

# WATER SUPPLY ENGINEERING

ENCE 254

**Lecture** : 3  
**Tutorial** : 2  
**Practical** : 2/2

**Year** : II  
**Part** : II

## Course Objectives:

This course is designed to offer a comprehensive understanding of Water Supply Engineering. It covers fundamental theories, principles, design considerations, and practical knowledge in the field. Topics include various drinking water requirements and quantity estimation, sources and their selection, water examination (physical, chemical and biological) methods, quality requirements, engineering design of the conveyance networks, treatment plant components, reservoirs, distribution networks, construction, operation, and maintenance of water supply system. It also covers brief introduction to advanced water treatment methods. The course places strong emphasis on hands-on learning through examples and experiments, which are considered highly effective for helping students grasp and apply the course material.

## 1 Introduction (2 hours)

- 1.1 Importance of water, including water sanitation and hygiene (WASH) aspects
- 1.2 Historical development of water supply systems (Global to National context)
- 1.3 Pure and impure water; potable and wholesome water; polluted and contaminated water
- 1.4 Objectives and importance of water supply system
- 1.5 Types of water supply systems (Gravity, pumped, and combined); planning, typical components, and their functions
- 1.6 Schematic diagram of typical water supply systems

## 2 Sources of Water (4 hours)

- 2.1 Distribution of earth's water, water cycle (Hydrological cycle)
- 2.2 Climate change and water availability
- 2.3 Classification of water sources
  - 2.3.1 Surface water sources: Rivers, streams, lakes, ponds, and impounded reservoirs (capacity of reservoirs using mass curve and analytical methods)
  - 2.3.2 Groundwater sources (Confined aquifer and unconfined aquifer, springs, wells, infiltration galleries, sump wells), jack wells
  - 2.3.3 Alternative sources: Rainwater harvesting, reclaimed water sources
- 2.4 Yield of surface sources and wells (Practical approach)

- 2.5 Selection of sources: Technical and legal considerations
- 2.6 Conservation of drinking water sources

**3 Quantity of Water (5 hours)**

- 3.1 Water quantity estimation
  - 3.1.1 Per capita demand
  - 3.1.2 Design and base periods and selection criteria
  - 3.1.3 Demographic trends and forecasting (Arithmetical increase method, geometrical increase method, incremental increase method and decrease rate of growth method, zoning method, numerical on population forecasting)
- 3.2 Types of water demand (Domestic, livestock, commercial, public/municipal, Industrial, firefighting, loss/wastage, and total demand)
- 3.3 Variation in water demand, peak factors and its significances
- 3.4 Factors affecting water demand

**4 Quality of Water (5 hours)**

- 4.1 Types of impurities (Suspended, colloidal and dissolved) and their effects
- 4.2 Living organisms in water (Algae, bacteria, viruses, worms)
- 4.3 Water-related diseases (Water borne, water washed, water based, and water vector disease) causes and effects, their transmission routes, and preventive measures (Primary and secondary barriers)
- 4.4 Physical water qualities and their significance
  - 4.4.1 Solids (Suspended and dissolved)
  - 4.4.2 Turbidity
  - 4.4.3 Color
  - 4.4.4 Taste and odor
  - 4.4.5 Temperature
  - 4.4.6 Health, environment, and engineering significance
- 4.5 Chemical water qualities
  - 4.5.1 Chemistry of solutions: pH, solubility and pH dependence
  - 4.5.2 Hardness and alkalinity (Lime incrustation in pipeline and customer meter)
  - 4.5.3 Metals: Toxic and non-toxic metals
  - 4.5.4 Pollutants of emerging concerns
  - 4.5.5 Health, environment, and engineering significance
- 4.6 Biological water qualities
  - 4.6.1 Microorganisms in water and their classification (Oxygen requirement, temperature, disease-causing, life process, and shapes)

- 4.6.2 Health, environment, and engineering significance
- 4.6.3 Pathogen's indicators and their tests (Multiple tubes, membrane fermentation, and standard plate count method), the most probable number
- 4.7 Standard methods of water quality examination: US- Environmental Protection Agency (EPA), American Public Health Association (APHA) methods
- 4.8 Water quality standard for drinking purposes (World Health Organization and National)

