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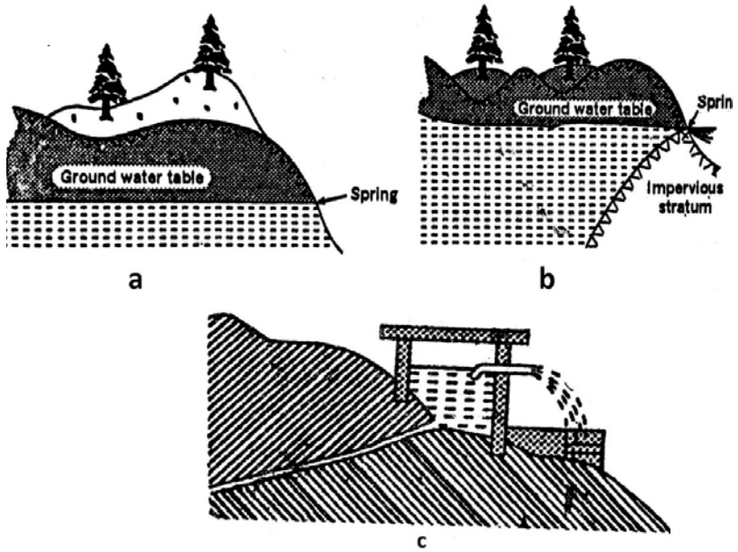
Water Supply and Sanitary Engineering



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Technical and Vocational Stream
Learning Resource Material

Water Supply and Sanitary Engineering

(Grade 9)
Civil Engineering

Government of Nepal
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Preface

The curriculum and curricular materials have been developed and revised on a regular basis with the aim of making education objective-oriented, practical, relevant and job oriented. It is necessary to instill the feelings of nationalism, national integrity and democratic spirit in students and equip them with morality, discipline, self-reliance, creativity and thoughtfulness. It is essential to develop linguistic and mathematical skills, knowledge of science, information and communication technology, environment, health and population and life skills in students. It is also necessary to bring the feeling of preserving and promoting arts and aesthetics, humanistic norms, values and ideals. It has become the need of the present time to make them aware of respect for ethnicity, gender, disabilities, languages, religions, cultures, regional diversity, human rights and social values to make them capable of playing the role of responsible citizens with applied technical and vocational knowledge and skills. This learning resource material for civil engineering has been developed in line with the Secondary Level civil engineering Curriculum with an aim to facilitate the students in their study and learning on the subject by incorporating the recommendations and feedback obtained from various schools, workshops, seminars and interaction programs attended by teachers, students, parents and concerned stakeholders.

In bringing out the learning resource material in this form, the contribution of the Director General of CDC Mr. Yubaraj Paudel and members of the subject committee Dr. Jagat Kumar Shrestha, Dr. Bhim Kumar Dahal, Er. Anisha Lamsal, Er. Gita Lamichhane, Er. Durga Bahadur Pun is highly acknowledged. This learning resource material is compiled and prepared by Er. Jagadishchandra Karki, Er. Kedarnath Dahal, and Er. Ashish Sharma Ghimire. The subject matter of this material is edited by Mr. Badrinath Timsina and Mr. Khilanath Dhamala. Similarly, the language is edited by Mr. Nabin Kumar Khadka. CDC extends sincere thanks to all those who have contributed to developing this material in this form.

This learning resource material contains a wide coverage of subject matters and sample exercises which will help the learners to achieve the competencies and learning outcomes set in the curriculum. Each chapter in the material clearly and concisely deals with the subject matters required for the accomplishment of the learning outcomes. The Curriculum Development Centre always welcomes creative and constructive feedback for the further improvement of the material.

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Table of Content

Guidelines to Teachers

A. Facilitation Methods

The goal of this course is to combine the theoretical and practical aspects of the contents needed for the subject. The nature of contents included in this course demands the use of practical or learner focused facilitation processes. Therefore, the practical side of the facilitation process has been focused much. The instructor is expected to design and conduct a variety of practical methods, strategies or techniques which encourage students engage in the process of reflection, sharing, collaboration, exploration and innovation new ideas or learning. For this, the following teaching methods, strategies or techniques are suggested to adopt as per the course content nature and context.

Brainstorming

Brainstorming is a technique of teaching which is creative thinking process. In this technique, students freely speak or share their ideas on a given topic. The instructor does not judge students' ideas as being right or wrong, but rather encourages them to think and speak creatively and innovatively. In brainstorming time, the instructor expects students to generate their tentative and rough ideas on a given topic which are not judgmental. It is, therefore, brainstorming is free-wheeling, non-judgmental and unstructured in nature. Students or participants are encouraged to freely express their ideas throughout the brainstorming time. Whiteboard and other visual aids can be used to help organize the ideas as they are developed. Following the brainstorming session, concepts are examined and ranked in order of importance, opening the door for more development and execution. Brainstorming is an effective technique for problem-solving, invention, and decision-making because it taps into the group's combined knowledge and creative ideas.

Demonstration

Demonstration is a practical method of teaching in which the instructor shows or demonstrates the actions, materials, or processes. While demonstrating something the students in the class see, observe, discuss and share ideas on a given topic. Most importantly, abstract and complicated concepts can be presented into visible form through demonstration. Visualization bridges the gap between abstract ideas and concrete manifestations by utilizing the innate human ability to think visually. This enables students to make better decisions, develop their creative potential, and obtain deeper insights across a variety of subject areas.

Peer Discussion

Peer conversation is a cooperative process where students converse with their peers to exchange viewpoints, share ideas, and jointly investigate subjects that are relevant or of mutual interest. Peer discussion is an effective teaching strategy used in the classroom to encourage critical thinking, active learning, and knowledge development. Peer discussions encourage students to express their ideas clearly, listen to opposing points of view, and participate in debate or dialogue, all of which contribute to a deeper comprehension and memory of the course material. Peer discussions also help participants develop critical communication and teamwork skills by teaching them how to effectively articulate their views, persuasively defend their positions, and constructively respond to criticism.

Peer conversation is essential for professional growth and community building outside of the classroom because it allows practitioners to share best practices, work together, and solve problems as a group. In addition to expanding their knowledge horizon and deepening their understanding, peer discussions help students build lasting relationships and a feeling of community within their peer networks.

Group Work

Group work is a technique of teaching where more than two students or participants work together to complete a task, solve a problem or discuss on a given topic collaboratively. Group work is also a cooperative working process where students join and share their perspectives, abilities, and knowledge to take on challenging job or project. Group work in academic contexts promotes active learning, peer teaching, and the development of collaboration and communication skills. Group work helps individuals to do more together than they might individually do or achieve.

Gallery Walk

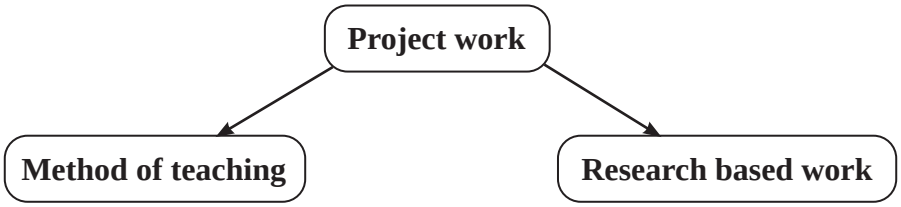
Gallery walk is a critical thinking strategy. It creates interactive learning environment in the classroom. It offers participants or students a structured way to observe exhibition or presentation and also provides opportunity to share ideas. It promotes peer-to-peer or group-to-group engagement by encouraging participants to observe, evaluate and comment on each other's work or ideas. Students who engage in this process improve their communication and critical thinking abilities in addition to their comprehension of the subject matter, which leads to a deeper and more sophisticated investigation of the subjects at hand.

Interaction

The dynamic sharing of ideas, knowledge, and experiences between people or things is referred to as interaction, and it frequently takes place in social, academic, or professional settings. It includes a broad range of activities such as dialogue, collaboration or team work, negotiation, problem solving, etc. Mutual understanding, knowledge sharing, and interpersonal relationships are all facilitated by effective interaction. Interaction is essential for building relationships, encouraging learning, and stimulating creativity in both in-person and virtual contexts. Students can broaden their viewpoints, hone their abilities, and jointly achieve solutions to difficult problems by actively interacting with others.

Project Work

Project work is a special kind of work that consists of a problematic situation which requires systematic investigation to explore innovative ideas and solutions. Project work can be used in two senses. First, it is a method of teaching in regular class. The next is: it is a research work that requires planned investigation to explore something new. This concept can be presented in the following figure.



Project work entails individuals or teams working together to achieve particular educational objectives. It consists of a number of organized tasks, activities, and deliverables. The end product is important for project work. Generally, project work will be carried out in three stages. They are:

- Planning
- Investigation
- Reporting

B. Instructional Materials

Instructional materials are the tools and resources that teachers use to help students. These resources/materials engage students, strengthen learning, and improve conceptual comprehension while supporting the educational goals of a course or program. Different learning styles and preferences can be accommodated by the variety of instructional

resources available. Here are a few examples of typical educational resource types:

- Daily used materials
- Related Pictures
- Reference books
- **Slides and Presentation:** PowerPoint slides, keynote presentations, or other visual aids that help convey information in a visually appealing and organized manner.
- **Audiovisual Materials:** Videos, animations, podcasts, and other multimedia resources that bring concepts to life and cater to auditory and visual learners.
- **Online Resources:** Websites, online articles, e-books, and other web-based materials that can be accessed for further reading and research.

Maps, Charts, and Graphs: Visual representations that help learners understand relationships, patterns, and trends in different subjects.

Real-life Examples and Case Studies: Stories, examples, or case studies that illustrate the practical application of theoretical concepts and principles.

C. Assessment

Formative Test

Classroom discussions: Engage students in discussions to assess their understanding of concepts.
Quizzes and polls: Use short quizzes or polls to check comprehension during or after a lesson.
Homework exercises: Assign tasks that provide ongoing feedback on individual progress.
Peer review: Have students review and provide feedback on each other's work.

Summative Test

Exams: Conduct comprehensive exams at the end of a unit or semester.
Final projects: Assign projects that demonstrate overall understanding of the subject.

Peer Assessment

Group projects: Evaluate individual contributions within a group project.
Peer feedback forms: Provide structured forms for students to assess their peers.
Classroom presentations: Have students assess each other's presentations.

Objective Test

Multiple-choice tests: Use multiple-choice questions to assess knowledge.
True/False questions: Assess factual understanding with true/false questions.
Matching exercises: Evaluate associations between concepts or terms.

Portfolio Assessment

Compilation of work: Collect and assess a variety of student work samples.
Reflection statements: Ask students to write reflective statements about their work.
Showcase events: Organize events where students present their portfolios to peers or instructors.

Observational Assessment

Classroom observations: Observe students' behavior and engagement during class.
Performance observations: Assess practical skills through direct observation.
Field trips: Evaluate students' ability to apply knowledge in real-world settings.

Unit 1: Introduction

Introduction

Water is the natural resource (surface and underground water) for the survival of human as well as living things. It is useful for production of food and energy that contributes to the economic and industrial development of a society. So, safe and reliable supply of water is essential for any city or town.

1.1 Importance of Water to Life and Our Environment

Water covers two third of the earth's surface; and 75 percent of a human body, by its volume, is water. It shows that water is one of the prime elements responsible for life on earth. Water circulates through the land just as it does through the human body, transporting, dissolving, and replenishing nutrients and organic matter, while carrying away waste material. Further, in the body, it regulates the activities of fluids, tissues, cells, lymph, blood and glandular secretions.

An average adult body contains 42 liters of water and with just a small loss of 2.7 liters he or she can suffer from dehydration, displaying symptoms of irritability, fatigue, nervousness, dizziness, weakness, headaches and consequently reach a state of pathology.

Necessity of water

The use of water by man, animal and plants is universal. Without it, there can be no life. Every living thing requires water. Everywhere water is necessary for various purposes, such as:

a. for drinking and cooking
b. for bathing and washing
c. for watering of lawns and gardens
d. for growing of crops
e. for street washing
f. for fire fighting
g. for power production

h. for various industrial production

i. for recreation in swimming pools, fountains and cascades

j. for heating and air conditioning system

k. for sanitation, etc.

1.2 Importance of Water and Sanitation

Water is one of the most important substances on earth. All plants and animals must have water to survive. If there were no water, there would be no life on earth.

Apart from drinking it to survive, the other uses for water include:

- cooking
- bathing
- washing clothes
- washing Kitchen utensils
- keeping houses and communities clean
- recreation, such as swimming pools
- keeping plants alive in gardens and parks.

Water is also essential for the healthy growth of farm crops and farm stock and for manufacturing of many products. It is most important that the water, which people use to drink and use for other purposes, be clean and pure water. This means that the water must be free of germs and chemicals.

Sanitation literally means measures necessary for improving and protecting health and well-being of the people. Sanitation is any system that promotes proper disposal of human and animal waste, proper use of toilets and avoiding open space defecation.

The following points clearly illustrates the importance of water and sanitation:

- disease spread from poor quality water and sanitation are a huge cause of mortality and morbidity worldwide, especially in children.
- diarrheal disease caused by contaminated water contributes to malnutrition and respiratory disease, these results in about 2.1 million preventable deaths every year mainly in children. (Water Aid report 2021)
- an estimated 1.4 million deaths annually could have been prevented by safely managed WASH in 2019.

- children cannot attend school if they suffer from various types of water related disease.
- adolescent girls and women do not have privacy and dignity in lack of proper sanitation system.
- expenditure on medical aid cuts the poor man's pocket.
- it causes most death due to gastrointestinal disease, jaundice, worms etc.

1.3 Objectives of Water Supply System

- to supply safe and wholesome water to consumers.
- to supply sufficient quantity of water to the consumer at the right time.
- to control possible water borne disease.
- to supply water at reasonable cost to the consumer.
- to encourage personal and household cleanliness of users.
- to provide sufficient quantity of water for firefighting.
- to supply sufficient water for sanitation.

1.4 Community Mobilization for Construction and Maintenance of Water Supply

Community mobilization is defined as the use of the communities in its project areas, mainly through awareness campaigns and transfer of knowledge.

The objectives of the community participation and mobilization is to use socially acceptable right level of technology, effective materials and methods of construction. It helps to operate and maintain water supply projects using minimum outside resources. It is highly desirable to mobilize the community in the planning, implementation and maintenance of the water supply projects to get maximum benefit and its sustainability.

Community participation or mobilization is ensured by the formation of smaller to larger institutions inclusive of women and several group through community meetings.

1.4.1 Water Supply Schemes and Flow Diagram

Water supply schemes is the branch of engineering which deals with the supply of safe and suitable water in sufficient quantity for various purposes such as domestic

purpose, industrial purpose, public purpose etc. Water supply is the provision of water by public utilities, commercial organizations, community endeavors or by individuals usually via a system of pumps and pipes. A water supply schemes extracts a suitable water from a source and supplies it to the water consumers through its distribution system after giving necessary treatments.

A typical water supply scheme consists of the following components.

1. **Sources of water:** River, streams, lakes, ponds, wells etc.
2. **Intake/collection work:** For collection of water.
3. **Treatment system:** For making water safe and suitable for various purposes.
4. **Distribution system:** To distribute treated water in the right time.

Exercise

Choose the correct answer from the given alternatives.

1. Where do we place a BPT?

   a. Treatment plant
   b. Distribution system
   c. Transmission system
   d. Before tap

2. Which is not used in a rural gravity water supply system?

   a. Pump
   b. BPT
   c. IC
   d. Taps

Write short answer to the following questions.

1. Describe about water supply engineering.
2. Enlist the objectives of a water supply system.
3. Write about community mobilization for construction and maintenance of water supply.

Write long answer to the following questions.

1. Describe the importance of water and sanitation.
2. Discuss the importance of water for life and environment.

Project Work

1. Prepare a plan to organize Water Supply and Sanitary Users Group (WSSUG) for community mobilization for construction and maintenance of water supply in any village or tole.

Unit 2 : Sources of Water

Introduction

The source of water is that place from where water can be extracted for various purposes. These units focus on the various sources of water: rainwater, surface water and ground water. Explanation about the criteria to be adopted, while selecting a source for a water supply scheme has also been given here. Furthermore, it provides the idea to measure the yield of source.

2.1 Sources of Water

Water comes from the three main sources: rainwater, underground water and surface water. Rainwater includes rain, snow, and other forms of precipitation. Underground includes water tables and water hidden in the soil. Surface water includes oceans, rivers, lakes, ponds and any other above ground collection of water. The various sources of water are briefly described below.

Rainwater

The evaporated water from large water bodies like sea, ocean, river etc. condenses at the high altitude in the form of clouds and when it falls below the dew point, it starts falling in the form of rain, hails, dew, frost, etc. During its fall from high altitude to ground, it absorbs oxygen, carbon dioxide and other gases along with dust smoke, fumes, bacteria, etc. Therefore, rainwater may contain large amount of impurities. The quantity of impurities is maximum in the first rain and minimum in the last season rains.

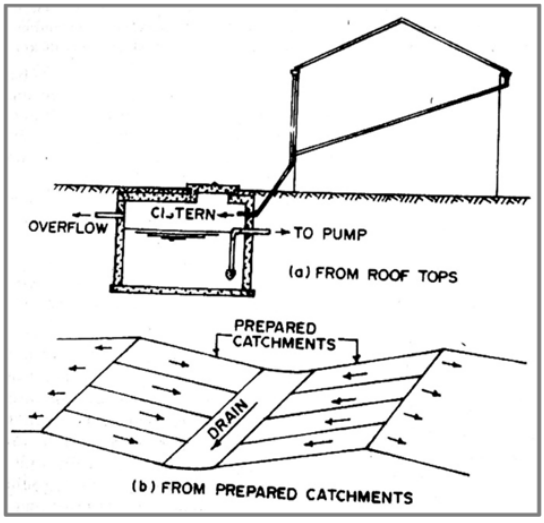


Fig 2.1: Collection of rainwater The rain water can be collected in following ways,

a. **The roof of the houses:** Water is stored in a small underground tank or cistern, for small individual supply.

b. **From prepared catchment:** The surface of catchments is made impervious by suitable lining material, and suitable slope is given so that water is stored in moderate size reservoirs. This water is used for communal supplies, mostly for drinking purposes.

The quality of rainwater falling on the open land is better than that falling on the cities or town. The quality of rainwater of the last season is usually good and can be used after little treatment.

2.2 Surface Water

The water, which is available in the surface of the earth, is known as the surface source of water and the source containing that surface water is termed as surface sources. Surface sources of water include rivers, streams, lakes, ponds, etc. There is large variation in the water yield of the surface source, which may vary from season to season. The following are the main surface sources of water.

1. **Streams**
2. **Rivers**
3. **Lakes**
4. **Ponds**
5. **Impounded reservoirs**

1. Streams

Streams are formed by runoff in the mountainous region. The discharge in streams is much in rainy seasons than other seasons. Those streams, which dry up in summer and contain water only in rainy season, are called “raining streams”. The quality of water in the streams is normally good except the water of first runoff. However, sometimes stream water may contain large amounts of clay, sand and dissolved impurities.

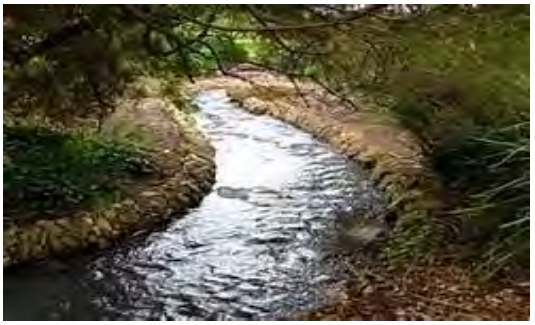


Fig. Stream

As the quantity of water in the stream is not more, streams can be used as source of water supply only for small village after giving a necessary treatment.

2. River

Rivers are born in the hills, when discharge of large number of springs and streams combine together. In mountains, the quantity of water in river remains small, therefore, at such place these are called as small rivers.

Rivers are the only surface source of water which have the maximum quantity of water and that can be easily taken. Therefore, rivers are widely used as a source of water supply throughout the world. River water should always be used after necessary treatment as it might contain suspended and dissolved impurities in it.

Fig. River

3. Lakes

In mountains at some places, natural basins are formed with impervious beds. Water from springs and streams generally flows towards these basins and lakes are formed. The quantity of water in the lakes depends on its basin capacity, catchment area, annual rainfall porosity of ground, etc.

Fig. Lake

The quality of large lakes is better than that of the small lakes. The lake, which is situated at high altitudes, contain almost pure water, which can be used without any treatment.

