &
Pollution Issues**

L27– Surface Water Quality & Pollution Issues

- **Topics Covered**
- Water quality, pollution sources, types of pollution, water quality parameters, water quality standards.
- **Keywords:** Water quality, pollution sources, types of pollution, parameters, standards.

Digitel Elevation Model Anas river watershed (Jhabsud), India



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Watershed Management & Water Quality

- Watershed management – Water quantity & quality – Importance
- Assessment & monitoring of water quality – livelihoods of watershed dwellers
- WQ – examination to determine organisms, minerals & organic compounds in water
- Depending on use of water
- Physico-chemical, chemical & microbiological analyses of water
- **Common issues of Surface and Groundwater**
- Pathogenic (Bacteriological) Pollution; Salinity
- Toxicity (micro-pollutants and other industrial pollutants)

Water Quality Standards

- Water quality indicates the physical, chemical and biological characteristics of water.
- It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose.
- It is most frequently used by reference to a set of standards against which compliance can be assessed.
- The most common standards used to assess water quality relate to health of ecosystems, safety of human contact and drinking water.

Water Quality Categories

- **Human consumption-**
 - Drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants.
 - Presence of these contaminants does not necessarily indicate that water poses a health risk.
- **Industrial use**
 - Dissolved minerals may affect suitability of water for a range of industrial and domestic purposes.
 - presence of ions of calcium and magnesium which interfere with the cleaning action of soap, and can form hard sulfate and soft carbonate deposits in water heaters or boilers. Hard water may be softened to remove these ions.
 - Softening may sacrifice nutrition for cleaning effectiveness.

Water Quality Categories

- In the environment.
 - Toxic substances and high populations of certain microorganisms can present a health hazard for non-drinking purposes such as irrigation, swimming, fishing, rafting, boating, and industrial uses.
 - These conditions may also affect wildlife, which use the water for drinking or as a habitat.
- **Irrigation purpose:** Crop production – irrigation water quality requirements
- **Agriculture-** single largest user of freshwater - a major cause of degradation of surface and groundwater resources through erosion and chemical runoff

Water Pollution Sources

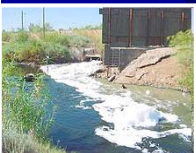
- Water pollution is the contamination of water bodies e.g. lakes, rivers, oceans and groundwater.
- Water pollution occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds.
- Water pollution affects plants and organisms living in these bodies of water.
- The effect is damaging to individual species and populations and natural biological communities.

Water Pollution – Source Types

- Water Pollution – Point or non-point sources
- Water pollution- point sources: contaminants that enter a waterway from a single, identifiable source, such as a pipe or ditch.
- Traced to a specific source
- Leaking chemical tank, effluents coming from a waste treatment or industrial plant, or a manure spill from a hog confinement lagoon

Examples

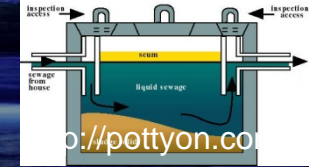
- discharges from a sewage treatment plant; a factory; a city storm drain; municipal storm sewer systems; industrial storm water, such as from construction sites



Water Pollution - Source Types

- **Water pollution- non point sources**
 - Non–point source pollution (NPS)- contamination that does not originate from a single discrete source.
 - NPS pollution is the cumulative effect of small amounts of contaminants gathered from a large area.
 - Pollutants will come from wide spread area
 - They can't be tracked to a single point or source
 - **Examples: Soil erosion, chemical runoff, animal waste pollution**
 - leaching out of fertilizers/ nutrients agricultural lands.
 - Nutrient runoff in storm water- agricultural field/ forest.
 - Contaminated storm water washed off of parking lots, roads and highways, called urban runoff,





Water Pollution – Specific Sources

- **Septic systems** - Use a large tank buried in the ground to contain and break down household sewage; Fats, oils, and grease as well as large waste particles, are stored and later pumped out of the holding tank; source of concern for groundwater pollution & surface water pollution
- **Lagoons:** shallow holding pits into which wastes are pumped and treated; Water Quality Problems: Poorly constructed lagoons (leakage); lagoons built on high water table; Nitrates: most often found contaminant
- **Waste Disposal:** Underground or above ground disposal practices of domestic, municipal, or industrial liquid waste



