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ENVIRONMENTAL ENGINEERING

For

CIVIL ENGINEERING

ENVIRONMENTAL ENGINEERING

SYLLABUS

Water Requirements: Quality standards, basic unit processes and operations for water treatment. Drinking water standards, water requirements, basic unit operations and unit processes for surface water treatment, distribution of water. Sewage and sewerage treatment, quality and characteristics of wastewater. Primary, secondary and tertiary treatment of wastewater, sludge disposal, effluent discharge standards. Domestic wastewater treatment, quantity of characteristics of domestic wastewater, primary and secondary treatment unit operations and unit processes of domestic wastewater, sludge disposal.

Air Pollution : Types of pollutants, their sources and impacts, air pollution meteorology, air pollution control, air quality standards and limits.

Municipal Solid Wastes : Characteristics, generation, collection an transportation of solid wastes, engineered systems for solid waste management (reuse/recycle, energy recovery, treatment and disposal).

Noise Pollution : Impacts of noise, permissible limits of noise pollution, measurements of noise and control of noise pollution.

ANALYSIS OF GATE PAPERS

Exam Year	1 Mark Ques.	2 Mark Ques.	Total
2003	4	9	22
2004	3	9	21
2005	4	8	20
2006	3	6	15
2007	3	6	15
2008	2	6	14
2009	2	6	14
2010	3	3	9
2011	3	3	9
2012	2	4	10
2013	2	3	8
2014 Set-1	3	3	9
2014 Set-2	2	4	10
2015 Set-1	3	2	6
2015 Set-2	2	4	10
2016 Set-1	4	3	10
2016 Set-2	5	4	13
2017	3	4	11

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1 WATER DEMAND, ITS SOURCE & CONVEYANCE

WATER DEMAND, ITS SOURCE & CONVEYANCE

To design a water supply scheme, we must first estimate the population for which the scheme should be designed. The scheme up to some predetermined future date.

1.1 DESIGN PERIODS

- A water supply scheme includes huge and costly structures (such as dams, reservoirs) which cannot be replaced of increased in their capacities, easily and conveniently. In order to avoid these future complications of expansion, the various components of a water supply scheme are purposely made larger, so as to satisfy the community needs for a reasonable number of years to come.
- This future period or the number of years for which a provision is made in designing the capacities of 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. It should not exceed the useful life of the component structure.

Units	Design Period
Water treatment units	15 years
Pipe connections to the several treatment units	30 years
Service reservoirs (overhead of ground level)	15 years
Distribution System	30years

1.2 POPULATION FORECASTING

Water demand is assessed on the basic of future population. The future population is assessed as discussed below.

1.2.1 POPULATION GROWTH

There are three main factors responsible for changes in population :-

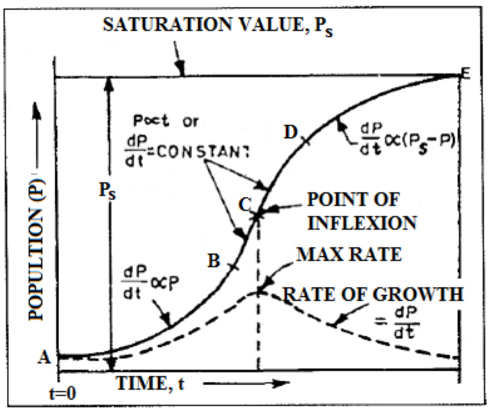
(i) Births
(ii) Deaths
(iii) Migrations

- Population forecasting is done by mathematical formulae and graphical solutions based upon previous population records

1.2.2 GROWTH CURVE

The population would probably follow the growth curve characteristics of living things within limited space or with limited economic opportunity. The curve is S-shaped as shown below and is known as **logistic curve.**

- The curve represents early growth AB at an increasing rate (i.e., geometric of log growth, $\frac{dp}{dt} \propto P$); and late growth DE at a decreasing rate [i.e., 1st order curve , $\frac{dp}{dt} \propto (P_s - P)$] as the situation value (P_s) is approached.
- The transitional middle curve BD follows an arithmetic increase (i.e., $\frac{dp}{dt}$ = constant). What the future holds for a given population, depends upon as to where the point lies on the growth curve at a given time.



1.3 POPULATION FORECASTING METHODS

The various methods which are generally adopted for estimating future population by engineers are not exact, and they are all based on the laws of probability, and thus, only approximate estimates for the possible future population can be made. The various methods followed are as discussed below:

1. **Arithmetic Increase Method :** This method is based upon the assumption that the population increases at a constant rate

   i.e,. $\frac{dp}{dt}$ = constant = k or

   dp = kdt or

   $$\int_{p_1}^{p_2} dp = \int_{t_1}^{t_2} kdt = k(t_2 - t_1)$$

   where, $t_2 - t_1$ = number of decades

   Forecasted population after n decades from the present (i.e., last known census) is given by

   $Pa = Po + n\bar{x}$

   Where,

   P_n = prospective population after n decades from present.