4. Ponds

Ponds are the depressions in plains, like lakes of mountain, in which water is collected mostly during rainy season. Ponds are constructed artificially for some purpose or sometimes, they are formed when much excavation is done for building construction, embankment for road and manufactures of brick.

Fig. Pond

Generally, quantity of water in ponds is very small and it contains large amount of impurities in it, therefore pond water cannot be used for water supply purpose but it can be used for washing of clothes, animal bathing, etc.

5. Impounded Reservoirs

It is found that there is great variation in the quantity of water in the river in the monsoon and the summer season. In some rivers, the flow becomes very small and cannot meet the requirement of hot weather. In such cases, it becomes essential to store the excess water of monsoon to for summer season.

The water can be stored in the river by constructing a weir or a dam across the river at a suitable location. The reservoir thus formed is known as impounded reservoir.

2.3 Ground Water

The water, which is found below the surface of the earth, is known as underground water and the source containing such water is known as underground source of water.

The main source of ground water is precipitation. A portion of precipitation enters the surface of the earth. The entrance of rainwater into the ground is known as infiltration and the movement of this water after infiltration is known as percolation. A portion of rainfall percolates into the ground and is stored as ground water at hard (impervious) stratum. The ground water reservoir consists of water held in voids within a soil stratum. Sometimes this ground water percolates through the soil and appears again at the surface in the form of spring. Alternatively, this stored water below the earth surface can be taken out by some suitable arrangement like construction of well and tube well.

The following are the main underground sources of water:

1. Springs
2. Wells

1. Springs

A spring is any natural situation where water flows from an aquifer to the earth's surface.

Ground water is stored in aquifers, which are underground water reservoirs. They contain billions of gallons of water. Sometimes this water reappears at the ground surface in the form of spring. A spring is formed when the pressure in an aquifer causes the water to flow at the surface.

Generally, spring are formed under following circumstances;

1. when the surface of earth drops sharply below the normal water table
2. when, due to an impervious obstruction the ground water is collected in the form of reservoir and forces the water to overflow at the surface.
3. when fissure in impervious stratum allows artesian water to flow in the form of spring.

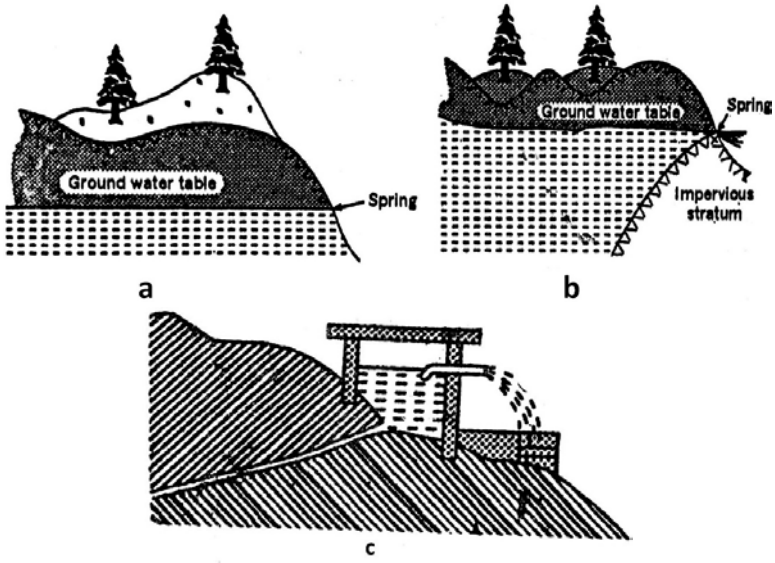


Fig. Formation of springs

Spring generally can supply small quantities of water; hence, these cannot be used as a source of water to big towns. Good developed springs can be used as a water supply source for small towns. Normally the quality of water in the spring is good and little treatment is enough before supply.

2. Wells

Wells are the vertical hole or shaft excavated in the earth for bringing ground water to the surface. Wells are mainly divided into two types, they are.

a. Open wells or Dug wells
b. Bored or Drilled wells or Tube wells

a. Open Wells or Dug Wells

These are shallow wells, which are usually confined to soft ground, sand and gravel to intercept water from topmost water bearing stratum. These wells are suitable for small discharge of about 20 cu.m/hour. Open wells are constructed mostly in circular

shape, diameter of which may be between 1 to 4 m and depth may be up to 20m.The walls of these wells may be constructed with precast R.C.C. blocks, bricks or stone masonry.

- dug wells are very cheap in construction.
- the yield of open well is low, because they receive water from top unconfined aquifer only.

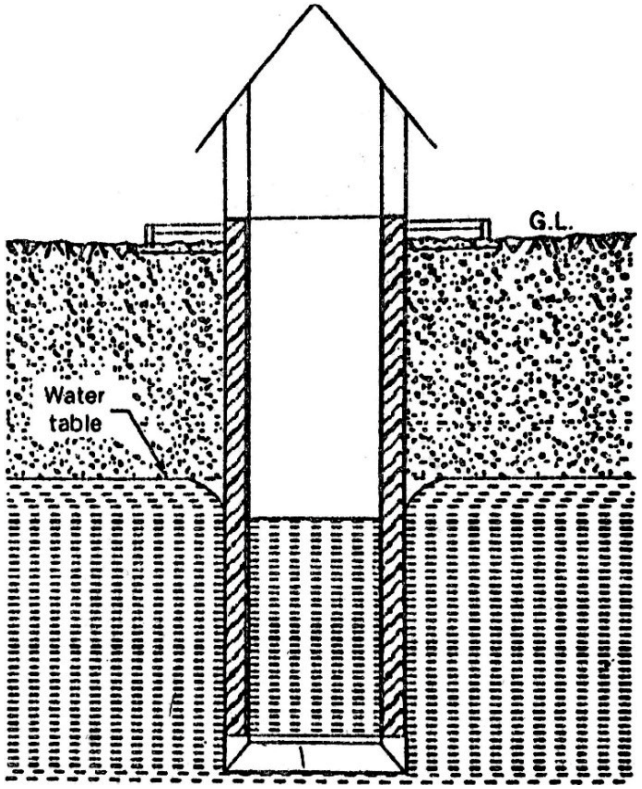


Fig. Open well

b. Bored or Drilled Wells or Tube Wells

The discharge available from the ordinary open well is very low. Due to their low yield, open wells are only useful for small locality or for private building. For obtaining more yield, nowadays tube-wells are commonly used.

A tube well is a long pipe sunk into the ground with the strainer, which allows water to pass through but prevents sand from coming along with water. Because of the strainer, water can be taken out from aquifer at high velocity without any danger of soil particles being carried away with water. These wells receive their yield from

large number of aquifers; hence, their discharge capacity is much more than ordinary open wells.

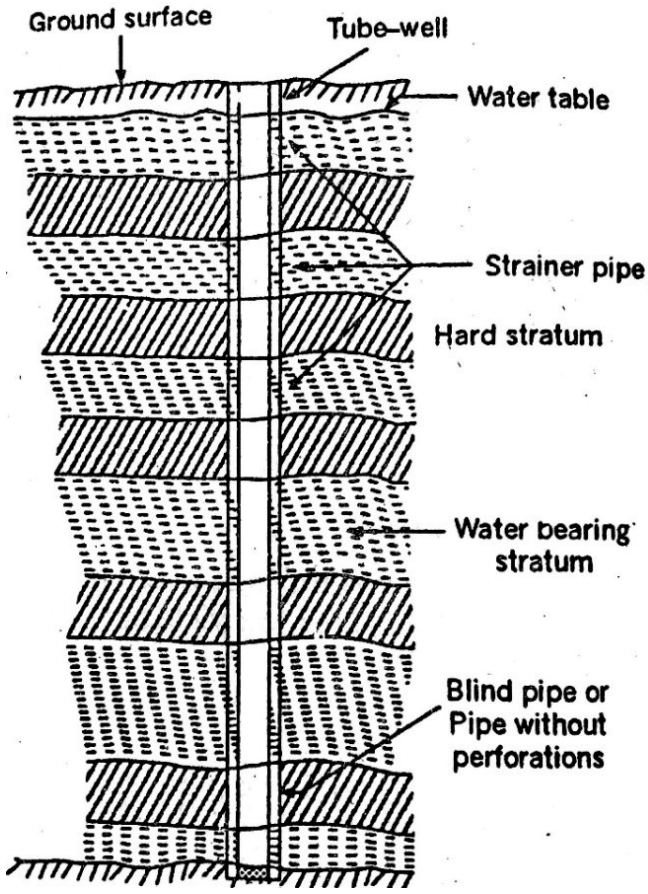


Fig. Tube well

- a tube well consists of a long special pipe with strainer, installed deep below the surface of earth to tap water from various water layer.
- the depth of tube well may vary from 50 to 500m.
- the maximum yield of tube well may be up to 200 liters/second
- the yield of average tube well is 50litre/second.
- tube discharges more water than open wells. This is because tube wells receive their supply from more than one water layer but open wells get supply from only top layer of underground water.
- the quality of water from tube wells is much better than open wells as they drew their supplies from deep.

2.4 Source Selection Criteria

There are two sources of water; surface source and underground sources. Both the sources may be selected for the public water supply schemes. The selection of particular source depends upon its permanency, adequacy, and the cost of scheme. The selected source should have the capability to fulfill the water demand of the targeted group through the years. In addition, the source should be located at such places from which water can be distributed to consumers easily at low cost. Thus, the following points are considered while selecting a source.

i. Quality of Water

The quality of water is the most important point to be considered while selecting a source. The quality of water in the source should be good, so that it can be treated easily at low cost. It should not contain disease germs and pathogenic bacteria, which may endanger the public health.

ii. Quantity of Water

The selected source of water should have sufficient quantity of water to meet various demands of the city throughout the year. The selected source should be ableto meet the present as well the future demand of the city. The source of water shouldbe able to meet the maximum demand in dry weather also.

iii. Location of Source

The source should be selected at such a location, which is free from pollution. If possible, sources should be selected at high altitude from the service area, so that water can be supplied to the consumer by gravity system avoiding the cost of pumping.

iv. Cost

The cost of a water supply project should also be taken into account while selecting the source of water. The cost of a water supply scheme depends on many factors such as system of supply, distance between source and supply area, method of distribution, treatment method, etc. If water flows under the gravitational force, it will be cheap. Similarly, if the distance between the source and service area is more,it will be costly.

2.5 Discharge Measurement (Volumetric method)

The volume of water following through the source is called discharge. It is generally

expressed as m^3/s

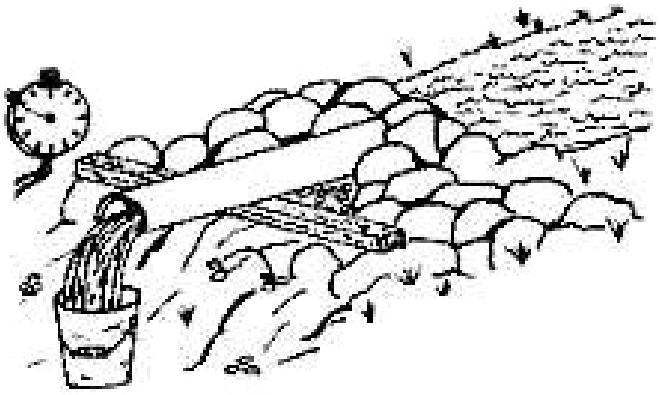


Fig. Discharge measurement by volumetric method

The volumetric method of discharge measurement is the simplest way to estimate the flow by direct measurement of time to fill a container of known volume. The following procedure is followed to measure discharge from the source.

1. take a suitable size of container and determine its volume, say V liter.
2. the flow from source is diverted into a channel or pipe which discharges into a container.
3. the time required to fill the container is measured accurately with the help of a stopwatch. Let say it is T second
4. Discharge (Q) is calculated as,

   Q = V/T (liter/second)

2.6 Source Protection Plan

The source used in the water supply system should be protected to avoid contamination and damage. Source protection plan is prepared to protect it from runoff, animals, bathing, unauthorized entrance of people, etc. A provision of hedge or barbed wired fencing with a lockable gate in the source area can control the unauthorized entrance of people and animals. The catchment area of the source should be covered by fencing. Besides that, improvement of catchment should be done using civil engineering technique, bioengineering technique, vegetation plantation (grass, shrubs and trees) to control erosion of soil, landslides, etc. It also helps in increasing the yield of the spring.

2.7 Numerical Practise

1. Calculate the discharge of a water source which fills the bucket of volume 5 litres in 40 seconds.

Given :

Volume of bucket = 5 litres

Time taken to fill the bucket = 40 seconds

We know that,

$$\text{Discharge (Q)} = \frac{\text{Volume of Bucket (V)}}{\text{Time taken (T)}}$$

$$= \frac{5 \text{ ltr}}{40 \text{ sec}}$$

= 5 Ltr.40 Sec.

$\therefore$ Q = 0.125 litres per second (lps)

2. Calculate the time taken to fill a vessel by a water source having discharge of 0.1m^3/sec. The volume of vessel is 1 m^3.

Given,

Discharge (Q) = 0.1 m^3/sec

Volume (V) = 1 m^3

We know that,

$$\text{Discharge (Q)} = \frac{V}{t}$$

or, 0.1 x t = 1

$\therefore$ t = 10 seconds

Exercise

Choose the correct answer from the given alternatives.

1. Which one is considered as the primary sources of water?

   a. Stream b. Well c. Rainfall d. Spring

2. Non perennial rivers are formed only by……..

   a. Spring b. Rainfall c. Snow d. Perennial stream

3. …….. is not meant for the protection of source.

   a. Plantation b. Painting c. Fencing d. Bioengineering

4. Which source of water among the following is not a ground source?

   a. Spring b. Well c. Stream d. Tube well

Write short answer to the following questions.

1. Write short notes on “Rainwater”.
2. What is an underground source?
3. Discuss the suitability of streams as a source of water supply.

Write long answer to the following questions.

1. Write short notes on following:

   a. Streams b. Lakes

   c. Rivers d. Ponds

2. What are the criteria for selecting a source for a water supply scheme

Project works

1. Perform measurement of the discharge at the source of water supply in your school or nearby source and calculate safe yield and design yield.
2. Prepare Source protection plan for a spring/stream or well source.

Unit 3 : Demand of Water

Introduction

The demand for water is the total amount of water used by the consumer within the water system. Determination of water demand is the most important aspect before designing water supply schemes. This unit gives the idea on how to determine the total water demand of a city/town. Various types of water demand of city/towns are described in this unit with reasonable data. Population forecasting methods such as arithmetical increase method, geometrical increase method and incremental increase method have also been described with suitable example to facilitate learning of student.

3.1 Water Demand

When designing the water supply scheme for a city and a town, it is necessary to determine the total quantity of water required for various purposes by the city. The duty of a water engineer is to determine the water demand of town and to find out the suitable water sources from where the demand can be met.

The determination of the water demand involves the following items,

1. rate of demand (Per capita demand) determination
2. population determination

To calculate the rate of demand, it is necessary to understand the types of water demand.

3.2 Types of Water Demand

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

1. domestic water demand:
2. commercial and Industrial demand
3. demand for public use
4. fire demand
5. compensate losses demand
6. institutional water demand

1. Domestic Water Demand:

It includes the quantity of water required in the houses for drinking, bathing, cooking, washing, etc. The quantity of water required for domestic use mainly depends on the habits, social status, climatic conditions and customs of the people. The water requirement for domestic purposes is given below:

S.N.	Community Population	Adopted (lpcd)	Remarks
1	<70000	45	Supply through public tap
2	<70000	70-100	Supply through private tap
3	70000-100000	100-150	Supply through private tap
4	>100000	150-200	Supply through private tap

Source: *Design guidelines for community-based gravity flow rural water supply schemes (DWSS)*

2. Commercial and Industrial Demand

The presence of industries in town has a great effect upon total consumption of water. There is no direct relation of this consumption with the population and hence the actual requirements for all industries should be carefully estimated. The water required in the industries mainly depends on the type and size of industry. The water required by the factories, paper mills, cloth mills, sugar refineries, etc. comes under industrial use. The quantity of water demand for industrial use is around 20 to 25% of the total demand of the city.

Commercial buildings and commercial centres include office building, warehouse, stores, hotels, shopping centers, health centers, schools, cinema houses, bus station, etc. The requirements of commercial and public places may be up to 45 liters/day/capita. The water requirements for commercial buildings are given below.

S.N.	Types of building	Demand	Remarks
1	Health post	500 lit/bed	
		3000 lit/day	If not bedded health post
2	Public institutions	500-100 lit/day	
3	Restaurant, Tea stall etc.	500-100 lit/day	
	Tourist hotel	500lit/bed	Unclassified

Source: *Design guidelines for community-based gravity flow rural water supply schemes (DWSS)*

3. Demand for Public Uses

The quantity of water required for public utility purposes such as for washing and sparkling of roads, cleaning of sewers, watering of public parks, etc. comes under public demand. Usually, 5% of the total water demand of the city should be considered for public use.

Institutional Use

Institutional demand refers to the water needed for offices, schools and health posts in the community. The following institutional water demand should adopt.

S.N.	Types of institutions	Demand	Remarks
1	School	10lit/student	Day scholars
		65lit/student	Boarders
2	Health post	100lit/day	Without sanitation
		3000lit/day	With sanitation
3	Health Centre	500lit/bed	

Source: *Design guidelines for community-based gravity flow rural water supplyschemes (DWSS)*

4. Fire Demand

The water required for the firefighting is generally known as the fire demand. It is related as a function of population and may be computed from the following empirical formulae.

1. Kuichling's Formula

$Q = 3182\sqrt{P}$

2. Buston's Formulae

$Q = 5663\sqrt{P}$

3. Freeman's Formulae

$$Q = 1136\left(\frac{P}{5} + 10\right)$$

Where,

Q = Quantity of water in liters per minute

P = Population in thousand

5. Compensate Losses Demand

All the water that goes into the distribution pipe, does not reach the consumers. Some portion of this is wasted in the pipelines due to defective pipe joints, cracked and broken pipes, faulty valves and fittings. Sometimes consumers keep open their taps on or public taps even when they are not using the water resulting in the continuous wastage of water.

While estimating the total requirement of water of a town, compensation for these losses and wastage should be done. Generally, 15% of the total quantity of water is needed to compensate for losses, thefts and wastage of water.

Per Capita Demand

Per capita demand means the average amount of water each person in a particular community uses on a daily basis, this is expressed as "liters per capita per day".

If Q is the total quantity of water consumed by a town per year in liters, and the population of town is P, the per capita demand will be.

Per capita demand = $\frac{Q}{p \times 365}$ liters/day

Design Period

Design period is the time span a system is expected to serve the population effectively.

The number of years for which the design of water works has been done is known as design period. In another word, design period refers to the duration for which a scheme will meet water demand of water users. This period should be neither too short nor too long. Mostly in Nepal, water works are designed for designed periodof 15- 20 years.

The Following factors should be kept in mind while fixing the design period.

a. fund available for the competitions of the project. The more the funds, less the design period

b. life of pipe and other structural materials used in the water supply schemes

c. design period in no case should have more life than the components and materials used in the scheme

d. as far as possible, the design period should be nearly equal to the materials used in the water supply works

e. if the rate of interest is less, it will be good to keep the design period longer. But if the interest rate is very high, the design period should be small

f. rate of population growth

3.3 Factors Affecting Water Demand

It has been noted that the average per capita demand of various cities considerably varies. The following are main factors which affect the per capita demand of the city:

1. Climatic Conditions

A large quantity of water is required in the hotter and dry place because the consumption of water in these places are high due to use of air coolers, air conditioners, sprinkling of water in lawns, more washing of clothes, bathing etc. In cold places, the quantity of water required is less.

2. Size of Community

The per capita demand of town increases with the size of town, because much water will be required in street washing, running sewers, maintenance of parks and gardens.

3. Class of Consumer

High-class families consume much water due to their better living standard. They use water for air conditioners, room coolers, maintenance of lawns, use of flush latrine, etc. Middle class families consume less water as compared to higher-class families. For low-class families a single water tap may be sufficient.

4. Quality of Water

If the quality of water is good, a large quantity of water will be consumed. Since by using good, safe and wholesome water, the public find themselves safe against water borne disease.

5. Cost of Water

The cost of water affects its demand. Higher the cost of water, lower the demand and lower the cost of water, higher the demand, if all other conditions remain the same.

6. System of Sanitation

The per capital demand of the towns having water carriage system will be more than the town where this system is not being used.

7. System of Water Supply

There are two types of water supply system; continuous and intermittent. In continuous system, water is supplied for 24 hours. While in intermittent system, water is supplied for limited hours only. The amount of water used in continuous system is more than in the intermittent system due to carelessness of the consumers.

8. Metering or non-metering System

Water supply schemes having non-metering system requires more water than metering system due to more wastage of water.

