Environmental Engineering- I (BCE-26)
Online Lecture

By

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B. Tech (Civil Engineering), Semester -V
Environmental Engineering- I (BCE-26)

- L-3, T-1, P-2 (Credits:5)
- Unit I: Water supply, Sources of Water
- Unit II: Transmission of Water
- Unit III: Storage and distribution of water, Water supply Plumbing System
- Unit IV : Wastewater Collection, Flow in Sewers

What is Environmental Engineering?

Engineering?

- Engineering may be defined as the application, under constraints of scientific principles to the planning, design, construction and operation of structures, equipment and system for the benefit of society.
- Environmental Engineering may be defined as the application of engineering principles under constraints to the protection and enhancement of the quality of environment and to the protection and enhancement of public health and welfare.
- Before 1968,
    - Public Health Engineering: An older term in the United Kingdom and countries with colonial ties to U.K., e. g., India.
    - Sanitary Engineering: An older term in the United States and countries with historical ties with U. S. A., e. g., Philippines.

Coverage

- Environmental Chemistry and Microbiology
- Environmental Hydrology
- Environmental Hydraulics and Pneumatics
- Environmental Quality and Modelling
- Water Treatment
- Wastewater Treatment
- Pollution from Combustion and Atmospheric Pollution
- Solid Waste Management
- Air Pollution and Control
- Hazardous Waste Management and Risk Management

Coverage

- Noise Pollution and Control
- Thermal Pollution and Control
- Environmental Impact Assessment, Management and Environmental Audit
- Industrial Pollution Control
- Pollution of Water Bodies and Control
- Groundwater Management
- Geo-environmental Engineering

Water Supply

Water Supply and Sewage

- Water Supply

The objective of a public protected water supply system is to supply safe and clean water in adequate quantity, conveniently and as economically as possible.

Water Quality and Quantity

- Safe and Wholesome Water (IS: 10500-2012)
- Manual on Water Supply and Treatment, 1999
- National Building Code of India
- IS :1172-1993

Water Supply

Water Demand

- Total Yearly Water Requirement
- Required Average Rates of Flow and the Variations
- Kilolitres per day (KLD)
- Million litres per day (MLD)

Various Types of Water Demand

- Domestic Water Demand
- Industrial Water Demand
- Institutional and Commercial Water Demand
- Fire Demand
- Water Required to Compensate Losses in Wastage and Thefts (Uncounted for Water - UFW)

Water Supply

Domestic Demand

Table 1 : Minimum Domestic Water Consumption (Annual Average) for Indian Towns and Cities with Full Flushing System as per IS : 1172-1993

Use	Consumption in litre per head day (l/h/d)
Drinking	5
Cooking	5
Bathing	75
Washing of clothes	25
Washing of utensils	15
Washing and cleaning of houses and residences	15
Lawn watering and gardening	15
Flushing of water closets, etc.	45
Total	200

Table 2 : Minimum Domestic Water Consumption (Annual Average) for Weaker Sections and LIG Colonies in Small Indian Towns and Cities

Use	Consumption in litre per head day (l/h/d)
Drinking	5
Cooking	5
Bathing	55
Washing of clothes	20
Washing of utensils	10
Washing and cleaning of houses and residences	10
Flushing of water closets, etc.	30
Total	135

Water Supply

Per Capita Water Supply

Basic Need

Water supplies for communities should provide adequately for the following as available:

I. Domestic needs such as drinking, cooking, bathing, washing, flushing of toilets, gardening and individual air conditioning.

II. Institutional needs .

III. Public purposes such as street washing or street watering, flushing of sewers, watering of public parks.

IV. Industrial and commercial uses including central air conditioning.

V. Fire Fighting

VI. Requirement of livestock

VII. Minimum permissible UFW

Water Supply

Per Capita Water Supply

Factors Affecting Consumption

- Size of City
- Characteristics of Population and Standard of Living
- Industry and Commerce
- Climate Conditions
- Metering

Table 3 : Recommended Per Capita Water Supply Levels for Designing Schemes

S.No.	Classification of towns/cities	Recommended Minimum Water Supply Levels (l)
1	Town provided with piped water supply but without sewerage system	70
2	Cities provided with piped water supply where sewerage system is existing/contemplated	135
3	Metropolitan and mega cities provided with water supply where sewerage system is existing/ contemplated	150

Water Supply

Variations in Water Demand

The per capita water demand is defined as the annual average daily consumption of water per person

Variations in Water Demand

- Seasonal
- Hourly rate of consumption
- Maximum daily water consumption
- Maximum hourly water consumption
- Maximum water consumption

Effect of Variations in Demand on the Design Capacities of Components of a Water Supply Scheme

