

ATME College of Engineering

**13th K M Stone, Bannur Road, Mysore – 570028**



**DEPARTMENT OF CIVIL ENGINEERING (ACADEMIC YEAR 2023-24)**

**WATER SUPPLY AND WASTEWATER ENGINEERING SUB CODE: BCV304**

**SEMESTER: III**

# INSTITUTIONAL MISSION AND VISION

**Vision of the Institute**

Development of academically excellent, culturally vibrant, socially responsible and globally competent human resources.

# Mission of the Institute

* To keep pace with advancements in knowledge and make the students competitive and capable at the global level.
* To create an environment for the students to acquire the right physical, intellectual, emotional and moral foundations and shine as torch bearers of tomorrow's society.
* To strive to attain ever-higher benchmarks of educational excellence

# DEPARTMENT VISION AND MISSION

**Vision of the Department**

To develop globally competent civil engineers who excel in academics, research and are ethically responsible for the development of the society.

# Mission of the Department

* To provide quality education through faculty and state of art infrastructure
* To identify the current problems in society pertaining to Civil Engineering disciplines and to address them effectively and efficiently
* To inculcate the habit of research and entrepreneurship in our graduates to address current infrastructure needs of society

# Program outcomes (POs)

**Engineering Graduates will be able to:**

**PO**1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

**PO**2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

**PO**3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

**PO**4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

**PO**5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

**PO**6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

**PO**7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

**PO**8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

**PO**9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

**PO**10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

**PO**11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

**PO12. Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

# Program Specific Outcomes (PSOs)

**PSO 1 –** Provide the necessary infrastructure for all situations through competitive plans, maps and designs with the aid of a thorough Engineering Survey and Quantity Estimation.

**PSO 2 –** Assess the impact of anthropogenic activities leading to environmental imbalance on land, in water & in air and provide necessary viable solutions revamping water resources and transportation for a sustainable development

# Program Educational Objectives (PEOs)

**PEO 1**- Engaged in professional practices, such as construction, environmental, geotechnical, structural, transportation, water resource engineering by using technical, communication and management skills.

**PEO 2**- Engaged in higher studies and research activities in various civil engineering fields and life time commitment to learn ever changing technologies to satisfy increasing demand of sustainable infrastructural facilities.

**PEO 3**- Serve in a leadership position in any professional or community organization or local or state engineering board

**PEO 4**- Registered as professional engineer or developed a strong ability leading to professional licensure being an entrepreneur.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Course Title: Water supply and wastewater Engineering**  As per Choice Based Credit System (CBCS) scheme  SEMESTER:III | | | | | |
| Subject Code | BCV304 | IA Marks | | | 50 |
| Number of Lecture Hours/Week | 03 | Exam Marks | | | 100 |
| Total Number of Lecture Hours | 40 | Exam Hours | | | 03 |
| **CREDITS – 03** | | **Total Marks-100** | | | |
| **Course objectives:** This course will enable students to;  1. Analyze the variation of water demand and to estimate water requirement for a community.  2. Study drinking water quality standards and to illustrate qualitative analysis of water.  3. Analysis of physical and chemical characteristics of water and wastewater.  4.Understand and design of different unit operations and unit process involved in water and wastewater treatment process  5. Design various oxidation processes. | | | | | |
| **Modules** | | | **Teaching Hours** | **Revised Bloom’s Taxonomy**  **(RBT) Level** | |
| **Module -1:** | | | | | |
| **Introduction**: Water: Need for protected water supply, Demand of Water: Types of water demands -  domestic demand, industrial, institutional and commercial demand, public use and fire demand  estimation, factors affecting per capita demand, Variations in demand of water, Peak factor. **Design period** and factors governing design period.  Methods of population forecasting and numerical  problems. Physico chemical characteristics of water (Analysis to be conducted in laboratory session).  Sampling. | | | 08 hours | L1, L2 | |
| **Module -2:** | | | | | |
| Workability-factors affecting workability. Measurement of workability– slump, Compaction factor and Vee-Bee Consistometer tests, flow tests. Segregation and bleeding. Process of manufacturing of concrete- Batching, Mixing, Transporting, Placing and Compaction. Curing – Methods of curing  – Water curing, membrane curing, steam curing, accelerated curing, self- curing. Good and Bad practices of making and using fresh concrete and Effect  of heat of hydration during mass concreting at project sites. | | | 08 hours | L2,L3,L4 | |
| **Module -3:** | | | | | |
| **Disinfection:** Methods of disinfection with merits and demerits. Breakpoint of chlorination (Analysis to be conducted in laboratory session) Softening: Lime soda and Zeolite process.  **Wastewater**:  **Introduction:** Need for sanitation, methods of sewage disposal, types of sewerage systems,  **Treatment of municipal waste water:** Waste water characteristics (Analysis to be conducted in laboratory session): sampling, significance and techniques, physical, chemical and biological characteristics, Numericals on BOD,. | | | 08 hours | L3,L4,L5 | |
| **Module -4:** | | | | | |
| **Treatment Process:** flow diagram for municipal waste water Treatment unit operations and process, Screens: types, disposal. Grit chamber, oil and grease removal. primary and secondary settling tanks (no numericals), Suspended  growth system - conventional activated sludge process and its modifications. | | | 08 hours | L2,L3,L4 | |
| **Module -5:** | | | | | |
| Attached growth system – trickling filter, numericals on Trickling filters, bio- towers and rotating biological contactors. Principle of stabilization ponds, oxidation ditch, Sludge digesters(aerobic and anaerobic), Equalization., thickeners and drying beds. | | | 10 hours | L1,L2,L3 | |