   P_o = population at present

   n = number of decades between now and future.

   $\tilde{x}$ = average (arithmetic mean) of population increase in the known decades.

Example 1

The population of 5 decades from 1930 to 1970 are given in table. Find out the population after one and six decades beyond the last known decade by using arithmetic increase method.

Year	Population
1930	25.000
1940	28,000
1950	34,000
1960	42,000
1970	47,000

Solution

Year	Population	Increase in Population (x)
1930	25,000	
1940	28,000	3000
1950	34,000	6000
1960	42,000	8000
1970	47,000	5000
Total		22000

Average increase per decades ($\bar{x}$)

($\bar{x}$) = 22000/4 = 5,500

(a) Population after 1 decade beyond 1970

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

= 47,000 + 5,500

= 52,500

(b) Population after six decade beyond 1970

$P_{2030} = P_{1970} + 6.\bar{x}$

= 47,000 + 6 × 5,500

= 80,000

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 also known as uniform increase method. The forecasted population (P_n) after n decades is given by

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

   Where,

   P_o = Population at the end of last known census.

   r = Assumed growth rare (%)

   r can be computed in several ways from the past known population data.

(a) $r = \sqrt[n]{\frac{P_2}{P_1}} - 1$

Where,

P_1 = Initial known population

P_2 = Final known population,

N = Number of decades between P_1 & P_2

(b)

$$r = \frac{\text{increase in population}}{\text{Original population}} \times 100$$

For knowing each decades $r_1.r_2......r_n$ the average value of r can be found by

(i) Arithmetic average method

$$r = \frac{r_1 + r_2 + \ldots + r_3}{n}$$

(ii) Geometric average method

$$r = (r_1 \times r_2 \times r_3 \times \ldots\ldots \times r_n)^{1/n}$$

Note: The design engineers in the field adopt arithmetic average method since it gives more values than geometric average method. However the "**GOI** Manual on Water Treatment" recommends 'Geometric mean' method

Example 2

Determine the future population of a town by the geometric increase method for the year 2011, as given in the following data:

Year	**Population**
1951	93
1961	111
1971	132
1981	161
.......2011	......?

Solution

WATER DEMAND, ITS SOURCE AND CONVEYANCE

Year	1951	1961	1971	1981
Population (in thousand)	93	111	132	161
increase in population (in thousand)		18	21	29
% increase in population		$\frac{18}{93}\times 100 = 19.35$	$\frac{21}{111}\times 100 = 18.92$	$\frac{29}{132}\times 100 = 21.97$

Constant growth rate, assumed for future

r = geometric mean of past growth rate

$$r = \sqrt[3]{19.35 \times 19.82 \times 21.97}$$

r = 20.23% per decade

The population after n decades is

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

P_{2011} = population after three decades from 1981 $P_{2011} = P_{1981}\left(1 + \frac{20.03}{100}\right)^3$

$$P_{2011} = 161(1.2003)^3$$

$$P_{2011} = 278.41 \text{ (in thousand)}$$

$$P_{2011} = 278417$$

3. Incremental Increase Method (or Method of Varying Increment)

- In this method, 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 future decade is found out by adding the mean arithmetic increase ($\bar{x}$) to be last known population as in arithmetic increase method and this is added to the average of the incremental increases $\bar{y}$. Once for the first decade, twice for the second decade, and so on.
- The population after n decades from present. (i.e., last known census) is given by

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

Where,

$\bar{x}$ = average increase of population of known decades

$\bar{y}$ =average of incremental increase of the known

This method will give results, somewhere between the result given by arithmetic increase method and geometric increase method and thus considered to be given quite satisfactory results.

Note: The geometric progression method, gives highest values of forecasted population. This method is suitable for new younger cities expanding at faster rate. For old cities, the arithmetic method may be better, although incremental method is considered to be the best for any city whether old or new.

Example 3

In a town, it has been decided to provide 200/per head per day in the 21st century. Estimate the domestic water requirements of this town in the year 2000 AD by projecting the population of the town by incremental increase method.

