UNESCO-NIGERIA TECHNICAL &
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NATIONAL DIPLOMA IN
CIVIL ENGINEERING TECHNOLOGY

WATER SUPPLY AND SANITARY ENGINEERING

COURSE CODE: CEC 202

YEAR II- SE MESTER 2

THEORY/

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WEEK ONE

1.0 ESTIMATE WATER DEMAND

1.1 (A) USE OF WATER IN PRIMARY TERMS

- Washing and bathing
- Laundry
- Cleaning (windows, doors, floors etc)
- Watering lawns and Gardens
- Heating and cooling systems
- Sprinkling and cleaning streets
- Filling swimming and wading pools
- Display in fountains and cascades
- Production of hydraulic and steam power
- Varied industrial processes
- Fire fighting (Protecting life/property)
- Removal of offensive and Potential dangerous wastes from household (Sewage) and industry (industrial waste)

(B) IMPORTANCE OF WATER IN BROAD TERMS.

- Agriculture (irrigation)
- Industrial purposes
- Domestic use
- Recreation
- Commercial
- Hydroelectric power
- Sewer flushing
- Public supply

1.2 HOURLY, DAILY AND SEASONAL VARIATIONS IN DEMAND (WORKING HOURS, WEEKENDS, DRY & RAINY SEASON)

Water Demand – Is a schedule of the total quantity of water required for a specific purpose such as municipal use, power, irrigation, storage etc.

Water Consumption – Is the amount of water consumed in a specified area. Consumption in areas with comparable condition is often used as a guide for making estimation for new district. Water supply systems are designed to meet community used for a reasonable number of years in future. Rate of consumption is normally expressed as mean annual use in gallon per capita daily.

There are variations in hourly, daily and seasonal demand. Demand may be high in the early hours, mid day and early evenings. Demand may also be high at weekends than week days. At weekends more people are around to use water for domestic purposes. Demand may also be high at dry seasons because of dehydration.

1.3 FACTORS AFFECTING WATER CONSUMPTION

1- **Population**: Related to volume in consumption

2- **Availability of water:** Influences usage

3- **Quality of the water:** Clean water ➔ high demand and vice-versa

4- Presence of water demanding Industries: There should be high demand in towns like Lagos, Kaduna and Jos because (Textiles, Breweries etc).

5- **Availability of funds:** For water treatment plant, in relation to design period which can be increased from 25 to 50 years.

6- **Climate:** high consumption in dry season than wet season because of dehydration.

7- **Cost of delivery:** If of cost production of potable water is high➔ higher tariff ➔ reduction in the rate of consumption.

8- **Standard of living of the consumers:** Rich ➔ high consumption and vice – versa.

9- **Management and efficiency of water works:** good management ➔ better service (delivers) ➔ high consumption.

10- **Pressure of the water:** Low pressures leads to frustration ➔ look for alternative sources (wells) Low consumption.

11- **Metering of water instead of flat rate:** This increases the tariff and is controls consumption.

12- **Characteristics of the population:** culture, age distribution and religion.

1.4 METHODS OF POPULATION PREDICTION

- **Population Data:** The best source of information on the population living in a given community or area at a given time is by conducting an official census or enumeration. This is done through special surveys conducted by public authorities or private agencies for governmental, social or commercial purposes.

- **Population growth**: Population is increased by birth and decreased by death, increased or decreased by migration. If the sum of these changes is positive then a gain is registered, and if it is negative a loss occurs. Urbanization and industrialization bring about social and economic changes as well as growth, educational and employment opportunities and medical care are among the desirable changes. Among unwanted changes are the creation of slums and the pollution of air, water and soil.

- Methods of Population prediction (forecasting)

1- Graphical method
2- Comparative method
3- Ratio and correlation method
4- Incremental increase method
5- Decrease rate of increase method, or decreasing rate method of changing rate of increase method
6- Master plan or zoning method
7- Component method
8- Logistic curve method.

FACTORS AFFECTING THE FORECAST OF POPULATION

1. The period of forecast (when the period increases, the accuracy decreases)
2. The population of the are (when the population decreases the accuracy decreases)
3. The rate of increase of population (when the rate increases, the accuracy decreases).

EXAMPLES ON METHODS OF POPULATION PREDICTION

1) Arithmetic Increase Method: This method is based upon the assumption that the population is increasing at a constant rate. The rate of population change has been and will remain constant. ie. the rate of change of population with time.

Mathematically ➔

$$\frac{dp}{dt} = K_a \text{-------------------------} (1)$$

$$dp = Kadt \text{-----------------------} (2)$$

dp/dt represents the changes in population P in unit time, t and Ka is an arithmetic constant.

Integrating between the initial population, P_i at the initial year t_i and population P_f at the future year t_f ➔

$$\int_{P_i}^{P_f} dp = K_a \int^{t_f} dt$$

t_i

$$P_f - P_i = Ka\,(t_f - t_i) \text{---------------} (3)$$

$$P_f = P_i + Ka\,(t_f - t_i) \text{--------------} (4)$$

$$K_a = \frac{P_f - P_i}{t_f - t_i} \text{----------------------} (5)$$

$$= \frac{P_i - P_e}{t_i - t_e} \text{--------------------------} (6)$$

Where P_c is the population in some earlier year t_e. From equation above It is clear that the relationship between time and population is straight line and the shape of the line will give the value of K_a (average increase per census).

Example: 1

The census record of a city is given below estimate the population of the city in 1970 and 1980 assuming arithmetic trend in growth.

Year	**population**
1930	62
1940	74
1950	85
1960	100

Soln.

Year population $K_a = \frac{P_f - P_i}{t_f - t_i}$

1930	62,000	$\frac{74000 - 6200}{10} = 1200$
1940	74,000	$\frac{85000 - 74000}{10} = 1100$
1950	85,000	$\frac{100,000 - 85000}{10} = \underline{1500}$
1960	100,000	Average K_a = $\frac{1200 + 1100 + 1500}{3} = 1266.66$

Note: $P_f = P_i + K_a (t_f - t_1)$

$$\therefore P_{1970} = 100,000 + 1266.66 (1970 - 1960)$$
$$= 100,000 + 1266.66 (10)$$
$$= \underline{112,666}$$

$$P_{1980} = 112,666 + 1266.66 (10)$$
$$= 125,332$$

Example: 2

The populations of a city for five decades from 1930 to 1970 are given below, find out the population after one, two and three decades beyond the last known decade by using arithmetic increase method.

Year	population.
1930	25,000
1940	28,000
1950	34,000
1960	42,000
1970	47,000

$$\frac{28000 - 25000}{10} = 300$$

$$\frac{34000 - 25000}{10} = 300$$

$\underline{42000 - 34000} = 800$

10

47000 – 42000 = 500

The Average $K_a = \frac{300 + 600 + 800 – 500}{4}$

$K_a = 550$

:. $P_{1980} = P_i + Ka (t_f – t_1)$

= 47000 + 550 (10)

= 52,500

P_{1990} = 52500 + 550 (10)

= 58,000

P_{2000} = 58,000 + 550 (10)

= 63,500

This can also be simply solved arithmetically as follows,

Year	Population	increase in population		
1930	25,000	3000		
1940	28,000	6000		
1950	34,000	8000		
1960	42,000	5000		
1970	47,000			
	Total	22,000		
	Average/Decade	$\frac{22,000}{4}$	=	5,500

:. The expected population of the end of year

1980	=	47000 + 5500
	=	52500
1990	=	52500 + 5500
	=	58,000
2000	=	58,000 + 5500
	=	63500

2) Geometric Increase Method: In this method it is assumed that the rate of population change is equivalent that the percentage increase in population from decade to decade remains constant.

$$\frac{dp}{dt} = Kg\ P \text{--------}(1)$$

kg = geometric constant

integrating between the initial population P_i at the year t_i and population P_f of the forecast year t_f, we have

$$\int_{P_i}^{P_f} dp/p = kg \int_{t_i}^{t_f} dt$$

$$\text{In } \frac{P_f}{P_i} = kg\,(t_f - t_i) \text{---------------}(2)$$

$$\text{In } P_f = \text{In } P_i + kg\,(t_f - t_i) \text{--------------------}(3)$$

$$kg = \frac{\text{In } P_f - \text{In } P_i}{t_f - t_i} \text{--------------}(4)$$

$$= \frac{\text{In } P_i - \text{In } P_e}{t_i - t_e}$$

Where P_c is the population at some earlier year t_e indicates that if population is plotted on a logarithmic scale and time is plotted on a linear scale, a straight line will be obtained. The slope of the graph will give the value of kg.

