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
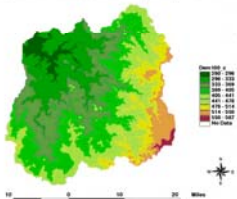
WATERSHED MANAGEMENT

Prof. T. I. Eldho

Department of Civil Engineering, IIT Bombay

Lecture No - 30 Environmental Guidelines for Water Quality Management

L30– Environmental Guidelines for Water Quality Management

- **Topics Covered**

- Water quality management; Monitoring, Water quality Guidelines; Steps in Water Quality Management

- Keywords: Water quality management, Environmental guidelines

Digital Elevation Model Anas river watershed (Jhabua), India

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay

Water Quality Management

- **Water quality management-** importance
- **Watershed based –** WQM
- Various pollution sources & its control
- **WQM - guidelines**
- Water quality management is for a great deal controlled by authorization of discharges of dangerous substances for which monitoring of discharges, effluents and influenced surface/ groundwater is essential.
- On national and state levels, we have several policies and regulation for WQM

Water Quality Management...

- Presently the quality & availability of the fresh water resources is most pressing of the many environmental challenges on the national horizon

- Geometric increase in population coupled with rapid urbanization, industrialization & agricultural development has resulted in high impact on quality & quantity of water

- National benchmarks to assess potential or actual impairment of socially relevant resource uses

- Scientific basis for the development of site-specific criteria- guidelines, objectives or standards indicators

- Scientific tools for assessing risks- with existing concentrations of persistent, bio-accumulative & toxic substances in the ambient environment

Environmental Water Quality

- Environmental water quality - **ambient water quality** - relates to water bodies such as lakes, rivers, & oceans.

- Parameters for water quality –depends on intended use.

- Water quality standards - focused on water treated for human consumption, industrial use, or for environment.

- Water quality standards for surface/ ground waters vary significantly due to different conditions/ uses –

- Eg. Toxic substances & microorganisms - a health hazard for non-drinking purposes such as irrigation, swimming, fishing, rafting, boating, & industrial uses.

- Modern water quality laws - specify protection of water resources depending on use, as a minimum, retention of current quality standards.

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay

Water Quality Guidelines– Goals

- **Science-based goals** or performance indicators for regional, national, or international management strategies for toxic substances

- **Interim management objectives** for persistent, bio-accumulative, and toxic substances to track progress toward their virtual elimination

- **Indicators of eco-toxicologically** relevant concentrations of persistent, bio-accumulative, & toxic substances for the purpose of improving analytical detection & quantification capabilities

- **Tools to evaluate** the effectiveness of point-source controls

- **Scientific basis** for environmental regulations & benchmarks or targets in the assessment & remediation

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay

6

Water Quality Guidelines

- Water quality guidelines - values for indicators & are designed to ensure that Environmental Values (EV) of waters are protected.

- Main nationally recognized EV for waters are:

- Ecosystem values

- Ecosystem protection (aquatic plants, fish and other flora and fauna, habitat).

- Human use values: Agricultural; Recreational use;

- Drinking water supply

- Cultural values.

Water Quality Guidelines...

- **Each of these EVs** requires its own specific set of guidelines because the acceptable guideline values to maintain one type of EV may not be acceptable to maintain another EV.

- An example of this is the **pesticide levels** required to protect fish and other fauna are usually lower than those required for protection of irrigated crops.

- Another **reason is that the indicators** used to assess one EV may be different to those used for other EVs. For example, a key indicator for recreational use is fecal bacteria numbers, but this indicator is not used for most other EVs.

Water Quality Guidelines…

- **Recognized guideline** documents for the above EVs are:

- **Ecosystem protection**

- **Recreational use**: Guidelines for Managing Risks in Recreational Waters:

- **Human consumption**: National standards eg: Australia New Zealand Food Standards Code:

- **Drinking water supply**: Indian Drinking Water Guidelines

- **Cultural values**: No recognized guidelines

Steps in Water Quality Management

- Step-I: Setting Water Quality Goal
- Step-II: Water Quality Monitoring
- Step-III: Identification of Nature and Magnitude of Pollution
- Step-IV: Source Inventory

  http://www.cpcb.nic.in

- Step– V: Water Quantity information
- Step-VI: Selection of Technology
- Step-VII: Financing Waste Management
- Step–VIII: Maintenance of sewage treatment plants
- Step–IX: Pollution from industrial sources
- Step–X: Pollution from non-point sources
- Step–XI: Some other Important Options for Water Quality Management

Step I: Setting Water Quality Goal

- Identification of uses of water in the given water body
- The term quality therefore, must be considered relative to the proposed use of water
- "Water quality" is defined as "those physical, chemical or biological characteristics of water by which the user evaluates the acceptability of water"
- Each water use has specific water quality needs
- Designated best use: Out of several uses a particular water body is put to, the use which demands highest quality of water is called its "designated best use".

