ECG Publications

AS PER NEW SYLLABUS

2019

GATE

Graduate Aptitude Test in Engineering

Civil Engineering

Environmental Engineering

Includes

Detailed Theory
Solved Workbook
Practice Assignments
Previous Year Questions
With Chapter Wise Solutions
And much more ...

ENGINEERS CAREER GROUP™

GATE

2019

ENVIRONMENTAL ENGINEERING

CIVIL ENGINEERING

ECG Publications

ECG Publications

A Unit of **ENGINEERS CAREER GROUP**

Head O ce: S.C.O-121-122-123, 2nd Floor, Sector-34/A, Chandigarh-160022

Website: www.engineerscareergroup.in **Toll Free:** 1800-270-4242

E-Mail: ecgpublica ons@gmail.com | info@engineerscareergroup.in

ESE-2019: Environmental Engineering | Detailed theory with GATE & ESE previous year papers and detailed solu ons.

First Edi on: 2016

Price of Book: *INR 650/-*

ECG PUBLICATIONS (A Unit of ENGINEERS CAREER GROUP) collected and proving data like: theory for di erent topics or previous year solu ons very carefully while publishing this book. If in any case inaccuracy or prin ng error may nd or occurred then **ECG PUBLICATIONS** (A Unit of ENGINEERS CAREER GROUP) owes no responsibility. The sugges ons for inaccuracies or prin ng error will always be welcome by us.

CONTENTS

CHAPTER - 1
QUALITY PARAMETERS OF WATER

1.1 INTRODUCTION
Water impurities are classified as physical, chemical and biological impurities.

1.2 PHYSICAL WATER QUALITY PARAMETER
1. Suspended solids
2. Turbidity
3. Colour
4. Taste and odour
5. Temperature

1.2.1 Suspended Solids
1. Source

These are called as physical parameters where as dissolved solids are considered as chemical parameters. SS comes from inorganic particles like silt, clay etc. immiscible liquids like oils and greases and organic particles like plant fibre, algae, etc. Inorganic solids are non-degradable solids.

> Problem of SS comes only in surface water not in ground water.

2. Objection

These are objectionable because
(i) Aesthetically displeasing,
(ii) It provides adsorption sites for chemical and biological agents
(iii) They may also be biologically active and may form disease causing organisms as well as organisms such as toxin producing strains of algae.

3. Measurement

(i) Most of the methods are gravimetric i.e. SS are calculated by weighing them.
(ii) Total solids i.e. all solids (suspended or dissolved), are calculated by evaporating the sample and measuring the residue. Heating temperature is 104°C.
(iii) Suspended solid is obtained by filtration and heating the residue on filter at 104°C
Dissolved solids (DS) = Total solids (TS) - Suspended solids (SS)

> Filtration in real terms does not exactly divides the solids into suspended and dissolved fractions because some. colloids may pass through the filter and car, get measured along with dissolved fraction. Hence, classification is done as filterable and non-filterable solids, Hence suspended solids are corresponding to non-filterable solids and dissolved solids are corresponding to filterable solids.

WORKBOOK

Example 1. Water contains 210 gm of CO_3^{2-}, 122 gm of HCO_3^- and 68 gm of OH^- what is the total alkalinity of water expressed as $CaCO_3^-$.

Solution.

210 gm CO_3^{2-} will have

$$= \frac{210}{60/2} = \frac{210}{30} = 7\text{gm equivalent.}$$

$\therefore$ 7 gm equivalent of CO_3^{2-} = 7 gm equivalent of $CaCO_3$

122 mg of HCO_3^- will have = $\frac{122}{61/1} = 2\text{gm}$ equivalent of HCO_3^-

$\therefore$ 2g equivalent of HCO_3^- = 2 gm equivalent of $CaCO_3$

68 gm of OH^- will have = $\frac{68}{17/1} = 4\text{gm}$ equivalent of OH^-

$\therefore$ 4gm equivalent of OH^- = 4 gm equivalent of $CaCO_3$

$\therefore$ Total alkalinity of water = 7 + 2 + 4 = 13 gm equivalent of $CaCO_3$

$\therefore$ Weight in gm of $CaCO_3$ = $\frac{100}{2}\times 13$ = 650 gm of $CaCO_3$

$\therefore$ Total alkalinity of water = 650 gm expressed as $CaCO_3$.