|  |
| --- |
| **Course outcomes:** After studying this course, students will be able to:   1. Estimate average and peak water demand for a community 2. Evaluate water quality and environmental significance of various parameters and plan suitable treatment system 3. Design the different units of water treatment plant 4. Understand and design the various units of wastewater treatment plant. 5. Acquire capability to conduct experiments and estimate the concentration of different parameters and compare the obtained results with the concerned guidelines and regulations. |
| **Program Objectives:**   * Engineering knowledge * Problem analysis * Interpretation of data |
| **Question Paper Pattern:**   * The question paper will have 5 modules comprising of ten questions. Each full question carrying 16 marks * There will be two full questions (with a maximum of three subdivisions, if necessary) from each module. * Each full question shall cover the topics as a module * The students shall answer five full questions, selecting one full question from each module. If more than one question is answered in modules, best answer will be considered for the award of marks   limiting one full question answer in each module. |
| **Text Books:**  **List of Text Books**   1. Howard S. Peavy, Donald R. Rowe, George T, “Environmental Engineering” - Tata McGraw Hill, New York, Indian Edition, 2013. 2. S. K. Garg, Environmental Engineering vol-I, Water supply Engineering – M/s Khanna Publishers, New Delhi2010 3. B.C. Punmia and Ashok Jain, Environmental Engineering I-Water Supply Engineering,Laxmi Publications   (P) Ltd., New Delhi2010. |
| **Reference Books**:   1. B C Punmia, “Environmental Engineering vol-II”, Laxmi Publications 2nd, 2016 2. Karia G.L., and Christian R.A, “Wastewater Treatment Concepts and Design Approach”, Prentice Hall of India Pvt. Ltd., New Delhi. 3rd, Edition, 2017 3. S.K.Garg, “Environmental Engineering vol-II, Water supply Engineering”, Khanna Publishers, – New Delhi, 28th edition and 2017 |

Module 1

* INTRODUCTION
* WATER TERMS
* NECESSITY AND REQUIREMENT OF WATER
* NECESSITY OF WATER SUPPLY
* FACTORS CONSIDRED FOR WATER SUPPLY SCHEME
* FACTORS AFFECTING POPULATION GROWTH
* DEMAND OF WATER
* PER CAPITA DEMAND AND TOTAL QUANTITY OF WATER REQUIRED FOR A TOWN
* FACTORS AFFECTING PER CAPITA DEMAND
* VARIATION IN DEMAND WATER
* DESIGN PERIOD AND FACOTORS GOVERNING DESIGN PERIOD
* FORECASTING OF POPULATION
* DIFFERENT METHODS OF POPULATION FORECASTING
* PHYSIO CHEMICAL CHARACTERISTICS OF WATER SAMPLING

# INTRODUCTION

Next to air, other important requirement for the existence of human life is water. Water is available in various forms such as lake, rivers, streams etc. Water is essential for life; our food cannot grow without water and millions of plants and animals live in it.

Despite this, it is taken for granted in many parts of the world. At times it may feel as though there is an infinite stock of freshwater but available freshwater in the world is less than 1%of all the water on earth. The human population has increased enormously and data show that Iresh water species are threatened by human activities. The average population of freshwater species fell by around 47% between 1970 and 2000 (UNESCO, 2006). The problems we face today are numerous but we experience only some of them directly. For example, while many people and animals have died dưe to water scarcity in various parts of the world, excess nitrate runoff is responsible for dead zones (low-oxygen areas in the oceans) in other parts of the world. Water constitutes one of the important physical environments of man and has a direct bearing on his health. There is no gainsaying that contamination of water leads to health hazards. Water is precious to man and therefore WHO refers to "control of Water Supplies to ensure that they air pure and wholesome as one of the primary objectivęs of environmental sanitation". Water may be polluted by physical, chemical and bacterial agents. Therefore, protected water supply is a sine qua non (without which nothing) of public health of a community.