Example

Solve previous example using geometric increase method:

Year	population	$kg = \frac{\text{In } P_f - \text{In } P_i}{t_f - t_i} = \frac{\text{In } P_f/P_i}{t_f - t_i}$
1930	62,000	
		$= \frac{1n\,(\frac{74000}{62000})}{10} = 0.01769$
1940	74000	
		$= \frac{\ln\,(\frac{85}{74})}{10} = 0.0138$
1950	85000	

$$= \frac{\ln\left(\frac{100}{85}\right)}{10} = 0.0163$$

1960	10000

Total = 0.04779

Average Kg = $\frac{0.04779}{3}$ = 0.01593

:. $\ln P_f = \ln P_i + Kg\,(t_f - t_1)$

$\ln P_{1970} = \ln 100{,}000 + 0.0158\,(10)$

$\text{Log } P_{1970} = 5.069$

$P_{1970} = 117.200$

The average value of the percentage increase may be calculated and the future population are calculated at this rate.

Example: Solve by geometric increase

Soln.

Year	population	Increase in pop.	% increase in pop
1930	25,000		$\frac{3000}{25000}$ x 100 = 12%
		3000	
1940	28,000	6000	$\frac{6000}{28000}$ x 100 = 21.4%
1950	34,000	8000	$\frac{8000}{34000}$ x 100 = 23.5%
1960	42,000		
1970	47000	5000	$\frac{5000}{42000}$ x 100 = 11.9%
Total		22,000	

Average / decade $\frac{2200}{4} = 5500$ $\frac{68.8}{4} = 17.2\%$

(a) :. Expected population at the end of 1980

$$= 47000 + \frac{17.2}{100} \times 47000$$
$$= 55084$$

(b) Year 1990 $= 55084 + \frac{17.2}{100} \times 55084$
$$= 64,558$$

(c) Year 2000 $= 64558 + \frac{17.2}{100} \times 64558$

$$= 75662.$$

Note:

Before choosing either the arithmetical or the geometrical method, the past population values should be plotted against time on ordinary gape paper. If the relationship between population and time is approximately linear, then the arithmetic method should be used for forecasting the population. If the graph is concave upwards, then she geometrical method may be employed. The time interval selected for finding the values of Ka and kg may be either the last census interval, or an average of several intervals, or any other selection deemed desirable.

WEEK TWO

2.1 SOURCES OF WATER

1. GROUNDWATER

(Underground water) aquifers, this is found in wells, springs, infiltration galleries, etc. There are two sources of ground water:

(a) Rainfall which infiltrates, percolate or permeates into the ground through the pores or cracks in the rock formation and finally reaches the underground water table.

(b) The water from streams: Rivers, lakes and reservoirs which seeps or permeates through the soil to the underground water table

Because of the seepage through pores of soil and rock, ground water rarely needs any treatment before consumption, unless there is a highly contaminated area around the particular ground water or aquifer.

2. SURFACE WATER

This is exposed to contamination and so it must be treatment before use. It may contain both organic and inorganic impurities, gases and micro organisms. It is generally used for drinking purposes when the ground water supply is inadequate in quantity.

a) **Rain water:** This is generally collected from the roofs of buildings and stored in cisterns for domestic consumption. It may also be collected in reservoirs. Rain water is soft and suitable for laundry purposes, it also corrosive when in equilibrium with atmospheric gases. It is normally in very small communities which as other source of water supply (deserts).

b) **River water:** This is rainfall that does not percolate into the ground, taken in by plants or evaporates. It flows on the ground surface as rivers, streams and into the sea. Water may be drawn from a river continuously throughout the year or it may be stored during times of flood and then supplied to the community during drought. Because of pollution river water has to be properly treated.

c) **Lakes and ponds:** These are areas of water surrounded by lend. Deep lakes and ponds having sufficiently large surface areas can be used for municipal water supply. Here the water may be of better quality than the river water and can be used for domestic purposes without much treatment. During floods and heavy rain, lakes and ponds fill up and discharge to the rivers and streams increases.

2.2 FACTORS FOR SOURCE SELECTION

a) **Purity of the raw water:** This is with respect to the possibility of treatment (cost)

b) Volume of water available to be enough to satisfy minimum requirement. Normally inflow should be greater than outflow.

c) **Permanency of the sources:** Available in large quantity with a continuous recharge.

d) **Elevation of the water level with respect to the area to be supplied:** Cost of lifting the water to a higher elevation will be higher than that from a lower elevation and may requires the use of pumps.

e) Availability of finance: to carry out the design, construction, running and maintenance. This is related to the kind of structures.

3.0 WATER INTAKES

An intake is a structure required to withdraw water from a river, lake or reservoir. The primary functions of an intakes is to

- To supply highest quantity of water from the sources
- To protect piping and pumps from damage or clogging as a result of floating and submerged debris.

3.1 TYPES OF INTAKES

a) Direct Intake

These are located waters, and cheaper than any other intake. Direct intake is suitable when the source is deep such as rivers or lakes, and also when the embankment is resistant to erosion and sedimentation (very stable)

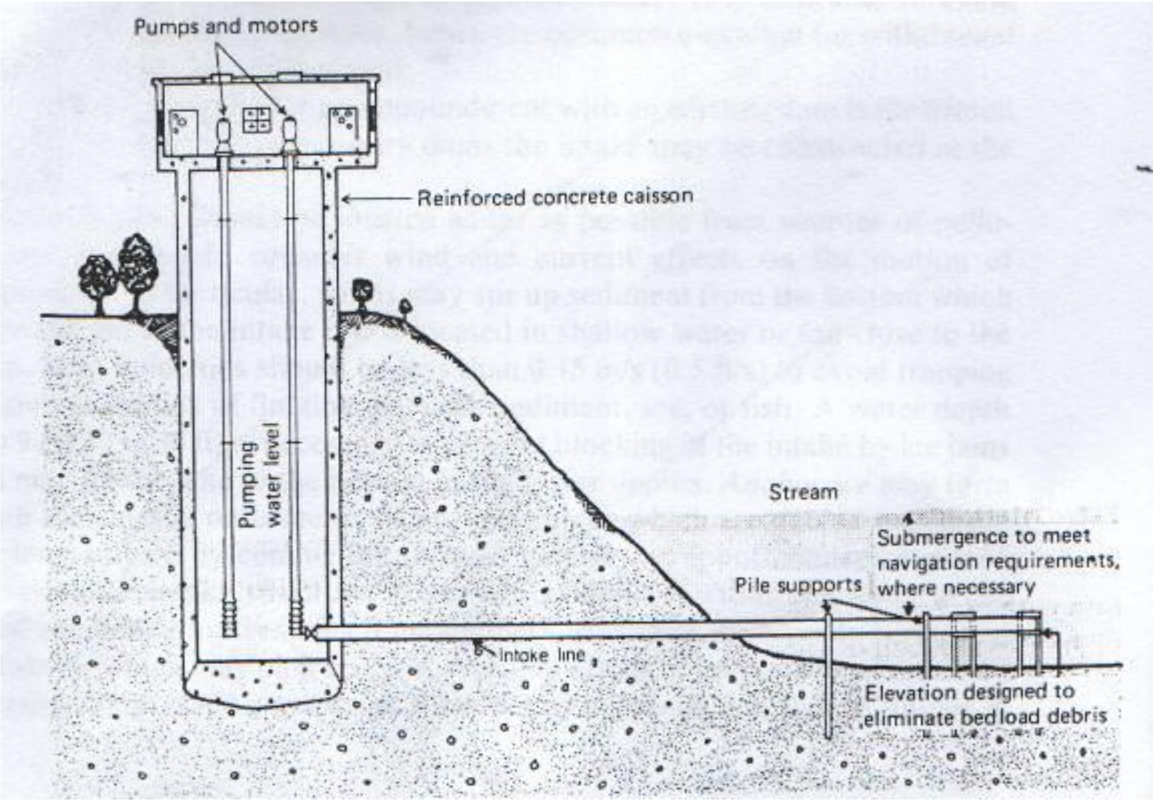


Fig 2.1 Screen Pipe intake

b. **Canal Intake**

These are built and used to draw water from canals. A masonry chamber with an opening is built partially in the canal bank. The opening is provided with a course screen. From the chamber water is drawn by a pipe having a bell mouth covered with a perforated hemispherical cover.

