CHAPTER 1

Introduction to Water Supply, Quantity and Quality ofWater

Introduction to Water Supply, Quantity and Quality of waterCONTENT

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- **Introduction**

  water is used for many purposes associated with human activity. In its natural state it occurs in and on the ground in sub-surface and surface reservoirs. The quality and reliability of a source of water will vary considerably, both in time and space. This means that characteristics (chemical, physical, and biological) will differ greatly depending upon the location and type of source. It also means that a given source mayvary over the seasons of the year.

  Water Supply System

  This process consists of supply of purified water to the consumer by appropriatetreatment to raw water by conceding its source, intake, pumping.

  Need or requirement of water supply

The sanitation of the area is considerably improved by the adequate water supply.

- There is less changes of water born diseases.
- The public in general get purred water.
- It fulfill in general get purred water.

Requirement of Water for different purposes

Water is the most essential commodity for the continuation of life. An adequate & clean water supply is the basic requirement for domestic use for various purposes like—

(i) for drinking & cooking

(ii) for bathing & washing

(iii) for watering of lawns & gardens

(iv) for air-conditioning system

(v) For street washing etc.

(vi) Water is also required for various types of industrial & commercial purposes.

Quantity Of Water

Before designing any water supply Project, first of all the estimation quantity of water is calculated. These calculation based on two factor.

(i) Rate of demand

(ii) Population

Rate of demand : The requirement of water for various uses are properly & the rate of

consumption per head is calculated.
Population: The person to be served by the scheme is calculated & estimate the future population.

Rate of Demand

During planning a water supply scheme , it is the duty of the engineer to carefully examine the various types of water demand of the town & then to find out the suitable water sources from where the demand can be met. The various types of water demand of a city or town are:-

(i) Domestic Water Demand

(ii) Commercial & Industrial Demand

(iii) Demand for public uses

(iv) Fire Demand

Domestic Water Demand:-

- This demand includes the quantity of water required in the houses for drinking, cooking, bathing, washing, gardening, sanitary purposes etc.
- It mainly depends upon the living conditions of the consumer.
- As per IS:1172-1963 water required for domestic purposes for average Indian condition per head per day may be taken as 135 litres.
- In developed countries this may be as high as 350 litres. The total domestic water consumption may amount to 50 to 60% of the total water consumption.

Detail of water requirement for Domestic purposes:-

Sl.No.	Description	Consumption of water per head per day in litres
1.	Drinking	5
2.	Cooking	5
3.	Bathing	55
4.	Washing of clothes	20
5.	Washing of utensils	10
6.	Washing of houses	10
7.	Flushing of Latrines etc.	30
	Total	135

Commercial & Industrial Water Demand :-

- This includes offices, hotels, hospitals, schools, stores, Shopping centres etc.
- This demand depends upon the nature of the city, number and types of industries.
- On an average, 20 to 25% of the total water demand may be allowed for this type of demand in the design.

Demand for public uses :-

- Public demand includes the quantity of water required for public utility purposes such as watering of public parks, gardening, sprinkling on roads, use in public fountains etc.
- In many water supply schemes these demands are not believed as essential and a nominal amount not exceeding 5% of the total demand is kept on arbitrary basis.

Fire Demand :- It is the quantity of water required for fighting a fire outbreak.

For high value cities , water requirement for this purpose is particularly essential.

The quantity of water required for this purpose can be found out by applying certain empirical formula.

These are :-

(i) National Board of Fire Underwriters Formula :

$Q = 4637 \sqrt{P}(1- 0.01\sqrt{P})$

Where Q = Quantity of water required in litres per minute. P = Population of the town in thousands

(ii) Freeman formula : $Q = 1136.50(P/5)+10)$

(iii) Kuichling's Formula : $Q = 3182\sqrt{P}$

(iv) **Buston**'s Formula : $Q = 5663\sqrt{P}$

Per capita Demand :- It is the annual average amount of daily water required by one person and includes the domestic, industrial , and public use.