3.4 Population Forecast

Methods of population forecasting

The following are the standard methods used to forecast the population of an area.

1. Arithmetical increase method
2. Geometrical increase method
3. Incremental increase method

1. Arithmetical Increase Method

This is the simplest method of population forecast. In this method, the increase in population from decade to decade is assumed constant. From the census data of past3 to 4 decades, the increase in population for each decade is found, and from that, an average increment is found.

Following Expression is used to forecast the population by this method.

$$P_n = P_o + nI$$

Where

P_n = Future population at the end of n decades

P_o = present population

I = average increment for a decade

2. Geometrical Increase Method

This method is based on the assumption that the percentage increase in population from decade to decade remains constant. From the population data of the previous threeor four decades, the percentage increase in population is found and its average is determined. In this method, population is forecasted by using the following formulae.

$P_n = P_0(1+r/100)^n$

Where,

P_n = Future population at the end of n decades

P_o = present population

I = Average percentage growth of population per decade

3. Incremental Increase Method

This method combines both the arithmetic increase method and geometrical increase method. From the census data for the past several decades, the actual increase in each decade is found. Then, the increment in increase for each decade isfound. From these, average increment of the increase is found.

In this method future population at the end of n decades is given by,

$P_n = P_0+nI+n(n+1)/2*y$

P_n = Future population at the end of n decades

P_o = Present population

I= Average increase per decaden = Number of decades

Y = Average incremental increase

3.5 Demand Calculation

Water demand calculations require the following two pieces of data.

1. Water consumption rate (per capita demand in liters per day per head)
2. Population to be served.

After computations of population to be served and water rate of water consumption (i.e. Per capita demand) the water demand of city/town is calculated as

Water demand = Per capita demand × Population to be served

Exercises

Choose the correct answer from the given alternatives.

1. Which is the value of domestic demand rate generally taken in calculating domestic demand of a urban area of Nepal?

   a. 25 lpcd b. 45 lpcd c. 65 lpcd d. 112 lpcd

2. Which is the value of domestic demand rate generally taken in calculating domestic demand of a rural area of Nepal?

   a. 25 lpcd b. 45 lpcd c. 65 lpcd d. 112 lpcd

3. For designing of distribution systems in Nepal, the peak factor is taken as …

   a. 2 b. 4 c. 2 to 4 d. 20

4. Which of population forecasting is followed in the design of rural water supply schemes of Nepal?

   a. Arithmetical b. Geometrical

   c. Incremental increase d. Logistic curve

5. Livestock demand greater than …% of domestic demand are not taken in the design of a rural water supply project in Nepal.

   a. 25 b. 20 c. 65 d. 112

Write short answer to the following questions.

1. Define population forecasting? Why is it necessary?

2. How does a sanitation system effect on water demand?

Write long answer to the following questions.

1. Discuss the factor affecting water demand in a water supply scheme.

2. Determine the population of the town in the year 2109 from different methods. The census population of the city is as follows:

Year B.S.	2034	2044	2054	2064	2074
Population(Nos)	45500	49000	53000	57000	59500

3. For a city having a population of 200000 numbers, calculate the fire demand from various formulas.

Project works

1. Forecast the population for a ward of your village by arithmetic increase method.
2. Calculate the demand of water for the above population.

Unit 4 : Quality of Water

Introduction

Quality of water refers to the chemical, physical, biological and radiologicalcharacteristics of water. It is a measure of the condition of water relative to the requirements of human need or purpose. Condensation of water vapor makes rainfall,but this water initially is pure containing two parts of hydrogen and one part of oxygen only by volume. On the way of falling, it absorbs different gases, dust and other impurities. Also, during surface runoff, the water carries a large number of impurities such as silt, organic, non-organic minerals, suspended matters, etc. while moving on earth's surface. These substances not always be harmful but may beuseful to human life.

The water we drink should not create any problem. In this unit concept of wholesome water and requirements of safe water will be discussed. Water becomes polluted due to different types of impurities, and the disease-causing organisms survive in these impurities. Preventive measures are needed for not to suffer from those diseases. Hence, different types of impurities, types of living organisms surviving there, and the preventive measures will be discussed in this unit. The diseases related to water are categorized in four types and there are different transmission routes for causing water related diseases which are also discussed in this unit.

4.1 Characteristics of Safe Water

The water will be safe if it has following characteristics:

- it should be free from bacteria and other pathogenic organisms
- it should be Colourless and odor free
- it should be tasty and cool
- it should not corrode pipes
- it should be free from iron, manganese, lead, arsenic and other poisonous metals and objectionable gases
- pH should be balanced. For drinking purpose pH value ranging from 6.5 to 8 is allowable

- if it is soft, washing of becomes easy
- it should contain dissolved oxygen
- if water contains some chemicals which are not harmful to health, then that water is called wholesome water

4.2 Water Pollutants and Their Effects on Health

Water becomes polluted if it contains impurities like suspended impurities, colloidal impurities and dissolved impurities. Impurities may contain living organisms like viruses, algae, worms, bacteria, etc. Contaminated or polluted water isthe water from rivers, lakes and seas that have become impure by fertilizers, pesticides, sewage, oil or toxic waste from households, lands, ships and factories.

Impurities in Water

All undesirable substances contained in water in any form are called impurities in water. The following are the types of impurities.

Suspended Impurities

The suspended impurities in water are because of the presence of bacteria, algae, clay, silt etc. These are those impurities or pollutants which remain in suspension. Some types of bacteria cause diseases. Suspended impurities cause turbidity in water. Besides turbidity, presence of algae, protozoa may cause odour and Colour.

Colloidal Impurities

These impurities are small and cannot be seen with the naked eye. They remainin continuous motion. They are materials generally containing organic matters containing bacteria. Their size is between 10^{-3}mm to 10^{-6}mm. The organic matters may be vegetable waste, dead animals etc. which produce harmful disease germs.

Dissolved Impurities

Water being a good solvent some solid, liquid and gas get dissolve in the water when they move over the rocks and soil, etc. because water is a good solvent. Organic compounds, organic salts and gases that dissolve render bad taste, hardness and alkalinity to water. the concentration of these impurities is measured in ppm or mg/liter.

Alkalinity in Water

When PH value of water is more than 7, it is said to be alkaline. If PH is 14 it indicates maximum alkalinity in water. Generally, alkalinity is caused by hydroxides, carbonates

and bicarbonates but most natural alkalinity is due to bicarbonates. Alkalinity caused by hydroxides is called hydroxide alkalinity or caustic alkalinity, caused by carbonate is carbonate alkalinity and caused by bicarbonate is called bicarbonate alkalinity. Mostly drinking water is alkaline due to sweeping of salts during the flow and decaying of organic matter in water. Alkaline water is harmful if taken directly for public water supply. The drinkable rangeof PH of water is in between 6.5 to 8.

4.3 Water Related Diseases, Causes and Prevention

Some diseases are due to consumption of impure water, some are due to infection transmitted through aquatic animals and pathogens, some are transmitted through biting of mosquitoes, and some are due to lack of sufficient water or cleanliness. They can be categorized into the following types.

4.3.1 Water Borne Disease

The diseases caused due to consumption of impure water are known as water borne diseases. Their spacing is due to chemicals in water or presence of micro-organism in water. Hence, for the prevention of water borne disease, water should be free of germs and it should be made wholesome, or it should be drinkable. Examples of water borne diseases are cholera, typhoid, paratyphoid, diarrhea, dysentery etc.

4.3.2 Water Based Disease

Disease or infection transmitted through aquatic animals and pathogens which spend their lifecycle in water is called water-based disease. For the prevention of this type of water related disease, we should avoid the collection of rainwater and dirty water near to our vicinity. Water bodies near to our living place should be clean. Moreover, we should not be in contact of dirty water where these is the possibility of disease-causing animals and pathogens. Common diseases to this group are bilharzia, guinea worm, lung flukes, schistosomiasis, etc.

4.3.3 Water Vector Transmitted Disease

It is most commonly transmitted through biting of mosquitoes that breed; those are developed near water bodies. We should avoid the collection of rainwater and we should not make the nearby water bodies dirty. Diseases in this group are malaria, yellow fever, dengue, sleeping sickness, filariasis, etc.

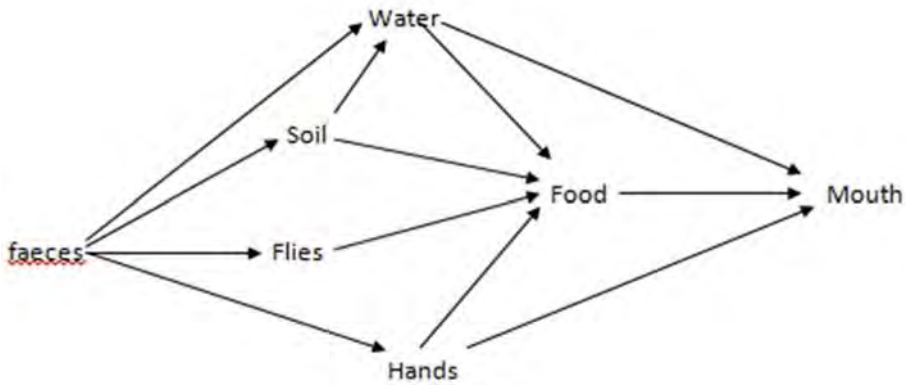
4.3.4 Water Washed Disease

This disease is also called water hygiene disease. It is caused the due to lack of

sufficient water or cleanliness. Common diseases in this group are trachoma (eye inflammation), scabies, fungal infection, lice infection, etc. For prevention, awareness and quantity of water should be increased.

4.4 Transmission Routes

Water is one of the means of transmission of various diseases formed. The major diseases that are responsible for most of death in developing countries are form of fecal-oral group. Fecal oral infections may be water born and water washed. Organisms from the urine and faeces reach the water sources mainly from sewage disposal, and then, this water is transmitted in the human body orally from the food or contaminated water. This transmission is called faecal-oral transmission. The pathways of faecal oral transmission are as shown below.



Faecal oral transmission

4.5 Preventive Measures

Following are the preventive measures for the transmission of diseases through the faecal oral way.

- proper arrangement of faeces should be done by making and using toilets. It should be prevented from mixing with water.
- hand cleaning should be done properly before a meal, after work and after the toilet.
- food and water should be kept covered.
- there should be arrangement of water supply in sufficient amount.
- there should be awareness development programs to make people aware of their health and hygiene.

4.6 Drinking Water Quality Standard (WHO, GoN)

As per GoN guidelines, 2079

SN	Parameter	Unit	Maximum Concentration	Remark
Physical parameter				
1	Turbidity	NTU	5	NHBGV
2	pH		6.5-8.5	NHBGV
3	Colour	TCU	5	NHBGV
4	Taste and Odor		Should not be offensive	NHBGV
5	Electrical Conductivity	uS/cm	1500	NHBGV
Chemical Parameter				
6	Iron	mg/L	0.30(3)	NHBGV
7	Manganese	mg/L	0.2	NHBGV
8	Arsenic	mg/L	0.05	NHBGV
9	Flouride	mg/L	0.5-1.5 (min-max)	HBGV
10	Ammonia	mg/L	1.5	NHBGV
11	Chloride	mg/L	250	NHBGV
12	Sulphate	mg/L	250	NHBGV
13	Nitrate	mg/L	50	NHBGV
14	Copper	mg/L	1	NHBGV
15	Zinc	mg/L	3	NHBGV
16	Aluminium	mg/L	0.2	NHBGV
17	Total Hardness	mg/L	500	NHBGV
18	Residual Chlorine	mg/L	0.1-0.5(3min-max)	HBGV(for system with chlorination only)
Microbiological Parameters				
19	E.Coli	CFU/100ml	0	HBGV

Note:

HBGV Health Based Guideline Value

NHGBV Non-Health Based Guideline Value

As per WHO guidelines

Summary in table format, based on the WHO's most recent report, focusing on key parameters and their recommended limits:

Parameter	WHO Guideline (mg/L)	Notes
Arsenic	0.01	A naturally occurring toxic metalloid
Cadmium	0.003	A toxic heavy metal
Chromium (total)	0.05	Can be carcinogenic
Lead	0.01	A toxic heavy metal
Fluoride	1.5	Excessive levels can cause dental and skeletal fluorosis
Nitrate (as NO_3)	50	Can cause methemoglobinemia in infants
Nitrite (as NO_2)	3	Can cause methemoglobinemia in infants
pH	6.5 - 8.5	Affects taste and corrosiveness of water
Turbidity	5 NTU (or 1 NTU for treatment)	Measures water clarity, can affect disinfection
E. coli	0 CFU/100 mL	Indicates fecal contamination
Total Coliforms	0 CFU/100 mL	Indicates possible fecal contamination

4.7 Water Sampling and Storing

For carrying out physical, chemical or biological test of the water, first the sample water is collected. The collection of water follows some simple rules which when not taken into account may vary the result. The water should be collected in such away that it represents the whole water from that source.

The following are the points to be remembered for collecting and storing water

samples.

- in the case of rivers, streams, lakes water the surface water should be avoided because it contains suspended matter, so the water should be collected from 40 to 60 cm below the surface.
- for the ground water, sufficient quantity of water should be pumped out so that floating matter can be removed.
- after the sampling is done the sample water should not be stored for a long time, especially for the biological test. The test should be performed within 24 hours and the water should be kept in a cool place.

4.8 Physical Analysis

1. Temperature

2. Colour

3. Turbidity

1. Temperature

Density, viscosity, vapor pressure and surface tension of water depends upon its temperature. Chemical, biochemical and biological activity also depends upon temperature of water. Too cold and too hot water is not desirable for drinking purposes. It also plays a vital role in designing different components of water supply. It is determined in lab using ordinary or digital thermometers. It is measured either in degree Kelvin (°K) or degree Celsius (°C) or degree Fahrenheit (°F). For drinking purposes, temperature of water between 4.4°C to 10°C is good, greater than 25°C is undesirable and greater than 35°C is unfit.

2. Colour

Colour in water is defined as the state of water to absorb light. Colour in water is due to presence of dissolved organic matters, colloidal matters, natural metallic ions (iron and manganese), peat (decayed vegetable matter), weeds, humus, plankton, mineral, industrial wastes etc. It makes water objectionable in appearance and disliked by people. It may spoil clothes and affect the industrial process. It is measured in terms of platinum-cobalt scale in mg/l or ppm. Colour obtained by the mixture of 1 mg of platinum cobalt in 1 liter of distilled water represents 1 mg/l of Colour in platinum cobalt scale. Sometimes, it is also expressed in degree Hazen (°H). The mixture of 1.245 g potassium chloroplatinate and 1 g of cobalt chloride in 1 liter of distilled

water represents the Colour of 500°H.

Pure water is Colourless. The Colour of water is not harmful but aesthetically objectionable. So, Colour of drinking water should not be greater than 5 mg/l in platinum cobalt scale, greater than 5 mg/l is tolerable and greater than 25 mg/l is rejected. Colour can be removed by sedimentation, filtration, aeration and use of chemicals.

3. Turbidity

Turbidity is defined as the measure of the degree of clarity of water. It is caused due to suspended matters (clay, silt, finely divided organic and inorganic matters etc.), other organic and inorganic matters, plankton, vegetable fibers, algae, microorganisms etc. It makes water muddy, cloudy and unattractive. It also makes filtration process difficult and costlier.

It is measured in terms of silica scale in mg/l or ppm. Turbidity obtained by the mixture of 1 mg of silica in 1 liter of distilled water represents 1 mg/l of turbidity in silica scale. It is also expressed in Jackson's Turbidity Unit (JTU), Baylis Turbidity Unit (BTU), Nephelometric Turbidity Unit (NTU), Formazine Turbidity Unit (FTU) and Formazine Nephelometric Unit (FNU) depending upon the method and instrument used. In general, turbidity of drinking water should not be greater than 5 mg/l in silica scale, up to 10 mg/l is tolerable but greater than 25 mg/l is rejected. It can be removed by sedimentation, chemical aided sedimentation, filtration, etc.

Various instruments used to measure turbidity of water are as follows:

1. Turbidity rod
2. Jackson's turbidimeter
3. Baylis turbidimeter
4. Hellige or Aplab turbidimeter
5. Digital turbidimeter or nephelometer

Among them, turbidity rod is used directly in the field. Other three are commonly used in lab except digital turbidity meter may be used in both lab or field. Digital turbidity meter is very common nowadays due to its high precision and ease in measuring turbidity value of water. So, it is described here.

Digital turbidimeter or nephelometer is the portable turbidimeter. It can be used both

in lab or field. It gives turbidity value directly in digital display after its calibration with the standard turbidity solutions. Its photographic view is shown in figure 4.3. There are several types of commercially available nephelometers with different procedures. But all of them works on a same principle. When a beam of light is passed through the water sample placed in the instrument, the suspended matter scatters the light. This scattered light is received on the photoelectric cell and amplified to the electronic pulse and read directly in the digital display. It is precise in the range of 0 to 1 NTU.

4. Taste and Odour

Taste of water may be pleasant, bitter, salty, sour, sweet etc. and odour may be unpleasant, earthy, fishy, grassy etc. Both are due to presence of dissolved gases, salts, organic matters, chemicals minerals, suspended particles, aquatic life etc. in water.

Taste is measured by flavour threshold test. It is expressed in flavour threshold number (FTN). Odour is measured by threshold odour test. It is expressed in terms of threshold odour number (TON). The drinking water should not have undesirable and objectionable taste and odour. FTN and TON should not exceed 3, preferably 1. Undesirable and objectionable taste and odour can be removed by aeration and chemical treatment of water.

4.9 Chemical Analysis

The analysis of parameters (total solids, pH, hardness, alkalinity, chloride, chlorine, dissolved oxygen etc.) of water after their examination is called as chemical analysis of water.

Among them, we are only concerned with the following chemical analysis of drinking water:

1. **Total Solids**
2. **pH or hydrogen ion concentration**
3. **Chlorine Content**

1. Total Solids

Total solids (TS) represent the sum of the total dissolved solids (TDS) and total suspended solids (TSS) present in water. These solids present in water are expressed in mg/l or ppm. TDS should not be greater than 500 mg/l, greater than 500 mg/l is

tolerated but greater than 1500 mg/l in water is rejected for human consumption. Determination of solid content is useful in the design of different treatment units. In lab, the solids are determined as follows:

a. take volume 'V' ml of well mixed water sample (generally 100 to 300 ml) in a clean and dry crucible of weight 'W_1' mg.
b. evaporate it to dryness in a Bunsen burner.
c. keep it in an oven at 103 to 105 °C for 30 minutes and cool it in the desiccator with CaCO3 for 10 minutes.
d. take out the crucible and take its weight (W2) in mg, Then, calculate total solids by:

   TS= (W_2-W1)/V×1000 mg/1

2. Determination of Total Dissolved Solids (TDS)

a. take volume 'V' ml of well mixed water sample (generally 100 to 300 ml) and filter it through the Whatman filter paper no 44 in a clean and dry crucible of weight 'W1' mg.
b. evaporate the filtrate to dryness in a Bunsen burner.
c. keep it in an oven at 103 to 105 °C for 30 minutes then cool it in the desiccator with CaCO3 for 10 minutes.
d. take out the crucible and take its weight (W2) in mg, Then, calculate total dissolved solids by:

   TDS= (W2-W1)/Vx1000 mg/1

3. Determination of Total Suspend Solids (TSS)

TSS is generally determined after determination of TS and TDS as stated in 1 and 2 and calculated by:

TSS= TS -TDS (in mg/l)

2. pH or Hydrogen Ion Concentration

pH is defined as the negative logarithm of hydrogen ion concentration. It is the measure of degree of acidity or alkalinity.

A pH value of 7 represents neutral (neither acidic nor alkaline). A decrease of pH value from 7 to 0 represents the increment in acidity. An increase of pH value from 7 to 14 represents the increment in alkalinity.

Pure or neutral water has a pH value of 7. The lower value of pH (acidic) in water causes corrosion. Its higher value (alkalinity) may produce sediment deposition and make chlorination difficult. pH value of water is useful in selecting treatment methods and process control activities.

A pH value of 6.5 to 8.5 is accepted and less than 6.5 or greater than 9.2 is rejected in public water supply. The pH value of water can be measured by:

i. Colourimetric

ii. Electrometric Method

i. Colourimetric Method

In this method, pH indicator paper is dipped in water or some chemical reagent or indicator (such as methyl orange, methyl red, bromophenol blue, phenol red, etc.) is added to the water sample. The colour produced is then compared with the colour tubes, glass discs, charts, etc. supplied by the manufacturers and pH is estimated. It is the less précised method.

ii. Electrometric Method

In this method, the pH of water is measured by potentiometer Dol it in called as digital pH meter. Several types of digital pH meters are available in the market and the procedures may differ but the principles are same. First of all, it is calibrated by dipping its electrode into different buffer solutions of known pH. Then, it is immersed in the water sample to read pH value of the sample in its digital display.