Water Pollution – Specific Sources

- **Industrial liquid waste** – treated/ untreated
- **Solid waste** - Land disposal of municipal and industrial solid waste – leaching
- **Storage and Transport of Commercial Materials**
– storage tanks & spills
- **Mining operations:** Mines, Oil & gas- Acid mine drainage, Leaching of toxic metals, Wastewater generated
- **Agricultural operations:** Fertilizers; Pesticides
- Saline water intrusion



Water Pollution- Causes

- Wide spectrum of chemicals, pathogens, and physical or sensory changes such as elevated temperature and discoloration.
- Natural occurring – eg. Salts, fluoride, arsenic, Ca, Mg, Na etc.
- Artificial – disposed by humans from various sources
- Water's physical chemistry includes acidity (change in pH), electrical conductivity, temperature, and eutrophication

Water Pollution Types

Water pollution- organic pollutants

- Detergents; Disinfection by-products
- Food processing waste, fats and grease
- Insecticides & herbicides, organohalides and other chemical compounds
- Petroleum hydrocarbons, including fuels (gasoline, diesel fuel, jet fuels, and fuel oil) & lubricants (motor oil), & fuel combustion byproducts
- Tree and bush debris from logging operations
- Volatile organic compounds (VOCs), such as industrial solvents.
- Chlorinated solvents, dense non-aqueous phase liquids (DNAPLs), Polychlorinated biphenyl (PCBs) –Trichloroethylene, Perchlorate .
- Various chemical compounds found in personal hygiene & cosmetic products

Water Pollution Types

Water pollution- inorganic pollutants

- Acidity caused by industrial discharges (sulfur dioxide from power plants)
- Ammonia from food processing waste
- Chemical waste as industrial by-products
- Fertilizers containing nutrients- nitrates and phosphates- which are found in storm water runoff from agriculture, as well as commercial and residential use
- Heavy metals from motor vehicles (via urban storm water runoff) and acid mine drainage
- Silt (sediment) in runoff from construction sites, logging, slash and burn practices or land clearing sites

Pollution- macroscopic/ Micro pollutants

Macroscopic - Large visible items polluting the water— may be termed "floatables" in an urban stormwater context, or marine debris when found on the open seas like

- Trash or garbage (e.g. paper, plastic, or food waste) discarded by people on the ground
 - dumping of rubbish, that are washed by rainfall into storm drains and eventually discharged into surface waters
 - Nurdles, small ubiquitous waterborne plastic pellets
 - Shipwrecks, large derelict ships

Microscopic pollutants – micro organisms, dissolved/ dispersed pollutants

Water pollution- thermal pollution

- The rise or fall in the **temperature** of a natural body of water caused by human influence.
- Thermal pollution results in a change in the physical properties of water.
- A common cause of thermal pollution is the use of water as a coolant by power plants and industrial manufacturers.
- Elevated water temperatures decreases oxygen levels (which can kill fish) and affects ecosystem
- Urban runoff may elevate temperature in surface waters.
- Thermal pollution can also be caused by the release of very cold water from the base of reservoirs into warmer rivers.

Water Quality - Parameters

Following is a list of indicators often measured:

- Alkalinity; Color of water; pH; Taste and odor
- Dissolved metals and salts (sodium, chloride, potassium, calcium, manganese, magnesium)
- Microorganisms such as fecal coliform bacteria , Cryptosporidium, and Giardia lamblia
- Dissolved metals & metalloids (lead, mercury, arsenic, etc.)
- Dissolved organics: colored dissolved organic matter (CDOM), dissolved organic carbon (DOC), Heavy metals
- Pharmaceuticals byproducts
- Parameters depend on type of use – eg. Drinking, Industrial use, Irrigation etc.

Water quality-environmental indicators

- **Chemical assessment:** Dissolved oxygen (DO); Nitrate-N; Orthophosphates; Chemical oxygen demand (COD); Biochemical oxygen demand (BOD); Pesticides; Metals
- **Physical assessment:** pH; Temperature; Total suspended solids (TSS); Turbidity; Total dissolved solids (TDS)
- **Biological assessment:** Biological monitoring metrics have been developed in many places, and one widely used measure is the presence and abundance of members of the insect orders Mayfly, Stonefly and Caddisfly.

