Semester-V

19BECE504Environmental Engineering **3H-3C**

Instruction Hours/week: L: 3 T: 0 P: 0 **Marks:** Internal**:40** External**:60** Total**:100**

End Semester Exam:3 Hours

Course Objectives

1. Understand the impact of humans on environment and environment onhumans
2. Be able to identify and value the effect of the pollutants on the environment: atmosphere, water andsoil.

Course Outcomes

1. Analyze the impact of humans on environment and environment onhumans
2. Be able to examine the effect of the pollutants on the environment: atmosphere, water andsoil.
3. Be able to plan strategies to control, reduce and monitorpollution.
4. Be able to select the most appropriate technique for the treatment of water, wastewater solid waste and contaminatedair.
5. Be conversant with basic environmentallegislation.

UNIT-I: *Water:* -Sources of Water and quality issues, water quality requirement for different beneficial uses, Water quality standards, water quality indices, water safety plans, Water Supply systems, Need for planned water supply schemes, Water demand industrial and agricultural water requirements, Components of water supply system; Transmission of water, Distribution system, Various valves used in W/S systems, service reservoirs and design.

Water Treatment: aeration, sedimentation, coagulation flocculation, filtration, disinfection, advanced treatments like adsorption, ion exchange, membrane processes

UNIT-II: *Sewage-* Domestic and Storm water, Quantity of Sewage, Sewage flow variations. Conveyance of sewage- Sewers, shapes design parameters, operation and maintenance of sewers, Sewage pumping; Sewerage, Sewer appurtenances, Design of sewerage systems. Small bore systems, Storm Water- Quantification and design of Storm water; Sewage and Sullage, Pollution due to improper disposal of sewage, National River cleaning plans,

Wastewater treatment, aerobic and anaerobic treatment systems, suspended and attached growth systems, recycling of sewage – quality requirements for various purposes.

UNIT-III: *Air* - Composition and properties of air, Quantification of air pollutants, Monitoring of air pollutants, Airpollution- Occupational hazards, Urban air pollution automobile pollution, Chemistry of combustion, Automobile engines, quality of fuel, operating conditions and interrelationship. Air quality standards, Control measures for Air pollution, construction and limitations

Noise- Basic concept, measurement and various control methods.

UNIT-IV: *Solid waste management-*Municipal solid waste, Composition and various chemical and physical parameters of MSW, MSW management: Collection, transport, treatment and disposal of MSW. Special MSW: waste from commercial establishments and other urban areas, solid waste from construction activities, biomedical wastes, Effects of solid waste on environment: effects on air, soil, water surface and ground health hazards. Disposal of solid waste-segregation, reduction at source, recovery and recycle. Disposal methods- Integrated solid waste management. Hazardous waste: Types and nature of hazardous waste as per the HW Schedules of regulatingauthorities.

UNIT-V: *Building Plumbing*-Introduction to various types of home plumbing systems for water supply and waste water disposal, high rise building plumbing, Pressure reducing valves, Break pressure tanks, Storage tanks, Building drainage for high rise buildings, various kinds of fixtures and fittingsused.
Government authorities and their roles in water supply, sewerage disposal. Solid waste management and monitoring/control of environmental pollution.

Practical Work: List of Experiments

1. Physical Characterization of water: Turbidity, Electrical Conductivity,pH
2. Analysis of solids content of water: Dissolved, Settleable, suspended, total, volatile, inorganicetc.
3. Alkalinity and acidity, Hardness: total hardness, calcium and magnesiumhardness
4. Analysis of ions: copper, chloride andsulfate
5. Optimum coagulantdose
6. Chemical Oxygen Demand(COD)
7. Dissolved Oxygen (D.O) and Biochemical Oxygen Demand(BOD)
8. Break pointChlorination
9. Bacteriological quality measurement:MPN,
10. Ambient Air quality monitoring (TSP, RSPM, SOx,NOx)
11. Ambient noisemeasurement

Text/Reference Books:

1. Introduction to Environmental Engineering and Science by Gilbert Masters, Prentice Hall, NewJersey.
2. Introduction to Environmental Engineering by P. AarneVesilind, Susan M. Morgan, Thompson /Brooks/Cole; Second Edition2008.
3. Peavy, H.s, Rowe, D.R, Tchobanoglous, G. *Environmental Engineering*, Mc-Graw - Hill International Editions, New York1985.
4. MetCalf and Eddy. *Wastewater Engineering, Treatment, Disposal and Reuse*, Tata McGraw-Hill, NewDelhi.
5. Manual on Water Supply and Treatment. Ministry of Urban Development, NewDelhi.
6. Plumbing Engineering. Theory, Design and Practice, S.M. Patil,1999
7. Integrated Solid Waste Management, Tchobanoglous, Theissen& Vigil. McGraw Hill Publication
8. Manual on Sewerage and Sewage Treatment Systems, Part A, B and C. Central Public Health and Environmental Engineering Organization, Ministry of UrbanDevelopment.

KARPAGAM ACADEMY OF HIGHER EDUCATION

(Established Under Section 3 of UGC Act, 1956)

COIMBATORE-641 021

ENVIONMENTAL ENGG

Staff Name : Dr.N.Balasundaram
Semester : 5 (2018-19)
Course Type : Core
Number of credits : 3
LTPC : 3 0 0

S.No	Lecture Duration (Hour)	Topics to be covered	Support Materials
		UNIT I	
1.	1	Sources of Water and quality issues, water quality requirement for different beneficial uses, Water quality standards,	T_1/14
2.	1	water quality indices, water safety plans, Water Supply systems, Need for planned water supply schemes,	T_1/11,12
3.	1	Water demand industrial and agricultural water requirements,	T_1/12
4.	1	Components of water supply system; Transmission of water, Distribution system,	T_1/12
5.	1	Various valves used in W/S systems, service reservoirs and design.	T_1/200
6.	1	*Water Treatment:* aeration, sedimentation,	T_1/250
7.	1	coagulation flocculation,	T_1/232
8.	1	filtration, disinfection,	T_1/221
9.	1	advanced treatments like adsorption, ion exchange, membrane processes	T_1/266
		UNIT II	
10.	1	*Sewage*- Domestic and Storm water, Sewage and Sullage,	T_1/18
11.	1	Conveyance of sewage- Sewers, shapes design parameters, operation and maintenance of sewers, Sewage pumping;	T_1/25,26
12.	1	Sewerage, Sewer appurtenances, Design of sewerage systems. Small bore systems,	T_1/25,29,30
13.	1	Storm Water- Quantification and design of Storm water;	T_1/28
14.	1	National River cleaning plans, Wastewater treatment.	T_1/29,27
15.	1	aerobic and anaerobic treatment systems,	T_1/253
16.	1	recycling of sewage – quality requirements for various purposes.	T_1/225
17.	1	Quantity of Sewage, Sewage flow variations.	T_1/219
18.	1	Pollution due to improper disposal of sewage, suspended and attached growth systems	T_1/236
		UNIT III	
19.	1	*Air* - Composition and properties of air, Quantification of air	T1/29

		pollutants, Monitoring of air pollutants,	
20.	1	Urban air pollution automobile pollution	T_1/221
21.	1	Airpollution- Occupational hazards,	T_1/155
22.	1	Chemistry of combustion.	T_1/136
23.	1	Urban air pollution automobile pollution, Chemistry of combustion.	T_1/165
24.	1	Automobile engines,	T_1/144
25.	1	quality of fuel, operating conditions and interrelationship. Air quality standards,	T_1/133
26.	1	Control measures for Air pollution, construction and limitations	T_1/121
27.	1	*Noise*- Basic concept, measurement and various control methods.	**T1/541**
UNIT IV			
28.	1	**:** *Solidwaste management*-Municipal solid waste, Composition	T_1/146
29.	1	**Chemical parametes**	T_1/117
30.	1	physical parameters of MSW, MSW management:	T_1/114
31.	1	Collection, transport, treatment and disposal of MSW.	T_1/127
32.	1	Special MSW: waste from commercial establishments and other urban areas,	T_1/261
33.	1	solid waste from construction activities, biomedical wastes,	T_1/265
34.	1	Effects of solid waste on environment: effects on air, soil, water surface and ground health hazards.	T_1/269
35.	1	Disposal of solid waste-segregation, reduction at source, recovery and recycle. Disposal methods- Integrated solid waste management.	T_1/272
36.	1	Hazardous waste: Types and nature of hazardous waste as per the HW Schedules of regulatingauthorities	T_1/277
UNIT V			
37.	1	*Building Plumbing*-Introduction to various types of home plumbing systems for water supply	T_1/99
38.	1	various kinds of fixtures and fittingsused.	T_1/110
39.	1	Break pressure tanks	T_1/112
40.	1	High rise building	T_1/116
41.	1	waste water disposal	T_1/118
42.	1	plumbing, Pressure reducing valves,	T_1/203
43.	1	Storage tanks, Building drainage for high rise buildings,	T_1/206
44.	1	Government authorities and their roles in water supply, sewerage disposal.	T_1/209
45.	1	Solid waste management and monitoring/control of environmental pollution.	T_1/211

TEXT BOOKS:

1. Introduction to Environmental Engineering and Science by Gilbert Masters, Prentice Hall, NewJersey.
2. Introduction to Environmental Engineering by P. AarneVesilind, Susan M. Morgan, Thompson /Brooks/Cole; Second Edition2008.
3. Peavy, H.s, Rowe, D.R, Tchobanoglous, G. *Environmental Engineering*, Mc-Graw - Hill International Editions, New York1985.

UNIT NOTES

PART -A

1. What are the methods of population forecasting?

- Arithmetic increase method
- Geometric increase method
- Method of varying increment (or) Incremental increase method
- Decreasing rate of growth method
- Simple graphical method
- Comparative graphical method
- Master plan method (or) zoning method
- The logistic curve method

2. Define design period?

The future period for which a provision is made in designing the capacities of the various components of the water supply scheme is known as design period.

3. What are the factors governing the design period?

The Factors governing design period are

(i) **Useful life of component structures** and the chances of their becoming old and obsolete. Design periods should not exceed those respective values.
(ii) **Ease and difficulty** that is likely to be faced-in expansions, if undertaken at future dates. For example, more difficult expansions mean choosing a higher value of the design period.
(iii) **Amount and availability of additional investment** likely to be incurred for additional provisions. For example, if the funds are not available, one has to keep a smaller design period.

4. What are various type of water demand?

a. Domestic water demand
b. Industrial
c. Institution and commercial
d. Demand for public use
e. Fire demand

5. What are the various type of water available on the earth?

1. Surface sources such as
   a. ponds and lakes
   b. Stream and rivers
   c. Storage reservoirs
   d. Ocean.
2. Sub surface sources
   a. Spring
   b. Infiltration galleries
   c. Infiltration wells
   d. Wells and tube wells

6. What is hydrologic cycle?

Water is lost to the atmosphere as vapor from the earth. Which is then precipitated back in the form of rain, snow, hail dew, sleet or frost etc. This process is known as hydrologic cycle.

9. What are springs?

The natural out flow of ground water at the earth surface is called as springs.

10. What are the types of springs?

a. Gravity springs.
b. Surface springs.
c. Artesian springs.

12. What are the different types of wells?

a. Open wells
   Shallow wells.
   Deep wells.
b. Tube well

13. What is artesian spring?

The pervious layer which contains water combined between two impervious layers is called artesian spring.

14. What are the factors governing the selection of a particular source of water?

The factors governing are as follows

a. the quantity of available water
b. The quality of available water
c. Distance of the source of supply
d. General topography of the intervening area
e. Elevation of the source of supply.

15. What are tube wells?

Tube wells which a long pipe or a tube is bored or drilled deep in to the ground.

16. What are the factors affecting per capita demand?

The Factors affecting per capita demand are,

a. Climatic condition.
b. Habit of people.
c. Size of city.
d. Cost of water.
e. Industry.
f. Pressure in water tank.
g. Quantity of water.
h. System of sanitation.
i. Supply of system.

17. Write the formulae used in arithmetic and geometric increase method?

Arithmetic increase method:

$$P_n = P_o + n\bar{x}$$

Geometric increase method:

$$P_n = P_o\left(1 + \frac{r}{100}\right)^n$$

Where,

P_n → Forecasted population after n decades from the present.
P_o → Present population
N → No. of decades between now and future.

18. State the objectives of public water supply scheme?

- To supply safe and wholesome water to consumers
- To supply water in adequate quantity
- To make water easily available to consumers so as to encourage personal and household cleanliness.
- To provide design period

19. Define per capita demand?

The demand of water per person per day is known as per capita demand or per capita consumption.

Per capita demand = (Total yearly water requirement of the city in litres) / (365x design population)

20. Define wholesome, potable water and palatable water?

Water which has both the characteristics of wholesome water and palatable water is known as **potable water.**

Water, at a desirable temperature, that is free from objectionable tastes, odors, colors, and turbidity is called **Palatable Water**

Water that is safe and palatable for human consumption is known as **wholesome water.**

21. List out the physical characteristics of water. State the IS standards recommendation?

Physical Characteristics of water are:

1. Turbidity - 1NTU
2. Colour - 5to20 (Platinum cobalt scale)
3. Taste – No objection
4. Odour- 0 to 4
5. Temperature - 10 to 15.6 deg cel

22. List the chemical properties of water?

pH, Acidity, Alkalinity, hardness, chloride, sulphates, iron, solids, nitrates

23. List the components of water supply system?

- Intakes& reservoirs
- Screening
- Clariflocculator
- Filtration
- Disinfection
- Valve, hydrants etc

24. State the purposes of carrying water quality characteristics?

To ensure the diseases away environment and then promoting better health.

25. List the assumptions made in 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 per decade growth rate is assumed not to be constant.

26. Distinguish between carbonate and non-carbonate hardness. (Or) Distinguish between temporary and permanent hardness.

Temporary (or) Carbonate Hardness is due to the carbonate and bicarbonates of calcium and magnesium being present in the water. This type of hardness can be removed by boiling the water to expel the CO_2, as indicated by the following equation: **permanent (or) non-carbonate hardness** is due to nitrates, sulphates, and chlorides etc of calcium and magnesium. This type of hardness cannot be eliminated by boiling.

27. Distinguish between shallow well and deep well.

A **shallow well** is the one which rests in pervious strata and draws its supplies from the surrounding materials.

A **deep well** is the one which rests on an impervious mota layer and draws its supplies from the previous formation lying below the mota layer, through a bore hole made into the mota layer.

PART-B

1. What are the objectives of water supply scheme and requirements of wholesome water?

The objectives of the community water supply system are

1. To provide whole some water to the consumers for drinking purpose.

2. To supply adequate quantity to meet at least the minimum needs of the individuals

3. To make adequate provisions for emergencies like firefighting, festivals, meeting etc.

4. To make provision for future demands due to increase in population, increase in standard of living, storage and conveyance

5. To prevent pollution of water at source, storage and conveyance

6. To maintain the treatment units and distribution system in good condition with adequate staff and materials

7. To design and maintain the system that is economical and reliable

Wholesome water is defined as the water which containing the minerals in small quantities at requisite levels and free from harmful impurities. The water that is fit for drinking safe and agreeable is called **potable water.**

The following are the requirements of wholesome water.

1. It should be free from bacteria

2. It should be colorless and sparkling

3. It should be tasty, odour free and cool

4. It should be free from objectionable matter

5. It should not corrode pipes

6. It should have dissolved oxygen and free from car.

2. Discuss the factors to be considered in fixing the design periods for water supply components? (Nov 2014)

Design Periods

The future period or the number of years for which a provision is made in designing the capacities of the various components of the water supply scheme is known as **design period**. The design period should neither be too long nor should it be too short. The design period cannot exceed the useful life of the component structure, and is guided by the following considerations:

Factors Governing the Design Period

(i) Useful life of component structures and the chances of their becoming old and obsolete. Design periods should not exceed those respective values.
(ii) Ease and difficulty that is likely to be faced-in expansions, if undertaken at future dates. For example, more difficult expansions mean choosing a higher value of the design period.
(iii) Amount and availability of additional investment likely to be incurred for additional provisions. For example, if the funds are not available, one has to keep a smaller design period.
(iv) The rate of interest on the borrowings and the additional money invested. For example, if the interest rate is small, a higher value of the design period may be economically justified and, therefore, adopted.
(v) Anticipated rate of population growth, including possible shifts in communities, industries and commercial establishments. For example, if the rate of increase of population is less, a higher figure for the design period may be chosen.

3. List out the methods of population forecasting? (Or) Explain the different methods used for prediction of future population of a City, with reference to the design of a water supply system.

<u>Population Forecasting Methods</u>

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
2. Geometric Increase Method
3. Incremental Increase Method
4. Decreasing Rate of Growth Method
5. Simple Graphical Method

6. Comparative Graphical Method
7. Master Plan Method or Zoning Method
8. Ratio Method
9. Logistic Curve Method

1. Arithmetic Increase Method

This method is based upon the assumption that the population increases at a constant rate; *i.e.* the rate of change of population with time $(\frac{dP}{dt})$ is constant.

$$\left(\frac{dP}{dt}\right) = \text{Constant} = K$$

$$P_n = [P_o + n\bar{x}]$$

Where,

P_n = Prospective or forecasted population after n decades from the present (i.e. last known census)
P_o = Population at present (i.e. last known census)

2. Geometric Increase Method

In this method, the per decade percentage increase or percentage growth rate (r) is assumed to be constant, and the increase is compounded over the existing population every decade. This method is, therefore, also known as uniform increase method.
The basic difference between arithmetic and geometric progression methods of forecasting future populations is that: whereas, in arithmetic method, no compounding is done; in geometric method, compounding is done every decade. The computations in two methods are, thus, comparable to simple and compound interest computations, respectively.

$$P_n = P_O\left(1 + \frac{r}{100}\right)^n$$

Where,

P_o = Initial population; i.e. the population at the end of last known census.
P_n = Future population after n decades.
r = Assumed growth rate (%).

The average may again be either the arithmetic average i.e.

$$r = \frac{r_1 + r_2 + r_3 + \cdots + r_n}{t}$$

Or the geometric average i.e. $r = \sqrt[t]{r_1 . r_2 . r_3 \dots r_t}$

The design engineers in the field generally consider the arithmetic mean here, because

it is slightly higher than the geometric mean, and hence gives conservative higher value of forecasted population. However, the "GOI Manual on Water and Water Treatment" recommends the use of geometric mean here; and hence, we can safely use that value.

3. Method of Varying Increment or Incremental Increase Method.

In this method, the per decade growth rate is not assumed to be constant as in the arithmetic or geometric progression methods ; but is progressively increasing or decreasing, depending upon whether the average of the incremental increases* in the past data is positive or negative.

The population for a future decade is worked out by adding the mean arithmetic increase (say $\bar{x}$) to the last known population as in "arithmetic increase method", and to this is added the average of the incremental increases $\bar{y}$, once for the first decade, twice for the second decade, thrice for the third decade, and so on.

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

Where,

P_n = Prospective or forecasted population after n decades from the present (i.e. last known census)

P_o = Population at present (i.e. last known census)

x = Average increase of populations of known decades

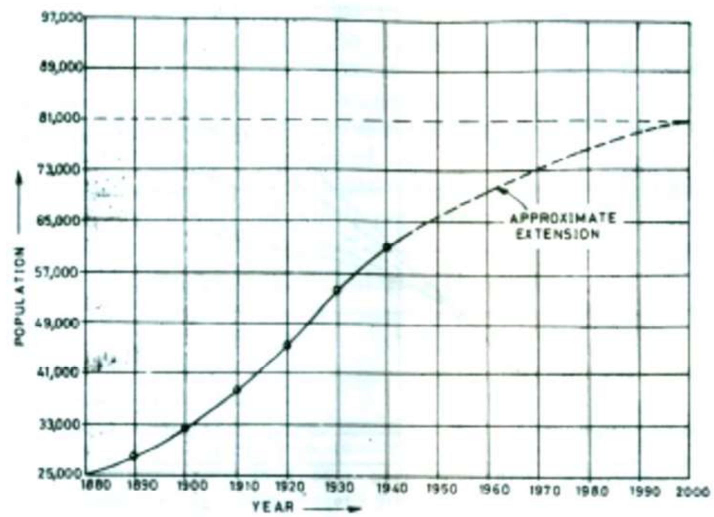
y = Average of incremental increases of the known decades.

4. Decreasing Rate of Growth Method

Since the rate of increase in population goes on reducing, as the cities reach towards saturation, a method which makes use of the decrease in the percentage increase, is many a times used, and gives quite rational results. In this method, the average decrease in the percentage increase is worked out, and is then subtracted from the latest percentage increase for each successive decade. This method is however, applicable only in cases, where the rate of growth shows a downward trend

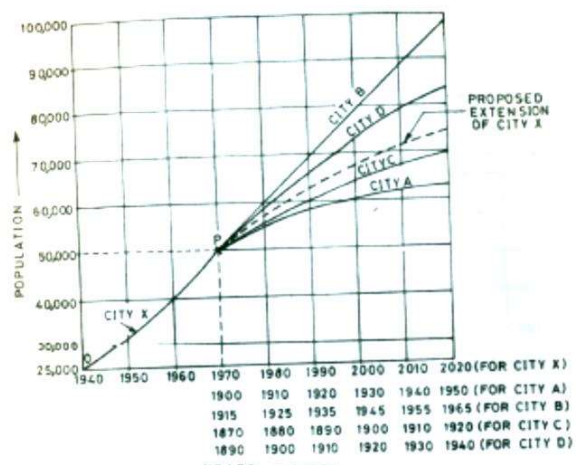
5. Simple Graphical Method

In this method, a graph is plotted from the available data, between time and population. The curve is then smoothly extended up to the desired year. The method, however, gives very approximate results, as the extension of the curve is done by the intelligence of the designer.



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, first of all, selected. It is then assumed that the city under consideration will develop, as the selected similar cities have developed in the past. This method has a logical background, and if statistics of development of similar cities are available, quite precise and reliable results can he obtained. However, it is rather difficult to find identical cities with respect to population growth.