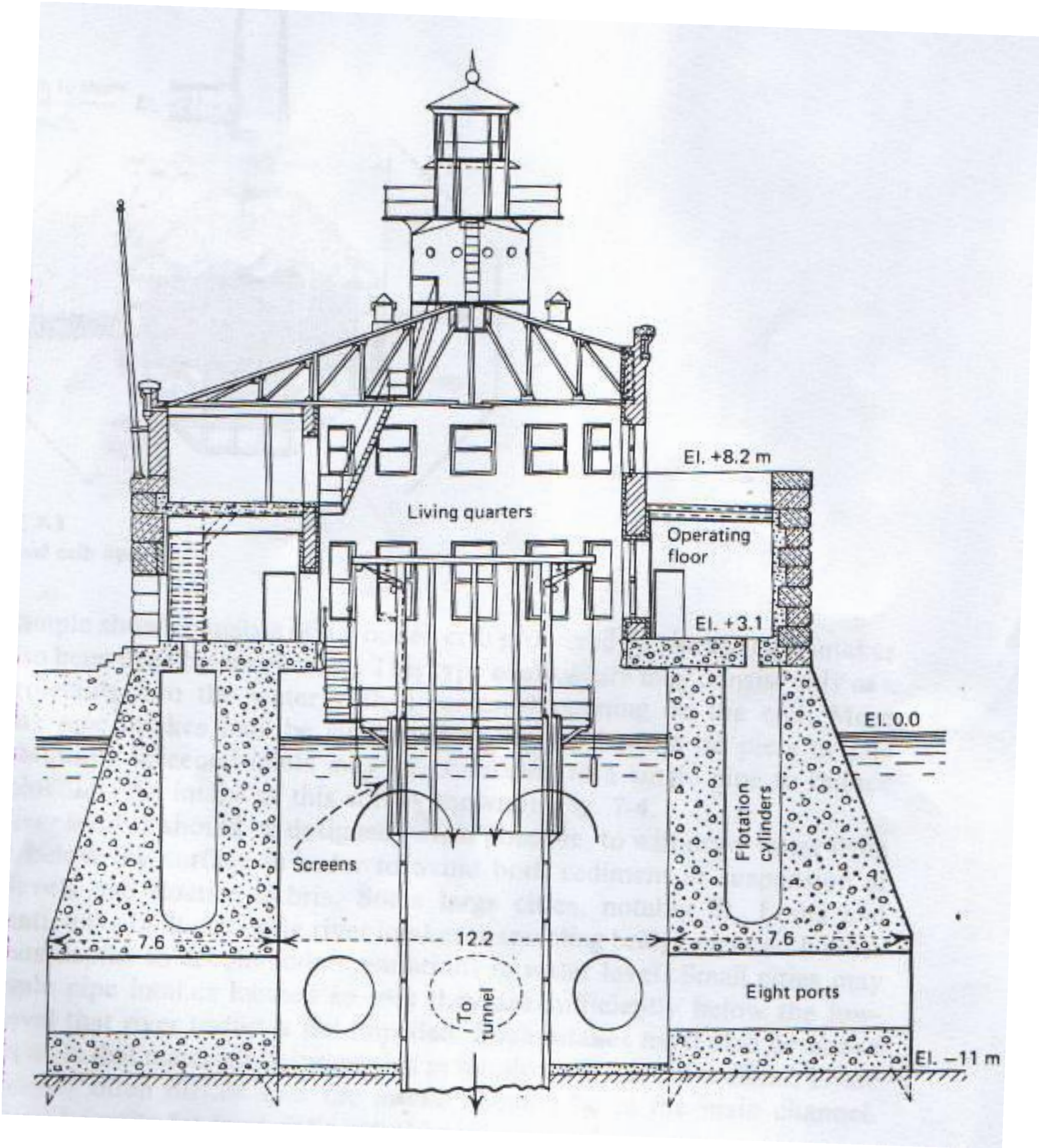
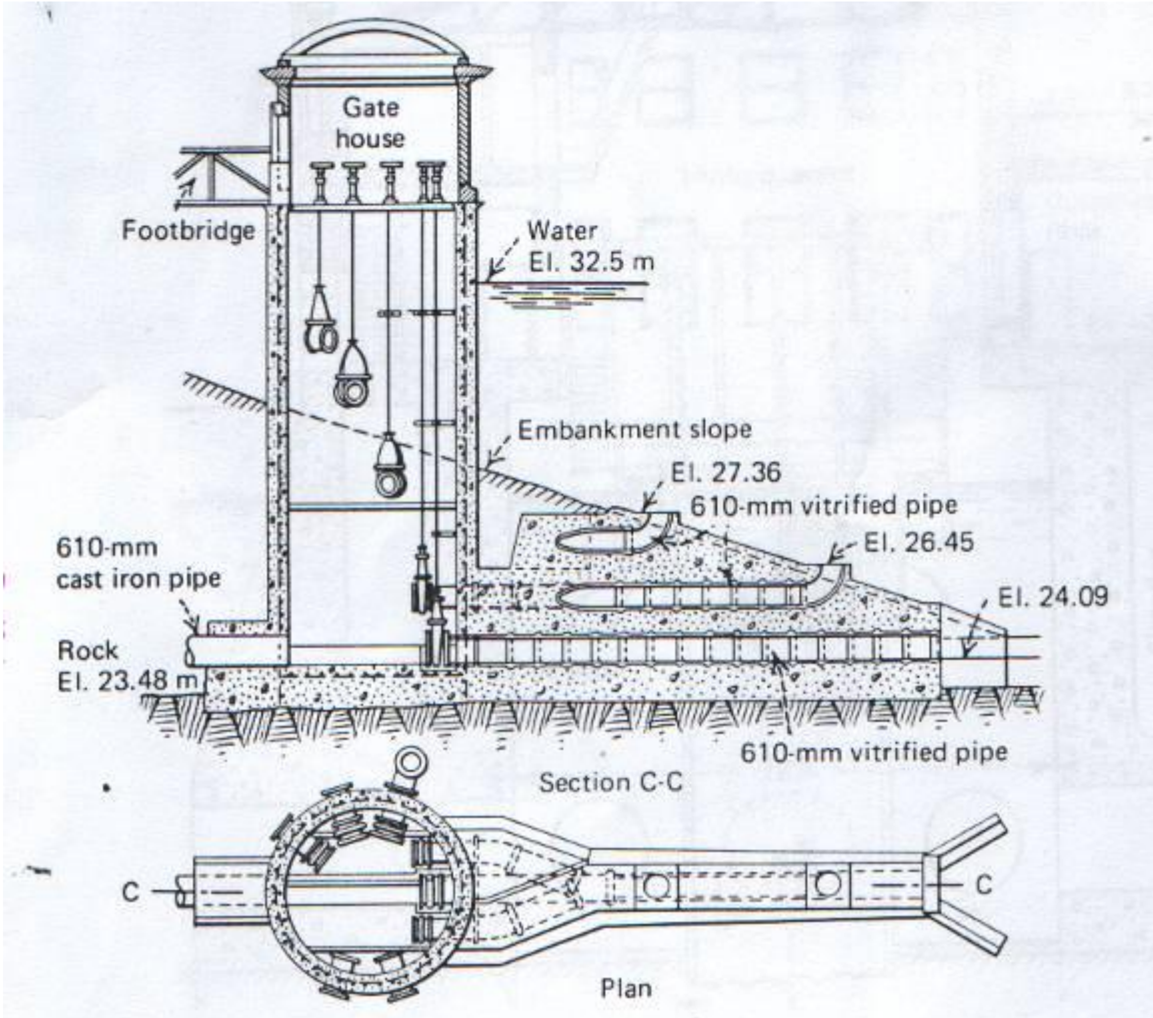


Fig 2.2 Canal Intake

c. **Reservoir Intake**

In the type, the intake tower is either located at the spillway section or wear the toe of an earthen dam. The foundation of the tower is separated from that of the dam. It is constructed on the upstream side. A number of inlets at various levels are provided by the tower to compensate for water level fluctuations. When reservoirs are at such a level that water can flow by gravity to the purification works, then an intake tower is not required.



3.2 PRINCIPLE OF INTAKE DESIGN

Factors to be consider in the location of an intake:

a) Intakes should be located where there is no fast current which may damage the intake causing interruption in the water supply.

b) The ground near an intake should be stable. A straight section of the river is preferable as erosion is minimal.

c) The approach to the intake should be free from obstacle.

d) The intake should be well below the water surface and well above the bottom of the water body for preventing floating matter and suspended matter near the bottom respectively.

e) The intake should be located at some distance from the bunk to avoid contamination of bark.

f) The intake should be located on the upstream of the town.

WEEK THREE

4.0 PUMPS AND PUMPING STATIONS

4.1 NEED FOR PUMPING WATER

Simply put, a pump is a device for lifting water from a lower level. Sometimes a pump can be used to increase the flour pressure of water, oil or gas.

Normally most water sources are in lower levels compared to delivery points, for the water to get to the treatment works and then delivered to consumes, there is the need for the delivered to consumers, there is the need for the use of pumps to carry or pump the water to it's destination.

Sometimes there is the need for water to travel long distances along pipes, this results in loss of pressure and requires pump to maintain or increase the pressure of water alone, the pipe network. Pumps are also used to take water up to elevated tanks for storage and onward delivery to consumers. The use of pumps are also employed in irrigation process to deliver water to crops been irrigated.

Pumping facilities have to be provided to pump water for water supply if economical gravity systems cannot be constructed. Most large pumping stations abstract water from surface sources such as rivers, canals lakes, etc. whereas ground water abstraction is usually provided by smaller (usually submerged) pumping units.

Pumping installations may also be needed to pump sewage or storm sewer flows from low level networks to high level screening/treatment plants. Also booster pumps may be needed in water supply network to boost pressure heads. Reversible pump turbine units are utilized in pumped storage hydroelectric schemes.