Year	1940	1950	1960	1970	1980
population	2379 8624	4697 8325	5478 6437	6346 7823	6907 7421

Solution

Year	Population	Increase in population	Increment over the increase, i.e. incremental increase.
1940	23798624	23179701	(-)15371589
1950	46978325	7808112	(+) 873274
1960	54786437	8681386	(-) 3071788
1970	63467823	5609598	
1980	69077421		
Total		45278797	(-)17570103

Average per decade

$$\bar{x} = 11319699$$

$$\bar{y} = \frac{17570103}{3}$$

$$\bar{y} = (-)5856701$$

Expected population at the end of year 2000 i.e,. after 2 decades from 1980

$$= p_o + 2_{\bar{x}} + \frac{2\times3}{2}\bar{y}$$

$$= 69077421 + 2\times11319699 - 3\times5856701$$

$$= 74146716$$

Water requirement in 2000 AD @ 200 // head/day

= 200 x 74146716 //day

= 14829 x 10^6 /day

4. The logistic Curve Method

This method was given by P.F. Verhulst. The population at any time t from the start is given by

$$P = \frac{p_s}{1 + m\log_e^{-1}(nt)}$$

P_s = saturation population

M= constant

5. Decreasing rate of growth

- This method is applicable only when the rate of growth shows a downward tread.
- Since the rate of increase in population go 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 quit 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 for each successive decade as explained in example blow

Example 4

The census record of a particular town shows the population figures as follows:

Year	Population
1960	55,500,
1970	63,700
1980	71,300
1990	79,500

Estimate the population for the year 2020 by decreasing rate growth.

Solution

The decreasing rate of growth method is as follows

Avg. Value of

Year	pop	Incr in pop.	% Incr in pop. (r)	Decr in	% increase (r^1)
1960	55,500				
		8200	14.77		
1970	63,700				2.84
		7600	11.93		
1980	71,300				0.43
		8200	11.5		
1990	79,500				

$$r' = \frac{2.84+0.43}{2} = 1.635$$

$$r = 11.5$$

$$P_{2000} = P_{1990} + \left(\frac{r - r'}{100}\right) \times P_{1990}$$

$$= 79,500 \pm \left(\frac{11.5-1.635}{100}\right) \times 79,500$$

$$= 87,343$$

$$P_{2010} = P_{2000} + \left(\frac{r - 2r'}{100}\right) \times P_{2000}$$

$$= 87,343 + \left(\frac{11.5 - 2\times1.635}{100}\right) \times 87,343$$

$$= 94.531$$

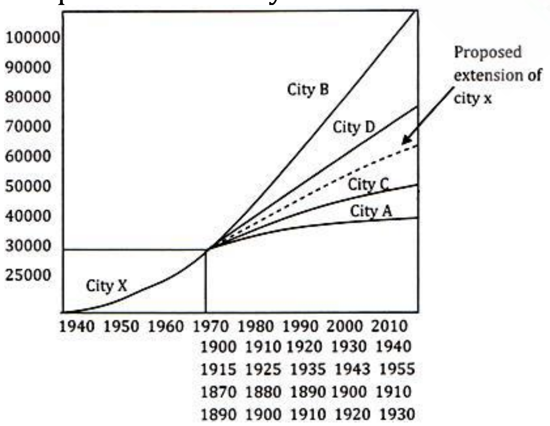
$$P_{2000} = P_{2010} + \left(\frac{r - 3r'}{100}\right) \times P_{2010}$$

$$= 94,531 + \left(\frac{11.5 - 3\times1.635}{100}\right) \times 94.531$$

= 1,00,765

The population for the year 2020 is **1,00,765**

6. **Comparative Graphical Method**
   Cities of similar conditions and characteristics are selected which have grown in similar fashion in the past as that of the city under consideration and their graph is plotted and then mean graph is also plotted. This method given quite satisfactory results.



1.4 WATER DEMANDS

Whenever an engineer is given the duty to design a water supply scheme for a particular section of the community, the first study is to consider the demand and then the second requirement is to find sources to fulfill that demand.

1.4.1 VARIOUS TYPES OF WATER DEMANDS ARE

Domestic Water Demand:
This includes the water required in private building for drinking, cooking, bathing, gardening purposes etc which may vary according to the living condition of the consumers.

- The total domestic water consumption usually amounts to 50 to 60% of the total water consumption.
- The IS code lays done a limit on domestic water consumption between 135 to 225 l/h/d.
- Under ordinary conditions (as per I.S. code) the minimum domestic water demand for a town with full flushing system should be taken at 200 l/h/d although it can be reduced to 135 l/h/d for economically weaker sections and LIG colonies (Low Income Group) depending upon prevailing conditions.

A) **Institutional and Commercial Water Demand:**
   On an average, a per capita demand of 20 l/h/d is usually considered to be enough to meet such commercial and institutional water requirements, although of course, this demand may be as high as 50 l/h/d for highly commercialized cities:
   The individual requirements would be as follows:
   i) **Schools/Colleges :** 45 to 135 lpcd
   ii) **Offices :** 45 lpcd
   iii) **Restaurants :** 70 lpcd
   iv) **Cinema and theater :** 15 lpcd
   v) **Hotels :** 180 lpcd
   vi) **Hospitals :** 340 lpcd (when beds is less than 100), & 450 lpcd (beds exceeding 100).

B) Industrial Water Demand:

The 'industrial water demand', represents the water demand of industries, which are either existing or likely to be started in the city for which water supply is being planned.