Example 2. A 200 ml of sample of water has initial pH of 10.30 ml of 0.02 N H_2SO_4 is required to titrate the sample to pH = 4.5. What is the total alkalinity of water in mg/ℓ s $CaCO_3$?

Solution.

30 ml of 0.02 N H_2SO_4 is required to reduce the pH upto 4.5.

$\therefore$ Total alkalinity of 200 ml of water sample = 30 mg as $CaCO_3$

$\therefore$ Total alkalinity of water in mg/ℓ =

$$30\times\frac{1000}{200} = 150\text{mg}\ell \text{ as } CaCO_3$$

Example 3.

Size of Sample (mℓ)	Number of +ve	Number of –ve
1	4	1
0.1	3	2
0.01	2	3
0.001	0	5

Determine the MPN using the Thomas equation

Solution.

Number of the tube = 4 + 3 + 2 = 9

mℓ of sample in –ve tube = 1 × 1 + 2 × 0.1 + 3 × 0.01 + 5 × 0.001 = 1.235ml of space in all tube = 5 × 1 + 5 × 0 .1 + 0.01 × 5 + 0.001 × 5 = 5.555

$$\text{MPN}/100\text{m}\ell = \frac{9\times 100}{\sqrt{1.235\times 5.555}} = 344$$

Example 4. Determine the most probable number of coliforms. A standard multiple fermentation test is run on a sample of water from a surface stream. The results of the analysis for the confirmed test are shown below.

Size of sample Mℓ	No. of positive	No. of negative
10	4	1
1	2	3
0.1	1	4
0.01	0	5

Determine the MPN of coliform organisms.

Table: MPN index and 95% confidence limits for various combination of positive results when 5 tubes are used per dilution (10 mL, 1 mL, 0.1mℓ)

Combination of positive	MPN index /100 mℓ	95% confidence limit	
		Lower	Upper
2-1-0	7	1	17
4-2-1	26	9	78

CHAPTER - 2
WATER DEMAND, ITS SOURCE & CONVEYANCE

2.1 INTRODUCTION
To design a water supply scheme, we must first estimate the population for which the scheme should be designed. The scheme once installed must cater for the demand of projected population upto some predetermined future date.

2.2 DESIGN PERIODS
1. A water supply scheme includes huge and costly structures (such as dams, reservoirs) which cannot be replaced or 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.
2. 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.
3. 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.
The design period recommended by the GOI manual on water supply, for designing the various components of a water supply project are as given below.

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

2.3 POPULATION FORECASTING
Water demand is assessed on the basis of future population. The future population is assessed as discussed below.

2.3.1 Population Growth
There are three main factors responsible for changes in populations
1. Births
2. Deaths
3. Migrations

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

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

1. Ionic Layer Compression

The quantity of ions in water surrounding a colloid has an effect on reducing the repulsive force.
A high ion concentration compresses the layer composed predominantly of (+ve) charge ions towards the surface of colloid. If this layer is sufficiently compressed then attractive forces (Vanderwaal force) will be predominant. Thus the particles will collese and will grow in size. Thus they will be removed in the sedimentation tank.

2. Adsorption and Charge Neutralisation

Nature rather than quantity of ion is of prime importance in the theory of adsorption and charge neutralisation. If Alum is added in water, it will form Al^{3+} and SO_4^{2-}. The sulphate ion (SO_4^{2-}) may remain in this form or may combined with other cations like Na^+, Mg^{2+}.
However $A1_3^+$ ion will react immediately with water to form various aquametallic cations like. $A1(OH)^{2+}$, $A1(OH_2)^+$, $Al_7(OH)_{17}^{4+}$, $A1(OH)_3 \downarrow H^+$.
These cations surrounds the clouds of (–ve) charge and as they have an affinity for surface, they are adsorbed on to the surface, thereby neutralising the surface charge.
Once the charge is neutralise, free contact can occur. Thus size increases and settling takes place:

Overdosing may lead to net (+ve) charge which will again result in suspension

3. Sweep Coagulation

The aluminium hydroxide ($A1(OH)_3$) formed when alum is added to water is a amorphous (shapeless) and gelatinous (sticky) ppt. These are heavier than water is settles down by gravity. Colloids may become entrapped in the flocs as the flocs settle down. This process by which colloids are swept away from the system in this manner is called sweep coagulation.