Protected water supply is of prime importance in a high population density agglomeration to ensure desirable living environment. Lack of protected water supply will act as a root cause for Increased medical budget, high death rates and less incentive for promotion of economic activities and deterioration of urban environment. Thus water supply is enlisted as one of the basic Services. The objectíve of a public protected water supply system is to supply safe- and clean water in adequate quantity, conveniently and as economically as possible.

The following points highlights need for protected water supply to town/city:

* The earliest civilizations organized on the banks of major river systems and required water for drinking, cooking, bathing etc, But with the advancement of civilization the utility of water enormously increased and now such a stage has arrived that without well organized public Water supply scheme, it is impossible to run the present civic life and develop the towns. The importance of water has shifted from quantity point of view to quality point of view in the recent days.
* Drinking water that is clean and safe is one of the basic needs for the survival of human beings and other species. It has a large effect on our daily lives and therefore civilizations are concentrated around water bodies. We may have to pay a certain amount of money to water suppliers to access drinking water, or we may receive the water supply as an amenity from governments.
* Statistically there are many problems associated with a lack of a clean freshwater supply Diseases and contamination are spread through unsafe water and many people become sick as a result. Problems with water are expected to grow worse in the coming decades, with water scarcity occurring globally.
* Access, to potable clean and safe drinking water has been reported as a major problem faced by the people affected by natural disasters.
* Water stress can be defined as a situation where there is insufficient water for all uses. It results from an increase in population, invention of new uses for water and the use of water bodies as disposal points for wastes.
* Technology has also made it easy to extract water from the groundwater table, divert surface water flows and transport the water to water-scarce locations. Intense urbanization and industrialization have resulted in climate change, thereby enhancing water scarcity and reducing the sustainable supply.
* According to water.org (2009; accessed 13 December 2013), 3.575 million people die every year from water-related disease and 98% of these deaths occur in the developing world. About 1.2 billion people across the world have no access to sanitation at all.

Lack of access to clean drinking water could be due to one or many of the following reasons:

1. Financial inability to dig wells or drill bore wells.
2. With the evolution of mankind, nomads started settling where there is an abundance of water but with time people might have moved away from water due to clashes or in search of land. People who inherited land would have lost access to water resources.
3. Rural people who migrated to urban areas in search of jobs ended up in slums and places where water is not available
4. Earlier generations could have overused water sources beyond their recharge capacity.
5. Water demands due to urbanization and migration might exceed the water available to fulfil the demands.
6. Pollution/ contamination due to human/natural causes.
7. Improper use (using ground water in water deficient region to grow crops like sugar cane or rice, which need abundant water).
8. Wastage of water (water loss due to seepage and leakage) and the use of furrow agriculture instead of drip irrigation.

In the past unsustainability of clean drinking water supplies and sanitation occurred mainly due to a poor understanding of the subject and the economics of treatment but the problem has extended into the present despite advances in science and technology. This could be mainly due to professionals in the field making it uneconomical,

The key reasons for increase in water demand are

1. climate change,
2. population growth,
3. urbanization and industrialization,
4. economic development,
5. changes in public behaviour,
6. changes in governance,
7. water loss and
8. increase in consumption.

The major challenges in providing safe water and sanitation are:

1. water contamination in distribution systems,
2. rising water scarcity,
3. implementing innovative cost-effective sanitation systems,
4. reducing global and regional disparities with respect to water and sanitation and
5. providing sustainable water supply and sanitation for megacities

# WATER TERMS

1. **Water quantity:** The amount of water available to meet desired demands.
2. **Water quality:** The degree to which the water is pure enough to fulfill the requirements of various uses.
3. **Fresh water:** Water having a salt concentration less than 0.1% i.e., 1000 mg/1. As a result of purification by evaporation, all forms of precipitation are fresh water, as are lakes, rivers, ground water, and other bodies of water that have a through flow of water from precipitation.
4. **Pure water**: Water that has two moles of hydrogen and one mole of oxygen
5. Salt water: Water, typical of oceans and seas, that contains at least 3% (30,000 mg/l) salt.
6. **Brackish water**: Mixture of fresh and salt water, typically found where rivers enter the Oceans.
7. **Hard water**: Water that contains minerals, especially calcium and /or magnesium, cause Soap to precipitate, produce scum curd or scale in boilers.
8. Soft water: Water that is relatively free of minerals.
9. **Polluted water:** Water that contains one or more impurities, making it unsuitable for a da use. It has potential to cause harm to the health of consumers/users.
10. **Contaminated water:** Water that contains substances injurious to the health of humans. presence of mercury or pathogens in water.
11. **Purified water:** Water that has had pollutants removed or is rendered harmless.
12. **Good quality water**: A phrase that refers to the quality of water based on the basis of h. consumer. e.g., quality of water acceptable for car washing is not acceptable for drinking
13. **Wholesome water:** Water that can be consumed in any desired quantity at any time with many health and/or aesthetic concerns.
14. **Green water:** Water in the soil or in organisms that eventually ends up as water vapour- the main source of water for natural ecosystems and rain fed agriculture.
15. **Blue water:** Renewable surface water run-off and ground water recharge the focus of management and the main source of water for human withdrawals.
16. **Gray water**: Water discharged from sinks, showers, bathrooms, laundry tubs etc. which is less dirty/polluted.
17. **Black Water:** Waste water containing feces, urine and flush water from flush toilets along with anal cleansing water (if water is used for cleansing) or toilet paper.
18. **Storm water:** Water from precipitation that runs off land surfaces in surges.