- This quantity will thus vary with the number and types of industries present in the city
- In industrial cities, the per capita water requirement may finally be computed to be as high as 450 l/h/d as compared to the normal industrial requirement of 50 l/h/d.

WATER DEMAND OF CERTAIN IMPORTANT INDUSTRIES (AS PER GOI MANUAL)

Name of Industry	Unit of Production	Approximate quantity of water required per unit of production
1. Automobile	Vehicle	40
2. Fertilizers	Tonne	80 – 200
3. Leather	Tonne (or 100 kg)	40 4
4. Paper	Tonne	200 – 400
5.Petroleum Refinery	Tonne (crude)	1 - 2
6. Sugar	Tonne(cane crushed)	1 – 2

C) Demand for Public Uses:

This includes water requirement for parks, gardening, washing of roads, etc. A nominal amount not exceeding 5% of the total consumption may be provided to meet this demand.

D) Fire Demand:

The quantity of water required foe extinguishing fire is not very large. For a total amount of water consumption for a city of 50 lakhs population hardly amounts to 1 lpcd of fire demand. But this water should be easily available and kept always stored in storage reservoirs.

Following requirements must be met for the fire demand.

- Three jet streams are simultaneously thrown from each hydrant; one on the burning property, and one each on either sides of the burning property. The discharge of each stream should be about 1100 l/min.
- The minimum water pressure available at fire hydrants should be of the order of 100 to 150 KN/m^2 (10 to 15 m of water head) and should be maintained even after 4 to 5 hours of constant use of fire hydrant.
- For cities having population exceeding 50,000, the water required in **kilo liters** may be computed by the formula of $100\sqrt{P}$, where P = population in thousands.
- Some other formulas (Kuichling's, freeman, National Board of fire Under Writers, Boston's Formula) are also used.

1) Kuichling's Formula

Q = $3182\sqrt{P}\ l/\min$.

Where, P = population in thousands

2) National Board of Fire Under Writers Formula

(a) For a central congested high valued city.

(i) When population is < or =2lakhs

$$Q = 4,637\sqrt{p}\left[1-0.01\sqrt{p}\right] l/\min.$$

Where P is in thousands

(ii)When population is > 2 lakhs, a provision for 54600 l/min. may be made with an extra additional provision of 9,100 to 36,400 l/min. for second fire.

Example 5

Compute the 'fire demand' for a city of 2 lack population by any formulae (including that of the National Board of Fire Underwriters).

Spolution

(i) The rate of fire demand as per National Board of fire Under Writers Formula for a central congested city whose population is < or = 2 lakhs is given by

$$Q = 4637\sqrt{P}\left[1-0.01\sqrt{P}\right]$$

$$Q = 4637\sqrt{200}\left[1-0.01\sqrt{200}\right]$$

$Q = 56303.08 l/\min.$

$= \frac{56303.08 \times 60 \times 24}{10^6} \text{MLD}$

$= 81.08 \text{MLD}$

(ii) Kuichling's formula

$Q = 3182\sqrt{P} = 3182\sqrt{200} l/\min.$

Q=45000.27l/min. = 64.8 MLD

- **Water Demand For Losses and Theft**
  This includes the water lost in leakage due to bad plumbing, stolen water due to bad plumbing, stolen water due to unauthorized water connections, and other losses and wastes.
- This amount may be as high as 15% of the total demand.

1.5 THE PER CAPITA DEMAND (q)

This is the annual average amount of daily water required by one person, and includes the domestic use, industrial and commercial use, public use, wastes, thefts etc.

Per capita Demand (q) in litres per day per head

= Total yearly water requirement of the city in liters/ (365 × Design of population)

1.6 FACTORS AFFECTING PER CAPITA DEMAND

(i) Size of the City: Demand increases with the size of the city.

- On an average, the per capita demand for Indian towns may vary with the population as shown below

Population	Per capita Demand (lpcd)
< 2000	110
20 to 50 thousands	110 – 150
50 to 200 thousands	150 – 240
2 lakhs to 5 lakhs	240 – 275
5 lakhs to 10 lakhs	275 – 335
> 10 lakhs	335 – 360

- The above figures are liable to variation up to above 25%.
- For Indian condition, I.S. Code permits maximum value of 335 lpcd.

(ii) Climatic condition

(iii) Type of Gentry and habit of people.

- Rich and Upper class communities generally consume more water due to their affluent living standards

(iv) Industrial and commercial activities

(v) Quality of water supply

(vi) Deelopment of Sewerage facilities

(vii) Cost of water and method charging

(viii) Pressure in the distribution system

Higher pressure in the distribution pipes ensure more water consumption

(ix) System of supply

- The water may be supplied either continuously or intermittently.
- The intermittent supplies, may lead to some saving in water consumption due to losses occurring for lesser time.