In all these cases different types of pumps with appropriate sump and intake arrangement of the abstraction point are used to transfer the liquid from low to high levels.

Finally pumps are hydraulic machines which convert mechanical energy (imparted by rotation) into water energy used in lifting (pumping) water/sewage to higher elevations. The mechanical energy is provided by electrical power (motor) or a diesel or gas or stream prime movers using either vertical or horizontal spindles.

4.2 TYPES OF PUMPS

Some form of pumping is used in most water supply. In water supply systems pumps are required to deliver water from wells, to lift water to distribution reservoirs and elevated tanks, and to increase pressure in distribution systems. The movement of water from one location to another is the most common application of pumps.

The types of pumps used most commonly in the water and wastewater systems are described in this section. In general, pumps may be classified according to their

1. Principle of operation
2. Field of application (i.e. liquids handled)
3. Operational duty (i.e. head and capacity)
4. Type of construction, and
5. Method of drive.

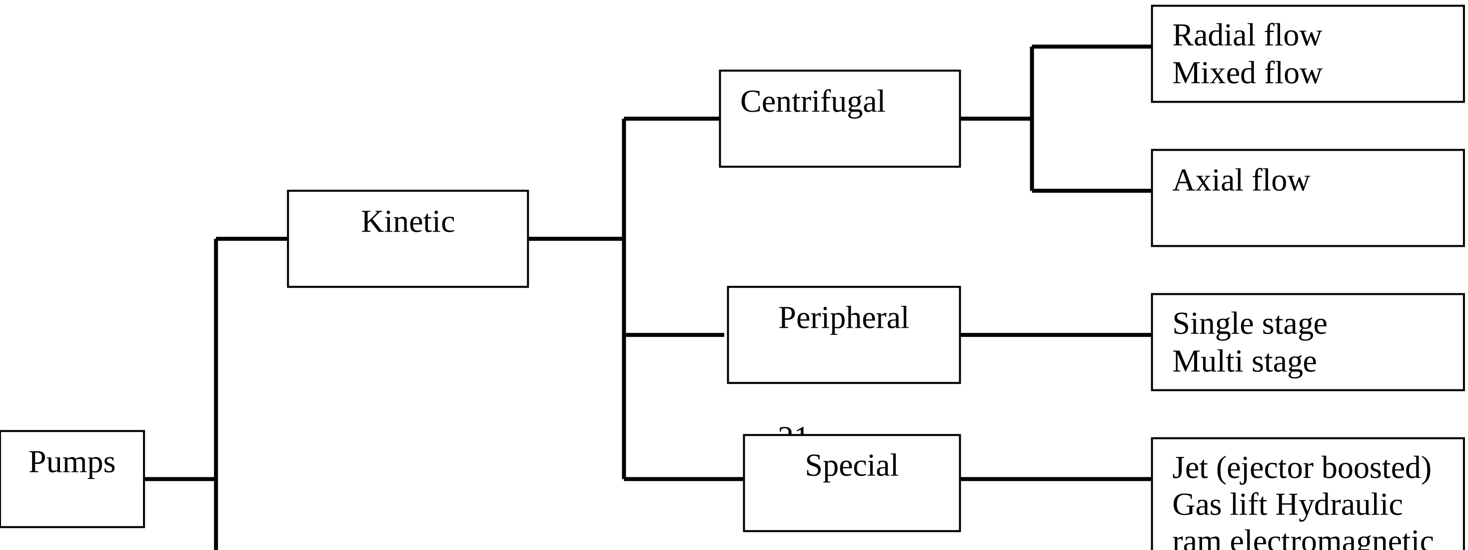
With respect to the principle of operation, pumps may be classified as Kinetic – energy pumps or positive – displacement pumps. The term turbo machine is also used to describe kinetic – energy pumps. The principal types of pumps include under these two classifications are shown in fig 3.1 below

a. Kinetic Energy Pumps

The principal sub-classification of kinetic – energy pumps is centrifugal, which, in turn, is divided further into three groups:

1. Radial – flow pumps
2. Mixed – flow pumps
3. Axial – flow pumps

The above classifications are derived from the manner in which the fluid is displaced as it moves through the pump. Thus, the fluid is displaced radially in a radial – flow pump, axially in an axial – flow pump, and both radially and axially in a mixed flow pump



The principal components of kinetic – energy pumps are;

1. The rotating element called the impeller that imparts energy to the liquid being pumped.
2. The shaft on which the impeller is mounted.
3. The pump casing that includes the inlet and outlet passages for leading the liquid being pumped into and out of the pump, and the recuperating section which receives the liquid discharged from the impeller and directs it to the outlet passage. The function of the recuperating section is to convert a portion of the kinetic energy of the fluid into pressure energy. Typically this is accomplished by means of a volute or a set of diffusion vanes. In a volute casing, the size of the channel surrounding the impeller increases gradually to the size of the pump discharge nozzle, and most of the conversion of velocity to pressure occurs within the vane passages.
4. The frame which supports the pump casing.

Because rags and trash in wastewater (even though screened) would quickly clog the small passages in typical Clearwater radial – flow pumps, the pumps used for untreated wastewater are usually the single – end section volute type, fitted with nonclog impellers. Nonclog pumps have open passages and a minimum number of vanes (not exceeding two in the smaller sizes and limited to three, or at the most four, in the larger sizes).

Wastewater pumps must be able to pass solids that enter the collection system. Because a 70mm diameter solid can pass through most domestic toilets, it is common practice to require that pumps be able to discharge a 75mm solid. Most 100mm pumps i.e. pumps with a 100mm discharge opening normally should be able to pass 75mm diameter solids, and 200mm pumps should be able to pass 100mm diameter solids, and 200mm pumps should be able to pass 100mm diameter solids, etc. Nonclog pumps smaller than 100mm should not be used in municipal pumping stations for handling untreated wastewater.

b. Positive – Displacement Pumps

Positive – displacement pumps are usually divided into two major categories; reciprocating (piston or diaphragm) pumps and rotary pumps. Pneumatic ejectors and the Archimedean screw pump are also included under this category.

Piston – type reciprocating pumps utilize a reciprocating piston or plunger in a cylinder to draw a fluid in on the suction side and to discharge it under pressure on the discharge side. In a diaphragm pump, the reciprocating element is a flexible diaphragm. In both of these pumps check valves are used to control the pump suction and discharge.

In rotary positive – displacement pumps, the essential working element is a rotor that may have the form of an impeller, vane, lobe, or any other suitable configuration. The principal types of rotary positive – displacement pumps are

1. Eccentric rotor screw (progressive cavity)
2. Gear,
3. Lobe,
4. Peristaltic
5. Piston
6. Screw
7. Vane
8. Flexible vane

Pneumatic ejectors are often used for raising wastewater from building sumps. The ejector consists of an airtight tank into which wastewater flows by gravity and out of which the wastewater is forced automatically whenever sufficient wastewater has accumulated to raise a float and open the compressed air – inlet valve.

The screw pump is based on the Archimedean screw principle in which a revolving shaft fitted with one, two, or three helical blades rotates in an inclined trough and pushes the wastewater up the trough (see fig). Screw pumps are commonly used in waste water – treatment plants to pump untreated wastewater and return waste activated sludge.

4.3 CRITERIA FOR PUMP SELECTIONS

1. The head to be pumped against (e.g. ground to reservoir) (i.e. distance, how high)
2. The required volume rate (discharge rate) of flow i.e among o water in volume to be pumped at a given time.
3. The characteristics of the fluid to be pumped. i.e.
   i) Temperature
   ii) Amount of suspended solids

iii) viscosity of fluid etc. this is because different pumps are designed to handle different types of fluids of different characteristics (e.g. water and oil)

WEEK FOUR

5.0 BASIC WATER TREATMENT PROCESSES

5.1 DESIRABLE STANDARDS OF WATER

In order for water delivered to the ultimate consumer to be considered safe or portable, it must be scrutinized with a multi-science approach involving bacteriology, chemistry, physics, engineering and public health, preventive medicine, and control and evaluation management.

Portable or ‘drinking’ water can be defined as the water delivered to the consumer that can be safely used for drinking, cooking and washing.

The public health aspects are of such importance and complexity that the health authority having jurisdiction in the community now reviews, inspects, samples, monitors and evaluates on a continuing basis the water supplied to the community, using constantly updated drinking water standards. Such public health control helps to guarantee a continuous supply of water maintained within safe limits.

The drinking water standards established by EPA (environmental protection agencies) reflect the best available scientific and technical judgment.

Water analysis alone is not sufficient to maintain quality but must be combined with the periodic review and acceptance of the facilities involved. this approval consist of the evaluation and maintenance of proper protection of the water source qualifications of personnel, water supplier’s adequate monitoring work, and also evaluation of the quality and performance of laboratory work.

