CHAPTER 1
INTRODUCTION TO WATER SUPPLY, QUANTITY AND QUALITY OF WATER

TH4: WATER SUPPLY AND WASTE WATER ENGINEERING

BY

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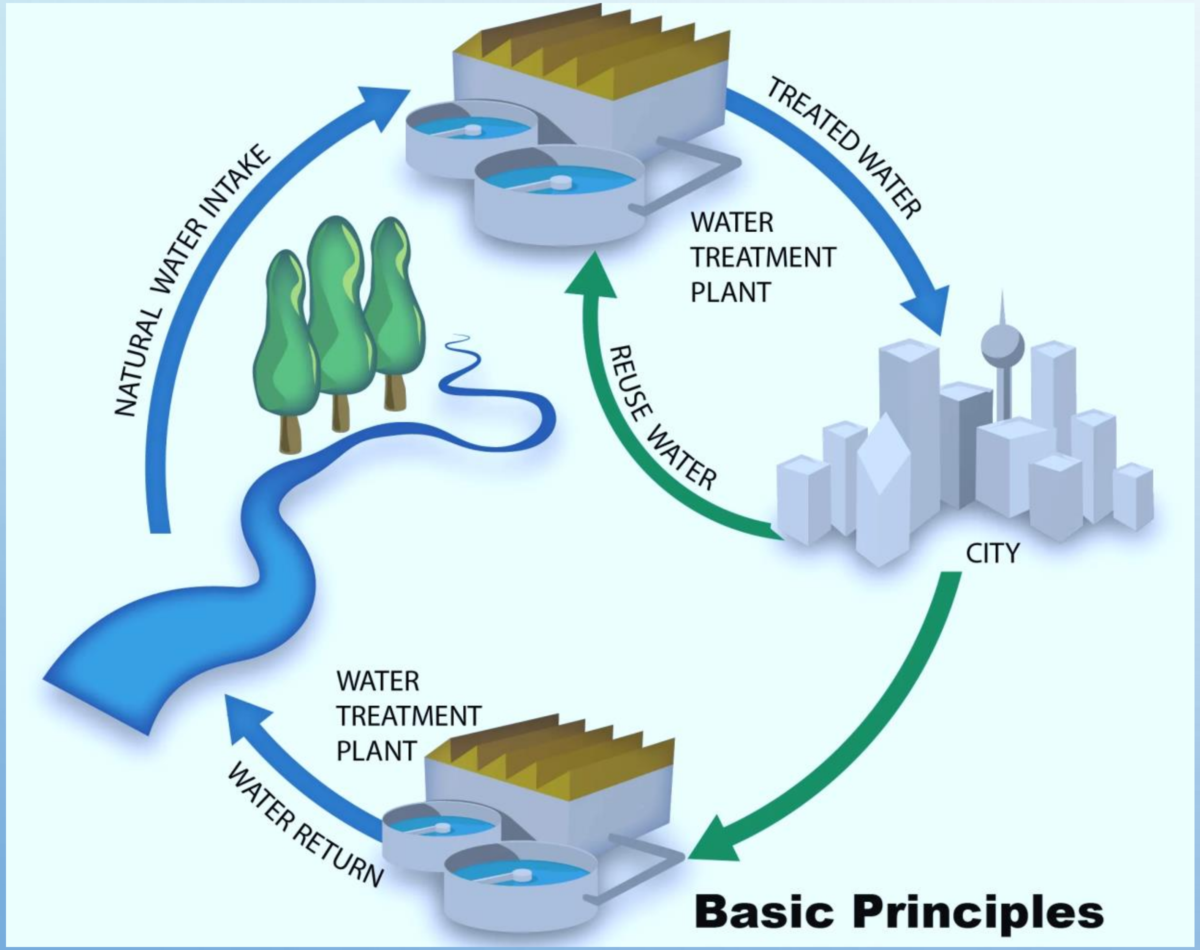
INTRODUCTION



- WATER SUPPLY ENGINEERING DEALS WITH THE COLLECTION, TREATMENT, STORAGE, AND DISTRIBUTION OF POTABLE WATER TO MEET THE NEEDS OF A COMMUNITY.
- THE PRIMARY GOALS ARE TO ENSURE **ADEQUATE QUANTITY, DESIRABLE QUALITY,** AND **RELIABILITY OF SERVICE**.

1.1 NECESSITY OF TREATED WATER SUPPLY

- **PUBLIC HEALTH PROTECTION:** Raw water may contain harmful microorganisms, suspended solids, and chemicals. Untreated water can lead to diseases like cholera, typhoid, dysentery, etc.
- **AESTHETIC QUALITIES:** Treated water should be clear, colourless, odourless, and pleasant in taste.
- **INDUSTRIAL AND DOMESTIC USES:** Many processes require clean and non-corrosive water to avoid damage to equipment.
- **AGRICULTURAL REQUIREMENTS:** While potable quality isn't needed, water should be free from toxic substances.
- **URBANIZATION AND POPULATION GROWTH:** Increase in population demands large-scale and continuous water supply systems.