If Q = total quantity of water required by a city per year in litres & P = Population of the city Then Per Capita Demand in litre per day = Q / (P* 365)

Variation in Demand:- It has been seen that the demand does not remain uniform throughout the year, but it varies from season to season, even from hour to hour. So variation in rate of demand may be termed as

(i) Seasonal variation.

(ii) Daily variation.

(iii) Hourly variation.

1. **Seasonal Variation**:- In Summer the water demand is maximum, because people will use more water in bathing , cooling, lawn watering, street sprinkling etc. This demand goes on reducing & in winter it becomes minimum, because less water will be used in bathing & there will be no lawn watering.

2. **Daily Variation :-** The rate of demand may vary from day to day also. This is due to habits of the consumer, climatic conditions, holidays etc. On hot and dry day water requirements will be more as compared to a rainy day.

3. **Hourly Variation :-** The rate of demand during 24 hours does not remain uniform & it varies according to hours of the day. On Sundays & other holidays the peak hours may be about 8 A.M due to last awakening whereas it may be 6 A.M. on the other working days. Certain industries may be working in day & night shifts & consuming more water.

Factors affecting Per Capita Demand :-

The various factors which affect the per capita demand are :-

1. **Climatic condition** :- Water requirements during summer are more than winter . During summer more water is used for bathing , drinking & also more water is consumed in running coolers etc. Hence water consumption is much more in summer than that in winter.

2. **Size of city** :- Generally the demand of water per head will be more in big cities than that in small cities. In big cities lot of water is required for maintaining clean & healthy environments while in small towns it is not required.

3. **Habits of people** :- High class community uses more water due to their better standard of living & higher economic status. Middle class people use water at average rate and for poor people ,a single water tap may be sufficient for several families.

4. **Industries** :- More water will be required in highly industrialised city .

5. **Cost of water** :- More costly is the water less will be rate of demand. Hence the cost at which water is supplied to the consumer may also affect the rate of demand.

6. **Quality of water** :- A water works system having a protected & good quality of water supply would always be more popular with consumers. Hence more quantity of water will be consumed if the quality is good.

7. **Pressure in the distribution system** :- These would be of great importance in the case of localities having a number of two or three storied buildings. Adequate pressure would mean an uninterrupted and constant supply of water.

8. **System of supply** :- The system of supply may be continuous or intermittent. In continuous system water is supplied all the 24 hours while in case of intermittent system , water is supplied for certain fixed hours of the day only, result in some reduction in the consumption. This may be due to decrease in losses & other wasteful use.

II) **POPULATION:**

In this method the person to be served by water- supply scheme & the future population is calculation to design the water supply system.

Method of population forecast :-

The following are the method of population forecast.

(1) Arithmetical increase method
(2) Geometrical increase method
(3) Increment increase method
(4) Graphical method
(5) Comparative method
(6) Zoning method
(7) Ratio & Correlation method

(8) Growth composition analysis method
(9) Logistic curve method

The following are the methods generally used for forecasting population :

(i) Arithmetical Increase Method :- In this method, the increase in population is assumed to be constant and an average increase of the last 4 to 5 decades is calculated and added in the present population to determine population of the next future decade.

(ii) The population can be found out at the end of " n " year or decades is given by

Pn = P + n*i (where P = Present population , i = Yearly or per decade increase in population).

(iii) Geometrical Increase Method :- In this method the average %age of growth of last few decades is determined. The population forecasting is done on the basis that %age increase per decade will be the same.

Thus population at the end of n years or decades is given by :

Pn = P (1 +(i/100))n Where i = % age rate of increase per decade

(iv) Incremental Increase Method :- This method is improvement over the above two methods . The average increase in the population is determined by the arithmetical method and to this is added the average of the net incremental increase once for each future decade .

Thus population at the end of n years or decades is given by :

Pn = P + n (Ia + Ic) Public Health

Where Ia = Average Arithmetical Increase & Ic = Average incremental Increase

Problem :-

The following data have been noted from the census department.

Year	Population
1940	8,000
1950	12,000
1960	17,000
1970	22,500

Calculate the probable population in the year 1980, 1990 & 2000.