7. Master Plan Method or Zoning Method

Big and metropolitan cities are generally not allowed to develop in haphazard and natural ways, but are allowed to develop only in planned ways. The expansions of such cities are regulated by various by-laws of corporations and other local bodies. Only those expansions are allowed, which are permitted or proposed in the master plan of that city. The master plan prepared for a city is generally such, as to divide the city in various zones, and thus to separate the residence, commerce, and industry from each other. The population densities are also fixed. Say for example, there may be 5 persons living in a residential plot and there may be 10,000 plots in a zone. Then, the total population of this zone, when fully developed, can be easily worked out as 5 x 10,000 = 50,000. Hence, when the development is regulated by such a scheme, it is very easy to access precisely the design population, because the master plan will give us as to when and where the given number of houses, industries and commercial establishments would be developed.

8. Ratio Method or the Apportionment Method.

In this method of forecasting future population of a city or a town, the city's census population record is expressed as the percentage of the population of the whole country. In order to do so, 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 worked out for these decades. A graph is then plotted between time and these ratios, and extended up to the design period, so as to extrapolate the ratio corresponding to the future design year. Sometimes, the last census ratio or the average of the past few years may be used. 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. The expected national population in different future years are generally available, as they are worked out precisely by the Census Dept. by some rational recommended method. This method is, therefore, very suitable for areas whose growths are parallel to the national growth. However, this method does not take into consideration, the abnormal conditions that may prevail in certain local areas.
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.

9. 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.

4. The population of 5 decades from 1930 to 1970 are given below in table 2.9. Find out the population after one, two and three decades beyond the last known decade, by using Arithmetic Increase Method.

Year	**1930**	**1940**	**1950**	**1960**	**1970**
Populatio	**25,000**	**28,000**	**34,000**	**42,000**	**47,000**

Solution. The given data is extended, so as to compute the increase in population (x) for each decade (col. 3), the total increase, and average increase per decade (x), as shown.

Year (1)	Population (2)	Increase in population (x) (3)
1930	25,000	
		3000
1940	28,000	
		6000
1950	34,000	
		8000
1960	42,000	
		5000
1970	47,000	
Total		22,000
Average per decade (x)		$x = \frac{22000}{4} = 5,500$

The future populations are now computed by using Eqn. (2.14) as:

$$P_n = [P_o + n\bar{x}]$$

(a) Population after **1** decade beyond 1970

$$P_{1980} = P_1 = P_{1970} + 1 \times \bar{x}$$

$$P_{1980} = 47000 + 1 \times 5500 = 52500$$

(b) Population after 2 decades beyond 1970

$$P_{1990} = P_2 = P_{1970} + 2 \times \bar{x}$$

$$P_{1980} = 47000 + 2 \times 5500 = 58000$$

(c) Population after 3 decades beyond 1970

$$P_{2000} = P_2 = P_{1970} + 3 \times \bar{x}$$

$$P_{2000} = 47000 + 3 \times 5500 = 63500$$

5. The population of 5 decades from 1930 to 1970 are given below in table 2.9. Find

out the population after one, two and three decades beyond the last known decade, by using geometric increase method.

Table 2.9

Year	1930	1940	1950	1960	1970
Populatio	25,000	28,000	34,000	42,000	47,000

Solution. The given population data of table2.9, is used to complete the growth rates (%) for each decade, as table 2.11

Year (1)	Population (2)	Increase in population in each decade (3)	Percentage increase in Population i.e. growth =col.(3)/col.(4)x100 (4)
1930	25,000		
		3000	(3000/25000)x100=12%
1940	28,000		(6000/28000)x100=21.4%
		6000	(8000/34000)x100=23.5%
1950	34,000		(5000/42000)x100=11.9%
		8000	
1960	42,000		
		5000	
1970	47,000		

The geometric mean of the growth rates(r)

$$r = \sqrt[4]{12 \times 21.4 \times 23.5 \times 11.9}$$

$$= 16.37\% \text{ per decade.}$$

Now, assuming that the future population increase at this constant rate (16.37%), we have

$$P_n = P_o\left(1 + \frac{r}{100}\right)^n$$

Or, $$P_n = Po\ (1+0.1637)^n$$

$$= Po\ (1.1637)^n$$

Using n=1, 2, 3 decades, we have

The population after 1 decade i.e. for the year 1980

$$= P_{1980} = 47{,}000 \text{ X } (1.1637)$$

$$= 54{,}694.$$

Similarly P_{1990} = population after 2 decades

$$= 47000 \text{ X } (1.1637)^2 = 63{,}647.$$

Similarly P_{2000} = population after 3 decades

$= 47000 \ X \ (1.1637)^3 = 74{,}066.$

6. The population of 5 decades from 1930 to 1970 are given below in table 2.9. Find out the population after one, two and three decades beyond the last known decade, by using incremental increase method.

Table 2.9

Year	1930	1940	1950	1960	1970
Populatio	25,000	28,000	34,000	42,000	47,000

Solution.

Year (1)	Population (2)	Increase in population (3)	Incremental increase; i.e. increment on the increase (4)
1930	25,000		
		3000	
1940	28,000		(+)3000
		6000	(+)2000
1950	34,000		(-)3000
		8000	
1960	42,000		
		5000	
1970	47,000		
Total		22,000	(+)2000
Avg. per decade		x = (22,000/4) = 5500	y = (2000/3) = 667

The future population P_n is now given by eqn. (2.19) as:

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

Hence, $$P_{1980} = P_{1970} + 1 \times \bar{x} + \frac{1(1+1)}{2}\bar{y}$$

$$P_{1980} = 47000 + 1 \times 5500 + \frac{1(1+1)}{2} \times 667$$

$= 53{,}167.$

$$P_{1990} = P_{1970} + 2 \times \bar{x} + \frac{2(2+1)}{2}\bar{y}$$

$$P_{1990} = 47000 + 2 \times 5500 + \frac{2(2+1)}{2} \qquad = 60{,}001.$$

$\times 667$ ^{2}

$$P_{2000} = P_{1970} + 3 \times \bar{x} + \frac{3(3+1)}{2} \bar{y}$$

$$P_{2000} = 47000 + 3 \times 5500 + \frac{3(3+1)}{2} \times 667$$

$= 67{,}502.$ $\times 667$

2

15. What are the factors that affect the per capita demand?

The annual average demand for water (i.e. per capita demand) considerably varies for different towns or cities. This figure generally ranges between 100 to 360 litres/capita/day for Indian conditions. The following are the main factors affecting for capita demand of the city or town.

a) Climatic conditions: The quantity of water required in hotter and dry places is more than cold countries because of the use of air coolers, air conditioners, sprinkling of water in lawns, gardens, courtyards, washing of rooms, more washing of clothes and bathing etc. But in very cold countries sometimes the quantity of water required may be more due to wastage, because at such places the people often keep their taps open and water continuously flows for fear of freezing of water in the taps and use of hot water for keeping the rooms warm.

b) Size of community: Water demand is more with increase of size fo town because more water is required in street washing, running of sewers, maintenance of parks and gardens.

c) Living standard of the people: The per capita demand of the town increases with the standard of living of the people because of the use of air conditioners, room coolers, maintenance of lawns, use of flush, latrines and automatic home appliances etc.

d) Industrial and commercial activities: As the quantity of water required in certain industries is much more than domestic demand, their presence in the town will enormously increase per capita demand of the town. As a matter of the fact the water required by the industries has no direct link with the population of the town.

e) Pressure in the distribution system: The rate of water consumption increase in the pressure of the building and even with the required pressure at the farthest point, the consumption of water will automatically increase. This increase in the quantity is firstlydue to use of water freely by the people as compared when they get it scarcely and more water loss due to leakage, wastage and thefts etc.

f) System of sanitation: Per capita demand of the towns having water carriage system will be more than the town where this system is not being used.

g) Cost of water: The cost of water directly affects its demand. If the cost of water is more, less quantity of water will be used by the people as compared when the cost is low.

16) Explain about the 5 demands- its characteristics? (8) (May 2013, Nov 2011) Various types of water demands:

While designing the water supply scheme for a town or city, it is necessary to determine the total quantity of a water required for various purposes by the city. As a matter of fact the first duty of the engineer is to determine the water demand of the town and then to find suitable water sources from where the demand can be met. But as there are so many factors involved in demand of water, it is not possible to accurately determine the actual demand. Certain empirical formulae and thumb rules are employed in determining the water demand, which is very near to the actual demand.

Following are the various types of water demands of a city or town:

i. Domestic water demand ii. Industrial demand
iii. Institution and commercial demand iv. Demand for public use
v. Five demand

vi. Loses and wastes

DOMESTIC WATER DEMAND

The quantity of water required in the houses for drinking, bathing, cooking, washing etc is called domestic water demand and mainly depends upon the habits, social status, climatic conditions and customs of the people. As per IS: 1172-1963, under normal conditions, the domestic consumption of water in India is about 135 litres/day/capita. But in developed countries this figure may be 350 litres/day/capita because of use of air coolers, air conditioners, maintenance of lawns, automatic household appliances. The details of the domestic consumption are a) Drinking → 5 litres
b) Cooking → 5 litres
c) Bathing → 55 litres
d) Clothes washing → 20 litres
e) Utensils washing → 10 litres
f) House washing → 10 litres
g) Flushing of water closets → 30 litres

Total → 135 litres/day/capita

INDUSTRIAL DEMAND

The water required in the industries mainly depends on the type of industries, which are existing in the city. The water required by factories, paper mills, Cloth mills, Cotton mills, Breweries, Sugar refineries etc. comes under industrial use. The quantity of water demand for industrial purpose is around 20 to 25% of the total demand of the city.

INSTITUTION AND COMMERCIAL DEMAND

Universities, Institution, commercial buildings and commercial centers including office buildings, warehouses, stores, hotels, shopping centers, health centers, schools, temple, cinema houses, railway and bus stations etc comes under this category. As per IS: 1172-1963, water supply requirements for the public buildings other than residences as follows.

DEMAND FOR PUBLIC USE

Quantity of water required for public utility purposes such as for washing and sprinkling on roads, cleaning of sewers, watering of public parks, gardens, public fountains etc comes under public demand. To meet the water demand for public use, provision of 5% of the total consumption is made designing the water works for a city.

FIRE DEMAND

Fire may take place due to faulty electric wires by short circuiting, fire catching materials, explosions, bad intension of criminal people or any other unforeseen mishappenings. If fires are not properly controlled and extinguished in minimum possible time, they lead to serious damage and may burn cities. All the big cities have full fire-fighting squads. As during the fire breakdown large quantity of water is required for throwing it over the fire to extinguish it, therefore provision is made in the water work to supply sufficient quantity of water or keep as reserve in the water mains for this purpose. In the cities fire hydrants are provided on the water mains at 100 to 150 m apart for fire demand. The quantity of water required for firefighting is generally calculated by using different empirical formulae. For Indian conditions kuichings formula gives satisfactory results.

$Q=3182\sqrt{p}$

Where 'Q' is quantity of water required in litres/min

'P' is population of town or city in thousands

LOSSES AND WASTES

All the water, which goes in the distribution, pipes does not reach the consumers. The following are the reasons

1. Losses due to defective pipe joints, cracked and broken pipes, faulty valves and fittings.
2. Losses due to, consumers keep open their taps of public taps even when they are not using the water and allow the continuous wastage of water
3. Losses due to unauthorised and illegal connections

17. Explain about the surface source of water supplies? SURFACE SOURCES OF WATER SUPPLIES

Surface sources are those sources of water in which the water flows over the surface of

the earth, and is thus directly available for water supplies. The important of these sources are:

(i) Natural ponds and lakes; (ii) Streams and

rivers; and (iii)
Impounding reservoirs.

These sources are discussed below:

Ponds and Lakes as Surface Sources of Supplies

A natural large sized depression formed within the surface of the earth, when gets filled up with water, is known as a pond or a lake. The difference between a pond and a lake is only that of size. If the size of the depression is comparatively small, it may be termed as a pond, and when the size is larger it may be termed as a lake. The flow of water in a lake is just like the flow in a stream channel. Generally, the surface run-off from the catchment area contributing to the particular lake, enters the lake through small drains or streams. Sometimes, the underground water through some spring, also enters natural depressions and gets collected there, forming ponds and lakes.

The quality of water in a lake is generally good and does not need much purification. Larger and older lakes, however, provide comparatively purer water than smaller and newer lakes. Self-purification of water due to sedimentation of suspended matter, bleaching of colour, removal of bacteria, etc. makes the lake's water purer and better. On the other hand, in still waters of lakes and ponds, the algae, weed and vegetable growth take place freely, imparting bad smells, tastes and colours to their waters.

The quantity of water available from lakes is, however, generally small. It depends upon the catchment area of the Lake Basin, annual rainfall, and geological formations. Due to the smaller quantity of water available from them, lakes are usually not considered as principal sources of water supplies. They are, therefore, useful for only small towns and hilly areas. However, when no other sources are available, larger lakes may become the principal sources of supplies. For example, in Bombay city, water is supplied and brought from lakes about 70 km from there.

Streams and Rivers as Surface Sources of Supplies

Small stream channels feed their waters to the lakes or rivers. Small streams are, therefore, generally not suitable for water supply schemes, because the quantity of water available in them is generally very small, and they may even sometimes go dry. They are, therefore, useful as sources of water only for small villages, especially in hilly regions. Larger and perennial streams may, however be used as sources of water, by providing storage reservoirs, barrages, etc. across them.

Rivers are the most important sources of water for public water supply schemes. It is a well known fact that most of the cities are settled near the rivers, and it is generally easy to find a river for supplying water to the city. Rivers may be perennial or non-perennial. Perennial rivers are those in which the water is available throughout the year. Such rivers are generally fed by rains during rainy season and by snow during summer season. Perennial rivers can be used as sources of public supplies directly, whereas the non- perennial rivers can be used as sources of public supplies by providing storage on the upstream of the intake works. The construction of a dam is generally adopted on a highly non-perennial river and may be adopted even on a perennial river when water is used for multiple uses such as irrigation, hydropower, etc. The head works, such as a barrage or a weir, may also be constructed on those perennial rivers, where supplies are considerably reduced during dry weather periods.

The quality of water obtained from rivers is generally not reliable, as it contains large amounts of silt, sand and a lot of suspended matter. The disposal of the untreated or treated sewage into the rivers is further liable to contaminate their waters. The river waters must, therefore, be properly analysed and well treated before supplying to the public.

Impounding reservoirs

A **reservoir** is a natural or **artificial lake**, **storage pond**, or **impoundment** from a dam which is used to store water. Reservoirs may be created in river valleys by the construction of a dam or may be built by excavation in the ground or by conventional construction techniques such as brickwork or cast concrete.

The term reservoir may also be used to describe naturally occurring underground reservoirs such as those beneath an oil or water well.

A **dam** is a barrier that impounds water or underground streams. Dams generally serve the primary purpose of retaining water, while other structures such as floodgates or levees (also known as dikes) are used to manage or prevent water flow into specific land regions. Hydropower and pumped-storage hydroelectricity are often used in conjunction with dams to generate electricity. A dam can also be used to collect water or for storage of water which can be evenly distributed between locations.

Arch dams

In the arch dam, stability is obtained by a combination of arch and gravity action. If the upstream face is vertical the entire weight of the dam must be carried to the foundation by gravity, while the distribution of the normal hydrostatic pressure between vertical cantilever and arch action will depend upon the stiffness of the dam in a vertical and horizontal direction.

Gravity dams

In a gravity dam, the force that holds the dam in place against the push from the water is Earth's gravity pulling down on the mass of the dam. The water presses laterally (downstream) on the dam, tending to overturn the dam by rotating about its toe (a point at the bottom downstream side of the dam). The dam's weight counteracts that force, tending to rotate the dam the other way about its toe. The designer ensures that the dam is heavy enough that the dam's weight wins that contest. In engineering terms, that is true whenever the resultant of the forces of gravity acting on the dam and water pressure on the dam acts in a line that passes upstream of the toe of the dam.

Earth-fill dams

Earth-fill dams, also called **earthen dams**, **rolled-earth dams** or simply **earth dams**, are constructed as a simple embankment of well compacted earth. A homogeneous rolled-earth dam is entirely constructed of one type of material but may contain a drain layer to collect seep water. A zoned-earth dam has distinct parts or zones of dissimilar material, typically a locally plentiful shell with a watertight clay core. Modern zoned-earth embankments employ filter and drain zones to collect and remove seep water and preserve the integrity of the downstream shell zone. An outdated method of zoned earth dam construction utilized a hydraulic fill to produce a watertight core. Rolled-earth dams may also employ a watertight facing or core in the manner of a rock-fill dam. An interesting type of temporary earth dam occasionally used in high latitudes is the frozen-core dam, in which a coolant is circulated through pipes inside the dam to maintain a watertight region of permafrost within it.

18. Explain about aquifers and its types?

Aquifers and Their Types

A permeable stratum or a geological formation of permeable material, which is capable of yielding appreciable quantities of ground-water under gravity, is known as an aquifer. The term 'appreciable quantity' is relative, depending upon the availability of the ground-water. In the regions, where ground-water is available with great difficulty, even fine-grained materials containing very less quantities of water may be classified as principal aquifers.

When an aquifer is overlain by a confined bed of impervious material, then this confined bed of overburden is called an aquiclude, as shown in fig. The amount of water yielded by a well excavated through an aquifer, depends on many factors; some of which, such as well diameter, are inherent in the well itself. But all other things being equal, the permeability and the thickness of the aquifer are the most important.

Aquifers vary in depth, lateral extent, and thickness; but in general, all aquifers fall into one of the two categories, i.e.,

Unconfined or Non-artesian aquifers; and

Confined or Artesian aquifers, as discussed below:

Unconfined Aquifers or Non-artesian Aquifers: The top most water bearing stratum having no confined impermeable over burden (i.e., aquiclude) lying over it, is known as an unconfined aquifer or non-artesian aquifer

The ordinary gravity wells of 2 to 5 m diameter, which are constructed to tap water from the top most water bearing strata, i.e., from the unconfined aquifers, are known as unconfined or non-artesian wells. The water levels in these wells will be equal to the level of the water table. Such wells are, therefore, also known as gravity wells or water-table wells.

<u>Confined Aquifers or Artesian Aquifers:</u> When an aquifer is confined on its upper and under surface, by impervious rock formations (i.e., aquicludes), and is also broadly inclined so as to expose the aquifer somewhere to the catchment area at a higher level for the creation of sufficient hydraulic head, it is called a confined aquifer or an artesian aquifer.

A well excavated through such an aquifer, yields water that often flows out automatically, under the hydrostatic pressure, and may thus, even rise or gush out of surface for a reasonable height. However, where the ground profile is high, the water may remain well below the ground level. The former type of artesian wells, where water gushes out automatically, are called flowing wells.

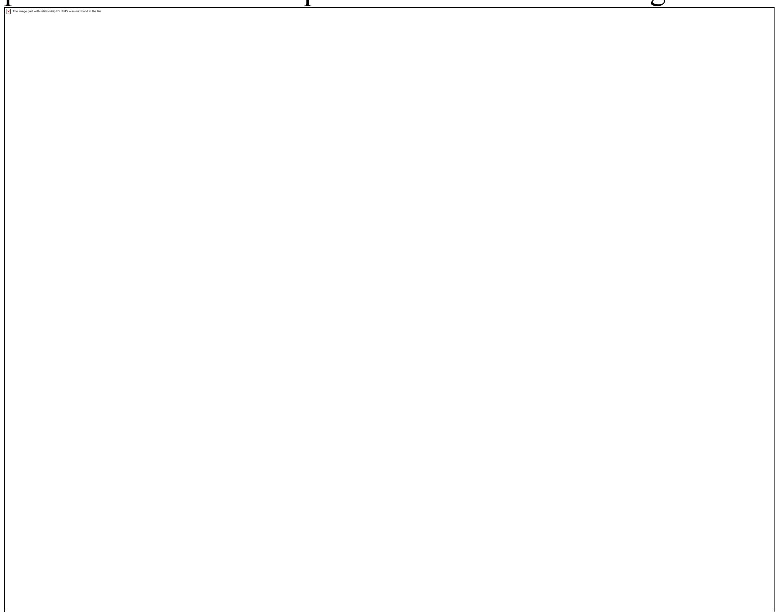
The image part with relationship ID rId44 was not found in the file.

The level to which water will rise in an artesian well is determined by the highest point on the aquifer, from where it is fed from the rains falling in the catchment (i.e., by discharge). However, the water will not rise to this full height, because the friction of the water moving through the aquifer uses up some of the energy.

The question whether it will be a flowing artesian well or a non-flouring artesian well depends upon the topography of the area, and is not the inherent property of the artesian aquifer. In fact, if the pressure surface* lies above the ground surface, the well will be a flowing artesian well, whereas ,if the' pressure surface is below the ground surface, the well will be artesian but non-flowing, and will require a pump to bring water to the surface, as shown in Fig. 4.6. Such non-flowing artesian wells are sometimes called sub-artesian wells.

Perched Aquifers: Perched aquifer is a special case which is sometimes found to occur within an unconfined aquifer.

Sometimes, a lens or a localised patch of an impervious stratum can occur inside an unconfined aquifer in such a way that it retains a water table above the general water table, as shown in Fig. 4.7. Such a water table retained around the impervious material is known as a perched water table, while the supported body of the saturated material is known as a perched aquifer. Usually, the perched water table is of limited extent, and the ground water yield from such geological occurrence is very small. In ground water exploration, a perched water table is quite often confused as the general water table.



19. With neat sketch, explain how water is drawn from infiltration galleries and wells? (10) (Nov 2010)

An **infiltration gallery** is a structure including perforated conduits in gravel to expedite transfer of water to or from a soil aquifer.