1.2 PER CAPITA DEMAND, VARIATION IN DEMAND AND FACTORS AFFECTING DEMAND

A. Per Capita Demand (q):

The per capita demand or per capita consumption is the average amount of water required **per person per day**, usually expressed in **liters per capita per day (lpcd)**.

$$q = \frac{\text{Total Annual Water Demand}}{\text{Population} \times 365}$$

Note: Actual per capita demand varies based on country, climate, lifestyle, etc.

Purpose	Approx. Demand (lpcd)
Domestic use	135
Industrial use	50
Institutional and commercial use	20
Public use (parks, street cleaning)	10
Fire demand	15
Losses and wastage	55
Total	~ 270 lpcd

B. VARIATIONS IN DEMAND:

Type of Variation	Reason
Daily Variation	Usage is higher in mornings and evenings.
Seasonal Variation	More water is used in summer than in winter.
Monthly/Weekly Variation	Certain days (e.g., holidays, festivals) see increased demand.
Hourly Variation	Used for designing peak load conditions (e.g., 1.8 × average demand).

C. FACTORS AFFECTING WATER DEMAND:

- **CLIMATE** – Hot and dry regions have higher demand.
- **POPULATION AND LIVING STANDARDS** – Urbanization, modern amenities.
- **INDUSTRIALIZATION** – More factories mean more water needed.
- **FIRE PROTECTION** – Cities must plan for fire-fighting reserves.
- **SYSTEM LOSSES** – Due to leakage, illegal connections.
- **QUALITY OF WATER** – High-quality water may increase consumption.
- **COST OF WATER** – High water tax may decrease consumption.
- **SEWERAGE SYSTEM** – Existence of sewerage system increases the demand.

1.3 METHODS OF FORECASTING POPULATION

Population forecasting is essential for designing water supply systems. Methods include:

1. Arithmetic Increase Method
2. Geometric Increase Method
3. Incremental Increase Method
4. Graphical Method

1. Arithmetic Increase Method

•Assumes the population increases by a **constant amount** every decade.
•Suitable for cities with slow and steady growth.

Mathematically

$$P_n = P_0 + n.\bar{x}$$

where:

- P_n = Population after n decades
- P_0 = current population
- $\bar{x}$ = Average increase per decade
- n = number of decades

Problem-1: The population of 5 decades from 1980 to 2020 are given below. Find out the population after one and two decades beyond the last known decades using arithmetic increase method.

Year	1980	1990	2000	2010	2020
Population	40500	43200	46800	52000	56700

Solution:

- Population forecasting using Arithmetic Increase Method

$$P_n = P_0 + n.\bar{x}$$

Year	Population	Increase in population
1980	40500	-----
1990	43200	2700
2000	46800	3600
2010	52000	5200
2020	56700	4700
	Total	16200

- Average increase per decade, $\bar{x} = \frac{16200}{4} = 4050$
- Population after one decade, $P_{2030} = P_{2020} + 1.\bar{x}$
  = 56700 + 1. 4050
  = 60750
- Population after two decade, $P_{2040} = P_{2020} + 2.\bar{x}$
  = 56700 + 2. 4050
  = 64800

2. Geometric Increase Method

- Assumes the population increases at a **constant percentage** (compound rate).
- Best for rapidly growing cities.

Mathematically,

$$P_n = P_0(1 + \frac{r}{100})^n$$

where:

- P_n = Population after n decades
- P_0 = current population
- r = geometric rate of increase
- n = number of decades

Problem-2: The population of 5 decades from 1980 to 2020 are given below. Find out the population after one and two decades beyond the last known decades using geometric increase method.

Year	1980	1990	2000	2010	2020
Population	40500	43200	46800	52000	56700

Solution:

- Population forecasting using geometric Increase Method

$$P_n = P_0(1 + \frac{r}{100})^n$$

- Average increase rate, r $= \frac{35.14}{4} = 8.78\ \%$

- Population after one decade, $P_{2030} = P_{2020}(1 + \frac{8.78}{100})^1$
  = 56700 × 1.0878
  = 61678

- Population after two decade, $P_{2040} = P_{2020}(1 + \frac{8.78}{100})^2$
  = 56700 × 1.18
  = 67094

Year	Population	Increase in population	Percentage Increase
1980	40500	-----	-----
1990	43200	2700	6.66
2000	46800	3600	8.33
2010	52000	5200	11.11
2020	56700	4700	9.04
		Total	35.14

3. INCREMENTAL INCREASE METHOD

- Similar to arithmetic, but considers **change in increase (increment)** over time.
- More accurate than the arithmetic method for gradually changing rates.

Mathematically,

$$P_n = P_0 + n.\bar{x} + \frac{n(n+1)}{2}.\bar{y}$$

where:

- P_n = Population after n decades
- P_0 = current population
- $\bar{x}$ = Average increase per decade
- n = number of decades
- $\bar{y}$ = Average of incremental increases

Problem-2: The population of 5 decades from 1980 to 2020 are given below. Find out the population after one and two decades beyond the last known decades using geometric increase method.