- Source of Supply (Maximum Daily Consumption or Average Daily Consumption)
- Pipe Mains (Maximum Daily Consumption)
- Filter and the units of water treatment plant (Maximum Daily Demand)
- Pumps (Maximum daily draft plus some additional reserve for breakdown and repair)
- Distribution System (Coincident Draft)
- Service Reservoirs (Fire demand, emergency reserve provisions for pumping for entire day's water requirement in few hours)

Water Supply

Variations in Water Demand

Goodrich's Formula: $180\ t^{-0.10}$

p = percent of the annual average draft for time t in days

t= time in days (1/24 to 365)

Maximum daily demand = 180%

Maximum weakly demand = 148%

Maximum monthly demand = 128%

Maximum hourly demand = 1.5 × Maximum daily demand

Peak Factor - Peak factor is the ratio of maximum daily water consumption and average daily water consumption and average water consumption.

Table 4 : Peak Factor

S.No.	Population/ etc.	Peak Factor
1 (i) (ii) (iii)	Upto 50,000 50,001 – 2,00,000 Above 2 lakhs	3.0 2.5 2.0
2	For rural water supply schemes , where supply is effected through standposts for only 6 hours	3.0

Water Supply

Population Forecast

General Considerations

- The design population will have to be estimated with due regard to all the factors governing the future growth and development of the project area in the industrial, commercial, educational, social and administrative spheres.
- Special factors causing sudden emigration or influx of population should also be foreseen to the extent possible.
- A judgment based on these factors would help in selecting the most suitable method of deriving the probable trend of the population growth in the area or areas of the project from out of the following mathematical methods, graphically interpreted where necessary.

Demographic Method of Population Projection

- Population change can occur only in three ways (i) by births (population gain) (ii) by death (population loss) or (iii) migration **.**
- Annexation of an area may be considered as special form of migration.
- Population forecasts are frequently obtained by preparing and summing up of separate but related projections of natural increases and of net migration expressed as below –
    - The net effect of births and deaths on population is termed natural increase (natural decreases if death exceeds birth) Migration also affects the number of births and deaths in an area and so, projections of net migration are prepared before projections for natural increase.
    - This method thus takes into account the prevailing and anticipated birth rates and death rates of the region or city for the period under consideration.

Water Supply

Population forecast

(a) Arithmetic Increase Method

- This method is, generally, applicable to large and old cities.
- In this method, the average increase of population per decade is calculated from the past records and added to the present population to find out population in the next decade.
- This method gives a low value and is suitable for well-settled and established communities.

(b) Incremental Increase Method

- In this method the increment in arithmetic increase is determined from the past decades and the average of that increment is added to the average increase.
- This method increases the figure obtained by the arithmetic increase method.

(c) Geometric Increase Method

- In this method, percentage increase is assumed to be the rate of growth and the average of the percentage increases is used to find out future increment in population.
- This method gives much higher value and is mostly, applicable for growing towns and cities having vast scope for expansion.

Water Supply

(d) Decreasing Rate of Growth Method

- In this method, it is assumed that rate of percentage increase decreases and the average decrease in the rate of growth is calculated.
- Then the percentage increase is modified by deducting the decrease in rate of growth.
- This method is applicable only in such cases where the rate of growth of population shows a downward trend.

(e) Graphical Method

- In this approach there are two methods.
- In the one, only the city in question is considered and in the second, other similar cities are also taken into account.

(f) Graphical Method Based on Single City

- In this method the population curve of the city (i.e. the Population vs. Past Decades) is smoothly extended for getting future value.
- This extension has to be done carefully and it requires vast experience and good judgment.
- The line of best fit may be obtained by the method of least squares.

Water Supply

Population forecast

(g) Graphical Method Based on Single City

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(h) Graphical Method Based on Cities with Similar Growth Pattern

- In this method, the city in question is compared with other cities which have already undergone the same phases of development which the city in question is likely to undergo and, based on this comparison, a graph between population and decades is plotted.

(i) Logistic Method

- The ‘S’ shaped logistic curve for any city gives complete trend of growth of the city right from beginning to saturation limit of population of the city.

(j) Method of Density

- In this approach, trend in rate of density increase of population for each sector of a city is found out and population forecast is done for each sector based on above approach. Addition of sector-wise population gives the population of the city.

Water Supply

Design Period:

- Number of years for which a provision is made in designing the capacities of the various component of the water supply scheme is known as design period.
- Should be neither too long nor too short.

Factor Governing The Design Period

I. Useful life of component structures and chances of their becoming old and obsolete.

II. Ease and difficulty that is likely to be faced in expansion

III. Amount and Availability of additional investment is likely to be increases for additional provision

IV. The rate of interest on the borrowings and the additional money invested.

V. Anticipated rate of population growth including possible shift of communities, industries, and commercial establishments.