Infiltration galleries may be used to supplement a storm sewer, by directing storm runoff from non-road areas. While the catch basins under sewer grates work well on swift-flowing surfaces like asphalt and concrete, heavy storm water flow on grass lawns or other open areas will pool in low areas if there is no outlet.

Water supply:

Infiltration galleries may be used to collect water from the aquifer underlying a river. Water from an infiltration gallery has the advantage of bank filtration to reduce the water treatment requirements for a surface withdrawal. An infiltration gallery may also be the best way to withdraw water from a thin aquifer or lens of fresh water overlying saline water.

Infiltration Galleries (IG) or wells can be constructed near perennial rivers or ponds to collect infiltrated surface waters for all domestic purposes. Since the water infiltrate through a layer of soil/sand, it is significantly free from suspended impurities including microorganisms usually present in surface water. Again, surface water being the main source of water in the gallery/well, it is free from arsenic. If the soil is impermeable, well graded sand may be placed in between the gallery and surface water source for rapid flow of water.

Experimental units constructed in the coastal area to harvest low saline surface waters show that water of the open infiltration galleries is readily contaminated. The accumulated water requires good sanitary protection or disinfection by pot chlorination. Sedimentation of clayey soils or organic matters near the bank of the surface water source interfere with the infiltration process and require regular cleaning by scrapping a layer of deposited materials.

Infiltration Galleries:

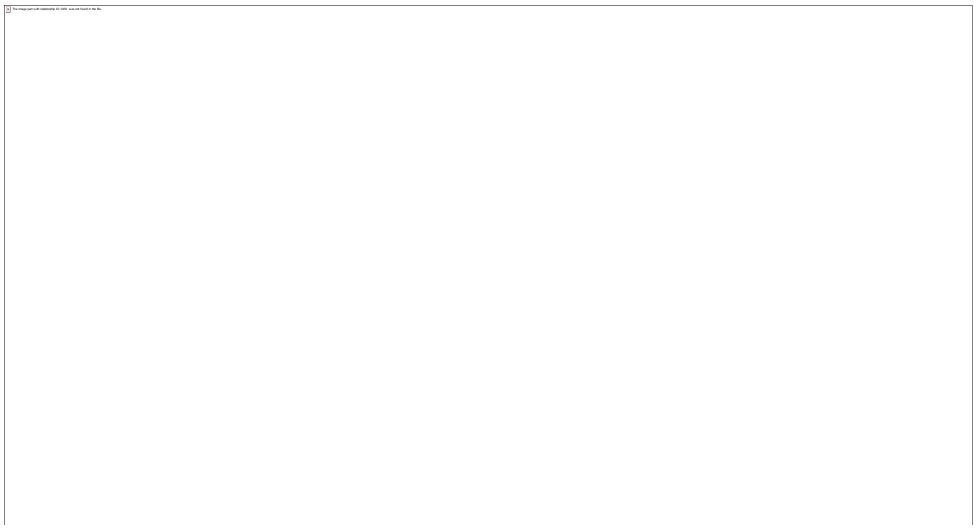
Infiltration galleries are the horizontal or nearly horizontal tunnels constructed at shallow depths (3 to 5 metres) along the banks of rivers through the water bearing strata, as shown in Fig. They are sometimes called horizontal wells.

An infiltration gallery is generally constructed of masonry walls with roof slab, and extracts water from the aquifer by various porous lateral drain pipes located at suitable intervals along the length of the gallery. These pipes are generally covered with gravel, so as to prevent the entry of the fine sand particles into the pipes. These tunnels or galleries are generally laid at a slope, and the water collected in them is taken to a sump well, from where it is pumped, treated and distributed to the consumers. These infiltration galleries- are quite useful when water is available in sufficient quantity just below the ground level or so.

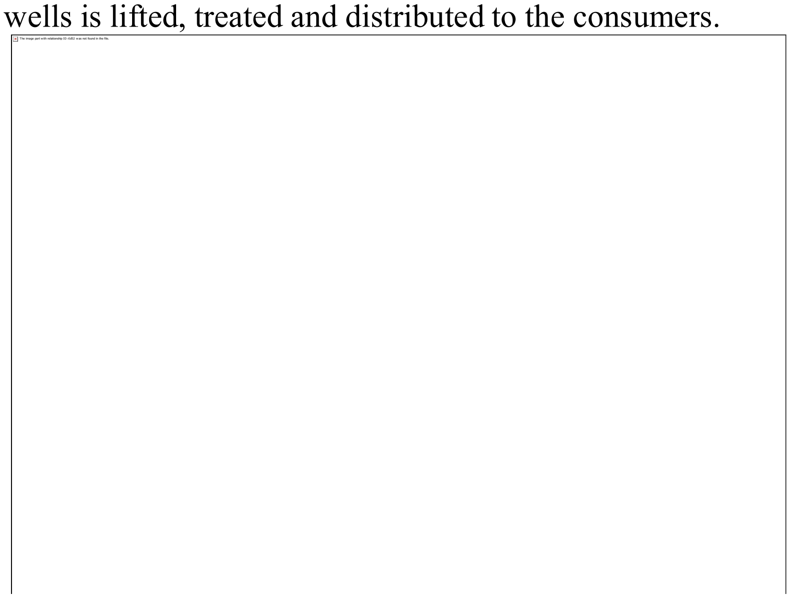
The infiltration galleries may have width of about 1 m , depth of about 2 m and length varying from 10 m to as long as 100 m, depending on the extent of the water filed. They are seldom deeper than 6 m below the ground level. The shaft or gallery of sufficient length is fed at intervals by lateral pipes, as stated above.

Infiltration well:

These wells are' generally constructed of brick masonry with open joints. They are generally covered at the top and kept open at the bottom, as shown in Fig. For inspection purposes, manholes are provided in the top slab cover.



The various infiltration wells are connected by porous pipes to a sump well, called jack well, as shown in Fig. The water reaching the jack well from the different infiltration wells is lifted, treated and distributed to the consumers.



Ranney wells. A new technique that has recently started is to construct a vertical well 3 to 6 m in diameter with horizontal radial collectors, and is known as radial well. Such a well is sunk to the required level and plugged at the bottom.

The image part with relationship ID rId53 was not found in the file.

Horizontal perforated steel pipes are then driven just at the level of the aquifer in the well by powerful hydraulic jacks" The length of these pipes or radial collectors may be of the order of 60 to 80 m or so. About 10 radial collectors can be installed at one level. Some other set or sets of such radial collectors can be installed at other levels, if possible, so as to increase the yield. The inner end of each collector pipe is fitted with a sluice valve, which can be operated from the pump house above. The inflow of water into the well is thus controlled. The water from the well can possibly be pumped directly into the mains, as the water obtained by this method is generally clean, fresh and free from bacterial contamination. These wells are, therefore, very useful for drawing water from polluted streams. This type of well construction is very common in France, and is sometimes referred to as French system of tapping underground water.

A patented type of a radial well is known as a ranney well or a ranney collector. It consists of a RC.C. caisson of 4.3 m (13') in diameter, 0.45m (18")thick, which is sunk into the ground up to the required level, and from which radial collectors are projected, as explained above.

20. Discuss about the different types of springs? (6) (Nov 2010)

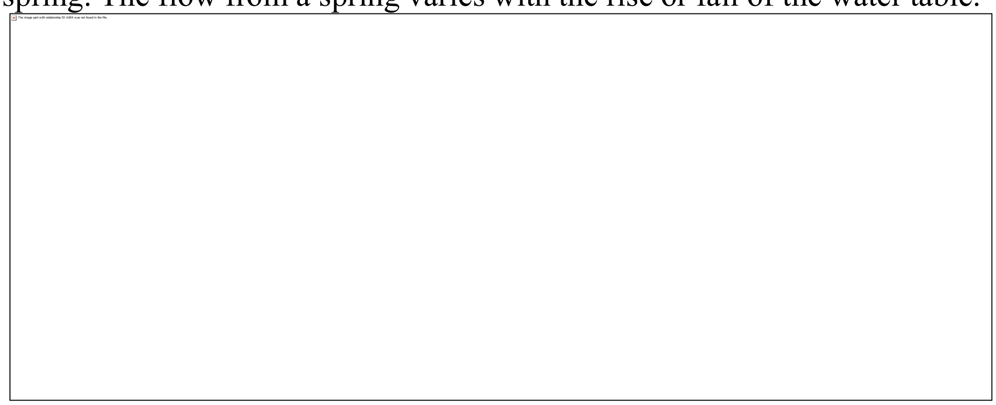
The natural outflow of ground water at the earth's surface is said to form a **spring**. A pervious layer sandwiched between two impervious layers, give rise to a natural spring. A spring indicates the outcropping of the water table. The springs are generally capable of supplying very small amounts of waters, and are, therefore, generally not regarded as sources of water supplies. However, good developed springs may sometimes be used as water supply sources for small towns, especially in hilly areas. Certain springs, sometimes discharge hot water due to the presence of sulphur in them. These hot springs (such as the one in Sohana in Haryana ; a group on the bed and banks of Sutlej river at Tattapani near Simla; and also another at Manikaran near Manali on Parvati river in H.P. state) usually emit sulphur mixed water (warm to boiling), and hence .cannot be used for water supplies, though sometimes useful for taking dips for the cure of certain skin ailments.

Formation and Types of Springs.

Springs are usually formed under three general conditions of geological formations, as explained below

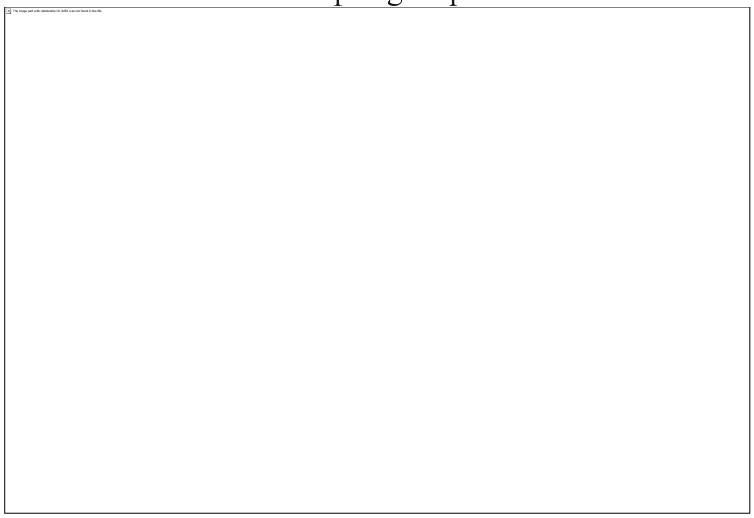
(a) Gravity springs:

When the ground water table rises high and water overflows through the sides of a natural valley or a depression (as shown Fig.), the spring formed is known as a gravity spring. The flow from a spring varies with the rise or fall of the water table.



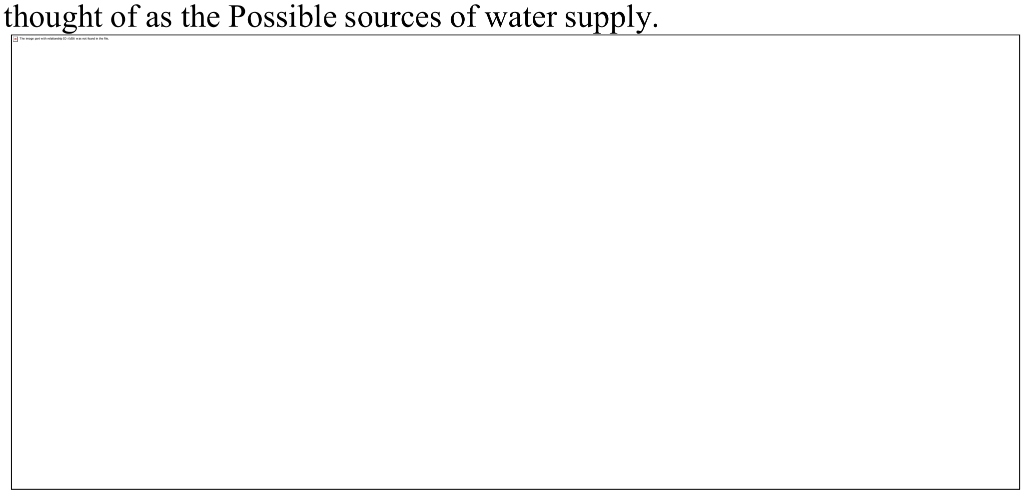
(b) Surface springs:

Sometimes, an impervious obstruction or stratum supporting the underground storages becomes inclined (such as shown in Fig.), causing the water table to go up and get exposed to the ground surface. This type of spring is known as surface spring. The quantity of water available from such a spring is quite uncertain.



(c) Artesian springs:

When the above storage is under pressure (i.e. the water is flowing through some confined aquifer), such as shown in Fig., the spring formed is mown as artesian spring. This type of springs are able to provide almost uniform quantity of water. Since the water oozes out under pressure, they are able to provide higher yields and may be thought of as the Possible sources of water supply.



21. Enumerate and explain the characteristics of surface and ground water and state their environmental significance? (May 2014) (OR) Discuss the various sources of water and give a brief account of the characteristics of water. (May 2015)

Refer Q.No.17, 18, 19, 20

22. Explain about the factors governing in selection of particular source of water?

Factors Governing the Selection of a Particular Source of Water:

The following important factors are generally considered in selecting a particular source for supplying water to a city or a town.

(i) The Quantity of Available Water: The quantity of water available at the source must be sufficient to meet the various demands during the entire design period of the scheme. Sometimes the water sources may be mobilized for the present day demand, and extra units added with the passage of time. If sufficient quantity of water is not available in the vicinity of the area, we may have to think of bringing water from distant sources.

(ii) The Quality of Available Water: The water available at the source must not be toxic, poisonous or in any other way injurious to health. The impurities present in the water should be as less as possible, and should be such as to be removed easily and economically by normal treatment methods.

(iii) Distance of the Source of Supply: The source of water must be situated as near the city as possible. Because when the distance between the source and the city is less, lesser length of pipe conduits and fewer number of associated appurtenances are required, thereby reducing the cost of the project.

(iv) General Topography of the Intervening Area: The area or land between the source and the city should not be highly uneven. In other words, it should not contain deep valleys or high mountains and ridges. In such uneven topographies, the cost of trestles for carrying water pipes in valley sand that of constructing tunnels in mountains, shall be enormous.

(v) Elevation of the Source of Supply: The source of water must be on a high contour, lying sufficiently higher than the city or town to be supplied with water, so as to make the gravity flow possible. When the water is available at lower levels than the average city level, pumping has to be resorted to, which involves huge operational cost and frequent possible breakdowns.

23. Write about the physical characteristics of water and its influence on water quality? (Nov 2012, 2011, May 2013, 2016)
Physical Characteristics of water are:

1. Turbidity
2. Colour
3. Taste and Odour
4. Temperature

Turbidity:

If a large amount of suspended solids are present in water, it will appear turbid in appearance. The turbidity depends upon fineness and concentration of particles present in water. Originally turbidity was determined by measuring the depth of column of liquid required to cause the image of a candle flame at the bottom to diffuse into a uniform glow. This was measured by Jackson candle turbidity meter. The calibration was done based on suspensions of silica from Fuller's earth. The depth of sample in the tube was read against the part per million (ppm) silica scale with one ppm of suspended silica called one Jackson Turbidity unit (JTU). Beacause standards were prepared from materials found in nature such as Fuller's earth, consistency in standard formulation was difficult to achieve. These days turbidity is measured by applying Nephelometry, a technique to measure level of light scattered by the particles at right angles to the incident light beam. The scattered light level is proportional to the particle concentration in the sample. The unit of expression is Nephelometric Turbidity Unit (NTU). The IS values for drinking water is **10 to 25 NTU**.

Colour:

Dissolved organic matter from decaying vegetation or some inorganic materials may impart colour to the water. It can be measured by comparing the colour of water sample with other standard glass tubes containing solutions of different standard colour intensities. The standard unit of colour is that which is produced by one milligram of platinum cobalt dissolved in one litre of distilled water. The IS value for treated water is 5 to 25 **cobalt units.**

Taste and odour:

Odour depends on the contact of a stimulating substance with the appropriate human receptor cell. Most organic and some inorganic chemicals, originating from municipal or industrial wastes, contribute taste and odour to the water. Taste and odour can be expressed in terms of odour intensity or threshold values.

A new method to estimate taste of water sample has been developed based on flavour known as 'Flavour Profile Analysis' (FPA). The character and intensity of taste and odour discloses the nature of pollution or the presence of microorganisms.

Temperature:

The increase in temperature decreases palatability, because at elevated temperatures carbon dioxide and some other volatile gases are expelled. The ideal temperature of water for drinking purposes is 5 to 12 °C - above 25 °C, water is not recommended for drinking.

24. Write the chemical characteristics of water? (Nov 2013)

Acidity

The acidity of water is a measure of its capacity to neutralise bases. Acidity of water may be caused by the presence of uncombined carbon dioxide, mineral acids and salts of strong acids and weak bases. It is expressed as mg/L in terms of calcium carbonate. Acidity is nothing but representation of carbon dioxide or carbonic acids. Carbon dioxide causes corrosion in public water supply systems.

Alkalinity

The alkalinity of water is a measure of its capacity to neutralise acids. It is expressed as mg/L in terms of calcium carbonate. The various forms of alkalinity are (a) hydroxide alkalinity, (b) carbonate alkalinity, (c) hydroxide plus carbonate alkalinity, (d) carbonate plus bicarbonate alkalinity, and (e) bicarbonate alkalinity, which is useful mainly in water softening and boiler feed water processes. Alkalinity is an important parameter in evaluating the optimum coagulant dosage.

Hardness

If water consumes excessive soap to produce lather, it is said to be hard. Hardness is caused by divalent metallic cations. The principal hardness causing cations are calcium, magnesium, strontium, ferrous and manganese ions. The major anions associated with these cations are sulphates, carbonates, bicarbonates, chlorides and nitrates.

The total hardness of water is defined as the sum of calcium and magnesium concentrations, both expressed as calcium carbonate, in mg/L. Hardness are of two types, temporary or carbonate hardness and permanent or non carbonate hardness. Temporary hardness is one in which bicarbonate and carbonate ion can be precipitated by prolonged boiling. Non-carbonate ions cannot be precipitated or removed by boiling, hence the term permanent hardness. IS value for drinking water is **300 mg/L as $CaCO_3$**.

Chlorides

Chloride ion may be present in combination with one or more of the cations of calcium, magnesium, iron and sodium. Chlorides of these minerals are present in water because of their high solubility in water. Each human being consumes about six to eight grams of sodium chloride per day, a part of which is discharged through urine and night soil. Thus, excessive presence of chloride in water indicates sewage pollution. IS value for drinking water is **250 to 1000 mg/L**.

Sulphates

Sulphates occur in water due to leaching from sulphate mineral and oxidation of sulphides. Sulphates are associated generally with calcium, magnesium and sodium ions. Sulphate in drinking water causes a laxative effect and leads to scale formation in boilers. It also causes odour and corrosion problems under aerobic conditions. Sulphate should be less than 50 mg/L, for some industries. Desirable limit for drinking water is **150 mg/L**. May be extended upto **400 mg/L**.

Iron

Iron is found on earth mainly as insoluble ferric oxide. When it comes in contact with water, it dissolves to form ferrous bicarbonate under favourable conditions. This ferrous bicarbonate is oxidised into ferric hydroxide, which is a precipitate. Under anaerobic conditions, ferric ion is reduced to soluble ferrous ion. Iron can impart bad taste to the water, causes discolouration in clothes and incrustations in water mains. IS value for drinking water is **0.3 to 1.0 mg/L**.

Solids

The sum total of foreign matter present in water is termed as 'total solids'. Total solids is the matter that remains as residue after evaporation of the sample and its subsequent drying at a defined temperature (103 to 105 °C). Total solids consist of volatile (organic) and non-volatile (inorganic or fixed) solids. Further, solids are divided into suspended and dissolved solids. Solids that can settle by gravity are settleable solids. The others are non-settleable solids. IS acceptable limit for total solids is **500 mg/L** and tolerable limit is **3000 mg/L** of dissolved limits.

Nitrates

Nitrates in surface waters occur by the leaching of fertilizers from soil during surface run-off and also nitrification of organic matter. Presence of high concentration of nitrates is an indication of pollution. Concentration of nitrates above 45 mg/L cause a disease methemoglobinemia. IS value is **45 mg/L**.

25. Write the biological or micrological characteristics of water?

Standard Plate Count Test

In this test, the bacteria are made to grow as colonies, by innoculating a known volume of sample into a solidifiable nutrient medium (Nutrient Agar), which is poured in a petridish. After incubating (35°C) for a specified period (24 hours), the colonies of bacteria (as spots) are counted. The bacterial density is expressed as number of colonies per 100 ml of sample.

Most Probable Number

Most probable number is a number which represents the bacterial density which is most likely to be present. E.Coli is used as indicator of pollution. E.Coli ferment lactose with gas formation with 48 hours incubation at 35°C. Based on this E.Coli density in a sample is estimated by multiple tube fermentation procedure, which consists of identification of E.Coli in different dilution combination. MPN value is calculated as follows:

Five 10 ml (five dilution combination) tubes of a sample is tested for E.Coli. If out of five only one gives positive test for E.Coli and all others negative. From the tables, MPN value for one positive and four negative results is read which is 2.2 in present case. The MPN value is expressed as 2.2 per 100 ml. These numbers are given by Maccardy based on the laws of statistics.

Membrane Filter Technique

In this test a known volume of water sample is filtered through a membrane with opening less than 0.5 microns. The bacteria present in the sample will be retained upon the filter paper. The filter paper is put in contact of a suitable nutrient medium and kept in an incubator for 24 hours at 35°C. The bacteria will grow upon the nutrient medium and visible colonies are counted. Each colony represents one bacterium of the original sample. The bacterial count is expressed as number of colonies per 100 ml of sample.