4. Inter Particle Bridging

Large molecules may be formed when Al or ferric sulphate dissociate in water (like $Al_7(OH)_{17}^{1+}$).
Several colloids may become attached to one molecule or various molecules may get enmeshed resulting in settleable mass.
Polymers may also be used either alone or in combination with alum or iron salts.

3.4.2 Common Coagulants added in Water

1. Alum
2. Copperas
3. Chlorinated copperas
4. Sodium aluminate
5. Lime

1. Alum

Chemical formula of Alum is $A1_2(SO_4)_3.\ 18H_2O$.
(i) Alum reacts with HCO_3 alkalinity to form gelatinous precipitate of $A1(OH)_3$.
(ii) This attracts other fine particles and suspended matter, thus grow in size and finally settle.
(iii) $$Al_2(SO_4)_3.18H_2O + 3Ca(HCO_3)_2 \rightarrow \underset{\substack{\text{Permanent}\\ \text{Hardness}}}{3CaSO_4} + \underset{\text{ppt.}}{2Al(OH)_3 \downarrow} + 6CO_2 \uparrow + 18H_2O$$

GATE QUESTIONS

1. A rapid sand filter comprising a number of filter beds is required to produce 99 MLD of potable water. Consider water loss during backwashing as 5%, rate of filtration as 6.0 m/h and length to width ratio of filter bed as 1.35. The width of each filter bed is to be kept equal to 5.2 m. One additional filter bed is to be provided to take care of break-down repair and maintenance. The total number of filter beds required will be

[GATE - 2018]

(a) 19 (b) 20
(c) 21 (d) 22

2. A flocculation contains 1800 m^3 of water, which is mixed using paddles at an average velocity gradient G of 100/s. The water temperature and the corresponding dynamic viscosity are 30°C and 0.798×10^{-3} Ns/m^3, respectively. The theoretical power required to achieve the stated value of G (in kW, up to two decimal places) is ___________

[GATE - 2018]

3. At a small water treatment plant which has 4 Filters, the rates of filtration and backwashing are 200 $m^3/d/m^2$ and 1000 $m^3/d/m^2$, respectively. Backwashing is done for 15 min per day. The maturation, which occurs initially as the filter is put back into service after cleaning takes 30 min. it is proposed to recover the water being wasted during backwashing and maturation. The percentage increase in the filtered water produced (up to two decimal places) would be ________

[GATE - 2018]

4. The spherical grit particles, having a radius of 0.01 mm and specific gravity of 3.0 need to be separated in a settling chamber. It is given that

(i) g = 9.81 m/s^2
(ii) The density of the liquid in the settling chamber = 1000 kg/m^3
(iii) The kinematic viscosity of the liquid in the settling chamber = 10^{-6} m^2/s

Assuming laminar conditions, the settlling velocity (in mm/s, up to one decimal place) is _________.

[GATE - 2017]

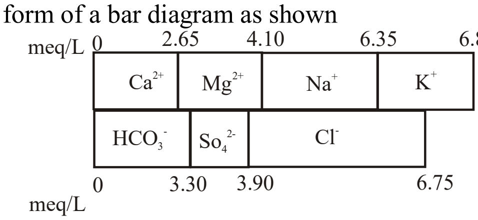
5. A municipal corporation is required to treat 1000 m^3/day of water. If is found that an overflow rate of 20m/day will produce a satisfactory removal of the discrete suspended particles at a depth of 3m. The diameter (in meters, rounded to the nearest integer) of a circular settling tank designed for the removal of these particles would be ________.

[GATE - 2017]

6. Effluent from an industry 'A' has a pH of 4.2. The effluent from another industry 'B' has double the hydroxyl (OH^-) ion concentration than the effluent from industry 'A'. pH of effluent from the industry 'B' will be _____.

[GATE - 2016]

7. A sample of water has been analysed for common ions and results are presented in the form of a bar diagram as shown



The non- carbonate hardness (expressed in mg/L as $CaCO_3$) of the sample is

[GATE - 2016]

(a) 40 (b) 165
(c) 195 (d) 205

8. The hardness of a ground water sample was found to be 420mg/L as $CaCO_3$. A softener containing ion exchange resins was installed t reduce the total hardness to 75mg/L as $CaCO_3$ before supplying to 4 households. Each

CHAPTER - 4
DISTRIBUTION SYSTEM

4.1 METHODS OF DISTRIBUTION

Water is forced in the distribution system by following ways:
1. Gravitational system
2. Direct pumping
3. Combined system

4.1.1 Gravitational System

In this system, water from high level source is distributed at lower levels by simple action of without pumping.
This system works well where lakes are, available at the top of a hill.