3. Chlorine Content

Chlorine is applied in water to kill pathogens. It is also consumed in satisfying organic matters present in water. The amount of free chlorine remained in water after its application is as called residual chlorine. But some residual chlorine in water is required to prevent recontamination. The chlorine content in water is determined from titration of sample with standard hypo solution using potassium iodide as an indicator. Concentration of chlorine greater than 0.3 ppm is felt by some people but its taste threshold limit is 5 mg/l. So, to prevent recontamination, 0.02 to 0.5 mg/l of residual chlorine content is desired after 15 to 30 minutes of application of chlorine.

Exercises

Choose the correct answer from the given alternatives.

1. When water contains electrically charged particles, the contaminants is called as …

   a. Suspended b. Colloidal c. Dissolved d. Undesirable

2. The diseases caused due to flies and mosquitoes ……. Diseases.

   a. Water borne b. Water washed c. Water based d. Water vector

3. What is the most desirable temperature for drinking water?

   a. 3.5 to 5.5^0C b. 5.2 to 7.5^0C c. 4.4 to 10^0C d. 7 to 9.5^0C

4. What is the maximum value of acidity?

   a. 0 pH b. 5 pH c. 7 pH d. 14 pH

Write short answer to the following questions.

1. How can you determine total solids in lab?
2. Define the following terms: Examination of water, Turbidity, Total solid, pH

Write long answer to the following questions.

1. What are the requirements of safe water?
2. Explain water washed diseases and its preventive measures.
3. Write short notes on: suspended impurities, colloidal impurities, dissolved impurities, chlorine content, taste and odour

Project works

1. Survey the water related diseases in your community with their possible route of transmission and recommend prevention plan for them.
2. Determine physical parameters (Colour, turbidity, temperature).
3. Determine pH value.

Unit 5 : Treatment of Water

Introduction

In this unit, different types of impurities and how these impurities could be removed are discussed. In order to remove the impurities in the water, the water needs to be treated. These are different types of treatment of water.

5.1 Need of Water Treatment

Raw water may contain suspended, colloidal and dissolved impurities. The purpose of water treatment is to remove all those impurities so as to make it suitable for drinking and other household purpose. Water needs to be treated in order to:

- reduce the objectionable colour, odour, turbidity, hardness and taste
- kill pathogens harmful to human health
- make water safe and potable for drinking
- eliminate corrosive nature of water to avoid corrosion of pipes and boilers
- make water suitable for a wide variety of industrial purpose
- remove harmful gases dissolved in water

The types of treatment of water are as follows:

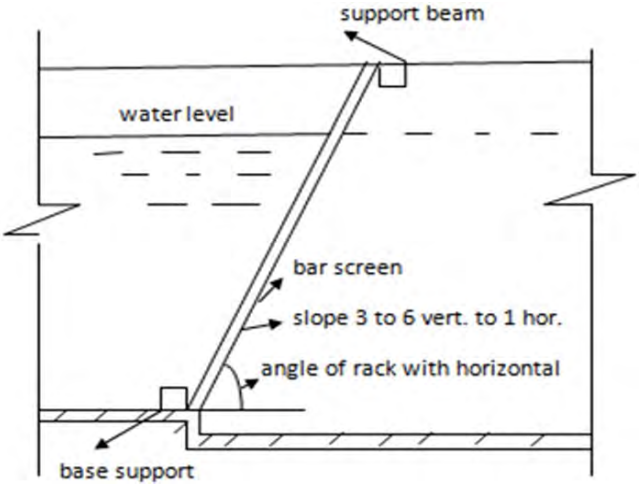
5.2 Screening

The process followed by passing water through screens to remove large suspended matters like sticks, branches of tree, leaves, dead animal body, pebbles, ice, etc. and other small suspended matters is called screening.

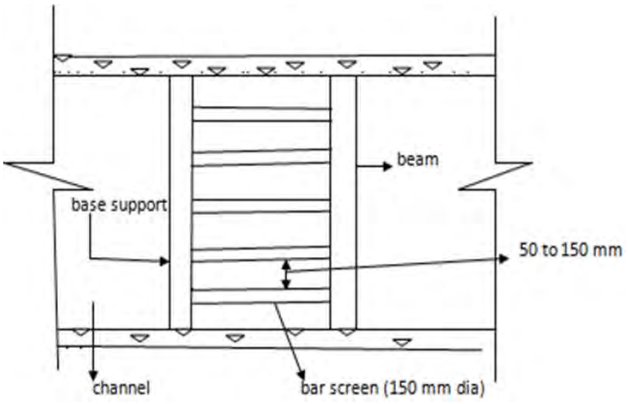
Two types of screens are used for the process of screening:

Coarse Screen

Coarse screens are generally placed in front of the fine screens at the inlet to remove large suspended and floating matters from surface sources. These screens are generally called trash rack or bar screen and, they consist of bar grills of 25 mm diameter. If openings are of 50mm to 150mm, it is called as coarse screen; and if it is 20mm to 50mm, it is called medium screen. Mostly bar screens are kept inclinedso that they can be cleaned easily with a rake and to increase the flow area of the water. The slope of inclined bars is 3 to 6 verticals to 1 horizontal. The bars are supported at the bottom by base support and by support beam at the top.



Section of bar screen (trash rack)

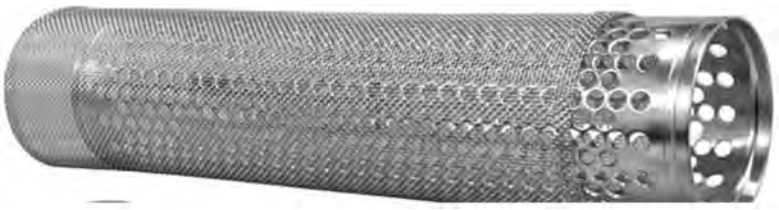


Plan of bar screen (trash rack)

Bar screen (trash rack)

Fine Screen

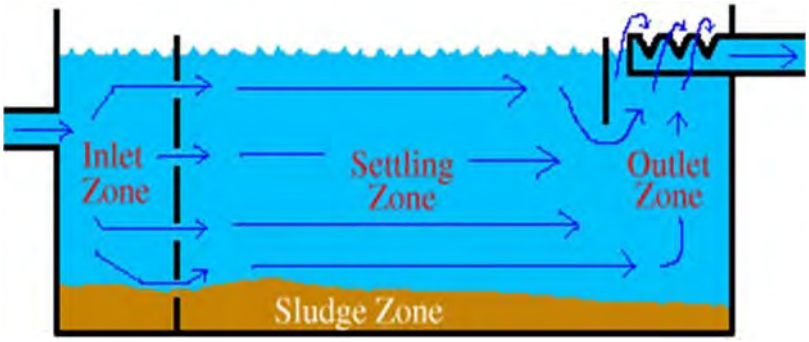
It is used to remove smaller suspended impurities at the surface or ground water intakes, sometimes alone or sometimes following a bar screen. Fine screens are usually drums perforated with holes of about 6mm diameter and called drum strainers. Fine screens normally get clogged and are to be cleaned frequently. So, they are avoided nowadays because surface intakes and fine particles are separated in sedimentation.



Fine or perforated screen

5.3 Sedimentation

This is the process to make suspended particles settle down in a tank and make achieve purer water from the downstream side of the tank or directly from the upper part of the tank. Sedimentation can remove suspended particles such as silt, sand, clay etc. It reduces the load in subsequent treatment plants. This also reduces the clogging of pipes and also reduces the load in pipes and fittings.



A sedimentation tank is ideal if the length and depth of tank is enough to settle down all moving suspended particles in its way, and the breadth is also enough to contain the whole discharge.

Types of Sedimentation Tank

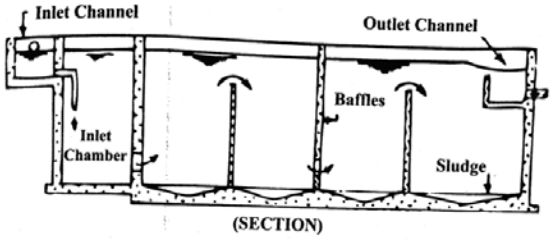
a. Fill and Draw Type Sedimentation Tank

This tank is normally rectangular in plan. The water is first filled and then allowed to some detention period of normally 24 hours for sedimentation of particles. The clear

water is drawn from outlet and the tank is then made empty and cleaning of sediment is done. After cleaning, again the filling and emptying process is repeated.These tanks need long detention period, more labor and supervision.

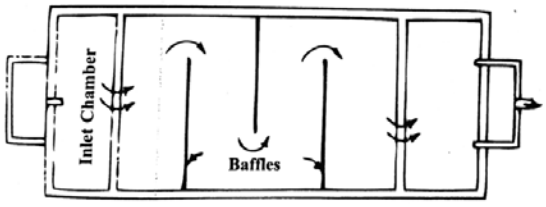
b. Continuous Flow Type Sedimentation Tank

In continuous flow type sedimentation tank, raw water is continuously admitted into the tank and allowed to flow slowly in the tank during which the particles in suspension settle down and clear water flows out continuously from the tank. These tanks work on the principle that by reducing the velocity of flow of water, a large number of suspended particles present in water can be made to settle down.



(SECTION)

(a) UP AND DOWN BAFFLE TANK



PLAN

(b) AROUND THE END BAFFLE TANK

c. Continuous Flow Sedimentation Tanks

Continuous flow sedimentation tanks should have sufficient length of travel for water in tank. Further, the velocity of flow of water in these tanks is so adjusted that the time taken by a particle of water to move from inlet to outlet is slightly more than that required for settling of a suspended particle in water. The continuous flow type sedimentation tanks may be rectangular, square or circular in shape.

5.3.1. Sedimentation with Coagulation

If sedimentation is done by adding certain chemicals to accelerate settling of fine suspended particles as well as to allow settling of colloidal particles, then it is known as sedimentation with coagulation. Very fine suspended clay particles are not removed by plain sedimentation explained earlier. Particle of 0.06 mm size requires

10 hours to settle in 3 m deep plain sedimentation, and 0.002 mm particle will require 4 days for settling. This settling time is spacing impracticable. Therefore, we need sedimentation with coagulation. Colloidal particles being charged particles and in continuous motion do not get sediment in plain sedimentation. The detention time required in sedimentation with coagulation will greatly reduce. The size of tank required is also smaller. In rural water supply projects, it is not feasible to apply chemicals regularly, but in urban water supply system sedimentation with coagulation may be necessary.

It removes fragments of animal and vegetable matters, plankton, finely divided matter including colloidal matter, organic Colouring matter, some bacteria and viruses and also turbidity, odour and taste producing substances.

The following steps prevail for the process of sedimentation:

a. Feeding of Coagulant

Coagulant may feed to water in dry or wet form known as dry feeding or wet feeding. Wet feeding means feeding after making solution.

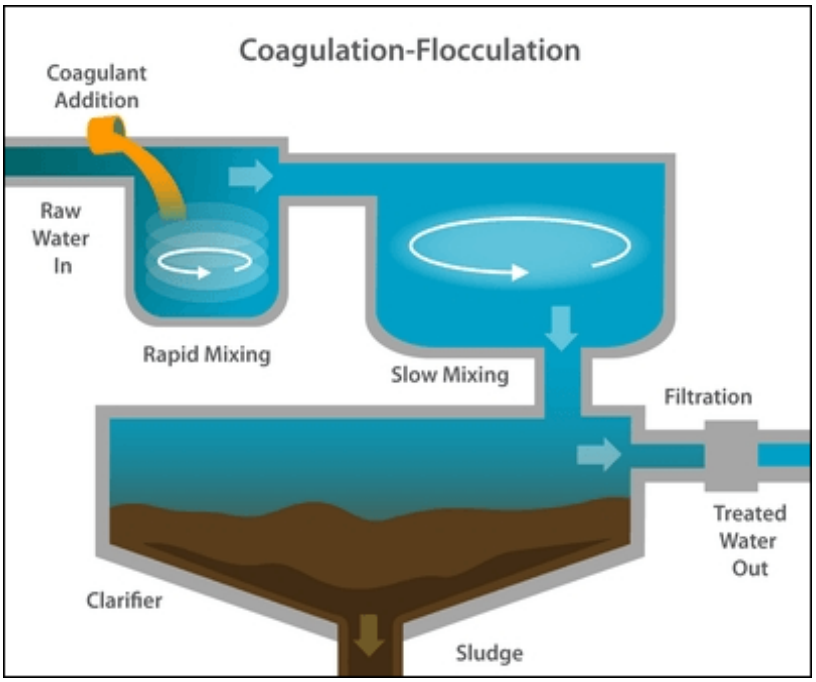
b. Mixing of Coagulant, Flocculation and Sedimentation

After the addition of coagulants to raw water it is thoroughly (whole part) and vigorously (with great speed) mixed so that the coagulants get fully dispersed into the entire mass of water. For mixing process, basins with baffle walls are used. These basins may be horizontal or vertical with proper arrangement of baffle walls. The disturbance created by the presence of baffle walls in the path of flowing water cause vigorous agitation of water, which thoroughly mixes water with coagulant. These coagulation tanks can be constructed in the same way as that of plain sedimentation tanks. These tanks are thus divided into many chambers where the flocculation also takes place, and the water is passed to the deeper sedimentation tank where flocs are settled down and treated water can be taken from outlet to pass to the filtration chamber.

Alternatively rapid mixing of coagulant is done in a basin at the entrance of raw water after addition of coagulant. Mixing is done mechanically with vertical shaft and horizontal blades. Then, water from top of the tank is taken to another slow mixing tank with similar type of blades arrangements, but, of larger sizes. Water from bottom of the slow mixing basin passes to the clarifier where the sludge or the large particles formed with coagulants settle at the bottom and treated pure water

passes from the outlet. Treated water is commonly taken to filtration tank for further treatment.

The amount of coagulant required is 40% less in the mechanically operated coagulation basins because of vigorous agitation. But the initial cost in the baffle type is less.



Sedimentation with coagulation

5.4 Filtration

The process of passing the water through a bed of filtering media is called filtration. Sedimentation process removes the large particles only which can settle down at the bottom. There are some particles which never settle down; and thus for removing such particles, bacteria, colour, dissolved minerals, filtration is used.

Theory of Filtration

a. Mechanical Straining

It states that the larger particles cannot pass through the pores in between sand. The pore size continuously become smaller due to use and hence the smaller particles are also checked in the sand layer. The floc which does not settle in the coagulation tank is checked by the layers of filtering media in the filter.

b. Sedimentation

The interstices between the sand grains act as a small sedimentation tank where the suspended matters and very small particles like bacteria and colloidal particles settle.

c. Biological Action

The organic impurities in the water become food for the micro-organisms. These micro-organisms decay the organic matters and form a layer at the top of sand bed which is called dirty skin. Micro-organism feeding on the dirty skin remains at the top layer and act on the incoming organic matters.

d. Electrolytic Action

As per ionic theory, when two substances of opposite charges come into contact, the charge is neutralized and in doing so, new chemical substances are formed. Sand particles in filter media also have charges of some polarity which attracts the suspended, colloidal and dissolved matters of opposite polarity. In neutralizing new, heavy chemicals are formed which settle down. After a long use charge in sand grains get exhausted by coating of new chemicals and thus it becomes necessary to clean filter for regeneration of charges

Types of Filters

There are three types of filters which are classified according to design and time period required for filtering water. They are classified as slow sand filter, rapid sand filter and pressure filter.

(i) Slow Sand Filter

This filter is called slow sand filter because rate of filtration is slow in this filter. Bed cleaning needs a lot of labor and hence this filter has high maintenance cost.

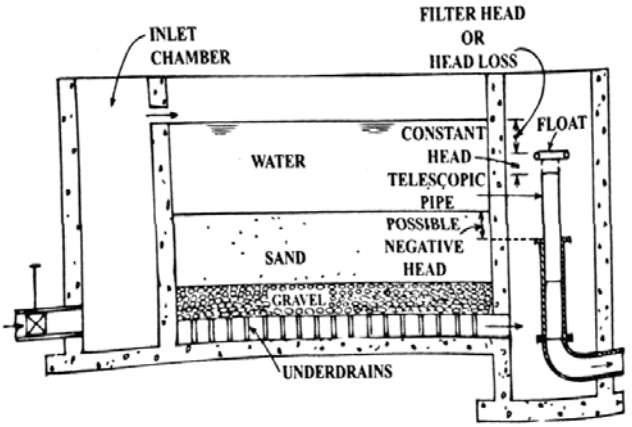
Filter Media for Slow Sand Filter

- It consists of 90 to 110 cm thick sand layer with size of sand 0.25 to 0.35 mm. Finer the sand, better will be the removal of turbidity and bacterial removal efficiency but lowers the filtration rate.
- The sand layer is supported on base material of 30 to 75 cm thick gravel bed. Gravel bed has four layers with 3 to 6 mm, 6 to 20 mm, 20 to 40 mm and 40 to 65 mm size gravel. Each layer is about 15 cm thick.

Working and Cleaning of Slow Sand Filter

Water from sedimentation tank enters the filter through inlet, then it passes through filter

media (sand and gravel) The purified water is collected from under the filter media and comes out of the outlet to clear water reservoir. The top layer of sand is scrapped after long use and washed to reuse. Cleaning of slow sand filter is done after 1 to 3 months.

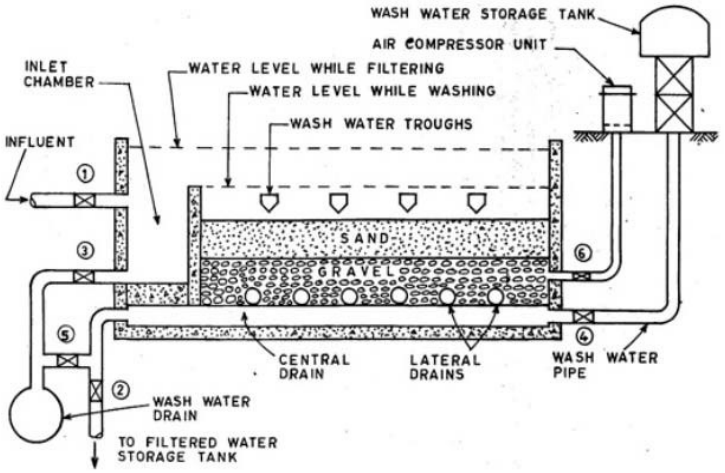


Slow sand filter

(ii) Rapid Sand Filter

Filter Media For Rapid Sand Filter

- This filter is free Free from dirt and clay, it consists of filter media consisting of 60 to 90 cm thick sand layer with effective size of sand 0.35 to 0.60 mm.
- The sand layer is supported on the base material of 45 to 60 cm thick gravel bed. There are four layers for gravel beds each layer with maximum 15 cm thick. These layers have gravel size of 2 to 6 mm, 6 to 12 mm, 12 to 20 mm and 20 to 50 mm from the top.



Rapid sand filter

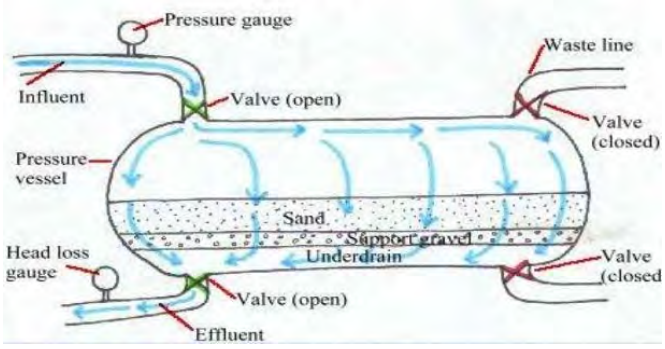
Working of Rapid Sand Filter

- water to be filtered or the influent enters through the inlet chamber from valve
- the water valve 3 has to be turned off when the water enters
- water from the inlet chamber overflows to the main chamber
- water infiltrates through sand layer and gravel layer and then becomes filtered
- this filtered water is captured by lateral drains
- water from lateral drains passes to central drain, and then it is taken to filtered water storage tank. In doing so, valve 2 is turned on and valve 5 turned in off
- the air compressor unit forces air to the gravel layer, and thus the pores inside it are created again
- after providing compressed air wash water is also collected by lateral drains and captured by central drain which passes through wash water drain. In doing so, valve 2 should be closed and valve 5 should be turned on
- to clean the central drain, water stored in wash water storage tank is used

Pressure Filter

Pressure filter is a rapid sand filter that consists of a closed steel cylindrical tank inwhich water is passed through pump under the pressure of 3-7 kg/cm^2 through pumping. Pressure is controlled with the help of a pressure gauge. Raw water with coagulant, commonly alum, is fed directly to this tank where coagulation also directly takes place inside it.