5.2 REASONS FOR ESTABLISHING STANDARDS

Hence, it could be summarized that portable water must meet the physical, chemical, bacteriological, and radionuclide parameters when supplied by an approved source, delivered to a treatment and disinfection facility of proper design, construction, and operation, and in turn delivered to the consumer through a protected distribution system in sufficient quantity and pressure. In addition, water should have palatability, be within reasonable limits of temperature, and possibly gain the confidence of the consumers.

During the last 20 centuries, serious attempts have been made to serve communities with sufficient amount of drinking water, but only recently has criteria for acceptability been developed in it complexity, with numbers instead of adjectives, with chemical and bacteriological examination to form the base for standards. When the relationship between water borne diseases and drinking water was established, then the technology for treatment and disinfection developed rapidly. Standards were developed at the same time, mostly originated by the health authorities and by dedicated sanitary engineers and scientists:

There are two main substances for which standards have been set pose immediate threat to health whenever they are exceeded:

a) **Bacteria -** Coliform bacteria from human and animal wastes may be found in drinking water if the water is not property treated. Water borne diseases such as typhoid, cholera, hepatitis and dysentery have been traced to improperly disinfected drinking water.

b) **Nitrate –** nitrate in drinking water above the national standard poses an immediate threat to children six months to one year old. It reacts with the hemoglobin in the blood to produce an anemic condition.

Drinking water standards of EPA

Contaminant	Limit
Primary standards (Maximum Contaminant Level, MCL)	
Total coliforms (av. Number/100ml	1
Total coliforms (max. numbedr/100 ml	5
Turbidity (ntu)	1-5
Inorganic chemicals (mg/l)	
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.7-2.4
Fluoride	0.05
Lead	0.002
Mercury	10.0
Nitrate (as N)	0.01
Selenium	0.05
Silver	
Radiounuclides (pC_i/L)	
Gross alpha	15
Ra-225 + Ra – 228	5
Gross beta	50
H-3	20,000
Sr-90	8
Organic chemicals (g/l)	
Endrin	0.2
Lindane	40
Methoxychlor	100
Toxaphene	5
2,4-D	100
2,4,5-TP	10
Trihalomethanes	100
Benzene	0.05
Carbon tetrachloride	0.05
1,2 Dichloroethane	0.05

Trichlorocthylene	0.05
Para-dichlorobenzene	0.75
1,1 Dichloroethylene	0.07
1,1,1 Trichloroethane	2.0
Vinyl chloride	0.02
Secondary Standards (Recommended Contaminant Levels, RCL)	
Chloride	250mg/l
Color	15 units
Copper	1mg/l
Iron	0.3 mg/l
Manganese	0.05mg/l
Odor	3 Ton
pH	6.5 – 8.5
Sulfate	250mg/l
Total dissolved solids	500mg/l
Zinc	5mg/l

5.3 SURVEILLANCE AND SAMPLING TECHNIQUES

Sampling is in fact the must important part of any analysis, since no matter how accurate the analysis is if the sample on which it is carried out is not representative; the result will be misleading.

A single grab sample is only suitable for a source of constant quality and quantity, something which is not common in practice. must waste water are continually changing in character and surface waters may exhibit sudden changes in flow and quality due to rainfall. In these cases a true sample can only be obtained by compositing individual samples obtained at frequent time intervals when the flow is made by mixing 24 separate hourly samples in proportion to the flow at the time of sampling. In certain circumstances it may be advisable to sample continually for such characteristics as P^H, DO, SS, Ct etc.

Ideally all analyses should be carried out on the sample immediately after collection and certainly the quicker the analysis can be done the more likely it is that the results will be a fair representation of the actual liquid insitu. Some analysis must be done treated to fix the content of certain instable constituents. Temperature and dissolved gases are examples of characteristics which require immediate action to prevent charges. Alterations in the composition of a sample can be retarded at low temperatures (4°C) and the exclusion of light is also advisable. The more polluted the water the shorter the time which can be allowed between collection of sample and analysis.

SAMPLING PROCEDURES (METHOD OF COLLECTION OF WATER SAMPLE)

(1) Surface Sources

i. Clean and rinse all apparatus with deionized water before setting out. Calibrate all instruments in the laboratory.

ii. At the site, choose a convenient location to layout apparatus and instrument. Check all instruments again.

iii. Collect sample from the main body of the water below its surface.

iv. Put the water sample in a clean beaker and determine the temperature, PH, conductivity, turbidity etc. and record the result in your note book. Observe and note the colour and odor.

v. Collect samples for laboratory analysis by filling plastic sample bottles completely to the basin, expelling air, and immediately close tightly and label appropriately (time of collection, type of sample, temperature, location etc) and delivery immediately to laboratory for analysis and storage (samples are stored in the refrigerator, but it is brought back to room temperature before analysis).

NOTE: that when trying to determine the total spectrum of the water quality of a body of water as it posses through a complete settlement e.g. a river, or a large lake several sampling.

2. Water from Underground Source Sampling

For underground water samples for bore holes and artisian wells water should be collected at well head after allowing the water to flow for at least 10mins in the case of a source that is used 30 – 40 minutes everyday, it not constantly used. Collect Samples from shallow plastic collector below the surface of the well. Take the sample of water and determine temperature, PH, conductivity turbidity etc.

5.4 METHOD OF WATER ANALYSIS

BASIC ANALYSIS

Water quality control analyses are based on analytical principles. This quantitative analysis may be carried out gravimetric, volumetric or colorimetric method. Determinations are usually carried out b a standard method.

1. Gravimetric Analysis

This depends on weighing solids obtained from the sample by evaporation, filtration or precipitation. This procedure is time- consuming because of the need for careful drying to drive off moisture before weighing, both from the solids and the dish or container in which they are placed.

The main uses of gravimetric analysis are as follows:

- Total and volatile solids
- Suspended solids
- Sulphate

2. Volumetric Analysis

Rapid and accurate determinations in water quality control can be carried out by volumetric analysis. This depends on the measurement of volumes of liquid reagent of known strength.

The requirements for volumetric analysis are relatively simple.

(a) Equipment to measure the sample accurately e.g. pipette.

(b) A standard solution of suitable strength

(c) An indicator to show when the end point has been reached.

(d) A graduated burette for accurate measurement of the volume of standard solution necessary to reach the end point.

(e) Typical uses of volumetric analysis are as follows:

(f) - Acidity and alkalinity

(g) - Chloride

(h) - Dissolved oxygen

(i) - Chemical oxygen demand.

3. Colorimetric Analysis

This is particularly useful when dealing with dilute solutions. To be of quantitative use a colorimetric must be based on the formation of a compound or complex with definite colour characteristics and the density of the colour must be proportional to the concentration of the substance under determination.

The colour produced may be measured by a variety of methods.

- Visual methods

*Comparison tubes (Nessler tubes)

*Colour compartor (Nesslerizer of tintometer)

- Instrument methods

*Absorptiometer or colorimeter

*Spectrophotometer.

4. Electrode

This is used for the measurement of parameter as pH.

WEEK FIVE

5.5 PHYSICAL-CHEMICAL TREATMENT METHODS

The characteristics of a water or waste water sample may be specified by reference to physical, chemical or biological parameter, therefore consideration must be given to the nature of the samples characteristics in the selection of suitable treatment processes.

Impurities may be present as:

a) Floating or suspended solids:

Water-leaves, branches, soil particles etc.

b) Colloidal solids:

Water-clay, silt, micro-organisms;

Wastewater – organic compounds, micro-organisms

c) Dissolved solids:

Water-inorganic salts, tannic acid,

Wastewater – organic compound, inorganic salts.

d) Dissolved gases:

Water- carbon dioxide, hydrogen sulphide

wastewater-hydrogen sulphide

e) Immiscible liquids:

e.g. oils and greases

The actual particle size at which the nature of the material changes from one group to the next depends on the specific gravity of the substance and the division is in any case indistinct.

There are three basic types of treatment process:

1. **Physical Processes**: This depends simply on physical properties of the impurities, e.g. particle size, specific gravity, viscosity, etc. Typical examples of this type of process are, screening, sedimentation filtration, gas transfer.
2. **Chemical Processes**: Dependent on the chemical properties of an impurity or which utilize the chemical properties of added reagents. E.g. are coagulation, precipitation, in exchange.
3. **Biological Processes**: Which utilize biochemical reactions to remove soluble on colloidal organic impurities. e.g. Are biological filtration and the activated sludge process.

Depending on its composition a particular sample may require one or more of the above processes for satisfactory treatment to a particular standard.

5.6 STAGES IN WATER TREATMENT

Aeration

Is used to altar the concentration of dissolved gases, to strip volatile organics, and to reduce tastes and odors, it also involves removal of dissolved gases ($C0_2$ and H_2S).

Screening

To ensure efficient and reliable operation the main units in a treatment plant it is first necessary to remove the large floating and suspended solids, eg branches, rags and other debris which could obstruct flow in the plant. This preliminary treatment usually involves a simple screening or straining. The flow is passed through a screen of 5-20mm aperture mesh. This is placed extending above and below and covering sides of the water intake pipe.