4.1.2 Direct Pumping

1. In the direct pumping system, the treated water, instead of pumping to the service or distribution reservoir, is directly pumped to the distribution mains.
2. Since water demand varies, pumps are required to be run at variable speed to meet water requirement at different time periods.
3. Due - to variable speed, the pumps do not work at their maximum efficiency, hence, the system is not so economical.

4.1.3 Combined System

1. In this system of water supply, pumping and gravity system is combined.
2. The treated water is pumped and stored in an elevated distribution reservoir or tank and distribution tank, it is fed to the distribution system by the action of gravity.
3. Pump works at constant and convenient schedule and the pressure can be maintained uniformly during the supply.

4.1.4 System of Supply

There are two system of supply of water:
1. Continuous supply: In continuous supply water is supplied continuously to the consumers.
2. Intermittent supply: In the intermittent supply, water is supplied mostly at peak hours or if the shortage of there then the whole distribution area is divided into different zones and water is supplied to the different zones at different fixed timings.

4.2 LAYOUTS OF DISTRIBUTION SYSTEM

1. The distribution pipe system consists of mains, submains, branches, laterals and finally service connections.
2. Pipes, except the service connections, are usually made of cast iron with some type of coating to avoid rusting where as for service connections galvanised cast iron pipes are used.
3. Distribution pipe are mostly laid along the road below the footpath. Depending upon local conditions and orientation of roads, any of the following pattern of layouts is adopted singly or in combination.
(i) Dead end or tree system.
(ii) Grid system or reticular system.
(iii) Ring or circular system.
(iv) Radial system

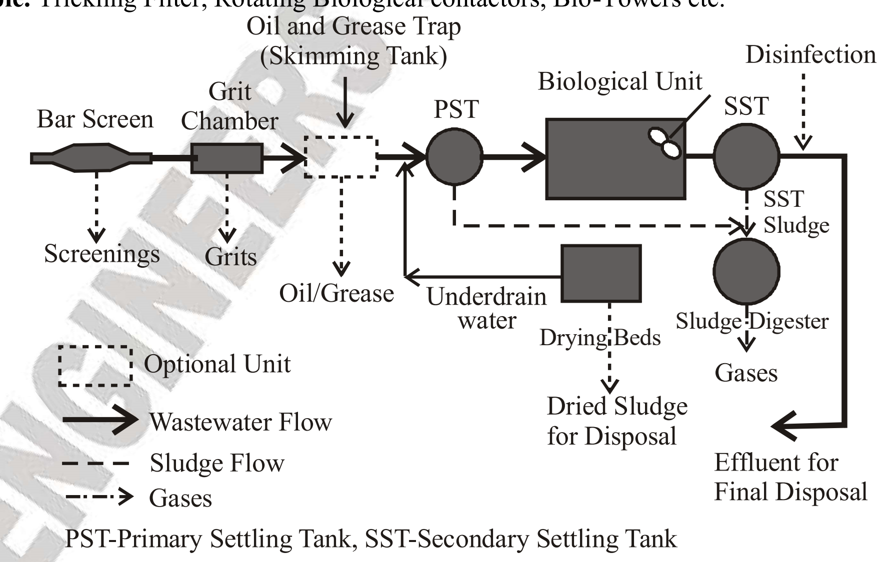
CHAPTER - 5
SEWAGE TREATMENT

5.1 INTRODUCTION
Wastewater can be defined as any water or liquid that contains impurities or pollutants in the form of solids, liquid or gases or their combinations in such a concentration that is harmful if disposed into the environment.

5.1.1 Treatment Method
Usually, Physical, Chemical or Biological, means are applied for wastewater to carry out specific function on the principles of either one or a combination of the means employed. Based on the means used, treatment methods have been broadly classified as unit operations and unit processes.

5.1.2 Unit Operations
The means of treatment in which the application of physical forces predominates are known as unit operations. Major treatment methods falling under this category are screening, mixing, sedimentation, etc.

5.1.3 Unit Process
The types of treatment in which the removal of contaminants is brought about by the addition of chemicals or the use of biological mass or microbial activities are known as unit process. Based on the Type of agent used biological unit process are
1. Suspended growth process
Example. Activated Sludge Process, Aerated Lagoon, Oxidation Pond, Aerobic & Anaerobic Digester etc.
2. Attached growth process
Example. Trickling Filter, Rotating Biological contactors, Bio-Towers etc.