The raw water enters from inlet valve and passes through sand and gravel bed, and then it enters to central drain through lateral drains. The drain pipes are covered with a perforated steel plank through which filtered water from gravel media passes to the lateral drains and to the central drain.



Pressure filter

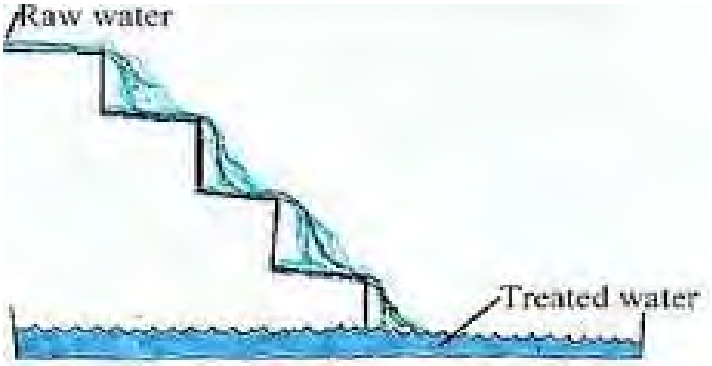
5.5 Aeration

Aeration is a method that is used to bring the water into contact with the atmospheric air so that oxygen is absorbed from air and the objectionable gases, odour, taste, etc. are released in atmosphere. Iron, manganese and other organic impurities are also removed by aeration. However, excessive aeration causes excessive oxygen absorption which further increases corrosion of pipes.

Methods of Aeration

Aerators can be categorized as gravity aerators, spray aerators and diffuse aerators. Gravity aerators can be further classified as cascade aerator, inclined aerator, salt tray aerator and gravel bed aerator.

Cascade Aerator

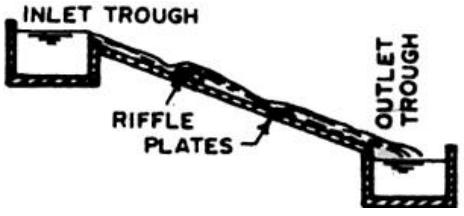


Cascade aerator

Water is allowed to fall 1 to 3 m height over a series of 4 to 6 concrete steps. Duringthis fall the water is mixed with air and gets aerated. It removes 20 to 45% carbon dioxide and 35% hydrogen sulfide.

Inclined Aerator (inclined apron with riffle plate aerator)

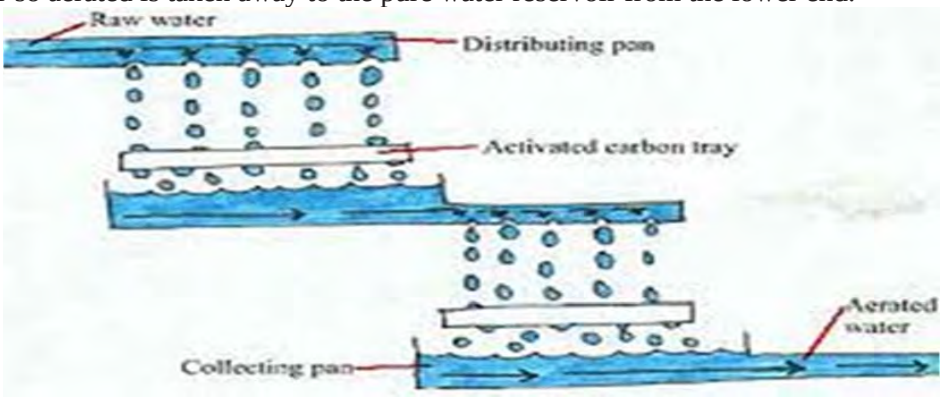
In this aerator, water is made to fall over the inclined plane with riffle plates. Riffle plates help to produce effervescence in water, and hence there is absorption of oxygen.



Inclined aerator

Salt Tray Aerator

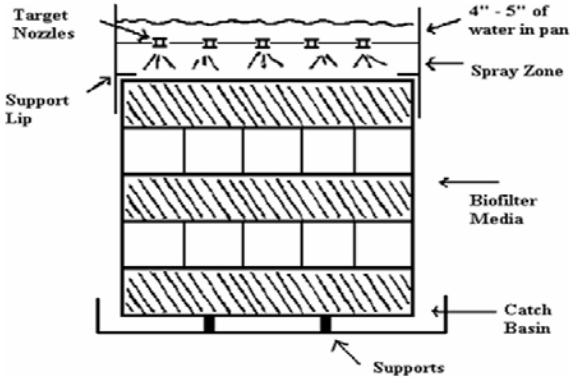
It consists of a cylindrical encloser containing wooden trays kept one above another with some vertical gap between them. The water falls through the trays absorbing oxygen. The water so aerated is taken away to the pure water reservoir from the lower end.



Tray aerator

Gravel Bed Aerator

In this method, the gravel is packed in a container, and the water is diffused from the top of the container onto the gravel. The aerated water is thus collected at the bottom of the container and collected from there.



Gravel bed aerator

5.6 Disinfection

Disinfection means to kill bacteria and microorganism which cause disease and make water safe for drinking.

Methods of Disinfection

There are different methods of disinfection the most common ones are as follows:

Boiling

Boiling water kills pathogenic bacteria and makes water safe to drink.

Treatment by boiling

Excessive Lime Treatment

Lime is usually used for reducing hardness of water. Excessive use of lime also disinfects the water.

Excess lime in water increases the PH value of water. If PH value increases to more than 9.5, all the bacteria are killed.

5.7 Water Softening

The characteristics of water which prevents the formation of lather with soap is called as hardness. Hardness is desirable in drinking water but not desirable in higher concentration for other use rather than health point of view. The process of treatment used to remove undesirable hardness in water is called water softening.

5.7.1 Removal of Temporary Hardness

The hardness in water produced mainly due to presence of bicarbonate of Mg and Ca called as temporary or carbonate hardness. It can be removed either by boiling or addition of lime.

5.7.2 Removal of Permanent Hardness

The hardness of water produced mainly due to the presence of sulphate, chloride and nitrates of Mg and Ca is called permanent or non-carbonate hardness. Removal of permanent hardness can be achieved by:

a. Lime soda process

b. Zeolite process

c. Demineralization process

Exercises

Choose the correct answer from the given alternatives.

1. Which of the following requires the addition of chemicals?

   a. Sedimentation b. Plain sedimentation

   c. Sedimentation with coagulation d. Plain coagulation

2. Efficiency of slow sand filters in removing bacteria is … %.

   a. 70 to 80 b. 80 to 90 c. 90 to 95 d. 98 to 99

3. The process of purifying water by passing it through a bed of fine granular material is called .....

   a. Filtration b. Agitation c. Aeration d. Bleaching

4. The process used to kill pathogens is called as .....

   a. Sterilization b. Disinfection c. Filtration d. Coagulation

Write short answer to the following questions.

1. What do you mean by aeration of water? Why is it required?
2. What is a filter? Enlist its types.
3. Explain the different types of aerators in brief.

Write long answer to the following questions.

1. Explain the working and cleaning of rapid sand filter with the help of sketch.
2. What are the factors affecting bacterial efficiency of chlorine?
3. Discuss the processes used in sedimentation with coagulation.

Project works

1. Demonstrate particle settling in quiescent sedimentation tank.
2. Demonstrate water filtration in a sand filter developed on a small scale.

Unit 6 : Distribution of Water

Introduction

The purpose of distribution system is to deliver water to consumer with appropriate quality, quantity and pressure. Distribution system is used to describe collectively the facilities used to supply water from its source to the point of usage. It is the network of pipelines inside the locality. The distribution system required the different large size mains, arterial mains of intermediate size and minor distribution together with valve, hydrant service connection, etc. In this unit, you will study about the requirement for water distribution, different water distribution system, and water reservoir and break pressure tank.

6.1 Requirements of Good Distribution System

The distribution system consists of a network of pipes for transporting water from purification plant to the consumer's tap. The distribution system includes pipes of various sizes, valves meters, pumps, distribution reservoir, hydrants, etc. Distribution systems are designed to satisfy the water requirements for domestic, industrial, commercial purposes.

The following are the requirements of a good distribution system:

a) the purity of water should be the same when it is reached to the consumers

b) the water should reach to every consumer with the required pressure head

c) a good distribution should be able to transport sufficient amount of water during emergency such as fire-fighting

d) it should convey the treated water up to the consumers with the same degree of purity

e) the system should supply water to the consumer's tap at reasonable pressure head, (not less, not excessive)

f) it should be easy for operation and maintenance

g) sufficient quality of treated water should reach for the domestic and industrial use

h) initial or construction cost must be minimum

i) during repair works, it should not cause obstruction to the traffic

j) it should be laid in proper way such that it causes minimum disturbance while maintenance

k) water should be available even during dry season

l) pressures should be great enough to adequately meet firefighting needs

m) at the same time, pressures should not be excessive because development of the pressure head brings important cost consideration. when pressure increases leakages increases too

Classification of Distribution System

Depending upon the method of distribution, distribution system can be classified as follows:

1. Gravity system
2. Pumping system without storage
3. Dual system(combined gravity and pumping system)

1. Gravity System

Gravity system of water supply is the system in which water flow under gravity without use of any external energy to deliver water from source to tap stand. When source of water is at sufficient height at that city/village, there is advantage the water can be distributed to the nearly town or village using natural gravity force only. No pumping of water is required in this system, and hence, more economic than pumping distribution system.

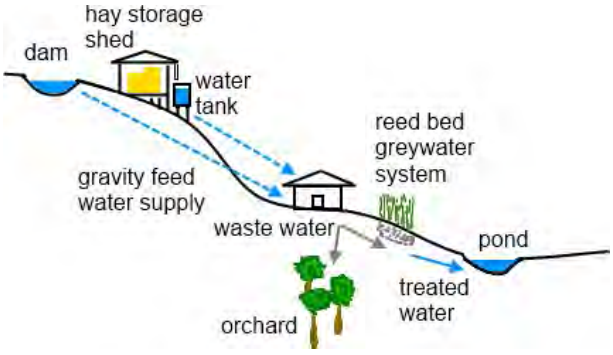


Fig: Gravity system

2. Pumping System Without Storage

In this system the pressure head is required to feed the water in the distribution system by pumping machine. This method of distribution is suitable when the source of supply is below the city or town. The disadvantage of this system is that if, power

fails the whole supply of town will be stopped, so it better to have diesel pumps in addition to electric pump.

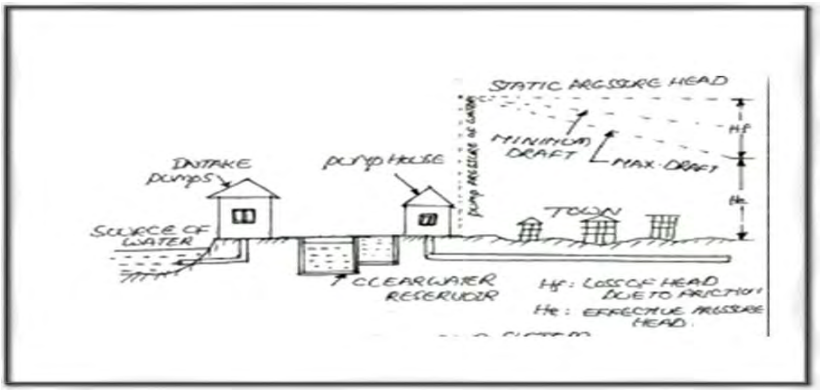


Fig: Pumping system without storage

3. Dual System (Combined Gravity and Pumping System)

Dual system is the combination of gravity and pumping system. This system is quite more effective than the pumping system without storage. In this system, the excess of water pumping during low consumption period was stored in the elevated tanks. And at the time of high demand of water, this tank will fulfill the peak demand. This method is most reliable, economical and convenient.

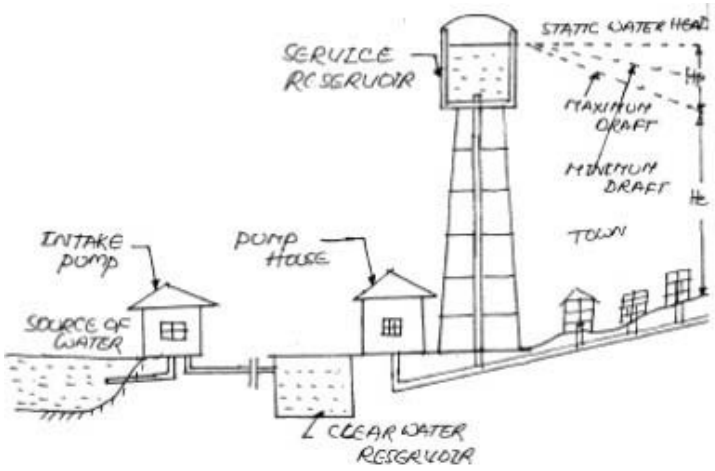


Fig: Dual system

Distribution Systems

a. Branching pattern with dead end.

b. Grid pattern.

c. Grid pattern with loop.

a. Branching Pattern with Dead End

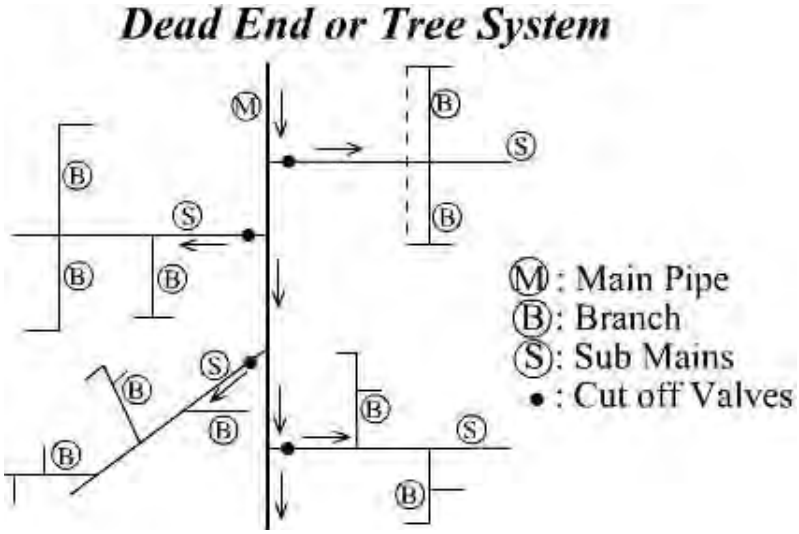


Fig: Dead End or tree system Similar to the branching of a tree. It consists of:

- main (trunk) line
- sub-mains
- branches

Main line is the main source of water supply. There is no water distribution to consumers from trunk line. Sub-mains are connected to the main line and they are along the main roads.

Branches are connected to the sub-mains and they are along the streets. Lastly service connections are given to the consumers from branches.

Advantages

- it is a very simple method of water distribution. Calculations are easy and simple to do
- the required dimensions of the pipes are economical
- this method requires comparatively a smaller number of cut-off valves

However, it is not usually favored in modern water works practice for the following disadvantages:

Disadvantages

- the area receiving water from a pipe under repair is without water until the work is

completed

- In this system, there are large numbers of dead ends where water does not circulate but remains static. Sediments accumulate due to stagnation of the dead end and bacterial growth may occur at these points. To overcome this problem, drain valves are provided at dead ends and stagnant water is drained out by periodically opening these valves, but a large amount of water is wasted
- It is difficult to maintain chlorine residual at the dead ends of the pipe
- Water available for firefighting will be limited since it is being supplied by only one water main
- The pressure at the end of the line may become undesirably low as additional areas are connected to the water supply system. This problem is common in many less-developed countries

b. Grid Pattern

In grid pattern, all the pipes are interconnected with no dead-ends. In such a system, water can reach any point from more than one direction.

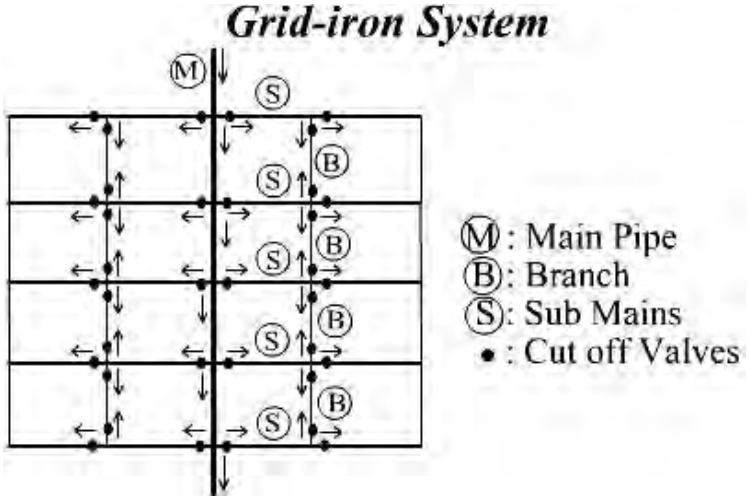


Fig: Grid –iron system

Advantages

- since water in the supply system is free to flow in more than one direction, stagnation does not occur as readily as in the branching pattern
- in case of repair or break down in a pipe, the area connected to that pipe will continue to receive water, as water will flow to that area from the other side

- water reaches all points with minimum head loss
- at the time of fires, by manipulating the cut-off valves, plenty of water supply may be diverted and concentrated for firefighting

Disadvantages

- cost of pipe lying is more because relatively more length of pipes is required
- a greater number of valves is required
- the calculation of pipe sizes is more complicated

c. Grid Pattern with Loops

- loops are provided in a grid pattern to improve water pressure in portions of a city (industrial, business and commercial areas)
- loops should be strategically located so that as the city develops the water pressure should be sustained

The advantages and disadvantages of this pattern are the same as those of the grid pattern:

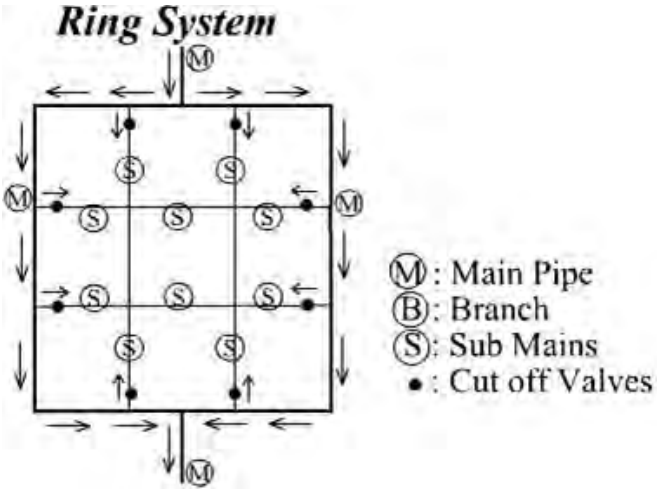


Fig: Ring system

6.2 Method of water supply

There are two methods of water supply:

1. Continuous system
2. Intermittent system

1. Continuous system

Continuous system is the best system as the water is supplied for 24 hours. This system is possible when there is adequate quantity of water for supply. In this system, water is always available for fire-fighting; and due to continuous circulation, water always remains fresh. It is the perfect method of supply of water. This method will provide the water throughout the time of supply. In this method, the separate storage tank will not require and also it will reduce the time as well as other conflict that the water timetable should not be made.

Advantage of Continuous System

- consumers get the fresh water throughout the time of supply
- consumer should not store the water separately in the storage tank because in this system, water will flow continuously that consumer can collect the water as their required time
- firefighting demand can be meet easily
- wastages of water will be less because the old water is throughout as wastewater

Disadvantage of Continuous system

- there will be misuse of water if people lacks civic scense and treating water as important substance
- to apply this system, the source of water must be enough that can be provided at the last home of the town

2. Intermittent System

If plenty (sufficient amount) of water is not available, the supply of water is divided into zones; and each zone is supplied with water for the fixed hours in the day. As the water is supplied after intervals, it is called intermittent system. The timing of the water supply may be changed to suit the season of the year. When the demand is high and the source does not have enough water, then this system is mostly applicable.

Advantage of Continuous System

- this system is suitable when water from the source is available in limited amount
- since people make storage tanks in their homes, there won't be any problem of water for household purposes

Disadvantage of Continuous System

- due to intermittent supply, consumer have to store water for non-supply time;

and this stored water may get contaminated from different bacteria

- consumers have to construct storage tanks, which take cost for the system
- due to meeting the large demand, the size of pipe must be in big size
- firefighting cannot be provided at any time

6.3 Clear Water Reservoir

- before supplying to distribution system, a reservoir may be necessary to store the treated water
- a reservoir is necessary to store overnight water so as to provide it during day hours

6.4 Break Pressure Tank

It is a tank for allowing flow to discharge into the atmosphere, therefore, reducing its hydrostatic pressure to zero and establishing a new static level. The pressure, which is not necessary, is reduced by constructing a break pressure tank. Ferro cement (containing iron) on stone masonry is used to construct break pressure tank.