Pre-Chlorination

This is the addition of chlorine immediately after screening. This is done for the following reasons:

- a) To reduce turbidity, colour and odour by killing suspended microorganisms or reduce their growth when the water is excessively contaminated by them.

-b) To improve the coagulating effect of the coagulant by bringing soluble ion into colloidal particle size that can be precipitated.

-c) To oxidize organic matter, sulphide and other odourous gases, ferrous ions, manganese and other oxidisable matter when present in large amounts in order to improve taste and odour.

Sedimentation

This is the process where water is allowed to flow slowly through a basin so that suspended sediments will settle down. The amount of suspended matter removed during sedimentation depends on the size of the sedimentation basin, the particle size, the detention time and the amount of water involved.

Coagulation

This is the use of certain chemical called coagulants. This is used because many impurities in water are present as colloidal solids which will not settle. Thus chemicals (Alum, lime, etc) convert fine sediments that can never settle into bigger sizes called flocs. These flocs are further aggregated together to from bigger amounts of suspended matter that can be precipitated. Large amounts of suspended and dissolved matter are removed in this process resulting in the removal of most of the taste, colour and odour. In modern times, iron compounds are used as coagulants typical called ferri flocs, silica, soda-lime.

Flocculation

The removal of colloidal particles can be achieved by promoting agglomerative of such particles by flocculation. This is the agitation of water by hydraulic or mechanical mixing which causes the collision between particle to produce settle able solids from a high concentration of colloidal particles. With low concentration of colloids a coagulant is added to produce bulky floc particles which enmesh the colloidal solids. Before flocculation can take place it is essential to disperse the coagulant, usually required in doses of 30-100mg/l, throughout the body of water in rapid mixing chamber.

Clarification and Stabilization

Clarification is divided into three parts:

(a) Rapid mix

(b) Flocculation and

(c) Settling.

Here the water is stirred gently by the flocculators so that sludge from coagulation can be removed completely and dispersed. This unit is called clarifier.

In stabilization, the hardness is checked, pH is checked. Sludge are finally removed by mechanical or chemical means.

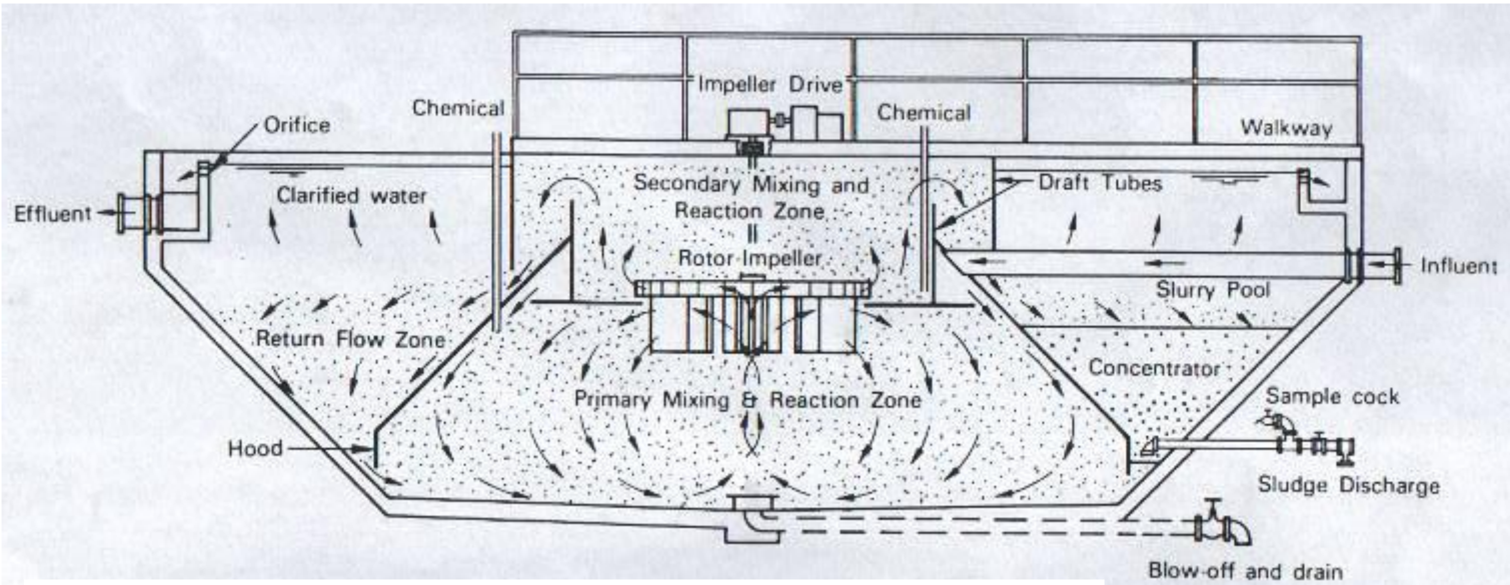


Fig 5.1 Suspended solids contact clarifier

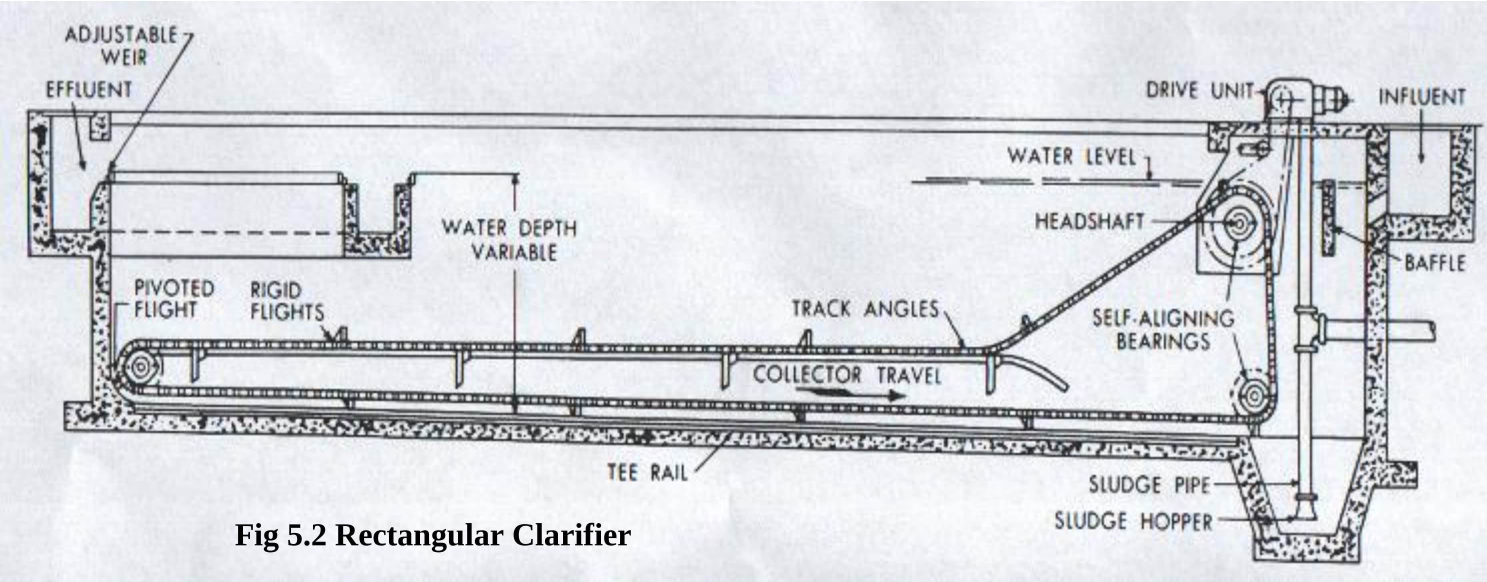


Fig 5.2 Rectangular Clarifier

WEEK SIX

5.7 FILTRATION

This is the process in which water is allowed to flow through granular material such as sand in order to remove colloidal impurities. Such impurities are those not removed during coagulation and sedimentation process. During filtration, a wide range of impurities and water contaminants are removed. It removes bacteria effectively, odour, taste, colour, iron and manganese.

There are various types of fitters in use, but early common ones are; the slow sand fitter and the rapid sand filter. Other filters are pressure filters, multiple media filters, up flow filters etc.

Slow Sand Filters: The operation of this type of filter is similar to the percolation of water through the ground. Water is allowed to flow through the slow sand filter over a long period of settling. During the operation of the slow sand filter, water is fed to it cot head between 0.9 to 1.6m and filtration takes place at rate of between 0.1 to 0.4 m/hr. (0.1 to 0.4 $m3/m^2$ – hr). the effective size of sand is between 0.25 to 0.35mm sieve size. The thickness of sand bed is between 1.0 and 1.5m supported on a layer of gravel of 0.3 to 0.5m thick. This lager prevents the penetration of fine sand into the treated water collector laterals that collects the filtered water.