Schematic flow diagram of a typical conventional treatment plant

CHAPTER - 6
SOLID WASTE MANAGEMENT

6.1 INTRODUCTION
1. Solid wastes are the total wastes arising from human and animal activities that are normally solid and hence are useless or unwanted.
2. It encompasses the heterogeneous mass of throw away from houses of commercial centres as well as the nearby homogeneous accumulation of a single industrial activity.
3. Refuse represents the dry wastes or solid wastes of the society.
4. The term ‘refuse’ is often used interchangeably with term solid wastes.
5. The density of Indian refuse is generally higher than that of the developed countries and hence the Indian refuse can be carried efficiently and economically by mechanical transport (carrying more wt. for the same volume).
6. The calorific value of Indian refuse is much smaller, and its moisture content is high.

6.2 TYPES OF SOLID WASTES
Major categories of solid waste generation are :
1. Municipal wastes
2. Industrial wastes
3. Hazardous wastes

6.2.1 Municipal Wastes
1. Solid wastes generated from different zones of the city differ in characteristics. There solid wastes comprise refuse, ordinary refuse (includes garbage & rubbish) and trash.
2. Refuse, refers to nonhazardous solid waste from the community requiring collection and transporting to processing/disposal site.
3. Garbage comprises items that are highly decomposable (putrescible) food, waste vegetables and meat scraps.
4. Rubbish contains mostly dry, nondecomposable (nonputrescible) material - glass, rubber, tin cans, also, or combustible material - paper, textile, wooden articles, etc.
5. Hence, community refuse can be referred to as municipal solid waste (MSW).

6.2.2 Industrial Wastes
1. Industrial wastes are generated from the industrial activities or manufacturing processes.
2. All the three types of wastes, solid, liquid and gaseous are generated
3. Industrial wastes can be categorised as non-hazardous and hazardous. It is well known that hazardous wastes have a potential for very deleterious impact on environment and life in general.
4. Some of the common industries which generate solid waste along with other wastes on a large scale are : (i) Paper and pulp (ii) Metallurgical industries (iii) Pesticides/Insecticides (iv) Fertilizers (v) Plastics (vi) Refineries

6.2.3 Hazardous Wastes
1. Hazardous substance can he defined as anything which because of its quantity, concentration or characteristics may contribute to increased mortality, illness or hazard to human health and environment if not properly stored and transported or disposed off

WORKBOOK

Example 1. Convert 120 mg/m^3 of SO_2 concentration into ppm.

Solution.

We know that all gas at 0^oC and atmospheric pressure occupies 22.4 litre/mole. (i.e. at STP (Standard Temp. and Pressure)

$V_1 = 22.4$ litre

Volume at $T^oC = V_2$

Now $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ [From gas law, (temperature is in Kelvin)]

But pressure is always atmospheric

$$\Rightarrow V_2 = \frac{V_1(T_2)}{T_1} = \frac{V_1(273+T)}{273}$$

$$1\text{ppm}\,SO_2 = \frac{1m^3 \text{ of } SO_2}{10^6 m^3 \text{ of air}}$$

Molecular wt of $SO_2 = 64$

$\Rightarrow$ 64 g of SO_2 occupies V_2 litre at T^oC

$1m^3$ of SO_4 will have $\frac{64000\,\text{mg}}{V_2} \times 1000$

$\Rightarrow$ 1 ppm SO_2 at T^oC

$$= \frac{64 \times 10^6 \text{ mg}}{V_2 \times 10^6 m^3 \text{ of air}} = \frac{64}{V_2} \text{mg/m}^3 \text{ of air}$$

$\Rightarrow$ 1ppm at T^oC

$$= \left[\frac{\text{Molecular wt}}{(\text{Volume of } T^oC \text{ in litre/mole})}\right] \frac{\text{mg}}{m^3 \text{ of air}}$$

$$\Rightarrow \frac{1\text{mg}}{m^3} \text{ of } SO_2$$

$$= \left(\frac{\text{Volume } T^oC \text{ in litre/mole}}{\text{Molecular wt}}\right) \text{ppm}$$

$$\Rightarrow \frac{120\,\text{mg}}{m^3} \text{ of } SO_2$$

$$= \frac{120 \times 22.4 \times \frac{293}{273}}{64} \text{ppm} = 45 \text{ ppm}$$

Example 2. A factory uses 1.5 ML of fuel oil per month. The exhaust gases from the factory contain the following quantities of pollutants per ML per year;

(i) Particulate matter : 4 t/year

(ii) SO_2 : 20j/year

(iii) NO_x : 5t/year

(iv) HC, CO and other : 3t/year

Determine the safe height of the chimney required for the safe dispersion of the pollutants.

