Program : **B.Tech**

Subject Name: **Environmental Engineering I**

Subject Code: **CE-602**

Semester: **6th**

Unit – I

Estimation of ground and surface water resources. Quality of water from different sources, demand & quantity of water, fire demand, water requirement for various uses, fluctuations in demand, forecast of population.

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1. **Raw Water Source**

The various sources of water can be classified into two categories:

1. Surface sources, such as
   a. Ponds and lakes;
   b. Streams and rivers;
   c. Storage reservoirs; and
   d. Oceans, generally not used for water supplies, at present.
2. Sub-surface sources or underground sources, such as
   a. Springs;
   b. Infiltration wells ; and
   c. Wells and Tube-wells.

Water Quality

The raw or treated water is analysed by testing their physical, chemical and bacteriological characteristics:

Physical Characteristics:

- Turbidity
- Color
- Taste and Odour
- Temperature.

Chemical Characteristics:

- pH
- Acidity
- Alkalinity
- Hardness
- Chlorides
- Sulphates
- Iron
- Solids
- Nitrates

Bacteriological Characteristics:

Bacterial examination of water is very important, since it indicates the degree of pollution. Water polluted by sewage contains one or more species of disease producing pathogenic bacteria. Pathogenic organisms cause water borne diseases, and many non pathogenic bacteria such as *E.Coli*, a member of coliform group, also live in the intestinal tract of human beings. *Coliform* itself is not a harmful group but it has more resistance to adverse condition than any other group. So, if it is ensured to minimize the number of coliforms, the harmful species will be very less. So, coliform group serves as indicator of contamination of water with sewage and presence of pathogens.

The methods to estimate the bacterial quality of water are:

- Standard Plate Count Test
  Most Probable Number
  Membrane Filter Technique

Water Quantity Estimation

The quantity of water required for municipal uses for which the water supply scheme has to be designed requires following data:

1. Water consumption rate (Per Capita Demand in litres per day per head)
2. Population to be served.

Quantity= Per capita demand x Population

Water Consumption Rate

It is very difficult to precisely assess the quantity of water demanded by the public, since there are many variable factors affecting water consumption. The various types of water demands, which a city may have, may be broken into following classes:

Water Consumption for Various Purposes:

S.No	Types of Consumption	Normal Range (lit/capita/day)	Average	%
1	Domestic Consumption	65-300	160	35
2	Industrial and Commercial Demand	45-450	135	30
3	Public Uses including Fire Demand	20-90	45	10

4	Losses and Waste	45-150	62	25

Fire Fighting Demand:

The per capita fire demand is very less on an average basis but the rate at which the water is required is very large. The rate of fire demand is sometimes traeted as a function of population and is worked out from following empirical formulae:

	Authority	Formulae (P in thousand)	Q for 1 lakh Population)
1	American Insurance Association	Q (L/min)=4637 √P (1-0.01 √P)	41760
2	Kuchling's Formula	Q (L/min)=3182 √P	31800
3	Freeman's Formula	Q (L/min)= 1136.5(P/5+10)	35050
4	Ministry of Urban Development Manual Formula	Q (kilo liters/d)=100 √P for P>50000	31623

Factors affecting per capita demand:

a. Size of the city: Per capita demand for big cities is generally large as compared to that for smaller towns as big cities have sewered houses.
b. Presence of industries.
c. Climatic conditions.
d. Habits of people and their economic status.
e. Quality of water: If water is aesthetically $ medically safe, the consumption will increase as people will not resort to private wells, etc.
f. Pressure in the distribution system.
g. Efficiency of water works administration: Leaks in water mains and services; and unauthorised use of water can be kept to a minimum by surveys.
h. Cost of water.
i. Policy of metering and charging method: Water tax is charged in two different ways: on the basis of meter reading and on the basis of certain fixed monthly rate.

Fluctuations in Rate of Demand

Average Daily Per Capita Demand
= Quantity Required in 12 Months/ (365 x Population)

If this average demand is supplied at all the times, it will not be sufficient to meet the fluctuations.

- *Seasonal variation*: The demand peaks during summer. Firebreak outs are generally more in summer, increasing demand. So, there is seasonal variation .
- *Daily variation* depends on the activity. People draw out more water on Sundays and Festival days, thus increasing demand on these days.
- *Hourly variations* are very important as they have a wide range. During active household working hours i.e. from six to ten in the morning and four to eight in the evening, the bulk of the daily requirement is taken. During other hours the requirement is negligible. Moreover, if a fire breaks out, a huge quantity of water is required to be supplied during short duration, necessitating the need for a maximum rate of hourly supply.