1.7 VARIATION IN DEMAND AND THEIR EFFECTS ON THE DESIGN OF VARIOUS COMPONENT OF A WATER SUPPLY SCHEME

- The smaller the town, the more variable is the demand. The shorter the period of draft, the greater is departure from the mean.
- The maximum demands (monthly , daily or hourly) are generally expressed as ratios of their means.

(i) Maximum Daily Consumption

Maximum daily consumption = 1.8 × Avg. daily consumption = 1.8 × q

(ii) Maximum hourly Consumption

Maximum hourly consumption of the maximum day i.e., Peak demand

= 1.5 × Avg hourly consumption of the maximum

= 1.5 × day

$\left[1.8 \times \frac{q}{24}\right] = 2.7\left[\frac{q}{24}\right]$

iii) Maximum Weekly Demand

Maximum weekly consumption = 1.48 × Avg weekly

iv) Maximum Monthly Demand

Maximum monthly consumption = 1.28 × Avg monthly

- Good-rich formula to find peak demand to an average demand ratio
  $P = 180 \times t^{-0.1}$
  Where P = percent of the annual average draft for the time 't' in days.

1.8 PEAK FACTOR

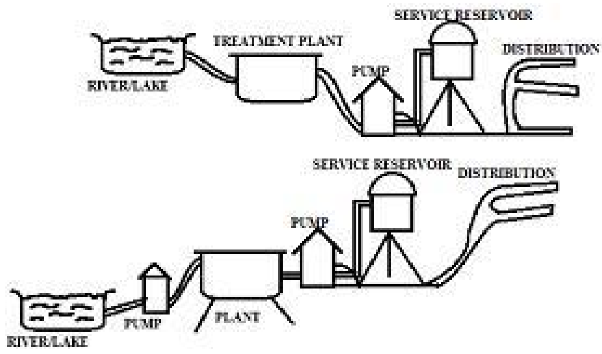
- The per capita rate of water supply indicates only the average consumption of water per day per person over a period of one year, however this season, months, day and hour.
- The fluctuation in consumption is accounted for, by considering the peak rate of consumption which is equal to average rate multiplied by a peak factor.
- The following peak factors are recommended for various population are
  i) Up to 50,000 …………………..3
  ii) 50,001 – 2,00,000…………2.5
  iii) Above 2 lakhs…………………2
  iv) For small water supply scheme…..3
  Note: As for as the design of distribution system is concerned, it is the hourly variation in consumption that matter.

1.9 COINCIDENT DRAFT

For general community purpose, the total draft is not taken as the sum of maximum hourly demand and fire-demand, but is taken as sum of maximum daily demand and fire demand or the maximum hourly demand, which every is more. The maximum daily demand (i.e., 1.8 × average daily demand) when added to the fire demand is known as the **coincident draft.**

1.10 DESIGN CAPACITY OF VARIOUS COMPONENTS OF WATER SUPPLY SCHEME

The various components of water supply scheme as shown in figure below



The following recommendations may be adopted for designing the capacities of different components, of a water supply scheme.

1. The sources of supply (such as wells) may be designed for maximum daily consumption or sometimes for average daily consumption.
2. The pipe mains (to take from source to service reservoir), filter and other treatment unit are designed for maximum daily draft.
3. The pumps may be design for maximum daily draft plus some additional reserve for break down and repair.
4. The distribution system (to carry water from service reservoir to water tamps) should be designed for maximum hourly draft of maximum day or coincident draft with fire, whichever is more.
5. The service reservoir is designed to take care of hourly fluctuations; fire demands and emergency reserves.

GATE QUESTIONS

1 WATER DEMAND

Q.1 The present population of a community is 28000 with an average water consumption of 4200 m^3 /d. The existing water treatment plants has a design capacity of 6000 m^3/d. It is expected that the population will increase to 44000 during the next 20 years .the number of years from now when the plant will reach its design capacity, assuming an arithmetic rate of population growth, will be

a) 5.5 years b) 8.6 years
c) 15.0 years d) 16.5 years

[GATE-2004]

Q.2 A conventional flow duration curve is a plot between

a) Flow and percentage time flow is exceeded
b) Duration of flooding and & ground level elevation
c) Duration of water supply in a city and proportion of area receiving supply exceeding this duration
d) Flow rate and duration of time taken to empty a reservoir at that flow rate

[GATE-2014]

ANSWER KEY:

1	2
(c)	(a)

EXPLANATIONS

Q.1 **(c)**

P_0 = 28,000

Average increase per decade, $\ddot{x}$ = $\frac{44,000-28,000}{2}$ = 8,000

4200m^{3}r required for 28,000 persons

6000m^{3}r sufficient for persons

= $\frac{28000 \times 6000}{4200}$ = 40,000

$P_n = P_0 + n\ddot{x}$

40,000 = 28,000 + n.8,000

n = 1.5 decades

= 15 years

Q.2 **(a)**

2 QUALITY CONTROL OF WATER SUPPLIES

Q.1 Use of coagulants such as alum
a) results in reduction of pH of the treated water.
b) results in increase of pH of the treated water.
c) results in no change in pH of the treated water.
d) may cause and increase or decrease of pH of the treated water
[GATE-2000]