Solution.

The concentrations of NO_x, HC, CO and others are generally very much less than the concentration of SO_2 in various industries. Hence the Board has made only SO_2 as the criterion for design, along with the particulate matter.

(a) Height of chimney on the basis of particulate matter

$h = 74\,(Q_p)^{0.27}$

Particulate matter emission = $4(1.5 \times 12)$

= 72 t/year

Assume 300 working days in a year, and 24 hours working a day,

$$Q_p = \frac{72}{300 \times 24} = 0.01\,\text{t/hour}$$

$\therefore$ h = 74 $(0.01)^{0.27}$ = 21.34 m

(b) Height of chimney on the basis of SO_2

$h = 14(Q_s)^{1/3}$

Now, SO_2 emission = 20 (1.5 × 12) = 360t/year

$$\therefore Q_s = \frac{360}{300 \times 24} = 0.05\,\text{t/hour} = 50 \text{ kg/hr}$$

$\therefore$ h = $14(50)^{1/3}$ = 51.58 m

$\therefore$ Required height of chimney ≈ 52 m.

Example 3. A factory uses 2,00,000 litres of furnace oil (specific density .097) per month. If for one million litres of oil used per year, the participate matter emitted is 3.0 tonnes per year, SO_2 emitted is 59.7 tonnes per year. NO_x. emitted is 7.5 tonnes per year, hydrocarbons emitted are 0.37 tonnes per year, and carbon

CHAPTER - 7
AIR POLLUTION

7.1 INTRODUCTION
Air is the most essential part of the life and man can hardly survive for few minutes without air although he can survive for few days or few weeks without water or food. But sometimes even the most important life supporting element, if gets polluted, can cause harmful effects both to human beings and plants and animals.

Polluted air is also harmful to non living materials like metals, stones, woods, papers etc. These materials gets spoiled by the contact with polluted air either due to physical corrosive action of polluted air or/and due. to the chemical attack of the pollutants on such material.
1. The earliest pollutants noted in the atmosphere were probably of natural origin.
2. Smoke, fumes, ash, and gases from volcanoes and forest fires: sand and dust from windstorms in arid regions: fog in humid, low-lying areas: were part of our environment long before human-induced or anthropogenic problems came on the scene.
3. Air pollution can be defined as the presence of one or more air contaminants (i.e.. dust, fumes, gas. mist, smoke, or vapor) in the outdoor atmosphere in sufficient quantities, of such characteristics and of such duration, that it becomes injurious to human, plant, or animal life or to property and also interferes with the comfortable enjoyment of life or property.

> Smoke is one of the earliest anthropogenic air pollutants.

7.2 SOURCE AND CLASSIFICATION OF AIR POLLUTANTS
Air pollutants can be classified as follows:
1. Natural contaminants: natural fog, pollen grains, bacteria and products of volcanic eruption.
2. Aerosols (particulates): dust, smoke, mists, fog and fumes.
3. Gases and vapours

Air contaminants		
S.No.	**Group**	**Examples**
1.	Sulphur compounds	SO_2^-, SO_3, H_2S mercaptans
2.	Nitrogen compounds	NO, NO_2, NH_3
3.	Oxygen compounds	O_3, CO, CO_2
4.	Halogen compounds	HF, HCl
5.	Organic compounds	Aldehydes, hydrocarbons
6.	Radioactive compounds	Radioactive gases

Some of these contaminants undergo chemical reactions when they enter the atmosphere. As a result, the end products formed are more harmful than the original contaminants. For example, unsaturated hydrocarbons react with nitrogen dioxide in sunlight to form smog.