26. Discuss about membrane filtration techniques? (8)

The Membrane Filter (MF) Technique was introduced in the late 1950s as an alternative to the Most Probable Number (MPN) procedure for microbiological analysis of water samples. The MF Technique offers the advantage of isolating discrete colonies of bacteria, whereas the MPN procedure only indicates the presence or absence of an approximate number or organisms (indicated by turbidity in test tubes).

Advantages of the MF Technique

- Permits testing of large sample volumes.
- Reduces preparation time as compared to many traditional methods.
- Allows isolation and enumeration of discrete colonies of bacteria.
- Provides presence or absence information within 24 hours.
- Effective and acceptable technique. Used to monitor drinking water in government laboratories.

- Useful for bacterial monitoring in the pharmaceutical, cosmetics, electronics, and food and beverage industries.
- Allows for removal of bacteriostatic or cidal agents that would not be removed in Pour Plate, Spread Plate, or MPN techniques.

Procedures

The simplest and the most recent method adopted for detecting and measuring the presence of coliform bacteria is to filter the water sample through a sterile membrane of special design (i.e. porosity 80%, pore size 5 to 10 mu), on which the bacteria will be retained, if at all present. The filter is then rinsed with a sterile buffer solution, placed upon a pad saturated with a suitable nutrient medium, and incubated at an appropriate temperature. The bacteria which are able to grow upon the nutrient medium will produce visible colonies which can be counted, each colony representing one bacterium in the original sample.

This incubation process is known as culturing through the culture medium. The medium to be used and the temperature of incubation depend upon the type of bacteria which are to be counted. For coliform bacteria i.e. for taking total coliforms count, M-Endo broth or LES Endo Agar are used with incubation at 35°C for 20 to 22 hours. Coliform bacteria will produce characteristic colonies, which are pink to dark red with golden metallic sheen, often with greenish tint. Non-coliform bacteria which grow in this medium will lack the characteristic sheen. For fecal coliforms count, the medium to be used is M-Fe broth and incubation is done at 44.5°C for 22 hours.

The coliform colonies here are blue, and the other bacteria which grow upon this medium are grey to cream coloured. Similarly, to determine the fecal streptococci count, the incubation is done on M -Enterococcus Agar or KF-streptococcus for 48 hours at 35°C. The colonies in this case are light pink to dark red with pink margins. This method of directly counting the coliforms is called the membrane filter technique or membrane Iuter test.

27. Write the laboratory procedure to find the physical, chemical and biological characteristics of waters? (16) (May 2012, 2016)

Physical Characteristics:

Turbidity

Colour

Taste and Odour

Temperature

Chemical Characteristics:

pH
Acidity
Alkalinity
Hardness
Chlorides
Sulphates
Iron
Solids

Nitrates

Bacteriological or Biological Characteristics:

Standard Plate Count Test
Most Probable Number
Membrane Filter Technique

Physical Characteristics:

Turbidity

Aim

To find out the turbidity of the given sample

Apparatus required

- Nephelometric turbidimeter
- Nesslers tube
- Beaker

Reagents

i) Dissolve 1 gm of hydrazine sulphate and dilute to 100 ml.

ii) Dissolve 10 gm of hexamethylene tetra amine and dilute to 100 ml

iii) Mix 5 ml of the above solution in a 100 ml volumetric flask and allow it to stand for 25 + or - 3°c and dilute to 1000 ml. this solution has a turbidity of 40 NTU.

Procedure

1. Switch on the nephelomertic turbidimeter
2. Set the instrument at 100 on the scale with 40 NTU standard suspension

   (In this case every division on the scale will be equal to 0.4 NTU turbidity)
3. Shake the sample thoroughly, and keep it for some time to eliminate the air bubble.
4. Dilute the sample with turbid free water and again read the turbidity

Result: The turbidity of the given water sample = NTU

Chemical Characteristics:

Chlorides:

Aim

To determine the chloride concentration of the given sample

Principle

Chlorides are determined by titration with $AgNO_3$ solution using Potassium Chromate as indicator. Only requirement is the pH of the solution between 7 to 8 or else silver chromate formed goes into solution

$NaCl + AgNO_3$ ----------- $AgCl + NaNO_3$ (white precipitate)

$AgNO_3 + K_2CrO_4$---------$AgCrO_4$+$2KNO_3$

Apparatus Required

- Burettes
- Pipette
- Conical flask
- Measuring Cylinder

Reagents required

i. Silver nitrate solution N/35.45; dissolve 4.775 gm of pure $AgNO_3$ in one lit of distilled water. The solution should be standardized with NaCl solution for getting correct Normality.

ii. Potassium Chromate indicator ; Dissolve 5 gm of potassium chromate in 100 ml of distilled water

Procedure

1. Take 50 ml of sample in conical flask
2. Add three drops of K_2CrO_4 indicator
3. Take in burette N/35.45 $AgNO_3$ solution
4. Titrate till the colour changes from yellowish to reddish brown stable precipitate

Result

The chloride Concentration of the given sample = ______ mg/lit

Sulphates:

Aim

To determine the amount of sulphates present in the given sample.

Principle

Sulphate ions(SO_4^{2}) is participated in an acetic acid medium with $Bacl_2$ so as to form $BaSo_4$ suspension is measured by a photometer and the SO_4^{2} concentration is determined by comparison of the reading with a standard curve.

Apparatus required

- 1.Conical flask
- 2.Stirring apparatus
- 3.Photometer

Reagents

1. Buffer solution

   Dissolve 30gm of magnesium chloride, 5gm of sodium acetate, 1gm of KNO_3 and 20ml of acetic acid (99%) in 500ml distilled water and makeup to 1000ml

   .

2. Barium chloride

   $BaCl_2$ crystals of 20 to 30 measures. In standardization uniform turbidity is produced with this mesh range and appropriate buffer.

3. Standard sulphate solution

   Dissolve 0.1479gm of anhydrous sodium sulphate is distilled water and diluted to 100ml. this is equivalent to 1000ppm.

Procedure

Formation of barium sulphate turbidity

Measure 100ml or a suitable amount made up to 100ml into a 250ml flask. Add 20ml buffer solution and mix in stirring apparatus. While stirring add a spoon full of crystals begin immediately. Stir for 60 + or – at a constant speed.

Measurement of barium sulphate turbidity

Pour the mixed solution onto absorption cell of photometer and measure turbidity at 520 Nanometer.

Preparation of calibration curve

Estimate SO_4^2 concentration in sample by comparing turbidity reading with a calibration curve prepared by carrying SO_4^2 standards throughout the entire procedure. Space standard at 5mg/l increment in the 0 to 40mg/l SO_4^2 range. Above 40mg/l , accuracy decreases and $BaSO_4$ suspension looses stability. Check the reliability of calibration curve by running a standard with every 3 or 4 samples.

Result

Sulphate content present in given sample = _______________ ppm

Hardness:

AIM

To determine the total hardness of the given sample.

APPARATUS REQUIRED:

Burette
Pipette
Conical flask

PRINCIPLE

In alkaline condition EDTA reacts with Ca, and Mg to form a soluble chelated complex. Ca and Mg ions develop wine red color with Erio Chrome Black T under alkaline condition. When EDTA is added as a titrant, Ca and Mg divalent ions get complexed resulting in sharp change from wine – red to blue, which indicates end point of the reaction.

$$Ca^{++} + Mg^{++} + EDTA \rightarrow Ca\ EDTA + MgEDTA$$

(pH 10 ±0.1)

$$M^{+2} + \text{Erio Chrome Black T} \rightarrow (\text{M Erio Chrome Black T wine –red})$$

The pH for this titration has to be maintained at 10±0.1. At higher pH i.e. at about 12 Mg^{++} Ion precipitates and only Ca^{++} ion remain in solution. At this pH Murexide indicator forms a pink Fiber with Ca^{++}.
When EDTA is added Ca^{++} gets complexed resulting in a change from pink to purple which indicates end point of the reaction.

REAGENTS

Buffer Solution

Erio Chrome Black T indicator
Standard EDTA solution 0.01 M
Standard Calcium solution
Murexide indicator
Sodium Hydroxide 2N

PREPARATION OF REAGENTS:

(i) Buffer solution:

Dissolve 16.9 gm of ammonium chloride in 143 ml of concentrated ammonium hydroxide and dilute to 250 ml with distilled water.

(ii) Erio-Chrome Black 'T' Indicator:

Mix 0.5 gm of Eriochrme black T with 100 ml of ethanol or isopropyl alcohol.

(iii) Standard EDTA solution 0.01 M:

Dissolve 3.723 gm of EDTA sodium salt in distilled water to prepare 1 litre of solution.

(iv) Standard hard water:

Dissolve 1 g of pure dry calcium carbonate in concentrated hydrochloric acid and make it upto 1 litre.

PROCEDURE

(i) Standardization of EDTA:

Pipette out 20 ml standard hard water into a clean conical flask and add one ml of buffer solution and mix. Add one drop of indicator solution and titrate with standard EDTA

(0.01 M) till wine red colour change to blue. Note down the volume of EDTA required. Repeat the titration for concordant valves.

(ii) Estimation of Total hardness:

Pipette out 20 ml of given sample into clean conical flask and add one ml of buffer solution and mix. Add one drop of indicator solution and titrate with standard EDTA till wine red colour changes to blue. Note down the volume of EDTA required. Repeat the titration for concordant valves. Repeat the same procedure with tap water to get the concordant valves.

Biological Characteristics:

Membrane Filter Technique

In this test a known volume of water sample is filtered through a membrane with opening less than 0.5 microns. The bacteria present in the sample will be retained upon the filter paper. The filter paper is put in contact of a suitable nutrient medium and kept in an incubator for 24 hours at 35°C. The bacteria will grow upon the nutrient medium and visible colonies are counted. Each colony represents one bacterium of the original sample. The bacterial count is expressed as number of colonies per 100 ml of sample.

28. Write the procedure to find chlorides, sulphates and turbidity? (16) (Nov 2010, May 2012)

Refer Q.No.27

29. Write the drinking water quality standards? (10) (Nov 2012, 2013)

SL. NO.	PARAMETERS	UNITS	DRINKING WATER IS: 10500 - 1991	
			Desirable	Maximum
1.	Colour	Hazen units	5	25

2.	Odour	-	Unobjectionable	-
3.	Taste	-	Agreeable	-
4.	Turbidity	NTU	5	10
5.	pH value	-	6.5 to 8.5	No relaxation
6.	Total hardness (as $CaCO_3$)	mg/l	300	600
7.	Iron	mg/l	0.3	1.0
8.	Chlorides	mg/l	250	1000
9.	Residual, free Chlorine	mg/l	0.2	-
10.	Dissolved Solids	mg/l	500	2000
11.	Calcium	mg/l	75	200
12.	Copper	mg/l	0.05	1.5
13.	Manganese	mg/l	0.1	0.3
14.	Sulphate	mg/l	200	400
15.	Nitrate	mg/l	50	No relaxation
16.	Fluoride	mg/l	1.0	1.5
17.	Phenolic compounds	mg/l	0.001	0.002
18.	Mercury	mg/l	0.001	No relaxation
19.	Cadmium	mg/l	0.01	No relaxation
20.	Selenium	mg/l	0.01	No relaxation
21.	Arsenic	mg/l	0.05	No relaxation
22.	Cyanide	mg/l	0.05	No relaxation
23.	Lead	mg/l	0.05	No relaxation
24.	Zinc	mg/l	5	15
25.	Anionic detergents	mg/l	0.2	1.0
26.	Chromium	mg/l	0.05	No relaxation

27.	Polynuclear aromatic Hydrocarbons	mg/l	-	-
28.	Mineral oil	mg/l	0.01	0.03
29.	Pesticides	mg/l	Absent	0.001
30.	Radioactive materials (a) Alpha emitters (b) Beta emitters	Bq/l Pci/l	- -	0.1 0.037
31.	Alkalinity	mg/l	200	600
32.	Aluminlum	mg/l	0.03	0.2
33.	Boron	mg/l	1	5

UNIT – 2 SEWAGE

PART – A

1. What are the methods of disposal of solid waste?

(a) By trenching

(b) By land filling

(c) By incineration

(d) By pulverization

(e) By composting

(f) By disposal to sea.

2. Write any four disadvantages of water conservancy system?

(i) The compact design of building is not possible, because the lavatory must be constructed separately and away from the main building.

(ii) The decomposition of night soil starts after five hours from the time of production. But the night soil is normally removed after twenty four hours .so, it creates bad odour and fly nuisance around the building.

(iii) The night soil trenching ground requires large area for disposal.

(iv) This system extremely depends on the mercy of sweepers. If the sweepers go on strike for any reason, then the public health will be in danger.

(v) The movement of the night soil vehicles through the main roads or residential area is highly undesirable.

3. What is water carriage system?

The system in which water is used as a medium for conveying the sewage to the treatment plant and final disposal is known as water carriage system.

4. Write down the empirical formula for calculating intensity of rainfall.

When rainfall records are non-available, the intensity of rainfall is ascertained by the following empirical formulae.

(a) $\mathbf{i} = \frac{672}{t+10}$ (for storm duration 5 to 20 mins)

(b) $\mathbf{i} = \frac{1020}{t+10}$ (for storm duration 20 to 100 mins)

(c) $\mathbf{i} = \frac{3430}{t+18}$ (where rainfall is frequency, and more than 100 mins)

Here, i =intensity of rainfall in mm/hr.; T= storm duration in mins.

5. A catchment area consists of the following surfaces,

(a)Cultivated area = 50 hectares (p=0.20)

(b)Forest area = 30 hectares (p=0.10)

(c)Garden = 5 hectares (p=0.05)

(d)Residential area = 15 hectares (p=0.50)

Find the run-off coefficient of the area

Solution:

Here, total area = 50 + 30 + 5 + 15 = 100 hectares.

From, expression, $K = \frac{a_1p_1 + a_2p_2 + \cdots}{A}$

$$= \frac{50\times0.20 + 30\times0.10 + 5\times0.05 + 15\times0.50}{100}$$

$$= \frac{20.75}{100}$$

= 0.2075

6. Define self cleansing (or) minimum velocity.

The sewage contains suspended particles to a considerable amount. So, the minimum velocity should be such that the silting of those particles in sewer may not occur. Such minimum velocity is known as self-cleansing velocity.

7. Write down the empirical formula for the estimation of storm water. (Apr/May 2015)

1. **Inglis formula,**

$$Q = \frac{123100A}{\sqrt{A + 10.36}}$$

Where, Q = storm water in lits. Sec. ; A = area in km^2

2. **Fanning's formula**

$$Q = 3125\ A^{5/8}$$

3. **Talbot's formula**

$$Q = 87000\ A^{1/4}$$

4. **Ryve's formula**

$$Q = 15\ CA^{2/3}$$

(C = A constant, its value varies from 450 to 675)

5. **Dicken's formula**

$$Q = 14\ CA^{3/4}$$

(C = A constant, its value is 250 for large area and 1600 for small area).

8. Explain about the biological characteristics of sewage.

1. Bacteria:

The bacteria may be of the following types

- **Pathogenic Bacteria:** This is the root of all water-borne disease.
- **Non-pathogenic Bacteria:** This is practically harmless to human being.
- **Aerobic Bacteria:** It helps the decomposition of sewage in septic tank, cesspool, etc.
- **Facultative Bacteria:** This bacteria has no function in sewage treatment.

2. Microorganisms:

The microorganism algae, fungi and protozoa help the process of decomposition of sewage by photosynthesis or by breaking the organic compounds.

9. Explain aerobic decomposition.

Aerobic decomposition is caused by the aerobic bacteria in presence of plenty of oxygen. This type of bacteria cannot survive without oxygen. This decomposition is also known as oxidation. In this process, the aerobic bacteria break up the organic matters and the organic matters are oxidized to form stable compounds. After oxidation the compounds like carbon dioxide, nitrates, sulphates etc. are formed the aerobic decomposition occurs in contact beds, oxidization ponds, trickling filters, etc.

10.Explain the necessity of testing of sewage.

To determine the strength, character and the stage of sewage for adopting proper treatment of sewage and the method of disposal.

(i) To regulate the treatment plant according to the variation in the nature of sewage.

(ii) To recommend the type of treatment to be adopted for the particular sample of sewage.

(iii) To adopt optimum treatment to sewage to obtain the effluent of high quality.

11. What are the factors governing design period?

The factors governing design period are,

a. Design period should not exceed the life period of structure.

b. If the funds are not in the sufficient the design period should has to bedecreased.

c. The rate of interest is less for the borrowing funds.

d. The of population increases due to industries and commercial establishment.

12. What are the various methods of purification of water?

The various methods of purification of water are,

a. Screening b. Plain sedimentation.

c. Sedimentation aided with coagulation.

d. Filteration. e. Disinfection.

f. Aeration. g. softening.

h. Miscellaneous treatments such as fluoridation, recarbornation, liming, desalination.

13. Define detention period?

Detention period of settling tank may be defined as the average theoretical timerequired for the water to flow

14. What are the two types of sewage system?

The two types of sewage system are,

a. Combined system:

When the drainage is taken along with the sewage then it is called as combined system.

b. Separate system: When the drainage and sewage are taken independently of each through two different sets of sewage is called as separate system.

15. What are the two types of water meter?

The two types of water meter are,

a. Inferential meter.

b. Displacement meter.

16. Define time of concentration?

The period after which the entire area will start contributing to the runoff is called time of concentration. **(Or)**

The longest time, without unreasonable delay, that would be required for a drop of water to flow from the upper limit of drainage area to the point where concentration or the maximum effects of flood is considered.

17. List the components of sewerage system?

The components of sewerage system are,

a. House sewers. b. Lateral sewers.

c. Branch sewers. d. Main sewers.

e. Outfall sewers. f. Man holes.

18. Define sludge age

The sludge age is defined as the average time for which particles ofsuspended soil remain under aeration

19. Define sludge volume index

Sludge volume index is defined as the volume occupied in ml by 1 gm ofsolids in the mixed liquor after settling for 30 minutes and is determinedexperimentally

20. What is meant by biodegradable organic matter?

The organic matters is decomposed by bacteria under biological action iscalled biodegradable organic matter

21. What are the various tests for finding the quality of sewage?

Turbidity test

Colour test

Odour test

Temperature test

22. What is meant by relative stability of a sewage effluent?

The relative stability of a sewage effluent is nothing but the ratio ofoxygen available in the effluent to the total oxygen required to satisfy itsfirst stage BOD demand

23. What are the methods of disposing the sewage effluent?

Disposal in water (dilution)

By disposal on land

24. Define dilution factor

The dilution factor is defined as the ratio of the amount of river water to the amount of the sewage

25. What is meant by self purification?

The automatic purification of natural water is known as self purification

26. List various natural forces of self purification

Physical forces

Chemical forces

27. What is co-efficient of run off?

Co-efficient of runoff (K), the impervious factor of runoff, representing the ratio of precipitation to run off.

28. What is BOD & COD?

Refer question no.5 definition in 16 marks.

29. What is sullage?

Sullage indicates wastewater from bathrooms, kitchen, washing places, & wash basin.

30. What is sewage?

Sewage indicated the liquid waste from the community. It includes sullage, industrial waste & also from ground surface and storm water.

31. Define the term sewerage?

Structures, device, equipment and appurtenances intended for the collection, transportation and pumping of sewage and liquid waste, but excluding works for the treatment of sewage.

32. Define waste water?

It includes both organic and mineral matter carried through liquid media.

33. Why waste water need to be treated before its ultimate disposal?

(i) To reduce the spread of communicable diseases caused by pathogenic organisms in sewage.

(ii) Prevent pollution of surface and ground water.

34. Distinguish between dry weather flow and wet weather flow?

Dry weather flow: Flow through the sewers that would normally be available during non- rainfall periods

Wet weather flow: Additional flow that would occur during the rainy season. It consists of runoff available from roofs, streets, yards, open spaces etc., during rainfall.

Previous year Anna University Questions - PART –A

(a). What do you mean by time of concentration? State its significance in sewer design.

Refer; Part –A, Ques. No.16 , Pg. 4

(b). State the pollution control board norms for effluent discharge into streams?

Refer; Part –B Ques. No.20 , Pg. 42 (Discharge in Streams)

(c). List the factors influencing the fixing of design period?

Refer : Part –A, Ques. No.11, Pg. 4

(d).What are the typical characteristics of sewage from south Indian cities?

Refer : Part –B, Ques. No.18, Pg. 40 (List only the characteristics)

(e). Explain the meaning and significance of time of concentration?

Refer; Part –A, Ques. No.16 , Pg. 4

(f).Distinguish between dry weather flow and wet weather flow?

Refer; Part –A, Ques. No.10 ,Pg. 3

(g).State the necessity of wastewater characterization?

Refer; Part –A, Ques. No.34, Pg. 6

35. Why do you analyse BOD and COD usually give different results for the same wastewater?

BOD – it is used to measure the strength of waste water in terms of oxidation of only organic matter present in it.

COD – – it is used to measure the strength of waste water in terms of oxidation of only organic and inorganic matter present in it.

Hence the value of COD is usually higher than the one of BOD

36. What is the effect of suspended solid in on water bodies?

1. Suspended solid prevent the entry of sun light on the water bodies and makes it turbid.
2. It develops anaerobic condition
3. It affects the aquatic system present in the water body.
4. It makes unsuitable for drinking purposes
5. More sediments take place at the bottom and reduced the water intake
6. It clogs the pumping unit when the water is used for irrigation

37. What are the impacts of nutrients on water bodies? (Apr/May 2015)

- For many coastal waste bodies, the main pollution issue in excess nutrients, also termed nutrient over-enrichment.
- Farm field helps crops grow
- Nutrients entering lakes and rivers feed the growth of algae and bacteria.
- Impacts on Groundwater.
- Cause a number of adverse health and ecological effects.