Year	1980	1990	2000	2010	2020
Population	40500	43200	46800	52000	56700

Solution:

- Population forecasting using Incremental Increase Method

$$P_n = P_0 + n.\bar{x} + \frac{n(n+1)}{2}.\ \bar{y}$$

- Average increase per decade, $\bar{x} = \frac{16200}{4} = 4050$
- Average of incremental increase, $\bar{y} = \frac{+2000}{3} = \ +667$

- Population after one decade, $P_{2030} = P_{2020} + 1 \times 4050 + \frac{1(1+1)}{2} \times 667$
  = 56700 +4050+667
  = 61417

- Population after two decade, $P_{2040} = P_{2020} + 2 \times 4050 + \frac{2(2+1)}{2} \times 667$
  = 56700 +8100+2001
  = 66801

Year	Population	Increase in population	Incrementa l Increase
1980	40500	-----	-----
1990	43200	2700	-----
2000	46800	3600	+900
2010	52000	5200	+1600
2020	56700	4700	-500
	Total	16200	+2000

1.4 IMPURITIES IN WATER – ORGANIC AND INORGANIC, HARMFUL EFFECTS OF IMPURITIES

Types of impurities in water

- Water in its natural state is rarely pure and contains various **impurities**, which may be classified as:

A. Physical impurities

- Suspended solids (sand, silt, clay)
- Turbidity (cloudiness)
- Colour
- Taste and odour

B. Chemical impurities

I. Inorganic impurities

- **Salts**: chlorides, sulphates, nitrates of calcium, magnesium, sodium, potassium
- **Heavy metals**: lead, arsenic, mercury
- **Acids and alkalis**: affect ph balance

II. Organic impurities

- **Animal and plant matter**
- **Agricultural runoff**: fertilizers, pesticides
- **Industrial waste**: oils, chemicals, dyes

C. Biological impurities

- **Bacteria**, **viruses**, **protozoa**, **algae**, and **fungi**
- **Pathogens** causing diseases like typhoid, cholera, dysentery

HARMFUL EFFECTS OF IMPURITIES IN WATER

Type of Impurity	Harmful Effect
Suspended solids	Turbidity, unpleasant taste, damage to pipelines
Pathogens	Spread of waterborne diseases
Dissolved salts	Causes hardness, affects soap action
Organic matter	Causes bad smell and taste; promotes bacterial growth
Toxic metals	Leads to poisoning (e.g., lead, arsenic)
Agricultural/industrial pollutants	Eutrophication, health hazards

1.5 ANALYSIS OF WATER – PHYSICAL, CHEMICAL AND BACTERIOLOGICAL

Purpose of Water Analysis:
To determine if water is safe for **drinking**, **domestic**, **industrial**, or **agricultural** use.

A. Physical Analysis

Parameter	Description	Acceptable Limit (Drinking)
Turbidity	Cloudiness due to suspended solids	< 5 NTU
Colour	Should be colourless	< 5 Hazen units
Taste/Odour	Should be pleasant and acceptable	No objectionable taste/odour
Temperature	Affects taste, corrosion, solubility	< 25°C preferred

B. Chemical analysis

Parameter	Description & Acceptable Limits
pH value	Indicates acidity/alkalinity (6.5–8.5)
Total hardness	Due to Ca^{2+} and Mg^{2+} (max 200–600 mg/L)
Chlorides	Indicate salinity (max 250 mg/L)
Sulphates	Laxative effect (max 200 mg/L)
Fluoride	Dental health (optimum 1.0 mg/L)
Iron/Manganese	Staining and taste issues
Dissolved Oxygen	Indicates purity and aquatic health(5-10mg/l)

C. Bacteriological analysis

- **Coliform test (most probable number – MPN method)** indicates presence of **pathogenic organisms**.

E. Coli detection is crucial as it confirms **fecal contamination**.

- **Drinking water standard**: **0 coliforms/100 ml**

1.6 WATER QUALITY STANDARDS FOR DIFFERENT USES

Water quality varies according to **intended use**. The main standards followed in india are by **BIS (IS 10500:2012)**, **WHO**, and **CPCB**.

- **A. Drinking water quality (BIS – IS 10500:2012)**

Parameter	Acceptable Limit	Permissible Limit
pH	6.5–8.5	No relaxation
TDS	500 mg/L	2000 mg/L
Hardness	200 mg/L	600 mg/L
Nitrate	45 mg/L	No relaxation
Fluoride	1.0 mg/L	1.5 mg/L
Iron	0.3 mg/L	No relaxation
Coliform Bacteria	Absent/100 mL	Not permissible

B. Water For Irrigation

Parameter	Recommended Value
pH	6.0 – 8.5
Salinity (EC)	< 2 dS/m
Sodium Adsorption Ratio (SAR)	< 10
Boron	< 1.0 mg/L

C. Water for Industrial Use

- **Boiler feed water** requires very low TDS and hardness.
- Cooling water should have low scaling and corrosion potential.
- Specific industries may have unique requirements (e.g., Food, pharma).

THANK YOU