Important Water Quality Parameters

Important physicochemical parameters to be tested for ascertaining water quality are:

- pH; Colour, Taste and odour, turbidity, TDS, total hardness, chlorides, sulphates, fluorides, nitrates, calcium, heavy metals, dissolved oxygen, pesticides, detergents & radio-nuclides
- **pH** – neutral (pH = 7); acidic (pH < 7); basic (pH > 7); drinking water (6.5-8)
- **Electrical conductivity** – water ability to conduct electrical current – depends on concentration of dissolved, associated substances – to find TDS – unit micro siemens cm

Important Water Quality Parameters..

- **Odour, Colour & Taste** – Odour – classified as: very weak, weak, clear, strong or very strong
 - **Colour** – tested using colorimeter tubes – expressed in Hazen standard unit
 - **Taste** – purest form tasteless
- **Turbidity** – caused by presence of suspended matter – ranges in size from colloidal to coarse dispersions – measured by Nephelo/ turbidity meter & expressed in NTU (Nephelometric turbidity unit) – indicator necessity of treatment
- **Dissolved oxygen** – indicates amount of oxygen gas dissolved in water – solubility of atmospheric oxygen in fresh water ranges from 14.6 mg/l at 0°C to about 7 mg/l at 35°C under 1 atmospheric pressure – measured using DO meter.

Important Water Quality Parameters..

- **BOD (Biochemical Oxygen Demand)** – amount of dissolved O_2 demanded by bacteria during stabilization of the decomposable organic matter under aerobic conditions – BOD expressed in mgm of O_2 consumed/lit of sample during 5 days of incubation at $20\text{ }^\circ\text{C}$ & is often used as a robust surrogate of degree of organic pollution of water– pristine river $\text{BOD} < 1\text{mg/l}$.
- **Nitrate-** water soluble molecule made up of nitrogen & oxygen – natural constituent of plants
 - In natural form water contains less than 1mg of nitrate-nitrogen per litre – higher levels – contamination; common sources: fertilizers, animal wastes etc. – max. permissible 10ppm
- **Chlorides** – from dissolved salt deposits, discharge of effluents etc. max. limit: 250 ppm.

Important Water Quality Parameters..

- **Fluorides** - fluorine containing compounds - fluorides - found naturally in low concentration in drinking water and foods - Fresh water -between 0.01–0.3 ppm, ocean contains between 1.2-1.5 ppm; max. permissible 1ppm. more fluorine diseases like skeletal fluorosis
- **Hardness** – represents total concentration of Ca & Mg ions – ppm (weight/ volume) -Hard water is generally not harmful to one's health, but can pose serious problems in industrial settings.
- **Iron** - naturally occurring – not hazardous – recommended limit – 0.3mg/l.

Important Water Quality Parameters..

- **Heavy Metals:** Arsenic, Cadmium, Chromium, Copper, Iron, Manganese, Mercury, Nickel, Silver, Zinc etc. – Present in as minerals in soils; also artificially from man made things – some of these – major contaminations – determined by AAS (atomic absorption sepctrophotometer), polarography or colorimetry.
 - Arsenic – WHO guideline < 0.05 mg/l
- **Pesticides:** - harmful health effects such as cancer; eg. DDT, BHC, parathon, endosulphan etc.
- **Detergents, phenol, radio-nuclides etc.** - WHO guideline < 0.5 mg/l
- **Halogenated chloro-organic compounds** – due to higher chlorination for disinfection
- **Microbes** – indicator potential water-borne diseases – bacteria, viruses & pathogenic protozoa; eg. Coliform bacteria.