# NECESSITY AND REQUIREMENT OF WATER

Next to the air, the other important requirement for human life to exists is water. Water is available in various forms such as rivers, lake, streams, etc. The earliest civilizations organized on the banks of major river systems and required water for drinking, bathing, cooking, etc. But with the advancement of civilization the utility of water enormously inereased and now such a stage has come that without well organized public water supply scheme, it is impossible to run the present civic life and develop the towns. The importance of water from only a quantity viewpoint was recognized from the earliest days and the importance of quality come to be recognized gradually in the later days.

Water required for various purposes are listed below:

* For drinking and cooking
* For bathing and washing
* For watering lawns and gardens
* For heating and air conditioning systems
* For growing crops
* For street washing
* For fire fighting
* For recreation in swimming pools, fountains, etc.
* For steam power and various industrial process, etc. & so on.

# NECESSITY OF WATER SUPPLY

Water as it is available in nature cannot be used because it contains impurities. These can cause severe health hazards. Hence, it is imperative that safe water is made available to all consumers.

A public water supply system has to be both from the point of view of providing an adequate and reliable supply of water catering to all the public needs and also for ensuring that the supplies so made are not only potable but are fully protected against every infection which might otherwise pollute water and cause epidemics resulting in untold human sufferings and loss.

Protected water supply means the supply of water that is treated to remove the impurities and made safe to public health.

The water supply to the consumers should be protected for the following reasons:

* The water available from the surface sources such as rivers, lakes, reservoirs, etc. may be polluted by the people residing near the sources which may cause water-borne diseases like typhoid, dysentery, cholera, etc.
* The underground water may be polluted by the percolating water which may carry harmful chemicals. Such pollution may be the cause of skin diseases, and troubles of heart, lungs, kidney, etc.
* The source of water may be polluted by radioactive substances which may affect the human organs seriously.

The objectives of the community water supply system are

1. to provide whole some water to the consumers for drinking purpose.
2. to supply adequate quantity to meet at least the minimum needs of the individuals.
3. to make adequate provisions for emergencies like fire fighting, festivals, etc.
4. to make provision for future demands due to increase in population, increase in standard of living, storage and conveyance.
5. to prevent pollution of water at source, storage and conveyance.
6. to maintain the treatment units and distribution system in good condition with adequate staff and materials.
7. To design and maintain the system that is economical and reliable.

# FACTORS CONSIDRED FOR WATER SUPPLY SCHEME

The following are the factors considered for water supply scheme:

1. **Population Forecast**: Every scheme should be such that it may run satisfactorily at least for three decades. So, the probable population of the town or city should be ascertained for the future decades (According to the design periods).
2. **Rate of water demand**: Depending upon the probable population, the total water requirement for the town or city should be estimated considering the domestic demand, public demand, industrial demand, fire demand, etc. Rate of demand multiplied by the population, gives the total quantity of water required for the water supply scheme.
3. **Quality of Water**: The water should not be too turbid and there should be no or minimum source of contamination to avoid any excessive treatment.
4. **Sources of Water**: The cost of the water supply scheme depends on the selection of the site for the source of water. So, the source of water should be such that the cost of conveyance and water treatment may be reasonable.
5. **Survey of area**: The nature and number of industries in a town or city should be recorded because, the industries require much water for running and maintenance & also the nature and number of public places like markets, cinema halls, auditoriums, parks, swimming pools, schools, colleges, etc. should be recorded for the provision of additional water requirement.
6. **Topography**: The topographical map of the area for which water supply scheme to be implemented should be prepared & studied in relation to low laying area, density of population, ridges, etc., for economical water supply scheme.
7. **Trends of future development**: The trends of future development in a town or city should

be predicted and properly adjusted in the water supply scheme.