ESE OBJ QUESTIONS

1. Consider the following statements in respect of the troposphere:
1. The gaseous content constantly churns by turbulence and mixing.
2. Its behaviour makes the weather
3. The ultimate energy source for producing any weather change is the sun
4. The height of the troposphere is nearly 11 km at the equatorial belt and is 5 km at the poles.
Which of these are true of the troposphere?
[ESE - 2018]
(a) 1, 2 and 3 only (b) 1, 2 and 4 only
(c) 1, 3 and 4 only (d) 2, 3 and 4 only

2. **Statement (I):** The impact of Green House Gas emission on the environment may comprise accelerated increase in global warming as well as a significant rise in mean sea levels.
Statement (II): Green House Gas emission is responsible for decreased land masses, increased population densities and food short ages.
[ESE - 2018]

3. **Statement (I)**: Try quantities of over 30 rare gases would warm the atmosphere over the Earth more rapidly than CO_2.
Statement (II): A single molecule of some CFCs, methane and nitrous oxide absorbs as much heat as 15,000 molecules, 25 molecules and 230 molecules of CO_2, respectively.
[ESE - 2017]
(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of statement (I)
(c) Statement (I) is true but Statement (II) is false
(d) Statement (I) is false but statement (II) is true

4. Two parallel rails are running on railway sleepers. The centre-to-centre distance between the rail is 'b' with the sleepers projecting by an amount 'a' at each end beyond the rails. When the train passes over the rails, the reaction exerted by the ground can eb taken as uniformly distributed over the sleeper. The ratio $\frac{b}{a}$ for the condition that the maximum bending moment is as small as possible is
[ESE - 2017]
(a) 2.83 (b) 2.90
(c) 2.50 (d) 3.00

5. Consider the relevance of the following features for causing photochemical smog
1. Air stagnation
2. Abundant sunlight
3. High concentration of NO_x in atmosphere
4. High concentration of SO_2 in atmosphere
Which of the above features are correct ?
[ESE - 2016]
(a) 1, 2 and 4 only (b) 3 and 4 only
(c) 1, 2 and 3 only (d) 1, 2, 3 and 4

6. Assertion **(A):** Gases are normally formless fluids and can be changed to liquid or solid states by change of temperature and pressure.
Reason (R): Smog refers to the occurrence of a heavy, cloudy, hazy floating layer in the atmosphere formed by a mixture of smoke, dust, fog and mist.
[ESE - 2015]
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R-is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

7. Consider the following statements regarding ecology:

CHAPTER - 8
NOISE POLLUTION

8.1 INTRODUCTION

Noise can be defined as that unwanted sound pollutant which produces undesirable physiological and psychological effects in an individual, by interfering with one's social activities like work, rest, recreation, sleep etc.

Noise of sufficient intensity and duration can induce health problems like temporary and some times permanent hearing loss, besides causing several other diseases like general annoyance, irritation, disturbance, headaches, insomnia, fatigue, mental torture, nausea, high blood pressure, high pulse rate, greater perspiration, etc.

8.2 CHARACTERISTICS OF SOUND AND ITS MEASUREMENT

Alternating compression and rarefaction of the surrounding air produces sound waves which propagate in the form of sinusoidal path.

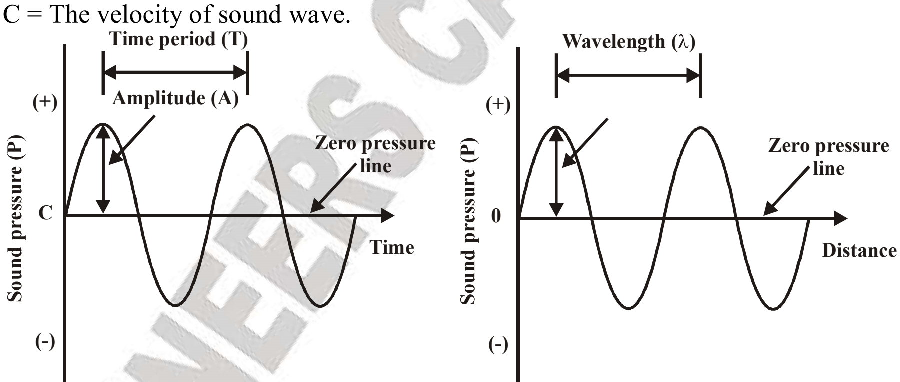
The time between the successive Peaks or troughs of oscillation is called the Time period (T). and its inverse, which represents the number of times a peak arrives in one second; is called the frequency (f).

Hence, $T = \frac{1}{f}$

The distance between successive peaks or troughs is called the **wave length** (λ), which is related to frequency (f) by the relation

$$\lambda = C.\frac{1}{f}$$

where, C = The velocity of sound wave.