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Common Water Related problems

| Observed Problems | Causes |
|------------------------------------|------------------------|
| Water turns black, smell | Waste water |
| Acidic taste | Low pH |
| Alkaline taste | High pH |
| Boiled Rice hard and yellow | High Alkalinity |
| White deposits on boiling | Hardness |

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Common Water Related problems

| Observed Problems | Causes |
|--|----------------------------|
| Iron taste, change in colour after exposure to atmosphere, change in colour of cloths, utensils Oily appearance on top of water body | Presence of Iron compounds |
| Soap not lathering | hardness |
| Brownish black streaks on teeth | Fluoride |
| Growth of Algae | Nitrate, phosphate |
| Fish kills | Low pH less DO |
| Salty taste | chloride |

WQ – Tolerance & Classification

- As per ISI-IS: 2296-1982, the tolerance limits of parameters are specified as per classified use of water (Table below) depending on various uses of water. <http://cpcb.nic.in>; <http://wrmin.nic.in>

| Classification | Type of use |
|----------------|---|
| Class A | Drinking water source without conventional treatment but after disinfection |
| Class B | Outdoor bathing |
| Class C | Drinking water source with conventional treatment followed by disinfection. |
| Class D | Fish culture and wild life propagation |
| Class E | Irrigation, industrial cooling or controlled waste disposal |

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Tolerance Limits for Inland Surface Water – Class A

| S. No. (1) | Characteristic (2) | Tolerance (3) |
|---------------|---|------------------|
| (i) | pH | 6.5 to 8.5 |
| (ii) | Dissolved Oxygen, mg/l. | 6.0 |
| (iii) | Bio-chemical Oxygen Demand | 2.0 |
| (iv) | Total Coliform Organisms, MPN/100 ml, Max | 50 |
| (v) | Colour, Hazen units, Max | 10 |
| (vi) | Odour | unobjectionable |
| (vii) | Taste | Agreeable taste |
| (viii) | Total Dissolved Solids, mg/l, Max | 500 |
| (ix) | Total Hardness (as CaCO ₃), mg/l, Max | 300 |
| (x) | Calcium Hardness (as CaCO ₃), mg/l, Max | 200 |
| (xi) | Magnesium (as CaCO ₃), mg/l, Max | 100 |
| (xii) | Copper (as Cu), mg/l, Max | 1.5 |
| (xiii) | Iron (as Fe), mg/l, Max | 0.3 |
| (xiv) | Manganese (as Mn), mg/l, Max | 0.5 |
| (xv) | Chlorides (as Cl), mg/l, Max | 250 |
| (xvi) | Sulphate (as SO ₄), mg/l, Max | 400 |
| (xvii) | Nitrates (as NO ₂), mg/l, Max | 20 |
| (xviii) | Fluorides (as F), mg/l, Max | 1.5 |
| (xix) | Phenolic compounds (as C ₆ H ₅ OH), mg/l, Max | 0.002 |
| (xx) | Mercury (as Hg), mg/l, Max | 0.001 |
| (xxi) | Cadmium (as Cd), mg/l, Max | 0.01 |
| (xxii) | Selenium (as Se), mg/l, Max | 0.01 |
| (xxiii) | Arsenic (as As), mg/l, Max | 0.05 |
| (xxiv) | Cyanides (as CN), mg/l, Max | 0.05 |
| (xxv) | Lead (as Pb), mg/l, Max | 0.1 |
| (xxvi) | Zinc (as Zn), mg/l, Max | 15 |
| (xxvii) | Chromium (as Cr ⁶⁺), mg/l, Max | 0.05 |
| (xxviii) | Anionic detergents, (as MBAS), mg/l, Max | 0.2 |
| (xxix) | Poly-nuclear aromatic hydrocarbons (PAH), | 0.2 |
| (xxx) | Mineral oil, mg/l, Max | 0.01 |
| (xxxi) | Barium (as Ba), mg/l, Max | 1.0 |
| (xxxii) | Silver (as Ag), mg/l, Max | 0.05 |
| (xxxiii) | Pesticides | Absent |
| (xxxiv) | Alpha emitters, µc/ml, Max | 10 ⁻⁹ |
| (xxxv) | Beta emitters, µc/ml, Max | 10 ⁻⁸ |