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay

11

Use Based Classification (CPCB, India)

http://www.cpcb.nic.in

Designated-Best-Use	Class of water	Criteria
Drinking Water Source without conventional treatment but after disinfection	A	1. Total Coliforms OrganismMPN/100ml shall be 50 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 6mg/l or more 4. Biochemical Oxygen Demand 5 days 20oC 2mg/l or less
Outdoor bathing (Organised)	B	1. Total Coliforms Organism MPN/100ml shall be 500 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 5mg/l or more 4. Biochemical Oxygen Demand 5 days 20oC 3mg/l or less
Drinking water source after conventional treatment and disinfection	C	1. Total Coliforms Organism MPN/100ml shall be 5000 or less 2. pH between 6 to 9 3. Dissolved Oxygen 4mg/l or more 4. Biochemical Oxygen Demand 5 days 20oC 3mg/l or less
Propagation of Wild life and Fisheries	D	1. pH between 6.5 to 8.5 2. Dissolved Oxygen 4mg/l or more 3. Free Ammonia (as N) 1.2 mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	E	1. pH between 6.0 to 8.5 2. Electrical Conductivity at 25oC micro mhos/cm Max.2250 3. Sodium absorption Ratio Max. 26 4. Boron Max. 2mg/l

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay

Step – II: Water Quality Monitoring

- **For acquiring information on existing water quality**
- Main objectives for water quality monitoring:
  - monitoring for establishing baseline water quality
  - observing trend in water quality changes
  - calculation of flux of water constituents of interest
  - surveillance for irrigation use
  - control & management of water pollution (groundwater only)
- **Water Quality Monitoring Protocol:**
- **Design approach and delineation** of actions necessary to operationalise the monitoring programme
- **Ready reference** for the field staff, laboratory personnel and managers of monitoring programmes

Steps: Frequency and Parameters; Sample Collection; Analysis and Record

13

Water Quality Monitoring Protocol – Frequency & Parameters

- **Groundwater:** Initially all stations will be classified as *baseline stations*

- About 20 to 25% of the baseline stations will also be classified as *trend or trend-cum-surveillance* stations

- Reclassification of stations after 3 years data collection

- **Surface water:** To start with, all stations will be a combination of *baseline and trend stations.*

- Samples will be collected every two months: May/June, August, October, December, February and April.

- This will generate six samples from perennial rivers and 3-4 samples from seasonal rivers, every year.

- After data are collected for three years, the stations will be classified either as *baseline, trend or flux station.*

Parameters of Analysis for Groundwater

Type of station	Frequency	Parameter
Baseline	Once every year, (pre-monsoon, May-June)	Temp, EC, pH, $NO_2^- + NO_3^-$, total P, K^+, Na^+, Ca^{++}, Mg^{++}, CO_3^{--}, HCO_3^-, Cl^-, SO_4^{--}, COD, SiO_2, F, B.
Trend	Four times every year, (pre-monsoon, May-June & after intervals of 3 months)	Temp, EC, pH, $NO_2^- + NO_3^-$, total P, Cl^-, COD.
Trend–cum–surveillance – *Fluoride* – *Iron* – *Industrial, mining* – *Salinity due to irrigation, natural contribution or sea water intrusion* – *Urban pollution*	Minimum four times a year (as above), higher frequency if dictated by importance of water use	According to the problem under surveillance (e.g. Heavy metals in mining areas) F^- Fe As, Cd, Hg, Zn Na^+, K^+, Ca^{++}, Mg^{++}, CO_3^{--}, HCO_3^-, Cl^-, SO_4^{--} Total and faecal coliforms

http://www.cpcb.nic.in

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay

15

Parameters of Analysis for Surface Water

http://www.cpcb.nic.in

Parameter Group	Initially	Baseline	Trend
General	Temp, EC, pH, DO,TDS	Temp, EC, pH, DO,TDS	Temp, EC, pH, DO
Nutrients	NH_3-N, NO_2 + NO_3, total P	NH_3-N, NO_2 + NO_3, total P	NH_3-N, NO_2 + NO_3, total P
Organic matter	BOD, COD	None	BOD, COD
Major ions	Ca^{++}, Mg^{++}, K^+, Na^+, CO_3^{--}, HCO_3^-, Cl^-, SO_4^{--}	Ca^{++}, Mg^{++}, K^+, Na^+, CO_3^{--}, HCO_3^-, Cl^-, SO_4^{--}	Cl^-
Other inorganics	None	None	None
Metals	None	None	None
Organics	None	None	None
Microbiological[b]	Total coliforms	None	Total and faecal coliforms
Biological	None	None	None