Construction of BPT

- inlet pipe
- outlet pipe with a gate valve
- overflow pipe
- washout pipe with a gate valve

S.N.	Items	Slow Sand Filter	Rapid Sand Filter
1	Area	Requires very large area	Requires small area
2	Quantity of sand	Requires more quantity of sand	Requires less quantity of sand
3	Rate of filtration	100-180litres/m2/hour	4000-5000litres/m2/hour
4	Size of unit	30mx60m	6mx8m to 8mx10m
5	Distribution	uniform	Smaller at top and coarser in bottom
6	Period of cleaning	1-3months	24-48 hours
7	Skilled supervision	Not required	Most essential
8	Overall cost of unit	More, because large area of land and much quantity of materials are required.	Cheap and economical

9	Cost of maintained	Small	More
10	Efficiency	High efficiency	Low efficiency

6.5 Types of Pipes

1. CI Pipes (Cast Iron)

These pipes are mostly used in water supply. They are well suited for pressure and can withstand external load because of their thickness. The pipes are easy in manufacturing, layout and joining. These pipes are manufactured by vertical casting in sand moulds, horizontal casting in sand moulds and centrifugal casting (spun casting pipes).

CI pipes are heavy in weight. Therefore, transportation is costlier and they are not suitable for inaccessible places. Due to heavy weight, these are generally made in short length. This increases layout and jointing cost. CI vertical casting pipes are not of very good quality and can be replaced by centrifugal casting (spun casting) pipes.

- life up to 100 years and well functioned up to 230 years
- suitable for high external, internal pressure
- used in distribution in village with U-profile
- heavy and brittle
- corrosion increases roughness, decreases life

2. GI Pipes (Galvanized Iron)

These pipes are extensively used for water supply. They are best suitable for long distance pipelines of high pressure and provide satisfactory performance during

service. These pipes have excellent mechanical properties and are ideally suited for welding. The pipes are made in length more than twice the length of CI pipes; which saves in transport, layout of pipe and joining cost. There is minimum damage to the pipes in transportation. The pipes being light in weight are used for large diameter pipelines.

- iron pipe coated with zinc
- corrosion is 1/5th than that of steel
- thinner than CI pipe, so lighter
- life 20-30 years
- most commonly used in buildings and other structures

3. Concrete Pipe

Main advantage of cement pipes in place of metallic pipes is their corrosion resistance. These pipes are bulky, heavy and require careful transportation and handling. The layout process of these pipes is costlier than steel pipes.

- these may be precast pipes or cast in situation
- precast pipes are of high quality due to proper control in quality
- with diameter Ø<0.6m-P.C.C.

- with diameter Ø>0.6m-R.C.C. required
- low maintenance cost
- commonly used in sewer
- life span about 50 years

4. Steel Pipes

Steel pipes are long, hollow tubes that are used for a variety of purposes. They are produced by two distinct methods which result in either a welded or seamless pipe. In both methods, raw steel is first cast into a more workable starting form.

- it has life 25 to 50 years
- steel pipe can with stand impact, vibration, bending, etc.
- more expensive than GI pipe
- it cannot resist more external pressure

5. Asbestos Pipes

These pipes are light in weight and easy in transportation and layout. They have smooth internal surface and are not affected by corrosion (rust). The pipes are extensively used for water supply systems. Holes can be drilled in these pipes. These pipes are not costlier.

- asbestos, silica and opc are mixed to make this pipe
- asbestos works as reinforcing materials
- light in weight, smooth surface, no-corrosion bad conductor of electricity
- brittle, generally not used in water supply

- used in fire-resistant area.

6. Plastic Pipes

These pipes are rigid PVC pipes. They are light in weight, tough, resistant to chemical attack and long in length. Due to long in length the cost of handling is much whereas transportation and installation cost is less. Smooth internal surface of pipes provide less friction which results in saving of energy. These pipes are not suitable for the area which is very hot.

- various types of plastic pipes are available
- HDP pipes are most commonly used

- cheap, durable, smooth, light in weight produce in longer length
- life spans 25-30 years
- most commonly used in rural water supply project
- present from high temperature, if exposed, can easily by damaged
- not used if very high internal pressure

6.6 Laying of Pipes

Pipe layers operate the backhoes and trenching machinery that dig the trenches to accommodate the placement of sanitary sewer pipes and storm water sewer drainpipes. They use surveyor's equipment to ensure the trenches have the proper slope and install the pieces of pipe in the trenches, joining the ends with cement, glue or welding equipment. Using an always-open or always-closed valve called a tap, pipe layers connect them to a wider system and bury the pipes.

Pipe fitters plan and test piping and tubing layouts, cut, bend or fabricate pipe or tubing segments and join those segments by threading them, using lead joints, welding, brazing, cementing or soldering them together. They install manual, pneumatic, hydraulic and electric valves in pipes to control the flow through the pipes or tubes. These workers create the system of tubes in boilers and make holes in walls and bulkheads to accommodate the passage of the pipes they install.

Step for Laying of Pipes

1. Map Preparation

i. Detailed map of pipe network must be prepared initially with reference points shown in map and ground.

2. Setting Out

i. Setting out must be done by the help of reference point.

ii. Centre line of pipe must be shown, usually by driving pegs in certaininternal.

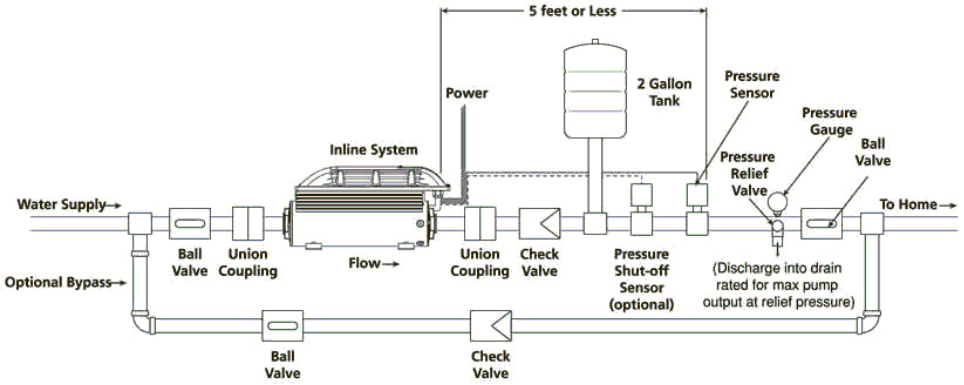
3. Excavation

i. Top part of pipe must be at lower level 1 meter below ground level (or more)

ii. Slop should be maintained.

4. Laying

i. Laying may be done manually or using chains.



Layout of pipes

6.7 Pipe Joints

1. At required intervals joint should be made.
2. Type of joint depends upon type of pipe material like GI, CI or HDP pipe.
3. Before back filling and after joining, tests must be conducted for leakage and pressure.
4. If these tests satisfy requirements, then only backfilling is done.

6.8 Valve and Fitting

Different types of fitting equipment are used in pipe systems to connect straight pipe or tubing sections, adapt to different sizes or shapes and for other purposes, such as regulating (or measuring) fluid flow. "Plumbing" is generally used to describe the conveyance of water, gas, or liquid waste in domestic or commercial environments; "piping" is often used to describe the high-performance (high-pressure, high-flow, high-temperature or hazardous-material) conveyance of fluids in specialized applications. "Tubing" is sometimes used for lighter-weight piping, especially that flexible enough to be supplied in coiled form.

Material

The material with which a pipe is manufacture is often the basic for choosing a pipe. Materials used for manufacture pipes include:

- carbon and galvanized steel
- impact tested carbon steel
- low temperature carbon steel
- stainless steel

- malleable iron

The bodies of fittings for pipe and tubing are most often the same base material as the pipe or tubing connected: copper, steel, PVC, chlorinated polyvinyl chloride (CPVC) or ABS. Any material permitted by the plumbing, health, or building code (as applicable) may be used, but it must be compatible with the other materials in the system, the fluids being transported and the temperature and pressure inside (and outside) the system. Brass or bronze fittings are common in copper piping and plumbing systems. Fire hazards, earthquake resistance and other factors also influence the choice of fitting materials.

6.8.1 Fittings

Elbow

An elbow is installed between two lengths of pipe (or tubing) to allow a change of direction, usually a 90° or 45° angle; 22.5° elbows are also available. The ends may be machined for butt, threaded (usually female), or socketed. When the ends differ in size, it is known as a reducing (or reducer) elbow.

A 90º elbow, also known as a "90 bend", "90 ell" or "quarter bend", attaches readily to plastic, copper, cast iron, steel, and lead, and is attached to rubber with stainless- steel clamps. Other available materials include silicone, rubber compounds, galvanized steel, and nylon. It is primarily used to connect hoses to valves, water pumps and deck drains. A 45º elbow, also known as a "45 bend" or "45 ell", is commonly used in water-supply facilities, food, chemical and electronic industrial pipeline networks, air-conditioning pipelines, agriculture and garden production, and solar-energy facility piping.

Fig: 90 º elbow

Fig: 45 º elbow

Elbows are also categorized by length. The radius of curvature of a long-radius (LR) elbow is 1.5 times the pipe diameter, but a short-radius (SR) elbow has a radius equal to the pipe diameter. Short elbows, widely available, are typically used in pressurized systems, and in physically tight locations.

Coupling

A coupling connects two pipes. If their sizes differ, the fitting is known as a reducing coupling, reducer, or an adapter. There are two types of couplings: "regular" and "slip". A regular coupling has a small ridge or stop internally, to prevent over-insertion of a pipe, and thus under-insertion of the other pipe segment (which would result in an unreliable connection). A slip coupling (sometimes also called a repair coupling) is deliberately made without this internal stop, to allow it to be slipped into place in tight locations, such as the repair of a pipe that has a small leak due to corrosion or freeze bursting, or which had to be cut temporarily for some reason. Since the alignment stop is missing, it is up to the installer to carefully measure the final location of the slip coupling to ensure that it is located correctly.

Fig: Pipe coupling

Union

A union, similar to a coupling, allows the convenient future disconnection of pipes for maintenance or fixture replacement. In contrast to a coupling requiring solvent, welding, soldering, or rotation (for threaded couplings), a union allows easy connection and disconnection, multiple times if needed. It consists of three parts: a nut, a female end and a male end. When the female and male ends are joined, the nut seals the joint by pressing the two ends tightly together. Unions are a type of very compact flange connector.

Fig: union

Nipple

A nipple is a short stub of pipe, usually male-threaded steel, brass, chlorinated polyvinyl chloride (CPVC), or copper (occasionally unthreaded copper), which connects two other fittings. A nipple with continuous uninterrupted threading is known as a closed nipple. Nipples are commonly used with plumbing and hoses.

Fig: Nipple

Tee

A tee, the most common pipe fitting, is used to combine (or divide) fluid flow. It is available with female thread sockets, solvent-weld sockets or opposed solvent-weld sockets and a female-threaded side outlet. Tees can connect pipes of different diameters or change the direction of a pipe run, or both. Available in a variety of materials, sizes and finishes, they may also be used to transport two-fluid mixtures. Tees may be equal or unequal in size of their three connections, with equal tees the most common.

Fig: Tee

Cap

Caps, usually liquid- or gas-tight, cover the otherwise open end of a pipe. A cap attaches to the exterior of a pipe and may have a solvent-weld socket end or a female-threaded interior. The exterior of an industrial cap may be round, square, rectangular, U- or I-shaped, or may

have a handgrip. If a solvent-weld cap is used to provide for a future connection point, several inches of pipe must be left before the cap; when the cap is cut off for the future connection, enough pipe must remain to allow a new fitting to be glued onto it.

Fig: Cap

6.8.2 Valves

To supply the water from the tank to the tap, the different valves will play the vital role. In the different condition like air release valve is required to release air from the pipe and hydrants are required for firefighting; and water meter to note the meter of water supply for the consumer. V valve is a device which is used for controlling the flow of water in the pipeline. If any maintenances work required, then the valve will play the vital role to separate the damaged section by using different valve. These are different kinds of valves, such as:

1. Sluice valve
2. Pressure relief valve
3. Check valve
4. Air relief valve

1. Sluice Valve

Sluice valves are also known as gate valve which can be operated by rotating the handle which will make the valve lifted up or brought down. When the valve is lifted up the valve will make open to flow the water; and if it is brought down, then it will block the flow of water. This may be completely or partially opened or closed.

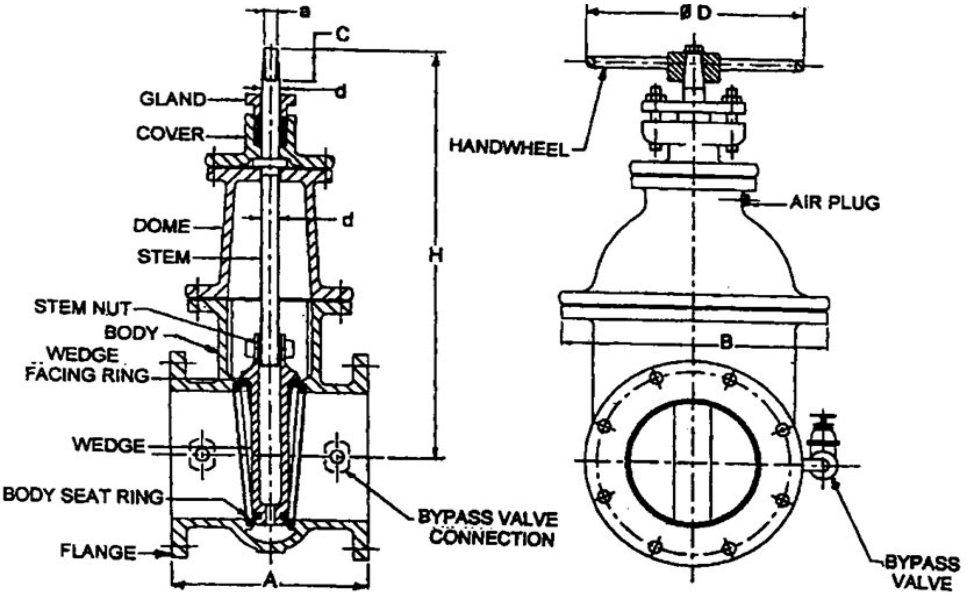


Fig: sluice valve

2. Pressure Relief Valve

These valves are fitted in the pipeline where the pressure gets maximum at the time when the water flows through the pipe. When the pressure inside the pipe get maximum, then the disc will be forced up and the exceeded pressure is released through the cross pipe, but there is no chance of get out the water from it.

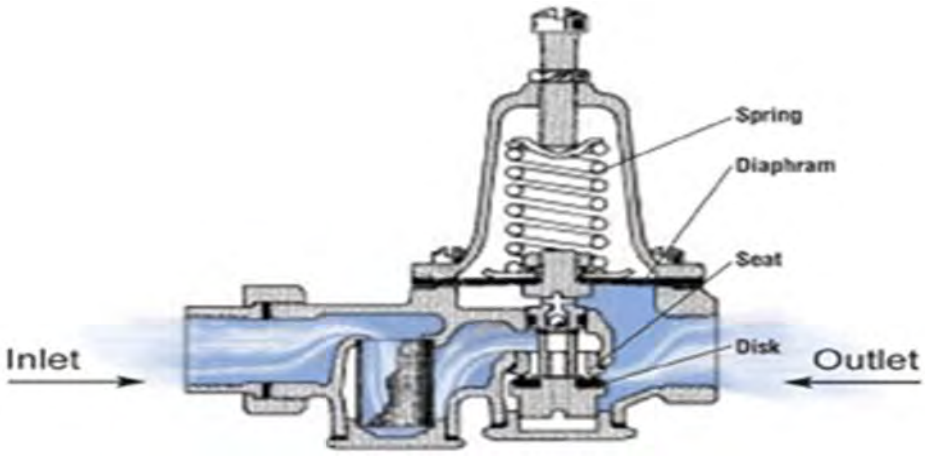


Fig: Pressure relief valve

3. Check Valve

These valves are also known as the reflux valve. It is used to make the water flow in

one direction only when it is required. At the junction of the main pipeline, a valve is installed to control the change in direction of water flow as needed.

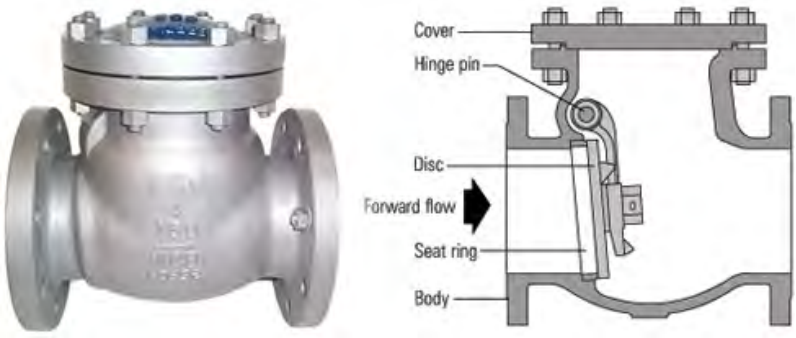


Fig: Check valve

4. Air Relief Valve

This valve allows air to escape from or enter a pipe is called an air relief valve. While flowing the water into the pipe, it will also carry the air with it. So, if it goes to the pipeline, then it will interfere to flow of water. So, all accumulated air will be released from it.

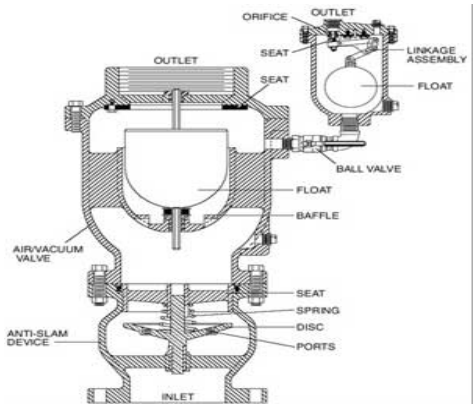


Fig: Air relief valve

6.9 Maintenance of Pipes

After the pipes are laid on the ground for water supply, proper maintenance must be required. The wastewater and the silt deposition should be checked time to time, the leakage should be stopped, and cracks in pipes should be replaced on time to time.

All the maintenance works of the pipes must be done by a licensed plumber and should be as per standard specifications. And if any service connection is needed by

the consumer, then the experienced and well-trained plumber needs to be employed.

Regular inspection of the pipelines has to be done for the uninterrupted supply of water to the consumer. If any defect or leakage is noticed, it must be repaired. For this different types of pipes, fitting and experienced plumber is required.

Exercise

Choose the correct answer from the given alternatives.

1. Which valve is used to regulate flow in the pipes?

   a. Sluice b. Globe c. Check d. Air

2. Which valve is used to release accumulated air in the pipes?

   a. Sluice b. Air relief valve c. Safety d. Drain

3. A GI pipe has a coating of .....

   a. Lead b. Zinc c. Aluminum d. Paint

Write short answer to the following questions.

1. What is pipe joint? Enlist different types of pipe joints.

2. Why is break pressure tank necessary in a water supply scheme?

Write long answer to the following questions.

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

2. Describe different systems of supply of water with its advantages and disadvantages.

3. Describe the various methods of water distribution with neat sketches.

Project Work

1. Design of water reservoir with inlet and outlet system.

2. Design of break pressure tank.

3. Identify different type of pipes and fittings.

4. Prepare different pipe joints.

5. Perform different pipe joining and fittings.

Unit 7 : Introduction of Sanitation

7.1 Sanitation

Sanitation is any system that promotes proper disposal of human and animal wastes. Sanitary engineering is the application of engineering methods to improve sanitation of human communities, primarily by removing and disposing human waste, and ensure the supply of safe potable water. Traditionally it was a branch of civil engineering, in the mid-19th century, the discipline concentrated on the reduction of disease, and then thought to be caused by miasma.

- it is not concerned with environmental factors that do not have an immediate and clearly understood effect on public health
- areas outside the purview of sanitary engineering include traffic management, concerns about noise pollution or light pollution, aesthetic concerns such as landscaping, and environmental conversion

Sanitary Works

The sanitary works involves:

- Collection works
- Treatment works
- Disposal works

Collection Works

The collection works mean collecting all types of waste products of town.

Refuse is collected separately, and sewage separately. The collection work should be carried out such a way that the waste matter can be collected and transported quickly and steadily to the treatment works plant. The sewage of town is collected through well-designed sewerage system.