<http://cpcb.nic.in;>
<http://wrmin.nic.in>

Tolerance Limits for Inland Surface Water – Class B

| S. No. (1) | Characteristic (2) | Tolerance Limit (3) |
|------------|--|---------------------|
| (i) | pH Value | 6.5 to 8.5 |
| (ii) | Dissolved Oxygen, mg/l, Max | 5.0 |
| (iii) | Biochemical Oxygen Demand (5 days at 20 °C), Max | 3.0 |
| (iv) | Total Coliform Organisms, MPN/100 ml, Max | 500 |
| (v) | Fluorides (as F) <mg/l, Max | 1.5 |
| (vi) | Colour, Hazen units, Max | 300 |
| (vii) | Cyanides (as CN), mg/l, Max | 0.05 |
| (viii) | Arsenic (as As), mg/l, Max | 0.2 |
| (ix) | Phenolic Compounds (as C ₆ H ₅ OH) mg/l, Max | 0.005 |
| (x) | Chromium (as Cr ⁶⁺), mg/l, Max | 1.0 |
| (xi) | Anionic detergents (as MBAS), mg/l, Max | 1.0 |
| (xii) | Alpha emitters, µc/ml, Max | 10 ⁻⁸ |

<http://cpcb.nic.in>;
<http://wrmin.nic.in>

Tolerance Limits for Inland Surface Water – Class C

<http://cpcb.nic.in>;
<http://wrmin.nic.in>

| S.No. | Characteristic | Tolerance Limit |
|---------|---|------------------|
| (1) | (2) | (3) |
| (i) | pH Value | 6.5 to 8.5 |
| (ii) | Dissolved Oxygen, mg/l Minimum | 4.0 |
| (iii) | Biochemical Oxygen Demand | 3.0 |
| (iv) | Total coliform organisms, MPN/100 ml, Max | 5000 |
| (v) | Colour, Hazen units, Max | 300 |
| (vi) | Fluorides (as F), mg/l, Max | 1.5 |
| (vii) | Cadmium (as Cd), mg/l, Max | 0.01 |
| (viii) | Chlorides (as Cl), mg/l, Max | 600 |
| (ix) | Chromium (as Cr ⁶⁺), mg/l, Max | 0.05 |
| (x) | Cyanides (as CN), mg/l, Max | 0.05 |
| (xi) | Total Dissolved Solids, mg/l, Max | 1500 |
| (xii) | Selenium (as Se), mg/l, Max | 0.05 |
| (xiii) | Sulphates (as SO ₄), mg/l, Max | 400 |
| (xiv) | Lead (as Pb), mg/l, Max | 0.1 |
| (xv) | Copper (as Cu), mg/l, Max | 1.5 |
| (xvi) | Arsenic (as As), mg/l, Max | 0.2 |
| (xvii) | Iron (as Fe), mg/l, Max | 50 |
| (xviii) | Phenolic compounds (as C ₆ H ₅ OH), mg/l, Max | 0.005 |
| (xix) | Zinc (as Zn), mg/l, Max | 15 |
| (xx) | Insecticides, mg/l, Max | Absent |
| (xxi) | Anionic detergents (as MBAS), mg/l, Max | 1.0 |
| (xxii) | Oils and grease, mg/l, Max | 0.1 |
| (xxiii) | Nitrates (as NO ₃), mg/l, Max | 50 |
| (xxiv) | Alpha emitters, µc/mg, Max | 10 ⁻⁹ |
| (xxv) | Beta emitters, µc/ml, Max | 10 ⁻⁸ |

Tolerance Limits for Inland Surface Water – Class D

<http://cpcb.nic.in>;

<http://wrmin.nic.in>

| S.No. | Characteristic | Tolerance Limit |
|--------|--|------------------|
| (1) | (2) | (3) |
| (i) | pH value | 6.5 to 8.5 |
| (ii) | Dissolved Oxygen, mg/l, Min. | 4.0 |
| (iii) | Free Ammonia (as N), mg/l, Max. | 1.2 |
| (iv) | Electrical Conductance at 25 °C, μ S, Max | 1000 |
| (v) | Free Carbon Dioxide (as CO ₂), mg/l, Max | 6.0 |
| (vi) | Oils and Grease, mg/l, Max | 0.1 |
| (vii) | Alpha emitters, μ c/ml, Max | 10 ⁻⁹ |
| (viii) | Beta emitters, μ c/ml, Max | 10 ⁻⁸ |

