ENVIRONMENTAL ENGINEERING

UNIT-I

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 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:

	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)	Qfor1lakh 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.

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

Design Periods & Population Forecast

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, tear, 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 discrection and intelligence of the designer.

1. Arithmetic Increase Method
2. Geometric Increase Method
3. Incremental Increase Method
4. Decreasing Rate of Growth Method
5. Simple Graphical Method
6. Comparative Graphical Method
7. Ratio Method
8. Logistic Curve Method

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:

Pn = 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

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

Physical Characteristics:

Turbidity
Colour
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 contain 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
Indian Standards for drinking water

Parameter	Desirable-Tolerable	If no alternative source available, limit extended upto
Physical		
Turbidity (NTU unit)	< 10	25
Colour (Hazen scale)	< 10	50
Taste and Odour	Un-objectionable	Un-objectionable
Chemical		
pH	7.0-8.5	6.5-9.2
Total Dissolved Solids mg/l	500-1500	3000
Total Hardness mg/l (as $CaCO_3$)	200-300	600
Chlorides mg/l (as Cl)	200-250	1000
Sulphates mg/l (as SO_4)	150-200	400
Fluorides mg/l (as F)	0.6-1.2	1.5
Nitrates mg/l (as NO_3)	45	45
Calcium mg/l (as Ca)	75	200
Iron mg/l (as Fe)	0.1-0.3	1.0