So, an adequate quantity of water must be available to meet the peak demand. To meet all the fluctuations, the supply pipes, service reservoirs and distribution pipes must be properly proportioned. The water is supplied by pumping directly and the pumps and distribution system must be designed to meet the peak demand. The effect of monthly variation influences the design of storage reservoirs and the hourly variations influences the design of pumps and service reservoirs. As the population decreases, the fluctuation rate increases.

To estimate water demand, following parameters must be determined or calculated.

To determine the maximum water demand during a fire, the required fir flow must be added to the maximum daily consumption rate. The shortage is fulfilled by elevated storage tanks which have been filled during lower demand in usual days

1. Average daily water consumption: It is based on complete one year supply of water. It is the total consumption during one year, divided by the population. q = (Q / P x 365) lpcd (liters per capita per day)
2. Maximum daily consumption: It is the maximum amount of water used during one day in the year. This amount is 180% of the average daily consumption MDC = 1.8 x Avg. daily consumption. It is usually a working day (Monday) of summer season.
3. Maximum weekly demand: The amount of water used by a population during a whole single week in a study span of 1 year.
   Maximum weekly demand = 1.48 x Avg. D. C
   Maximum monthly demand = 1.28 x Avg. D. C

Maximum hourly demand = 1.5 x Avg. D. C
Maximum daily demand = 1.8 x Avg. D. C

4. Fire water demand | Fire Demand: The amount of water used for firefighting is termed as fire demand. Although, the amount of water used in firefighting is a negligible part of the combine uses of water but the rate of flow and the volume required may be so high during fire that it is a deciding factor for pumps, reservoirs and distribution mains.
   Minimum fire flow should be 500 gpm (1890 L/m)
   Minimum fire flow should be 8000 gpm (32, 400 L/m)
   Additional flow may be required to protect adjacent buildings.

Maximum daily demand *= 1.8 x average daily demand*
Maximum hourly demand of maximum day *i.e. Peak demand*

= 1.5 x average hourly demand
= 1.5 x Maximum daily demand/24
= 1.5 x (1.8 x average daily demand)/24
= 2.7 x average daily demand/24
= 2.7 x annual average hourly demand

<u>Design Periods & Population Forecast</u>

This quantity should be worked out with due provision for the estimated requirements of the future . The future period for which a provision is made in the water supply scheme is known as the design period

Design period is estimated based on the following:

- Useful life of the component, considering obsolescence, wear, tears, etc.
- Expandability aspect.
- Anticipated rate of growth of population, including industrial, commercial developments & migration-immigration.
- Available resources.
- Performance of the system during initial period.

Population Forecasting Methods

The various methods adopted for estimating future populations are given below. The particular method to be adopted for a particular case or for a particular city depends largely on the factors discussed in the methods, and the selection is left to the discretion and intelligence of the designer.

1. **Arithmetic Increase Method**

   This method is based on the assumption that the population increases at a constant rate; i.e. dP/dt=constant=k; Pt= P0+kt. This method is most applicable to large and established cities.

2. **Geometric Increase Method**

   This method is based on the assumption that percentage growth rate is constant i.e. dP/dt=kP; lnP= lnP0+kt. This method must be used with caution, for when applied it may produce too large results for rapidly grown cities in comparatively short time. This would apply to cities with unlimited scope of expansion. As cities grow large, there is a tendency to decrease in the rate of growth.

3. **Incremental Increase Method**

   Growth rate is assumed to be progressively increasing or decreasing, depending upon whether the average of the incremental increases in the past is positive or negative. The population for a future decade is worked out by adding the mean arithmetic increase to the last known population as in the arithmetic increase method, and to this is added the average of incremental increases, once for first decade, twice for second and so on.

4. **Decreasing Rate of Growth Method**

   In this method, the average decrease in the percentage increase is worked out, and is then subtracted from the latest percentage increase to get the percentage increase of next decade.