Tolerance Limits for Inland Surface Water – Class E

| S.No. | Characteristic | Tolerance Limit |
|--------|---|-----------------|
| (1) | (2) | (3) |
| (i) | pH value | 6.0 to 8.5 |
| (ii) | Electrical Conductance at 25°C, μS , Max | 2250 |
| (iii) | Sodium Adsorption Ratio, Max | 26 |
| (iv) | Boron (as B), mg/l, Max | 2.0 |
| (v) | Total Dissolved Solids, (inorganic), mg/l, Max | 2100 |
| (vi) | Sulphates (as SO_4), mg/l, Max | 1000 |
| (vii) | Chlorides (as Cl), Mg/l, Max | 600 |
| (viii) | Sodium Percentage, Max | 60 |
| (ix) | Alpha emitters, $\mu\text{c/ml}$, Max | 10^{-9} |
| (x) | Beta emitters, $\mu\text{c/ml}$, Max | 10^{-8} |

Case Study: WQ Issues in India

- **Water resources are over-exploited** resulting in major WQ problems
- **Common issues of Surface & Ground water:** Pathogenic (Bacteriological) Pollution; Salinity; Toxicity (micro-pollutants and other industrial pollutants)
- **Surface Water:** Eutrophication; Oxygen depletion; Ecological health – Most of the Lakes & Rivers highly polluted
- **Ground Water:**
 - Fluoride <http://cpcb.nic.in>;
 - Nitrate <http://wrmin.nic.in>
 - Arsenic
 - Iron
 - Sea water intrusion

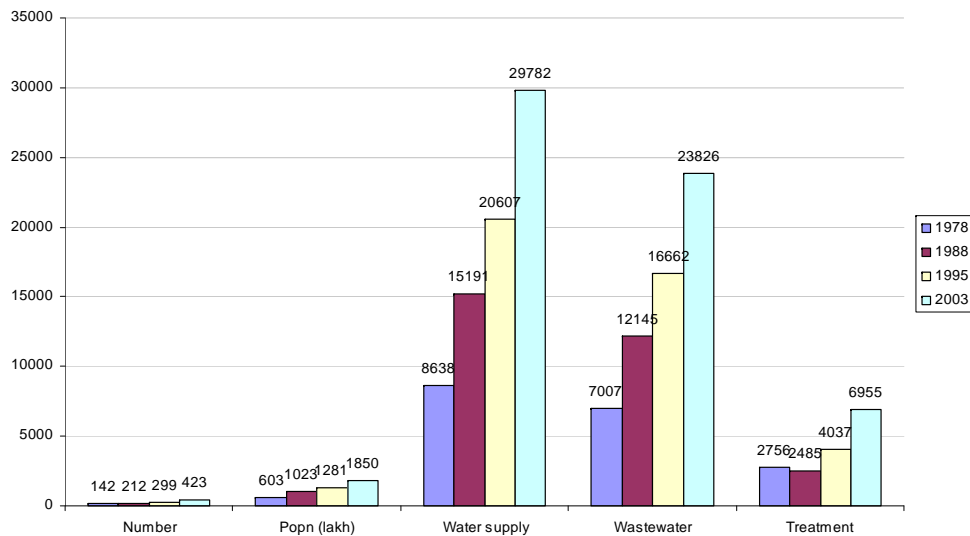
WQ Degradation – Major factors

- ✿ **Domestic:** About 430 class I cities and 500 class II towns harboring population of 30 Crore generate about 30000 mld of wastewater of which only about 25% is treated.
- ✿ **Industrial:** About 60,000 polluting industries in India generate about 15000 mld of wastewater out of which nearly 60% (generated from large & medium industries) is treated.
- ✿ **Non-point sources** also contribute significant pollution loads mainly in rainy season. Pesticides consumption is about 1,00,000 tonnes/year
- ✿ **Domestic** sewage is the major source of pollution in India in surface water
- ✿ **Sewage along with** agricultural run-off and industrial effluents also contributes large amount of nutrients
- ✿ A large part of the **domestic sewage** is not even collected.