The collection works include the house drainage works and networks of sewer laid in the town to collect wastewater from various places.

Treatment Works

Wastewater treatment works are required to treat the sewage before disposal so that it may not pollute the atmosphere as well as the water bodies in which it will be disposed of.

Disposal Works

The works which are done to dispose off the wastewater are called the disposal works. The treated or untreated wastewater are disposed off in the following ways:

- By irrigating fields
- By discharging into natural water bodies

Objectives of Sewage Disposal

The following are the aims and objectives of sewage disposal:

1. to have proper disposal of human excreta to a safe place, before it starts decomposition and causes insanitary conditions in the locality
2. to take out all kinds of wastewater from the locality immediately after its use, so that mosquitos, flies, bacteria etc. may not breed in it and cause nuisance
3. to have final disposal of sewage on land or in nearby watercourses after some treatment so that receiving land or the water does not get polluted
4. to use the sewage as fertilizer to increase crop production

Classification of Sewage

1. **Storm sewage:** This includes surface runoff developed during and immediately after rainfall in the particular area.
2. **Sanitary sewage:** This includes the liquid wastes of domestic and industrial places. This sewage is extremely foul in nature and required to be disposed off very carefully.

7.2 System of Sanitation

There are two types of sanitation system, they are:

1. Conservancy system
2. Water carriage system

Conservancy System

In this system, various types of refuse and storm water are collected, conveyed and disposed off separately. This method is also called dry system and is in practice from very ancient times. This method is being adopted in small town, villages and undeveloped parts of large city.

- in this method, garbage or dry refuse is collected in the dustbins and conveyed by trucks or carts once or twice a day. All the non-combustible portions such as sand, dust, clay, ashes, etc. are used for filing and the combustible portions such as dry leaves,

wastepaper, broken furniture, etc. are burnt

- the decaying fruits, vegetables, grass are first dried and then disposed off by burning or are used to manufacture manure
- human excreta or night soil is collected separately in privies or conservancy latrines, from where they are removed through human agency. After removal, they are taken out of the town in closed truck or carts up to disposal point and are buried in trenches. After 2-3 years, the buried night soil is converted into excellent manure which can be used for growing crops.
- in this system, sewage and storm water are carried separately in closed or open drains up to the point of disposal, where they are allowed to mix with streams, rivers or sea.

Advantages and Disadvantages

Advantages

1. initial cost is low, because storm water can pass through open drains and hence there is no need of complicated and costly sewerage system
2. the quality of sewage reaching at the treatment plant before disposal is low because conservancy system uses less water

Disadvantages

1. possibility of storm water to get mixed with sewers causing heavy load on the treatment plant
2. in crowded lanes, it is difficult to lay two sewers or construct drains by the roadside as it causes great obstruction to the traffic
3. much land is required for burying human excreta
4. liquid refuse which is disposed on the land may enter into the sub-soil and pollute the underground water
5. aesthetic view of city cannot be increased due to scattering of solid waste everywhere during collection and conveyance. Also, sewage that flows through open drain degrades the aesthetic view of city
6. decomposition of sewage in an open area causes insanitary conditions which are dangerous to public health
7. this system completely depends upon the human labors, and if they go on strike, it can create serious problem

Water Carriage System

In this system sewage is mixed up in the large quantity of water and are taken out from the city through properly designed system, they are then disposed off after necessary treatment.

The sewage so formed in water carriage system consists of 99.9 percentage of water and 0.1 percentages of solid matters. All the solid matters remain in suspension in the sewage and so do not settle during conveyance. Actually, all the sewage behaves as water which facilitates the conveyance through the sewage line.

Merits and Demerits of Water Carriage System

Merits

The following are the merits of water carriage system:

1. it is a hygienic method because all the sewage are collected and conveyed through water only
2. there is no nuisance in the streets of towns as sewage is conveyed through underground sewerage system
3. there won't be any problem due to strike of labor as it does not require through manpower
4. self-cleaning velocity can be obtained even at fewer gradients due to more quality of sewage
5. the land required for the disposal work is less as compared to conservancy system
6. this system does not depend on manual labor every time, hence labor cost is low
7. the usual water supply is sufficient and no additional water is required in water carriage system
8. risk of epidemics is reduced because of underground sewage system

Demerits

1. initial cost is high for constructing underground sewage system
2. the maintenance of this system is also costly
3. during monsoon, large volume of sewage has to be treated compared to remaining period of the year

Comparison of Conservancy and Water-Carriage System

Conservancy System	Water Carriage System
1. Very cheap in initial cost	1. It involves high initial cost
2. Due to foul smell from latrines, they are to be constructed away from the living room	2. As there is no foul smell, latrines remain clean and neat and hence are constructed within room.
3. The aesthetic appearance of the city cannot be increased.	3. Good aesthetic appearance of the city can be obtained.
4. Storm water is carried in usually surface drains, hence no problem of pumping the storm water.	4. Sewage is treated before disposing off, it may or may not require pumping it depends on the topography of the town.
5. The quantity of waste liquid reaching the disposed points is less; hence it can be disposed off without any treatment.	5. Large quantity of sewage highly polluted in nature, it requires its treatment before disposal, so it is costly process.
6. This system is fully dependent on the human agency.	6. Sewage is treated up to required degree of sanitation.
7. As sewage is disposed off without any treatment, it may pollute the natural water courses.	7. Sewage is treated up to required degree of sanitation.
8. For burying of excremental matter, large area is required.	8. Less area is required as compared to conservancy system.

7.3 Sewerage System

The entire system for collecting and carrying sewage through sewer is known as sewerage system.

The sewerage systems are classified as follows:

a) Combined system

b) Separate system

c) Partially separate system

(a) Combined System

When sewerage system is designed to carry both sanitary sewage and storms water on same sewer line, it is called combined sewerage system.

This system is best suited in areas having small rainfall. As only one sewer is laid in this system, it is best suited for crowded area because of traffic problems. The combined system can also be used in area having less sewage to obtain the self-cleaning velocity.

Merits and Demerits of Combined System

Merits

The following are the merits of combined system:

1. there is no need of flushing because self-cleaning velocity is available at every place due to more quality of sewage
2. the sewage can be treated easily and economically because rainwater dilutes the sewage
3. house plumbing can be done easily at low cost as only one set of pipes will be required

Demerits

The following are the demerits of the combined system:

1. the initial cost is higher as compared to separate system
2. it is not suitable for areas having rainfall for smaller period during the year because of single sewer
3. during heavy rainfall, the overflowing of sewers will harm the public health
4. if whole sewage is to be disposed off by pumping, it is uneconomical

(b) Separate System

If domestic and industrial sewage are taken in one set of sewers, and storm water is taken in another set of sewers, it is called separate system. For this system two sewer lines are required.

Merits and Demerits of Separate System

Merits

The following are the merits of the separate system:

1. since the sewage flows in the separate sewers, the quality to be treated is small which results in low treatment cost
2. separate system is cheaper than combined system, because only sanitary sewage flow in closed sewer and storm water which is not foul in nature can be taken through

open channel or drains

3. during disposal, if the sewage is to be pumped, the separate system is cheaper
4. there is no fear of stream pollution

Demerits

1. flushing is required at various points because self-cleaning velocity is not available due to less watery sewage
2. there is always risk that the storm water may enter the sanitary sewage sewer and cause heavy load in the treatment plant
3. maintenance cost is more because of two sewers
4. in busy lanes lying of two sewers is difficult. Besides, it causes great inconvenience to the traffic during repairs

c. Partially Separate System

In the separate system, a portion of storm water is allowed to enter in the sewers carrying sewage and the remaining storm water is diverted to the separate set of sewers, this system is called partially separate system.

7.4 Types of Sewers

According to construction materials, sewer can be classified as:

i. asbestos cement sewer
ii. brick sewer
iii. cast-iron sewer
iv. cement concrete sewer
v. corrugated iron sewer
vi. plastic sewer
vii. steel sewer
viii. stoneware sewer
ix. wood sewer

According to the shape sewers are classified as

1. Circular shape sewer
2. Noncircular sewer

Generally, the sewers of circular shape are adopted because of following facts:

1. circular shape has least perimeter and hence the construction cost is minimum
2. deposition of organic matter is reduced to minimum because of no corners
3. they are easy to manufacture or construct and handle

Some Non-Circular Sewers

If the sewer section is semicircular shape in, then it is called non – circular sewer. In the semicircular sewer due to the corner and the flat surface the deposition of organic matter is most likely, so it needs to be cleaned at regular interval. They are easy to manufacture or construct and handle.

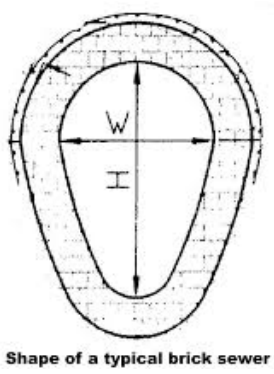


Fig: Parabolic Section

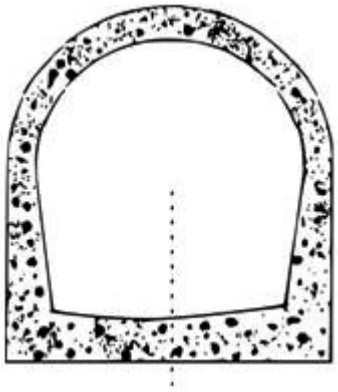


Fig: Horseshoe section

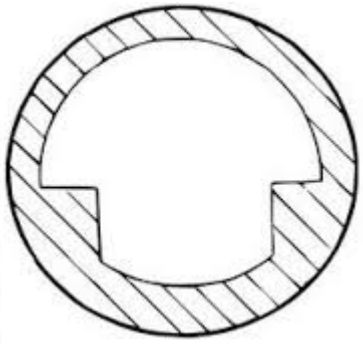
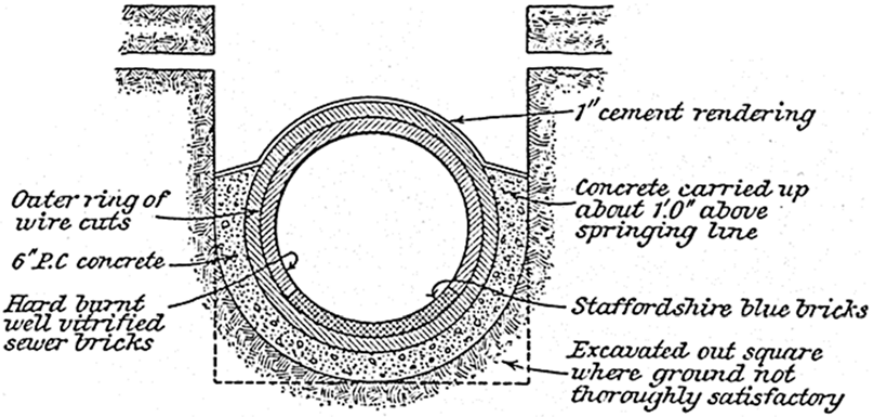


Fig: Basket handles section

7.5 Laying of Sewers

a) marking center lines of sewers
b) excavation of trenches
c) checking the gradient
d) lying of sewers
e) jointing
f) testing of sewer line
g) back filling



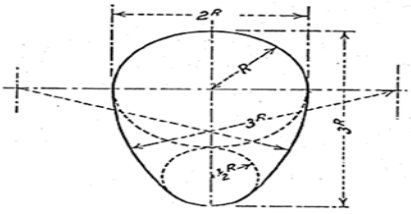


FIG. 2.—Standard Egg-shaped Section for Brick Sewer.

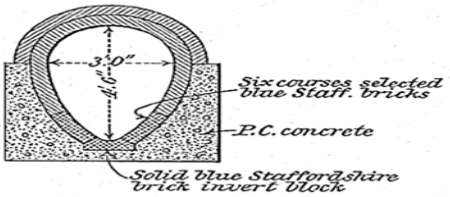


FIG. 4.—Main Sewer, Southampton.

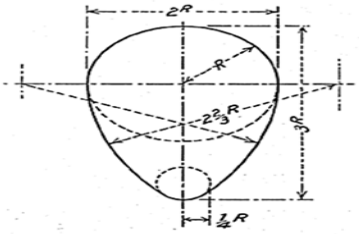


FIG. 3.—New Type of Section for Brick Sewers suited for both Small and Large Flows.

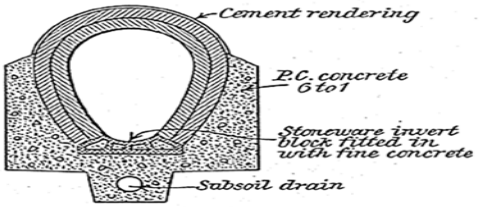


FIG. 5.—Section of Egg-shaped Sewer, showing use of Invert Block and Subsoil Drain.

Marking Center Line of Sewer

The centre line sewer is marked on the streets and roads from the plans (drawing) starting from the outfall and proceeding upwards with help of chain or tape and theodolite. To mark center line generally wooden pegs are driven at every 10-meter interval.

Excavation Trenches

After marking the layout of the sewer line on the ground, the first step is the removal of pavement, which starts from the lower end of the sewers and proceeds upwards. After removing pavement, the excavation of trenches is done manually or mechanically. The width of the trench depends upon the diameter of sewer line below the ground level. The width of sewer line is 15cm more than the external diameter of sewer for sassiness in lowering and adjusting the sewer pipe.

Checking of the Gradient

Gradient of sewer line should be such that the sewage flows smoothly through gravitational force maintaining self-cleaning velocity.

Laying

Smaller size pipes can be laid by the pipe-layers manually. But heavier and large sizes are lowered into the trenches with the help of ropes around them and supporting with hock.

Joining

After laying of the pipe, they are joined water tightly.

Testing of Sewer Line

Sewer lines should be tested against water and air tightness.

Back-Filling of Trenches

After testing, the defective pipes are replaced and, the trenches are filled back with excavated soil. The trench is filled15cm above the ground level. During the course of time, the back filled soil gets compacted and the filled soil comes to the ground level.

Exercise

Choose the correct answer from the given alternatives.

1. All the unwanted things to be disposed is called as ……

   a. Refuse b. Rubbish c. Garbage d. Sewage

2. After laying, sewers are tested for …….

   a. Obstruction b. Straightness c. Leakage d. Both a and b

3. Sewer is preferable to lay from ……

   a. Upstream b. Tail end c. Everywhere d. Treatment plant

Write short answer to the following questions.

1. Explain the system of sanitation.
2. Enlist the steps to be followed in the laying of sewers.

Write long answer to the following questions.

1. Discuss the role of sanitation in maintaining human health.
2. Compare the conservancy system and water carriage system in a tabular form.

Project works

1. Prepare sewer laying plan.

Unit 8 : Sewage Disposal

Introduction

After conveying the sewage through sewers, the next step is its disposal. The sewage can be disposed of without or after treatment. Sewage disposal is the process of disposing sewage. By sewage treatment, the sewage transforms into a harmless liquid that suffices to meet the requirements of sanitation, health and decency. Sewage disposal is the process in which sewage is transported through cities and inhabited areas to sewage treatment plants, where it is then treated to remove contaminants to produce environmentally-safe waste. Disposal of sewage waste protects public health and prevents disease as well as water pollution from sewage contaminants. Many modern cities have sewage disposal systems. The advanced technology has allowed for more environmentally friendly and healthy solutions to disposing and treating sewage. Sewage systems are part of modern infrastructure and urban utilities, which also include gas, electric, and water supply.

8.1 Importance of Disposal of Sewage

The following are the importance of disposal of sewage:

1. to render sewage inoffensive, without causing nuisance or odour
2. to reduce danger to public health by possible contamination of water supplies, bathing places etc.
3. to prevent the destruction of fish or aquatic life by not letting raw or untreated sewage into bodies of water
4. to re-use or recycle waste water if possible
5. to maintain and improve environment hygienic condition. The methods of sewage disposal can be classified as under

a) Natural Methods

1. Dilution
2. Land treatment
   a. Broad irrigation or sewage farming
   b. Sub-surface irrigation or land infiltration

b) Artificial Methods

1. Primary treatment
2. Secondary treatment

8.2 Land Treatment

When the sewage is evenly spread on the surface of land, this is called land treatment. This is also natural method of sewage disposal. In this method, the water of sewage percolates in the ground by straining action of ground soil and the suspended solids remain at the surface of the ground. The organic suspended solids are partly acted upon by the bacteria and are partly oxidized by exposure to atmosphere action of heat, light and air. Thus, the complex compounds of sewage are converted into harmless mineral salts, which serve as a valuable fertilizer.

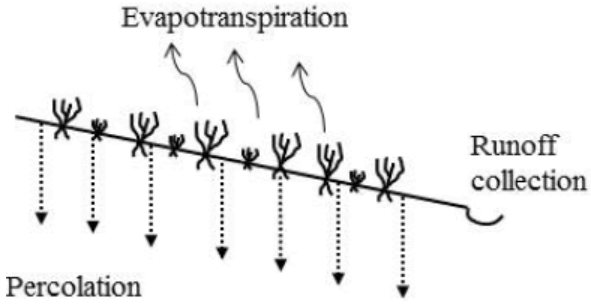


Fig. Overview of Land treatment

Suitability of Land Treatment

Land treatment of sewage is suitable under the following conditions:

1. When the overall rainfall is very low
2. When there is no river or natural water courses
3. When the quantity of sewage high
4. When rivers usually run dry or have very small flow during summer
5. When the water table is much deep even during monsoon
6. When the vegetable have good market
7. When large area of land is steady, loamy or alluvial soil over soft murmur, the land treatment is most suitable

8.3 Dilution Method

The disposal of sewage by discharging it into water courses like stream, rivers,

sea, etc. is called dilution. The disposed sewage may be raw or treated sewage is preferable. Practically at most all the towns of our country are discharging their sewage to the river. So while discharge the sewage in this way, care should be taken that the sewage does not pollute the natural water and render it unfit for any other purposes such as bathing, drinking, fish culture etc.

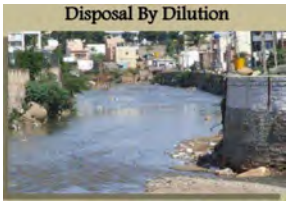


Fig. Overview of dilution method

Essential Condition for Dilution

Following are the essential conditions for the dilution:

1) When sewage is comparatively fresh or non-septic
2) Where sewage has been mostly removed of the floating and settable solids
3) Where it is possible to thoroughly mix sewage through dilution water
4) Where at the point of disposal the depth of water is sufficient and the current can prevent the deposition near the outfall
5) Where diluting, water high in dissolved oxygen content, is available
6) Where the volume of receiving water is large enough to take the load of the sewage safely without causing pollution
7) Where the volume of receiving water will not cause backward flow in sewers
8) Where the city is situated near the water courses like sea, river or lake

8.4 Self-purification of River

When sewage is disposed off in the stream, the quality of water changes. The quality of water u/s and d/s far away from disposal are much better than at the point of disposal. When sewage is discharged into streams, the water becomes polluted. The suspended solids are gradually deposited in the stream layers, depending upon the hydrographic characteristics of the stream. The organic matters of these so formed in layers starts decomposition and stabilization. In course of time, the decomposed materials are washed away with the current or are converted into simple constituents. Various types of organisms, algae, bacteria, protozoa are also responsible for self-purification of stream.

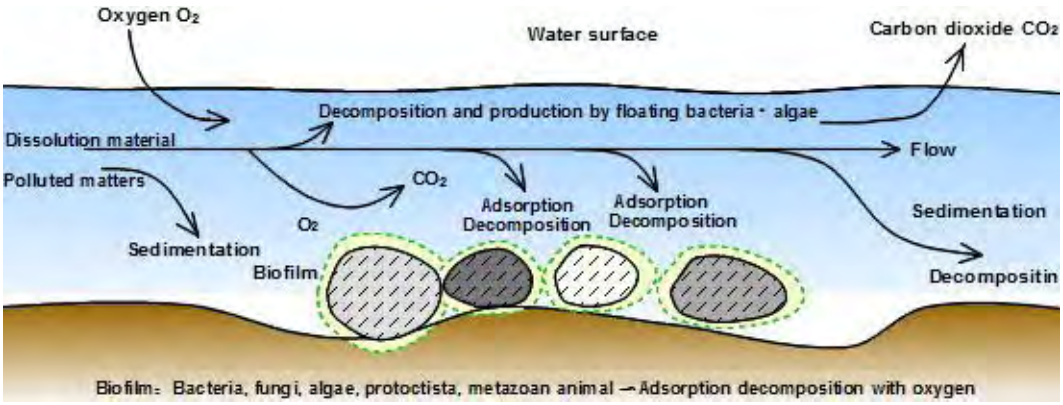


Fig. Overview of Self purification of river

The self purification of natural water systems is a complex process that often involves physical, chemical, and biological processes working simultaneously. The amount of dissolved Oxygen (DO) in water is one of the most commonly used indicators of a river health. As DO drops below 4 or 5 mg/L, the forms of life that can survive begin to reduce. A minimum of about 2.0 mg/L of dissolved oxygen is required to maintain higher life forms. A number of factors affect the amount of DO available in a river. Oxygen demanding wastes remove DO; plants add DO during day but remove it at night; respiration of organisms removes oxygen. In summer, rising temperature reduces solubility of oxygen, while lower flows reduce the rate at which oxygen enters the water from atmosphere.