38. How do you estimate storm water runoff? (Apr/May 2015)

$$\mathbf{Q_p = \frac{1}{36} \times K \times p_c \times A}$$

Qp = peak rate of runoff in cumecs

K = Co-efficient of runoff

A = Catchment area, hectares

p_c = Critical rainfall intensity, cm/hr

PART -B

1. Explain the factors influencing the dry weather flow?

The dry weather flow is the flow through the sewers that would normally be available during the non rainfall periods.The dry weather flow is also sometimes called as sanitary sewage and it is influenced by the following factors.

(i) Domestic wastewater:

A certain quantity of water is being supplied daily by the water works department, for domestic use. This water gets consumed in various ways and therefore all of it does not reach the sewer. The wastewater reaching the sewers will be that part of water which is used of flushing water closets, urinals, washing clothes, bathing, washing utensils etc.,

<u>(ii) Industrial wastewater:</u>

This is the wastewater generated by the industry after consuming water for its manufacturing processes.

<u>(iii) Wastewater from Public Utilities:</u>

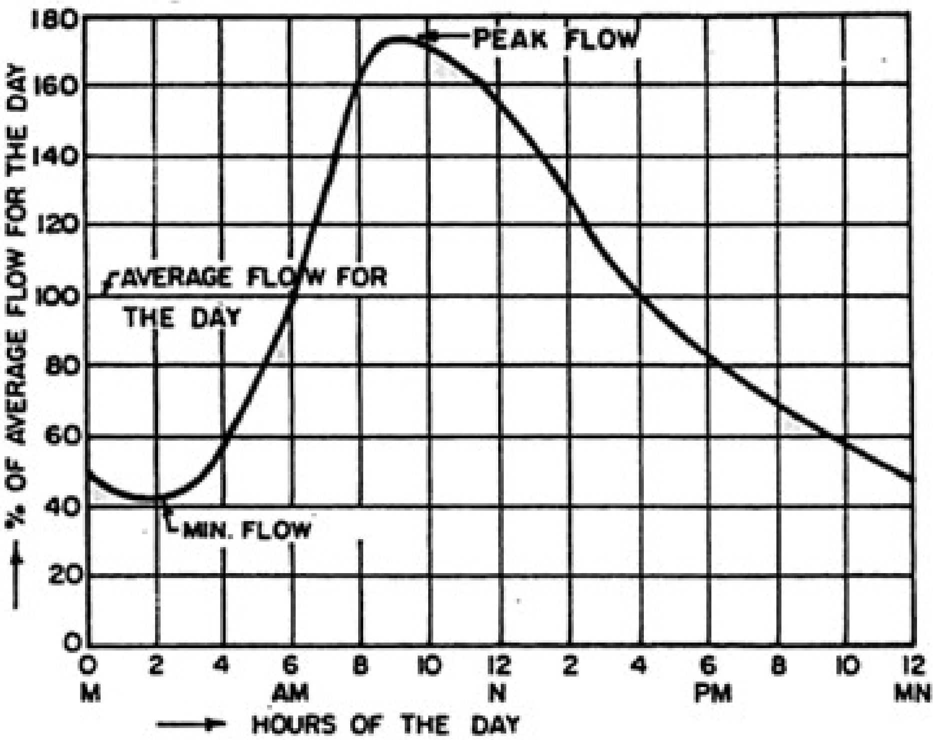
This is the wastewater from schools, cinema theaters, hotels, railway stations and street washings.

<u>(iv) Ground water Infiltration:</u>

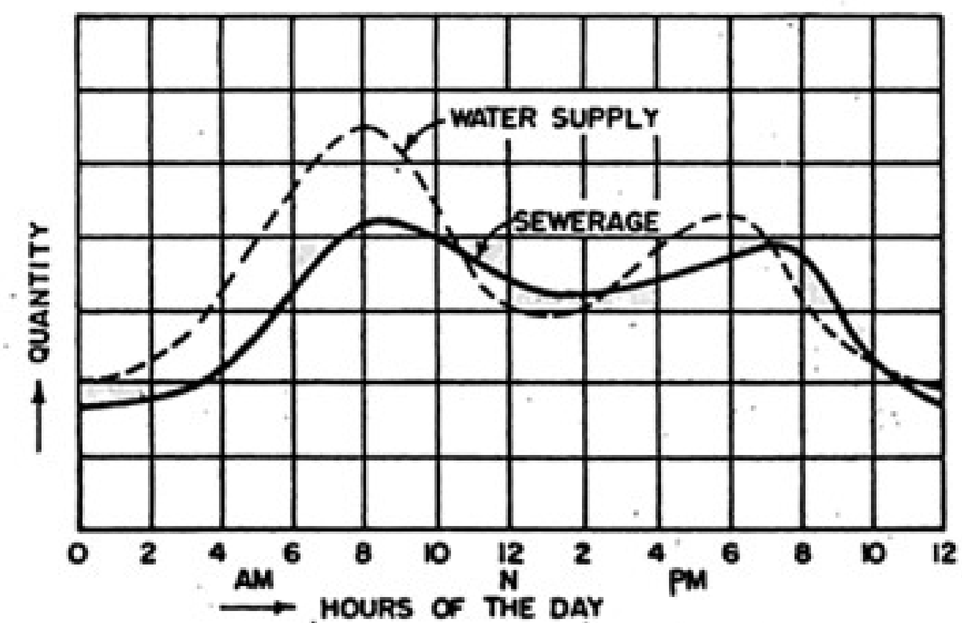
This is the quantity of ground water that infiltrates into the sewers. It depends upon the nature of soil, material of sewers, nature and condition of sewer joints, depth of sewer and position of water table.

2. Brief about sewage flow fluctuations and discuss the importance of studying them.

The rate of sewage flow is not constant. It varies with every hour of the day, every day of the season and every season of the year. Both the maximum and minimum flows are expressed as percentage of the average rate of flow. The variations in the flow may be due



HOURLY VARIATIONS OF SEWAGE FLOW



SEWAGE FLOW VARIATIONS WITH RESPECT TO WATER SUPPLY

Fig.2.0 shows the relationship between hourly variation of water consumption and sewage flow.

- Temperature and climatic conditions are the principal factors affecting the seasonal rate of sewage flow.

- For Indian conditions average rate of sewage flow may be assumed to occur in the month of October or November and March or April.
- Minimum rate of flow may be obtained during the month of December or January.
- Maximum rate may be obtained during the month of June or July.
- If the annual average rate of flow is taken as 100, then
- The maximum seasonal flow may be about 120.The maximum monthly flow may be about 140
- maximum day flow may be about 150 to 180 and maximum hourly flow may be 200 to 300.

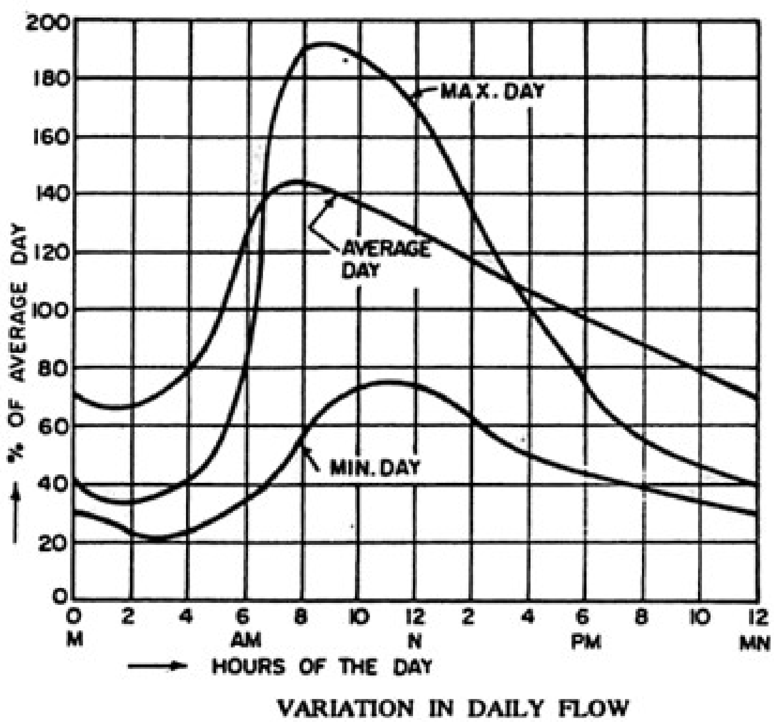


Fig.3.0 shows daily variations in sewage flow during minimum flow day , average flow day and maximum flow day.

3. What is population equivalent and state its uses.

The wastewater carried by the sewer consist mainly of domestic sewage and industrial wastewater. Since the contribution of solids to sewage should be nearly constant on the per capita basis, the BOD contribution (expressed in gms/person/day) should also be constant.

Generally BOD contribution per capita per day may be taken as 80 gms/day (0.08Kg/day)

Industrial wastewater are generally compared with per capita domestic sewage through the concept of population equivalent (P_E) using per capita BOD value as the basis

Thus, we have,

P_E = Total BOD_5 of the Industrial wastewater (Kg/d) / BOD_5 value per capita/day

For example, if the BOD_5 of an industrial wastewater is 800 Kg/day and BOD_5 value is 0.08 kg/capita/day

Therefore, $P_E = (800/0.08) = 10{,}000$.

Similarly if at the point of measurement we have a combined wastewater consisting of domestic sewage as well as industrial wastewater, population equivalent at the combined wastewater can be found by dividing BOD_5 of the combined wastewater by the per capita per day BOD value.

Generally the population equivalent is used to indicate the strength of the industrial wastewater required for

(i) Estimating the treatment required at common treatment plant (Municipal Treatment plant)

(ii) Charging appropriate levy on the industries to meet the proportionate cost of treating waste in the Municipal treatment plants.

4. The BOD of a sewage incubated for one day at 30^0c has been found to be 100 mg/l. What will be the 5-day 20^0c BOD. Assume K=0.12 (Base 10) at 20^0c.

Solution:

Given:

$$y_1\,(or)(BOD_1)_{30^\circ} = 100\,mg/l$$

$$k_{20} = 0.12$$

$$K_T = k_{20}\theta^{T-20^\circ}$$

Temperature range is 20^0 to 30^0, take

$$\theta = 1.056$$

$$k_{30} = 0.12(1.056)^{30-20}$$

$$= 0.207/\text{day}.$$

For T=30^0C

$$y_{t(30^\circ c)} = L_O(1 - 10^{-K_{30}t})$$

$$100 = L_O(1-10^{-0.207t})$$

$$L_O = 263.8mg/l$$

$$y_{t(20^\circ c)} = L_O(1-10^{-k_{20^\circ c}t})$$

$$y_{5(20^\circ c)} = 263.8(1-10^{-0.12X5})$$

$$BOD_5 at 20^\circ c = 197.5mg/l$$

5. Define the terms BOD and COD. Differentiate between first stage BOD and second stage BOD.

Biochemical Oxygen Demand (BOD):

It may be defined as the oxygen required for the microorganisms to carry pout biological decomposition of the dissolved solids or organic matter in the wastewater under aerobic conditions at standard temperature.

Chemical Oxygen Demand (COD):

It may be defined as amount of oxygen required for complete oxidation of both organic and inorganic constituents using strong oxidizing agent ($KMnO_4$&H_2SO_4).

Difference between first and Second stage BOD:

(i) First Stage BOD Formulation:

At a given temperature, the rate at which BOD is satisfied at any time ie., rate of deoxygenation may be assumed to be directly proportional to the amount of organic matter present in sewage.

Exertion of BOD, $dL_t/dt = -K'. L_t$

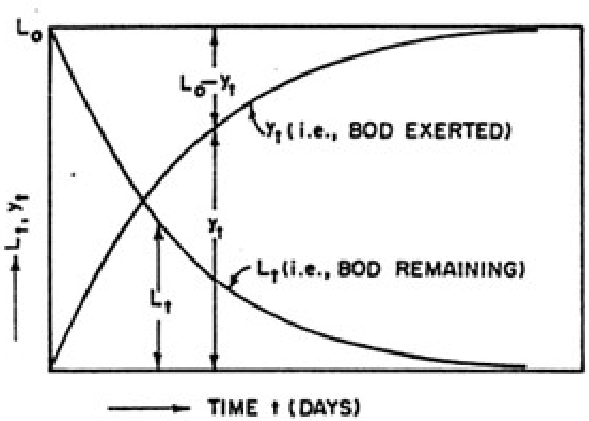
Where,

L_t = Amount of first stage BOD remaining in the sample at any time t (or oxygen equivalent of carbonaceous oxidisable organic matter present at any time t), mg/L.

K' = Rate constant signifying the rate of oxidation of organic matter, day^{-1}

t= time in days

The ultimate first stage BOD (Y_u) will be obtained by substituting t = infinity. In equation



FIRST STAGE BOD CURVE

Thus it is concluded that the ultimate first stage BOD of a given wastewater is equal to the initial oxygen equivalent of the organic matter present I the sample of wastewater.

Yu is thus a fixed quantity for the given specimen and does not depend on the temperature during the reaction. Value of K depends on (i) type of wastewater , (ii) temperature during the reaction.

(ii) <u>Second Stage BOD:</u>

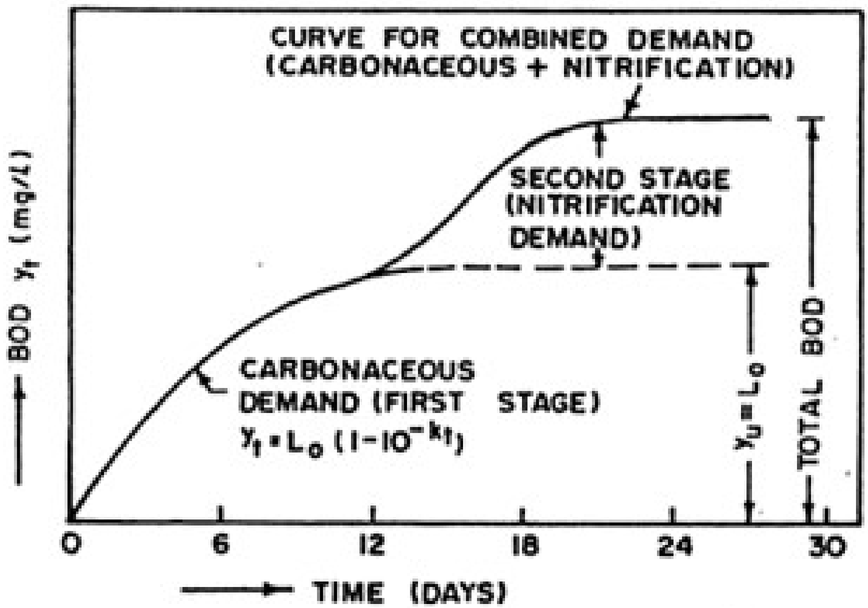
Carbonaceous matter is oxidized in the first stage of biochemical reaction, while nitrogenous matter is oxidized in second stage.

Some of the autotrophic bacteria are capable of using oxygen to oxidize non-carbonaceous matter such as ammonia to nitrites and nitrates.

This second stage reaction is called **nitrification.**

Thus, the nitrogenous oxygen demand caused by autotrophic bacteria is called second stage BOD.

Fig. below shows influence of nitrification on BOD curve.



COMBINED CARBONACEOUS AND NITRIFICATION DEMAND.

It should be noted that at 20 deg. Celsius the reproduction rate of nitrifying bacteria is very slow and it takes about 6 to 10 days to reach significant numbers and to exert a measurable oxygen demand.

6. The drainage area of one sector of a town is 12 hectares. The classification of the surface of this area is as follows

Percent of total surface area	**Type of surface**	**Co-efficient of run-off**
20%	**Hard pavement**	**0.85**
20%	**Roof surface**	**0.80**
15%	**Unpaved street**	**0.20**
30%	**Garden and lawn**	**0.20**
15%	**Wooded area**	**0.15**

If the time of concentration for the area is 30 minutes, find the maximum run-off. Use the formula R= 900/t+60

If A = total area, then

$K_1A_1 = 0.85 \times 0.20\ A = 0.17A$

$K_2A_2 = 0.80 \times 0.20\ A = 0.16A$

$K_3A_3 = 0.20 \times 0.15\ A = 0.03A$

$K_4A_4 = 0.20 \times 0.30\ A = 0.06A$

$K_5A_5 = 0.15 \times 0.15\ A = 0.0225A$

$\sum = 0.4425A$

$$K = \frac{\sum KA}{A} = \frac{0.4425A}{A}$$

$$K = 0.4425$$

Rainfall intensity, $R\left(\frac{mm}{hr}\right) = \frac{900}{t+60}$

Where t = concentration time (min)

$$R = \frac{900}{30+60} = 100mm/hr$$

$$R = 1cm/hr$$

$$P_C = 1cm/hr$$

$$Q_p = \frac{1}{36} K.P_C.A = \frac{1}{36}(0.4425)X(1)(12cumecs)$$

$$Q_p = 0.1475cumes.$$

$$Q_p = 0.148cumes.$$

Maximum rate of runoff expected from the area = 0.148 cumes.

7. A population of 30,000 is residing in a town having an area of 60 hectares. If the average co-efficient of run-off for this area is 0.60 and the time of concentration of the design rain is 30 minutes. Calculate the discharge for which the sewers of a proposes combined system will be designed for the town in question. Make suitable assumptions where needed.

Solution:

Let us first assume that the town is provided with a planned water supply from the water works at an average per capita rate equal to 180 liters/day/person.

Assume that 80% of this water supply will be reaching the sewers as sanitary sewage.

Therefore, quantity of sanitary sewage produced per day

$$= \left(\frac{80}{100}\right) * 120 * 30,000 \text{liters} = 2880 \text{m}^3$$

Quantity of sanitary sewage produced per second = $\frac{2880}{24*60*60}$ cumecs = 0.033cumecs therefore,

average sewage discharge = 0.033 cumecs

Assuming the maximum sewage discharge to be three times the average, we have,

Maximum discharge = 3 X 0.033 = 0.1 cumecs

The storm water discharge can be computed by using Rational formula

$$Q_p = \frac{1}{36} * K * P_c * A$$

Using $P_c = \frac{100}{T+20} = \frac{100}{30+20} = 2cm/hour$

$$Q_p = \frac{1}{36} * 0.60 * 2 * 60 = 2 \text{cumecs}$$

Total peak discharge for which the sewers of the combined system

= Maximum sewage discharge + maximum storm run –off = 0.1 + 2 = 2.1 cumecs

8. List the information to be collected while planning for sewerage system.

- The sewerage system must be properly and skillfully planned and designed, so as, to remove the entire sewage effectively and efficiently from the houses and upto the point of disposal.
- The sewers must be of adequate size, so as to avoid their overflow and subsequent damages to the properties of the pipes and the health hazard.
- In order to provide economically adequate sized sewers, it is necessary that the likely sewage discharge be estimated as correctly as possible.
- The sewer pipes should then be designed to be laid on a slope that will permit reasonable velocity of flow.
- The flow velocity should neither be so large, as to require heavy excavation and high lift pumping, nor should it be so small, as to cause the deposition of solids in the sewer bottom.

- The sewer are generally designed to carry the water from the basements and should therefore, be at least 2 to 3 m deep. As far as possible, they should be designed to flow under gravity with half or quarter full.
- Owing to the requirements of the seeking gravity flow, the sewage treatment plant should generally be located in a low lying area.
- The design of the treatment units also requires good engineering skills. In order to provide adequate and economical treatment, it is necessary to thoroughly study the constituents of the sewage produced in the particular project, and also the quality and other characteristics of the water body that will receive the sewage.
- The permissible standards for effluents and the possible uses of water downstream, should also be studied.
- The legal bindings if any, will also have to be taken into consideration, while deciding upon the quantum of treatment required to be given.
- No fixed standards can be laid for fixing these required treatment, as everything depends on the particular project.
- Since the treatment plant will have to be located at low level, the flood protection devices both during construction and thereafter should also have to be taken care of by the design engineers.

9. Discuss the methods of estimation of storm water runoff.

For the purpose estimating storm water flow for sewer design, the following two methods are used.

1. Rational Method
2. Empirical Formulae

(1) <u>Rational Method:</u>

The rational formula is most commonly used for design of storm drains. It takes into account the following three factors:

(i) Catchment Area (A)

(ii) Impermeability factor (I) of the catchment area.

(iii) Intensity of rainfall (R)

$$Q_p = \frac{1}{36} * K * P_c * A$$

Where, Q_p = peak rate of run –off in cumecs

K = Co-efficient of run-off

A = The catchment area contributing to run-off at the considered point, in Hectares

P_C = Critical Rainfall intensity of the design frequency ie., the rainfall intensity during the critical rainfall duration equal to the time of concentration in cm /hr.

K = 1 for perfectly impervious area.

K = 0.9 for paved areas and

K = 0.15 for lawns and gardens

Catchment Area (A):

The catchment area served by a given storm water sewer can be found directly from the map of the town.

(i) Impermeability Factor (I):

The storm water flow depends upon the Imperviousness of the surface over which rainfall takes place. If the ground is relatively impervious, more run off takes place. He percentage of rain water that is available in the form of run –off is known as impermeability factor or run –off co-efficient.

$$Iav = \frac{A_1I_1 + A_2I_2 + A_3I_3 + ... + A_nI_n}{A_1 + A_2 + A_3 + ... + A_n} = \frac{\sum AI}{\sum A}$$

(ii) Intensity of Rainfall (R):

Intensity of rainfall in mm/hr can be worked out from the rainfall records of the area.

R depends on the frequency and duration of storm.

For localities where rainfall is frequent

$$p = \frac{343}{T + 18}$$

Kuchling Formula :

$$p = \frac{267}{T + 20} \text{ (for storms having 10 years frequency)}$$

$$p = \frac{305}{T + 20} \text{(for storms having 15 years frequency)}$$

(2)Empirical Formula:

(i) Burkli –Ziegler Formula:

$$Q_p = \left(\frac{1}{455}\right) k' * p * A \sqrt{\frac{S_0}{A}}$$

Where,

Q_P = Peak run –off in cumecs

K' = Runoff Co-efficient depending upon the permeability of the surface and having an average of 0.7

p = maximum rainfall intensity over the entire area (2.5 to 7.5 cm/hr).