Q.2 Aeration of water is done to remove
a) Suspended Impurities
b) Color
c) Dissolved Salts
d) Dissolve Gases
[GATE-2001]

Q.3 The Ca^{2+} concentration and Mg^{2+} concentration of a water sample are 160 mg/lit and 40 mg/lit as their ions respectively. The total hardness of this water sample in terms of $CaCo_2$ in mg/lit is a approximately equation equal to
a) 120 b) 200
c) 267 d) 567
[GATE-2001]

Q.4 The following chemical is used for coagulation
a) Ammonium Chloride
b) Aluminium Chloride
c) Aluminium Sulphate
d) Copper Sulphate
[GATE-2001]

Q.5 The theoretical oxygen demand of a 0.001 mol/L glucose solution is
a) 180 mg/L b) 192mg/L
c) 90 mg/L d) 96 mg/L
[GATE-2002]

Q.6 In natural water, hardness is mainly caused by
a) Ca^{++} and Mn^{++} b) Ca^{++} and Fe^{++}
c) Na^{+} and K^{+} d) Ca^{++} and Mg^{++}
[GATE-2002]

Common data for Que. 7 & 8:
A water treatment plant treating 10mld of water requires 20 mg/l of filter Alum, $Al_2(SO_4)_3$ $18h_2O$. The water has 6 mg/l of alkalinity as $CaCO_3$ (Al = 26.97, S = 32, O = 16, H = 1, Ca = 40, and C = 12)

Q.7 Total alkalinity requirement (10^6 mg per day as $CaCO_3$) matching filter Alum, shall be
a) 180 b) 120
c) 90 d) 60
[GATE-2003]

Q.8 Quantity of Quick lime required (10^6 mg per year as year as CaO) shall b
a) 2132 b) 3000
c) 4132 d) 6132
[GATE-2003]

Q.9 The results of analysis of a raw water sample are given below

Turbidity	5 mg/1
pH	7.4
Fluorides	2.5 mg/1
Total Hardness	300 mg/1
Iron	3.0 mg/1
MPN	50 per 100 ml

From the data given above, it can be inferred that water needs removal of
a) Turbidity followed by disinfection
b) Fluorides and Hardness
c) Iron, followed by disinfection
d) Both (b) and (c)
[GATE-2003]

Q.10 Results of a water sample analysis are as follows:

Cation	Concentration (mg/1)	Equivalent Weight
Na^{+}	40	23
Mg^{+}	10	12.2
Ca^{+2}	55	20
$-K^{+}$	2	39

EXPLANATIONS

Q.1 (a)

Q.2 (d)

Q.3 (d)

T.H. = $C_a^{++} \times \frac{50}{20} + Mg^{++} \times \frac{50}{12}$

T.H. = $160 \times \frac{50}{20} + 40 \times \frac{50}{12}$

T.H. = 567

Q.4 (c)

Q.5 (b)

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

180 part of glucose demand 192 part of O_2=0.001 × 180 × 1000 = 180

0.001 moles/lit of glucose means 180mg/lit

$$\left\{\frac{mg}{lit} = \frac{moles}{lit} \times md.wt. \times 1000\right\}$$

Q.6 (d)

Q.7 (c)

Q = 10MLD = 10 × 10^6 Lit/day

Alum = 20 mg/Lit

1 mg of Alum requires 0.45 mg of Alkaline as $caco_3$

∴ 20 mg/Lit of alum requires

= 20 × 0.45 = 9 mg of alkaline as $caco_3$ per Lt of water

∴ Total alkalinity matching filter

Alum = 9 mg/Lit = 10 × 10^6 Lit/day= 90 × 10^6

Total alkalinity requirement (10^6 mg per day) = 90

Q.8 (d)

Natural available alkalinity = 6 mg/Lit

∴ Alkalinity to be added additionally

= 9 – 6 = 3 mg/Lit

∴ Alkaline to be added to the water

= 3 × 0.56 = 1.68 mg/Lit

Total quick lime required per year =

$$\frac{1.68 \times 10 \times 10^6 \times 365}{10^6}$$

Total quick lime required (10^6 mg per year) = 6132

Q.9 (d)

Q.10 (c)

TH = $Ca^{++} \times \frac{50}{20} + Mg^{++} \times \frac{50}{12}$

= $55 \times \frac{50}{20} + 10 \times \frac{50}{12}$

= 179 mg/lt

Q.11 (b)

Q.12 (a)

Q.13 (b)

Q.14 (d)

Positive combination: 4 – 3 – 1

MPN from the table = 33

Correct MPN = $\frac{\text{MPN value from the table}}{\text{Largest volume tested}} \times 100$

= 33 × 10 = 330

Q.15 (a)

All of these are pipe appurtenances which are required for the proper functioning of the pipeline.