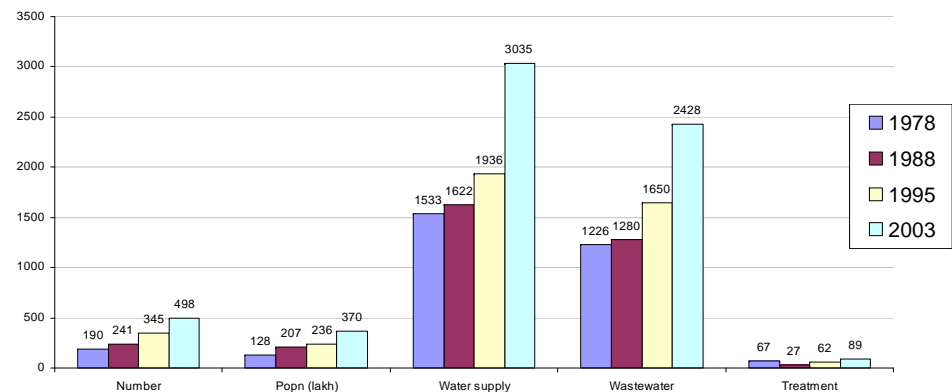
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WQ Issues in India

Water supply and sewage disposal status in class I cities



Water supply and wastewater generation and treatment in class II towns of India

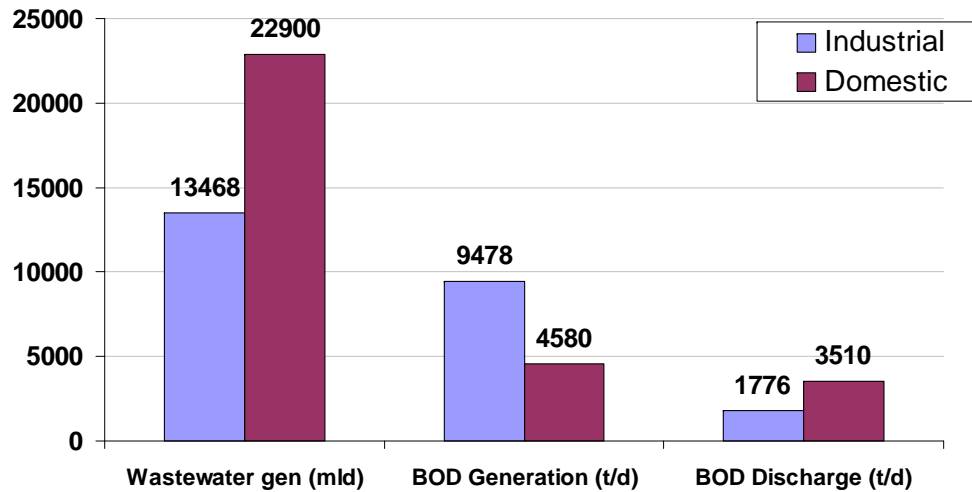


Ref: Presentation by Dr. R.C. Trivedi
: Central Pollution Control Board
<http://www.cpcb.nic.in>

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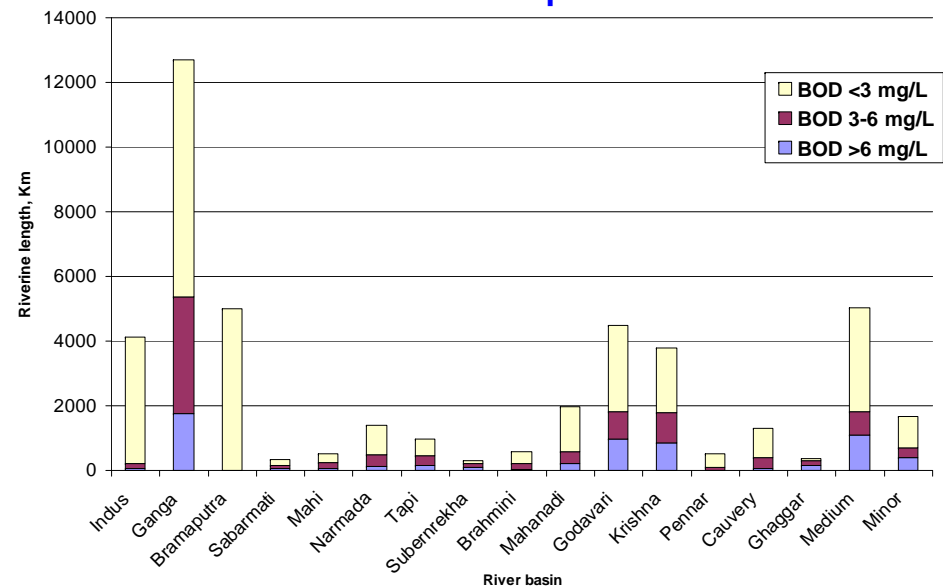
WQ Issues in India