1. **Overhead Reservoir**: The water, after treatment, is generally stored in overhead reservoir from where it is supplied to the consumers. The location of the reservoir should be such that the water can flow easily to the network of distribution system.

Table 1: Water supply system

|  |  |  |
| --- | --- | --- |
| **Sl**  **No** | **Name of the unit** | **Purpose** |
| 1 | Intake work including pumping plant | Raw water from the source for treatment |
| 2 | Plain sedimentation | To remove suspended impurities such as silt, clay, sand,  etc. |
| 3 | Sedimentation with coagulation | To remove the suspended matter |
| 4 | Filtration | To remove microorganism and colloidal matter |
| 5 | Water softening plant | To remove hardness of water |
| 6 | Miscellaneous treatment plants | To remove dissolved gases, tastes and odours |
| 7 | Disinfection | To remove pathogenic bacteria |
| 8 | Clear water reservoir | To store the treated water |
| 9 | Pumps for pumping the water in  service reservoirs | If town or city is situated at higher elevation then  pumping is required |
| 10 | Elevated or underground service  reservoir | For distribution of treated water |

# FACTORS AFFECTING POPULATION GROWTH

The population growth of a city may depend on following factors:

1. **Economic factors**: Such as development of new industries, discovery of oil or other minerals in the vicinity of the city.
2. **Development programmes**: Development of projects of national importance, such as river valley projects, etc.
3. **Social facilities**: Educational, medical, recreational and other social facilities.
4. **Communication links**: Connection of the town with other big cities, industrial areas, etc.
5. **Tourism**: Tourist facilities, religious places or historical buildings.
6. **Community life:** Living habits, social customs, and general education in the community.
7. **Unforeseen factors**: Earthquakes, floods, epidemics, frequent famines, etc.

# DEMAND OF WATER

During planning a water supply scheme. It is very essential to know various types of water demand. Because the water demand varies according to the needs.

The various types of water demand grouped as follows:

1. Domestic water demand
2. Industrial water demand
3. Institutional and commercial water demand
4. Demand for public places
5. Fire demand
6. Compensate losses

# Domestic water demand

This includes the water required in private building for drinking, cooking, washing, bathing. gardening, sanitary purposes, etc. The domestic water demand depends upon the living conditions of the consumer. The quantity of water required for domestic uses is function of the water consumption rate which differs from place to place as it depends on such factors as, characteristics of population, habits of people, living standards of people, climatic conditions, metering of water supply etc. Metering of the water supply reduces the water consumption.

1172-1993, the minimum consumption for a town or a city, (The nount of water need) per capita per day for domestic use is 200 l/h/d.

|  |  |  |
| --- | --- | --- |
| **Sl No** | **Use** | **Consumption in litre per head per**  **day (*l/h/d)*** |
| 1 | Drinking | 5 |
| 2 | Cooking | 5 |
| 3 | Bathing | 75 |
| 4 | Washing of clothes | 25 |
| 5 | Washing of utensils | 15 |
| 6 | Washing and cleaning of houses  and residences | 15 |
| 7 | Lawn watering and gardening  Use | 15 |
| 8 | Flashing of water closets, etc. | 45 |
| Total | | 200 |

According to I.S Code a limit is pointed out on domestic water consumption is between 135- 2235 l/h/d (with 200 1/h/d being minimum under ordinary- circumstances with flushing system).

# Industrial water Demand

The forecast of water requirement for industry obviously depends on the type and magnitude/size of the industry e.g.. the water intensive industries such as pulp and paper mills, dairy, textiles etc., require more water as compared to engineering industries such as foundries, fabrication etc.

For ordinary industries per capita consumption on account of industrial needs of a city is generally taken as 55 liters/person/daily: this is only to meet the demand of small scattered industries in the town or city. The water required by factories, paper mills, Cloth mills, Cotton mills, Sugar refineries, etc. comes under industrial use.

The quantity of water used by industry vary widely depending on the manufacturing proces, and practices adopted. It is also affected by many factors such as:

* Cost and availability of water
* Wastewater disposal problems
* Types of processes involved

This demand depends upon the nature of the city, number and types of industries. In industrial cities water requirement may be 450 l/h/d.

Separate provision will be made for large scale industries.

Big industries will have their own water supply system. Almost all the industries are nowadays a little away from town or cities.

# Institutional and commercial water demand

The institutional demand will also cover the commercial establishment. Generally the water demand for institutions will cover railway stations, hospitals, hostels, offices, factories, etc. An average of 201/h/d is usually considered to meet institutional and commercial water requirements.