Q.16 (c)

Q.17 (b)

The sum total of organic nitrogen and ammonia nitrogen is called Kjeldahl nitrogen.

Q.18 (d)

ASSIGNMENT QUESTIONS

Q.1 The multiplying factor, as applied to obtain the maximum daily water demand, in relation to the average i.e. per capita daily demand, is
a) 1.5 b) 1.8
c) 2.0 d) 2.7

Q.2 If the average daily water consumption of a city is 24000 cum, the peak hourly demand (of the maximum day) will be
a) 1000 cum/hr b) 1500 cum/hr
c) 1800 cum/hr d) 2700 cum/hr

Q.3 As compared to the geometrical increase method of forecasting population, the arithmetical increase method gives
a) lesser value
b) higher value
c) equal value
d) may vary as it may depend on the population figures

Q. 4 The growth of population can be conveniently represented by a curve, which is amenable to mathematical solution. The type of this curve is
a) semilog curve
b) straight line curve
c) logistic curve
d) exponential curve

Q.5 The total water consumption per capita per day, including domestic, commercial, and industrial demands, for an average Indian city, as per IS code, may be taken as
a) 135 l/c/d b) 210 l/c/d
c) 240 l/c/d d) 270 l/c/d

Q. 6 The population figures in a growing town are as follows:

Year	Population
1970	40,000
1980	46,000
1990	53,000
2000	58,000

The predicted population in 2010 by arithmetic regression method is
a) 62,000 b) 63,000
c) 64,000 d) 65,000

Q.7 The domestic use of water amounts to _______________ of the total water requirements per capita per day
a) 40% b) 50%
c) 20% d) 30%

Q.8 Freeman's formula for estimating the fire demand (Q) in l.p.m. is given by
a) $Q=1136\left(\frac{P}{10}+10\right)$
b) $Q=2500\left(\frac{P}{5}+10\right)$
c) $Q=2715\sqrt{P}$
d) $Q=3715\sqrt{P}$
P = population in thousands

Q.9 Which one of the following methods gives the best estimate of population growth of a community with limited land area for future expansion?
a) Arithmetical increase method
b) Geometrical increase method
c) Incremental increase method
d) Logistic method

Q.10 The formula, which is most appropriate for the design of pressure pipes is
a) Darcy Weisbach formula
b) Mannings formula
c) Chezy's formula
d) Dupuit's formula

Q.11 The internal pressure, to which a water supply pipe is subjected to, is
a) full hydrostatic pressure when water in the pipe is at rest
b) pressure head and velocity head in the pipe, when flow at full velocity is taking place
c) a + water hammer pressure
d) b + water hammer pressure

Q.12 The valve, which allows the flow only in one direction, is a
a) reflux valve b) sluice valve
c) gate valve d) None of these

Q.13 The valve, which is provided in the water distributing pipes at street corners and pipe junctions to control the flow in the distribution system, is
a) an air valve b) a sluice valve
c) a scour valve d) a reflux valve

Q.14 Scour valves are provided
a) at the street corners to control the flow
b) at the dead ends to drain out the wastewater
c) at every summit of the rising main
d) at the foot of the rising main along the slope, to prevent back running of water

Q.15 Cast iron pipes having plain ends, are joined by a joint, called
a) flanged joint
b) spigot and socket joint
c) dresser coupling
d) None of these

Q.16 Consider the following statements:
The basic difference between water pipes and sewer pipes is
1. In the material used for the pipes
2. In the pressure of the liquid flow
3. In the suspended solids they carry
Which of these statements is/are correct?
a) 1 and 3 b) 1 only
c) 2 and 3 d) 1, 2 and 3

Q.17 By using economical diameter of water mains, the benefit obtained is in terms of
a) minimum pumping cost
b) use of cheapest pipe
c) minimum cost of pipe and pumping
d) none of the above benefit is attained

Q.18 Consider the following pairs:
1. Darcy Weisbach Equation...... $V=C\sqrt{RS}$
2. Manning's Equation ......$V = \frac{1}{n}R^{2/3}S^{1/2}$
3. Hazen's William Equation........ $V = kCR^{0.63}S^{0.54}$
4. Chezy's Equation................ $\frac{h_f}{L}=\frac{f}{d}\left(\frac{V^2}{2g}\right)$
Which of these pairs are correct?
a) 1 and 2 b) 2 and 3
c) 3 and 4 d) 1 and 4

Q.19 The threshold odour number (TON) for a water sample of 40 ml, diluted to standard 200 ml mixture, in which odour is just barely detectable to the sense of smell, is
a) 8 b) 5
c) 50 d) None of these