Water Supply

Design Period Values

Water supply project, under normal circumstances, may be designed for a design period of 30 years.

Table 5 : Design Period for Different Components of a Water Supply Scheme

S.No.	Item	Design period in Year
1	Storage by Dams	50
2	Intake works	30
3	Pumping (i) Pump house (ii) Electric motors and pumps	 30 15
4	Water treatment units	15
5	Pipe connection to the several treatment units and other small appurtenances	30
6	Raw water and clear water conveying units	30
7	Clear water reservoirs at the head works, balancing tanks and service reservoirs(over head or ground level)	15
8	Distribution System	30

Sources of Water

Kind of Water Sources and Their Characteristics

- The origin of all sources of water is rainfall.
- Water can be collected as it falls as rain before it reaches the ground or as surface water when it flows over the grounds, or is pooled in lakes or ponds, or as groundwater when it percolates into the ground and flows or collects as groundwater, or from the sea into which it finally flows.
- The quality of the water varies according to the source as well as the media through which it flows.

Water from Precipitation

- Rain- water collected from roofs or prepared catchments for storage in small or big reservoirs, is soft, saturated with oxygen and corrosive.
- Microorganisms and other suspended matters in the air are entrapped but ordinarily the impurities are not significant. But the collecting cisterns or reservoirs are liable to contamination.

Surface waters

(a) Natural Quiescent Waters as In Lakes And Ponds

- These waters would be more uniform in quality than water from flowing streams.
- Long storage permits sedimentation of suspended matter, bleaching of colour and the removal of bacteria.
- Self-purification which is an inherent property of water to purify itself is usually less complete in smaller lakes than in larger ones.

Sources of Water

(b) Artificial Quiescent Waters as in Impounding Reservoirs

- Impounding reservoirs formed by hydraulic structures thrown across river valleys, are subject, more or less, to the same conditions as natural lakes and ponds.
- While top layers of water are prone to develop algae, bottom layers of water may be high in turbidity, carbon dioxide, iron, manganese and, on occasions, hydrogen sulphide.
- Soil stripping before impounding the water would reduce the organic load in the water**.**

(c) Flowing Waters as in Rivers, Other Natural Courses and Irrigation Canals

- Waters from rivers, streams and canals are generally more variable in quality and less satisfactory than those from lakes and impounded reservoirs.
- The quality of the water depends upon the character and area of the watershed, its geology and topography, the extent and nature of development by man, seasonal variations and weather conditions.
- Streams from relatively sparsely inhabited watersheds would carry suspended impunities from eroded catchment, organic debris and minerals salts.

(d) Sea Water

- Though this source is plentiful, it is difficult to extract economically water of portable quality because it contains 3.5% of salt in solution, which involves costly treatment.

Sources of Water

Wastewater Reclamation

- Sewage or other waste waters of the community may be utilized for non-domestic purposes, such as water for cooling, flushing, lawns, parks etc. fire fighting and for certain industrial purposes, after giving the necessary treatment to suit the nature of use.
- The supply from this source to residence is prohibited because of the possible cross connection with the potable water supply system.

Groundwater

(a) General

- Rain water percolating into the ground and reaching permeable layers (aquifers) in the zone of saturation constitutes groundwater source. Groundwater is normally beyond the reach of vegetation except certain species of plants called phreatophytes, and is usually free from evaporation losses.
- Groundwater resources are less severely affected by vagaries of rainfall than surface water resources.
- The water as it seeps down, comes in contact with organic and inorganic substances during its passage through the ground and acquires chemical characteristics representative of the strata it passes through.
- Generally, groundwaters are clear and colourless but are harder than the surface waters of the region in which they occur.

Sources of Water

- In limestone formations, ground waters are very hard, tend to form deposits in pipes and are relatively non-corrosive.
- In granite formations, they are soft, low in dissolved minerals, relatively high in free carbon dioxide and are actively corrosive.
- Some of the chemical substances like fluorides and those causing brackishness are readily soluble in water, others such as those causing alkalinity and hardness, are soluble in water containing carbon dioxide absorbed from the air or from decomposing organic matter in the soil.
- Such decomposing matter also removes the dissolved oxygen from the water percolating through. Water deficient in oxygen and high in carbon dioxide dissolves iron and manganese compounds in the soil.

(b)Spring

- Springs are due to the emergence of groundwater to the surface.
- Till it issues out on surface as a spring, the groundwater carries minerals acquired from the subsoil layers, which may supply the nutrients to microorganisms collected by spring if it flows as a surface stream.
- Spring waters from shallow strata are more likely to be affected by surface pollution than deep-seated waters. Springs may be either perennial or intermittent.
- The discharge of a spring depends on the nature and size of catchment, recharge and leakage through the sub-surface.
- Their usefulness as sources of water supply depends on the discharge and its variability during the year.

