Part – 5: Environmental Engineering

5.1 Water Quality & Standards

- Maximum daily consumption = 1.8 x Average daily demand.
- Maximum hourly consumption = 2.7 x Annual average hourly demand.
- Unit processes for water treatment, Aeration → Screening → Sedimentation → Disinfection ← Softening ← Filtration

Sources of Municipal Water Supply

1. **Surface Source**

   - Ponds & lakes
   - Streams and rivers
   - Storage reservoir

2. **Subsurface Source**

Characteristics of water

1. Physical characteristics
   i. **Turbidity**: Due to suspended matters like clay, silt etc. measured on silica scale
   Measure by: Turbidity meters
   A. Jackson turbid meter : Used to measure high turbidity.Longer the light path lower is the turbidity
   10.8 cm ≈ 200 JTU
   21.5 cm ≈ 100 JTU
   B. Nephelometer: Used for turbidity of range o to 1 ppm
   Units → NTU: Nephelometer turbidity unit FTU for mazin turbidity unit
   I.S value for drinking water is 10-25 NTU
   ii. **Colour:** Due to decaying vegetation or some inorganic colored soil. Algae etc.
   Measured by: Platinum cobalt method
   Permissible limit: 5 to 20 ppm
   5 to 25 cobalt unit
   iii. **Taste and odour:** Due to dissolved organic matter or inorganic salts, dissolved gasses
   Measured by: osmoscope
   Units: Taste FTN (Flavor threshold number)
   Odour: TON (threshold odour number)
   Permissible limit : 1 to 3 FTN
   iv. **Temperature:** At high temperature CO_2 and some other volatile gases are expelled loading to decrease in palatability (taste) desirable limit 5 to $12°C$
   v. **Specific conductivity:** Due to dissolved ions
   Measured by :Dionic water tester

Chemical Characteristics

1. **PH**
   Due to bicarbonates of ca and Mg and carbonates (CO_3), hydroxides (OH) of ca, Mg, K, Na.
   Measured by: potentiometers, colorimetric method
   Units: Measured on P^H scale
   Desirable limit: 6.5 to 8.5
2. **Hardness**
   Due to bicarbonates & carbonates (temporary hardness), Non-carbonates (permanent hardness)
   Measured by: EDTA test (Ethyl diamine tetra – acetic acid)
   Units: of C_aCO_3

- **Hardness**

  Temporary due to carbonate and bi – carbonates of calcium and magnesium

  Permanent due to presence of sulphates, chlorides and nitrates.

- Total hardness = Ca^{2+} (mg/L) x $\frac{\text{Combining cub.of } CaCo_3}{\text{combining wt.of } ca^{2+}}$ + Mg^2 (mg/L) x $\frac{\text{Combining weight of } CaCo_3}{\text{combining weight of } Mg^{2+}}$

- Hardness limits
  - If hardness≤ 75 ppm: Soft water
  - If hardness b/w 75 – 200 ppm: Moderate water.
  - If hardness > 200 ppm: Hard water.

- Total hardness (TH) = carbonate hardness (CH) + non carbonate hardness (NCH)
  - If TH> alkalinity then CH = Alkalinity
  - If TH < alkalinity then CH = TH

- Alkalinity measured in mg/l of $CaCO_3$

  $HCO_3 \times \frac{\text{combining weight of } CaCO_3}{\text{combining weight } HCO_3} + CO_3 \times \frac{\text{combining weight of } CaCO_3}{\text{combining weight } CO_3}$

- Chloride: Content detected by $AgNO_3$ solution with $KMnO_4$ as indicator.

- Permissible limit 250 mg/L

  Nitrogen content

  Different forms

  1. Free ammonia: Indicates the presence of un-decomposed organic matter limit < 0.15 ppm

2. Albuminoid nitrogen: Indicates that decomposition of organic matter has started. Limit.$<$ 0.3 mg/L
3. Nitrites: Indicates presence of partly decomposition organic matter. Permissible: Nil
4. Nitrates: Indicates fully oxidized organic matter, permissible limit $<$ 45 ppm
   Total kjeldahl nitrogen (TKN) $=$ free ammonia $+$ organic nitrogen

Bacterial and Microscopic Characteristics

1. Aerobic Bacteria → Required oxygen survival
2. Anaerobic Bacteria → Do not required dissolve O_2
3. Facultative Bacteria → Can survive with or without O_2
   - Through some species of bacteria it may be helpful in cleaning of water but other pathogenic bacteria are harmful
   - The presence of pathogenic bacteria can be tested by counting presence of coil forms

Measurement of Coliform

- Filter the water through 30 pore size and cultivate the coloness and count the number.
- MPN: Most Probable Number.

5.2 Water Supply and Its Treatment

Type of Water Demand

1. Domestic water demand (55 to 60% of total water demand)
2. Industrial water demand (50 lpcdlitre per capita/day)
3. Institutional and commercial water demand (20 lpcd)
4. Demand for public uses (10 lcpd)
5. Fire demand (11 lpcd)
   When population exceeds 50,000
   Then water required $V = 100\sqrt{P}$
   Where V is in kilo litre and P is in thousand

   Kuichling & formula: $Q = 3182\sqrt{P}$ where P is population in thousand.