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay

Sample Collection

- Reaching samples site using location maps
- Rinse the sample container three times with the sample before it is filled
- Leave a small air space in the bottle to allow mixing of sample at the time of analysis
- The sample code and the sampling date should be clearly marked on the sample container or the tag
- Samples for groundwater would be collected from: *Open dug wells / Tube wells in use for domestic or irrigation;*
- Samples will be collected from well-mixed section of the river (main stream) 30 cm below the water surface using a weighted bottle or DO sampler
- Samples from reservoir sites will be collected from the outgoing canal, power channel or water intake structure

Step-III: Identification of Nature & Magnitude of Pollution

- After repeated observations on water quality covering different seasons, the water quality data should be compiled and compared with the desired quality requirement as per the water quality goal set in step-I.

- This way, the polluted water body can be identified.

- This comparison would lead to identification of the gaps with respect one or more parameters and also extent of gap, which will ultimately help in identification of nature and magnitude of pollution control needed.

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay

18

Step- IV: Source Inventory

- Once the nature & magnitude of pollution is identified, the sources of such pollution are identified.

- Inventorise the number of outfalls joining the water body for identification of point sources

- Measure the quality & quantity of wastewater flowing through each of the outfalls

- For each outfall pollution load joining per unit time should be measured in terms of important pollutants

- This exercise requires continuous sampling for 24/48/72 hours on flow based composite basis.

- Inventorise the human activities in the upstream catchments area of the water body to identify the non-point sources of pollution

Step– V Water Quantity information

- In case of river or stream, acquire the flow data from various Govt. sources for atleast last 5 years or more.

- In case of lakes, reservoirs collect the information on water levels for atleast last 5 to 10 years

- Carry out mass balance to estimate the dilution available in different seasons.

- Estimate the least dilution available in last 5 years.

- Assess the assimilation capacity by applying simple Streeter-Phelps equation and generate different scenario to estimate the extent of pollution control required.

- This exercise would give precisely how much pollution load needs to be reduced to achieve desired water quality

Step– V: Water Quantity information..

- In case of river or stream, acquire the flow data from various Govt. sources for atleast last 5 years or more.

- In case of lakes, reservoirs collect the information on water levels for atleast last 5 to 10 years

- Carry out mass balance to estimate the dilution available in different seasons.

- Estimate the least dilution available in last 5 years.

- Assess the assimilation capacity by applying simple Streeter-Phelps equation and generate different scenario to estimate the extent of pollution control required.

- This exercise would give precisely how much pollution load needs to be reduced to achieve desired water quality

Step-VI: Selection of Technology

- Adoption of simple technology for sewage treatment

- Treatment scheme based on series of Waste Stabilization Ponds (WSP) technology is one of the most economical ones and suitable for small towns where sufficient land is easily available.

- Multiple stage ponds (at least three) with first pond as anaerobic one is the most widely used and suitable configuration.

- Use of low volume flushing tanks will help in reducing waste water volume and thereby cost of sewerage and sewage treatment

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay

www.engineering.leeds.ac.uk/

Step-VI: Selection of Technology..

- Some of the cost effective and environmental compatible treatment options:
  - land treatment
  - waste stabilization ponds
  - constructed wetlands
  - duck-weed pond
  - aerated lagoon
  - Rotating biological contractors
  - Up-flow anaerobic sludge blanket system and
  - Root zone treatment

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay

www.hgs.org

Step-VII: Financing Waste Management

- In India, with fast urbanization waste water quantity is about 30,000 mld

- Each mld cost about Rs. 10 Millions for establishing treatment facilities and about 40 Millions for collection facilities

- Operation and maintenance may be another about 10% of the above cost every year

- The major part of the cost on waste management should be born by urban population according to 'polluter pay principle'

- Two benefits: It reduces waste and treatment and can provide a source of revenue for financing wastewater treatment investments.

24

Step-VII: Financing Waste Management.