**5 Intakes (3 hours)**

- 5.1 Type of intakes and their components
- 5.2 Factors considered for site selection of an intake
- 5.3 Characteristics of intake (River intake, reservoir intake, spring intake, well intake)
- 5.4 Design considerations for intake

**6 Water treatment (14 hours)**

- 6.1 Overview of drinking water treatment unit operation and process
- 6.2 Objectives of water treatment: Treatment processes and impurity removal
- 6.3 Physical treatment: Impurities removal and operation mechanism; design considerations
  - 6.3.1 Screenings: Types, head losses and design steps
  - 6.3.2 Plain sedimentation, principle, mechanism, and design: Theory of particle settlement; Derivative of Stoke's law, Hazen's law and Newton's law; Temperature effect on settling; Ideal sedimentation; Types of sedimentation tank; Design of sedimentation tank
  - 6.3.3 Filtration, operation mechanism, and design considerations: Theory of filtration, types of filters, slow and rapid sand filter, pressure filter and design consideration
  - 6.3.4 Aeration: Purpose, mechanism and methods
- 6.4 Chemical Treatment
  - 6.4.1 Coagulation and flocculation: Coagulation mechanism; coagulants (Types and their chemical reactions; Mixing devices (Purpose and types); flocculation tank and its design considerations; clarifiers; jar test
  - 6.4.2 Disinfection: Purposes and significance of disinfection; physical methods (boiling and UV); chemical methods (Halogens, ozone, potassium permanganate, silver); chlorination (theory, chlorine demand, dose, residual chlorine and contact time); Kinetics (Chick's law; types of chlorine (Hypochlorites, chloramines, liquid/ gas chlorine, and their usage); forms of chlorination (Plain chlorination, pre-chlorination, post-chlorination, double chlorination, multiple

- chlorination, breakpoint chlorination, super chlorination, de-chlorination); factors affecting efficiency of chlorination
- 6.4.3 Softening: Purposes; removal of temporary hardness (Boiling and lime treatment); removal of permanent hardness (Lime soda, Zeolite); demineralization and deionization process
- 6.5 Advanced water treatment processes (Brief introduction, impurities removal, and removal mechanism)
  - 6.5.1 Removal of heavy metals (Iron, Arsenic and Manganese)
  - 6.5.2 Removal of color, odor, and taste
  - 6.5.3 Advance oxidation processes (AOPs)
  - 6.5.4 Membrane filters (Ultrafiltration, nanofiltration, reverse osmosis)
  - 6.5.5 Desalination and electrodialysis
  - 6.5.6 Ozonation
  - 6.5.7 Adsorption: Activated carbon

## **7 Reservoirs and Distribution System (6 hours)**

- 7.1 Water supply systems (Continuous and intermittent system)
- 7.2 Clear water reservoir
- 7.3 Service reservoir (Purpose, construction, types and design consideration)
- 7.4 Types of distribution system and layout (Tree, grid, ring and radial system)
- 7.5 Smart water distribution: Concept of district metering areas (DMAs) and supervisory control and data acquisition (SCADA)
- 7.6 Design of distribution system (Pipe hydraulics for branched and looped networks, design criteria and design steps)
- 7.7 Water supply systems for buildings (Hydraulic considerations)
- 7.8 Introduction to computer-aided design software: EPANET, WaterGems /WaterCADs, etc.

## **8 Conveyance of Water (2 hours)**

- 8.1 Mode of conveyance: Open channel and pressure flow
- 8.2 Pipe materials
  - 8.2.1 Requirements of good pipe material
  - 8.2.2 Pipe corrosion: Corrosion mechanism and protection
  - 8.2.3 Types of pipe material (Cl, Gl, Steel, PE, HDPE, PVC, PPR, DI)
- 8.3 Pipe joints: Purposes and types (Socket, spigot, flanged, collar, screwed socket joints, butt and electrofusion joints for PE and HDPE pipes)
- 8.4 Laying of pipes: Construction, operation and maintenance considerations