Q.20 Water is considered 'hard', if its hardness is of the order of
a) 50 ppm b) 100 ppm
c) 200 ppm d) 300 ppm

Q.21 Electrical conductivity (EC) of water and total dissolved solids (TDS) are interrelated. The value of EC will
a) decreases with increase in TDS
b) increases with increase in TDS
c) decreases initially and then increase with increase in TDS

EXPLANATIONS

Q. 1 (b)

Maximum daily demand = 1.8 × Average daily demand

Maximum hourly demand = 1.5 × Maximum daily demand

Q.2 (d)

Maximum hourly consumption of the maximum day i.e. peak demand

$= 1.5\times\left(\frac{1.8q}{24}\right)$

$= 2.7\times\frac{24000}{24} = 2700$ cum/hr

Q.3 (a)

In geometric increase method compounding is done every decade unlike in arithmetic increase method. Thus geometrical increase method gives higher value than the arithmetic increase method.

Q.4 (c)

Equation of logistic curve is given by

$\ln\left[\frac{P_s\text{-}P}{P_s\text{-}P_0}\right]=\text{-}kP_st$

where, P_0 = the population at the start pt. of the curve A

P_s = Saturation population

P = Population at any time t from the origin A

K = Constant

Q.5 (d)

Break up of per capita demand (q) for an average

Indian city

Use	Demand in *l*/h/d
Domestic use	200
Industrial use	50
Commercial use	20
Civil or public use	10
Wastes & thefts etc	55
Total = 335 = per capita demand (q)	

Q. 6 (c)

Year	Population	Decadal increase
1970	40,000	
1980	46,000	6000
1990	53,000	7000
2000	58,000	5000

∴ Design growth rate,

$= \frac{6000+7000+5000}{3}$

= 6000 per decade

In 2010 population will be

P = 58000 + 6000 = 64000

Q. 7 (b)

Total domestic water consumption usually amounts to 50 – 60% of the total water consumption.

Q.8 (a)

Freeman's formula

$\Rightarrow Q = 1136\left(\frac{P}{10}+10\right)$

Kuichling formula

$\Rightarrow Q = 3182\sqrt{P}$

P = Population in thousands

Q.9 (d)

Since the area is limited and there is estimation, therefore logistic curve method will be the best.

Q.10 (a)

Darcy-Weisbach formula is used to compute head loss in certain section of a pipe length.

$H_t=\frac{flv^2}{2gd}$

Q. 11 (c)

The internal pressure within a pipe is caused by the water head to which the pipe can be subjected and the additional transient pressures. The maximum internal pressure under worst circumstances is sum of full static pressure and the water hammer pressure

Q.12 (a)
Check values or Reflux valves: Check valves are sometimes called non-return valves because they prevent water to flow back in the opposite direction. They may be installed on the delivery side of the pumping set, so as to prevent the back flow of stored or pumped water, when the pump is stopped.

Q.13 (a)
Sluice valves are used to regulate the flow of water through the pipes. They are usually placed at the summits.

Q.14 (b)
In order to remove the entire water from within a pipe (after closing the supply), small gated off-takes are provided at low points. These valves are known as blow off valves or drain valves or scour valves. These valves, are necessary at low level points for completely emptying the pipe for inspection, repairs, etc.

Q.15 (c)
This type of a joint is used when it is required to join the plain ends of cast iron pipes. The joints are strong and rigid. They can withstand vibrations and are, therefore, useful for pipes to be carried over bridges or below bridges in hangers.

Q.16 (c)
Cast iron pipes can be used for both water pipes and sewer pipes. However the basic difference is pressure flow in water pipe and suspended solids carried in sewage.

Q.17 (c)
If diameter > Economical dia
- Less cost of Pumping
- High cost of pipe material

If diameter < economical dia
- Less cost of pipe material
- High cost of pumping

Q.18 (b)
Darcy Weishbach Equation,

$$\frac{h_f}{L} = \frac{f}{d}\left(\frac{V^2}{2g}\right)$$

Chezy's equation, V = $C\sqrt{RS}$

Q.19 (b)
Threshold odour number represents the dilution ratio at which the odour is hardly detectable

$$\text{TON} = \frac{200}{40} = 5$$

Q.20 (c)
Water with hardness upto 75 ppm are considered soft while those with 200 ppm and above are considered hard. In between the waters are considered as moderately hard.

Q.2 (b)
An approximate analysis for TDS is often made by determining the electrical conductivity of the water. The ability of water to conduct electricity is called specific conductance and it is a function of its ionic strength. Unfortunately, specific conductance and concentration of TDS are not related on a one to one basis. Only ionized substances contribute to specific conductance. Organic molecules and compounds that dissolve without ionizing are not measured. Additionally, the magnitude of specific conductance is influenced by the valence of the ions in the solution, their mobility and their relative numbers. The temperature