This demand may 50 l/h/d for highly commercialized cities. The quantities will vary with the nature of the city, type of commercial establishment, type of hospitals, etc.

# Demand for public places

Public demand includes the quantity of water required for public utility purposes, such as watering of public parks, gardening, sprinkling on roads, use in public fountains „etc. The water demand for public places is considered as 5% of the total consumption of water in the town or city.

# Fire demand

It is the quantity of water required for fighting a fire outbreak. Fire may take place due to faulty electric wires by short circuiting, fire catching materials, explosions, bad intention of criminal people or any other unforeseen mishappenings. If fires are not properly controlled and extinguished in minimum possible time, they lead to serious damages and may burn the cities. For busy areas of town or city, water requirement for this purpose is particularly essential. Hence, requisite amount of water for fire-fighting should always be kept stored in underground reservoirs in specific places and fire hydrants should be established in main pipe lines at an interval of about 100 m to 150 m. In the event of fire, the fire brigade pump is connected to the fire hydrant and the jet of water is thrown under high pressure over the fire.

It is treated as a function of population and may be computed from the following formulae.

1. Kuichling's formula Q= 3182√P
2. Freeman's formula

𝑃

𝑄 = 1136(

5

+ 10)

1. National Board of Fire Underwriters formula

𝑄 = 4637√𝑃(1 − 0.01√P)

1. Buston's formula

𝑄 = 5663√𝑃

# 6. Compensate losses

This includes the quantity of water lost in leakage due to following reasons:

* Defective pipe joints & fittings
* Crack in pipe line
* Damaged public taps
* Consumer may keep the taps open,
* Unauthorized & illegal water connections, etc.

These losses can be reduced by providing good fittings, proper inspection and investigation against water thefts. To compensate this losses, an allowance of about 1 5% of total water requirement should be considered.

# PER CAPITA DEMAND AND TOTAL QUANITY OF WATER REQUIRED FOR A TOWN

This is an approximate estimation for calculate the requirement of water demand of a town. If ‘q’ is the Per Capita Demand in litres per day per head and 'P' is design population of the town or city, then Per Capita demand will be,

𝑞 = 𝑉 ÷ 365𝑋𝑃

where, V=Total yearly water requirement of the city/town in litres.

The per capita demand depends upon various factors such as living conditions of consue type of industries, etc. For an average Indian city, as per I.S. code, the per capita demand (q) may be considered as below

|  |  |  |
| --- | --- | --- |
| **Sl No** | **Use** | **Demand in *l/h/d*** |
| 1 | Domestic Use | 200 |
| 2 | Industrial Use | 50 |
| 3 | Commercial Use | 20 |
| 4 | Civic and Public Purpose | 10 |
| 5 | Waste and theft etc., | 55 |

335

Total (q)

This 335 litres per capita demand will be multiplied with the expected population of the town at the end of design period to obtain the total quantity of water required per day. If total quantity water required per day multiplied by 365, gives the volume of the yearly water requirement in litres.

# FACTORS AFFECTING PER CAPITA DEMAND

The various factors which affect the per capita demand are:

1. **Climatic Condition**: Water requirements during summer are more than winter. During summer more water is use for drinking, washing, bathing, etc. Hence, water consumption is much more in summer than that in winter. Also the demand varies according to hot and cold places.
2. **Size of city**: Generally the demand of water per head will be more in big cities than that in small cities. In big cities lot of water is required for maintaining clean and healthy environments while in small towns it is not required.
3. **Habits of people**: High class community uses more water due to their better standard of living and higher economic status. Middle class people use water at average rate and for poor people a single water tap may be sufficient for several families.
4. **Industries:** More water will be required in highly industrialised city.
5. **Cost of the water**: The cost of water directly affects the demand. If water cost is more, less quantity of walk will be used by the people as compared when the cost is low.
6. **Quality of the water**: More quantity of water will be consumed if the quality is good.
7. **Pressures in the Distribution System:** High pressure results in increased use while low pressure result in decrease use. These would be of great importance in the case of localities having a number of two or three storeyed buildings.
8. **Sewage Facilities**: Town having water carrlage system will consume more water.
9. **System of Supply**: In continuous system water is supplied all the twenty four hours while in the case of intermittent system, water is supplied for certain fixed hours of the day only, result in some reduction in the consumption. This may be due to decrease in losses and other wasteful use.
10. **Method of charging**: In the town where metering is done less quantity of water will be used than the city without metering system. A metered supply ensures minimum of waste as the consumer then knows that he has to pay for the water used by him and consequently is more careful in use.

# VARIATIONS IN DEMAND OF WATER

The demand of water is not a constant factor. It will vary according to season i.e., seasonal variation, hourly variation and also diurnal variation. It is not possible to get an annual average daily consumption. During certain months of the year water demand is found to be high. Similarly, certain period or the day the water demand is maximum.