A = Drainage area in Hectares

S_0 = Slope of ground surface in m /1000 m.

(ii) Dickens Formula:

Peak discharge in cumecs, $Q_p = CM^{3/4}$ Where,M = Catchment area (Km^2)

(iii) Ryve's Formula:

$$Q_p = CM^{2/3}$$

(iv) Inglis Formula:

$$Q_p = \frac{123M}{\sqrt{M+10.4}} = 123\sqrt{M}$$

10. Write a short note on time of concentration and its significance in determining the storm water flow.

The time of concentration is defined as the longest time, without unreasonable delay, that will be required for a drop of water to flow from the farther point of the drainage area to the point of concentration.

The time required from the beginning of rainfall to the one corresponding to the achievement of maximum rate of run-off is called the time of concentration.This maximum rate of run-off will continue till the rainfall stops. After that the run –off will gradually decrease.

The time of concentration consists of two components

(i) Time of Entry, (t_e)

(ii) time of Flow (t_f)

(i) Time of Entry, (t_e):

The time of entry or inlet time is the time taken by the rainfall to run from the most distant point of the water shed to the inlet of the sewer. The area of tributary to most of the sewers are usually small. Hence it is customary to assume a suitable value of time of entry based on experience under similar conditions.

(ii) Time of Flow (t_f):

The time of flow is the time required for the flow of water in the sewer to the point under consideration. It is computed by assuming the velocity of flow in the drain and measuring the length of drain or sewer from inlet point to the point under consideration ie.,

$$t_f = \text{Distance} / \text{Velocity}$$

Thus the total time of concentration

$$t_c = t_e + t_f$$

can be computed. It is to be noted that larger the catchment, longer will be the time of concentration. It is generally considered that maximum run-off occurs when the duration of storm is equal to the time of concentration.

11. Explain the two systems involved for collection, disposal of liquid wastes.

Depending upon the type of waste, two systems may be employed for its collection, conveyance and disposal.

(a) Conservancy System

(b) Water Carriage System

(a) Conservancy System:

This is an old system in which various types of wastes such as night soil, garbage etc., are collected separately in vessels (or) deposited in pools or pits and then removed periodically at least once in 24 hours. The system is also known as the dry system.

The following are the methods of collection of various types of wastes in the system.

(i) Night Soil:

Night soils (or) human excreta in latrines (or) cesspools etc.,is collected separately in pans (or) pails and carried on heads of sweepers to a central place from where it is transported in bullock carts (or) motor vans to a place away from the town for its final disposal.

(ii) Garbage:

Garbage is collected separately in dust bins and conveyed on hand carts (or) twice a day.It may consist of waste matter of both non combustible as well as combustible type.

(iii) Sullage and Storm Water:

Sullage and storm water are collected and conveyed separately in closed (or) open gutters.

(b) Water Carriage System:

In this system the collection conveyance and disposal of various type of wastes are carried out with the help of water. Thus, water is used as medium to convey the waste from its point of production to the point of its treatment or final disposal.

Sufficient quantity of water is required to mix the wastes so that dilution ratio is so great that the mixture may flow just like water.

The wastes from kitchens, baths, wash basins etc., are also led to the sewers. The sewers are the underground closed pipes which are laid on suitable longitudinal gradient so that flow takes under gravity and proper flow velocity is maintained to keep the sewer clean.

The sewers lead the sewerage so collected to a suitable site where it is treated suitably and then is disposed of by irrigation (or) by dilution.

It should be noted that the garbage is collected separately and conveyed in the same manner as is done in the case of conservancy system.

If the garbage is permitted in the sewers, they may be clogged.

12. Explain the classification of water carriage system?

The water carriage system can be divided into the following types.

(i) Separate system

(ii) Combined system

(iii) Partially Separate system

(i) Separate System:

The separate system provides two separate system of sewers. The one intend for conveyance of foul sewage only such as fecal matter, domestic wastewater, the washings and the drainage of places such as slaughter houses, laundries, stables and the wastewater derived from the manufacturing process and the other for the rain water including the surface washing from certain streets overflow from public baths and f**oundation**s etc.,

(ii) <u>Combined System:</u>

The combined system provides only one sewer to carry both the foul sewage as well as the rain water. The sewage and rain water are carried to the seawage treatment plant before its final disposal. The combined system is advocated on the ground that the street surface washing are as impure as the sewage itself, and should therefore the suitably treated before being allowed to enter the natural stream.

(iii) <u>Partially combined System:</u>

In this system, only one set of underground sewer is laid. The sewer admit the foul sewage as well as the early washing by the rains. As soon as the quantity of storm water exceeds a certain limit, the storm water overflow and it is collected and conveyed in open drains to the natural streams. The foul sewage, however continues to flow in the sewer. Advantages and Disadvantages of seaparate, combined and Partial system – refer questions below.

13. Write the advantages and disadvantages of separate systems

<u>Advantages:</u>

- Cost of installation is low
- The storm water can be disposed off through the open channel along the road sides
- Load on the treatment units will be lowered, since only the foul sewage carried by the separate sewers need be treated
- If there is necessity oflifting the sewage mechanically, the system will prove to be economical both from point of view of capital cost as well as from the point of view of running cost.
- The sewage in the separate system will be of more uniform character and will lend itself more easily to putrefaction.
- Sewers of smaller section can be easily ventilated than those of larger section
- Night flow will be comparatively small. This may facilitate operations at the out fall works.
- Rain water can be discharged into streams or rivers without any treatment

<u>Disadvantages:</u>

- Difficult to clean since smaller size
- They are likely to get choked
- Two sets of sewers may ultimately prove to be costly
- Because of lesser air contact in small size sewers, foul smell may be there due to sewage gas formation.

14. List the advantages and disadvantages of combined system.

Advantages:

- The system requires only one set of sewers. Hence the maintenance costs are reduced.
- The sewers are of larger size and therefore the chances of their choking are rare. Also it is easy to clean them.
- The strength of the sewage is reduced by dilution.
- There is more air in the large sewers than in the smaller ones of the separate system. Hence the sewer gas that may be formed gets diluted. Thus the chances of foul smell are reduced.

Disadvantages:

- Cost of construction are very high because of large dimensions of the sewers to be constructed at sufficient depth to receive the sewage from the basement.
- Handling and transportation is difficult.
- Load on the treatment plant increases since intrusion of storm water.
- The system is uneconomical in the circumstances when pumping is required for the lifting of sewage.
- Storm water in un necessarily polluted.
- Ventilation is difficult.

15.List the advantages and disadvantages of partially combined system.

Advantages:

- The sewers are of reasonable size, their cleaning is therefore not very difficult.
- It combines the advantages of both the separate as well as the combined system.
- The storm water permitted in the sewers eliminates it chances of choking.
- The sewers are completely cleaned during the rainy seasons.
- Theproblem of disposing of storm water from homes is simplified.

Disadvantages:

- During the dry weather, when there is no rain water the velocity of flow will be low. Thus self cleansing velocity may not be achieved.
- Storm water increases the load on the treatment units.
- Storm water increases the pumping cost.

16. Explain briefly the characteristics of wastewater/ sewage. (Apr/May 2015)

The characteristics or properties of wastewater can be classified under the following three heads:

(a) Physical Characteristics

(b) Chemical Characteristics

(c) Biological Characteristics

(a) PHYSICAL CHARACTERISTICS

(i)Turbidity:

Sewage is normally turbid, resembling dirty dish water or wastewater from baths having other floating matter like faecel matter, pieces of paper etc.,

(ii) Colour:

If sewage colour is yellowish, grey or light brown, it indicates fresh sewage. If it is black or dark brown, it indicates stale and septic sewage.

(iii)Odour:

Fresh sewage is odourless but after 4 hours it gives offensive odour because of H2S.

(iv) Temperature:

It has an effect on the biological activities of bacteria in sewage.

(b) CHEMICAL CHARACTERISTICS OF SEWAGE:

(i) pH:

Fresh sewage is alkaline in nature. As the time passes, pH value tends to fall due to production of acids by bacterial action and sewage tends to become acidic.

(ii) Chloride Content:

Chlorides are generally present in municipal sewage, and are derived from the kitchenwastes, human faeces and urinary discharges, etc., the normal chloride content of domestic sewage is 120 mg/l whereas the permissible chloride content for water supply is 250 mg/l.

(iii) Nitrogen Content:

Presence of nitrogen indicates that the presence of organic matter in wastewater. Nitrogen is essential to the growth of protista and plants and it is known as nutrients or bio stimulants.

(iv) Fat, Grease and Oils:

It is mainly constituted from kitchen wastes because they are major components of food stuffs such as butter, vegetable oils and fats.

(v) Surfactants:

It comes primarily from the synthetic detergents. They are discharged from bathrooms, kitchen and washing rooms.

(vi) Phenol, Pesticides and Agricultural Chemicals:

It is found in industrial wastewater. It cause serious taste problem in drinking water when the water is disinfected by chlorination.

(vii) Toxic Compounds:

Copper, Lead, Silver, Chromium, Arsenic and Boron are some of the cations which are toxic to microbes resulting in the malfunctioning of biological treatment plant.

(viii) Sulphate, Suphide and H_2S gas:

These are formed due to the decomposition of various sulphur containing substance present in the wastewater.

(ix) Other Gases:

Nitrogen, Oxygen, Carbondioxide, Hydrogen Sulphide, Ammonia and Methane are the gases found in untreated wastewater.

(x) Dissolved Oxygen (DO):

It is the amount of oxygen in the dissolved state in the wastewater. Though wastewater generally does not have DO, its presence in untreated wastewater indicates that the wastewater is fresh.

(xi) Total Oxygen Demand (TOD):

To measure the organic content of wastewater.

(xii) Theoretical Oxygen Demand(ThOD):

This is the theoretical method of computing the oxygen demand of various constituents of the organic matter present in wastewater.

(xiii) Total Organic Carbon (TOC):

The TOC test is specially applicable to small concentration of organic matter. The TOC test consist of acidification of the wastewater sample to convert inorganic carbon to CO2 which is then stripped.

(xiv) Bio-Chemical Oxygen Demand (BOD):

It may be defined as the oxygen required for microorganisms to carry out biological decomposition of dissolved solids or organic matter in the wastewater under aerobic conditions at standard temperature.

(xv) Chemical Oxygen Demand (COD):

It may be defined as the amount of oxygen required for complete oxidation of organic and inorganic matter in presence of strong chemical agent.

<u>(c) BIOLOGICAL CHARACTERISTICS:</u>

The biological characteristics are related to the presence of microorganisms such as (i) Principal groups of microorganisms found in wastewater (ii) Pathogenic Organisms, (iii) Microorganisms used as indicators for pollution.

The various micro –organisms found in water or wastewater may be broadly classified under three categories (i) Aquatic plants, (ii) Aquatic Animals, (iii) Aquatic molds, bacteria and viruses.

17. Explain the limitations of BOD Test?

- BOD test measures only biodegradable organics
- Pre-treatment is needed if the sample contains toxic wastes.
- The effects of nitrifying bacteria should be reduced or eliminated by pre-treatment
- It is essential to have concentration of active bacteria present in the sample wastewater.
- The test loses its stochiometric validity after the soluble organic matter present in the solution has been used.
- The test uses an arbitrary long period of time to obtain the results.
- For BOD5 test, the 5 day period may or may not correspond to the point where
- soluble organic matter present has been used.

18. List out the characteristics of wastewater and their sources.

Sl. No.	Characteristics	Sources
1	**<u>Physical</u>** (i) Colour	Domestic & Industrial wastes, natural decay of organic materials
	(ii) Odour	Decomposing wastewater, Industrial Wastes
	(iii) Solids	Domestic water supply, soil erosion etc.,
2	**<u>Chemical</u>** **(A) <u>Organic</u>** (i)Carbohydrates	Domestic, Commercial & Industrial wastes
	(ii) Fats, Oils & Grease	Domestic, Commercial & Industrial wastes
	(iii)Pesticides	Agricultural wastes
	(iv)Phenols	Industrial wastes
	(v)Surfactants	Domestic & Industrial wastes
	(B) <u>Inorganic</u>	Domestic wastes, domestic water supply

	(i) Alkalinity	
	(ii)Chlorides	Domestic wastes, domestic water supply
	(iii)Nitrogen	Domestic & Agricultural wastes
	(C)Gases (i) Methane	Decomposition of domestic wastes
	(ii) H2S	Decomposition of domestic wastes
3	**Biological** (i) Animals & Plants	Open water sources and Treatment plants
	(ii) Viruses	Domestic wastes

19. Explain briefly the impacts / effects of wastewater constituents.

Pollutant / constituent	Parameter	Impacts / Effects
Suspended Solids	Volatile Compounds, Settleable, Suspended & Colloidal Impurities	- Development of sludge deposits causing anaerobic conditions - Plugging of irrigation equipments and systems such as sprinklers
Biodegradable organics	BOD,COD	- Depletion of DO in surface water - Development of septic conditions - Unsuitable habitat and environment - Fish mortality
Dissolved Inorganic substances	TDS,EC,Na, Ca, Mg, Cl &B	- Accumulate in aquatic organisms - Cause salinity - Affect permeability and soil structure
Heavy Metals	Cd, Pb, Ni, Zn, As, Hg etc.,	- Bio accumulate in fishes - Toxic to plants and animals

		- Possible health impacts - make wastewater unsuitable for irrigation
Hydrogen Ion Concentration	pH	- possible adverse impact on plant growth due to acidity or alkalinity
Residual Chlorine	Both free and combined Chlorine	- ground and surface water contamination - Green House Effect
Stable Organics	Phenols, Pesticides, Chlorinated Hydrocarbons	- Toxic to environment - Make wastewater unsuitable for irrigation
Pathogens	Viruses, Bacteria etc.,	- Cause Communicable diseases

20. Explain the regulatory standards for the discharge of wastewater / effluents.

Sl.No.	Parameter	STANDARDS			
		Inland surface water	**Public Sewers**	**Land for Irrigation**	**Marine Coastal Areas**
1	Suspended Solids (mg/L)	**100**	**600**	**200**	**100 (Process Water)**
2	pH	**5.5 – 9.0**	**5.5 – 9.0**	**5.5 – 9.0**	**5.5 – 9.0**
3	Oil & Grease (mg/L)	**10**	**20**	**10**	**20**
4	Ammonical Nitrogen (mg/L)	**50**	**50**	**-**	**50**
5	BOD (mg/L)	**30**	**350**	**100**	**100**
6	Hexavalent Chromium (Cr^{+6}) mg/L	**0.1**	**2.0**	**-**	**1.0**
7	Total Chromium (mg/L)	**2.0**	**2.0**	**-**	**2.0**
8	Dissolved	**5.0**	**-**	**-**	**-**

	Phosphate (mg/L)				
9	Phenolic Compounds	**1.0**	**5.0**	**-**	**5.0**
10	Nitrate Nitrogen (mg/L)	**10**	**-**	**-**	**20**
11	Manganese (mg/L)	**2.0**	**2.0**	**-**	**2.0**
12	Iron (mg/L)	**3.0**	**3.0**	**-**	**3.0**
13	Bio-assay Test	90% survival of fish after 96 hours in 100% Effluent	90% survival of fish	90% survival of fish	90% survival of fish

22. Explain the estimation of relative stability of a sewage.

The term relative stability of a sewage may be defined as the ratio of oxygen available in the effluent (as D.O., nitrite or nitrate) to the total oxygen required to satisfy its first B.O.D. demand. It is expressed as percentage of the total oxygen required, and can be expressed by the equation:

$$\text{Relative stability} = S = 100[1 - (0.794)^{t_{20}}$$

$$S = 100[1 - (0.630)^{t_{37}}$$

Where S = The relative stability, $t_{(20)}$ and $t_{(37)}$ represent the time in days for a sewage sample to decolourise a standard volume of methylene blue solution, when incubated at 20°C or 37°C

The decolourisation caused by the enzymes produced by anaerobic bacteria, infact, is an indication of the available oxygen in oxidizing the unstable organic matter.

The sooner the decolourisation takes place, the earlier the anaerobic conditions develop, which means lesser availability of oxygen. Hence, if the decolourisation takes place sooner (less than 4 days or so), the effluent sample may be taken as relatively unstable (as relativity is less than about 0.6). But samples which do not decolourise in four days can be relatively stable, and, thus, discharged into the stream without any troubles.

The above test for determining relative stability is suitable only in case of polluted stream waters or sewage effluents (i.e. treated sewage). In case of raw sewage, however, the colour is precipitated out due to presence of colloidal matter in the sewage, and therefore, the test is of little use in that case. This test is, however, very simple, and quickly gives a rough indication of the character of the treated sewage.

23. State the classification of solids present in sewage and the removal methods of each. (May/June 2013)

(i) Total Solids

(ii) Suspended Solids

(iii) Settleable Solids

(iv) Volatile solids

(v) Fixed solids

(vi) Setteable solids

Sewage normally contains very small amount of solids in relation to the huge quantity of water (99.9%). It only contains about 0.05 to 0.1 per cent (i.e. 500 to 1000 mg/l) of total solids. Solids present in sewage may be in any of the four forms : suspended solids, dissolved solids, colloidal solids, and settleable solids. Suspended solids are those solids which remain floating in sewage. Dissolved solids are those which remain dissolved in sewage just as salt in water. Colloidal solids are finely dividedsolids remaining either in solution or in suspension. Settleablesolids are that portion of solid matter which settles out, if sewageis allowed to remain undisturbed for a period of 2 hours. Theproportion of these different types of solids is generally found to beas given below:

It has been estimated that about 1000 kg of sewage contains about 0.45 kg of total solids, out of which 0.225 kg is in solution, 0.112 kg is in suspension, and 0.112 kg is settleable.

Further, the solids in sewage comprise of both: the organic as well as inorganic solids. The organic matter works out to be about 45 per cent of the total solids, and the remaining about 55 per cent is the inorganic matter.

Inorganic matter consists of minerals and salts, like: sand, gravel, debris, dissolved salts, chlorides, sulphates, etc.

Organic matter consists of (i) carbohydrates such as cellulose, cotton, fibre, starch, sugar, etc. (ii) fats and oils received from kitchens, laundries, garages, shops, etc. (iii) nitrogenous compounds like proteins and their decomposed products, including wastes from animals, urea, fatty acids, hydrocarbons, etc.

As a general rule, the presence of inorganic solids in sewage is not harmful. They require only mechanical appliances for their removal in the treatment plant. On the other hand, suspended and dissolved organic solids are responsible for creating nuisance, if disposed of, untreated. The amounts of various kinds of solids present in sewage can be determined as follows:

(a) The total amount of solids (S_1 in mg/l) present in a given sewage can be determined by evaporating a known volume of sewage sample, and weighing the dry residue left. The mass of the residue divided by the volume of the sample evaporated, will represent the total solids in mg/l, say S_1

(b) The suspended solids (S_2 are those solids which are retained by a filter of 1 μm pores; and they are, therefore, also called as non-filterable solids. Their quantity can be determined by passing a known volume of sewage sample through a glass-fiber filter apparatus, and weighing the dry residue left. The mass of the residue divided by the volume of sample filtered, will represent the suspended solids, say $(S_2)'$ in mg/l.

(c) The difference between the total solids (S) and the suspended solids (82) will represent nothing but dissolved solids plus colloidals, or filterable solids' say S where $S_3 = S_1 - S_2$

(d) Now, the total suspended solids (S_2) may either be volatile or fixed: In order to determine their proportion, the non-filtered dry residue of step (b) above, is burnt arid ignited at about 550°C in an electric muffle furnace for about 15 to 20 minutes. Loss of weight due to ignition will represent the volatile solids in the sample volume filtered through the .filter. Let the volatile suspended solids concentration be S_4 (in mg/l).

(e) The difference $S_2 - S_4 = S_5$ (say) will evidently represent the fixed solids.

(f) The quantity of settleable solids (S6) can be determined easily with the help of a specially designed conical glass vessel called Imhoff cone (Refer Fig.). The capacity of the cone is 1litre, and it is graduated up to about 50 ml.

Sewage is allowed to stand in this Imhoff cone for a period of two hours, and
the quantity of solids settled in the bottom of the cone can then be directly read out.
However, in order to obtain precise amount of settleable solids, the liquid from the cone should be decanted off, and the settleable solids collected at the bottom of the cone should be dried and weighed.

24. Briefly discuss the legislation requirements for sewage treatment. (Nov/Dec 2013, Apr/May 2015)

Municipal wastewaters contain organic/inorganic and other toxic matter which are injurious tothe general health of man apart from being of immense nuisance value. It is therefore obligatory that the wastewater is properly treated and safely disposed off.

Municipal Bylaws:

Most municipal bylaws provide for the owner of any property to dispose off his wastewater in a proper manner without causing any nuisance to others. Wherever municipal sewers exist within some specified distance, it is Obligatory that the wastewater of the property is discharged into it. The bylaws provide for action against defaulting owners. However in the case of areas not originally served with sewerage facilities, the owners may have to be persuaded to avail of the facilities provided to dispose off their wastewaters and in some cases it may even become necessary for the local body to show some incentive like loan/subsidy for getting the works necessary to dispose the wastewater into such municipal sewers.

Prevention of Pollution

The early law regulating pollution was enforced almost entirely through the process of individual suits for what was termed a private nuisance. The concept of public nuisance has also been used to some degree to control pollution. A public nuisance is an act which causes inconvenience or damage to the public as distinguished from one or a few individuals and includes any interference with the public health, safety, or inconvenience. A public nuisance is subject to abatement at the behest of state officials. It may also constitute a crime.