Typical sinusoidal sound waves produced by alternating compression and rarefaction of air molecules.

The amplitude (A) of the wave is the height of the peak sound pressure measured above or below the zero pressure line. The equivalent pressure of such a sine wave is represented" by root mean square pressure (p_{rms}) as

$$p_{rms} = \sqrt{\overline{p_{(t)}^2}} = \sqrt{\frac{1}{T}\int_0^T p_{(t)}^2 dt}$$

where, $p_{(t)}$ is Pressure at any time t

CHAPTER - 9
DESIGN OF SEWER

9.1 INTRODUCTION

9.1.1 Difference in the design of water supply pipes and sewer

The hydraulic design of sewer and drains, which means finding out their sections and gradients, is generally carried out on the same lines as that of the water supply pipes. However, there are two major differences

These differences are :

1. The water supply pipes carry pure water without containing any king of solid particles, either organic or inorganic in nature. The sewage, on the other hand, does contain such particles in suspension ; and the heavier of these particles may settle down at the bottom of the sewers, as a result the flow velocity reduces, thus ultimately resulting in the clogging of the sewers. In order to avoid such clogging or silting of sewere, it is necessary that the sewer pipes be of such a size and laid at such a gradient, as to generate self-cleansing velocities at different possible discharges. The sewer materials must also be capable of resisting the wear and tear caused due to abrasion of the solid particles present in the sewage , with the interior of the pipe.
2. The water supply pipe carry water under pressure, and hence, within certain limits, they may be carried up and down the hills and the valleys, whereas, the sewer pipes carry sewage as gravity conduits (or open channels) and they must, therefore, be laid at a continuous gradient in the downward direction up to the out fall point, from where it will be lifted up, treated and disposed of.

9.1.2 Laying of Sewer

All the sewer pipes are generally laid starting from their out fall ends, towards their starting ends. The advantage gained in starting from the tail end, (i.e. out fall end) is the utilization of the tail length even during the initial period of its construction, thus ensuring that the functioning of the sewage scheme has not to wait till the completion of the entire scheme

The laying of the sewer consists of the following steps

1. Marketing of the Alignment

The alignment (i.e., centre line) of the sewer is marked along the road with a thedolite and inver tape

The centre line may be marked according to the following two methods

(i) By reference line

(ii) By sight Rail

(i) By Reference Line

In this methods, a reference line is marked along any side of the busy roads by theodolite and inver tape. The points F_1F_2… are on the reference line. The starting point (P_1) of the centre line is marked with a peg. Then the distance F_1P_1 is with a peg. Then the distance F_1P_1 is measured by inver tape

CHAPTER - 10
DISPOSAL OF SEWAGE

10.1 INTRODUCTION

10.2 DISPOSAL OF SEWAGE EFFLUENT
There are two general methods of disposing of the sewage effluents
1. Dilution i.e, disposal in water
2. Disposal on land

Disposal by dilution is more common of these two methods

10.2.1 Disposal by dilution
Disposal of dilution is the process where by the treated sewage or the effluent from sewage treatment plant is discharged into a river stream ; or a large body of water , such as a lake or sea

Standards of dilution for discharge of wastewaters into rivers
The ratio of the quantity of the diluting water to that of the sewage is known solution factor ; and depending upon this factor , the Royal commission Report on Sewage Disposal has laid down the following standards and degree of treatment required to be given to a particular sewage

Dilution factor	Standards of purification required
Above 500	No treatment is required , Raw sewage can be directly discharged into the volume of water
Between 300 to 500	Primary treatment such as plain sedimentation should be given to sewage, and the effluents should not contain suspended solids more than 150 ppm
Between 150 to 300	Treatments such as sedimentation, screening and essentially should not contain suspended solids more than 60ppm
Less than 150	Complete through treatment should be given to sewage. The sewage effluent should not contain suspended solids more than 30 ppm, and it 5 days B.O.D should not exceed 20 ppm

10.2.2 BIS standard for Disposal of sewage

Parameter	Domestic sewage if discharged into surface water source	Industrial sewage	
		Surface water	Public sewer
BOD_5	20mgl	30mg/l	500mgl
pH	—	5.5-9.0	5.5-9.0
Suspended solids	30 mg/l	100mg/l	600mg/l
Phenolic compounds	—	1 mg/l	5 mg/l
Cyanides	--	0.2mg/l	2 mg/l