Answer by using Arithmetical Increase method :

Year	Population	Increase in population
1940	8,000	----------
1950	12,000	4000
1960	17,000	5000
1970	22,500	5500
	Total	14,500
	Average	4,833

Solution:

Year	Population
1980	22,500 + 1* 4833 = 27,333
1990	27333 + 1 * 4833 = 32,166

2000	32166 + 1 * 4833 = 36,999

Answer by using Geometrical Increase Method :

Year	Population	Increase in population	Percentage increase in population
1940	8,000	---------	----------
1950	12,000	4000	(4000/8000) *100 = 50.0%
1960	17,000	5000	(5000/12000)*100 = 41.7%
1970	22,500	5500	(5500/17000) *100 = 32.4%
Total		14,500	124.1
Average per decade		4,833	41.37

The population at the end of various decade will be as follows :

Year	Expected population
1980	22,500 +(41.37 / 100) * 22,500 =31,808
1990	31,808 + (41.37 / 100) * 31,808 = 44,967
2000	44,967 + (41.37 / 100) * 44,967 = 63570

Answer by using Incremental Increase Method :

Year	Population	Increase in Population	Incremental Increase
1940	8,000	-------	--------
1950	12,000	4000	--------
1960	17,000	5000	+1000
1970	22,500	5500	+500
Total		14,500	+1500
Average		4,833	+750

The population at the end of various decade will be as follows :

Year	Expected population
1980	22,500 + 1(4833 + 750) =28,083
1990	28,083 + 1(4833 + 750) = 33,666
2000	33,666 + 1(4833 + 750) =39,249

Answer by using Decreasing Rate Method :

Year	Population	Increase in Population	Percentage increase in population	Decrease in the % age increase
1940	8000	------	----------	-------
1950	12000	4000	(4000/8000) *100 = 50	-------
1960	17000	5000	(5000/12000) *100=	+ 8.3

			41.7	
1970	22500	5500	(5500/17000) *100= 32.4	+ 9.3
Total		14500		17.6
Average		4833		8.8

The population at the end of various decade will be as follows :

Year	net %age increase in population	Expected Population
1980	32.4 – 8.8 = 23.6	22,500 + (23.6/100) *22,500 = 27,810
1990	23.6 – 8.8 = 14.8	27,810 + (14.8/100) *27,810 = 31,926
2000	14.8 – 8.8 = 6.0	31,926 + (6.0/100) *31,926 = 33,842

WATER QUALITY:

water Analysis-

Various impurities present in water can be determined by water analysis. The following are the purpose of water analyses of raw water & purified water.

To classify water with respect to general level mineral constituent.
To determine chemical & bacteriological pollution of water.
To determine presence or absence of an excess of any particular constituent affecting
quality of waters.
To determine the degree of quality & clarity of matter in suspension.
In order to determine the quality of water it is subject to various test.

(i) Physical test
(ii) Chemical test
(iii) Bacteriological test

COMMON IMPURITIES IN WATER

The common impurities in water may be classified into following groups:

l. Physical impurities

2. Chemical impurities
3. Bacteriological impurities.

1. Physical Impurities

physical impurities may cause the following factors:

(a) Turbidity The turbidity of water indicates the presence of colloidal matters such as fine silt and clay. In some cases the salts of iron and manganese may impart turbidity in water. The colloidal substances and salts may be injurious to human health.

(b) Colour The water gets colour from the discharge of some industries such as tannery, textile industry, paper industry, etc. Those discharges mainly contain lignin, tannin and other waste products which may impart colour.

(c) Taste and Odour The discharges of waste products from some industries and trades contain strong smelling chemical compounds which impart taste and odour to the water. Generally, the smelling compounds are free chlorine, hydrogen sulphide, phenol, etc. Such compounds make the water very unpleasant to consume.

(d) Floating Matters At many places the dumping ground for debris or garbage may be close to the river. In rainy season garbage are carried by rainwater appearing as floating matters in the river or stream.

Unpleasant Gases:

The presence of gases in water is indicated by formation of foam in rivers which causes turbidity.