UNIT – 5

PART -A

1. What are the requirements of a good distribution system?

1. Should be capable of supplying water at all the intended places within the city with a reasonably sufficient pressure head.
2. should be cheap with the beast capital construction cost
3. should be capable of supplying the required amount of water for firefighting such needs

2. List the layouts of distribution networks?

1. Dead end system /tree system
2. Grid iron system /reticulation/interlaced system
3. Ring system/ circular system
4. Radial system

3. List the methods of distribution?

1. By gravitational system
2. By pumping system
3. By combined gravity and pumping system

4. What are the systems of supply for water?

1. Continuously supply for 24 hours
2. Intermittently supply for peak periods.

5. What are the functions of distribution reservoir or service reservoir?

❖ They absorb the hourly variations in demand, and allow the water treatment units and pumps to operate at a constant rate.

❖ They help in maintain constant pressure in the distribution mains

- They lead to an overall economy by reducing the size of pumps pipe lines & treatment units
- The pumping of water in shifts is made possible by them without affecting the supply

6. Classify the types of service reservoir?

1. Surface reservoir
2. Elevated reservoir

7. How to find the storage capacity of Distribution reservoirs?

The total storage capacity of a distribution reservoir is the summation of

1. Balancing storage
2. Breakdown storage
3. Fire storage

8. List out the methods for detection of leakage in the distribution pipes?

- By direct observation
- By using sounding rods
- By plotting hydraulic gradient line
- By using waste detection meter

9. What are the factors to be depended distribution mains pressure?

The desired pressure in the distribution mains depends on

- Height to which water is required to be supplied
- Fire fighting requirements
- Availability of funds
- Whether the supply is metered or not.

10. Define mass cure method?

A mass diagram is the plot of accumulated inflow (i.e. supply) or outflow (i.e. demand) verses time. The amount of balancing storage can be easily determined by adding the maximum ordinates between the demand and the supply lines.

11. How to analysis the complex pipe networks?

1. Hardy cross method
2. Equivalent pipe method
3. Electrical analyse method

12. List the components of house water connection?

- A ferrule
- A goose neck
- A service pipe
- A stop cock
- A water meter

13. Write about the requirements of a good hydrants?

- It should be cheap
- It should be easily detectable during the panicky atmosphere of fire.
- It should not get out of order during operation
- On being fully opened it should allow undisturbed water flow.

14. What are the two types of fire hydrants?

1. Post fire hydrant
2. Flush fire hydrant

15. Write the requirements of a good water meter?

- ❖ Its maintenance and repair should be easy.
- ❖ It should measure the discharges within the maximum limit of 20% error.
- ❖ It must record the entire water passing through it.
- ❖ It should prevent the back flow passing through it.

16. Write the types of water meters?

1. Velocity meter or Inferential meter
2. Positive meter or Displacement meter

17. What are the advantages of inferential meter (velocity meter) over displacement meter (positive meter)?

(i) They are cheaper.

(ii) They are light and require lesser head.

(iii) They are less accurate.

(iv) If anything stops the rotation of rotary or turbine meters, the water will continue to flow without being recorded.

(v) They can be installed only on horizontal flows; and hence on vertical pipes, the positive or strictly speaking semi-positive type of metres will have to be installed.

18. Write about equivalent pipe method?

- ❖ Used to solve large network of pipes
- ❖ In this method , pipe network is converted into single equivalent pipe.

19.What are the two conditions in any pipe network?

In any pipe network, the following two conditions must be satisfied:

(i) The algebraic sum of the pressure drops around a closed loop must zero, i.e. there can be no discontinuity in pressure.

(ii) The flow entering a junction must be equal to the flow leaving the same junction; i.e. the law of continuity must be satisfied.

20. What are the fittings used in plumping systems in building?

1. Stop cocks
2. Water taps and Bib cocks
3. Bends or Elbows
4. Increaser and Reducer

21. How to estimating storage capacity of water in buildings?

1. Hours of supply
2. Rate of supply
3. Demand pattern
4. Fire demand required

22. How to distribute water for multistoreyed building?

1. Piping system using direct supply
2. Piping system using overhead tank
3. Piping system using underground- overhead tank supply
4. Pumped system

23. What is "Ferrule"? (May/June 2013)

A ferrule is a right angled sleeve made of brass or gun metal, and is joined to a hole drilled in the water main, to which it is screwed down with a plug. Its size usually varies between 10 to 50 mm dia. For all other connections of more than 50 mm dia, a tee branch connection, off the water main, is used.

24. What do you mean by sanitary fitting? (Nov/Dec 2011)

The various pipe or sanitary fitting such as bends, cross, tees, elbows, wye unions, caps, plugs are frequently used in making service connections and also sometimes in bigger sized mains and sub-mains.

25. List out the components of a service connection pipe. (Nov/Dec 2011, May 2015)

- House water connection
- Stop cocks
- Water taps and bib cocks
- Pipe fittings

26. Name any two appurtenances used in water distribution system. (May/June 2014)

1. Fire hydrants
2. Water meter
3. Stop cocks
4. Water taps and Bib cocks
5. Bends or Elbows

27. List out the methods to reduce wastage of water in a distribution system. (Nov/Dec 2015)

1. Metering
2. House to house inspection of fitting
3. Licensed plumbing, etc.

28. Mention the role of computer application in water distributing system. (May 2016)

- The flow of water in each pipe,
- The pressure at each node,
- The height of the water in each tank, and

- The type of chemical concentration throughout the network during a simulation period,
- water age,
- source,

and -

tracing.

PART – B

1. What is meant by distribution system? What are the requirements of a good distribution system? (May/June 2013)

Distribution System

After the water has been properly treated and made safe and wholesome, it has to be supplied to the consumers in their individual homes. The water has, therefore, to be taken from the treatment plant to the roads and streets in the city, and finally to the individual houses. This function of carrying the water from the treatment plant to the individual homes is accomplished through a well-planned distribution system. A distribution system may, therefore, consists of pipe lines* of various sizes for carrying the water to the streets; valves for controlling the flow in the pipes, hydrants for providing connections with the water mains for releasing water during fires ; meters for measuring discharges; service connections (called services) to the individual homes pumps for lifting and forcing the water into the distribution pipes, distribution or service reservoirs for storing the treated water to be fed into the distribution pipes ; etc. Further, the water may be supplied to the public either continuously for all the -24 hours of the day or it may be supplied intermittently during certain fixed hours of the day. Also, the water may either be pumped directly into the distribution pipes, or it may first be stored in a distribution reservoir and then fed into the distribution pipes.

Requirements of a Good Distribution System

The various requirements for proper functioning of a distribution system are:

(i) It should be capable of supplying water at all the intended places within the city with a reasonably sufficient pressure head.

(ii) It should be capable of supplying the requisite amount of water for firefighting during such needs.

(iii) It should be cheap with the least capital construction cost. The economy and the cost of installing the distribution system is a very important factor, because the distribution system is the most costly item in the entire water supply scheme. So much so, that it gobbles up, upto about 70% of the total cost of the scheme.

(iv) It should be simple and easy to operate and repair, thereby keeping the RMO cost and troubles to the minimum.

(v) It should be safe against any future pollution of water. This aim may be achieved by keeping the water pipe lines above and away from the sewerage and drainage lines by sufficient amounts, and also by improving the general sanitary conditions of the area through which the distribution pipes have to pass.

(vi) It should be safe as not to cause the failure of the pipe lines by bursting, etc.

(vii) It should be fairly water-tight, as to keep the "losses due to leakage" to the minimum.

2. Discuss the layouts of distribution networks? (Nov/Dec 2012, 2014)

Layouts of Distribution Networks

As pointed out earlier, the distribution pipes are generally laid below the road pavements, and as such, their layouts will generally follow the layouts of the roads. There are, in general, four different types of pipe networks; anyone of which, either singly or in combinations, can be used at a particular place, depending upon the local conditions and orientation of roads. These systems are:

(1) Dead end system ;

(2) Grid iron system;

(3) Ring system; and

(4) Radial system.

The different types of distribution networks are described below. Their designs and calculations for working out the sizes of various pipes shall, however, be dealt later.

(1) Dead-end System:

In the dead end system, which is also sometimes called Tree system, there is one main supply pipe, from which originates (generally at right angles) a number of submain pipes. Each submain, then divides into several branch pipes, called laterals. From the laterals, service connections are given to the consumers. A typical plan of such a network is shown in Fig. 1.

This type of layout may have to be adopted for older towns which havedeveloped in a haphazard manner, without properly planned roads. The water supply mains have then to be taken along the main roads, and branches taken off wherever needed, thus resulting in the formation of a number of dead ends" as shown. This system is, therefore, suitable for localities which expand irregularly, and where the water pipes have to be laid at random due to the absence of any planned full fledged road network.

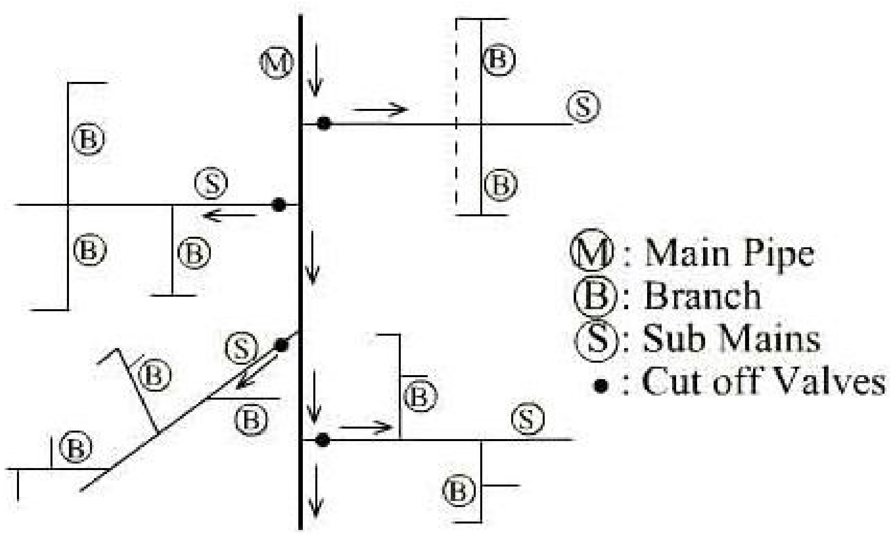


Fig. 1. Dead-end or Treesystem.

The advantages of this system are:

(1) The distribution network can be solved easily, and it is possible to easily and accurately calculate the discharges and pressures at different points in the system.

(ii) Lesser number of cut-off valves i.e. sluice valves) are required in this system. (iii) Shorter pipe lengths are needed, and the laying of pipes is easier. (iv) It is cheap and simple, and can be extended or expanded easily.

The disadvantages of this system are:

(i) Since, in this method, water can reach a particular point only through one route, any damage or repair in any pipe line will completely stop the wate r supply in the area being fed by that pipe. Thus, if damage occurs or repair is taking place in a main pipe or in a submain pipe, considerable areas may get affected, thereby causing great inconvenience to-the consumers.

(ii) There are numerous dead ends in this system, which prevent the free circulation of water. This stagnation of water may-lead to the degradation in its quality. This stale water should, therefore, be removed periodically at all the dead ends, by providing scour valves at each dead end. This will result in a greater wastage of treated water, and will necessitate careful attendance at each valve.

(iii) Since in this system, the discharge is reaching a point from only one direction, the supplies during firefighting cannot be increased by diverting any other supplies from any other side. Hence, it can give only limited supplies and may sometimes prove to be a serious handicap.

(2) Grid-iron System:

In this system, which is also known as Inter laced system or Reticulation system, the mains, sub-mains and branches are all inter-connected with each other, as shown in Fig. In fact, in a well-planned city or a town, the roads are generally developed in a grid-iron pattern, and the pipe lines in such places can follow them easily. Hence, this system is more suitable for well-planned towns and cities, and has been used in Chandigarh.

Nevertheless, the principle of grid-iron system can be applied to the dead end system also, by closing the loop, and thus removing the dead ends, as shown by a dotted line in Fig. 2. Dead-end system.

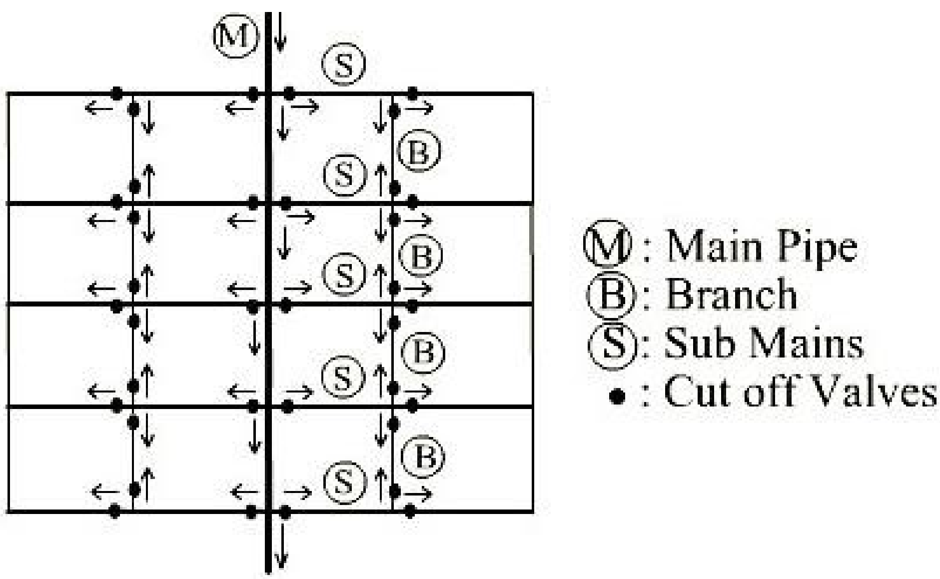


Fig. 2. Grid-iron system. The advantages of this system are:

(i) Since the water reaches at different places through more than one route, the discharge to be carried by each pipe, the friction loss, and the size of the pipe, therefore, get reduced.

(ii) In case of repairs, very small area will be devoid of complete supply, as atleast, some supply will be reaching at the point from some other route.

(iii) Because of the different inter-connections, the dead ends are completely eliminated, and, therefore, water remains in continuous circulation, and hence not liable to pollution due to stagnation.

(iv) During fire, more water can be diverted towards the affected point from various directions by closing and manipulating the various cut-off valves.

The disadvantages of this system are:

(i) This system requires more length of pipe lines, and a larger number of sluice valves (i.e. cut-off valves).

(ii) Its construction is costlier.

(iii) The design is difficult and costlier, the calculations for determining accurately the sizes of the pipes and the pressures at various key points, is a real tedious job, and may require the services of design experts and even computers.**(3) Ring System:**

This system is also sometimes called Circular system. In this system, a closed ring, either circular or rectangular, of the main pipes, is formed around the area to be served, as shown in Fig. 3. The distribution area is divided into rectangular or circular blocks, and the main water pipes are laid on the periphery of these blocks. The sub-mains may be placed as shown.

The ring system is very suitable for towns and cities having well planned roads. Sometimes, this system is used as a "looped feeder placed centrally around a high demand area" along with the grid iron system. In such a case, this enhances the capacity of the grid iron system, and will improve the pressures at various points. The advantages and disadvantages of this system are the same as that of the grid iron system.

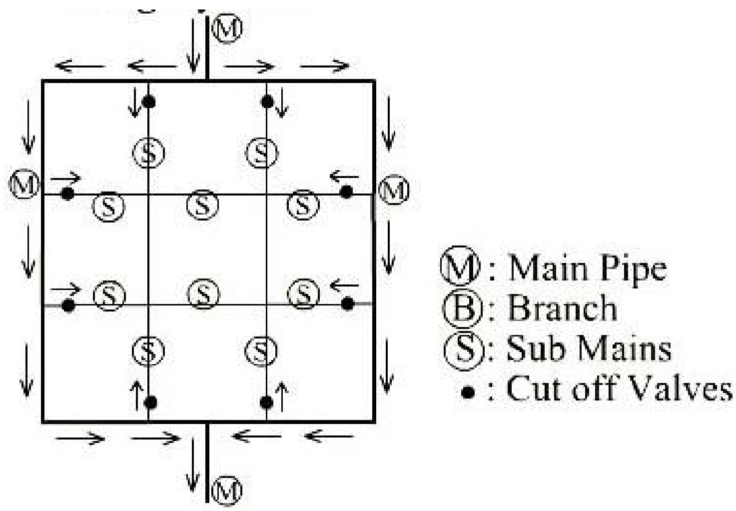


Fig. 3. Ring system.

(4) Radial System:

If a city" or a town is having a system of radial roads emerging from different centres, the pipe lines can be best laid in a radial method by placing the distribution reservoirs at these centres. In this system, water, is therefore, taken from the water mains, and pumped into the distribution reservoirs placed at different centres, as shown in Fig. 4.The water is then supplied through radially laid distribution pipes. This method ensures high pressures and efficient water distribution. The calculations for design of sizes are also simple.

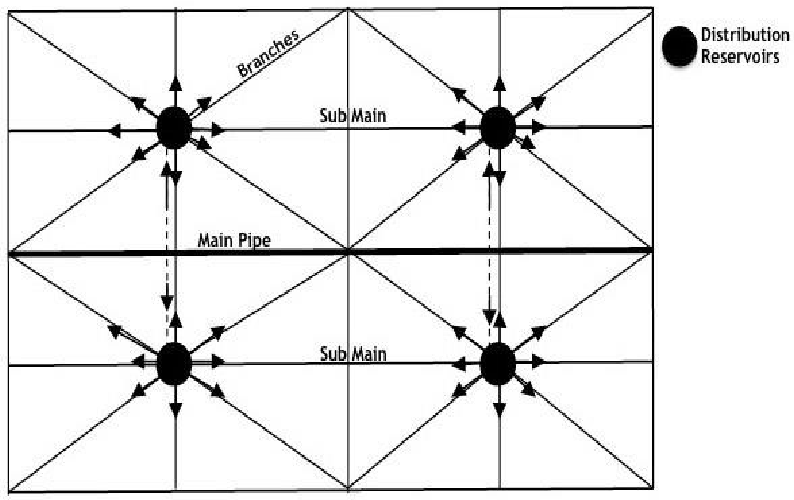


Fig. 4. Radial system.

3. Discuss briefly methods of water distribution system.

The main object of a distribution system is to develop adequate water pressures at various points of the consumer's taps. Depending upon the level of the source of water and that of the city, topography of the area, and other local conditions and considerations, the water may be forced into the distribution system in the following three ways:

(1) By gravitational system;

(2) By pumping system; and

(3) By combined gravity and pumping system.

(1) Gravitational System:

In this system, the water from the high levelled source is distributed to the consumers at lower levels, by the mere action of gravity without any pumping. For proper functioning of this system, the difference of head available between the source (rather the distribution reservoir at the treatment plant) and the localities, must be sufficient enough, as to maintain adequate pressure at the consumer's door-steps, after allowing the frictional and other losses in the pipes.

This method is the most economical and reliable, since no pumping is involved at any stage. However, it needs a lake or a reservoir as a source of supply. In Mumbai, the water which is brought from the high lakes situated in the hills, is distributed to the consumers by this method.

From the above discussion, it becomes evident that such a system can be adopted for cities which are situated at the foot-hills and the source of supply is available somewhere in the hills at sufficient elevation in relation to the elevation of the city. Fig.5 show the gravitational system with hydraulic gradients during maximum and minimum demands.

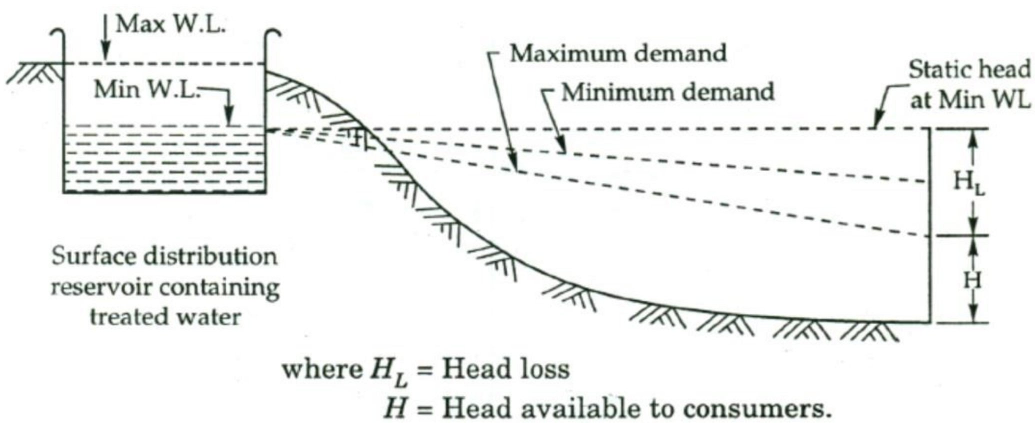


Fig. 5. Gravitational distribution system

In gravitational system, the pumping is normally not required at any stage. However, in a case, where the source, such as a lake is situated at a hill, and the treatment plant is also situated almost at the same level on the hill itself, then the water may have to be conveyed from the source to the treatment plant by low lift pumping. However, the treated water will be distributed to the low levelled consumers situated at the foothill by mere gravity. Hence, no pumping will be required in the distribution system.

The gravitational system is designed so as to leave only the minimum permitted available head to the consumers, and the rest is consumed in frictional and other losses. This will keep the leakages and the wastages to the minimum, and will also reduce the required sizes of the pipes. (Greater is H_L lesser dia. is reqd. to pass a given discharge). However, this will necessitate the use of motor pumps, so as to develop sufficient pressure during fires.

2) Pumping System:

In the pumping system, the treated water is directly pumped into the distribution mains without storing it anywhere. For this reason, this system is also sometimes called pumping without storage system. High lift pumps are required in this system, which have to operate at variable speeds, so as to meet the variable demand of water*. Thus, a continuous attendance is needed at the pumping station, so as to ensure the desired flow in the distribution system. Moreover, if the power supply fails, there will be complete stoppage of water supply, and if by chance, a fire breaks out at such a time, it will bring disaster. This method is, therefore, generally not used. However, the only advantage of this method is that during fires, it can force large volumes of water under high pressure in the required direction, so that the motor pumpers may be eliminated. Fig. 6 shows the pumping system with hydraulic gradients during maximum or minimum demands.