5. **Simple Graphical Method**
   In this method, a graph is plotted from the available data, between time and population. The curve is then smoothly extended upto the desired year. This method gives very approximate results and should be used along with other forecasting methods.
6. **Comparative Graphical Method**
   In this method, the cities having conditions and characteristics similar to the city whose future population is to be estimated are selected. It is then assumed that the

city under consideration will develop, as the selected similar cities have developed in the past

7. Ratio Method

In this method, the local population and the country's population for the last four to five decades is obtained from the census records. The ratios of the local population to national population are then worked out for these decades. A graph is then plotted between time and these ratios, and extended upto the design period to extrapolate the ratio corresponding to future design year. This ratio is then multiplied by the expected national population at the end of the design period, so as to obtain the required city's future population.

Drawbacks:

1. Depends on accuracy of national population estimate.
2. Does not consider the abnormal or special conditions which can lead to population shifts from one city to another.

3. Logistic Curve Method

The three factors responsible for changes in population are:
(i)Births, (ii) Deaths and (iii) Migrations.

Logistic curve method is based on the hypothesis that when these varying influences do not produce extraordinary changes, the population would probably follow the growth curve characteristics of living things within limited space and with limited economic opportunity. The curve is *S-shaped* and is known as *logistic curve*.

Que. Population Forecast by Different Methods

Problem: Predict the population for the years 1981, 1991, 1994, and 2001 from the following census figures of a town by different methods

Year	1901	1911	1921	1931	1941	1951	1961	1971
Population: (thousands)	60	65	63	72	79	89	97	120

Solution:

Year	Population: (thousands)	Increment per Decade	Incremental Increase	Percentage Increment per Decade
1901	60	-	-	-

1911	65	+5	-	(5+60) x100=+8.33
1921	63	-2	-3	(2+65) x100=-3.07
1931	72	+9	+7	(9+63) x100=+14.28
1941	79	+7	-2	(7+72) x100=+9.72
1951	89	+10	+3	(10+79) x100=+12.66
1961	97	+8	-2	(8+89) x100=8.98
1971	120	+23	+15	(23+97) x100=+23.71
Net values	1	+60	+18	+74.61
Averages	-	8.57	3.0	10.66

+=increase; - = decrease

Arithmetical Progression Method:

$$P_n = P + ni$$

Average increases per decade = i = 8.57

Population for the years,

1981= population 1971 + ni, here n=1 decade

= 120 + 8.57 = 128.57

1991= population 1971 + ni, here n=2 decade

= 120 + 2 x 8.57 = 137.14

2001= population 1971 + ni, here n=3 decade

= 120 + 3 x 8.57 = 145.71

1994= population 1991 + (population 2001 - 1991) x 3/10

= 137.14 + (8.57) x 3/10 = 139.71

Incremental Increase Method:

Population for the years,

1981= population 1971 + average increase per decade + average incremental increase

= 120 + 8.57 + 3.0 = 131.57

1991= population 1981 + 11.57

= 131.57 + 11.57 = 143.14

2001= population 1991 + 11.57

= 143.14 + 11.57 = 154.71

1994= population 1991 + 11.57 x 3/10

= 143.14 + 3.47 = 146.61

Geometric Progression Method:

Average percentage increase per decade = 10.66

$$P_n = P\,(1+i/100)^n$$

Population for 1981 = Population 1971 x $(1+i/100)^n$

= 120 x (1+10.66/100), i = 10.66, n = 1

= 120 x 110.66/100 = 132.8

Population for 1991 = Population 1971 x $(1+i/100)^n$

= 120 x $(1+10.66/100)^2$, i = 10.66, n = 2

= 120 x 1.2245 = 146.95

Population for 2001 = Population 1971 x $(1+i/100)^n$

= 120 x $(1+10.66/100)^3$, i = 10.66, n = 3

= 120 x 1.355 = 162.60

Population for 1994 = 146.95 + (15.84 x 3/10) = 151.70

Sedimentation Tank Design

Problem: **Design a rectangular sedimentation tank to treat 2.4 million litres of raw water per day. The detention period may be assumed to be 3 hours.**

Solution: **Raw water flow per day is 2.4×10^6 l. Detention period is 3h.**

Volume of tank = Flow x Detention period = $2.4 \times 10^3 \times 3/24 = 300\ m^3$

Assume depth of tank = 3.0 m.

Surface area = $300/3 = 100\ m^2$

L/B = 3 (assumed). L = 3B.

$3B^2 = 100\ m^2$ i.e. $B = 5.8$ m

$L = 3B = 5.8 \times 3 = 17.4$ m

Hence surface loading (Overflow rate) = $\underline{2.4 \times 10^6}$ = 24,000 l/d/m^2 < 40,000 l/d/m^2 (OK)