Radioactive substances:

The nuclear power plant, nuclear research centre and industries dealing with radioactive substances may discharge some substances having radio active property which affects human life and aquatic life.

2. Chemical Impurities

The presence of the following compound results in the chemical impurity of water.

(a) Acids :

- The waste products of some industries such as battery factory explosives factory. etc. contain, acids.
- If these waste products are directly discharged into river, then it will be harmful to the aquatic life and will destroy the self-purification property of river water.

(b) Alkalies:

- The waste products of some industries contain alkalies also.
- These alkalies have the same effect as that of acids.

(c) Inorganic Compounds:

- The waste products of some industries such as fertilizer industry, coke oven industry, etc. contain certain inorganic compounds.
- These compounds mainly consist of chloramines, sulphide, ammonia etc. which are toxic to a aquatic life.

(d) Organic Compounds The organic compounds may be of the following forms:

(i) The organic compounds may exist in water due to the presence of fats, proteins, carbohydrates, etc.

(ii) The suspended organic compound may develop due to decayed fruits, dead animals, etc. The organic compound like albuminoid ammonia is responsible for developing pathogenic bacteria which is dangerous to public health.

3. Bacteriological Impurities:

- The development of pathogenic bacteria, fungi, viruses, etc. in water is caused due to the fermentation of dead bodies and also due to the unhygienic discharge of sewage into river without proper treatment.

- Physical Test:
  the following are the test conducted under physical test.
  (1) Color
  (2) Taste & dour
  (3) Temperature
  (4) Turbidity

  Color

  The pure-water should be colorless.
  The impure water is having color, these color are contributed by the following sources.
  (a) Algae metabolism
  (b) End product degraded organic material
  (c) Distance of untreated & partially treats waste water,

  The color caused by the suspended matter is known as apparent color,
  The color is contributed by dissolved solid that remain after removal of suspended matter is known as true color.

- The color caused by the suspended matter is known as apparent color, the color is contributed by dissolved solid that remain after removal of suspended matter is known as true color.
- If colored impure water is present, it spoils the clothes & affect various industrial process.
  The measurement of color in water is carried out by mean of tinto meter.
- 'This instrument has an eye- piece with two holes.
- A slide of standard colored water is seen through. One hole & in other hole, the solid of water to be tested is inserted.
- The intensity of color in water is measured on an arbitrary scale.
- The unit of color on cobalt scale is the color produced by one mg of platinum cobalt in liter of distilled water.
- It should be less than 10.

Taste and odour:-

- The water possesses taste and odours due to various causes and they make the water unpleasant for drinking.
- The industrial wastes contain many strong smelling chemical compounds and when such trade wastes are discharged in to rivers or streams, the water of such rivers or streams gets unpleasant taste and odours.

The taste and odour in water in general have no real public health significance. But the pollution of water by taste and odour has the following effects.

(i) Such waters may prove detrimental to fish life and may damage the value of fisheries.

(ii) Such waters are not liked by public and they are rejected even in preference to tasteless and odourless waters of poor quality.

(iii) if taste and odour in water are due to certain toxic chemical gases, the use of such water may seriously injure the public health.

The test is carried out by in having through tests of an osmoscope. The taste and odour of water may also be tasted by thresholds number. For public water supply the threshold number should not be more that.

Temperature:

- The temperature of water to be supplied from stroge reservoir depends on the depth from which it is drawn.
- The desirable temperature of potable water is 10°c while temperature of 25°c is considered to be objectionable.

- The measurement of temperature of water is done with the help of ordinary the temperature.

Turbidity:-

a The colloidal matter present in water interferes with passage of light and thus imparts turbidity to the water.

b The turbidity in water may also be due to clay and silt practices, discharges of sewage or industrial wastes, presence of large numbers of nitro organisms etc. And the cloudy appearance developed in water due to turbidity is aesthetically unattractive and it may also be harmful to the consumers.

c Turbidity disturbs the disinfection process because the solids may practically shield the organics from the disinfectant.

d The turbidity is expressed in terms of parts of suspended matter per million parts of water or shortly written as P.P.M.

e It is to be noted that the expression p.p.m is also equivalent to mg per liter. or mg/ltr.

f The standard units of turbidity are the turbidity produced by one part of filters earth which is in the form of finely divided silica in a million parts of distilled water. The permissible turbidity for drinking water is 5 to 10 p.p.m.

g The measurement of turbidity in the field is done by means of turbidity rod and it is referred to as the visual method of turbidity measurement for lab, turbidity meters are used for to measure the turbidity of water.