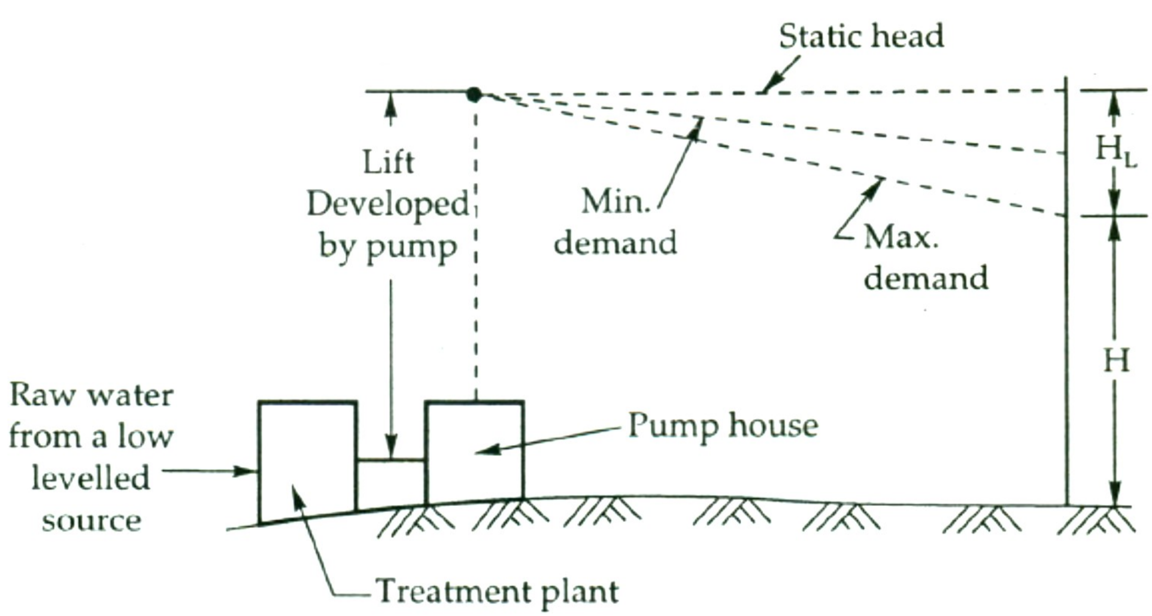


Fig. 6. Pumping system for water distribution

(3) Combined Gravity and Pumping System:

In this system, the treated water is pumped at a constant rate and stored into an elevated distribution reservoir, from where it is distributed to consumers by the mere action of gravity. Sometimes, the entire water is first of all pumped into the distribution reservoir, and many a times, it is pumped into the distribution mains and reservoirs, simultaneously. This method thus, combines pumping as well as gravity flow, and is sometimes called pumping with storage system.

The excess water during low demand periods gets stored in the reservoir and gets supplied during high demand periods. The pumps are worked at a constant rate, which is adjusted in such a way that the excess quantity of water stored in the reservoir during low consumption nearly equals the extra demand during high consumption. This system helps in operating the pumps at constant speeds at their rated capacities, thus increasing their efficiency and reducing their wear and tear. Fig. 7 shows this system with the hydraulic gradient lines for minimum and maximum demands.

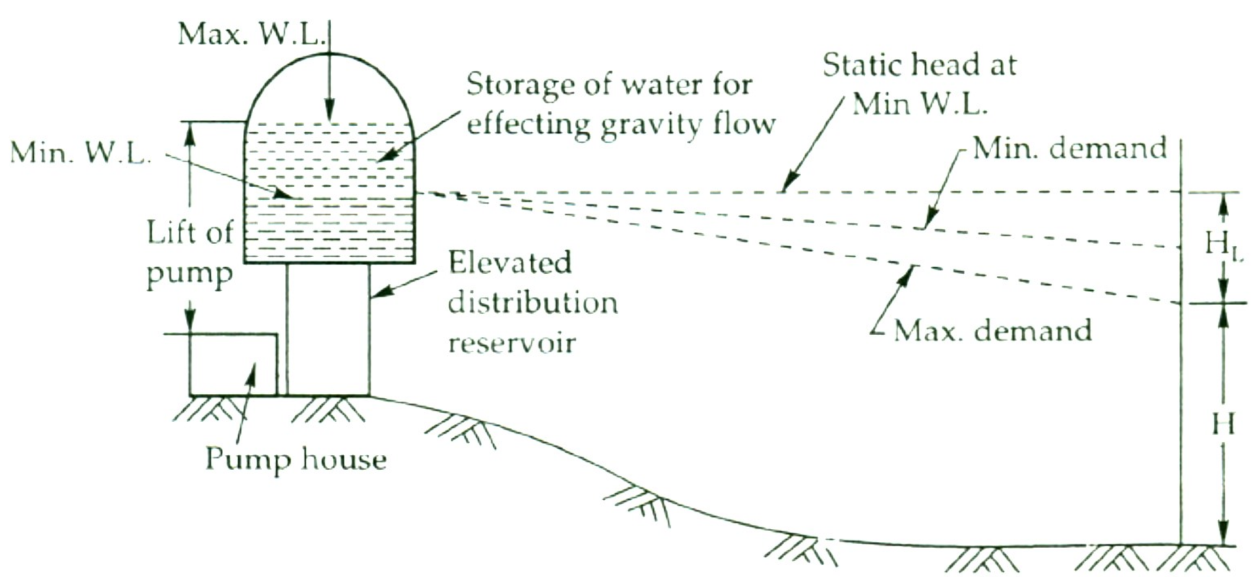


Fig. 7. Combined gravity and pumping system for water distribution

This type of system is invariably and almost universally adopted because of its following advantages:

(i) The balancing reserve of the distribution reservoir can be supplied to the places of fire. However, the necessary pressure required to be developed for firefighting can be achieved by closing down the supply of some localities or by using motor pumpers. In all modern firefighting squads, motor pumps are, therefore, provided.

(ii) The pumps are to be worked at uniform rate and, thereby operating them to their rated capacities. This increases their efficiency and also reduces the wear and tear of the pumps. The attendance and supervision required for operating these pumps is much less compared to the case when they are operated at variable speeds. In smaller towns, this method of distribution enables us to operate the pumps only for a part of the day, i.e. for 8 to 16 hours.

(iii) This method is quite reliable because even during the power failure or pumps failure, certain amount of water can be supplied from the storage or service reservoir.

(iv) This system proves to be overall cheap, efficient and reliable, and hence adopted practically everywhere.

4. How to supply the water in distribution system?

The water may be supplied either continuously for all the 24 hours of the day or may be supplied intermittently only for the peak periods during morning and evening. The second, i.e. the intermittent supply system may sometimes lead to some saving in water consumption due to losses occurring for lesser time and more vigilant use of water by consumers. This method may, therefore, be adopted at places where there is a shortage of water at the source. However, the intermittent system should not be continued as a long term policy, and be replaced by the continuous supply system at the earliest opportunity, because of the inherent limitations of this system. These limitations or disadvantages of the intermittent system are discussed below.

(i) Even the very first argument advocated in favour of the use of the intermittent system, that is that "saving in water is obtained" is debatable. At many places, the intermittent system may fail to give any saving of water over the continuous system.

mmense damage to life and property.

(iii) This system causes great inconvenience to consumers, keeping them on their toes for receiving and collecting water as soon as the supply is restored.

(iv) Since in this system, the supply of water for the whole day has to be pumped during 6 to 8 hours only, it will necessitate the use of bigger sized distribution mains, if the water is supplied to the whole town at the same time.

(u) When the supply of water is stopped and the water from the pipe is drawn off, a partial vacuum may be created in the pipe. This will induce suction through the leaky joints; and if the pipes are surrounded by dirts on the ground, the same may get into the pipes. This will contaminate the initial supplies as and when the supply is restored.

(vi) A number of air valves and sluice valves are required to be fitted in the distribution system. These valves will have to be operated daily while opening or closing the supply. This will necessitate additional watch and ward staff and high maintenance cost.

Inspite of these limitations and disadvantages, the intermittent supply system is largely employed in India*. This system may or may not help in saving water, but may definitely help in supplying water to high level areas with adequate pressures, by zoning the city. For improving the pressures, the entire city is divided into a number of zones, and different zones are supplied with water during different hours, thus obtaining better pressures. This system may also facilitate the repair works, as the same can be done during non-supply hours.

5. Explain the functions and types of distribution reservoirs (or) service reservoirs? (May & Nov 2015)

Distribution reservoirs, also called service reservoirs, are the storage

Functions of Distribution Reservoirs:

(i) They absorb the hourly variations in demand, and allow the water treatment units and pumps to operate at a constant rate. This will reduce the RMO costs and improve efficiency.

(ii) They help in maintaining constant pressure in the distribution mains. In their absence, the pressure will fall down as the demand of water increases, and if the pumps don't immediately respond to it.

(iii) The pumping of water in shifts is made possible by them without affecting the supply. Thus, 8 to 16 hours of pumping can be carried out, so as to pump the whole day's demand.

(iv) The water stored in these reservoirs can be supplied during emergencies, such as break-down of pumps, heavy fire demand, etc.

(v) They lead to an overall economy by reducing the sizes of pumps, pipe lines, and treatment units.

Types of Distribution Reservoirs:

The distribution reservoirs may be made of steel, RC.C, or masonry. Depending upon their elevation with respect to the ground, they may be classified into the following two types:

1. Surface reservoirs; and
2. Elevated reservoirs.

1. Surface Reservoirs:

Surface reservoirs are circular or rectangular tanks, constructed at ground level or below the ground level. They are, therefore, also called, ground reservoirs. They are generally constructed at high points in the city. If a city has more than one high point, more than one reservoir may be provided. In that case, directly sent from there into the distribution system. However, in a combined gravity and pumping system of distribution, the treated water is first of all stored in a ground reservoir, and then pumped into an elevated service reservoir, from where it can be supplied into the distribution mains.

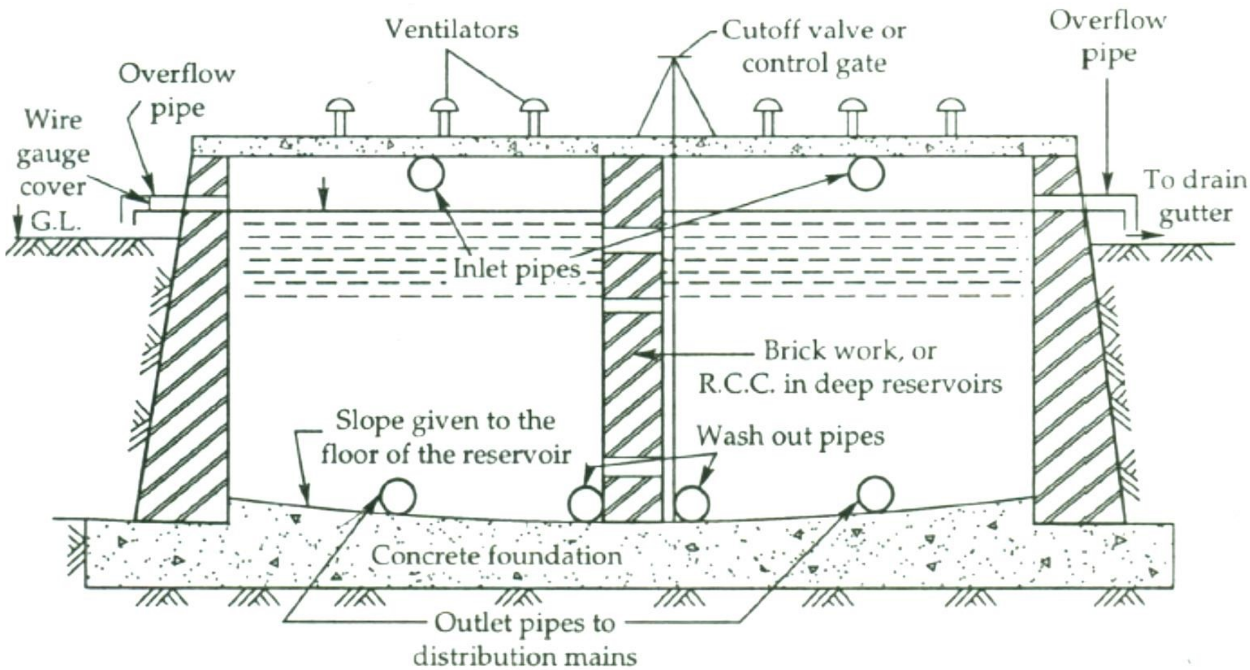


Fig. 8. Typical section of a ground water.

A typical section of a surface reservoir is shown in Fig. It is divided into two compartments, so that one may be cleaned and repaired, while the other is in use. The two compartments are connected with each other by shut off valve or sluice valves. Overflow pipes are provided at full supply level, so as to maintain a constant water level.

Ventilators are provided in the roof slab so as to affect free circulation of air. Although the stored water is treated, yet some sludge may settle down due to storage, and hence has to be removed. Such a reservoir is, therefore, cleaned through the washout pipes, at suitable intervals. The cement concrete floor may, therefore, be sloped towards the central washout pipes, as shown in Fig. 8.

2. Elevated Reservoirs:

Elevated reservoirs are the rectangular, circular, or elliptical overhead tanks erected at a certain suitable elevation above the ground level and supported on towers. They are constructed where the pressure requirements necessitate considerable elevation above the ground surface, and where the use of stand pipes becomes impracticable. They are constructed in areas where the combined gravity and pumping system for water distribution is adopted. Water is pumped into these elevated tanks from the filter units or from the surface reservoirs, and then supplied to the consumers. A typical sketch of a simple rectangular tank is shown in Fig. 9.

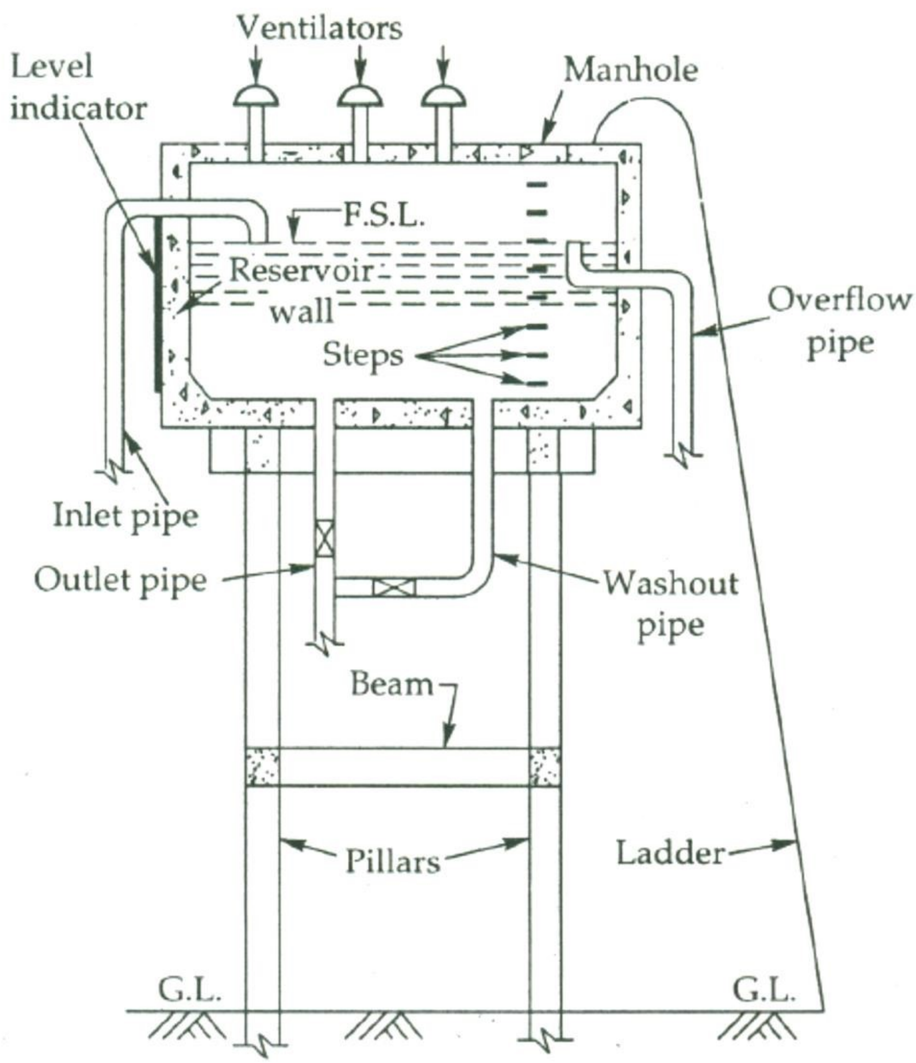
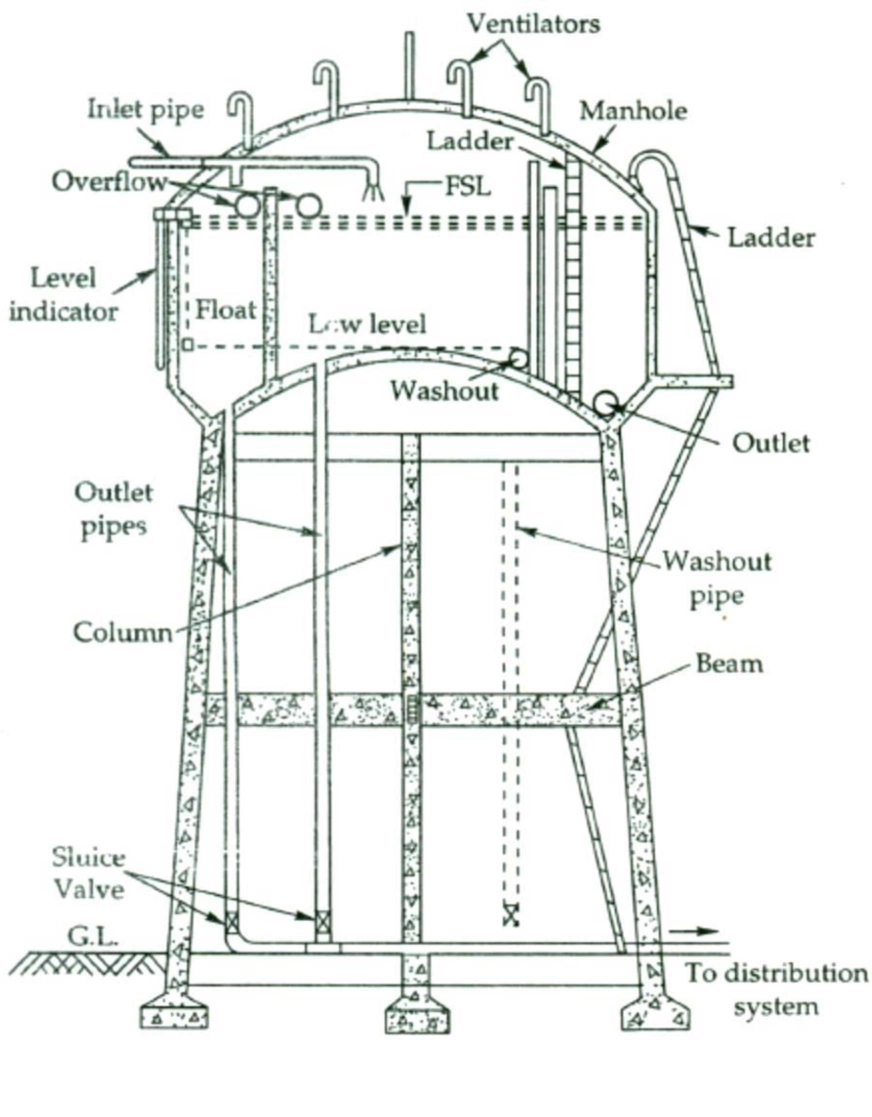


Fig. 9. Rectangular elevated tank.

These tanks may be made of R.C.C., steel, or prestressed concrete. With the advancement in structural analysis, it has been possible to construct them in any shape, so as to suit the architectural requirements. The R.C.C. tanks are now - a-days preferred to the steel tanks, because they are cheaper, do not corrode, arid require less maintenance. An R.C.C. tank of Intz type, such as shown in Fig. 10 has become very popular these days, because the same is structurally sound and quite economical. Prestressed concrete elevated tanks are also coming up in the modern days, and can give considerable savings in steel (up to 60%) and concrete (up to 40%). Their design computations can however, be found in any standard book on R.C.C. Designs:



These elevated reservoirs are generally very costly and, hence, are not designed for capacities of more than 6 to 8 hours of the average daily supply of the city; and possibly situated in the heart of the city. They are generally covered at top by the roof slabs in order to avoid the contamination of water due to dirts, birds, insects, etc. Roofs should, however, be provided with ventilators, so as to allow free circulation of air. Various other accessories of such a reservoir are:

(i) Inlet pipe for the entry of water.

(ii) Outlet pipe connected to the distribution mains for the exit of water.

(iii) Overflow pipe discharging into drain gutters and maintaining consta

v) A wash-out pipe (or drain pipe) for removing water after cleaning of the reservoir.

(vi) Automatic devices to stop pumping when the tank is full.

(vii) Ladders to reach the top of the reservoir and then upto the bottom of the reservoir for inspection.

(viii) Manholes for providing entry into the tank for inspection purposes.
(ix) Ventilator for fresh air circulation (as pointed out earlier also).

3. Stand Pipes

Stand pipes are a kind of elevated tanks without any erected towers for resting the tank body. They are thus tall cylindrical shells resting directly on the ground, as shown in Fig. 11. These stand pipes may be 15 to 30 m