Comparison of pollution load generation from domestic and industrial sources



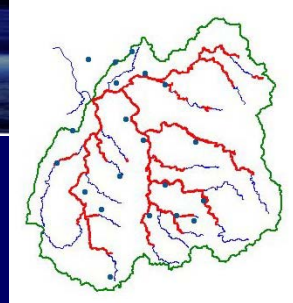
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River basin-wise riverine length under different level of pollution



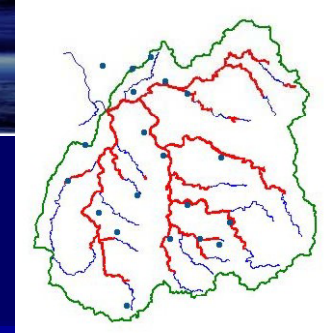
References

- GHOSH N.C and EDWARD .A , MCBEAN(1996), WATER QUALITY MODELING OF THE KALI RIVER, INDIA, *Water, Air, and Soil Pollution 102: 91–103, 1998*
- Guidelines for Water Quality Management, Central pollution control board (CPCB)
- Website : <http://www.cpcb.nic.in>
- Hydrology of Small Watersheds – P.V. Seethapathi, D. Dutta, R. Siva Kumar (Eds.), NRDMS, DST, New Delhi
- http://cpcb.nic.in/data_statics.php
- <http://wrmin.nic.in>
- Standard Methods for the Examination of Water and Wastewater; APHA, AWWA, and WEF, 21st Edition, 2005.
- Guidelines for drinking - water quality, 3rd Edition - vol 1: Recommendations. WHO; 2004.



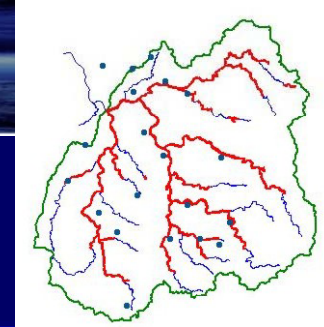
Tutorials - Question!?.

- Critically study the water quality problems of major Rivers/ River Basins in India. Study various sources and causes (details can be obtained from Internet: <http://cpcb.nic.in>;
- <http://wrmin.nic.in>).
- Study the various measures that can be adopted to reduce the River pollution/river basins.



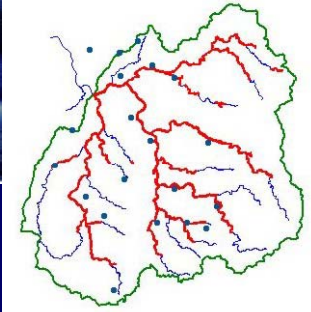
Self Evaluation - Questions!.

- Discuss the various water quality issues in watershed management.
- Describe various water quality categories.
- What are the different pollution source types?
- Describe various water pollution causes.
- Illustrate water pollution by thermal sources
- Describe various water quality parameters.



Assignment- Questions?.

- Describe the water quality standards.
- Discuss various water pollution sources
- Describe various specific sources of water pollution.
- Illustrate various water pollution types
- Describe various water quality indicators
- What are the various common water related problems?.



Unsolved Problem!.

- Critically study the possible surface water pollution problems in your watershed area.
- Identify the water sources & possible causes of pollution.
- What are the roles of agriculture, land use, and industries/ other uses in the pollution problems.
- Prepare a plan to reduce the possible pollution problems

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THANK YOU

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