The data obtained from turbidity measurements are helpful in the following ways.

i. It assists in deciding whether turbidity interferes with the photosynthesis reaction in streams and lakes.

ii. It gives indicator of the quantity of chemicals required for day to day operators of water treatment works. The excess turbidity may seriously affect the functioning of slow sand filters.

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Chemical impurities and chemical tests: -

1) **Chlorides:-**The chloride contains especially of sodium chloride or salt, are workout for a sample of water.

2) Presence of excess sodium chloride in natural water indicate pollution of water due to sewage, minerals, edible oil, mill separators, ice- cream plant effluents, chemical industries, sea water intrusion in costal regions etc.

3) For potable water, the highest desirable level of chloride content is 200mg/ltr. And its maximum permissible limit is 600mg/ltr.

Dissolved gases:-

- The water contains various gasses from its contact with the atmosphere and ground surfaces.
- The usual gasses are nitrogen, methyl, hydrogen sulphide, CO_2 and oxygen. Thecontents of these dissolved gasses in a sample of water are suitably worked out.
- The Nitrogen is not very important .The methane concentration is to be studied for its explosive property.
- The hydrogen sulphide gives disagreeable odour to the water even if its amount is very small.
- The carbon dioxide content indicates biological activities causes‘ corrosion,

increases the solubility of many minerals in water and gives taste to the water.

- The oxygen in the dissolved state is obtained from atmosphere and pure natural surface water is usually saturated with it. The simple test to determine the amount of dissolved oxygen present in a sample of water is to expose water for 4 hours at a temperature of 27°C with 10% acid solution of potassium permanganate.

- The oxygen in the dissolved state is obtained from atmosphere and pure natural surface water is usually saturated with it.
- The simple test to determine the amount of dissolved oxygen present in a sample of water is to expose water for 4 hours at a temperature of 27°C with 10% acid solution of potassium permanganate.

- The quantity of oxygen observed can then be calculated. This amount for portable water should be about 5 to 10 p.p.m.

Hardness:

The term hardness is defined as soap destroying property of water.The hardness may be of two types

- Temporary hardness
- Permanent hardness

✓ The temporary hardness is known as **carbonate hardness.**

✓ It is mainly due to the presence of bicarbonates of calcium & magnesium.

✓ It can be removed by adding lime to water.

❖ The permanent hardness is known as **non-carbonate hardness**.

❖ It is due to presence of sulphates, chlorides& nitrates of calcium & magnesium.

❖ It can be removed by boiling water. For potable water, the hardness should be more than 5 degree & less than 8 degree.

Hydrogen-ion concentration (PHvalue) . .

- The acidity & alkalinity of water is measures in terms of its **PH** value or H-ion concentrating.
- A neutral water has the PH value = 7
- , A acidic water has the PH value less than 7
- Zero value indicates maximum acidity.
- A alkaline water has the PH value more than 7.
- 14 value indicates maximum alkalinity
- For potable water the PH value should be in between 6.50 & 8.50.
- If PH value is below 4, it will produce a sour taste, if the PH value more than 8.50. it will imparts a bitter taste.

There are two method to measure PH value of water

Electrometric Method :- In this method a potentiometer is used to measure the electrical pressure exerted by positively changed H^+ -ions.

Colourimetric Method:- In this method a chemical reagent or indication are added in water & the colour produced is compared with a standard colour of known PH value.

Alkalinity:

The term alkalinity with reference to the water and waste water is defined as the capacity of substance contained in the water to take up hydronium (H_3O^+) to reach defined pH value **4.3 to 14.**

- The alkalinity is due to the presence of bicarbonate ($HCO3^-$),carbonate ($_{CO3-}$) or hydroxide (OH^-).
- The alkalinity is usually divided into the following two parts.