Factors Affecting Self Purification

1. **Dilution:** When sufficient dilution water is available in the receiving water body, where the wastewater is discharged, the DO level in the receiving stream may not reach to zero or critical DO due to availability of sufficient DO initially in the river water before receiving the discharge of wastewater.
2. **Current:** When strong water current is available, the discharged wastewater will be thoroughly mixed with stream water preventing deposition of solids. In small current, the solid matter from the wastewater will get deposited at the bed following decomposition and reduction in DO.
3. **Temperature:** The quantity of DO available in stream water is more in the cold temperature than in hot temperature. Also, as the activity of microorganisms is more at the higher temperature, hence, the self-purification takes less time at hot temperature than in the cold temperature.

4. **Sunlight:** Algae produces oxygen in presence of sunlight due to photosynthesis. Therefore, sunlight helps in purification of stream by adding oxygen through photosynthesis.

5. **Rate of Oxidation:** Due to oxidation of organic matter discharged in the river, DO depletion occurs. This rate is faster at higher temperature and low at lower temperature. The rate of oxidation of organic matter depends on the chemical composition of organic matter.

Exercise

Choose the correct answer from the given alternatives.

1. Throwing of sewage with or without its treatment is called as .....

   a. Processing b. Management c. Disposal d. Sickness

2. A natural method of sewage disposal is .....

   a. Sewage farming b. Septic tank disposal

   c. Composting d. Lagooning

3. Land treatment of sewage disposal is suitable when soil is .....

   a. Porous b. Clayey c. Fertile d. Sandy

4. Which type of current in water body is suitable in self purification?

   a. Slower b. Medium c. Higher d. All

5. The natural process under which the flowing river gets cleaned is known as .....

   a. Oxidation b. Photosynthesis c. Reduction d. Self purification

Write short answer to the following questions.

1. What is sewage disposal?
2. Define the various methods of sewage disposal.
3. What do you understand by the self purification of river?

Write long answer to the following questions.

1. Explain rapid infiltration with a neat sketch.
2. Explain the factors affecting self purification of stream.
3. What are the advantages and disadvantages of land treatment?

Project works

1. Observe land treatment of sewage in artificially prepared bed.

Unit 9 : Disposal of Excreta in Unsewered Area

Introduction

Nepal is a poor country, due to which it is not possible to have water carriage system in all towns, villages and cities. Generally, it has been seen that people do not pay any attention during the construction of bath rooms and toilets, therefore, this portion of the building remains as neglected. The rural areas, scattered localities and isolated village which are not served by the piped water supply, always have a shortage of water. The waste water from such areas can be easily disposed through broad irrigation. As there is no sewerage system, some methods should be developed for the safe collection and disposal of human excreta from such areas.

9.1 Pit Privy

Pit privy consists of a pit 1.3 x 1 m in plan and 1.5 to 2.8 m deep. At the top of this pit the squatting seat is provided in a compartment. The superstructure is of temporary nature. When the pit is filled, it is closed from top by 60cm thick layer and a new pit is excavated by the side of it.

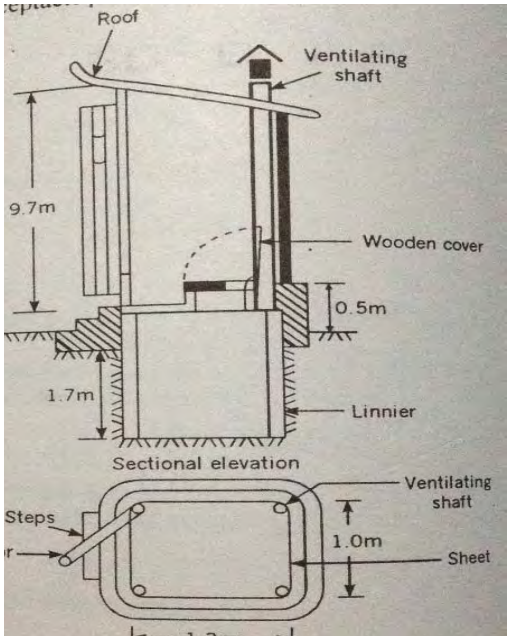


Fig. Pit Privy

The squatting pan along with the compartment is shifted to the new trench. A 10cm diameter vent pipe is also provided to take the foul gases. If the lime is applied frequently, it will reduce the odours. Pit privy should be constructed 30m away from the existing well in thenearby locality.

9.2 VIP Latrine

These are also known as ventilated improved pit (VIP) latrines. It is same as the pit privy but the difference is that the vent pipe is installed into the pit, which is used to exhaust the foul odour from the pit and it control flies. The major nuisances that discourage the use of simple pit latrines - smell and flies - are reduced or eliminated through the incorporation of a vertical vent pipe with a fly-screen at the top.

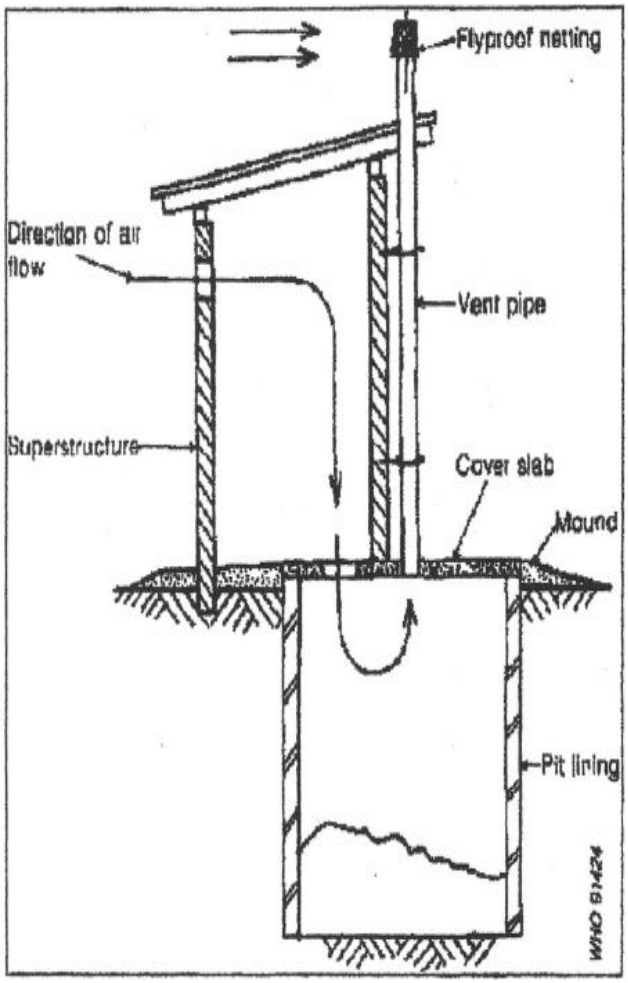


Fig. VIP Latrine

9.3 Pour Flush Latrine

Pour flush latrines use a pit for excreta disposal and have a special pan which is cast in the floor slab and provides a water seal of 20-30 mm. This ensures the smells cannot escape into the shelter. Sometimes a vent pipe, which should have a fly screen, is fitted to the pit. The pit may be below or offset from the shelter. Pour flush latrines can also be installed with the pan in the house and the pit outside.

Pour flush latrines require between 1-3 litres of water for flushing each time they are used, although ideally more should be used. Once the excreta is flushed into the pit, the liquids filters into the ground. Some of the solids decomposes and others remains in the pit.

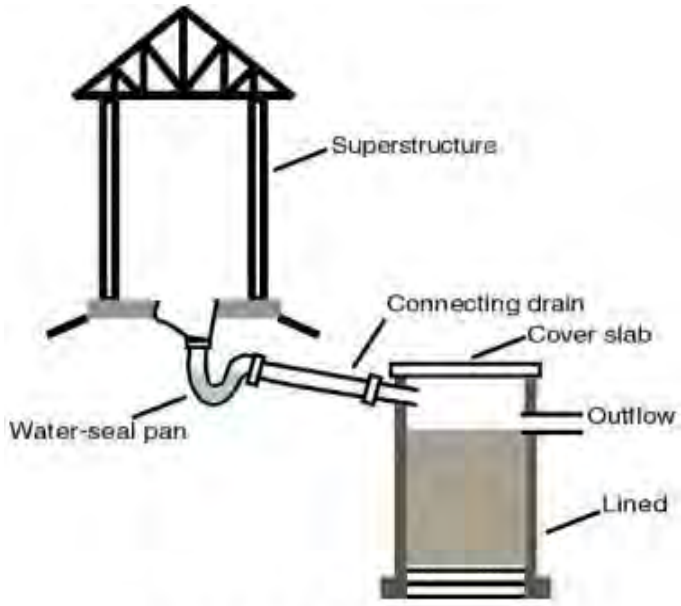


Figure 2.17: Pour flush latrine pan.

9.4 Septic Tank

A tank under the ground that holds human waste from toilets is known as septic tank. Households that are not served by public sewers usually depend on septic systems to treat and dispose of wastewater. Septic system is a significant financial investment. If cared for properly, a well designed, installed, and maintained system would provide years of reliable, low-cost service.

The septic tank is the most common small-scale decentralized treatment unit for

water and black water from cistern or pour-flush toilets. It is basically a sedimentation tank. Its shape can be rectangular or cylindrical.

Septic tanks are used for wastewater with a high content of settleable solids, typically for effluent from domestic sources, but they are also suitable for other wastewater of similar properties. Liquid flows through the tank and heavy particles sink to the bottom, while scum (mostly oil and grease) floats to the top. Over time, the solids that settle to the bottom are degraded. However, the rate of accumulation is faster than the rate of decomposition, and the accumulated sludge and scum must be periodically removed.

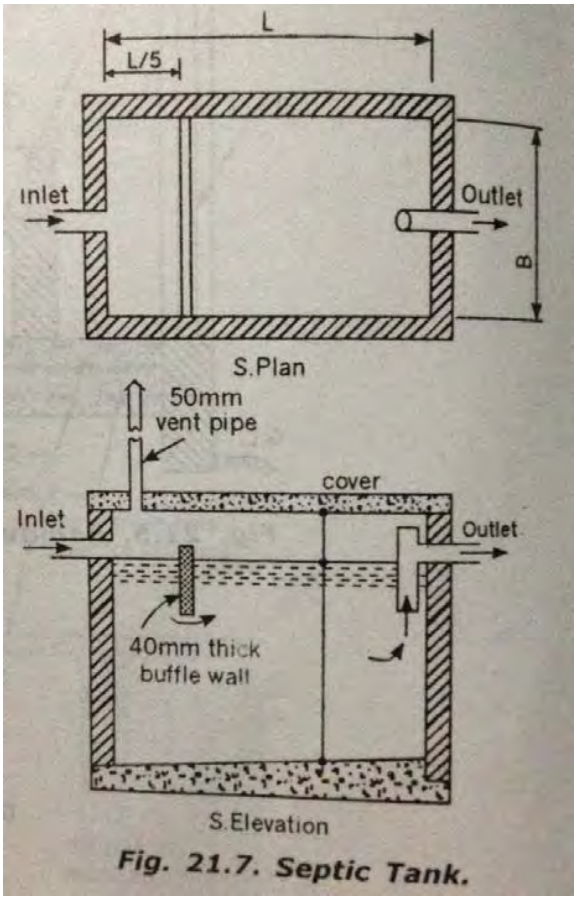
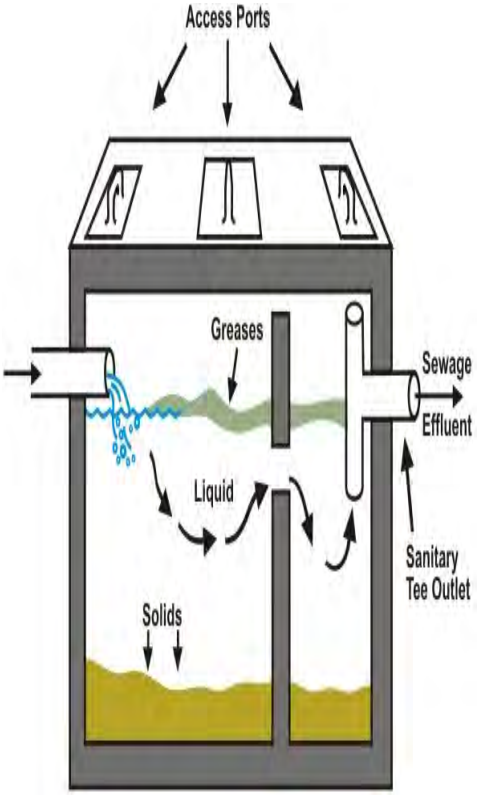


Fig. 21.7. Septic Tank.

9.4.1 Soak Pit

A soak pit, also known as a soak away or leach pit, is a covered, porous-walled chamber that allows water to slowly soak into the ground. Pre-settled effluent from a collection and storage/treatment or (semi-) centralized treatment technology is

discharged to the underground chamber from which it infiltrates into the surrounding soil.



Exercise

Choose the correct answer from the given alternatives.

1. VIP latrine is not constructed with a .....

   a. Pit b. Vent c. Superstructure d. Trap

2. Soak pit is used to dispose the ... from septic tank.....

   a. Sludge b. Scum c. Effluent d. Influent

3. In pour flush latrine, outcoming foul odour is prevented by .....

   a. Vent b. Door c. Window d. Trap

Write short answer to the following questions.

1. Define the following:

   Pit privy, VIP latrine, Pour flush latrine, Septic tank, Soak pit

2. Why can pour flush latrine be built inside buildings?
3. What are the advantages and disadvantages of pour flush latrine?

Write long answer to the following questions.

1. Explain the septic tank with a neat sketch.
2. Design a VIP latrine for a family of 6 users. Assume the necessary data suitably.

Project works

1. Design and draw free hand sketches of Pit privy, VIP latrine, Pour flush latrine.

Unit 10 : Solid Waste Management

10.1 Definition

Solid waste is unwanted/useless solid materials generated from combined residential, industrial and commercial activities in a given area. It may be categorized according to its origin (domestic, industrial, commercial, construction or institutional) according to its contents (organic, material, glass, metal, plastic, paper etc.) according to hazard potential (toxic, non-toxic, flammable, radioactive, infectious, etc.).

Management of solid waste reduces or eliminates adverse impacts on the environment and human health; and supports economic development and improved quality of life. A number of processes are involved in effectively managing waste for a municipality. These include monitoring, collection, transport, processing, recycling and disposal.

10.2 Types of Wastes, Effects and Disposal

Types of Wastes

- Rubbish
- Garbage
- Refuge

Rubbish

All sun dry solid waste as paper, broken furniture, waste building materials, etc. are known as rubbish.

Garbage

The term garbage is used to indicate dry refuge and it includes grass, leaves, paper pieces, vegetable, etc.

Refuge

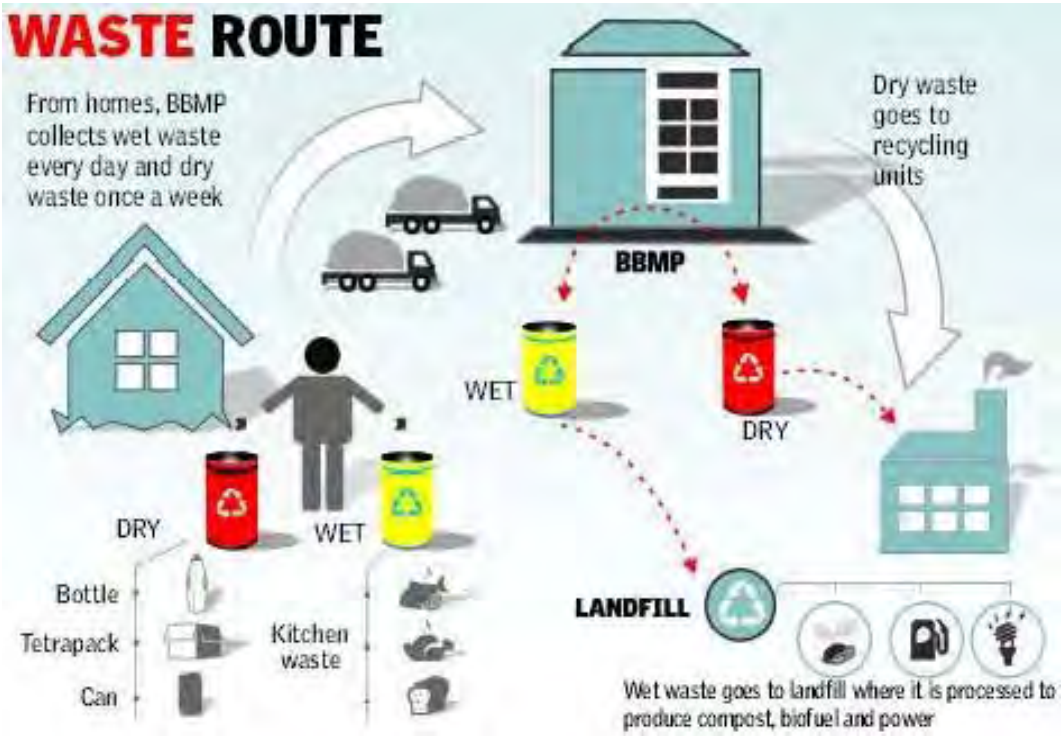
The term refuge is used to indicate what is rejected or left as worthless.

10.3 Onsite Management

When the waste materials are disposed at the origin of production, then it is called onsite management, but if it is disposed far away from the origin; is called offsite management.

10.4 Waste Segregation

Waste segregation means separation of waste into dry, wet and other form, so that, it is easier to handle it later.



10.5 Collection of Solid Waste

The frequency of refuge collection mainly depends on the quantity of the refuge and the season. Usually the collection of the refuse from the roadside refuge

containers and bins, and its proper disposal is the responsibility of the local bodies or municipalities. The refuse is collected in closed trucks, tractors trailers and taken out of the town for disposal. The frequency of refuge collection is kept such that the refuge may not start giving nuisance due to its odour and fly breeding.

Waste collection is generally considered to be the most important component of any waste management system because it is the most expensive and visible part of the system. Therefore, properly designed and executed waste collection systems can result in significant savings and reduction in environmental and public health risks. The following issues generally need to be considered in designing a waste collection system:

- containerization and on-site storage of waste
- source separation
- collection mechanism (roadside collection, door-to-door collection, communal containers, on-time collection etc.)
- cleansing of streets and other public places
- time of collection
- type of vehicles used for collection
- frequency of collection
- route planning
- number of staff used for collection
- special collection for bulk waste generators
- separate collection for special waste such as medical waste and household hazardous waste
- transfer of waste from primary collection vehicles to larger vehicle for secondary transport

10.6 4R Principle

- Reduce
- Reuse
- Recycle
- Replace

Reduce

As far as practicable, biodegradable or environment friendly materials have to be used. We should minimize the use of things like plastic shopping bags and other materials that makes the environment dirty.

Reuse

Provide separate bins for collecting used packing, card binding, and other materials that can be reused. Use reusable cutlery (knifes, spoon, etc.), dishes, cups and coffee filters (e.g. Avoid using paper cups).

Recycle

Set up a recycling scheme in the offices for scrap paper, toner, cartridges, plastic bottles, aluminum cans, etc. Donate old computers, electronic appliances andfurniture to charities. Separate scrap metal, wood and plastic from industrial wastefor recycling.

Replace

Use durable items instead of one-off disposable items. Eg. Replace paper cups with mugs glasses, replace paper towels with hand-dryers or cloth towel.

Exercise

Choose the correct answer from the given alternatives.

1. Which is not included in 4R principle?

   a. Reduce b. Reuse c. Recycle d. Regenerate

2. Dumping method of sewage disposal is .....

   a. Expensive b. Unhygienic c. Scientific d. Hygienic

Write short answer to the following questions.

1. What is solid waste management?
2. What are the major sources of solid waste?
3. Write about onsite management of solid waste.

Write long answer to the following questions.

1. How is solid waste collected from community? Explain.
2. Discuss 4R principle followed in solid waste management.

Project works

1. Perform segregation of waste from school including canteen.
2. Perform composting of organic waste in the compost bin or compost pit.

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