## **9 Pipe Appurtenances, Operation and Maintenance (4 hours)**

- 9.1 Valves: Purposes and types (Sluice, reflux, safety, air valves, pressure relieve valves, pressure sustaining valves, butterfly valves, gate valves, and drain valves); typical schematic diagram of a valve (With all accessories required)

- 9.2 Fittings: Purpose and types (Bends, reducers, tees, mechanical couplings, expansion joints, dismantling joints, stop cocks and water taps)
- 9.3 Flushing arrangements (Reservoirs, transmission mains, and at distribution lines)
- 9.4 Propose and construction of break pressure tank
- 9.5 Public stand post (Purposes, location, flows, and construction)
- 9.6 Pumps: Type of pumps, purpose and uses; layouts of pumps; introduction to pump curves
- 9.7 Operation of water supply system
- 9.8 Maintenance: Necessity, types (Regular, preventive and emergency maintenance)
- 9.9 Roles and responsibilities of different organizations in water supply management (Federal, provincial, local government, and user's committee)

### **Tutorial**

**(30 hours)**

There shall be related tutorials exercised in class and given as regular homework exercise. Tutorial can be as following for each specified chapters

1. Computation of capacity of impounded reservoir by mass curve and analytical method, yield and safe yield calculation for surface and ground water sources
2. Population forecasting by arithmetical increase method, geometrical increase method, incremental increase method and decrease rate of growth method, zoning method.
3. Water demands calculation for a settlement/community
4. Solution on hardness and alkalinity and water quality related numerical problems
5. Intakes: Numerical on design of intake (spring)
6. Water Treatment: Numerical on design of sedimentation tank, determination of size and number of filters, numerical on chlorine demand, chlorine dose and residual chlorine, disinfectant concentration and contact time, killing concentration, working mechanism on advanced water treatment methods
7. Reservoirs and Distribution System: Determination of service reservoir capacity, pipe hydraulic, design criteria of distribution systems, and equivalent pipe method for looped networks, hydraulic calculation for multistorey building
8. Conveyance of Water: Preparation of pipe layout diagram for urban water supply
9. Pipe appurtenances, operation & maintenance, and computer-aided tools
10. Schematic diagram of valves and fittings, flushings and urban household plumbing from water meter to tap, water supply management and tools (Introducing some software and optimizing tools for water supply schemes)

### **Practical**

1. Determination of temperature, color, turbidity and pH
2. Determination of suspended, dissolved and total solids

3. Determination of dissolved oxygen by modified Winkler method
4. Determination of optimum dose of coagulant by jar test apparatus
5. Determination of residual chlorine in water
6. Microbial analysis of water for fecal contamination

### Assignment

1. A complete design of water supply schemes for a community (Quantity estimation, treatment and conveyance with necessary drawings using computer-aided design software)
2. A case study report on a conventional water treatment unit of running water supply scheme

### Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	2	3
2	4	5
3	5	7
4	5	7
5	3	4
6	14	18
7	6	8
8	2	3
9	4	5
<b>Total</b>	<b>45</b>	<b>60</b>

\* There may be minor deviation in marks distribution.

### References

1. American Public Health Association (APHA). (2017). Standard methods for the examination of water and wastewater (23rd ed.). APHA.
2. CPHEEO (1999). Manual on Water Supply and Treatment, Ministry of Housing and Urban Affairs, Government of India
3. Crittenden, J., Trussell, R.R., Hand, D.W., Howe, K.J., Tchobanoglous, G. (2005). Water Treatment Principles and Design, MWH, 2nd Edition, John Wiley & Sons Inc., USA.
4. Droste, R.L. (2014). Theory and Practice of Water and Wastewater Treatment, Wiley, New Delhi.
5. Mackenzie, D. (2010). Water and Wastewater Engineering—Design principles and practices. New York: McGraw-Hill.
6. DWSS – GON. (2021). Urban water supply and sanitation (sector) project, Design Guidelines, version 4. Project Management Office, Kathmandu.
7. Modi, P.N. (1998). Water Supply Engineering. Standard Book House, Delhi.