1. Total alkalinity i.e., above pH 4.5
2. Caustic alkalinity i.e. above pH 8.2
   The alkalinity is measured by the volumetric analysis.

1) Acidity:-

The term acidity with reference to the water and waste water is defined as the capacity of substance contained in water to take up Hydroxyl ions to reach a defined pH value (0 to 8.2)

- The determination of acidity of water has got significance because of the following reasons.

1. It affects the aquatic life.
2. It affects the biological treatment of sewage.
3. It corrodes pipes.
4. The water having acidity more than 50mg/ ltr. Cannot be used for R.C.C construction.

Metal and other chemical substances: - Various tests are made to detect the presence of different metals and other chemical substance in a sample of water.

Name of metal	Maximum permissible concentration in mg/ ltr
Arsenic (As)	0.05
Copper (Cu)	1.00
Fluoride(F)	1.70
Iron (Fe)	0.30
Zinc(Zn)	5.00

2) **Nitrogen and its compounds: -**The nitrogen is present in water in the following four forms

1) Free ammonia
2) Albuminoid ammonia
3) Nitrites
4) Nitrates

- The amount of free ammonia in portable water should not be exceeded 0.15

  p.p.m. and that of albuminoid ammonia should not exceed 0.3 p.p.m.
- The term albuminoid ammonia is used to represent the quantity of nitrogen present in water before the decomposition of organic matter has started.

Total solids:- The term solids with reference to the environmental engineering is defined as the residue in water left after evaporation and drying in oven at 703°c. The total solids consist of dissolved and suspended matter.

1. **Dissolved solid:-** The dissolved solids are determined by evaporating the filtered water and weighing the residue after drying properly.
2. **Suspended Solids**:-The suspended particles are determined by filtering water through the filter and weighed after drying properly.

3. **Bacteriological Test:**

- It is the test carried out to found out presence of bacteria.
- The bacteria is a small organized it cannot be detected by microscope.
- The bacteria may be harmful or harmless to mankind.
- The harmless bacteria is known as non- pathogenic bacteria.
- The harmful bacteria is known as pathogenic bacteria.
- The combined group of pathogenic & non-pathogenic bacteria is designated as
- B-Coli group.(i.e Bacterium and Coli)

The different tests are conducted to find presence of bacteria.

- Total count or Agar Plate count test

- B-coli test(or E-coli test)

Total count or Agar Plate count test:

- In this test the bacteria are cultivated on specially prepared medium of agar for different dilution of sample of water with sterilized water.
- The diluted sample is then placed incubator for 24 hrs at 37°C or for 48hrs at 20°C.
- The bacteria colonies formed after this period are counted with the help of microscope.
- Again the diluted sample is placed in incubator for 48 hours at 20*C & the bacterial colonies formed in this case are also counted.
- The two results are added to know the total number of colonies.This is known as Total counts.It is then converted to colonies per c.c.
- For potable water the total count should not exceed 100 per cc.

B-Coli Test:

This test is divided into three parts
(a) Presumptive test
(b) Confirmed test
(C) Completed test

Presumptive test:

- The definite amount of diluted sample of water are taken. water is placed in a
- standard fermentation tubes containing lactose broth.
- The tube is maintained at a temperature of 37°C for 48 hrs.
- if gas is seen in the tube after this period is over then B-Coli group are present.
- The test is treated as +ve. The —ve result of this test indicates water fit for drinking purpose. Negative result indicate the water safe for drinking.

(b) confirmed test:

- The small portion of lactose broth showing ÷ve value of presumptive test is transported to another fermentation tube containing brilliant green lactose bile and kept for 48 hours, if gas is seen after 48hrs the result is consider as positive. \

(c)Completed test:

- The samples of previous test are taken into lactose broth fermentation tube & agar tube and both tubes are incubated at 37*C for 24 to 48 hours.
- If gas is seen after this periods it indicates +ve result. So the water is unsafe for drinking.

End