There are peak periods as well as lean periods. During holidays and festivals, demand is high. The demand in the mornings is greater due to activities such as bathing, washing of clothes and utensils, scrubbing of floors are under taken.

1. Seasonal variations: Water consumed is more during summer as compared to that during winter. The incidences of fire breakouts are also more during summer.
2. Daily variations: It refers to the total water requirements during a 24 hours period. Depends primarily on habits and characteristics of people. It is activity based. People consume more water on Sundays and festival days, thus increasing the demand on these days.
3. Hourly variations: It is defined as total water requirements to meet a one hour period of maximum demand during a maximum daily demand. Water demand is at the peak during active household working hours i.e., during six to ten in the morning and four to eight in the evening. During other hours the demand is negligible. In the event of fire breakouts, huge quantity of water is required during short duration, affecting the rate of hourly supply.

Hence, is order to design a water supply project, we must consider demand during peak hours of the day and peak periods in a year.

Based on the experience some more empirical formulae are presented below to calculate the Peak demand. The maximum daily consumption may be taken as 180 per cent of average daily consumption. Demand is usually maximum between 6-8 a.m. and minimum around 1.00 p.m. It can increases again, till it becomes maximum around 8.30 p.m., and then starts falling towards midnight, becoming minimum around 1.00 a.m.

Maximum daily demand = 1.8 x Average daily demand Maximum hourly demand of maximum day, i.e., Peak demand

= 1.5 x Average hourly demand

= 1.5 x Maximum daily demand

= 1.5 x (1.8 x Average daily demand)

= 2.7 x Average daily demand

= 2.7 x Annual average hourly demand

If the average demand for a town is 10 ml/day, then the maximum daily demand is 15 ml/day and the peak demand is 27 ml/day.

In order to take care of all such fluctuations, an adequate quantity of water must be available to satisfy the peak demand which influences the design service mains, reservoirs, pumps and the distribution mains. The design of different components of water supply scheme is influenced by type of fluctuations e.g., the design of storage reservoirs depends on the monthly variation while that of pumps and service reservoirs is influenced by the hourly variations.

# DESIGN PERIOD AND FACTORS GOVERNING DESIGN PERIOD

The number years for which the design of water works have been done is known as design period. This period should neither be too short or too long. Mostly water works are designed for design period of 20-30years, which is fairly good period. Design period depends on funds available, life of the pipes & other structural materials used in project, anticipated expansion rate of town, etc.

# Factors affecting the design period

1. **Useful life of the pipes, structures and equipment used in the water works**: Useful life of the components considering obsolescence, wear and tear etc. If the useful life is more, design period is also more.
2. **The anticipated rate of growth of population**: If the rate of growth is more, design period is less.
3. **The rate of interest of loans taken for the construction of the project**: If this rate of interest is more the design period will be less.
4. **The rate of inflation during the period of repayment of loans**: When the inflation rate is high, a longer design period is adopted.
5. **Efficiency of component units**: The more the efficiency, the longer the design period.
6. **Ease or difficulty in extension**: For the projects whose extension is easily possible, it is s kept low. For example we can install new tube wells at any time, so we do not need to install all tube wells which would be required after 20 years. But for the projects whose extension is difficult, their design period is kept greater. For example dams and reservoirs cannot be extended easily.

# FORECASTING OF POPULATION

After fixing design period, the population during future decades is calculated. Population Forecasting is a very important factor for desıgn purposes. Knowing the present population from the most recent census, it is possible to determine the present demand, but for the design what is required: is the demand in future. Generally population will be growing every year and hence there will be growing demand for water also.

Unless the current population and the projected population after a few decades is known, the water treatment plant cannot be designed properly. The cost of any water supply scheme depends on

* total demand per capita per day,
* total population to be served.

Any water supply scheme is usually designed in two stages:

* for an anticipated population after 25-30 years,
* for a future population at the end of 50 or 60 years.

Hence it is essential to know how to project the population at the end of a few decades, based on the present population.

# 1.14 DIFFERENT METHODS OF POPULATION FORECASTING

There are various methods of forecasting population. Some of them are most common used methods are explained below.

1. Arithmetical increase method
2. Geometrical increase method
3. Incremental increase method
4. Decrease Rate of Growth Method
5. Graphical Method
6. Graphical Comparison Method
7. Ratio and Correlation Method
8. Master plan method.
9. Logistic Curve Method
10. Growth Composition Analysis Method

# Arithmetical Increase Method

This method is based on the assumption that the population is increasing at a constant rate or old and large city, the population is calculated on the basis of census report for past decade, hence the increase is added to the present population to get the population for the next decade. Though this may not be so accurate, but it will be very close to get the increase population. Thus, population may be determined at the end of n years or n decades,

P =P+ n x i

Where. P= Present population (last known census), n = Number of decades between now and future, i= Average of population increases in the known decades.