- Pricing and demand management - important instruments for encouraging efficient domestic and industrial water-use practices
- Induce urban organisations to adopt water-saving technologies, including water recycling & reuse
- Demand management programmes- Ex:Promotion, distribution or sale of water-saving devices like "six-litre" toilets which use less than half the volume of water per flush than a standard toilet

The waste management benefits following:

- Local citizens; Protection of environment; Protection of Public health; Protection of water resources – water supply, irrigation, other uses; Protection of industrial use; Enhanced Property values; Enhanced tourism

Step-VIII: Maintenance of sewage treatment plants

- Regular analysis of operational parameters

- Persons should having adequate knowledge and trained to operate the STPs be engaged to manage STPs

- Provision of auxiliary power backup

- Proper maintenance of the sewage system, namely, sewers, rising mains, intermediate pumping stations

- Resource recovery by way of raising the revenue through sale of treated effluent for irrigation, of sludge as a manure and biogas utilization for power generation

Step-IX: Pollution from Industrial Sources

Pollution control at source

- The water polluting industries which had not so far installed ETPs should be asked to furnish a time bound programme for treatment of their effluents

- Emerging technologies such as aerobic composting, vermiculture, ferti-irrigation, etc. as secondary treatment should be adopted for the organic wastes by the industries

- Root-zone technology is also being advocated for energy saving for treatment of industrial wastewaters

- Incentives have to be made more attractive to make the industries undertake pollution control measures

Step-IX: Pollution from Industrial Sources…

- Reuse/recycling of treated industrial waste and resource recovery

The reuse and recycling of wastes for agricultural purposes: help to reduce the pollution ; Reduces requirement of fresh water for use; Supplement the much needed nutrients & organic manure to plants

- Segregation of waste water streams may help in reducing waste water volume & waste strength & may help recycling and reuse of majority of waste streams.

Waste minimization and clean technologies:

- Recycling technique
- Waste strength reduction
- Waste water discharge standards & charges on residual pollution

28

# Step-X: Pollution from Non-point Sources

- Extremely important to focus attention upon the problem of non-point pollution from

- Unsewered sanitation, Uncollected wastes dumped haphazardly in urban and industrial areas and application of chemicals in agriculture such as pesticides, insecticides and chemical fertilisers.

- Presence of unacceptably high levels of the persistent pollutants in the groundwater and run-off water

- An integrated pest management policy should be evolved and standards made to regulate the use of toxic pesticides and to develop substitutes which are ecologically more acceptable. (essential)

Step-XI: Other Important Options for Water Quality Management

- Reuse/recycling of treated domestic sewage
- Encourage participatory approach with involvement of all relevant stakeholders:
- Balance economic and regulatory instruments
- Prevent pollution rather than control

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay

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

- Hydrological Modeling of Small Watershed – C.T Han, H.P. Johnson, D.L. Brakensiek (Eds.), ASAE Monograph, Michigan

- Freeze, R.A. and Cherry J.A. (1979). Groundwater. Prentice Hall-INC., Englewood Cliffs, NJ

- www.epa.gov

- http://wrmin.nic.in

- Standard Methods for the Examination of Water and Wastewater; APHA, AWWA, and WEF, 21st Edition, 2005.

- http://cgwb.gov.in/

31
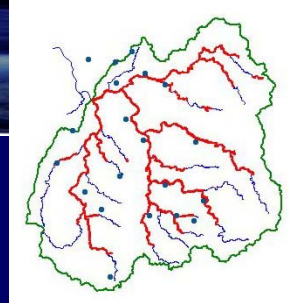
Tutorials - Question!.?.

- Critically study the environmental guidelines for water quality management for India and compare with the standards of USA http://cpcb.nic.in; www.epa.gov)

- Study the various measures that can be adopted to improve the WQM guidelines for India.

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay
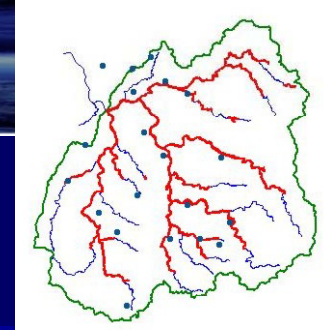
Self Evaluation - Questions!.

- Illustrate the importance of watershed based water quality management.

- What are the important goals of water quality guidelines?

- Discuss on "Water quality monitoring protocol, frequency & parameters for surface water and groundwater.

Prof. T I Eldho, Department of Civil Engineering, IIT Bombay

33
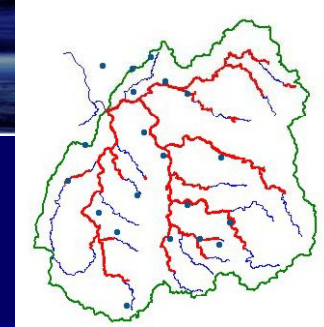
Assignment- Questions?.

- What are the important features of "Environmental Water Quality"?.

- Discuss on the important steps to be followed in water quality management as per CPCB norms.

- Illustrate "selection of technologies for waste water treatment".

THANK YOU

Dr. T. I. Eldho
Professor,
Department of Civil Engineering,
Indian Institute of Technology Bombay,
Mumbai, India, 400 076.
Email: eldho@iitb.ac.in
Phone: (022) – 25767339; Fax: 25767302
http://www.civil.iitb.ac.in