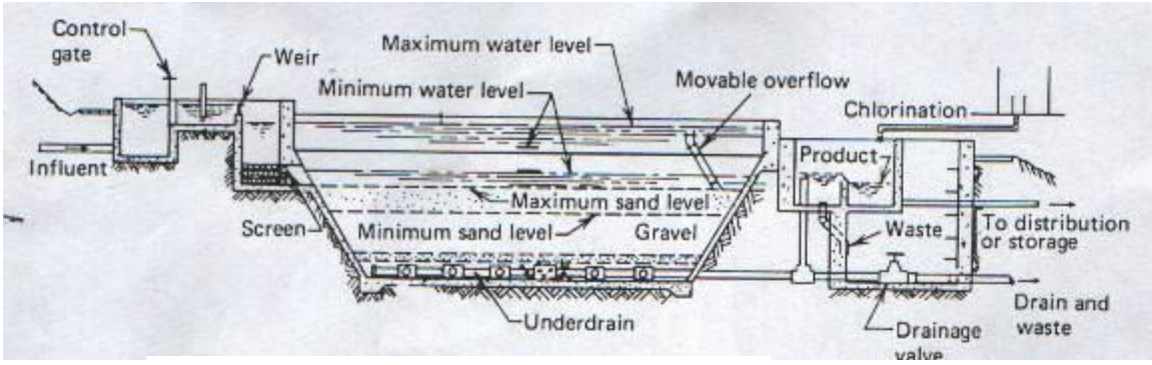
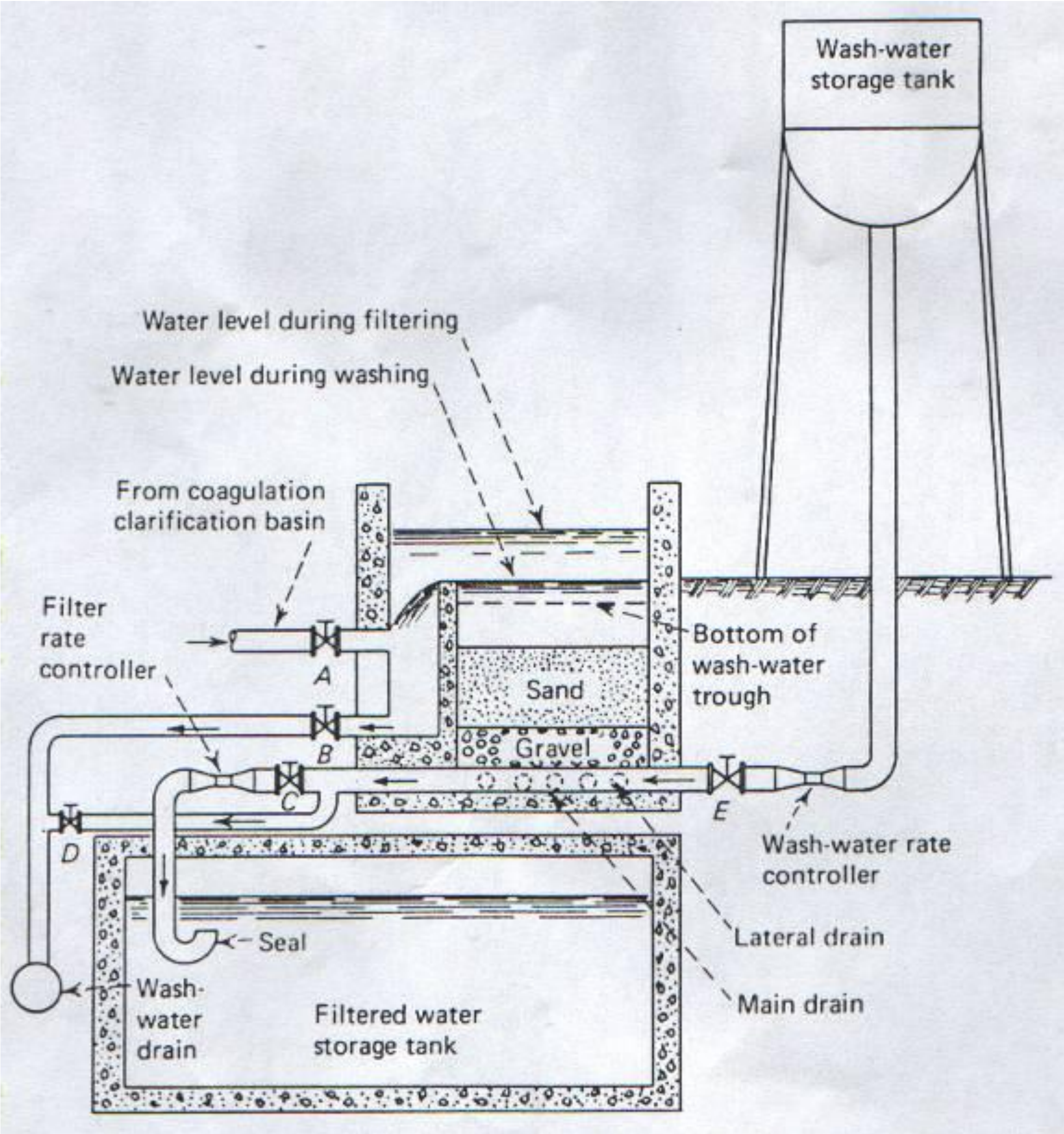


Fig 6.1 Cross section of a slow sand filter

Rapid Sand Filters: The rapid filter commands wide acceptability more than the slow sand filter. The velocity of flow in a rapid sand filter is very high and the rate of filtration is between 4 and 5 m^3/m^2 – ho. The size of sieve is 0.45 to 0.55mm. The filter bed is graded with heavier material at the bottom, while the finer materials are at the top. The filter bed is made up of 80cm of top sand and about 50em of gravel at the bottom. The filter is designed to accommodate a head loss of about 3m.



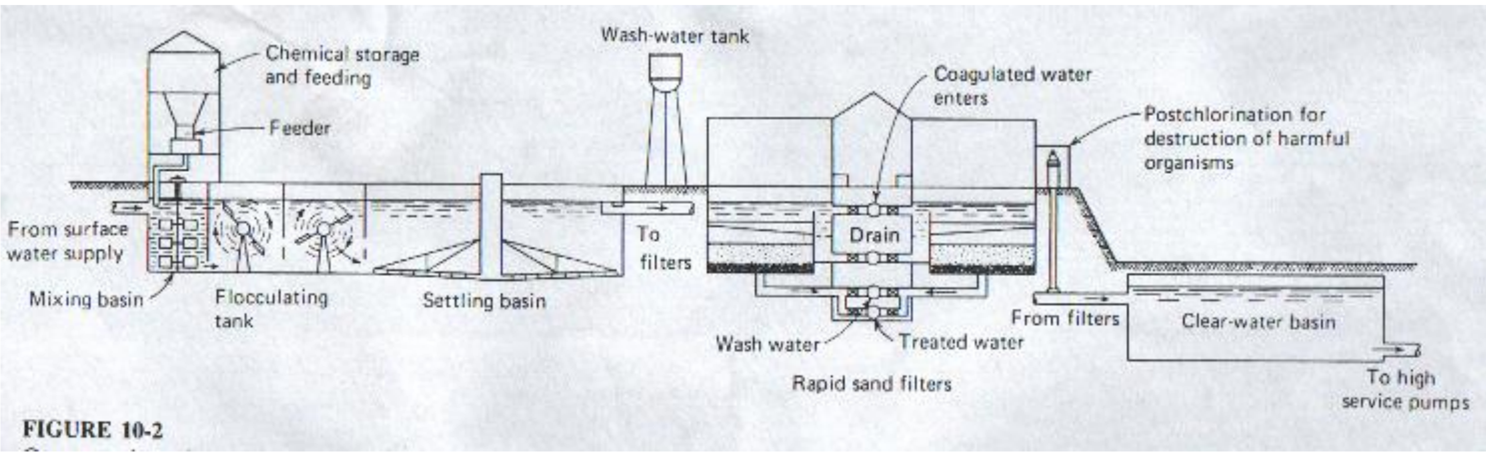


Fig. 6.3 Cross Section of a Complete Rapid Filtration Plant

Fig 6.2 Schematic Section of a rapid filter

Pressure Filters – The pressure filter, also known as mechanical filter, is identical to the rapid sand filter except that it is contained in an air tight steel chamber. This chamber is capable of withstanding pressures of about 10 atmospheres. The rate of filtration adopted is normally 4.8m/hr. it may stand a filtration rate of up to 15m/hr. but the quality of production may be low. Care is required during the operation of the pressure filter at very high rates. If the filter is not properly operated or designed its effect on the bacteria content of water is poor since the quality of the effluent may not be guaranteed, it is adopted as a pretreatment unit for highly turbid water and for the treatment of water used generally for special for washing, cooling and industrial process.