Variation in Demands

1. Maximum daily demand = 1.8 × average daily demand
2. Maximum hourly demand = 1.5 × average hourly demand
3. Maximum hourly demand in summer = 2.7 ×average hourly demand
   We can obtain these values using Goodrich's formulas
   $P = 180 + t^{-0.10}$
   Where P = percent of annual average demand for the time t in days

Population Fore Casting

1. Geometric Increase method

   $P_n = P_0\left[1 + \frac{r}{100}\right]^n$

   Where $r = r_1 \times r_2 \times r_3 \ldots\ldots xr_n$.

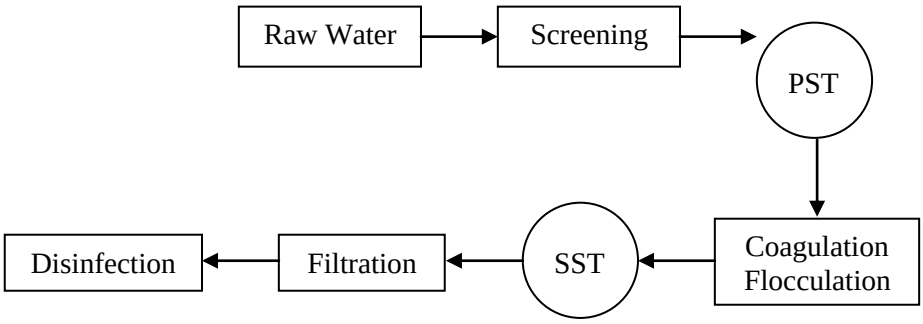
2. Average (arithmetic) method

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

3. Incremental increase method
   $P_1 = P_o + n\bar{x} + \frac{n(n+1)}{2}\bar{y}$
   A combination of arithmetic increase method and geometric method the average of increase in population is found from arithmetic method and is added to the average of net incremental increase

4. Decreasing method
   $P_n = P_o\left[1 + \frac{\gamma_o - \bar{D}}{100}\right]\left[1 + \frac{\gamma_o - 2\bar{D}}{100}\right]\ldots\left[1 + \frac{\gamma_o - n\bar{D}}{100}\right]$
   Where $\bar{D}$ is the rate of decrease in population growth rate .

- Basic units for surface water treatment



1. Screen: Velocity through screen < 0.8 to 1m/sec
2. Sedimentation: The velocity of flowing water is reduced nearly to zero and the sediments in water are allowed to settle by gravity

- Settling velocity, $Vs = \frac{g}{18}(G - 1)\frac{d_2}{r^2}$

Important Formulae Pertaining to Sedimentation

- Surface overflow rate $= \frac{Q}{B.L.}$
- Settling velocity $Vs = \frac{H}{t}$

  Where $t = \frac{\text{Volume of tank}}{\text{rate of flow}}$

- % of particle that can be removed in sedimentation tank $= \frac{V`}{V} \times 100\%$

  Where, $V`$ = Velocity of settling from slope's law.

  $V = H/t$

3. Coagulation and Flocculation is generally done by addition of Al^{3+} and Fe^{3+}
4. Filtration: Help in removing color, adour, turbidity and pathogenic bacteria
   a. The slow sand gravity filter
   b. The rapid sand gravity filter

Comparison of Slow Sand and Rapid Sand Filters

Items	Slow sand filter	Rapid gravity filters
1) Pre treatment	Effluent either from plain sedimentation tank or raw water without any treatment are generally fed into them and coagulation is not at all required	Coagulation flocculation and sedimentation is a must
2) Base material	The gravel base supports the sand. It varies from 3 to 65 mm in size and 30 to 75 cm in depth	The gravel base support the sand and also distributes the wash water uniformly on the surface of sand. It varies from 3 to 40 mm in size and its depth is slightly more than i.e. about 60 to 90 cm
3) Filter sand	The effective size of filter sand ranges between 0.2 to 0.4 mm and uniformity coefficient between 1.8 to 2.5 or 3.0	The effective size of the filter sand rages between 0.35 to 0.55 and uniformity coefficient between 1.2 to 1.8
4) Size of each unit	The grain size distribution is generally uniform throughout the depth of filter media except that top 10 to 15 cm may be laid of finer variety	The sand in layers with smallest grain size at top and corset grain size at the bottom
5) Rate of filtration	Large such as (30m × 60m) the area varying from 100 to 200 sq. m or more.	Small, such as 5m × 8m. The are varying from 10 to 80 sq.m
6) Efficiency	Small, such as 100 to 200 liters per hour per sq.m of filter are (50 to 60 ML/Ha/day)	Large such as 3000 to 6000 liters per hour per sq.m of filter are (1500 to 3000 ML/Ha/day)
7) Post treatment	Very efficient in removing bacteria (98 to 99%) but less efficient in removing color turbidity removal is upto 50 ppm	Less efficient (80 to 90%) very efficient in color removal
8) Method of cleaning		