If it is used for small, average or comparatively new cities, it will give lower population estimate than actual value.

# Geometrical Increase Method

This method is based on the assumption that the percentage increase in population from decade to decade remains constant.

On the basis of growth of the town the percentage population increased is assumed. For further increase of population an average increase of population is used. But this method will give the higher values and quite good for applicable to newly develop industrial town for two or three decades.

The population at the end of nth decade P can be estimated as:

Where,

I=geometric mean (%) P= Present population n= no. of decades

𝑃𝑛 = 𝑃 (1 +

𝐼𝑔 n

)

100

# Incremental Increase Method

This method is modification of arithmetical increase method and it is suitable for an average Size town under normal condition where the growth rate is found to be in increasing order. While adopting this method the increase in increment is considered for calculating future population.

The incremental increase is determined for each decade from the past population and the average value is added to the present population along with the average rate of increase.

P = P+ nI +n(n+1)/2 x r

Where P = Present population I= average increase per decade r= average incremental increase n = number of decades.

# Decrease Rate of Growth Method

This method may called the modified method of geometric increase method. It is observed that the early growth may be at an increasing rate and the later growth be at a decreasing rate.

In this method, after the geometric increase method failed after two or three decades. Then this method is applied to average size cities growing population under normal condition. In decrease rate of growth method the percentage fall increase is considered and after that the future population is calculated.

# Graphical Method

Population versus Year is correctly plotted to a suitable scale on graph. The curve is smoothly extended to forecast future population. After extending the curve, population at required decades can be determined directly on graph.

# Graphical Comparison Method

This method uses the past experience of other towns which had similar population characteristics 3-4 decades ago. Their population curves are drawn and extended reasonably. With the help of these curves, the plotted data of the city in question can be extended so as to determine its future population.

In Fig., the population curve for city A was drawn up to 1991, when its population was 80,000. The population of 80,000 was reached by cities B, C, D and E in 1961, 1965, 1971 and 1978, respectively.

Now, the curves for B, C, D and E may be drawn starting from the point corresponding to the year 1991 and population 80,000 of A. The curve of city A can now be continued considering the patterns of rates of growth of cities B, C, D and E.

This method gives a fairly accurate forecast of population. Hence, it is adopted frequently when data about populations of similar cities are available.

The population growth of a small town or area is related to big towns or big areas. The increase in population of big cities, bear a direct relationship to the population of the whole state or country. In this method, the local to national (or state) population ratio is determined in the previous two to four decades. Depending upon conditions or other factors, even changing ratio may be adopted. These ratios may be used in predicting the future population. This method takes into account the regional and national factors affecting population growth. This method is useful for only those areas whose population growth in the past is fairly consistent with that of state or nation.

In this method, a master plan of the city prepared by, dividing various zones such as residential, industrial and commercial zone, etc. The future expansion should also be regulated with the corporation bye laws. The population densities of different zones are pre-determined. When the city will be fully developed, the probable population may be forecasted by studying the master plan.

The master plans are prepared for the development of the cities for 25-30 years. The future development of the water works is also designed on the basis of the master plan. For example sector A of a residential zone has 2000 plots. Allowing 5 persons per plot, the population of this sector, when fully developed, will be 2000 x 5 = 10000 persons. Similarly, the development or each zone can be estimated. This method is more advantageous because of the fact that the total water requirement of the city depends not only for domestic purposes, but also for commercial industrial, social health and other purposes. Population density is generally expressed as number of persons per hectare, and their values may be estimated from data collected on existing areas and from zoning master plans for undeveloped areas.

# Logistic Curve Method

This method is used when the growth rate of population due to births, deaths and migrations takes place under normal situation and it is not subjected to any extraordinary changes like epidemic, war, earthquake or any natural disaster, etc., and the population follows the growth curve characteristics of living things within limited space and economic opportunity. If the population of a city is plotted with respect to time, the curve so obtained under normal condition looks like S- shaped curve and is known as logistic curve.

# Growth Composition Analysis Method

The change in population of a city is due to three reasons: (i) birth, (ii) death, and (iii) migration from villages or other towns. The population forecast may be made by proper analysis of these three factors. The difference between birth rate and death rate gives the natural increase in the population. Thus,

The estimated natural increase is given by the following expression:

P = P+ Natural increase + Migration

where

Natural increase = TU, P-I, P) T = design (forecast) period

P= present population

= average birth rate per year

I, = average death rate per year