Sources of Water

Saline Intrusion

- Saline intrusion or salt water creep may occur in tidal estuaries or in groundwater.
- Longitudinal mixing in tidal estuaries is kept in check by the prevention of fresh water and salt water flow components to mix vertically.
- Engineering studies are needed to examine this salt water creep viz, the upstream progress of a tongue of salt water moving inland while overriding fresh water may still flow towards the sea or ocean.
- The salt content of such river waters may also vary with the tides and it is essential to determine the periods when the supply should be tapped to have the minimum salt content.
- Groundwater in coastal aquifers overlies the denser saline water. Every metre rise of the water table above the sea level corresponds to a depth of 41 metre of fresh water floating over the saline water.
- In such cases the pumping from wells has to be carefully controlled or a fresh water barrier created to avoid the salt water tongue entering the wells and contaminating the same.

Factors Governing the Selection of a Source of Water Supply

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

(a)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.

Sources of Water

(b) 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.

(c) 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 numbers of associated appurtenances are required, thereby, reducing the cost of the project.

(d) 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 valleys and that of constructing tunnels in mountains shall be enormous.

(e) 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.

Sources of Water

Intakes

Intakes for Collecting Surface Water

- Whenever the water is withdrawn from a surface source such as a Lake or a river or a reservoir, and the entrance of the withdrawal conduit is not an integral part of a dam or any other related structure, then an intake structure mast be constructed at the entrance of the conduit.
- The basic function of the intake structure is to help in safely withdrawing water from the source over a predetermined range of pool levels and then to discharge this water into the withdrawal conduit (normally called intake conduit), through which it flows up to the water treatment plant.
- In case of a reservoir where gravity flow is possible, the water may be direct taken through the conduit up to the treatment plant, whereas, in case of direct river supplies, the water after entering the intake well may have to be lifted by low lift pump and then taken to the treatment plant through conduit.
- An intake structure constructed at the entrance of the conduit and thereby helping in protecting the conduit from being damaged or clogged by ice, trash, debris, etc., can vary from simple concrete block supporting the end of the conduit pipe to huge concrete towers housing intake gates, screens, pumps, etc. and even sometimes, living quarters and shops for operating personnel.

Sources of Water

Factors Governing the Location of an Intake

The site for locating the intake should be selected carefully, keeping the following points in mind:

As far as possible, the site should be near the treatment plant so that the cost of conveying water to the city is less.

The intake must be located in the purer zone of the source so that the best possible quality of water is withdrawn from the source, thereby reducing the load on the treatment plant.

The intake must never be located at the downstream or in the vicinity of the point of disposal of waste water, When it becomes necessary to locate the intake in the close proximity of the disposal of a drain etc., it is advisable to construct a weir or a barrage upstream of the disposal point and install the intake upstream of the barrage.

Types of intakes

Various types of intake that are commonly used are described below:

(a) Simple submerged Intake- A simple Submerged Intakes consists of simple concrete block or a rock filled timber crib supporting the starting end of the withdrawal pipe .

The withdrawal pipe is generally taken up to the sump well at shore from where the water is lifted by pump. The intake opening is generally covered by screen so as to prevent the entry of debris, ice, etc, into the withdrawal conduit.

In case of lakes, where silt tends to settle down, the intake opening is generally kept at about 2 to 2.5 m above the bottom of the lake and thus to avoid the entry of large amounts of silt and sediment.

Sources of Water

(b) Intake Tower

- Intake towers are generally used on large projects and on rivers or reservoirs where there are large fluctuations of water level.
- Gate controlled openings at various levels, called port, are provided in these towers, which may help in regulating the flow through the towers and permit same selection of the quality of water to be withdrawn.
- Access to these towers is generally provided for operating the gates, etc. by means of Foot Bridge from the tower up to dam or up to the shore.
- If the entry ports are submerged at all levels, then there is no problem of clogging or damage of ice or debris etc. However, the level of the lowest port should we high enough above the reservoir bed, so that sediment is not drawn into them. There are two major types of intake towers.

(i) Wet Intake Towers

A typical section of a wet intake tower is shown in Fig. It may consist of a concrete circular shell filled with water up to the reservoir level and has a vertical inside which is connected to the withdrawal pipe

(ii) **Dry Intake Towers-**

The essential difference between a dry intake tower a well intake tower and is that, whereas in a wet intake tower, the water enters from the entry ports into the tower and then it enters into the conduit through separate gate controlled openings; in a dry intake tower, the water is directly drawn into the withdrawal conduit through the gated entry ports.