When high quality of water is required, the pressure filter is adopted at the preliminary filtration level before subjecting the effluent to slow or rapid sand filter. High quality filtration may be obtained from the pressure filter if is moderately loaded with raw water.

5.8 BACKWASHING OPERATION IN FILTERS

The filtration of water by filters results in the clogging of the pores of the filter bed due to the extraction of the suspended particles in the water. This also result in the building up of head lobs. Backwashing is the means of cleaning the filter bed and it involves the flow of water from the bottom to the filter bed. This process is turn lifts the grains and particles. At constant velocity of flow at backwashing water, the particles will start to flow. The upward flow of water expands the bed producing a fluidized condition in which accumulated debris is scoured off the bed.

5.9 DISINFECTION

Due to the small size of bacteria it is not possible to ensure their complete removal from water by physical and chemical means alone and for potable water suppliers it is necessary to ensure the death of harmful micro-organisms by disinfection.

It is important to note the difference between **Sterilization** (the killing of all organisms) and **disinfection** (the killing of harmful organisms) which is the normal aim in water treatment.

5.10 METHODS OF DISINFECTION:

a) CHLORINE

Chlorine (and its compound) is widely used for the disinfection of water because of the following advantages.

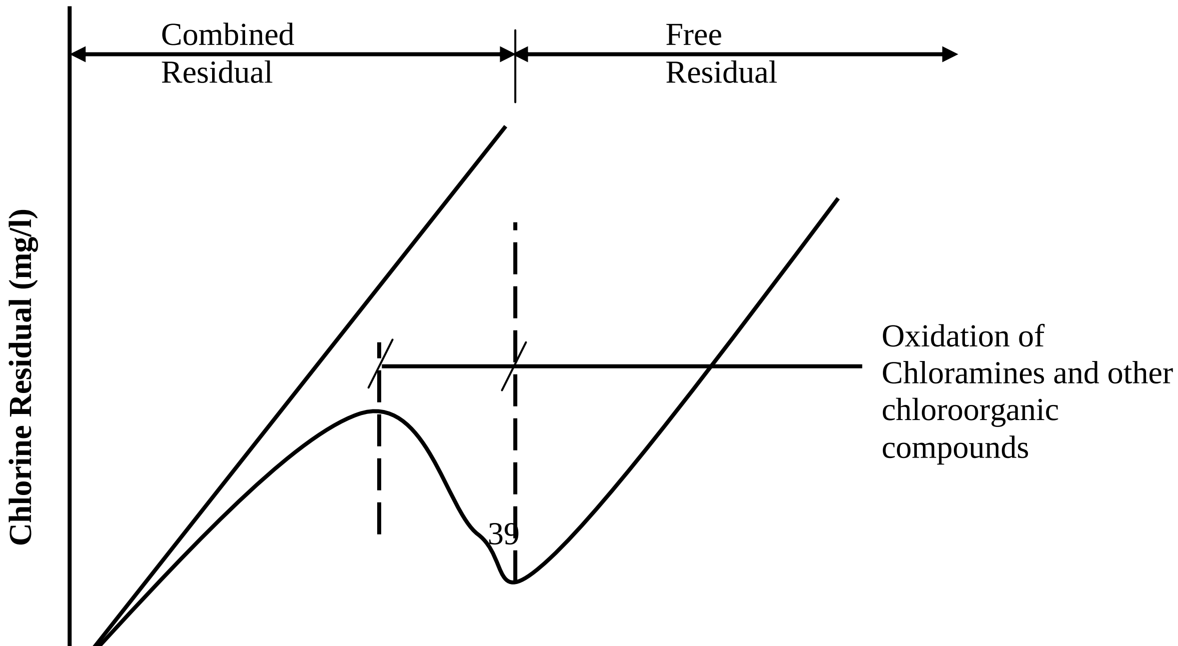
- It is readily available, as gas, liquid or power
- It is cheap
- It is easy to apply to its high solubility.
- It is very toxic to micro organisms
- It leaves a residual in solution, which while not harmful to man provides protection to distribution system.
- It has several secondary uses. e.g. oxidation of iron manganese and H_2S, destruction taste and odor.

It has some disadvantages

- It is a poisonous gas and must be carefully handled.
- It can give rise to taste and odor problems particularly in the presence of phenols.
- suspended materials may shield bacterial from the action o the chlorine.
- Chlorine is a powerful oxidizing agent and will attack a wide range of compounds thereby making it less available to attack microorganisms.
- Its effectiveness is PH – dependent. PH values of 7.2 are adequate.

5.11 BREAK POINT CHLORINATION

Organic and inorganic substances determine the chlorine demand. As the dose of chlorine is increased, combine available residual also increases. This continues until the residual starts decreasing, indicating the oxidation of floramines and other chlororganic compounds. When the oxidation is completed, there is a further rise in the chlorine residual and chlorine is then in the form of free available chlorine. The point at which this takes place is called the “Break point”. At and beyond this “break point”. A high germicidal effect is achieved and high into fen removal is obtained.



Chlorine Dosage (mg/l)

Fig 6.4 Residual chlorine curve showing break point.

b) **OZONE**

Ozone (0_3) is an allotropic form of oxygen produced by passing dry oxygen or air through an electrical discharge by passing dry oxygen or air through an electrical discharge (5000 – 20,000v, 50 – 500Hz). It is an instable, highly toxic blue gas with pungent odour of new mown hay. A powerful oxidizing agent it is an efficient disinfectant and useful in bleaching colour and removing tastes and odours. Like oxygen it is only slightly soluble in water and because of its instable form it leaves no residual. Unless cheap energy is available ozone treatment in much more expensive than chlorination but it does have the advantage of good colour removal.

Other disinfectants includes:

c) **Heat**

Disinfection by heat is very effective but costly and impairs palatability of water by removing do and dissolved salts. No residual effect.

d) **Ultraviolet and nuclear radiations.**

Microorganisms are fairly sensitive to radiation damage due to the toxic effects of energy absorption their limited use is the fact that radiation is readily absolved by water leaving a thin film. No residual affect.

e) **Silver**

Colloidal silver was used by the Romans to preserve the quality of water in storage jars, since at concentration of about 0.05mg/l, silver is toxic to most micro-organisms. The cost becomes excessive for other than very small suppliers.

f) **Bromine**

Bromine has similar disinfection properties, live chlorine and is sometimes used in swimming pools where residual tends to be less irritating to the eyes then chlorine residuals.

5.12 REMOVAL OF HEAVY METALS IN WATER

Heavy metals may exhibit toxic effects since they may be solubilized under the chemically reduced conditions which exist in anaerobic systems. The metals may be precipitated as sulfides by chemical addition if they are known to be present. It is far preferable to exclude such materials by requiring pretreatment of industrial wastes, not only to protect the function of the digester, but also to ensure that the sludge can be disposed of without violation of EPA or state regulations.

The obligate anaerobes which convert organic acids to methane and CO_2 are more sensitive to the surrounding environment than the facultative organisms which effect the first step; hence toxic constituents will affect them first and cessation or slowing of their activity can lead to failure of the digester. It is not sufficient to monitor pH, since the alkalinity of anaerobic digesters is very high and substantial changes in acid concentration can occur with little or no change in pH. Regular measurement of volatile acids is desirable, but the normal function can often be monitored by observing the rate of gas production. Digester problems are always accompanied by a change in gas production or composition.

5.13 CONTROL OF TASTE AND ODOUR

Tastes and odors associated with dissolved gas and some volatile organic chemicals may be removed by aeration processes. Materials which are not favorably altered or removed by aeration or oxidative techniques can generally be adsorbed on activated carbon.

Aeration is used in water treatment to alter the concentration of dissolved gases, to strip volatile organics, and to reduce tastes and odours. The last generally involved removal of dissolved gases (such as hydrogen sulfide or chlorine) or volatile organic materials. The tastes and odours associated with algal growth are not appreciably reduced by aeration.

Aeration techniques include spray, cascade, diffused – air, multiple tray, and packed – column systems. The object of all designs is to maximize the area of contact between the water and the air and to produce motion of one fluid relative to the other so that exchange can be enhanced by maximizing the concentration gradient.

WEEK SEVEN

6.0 THE METHODS OF STORAGE AND DISTRIBUTION OF TREATED WATER.

6.1 GENERAL LAYOUT OF PUBLIC WATER SUPPLY SCHEMES

METERING OF WATER

Metering of water supplied to individual users has been shown to reduce consumption substantially, perhaps by as much as 50%. In the absence of meters, users have no incentive to conserve water and waste in much more common. Metering is also desirable in that it permits analysis of use patterns of different classes of users, thereby providing data which is useful in planning expansion of facilities and in assessing the magnitude of loss due to leaks in the distribution system.

6.2 SERVICE/STORAGE RESERVOIRS

Impounding reservoirs have two functions; to impound water for beneficial use, and to retard flood flows.

Water may also be stored to equalize pumping rates in the short term, to equalize supply and demand in the long term, and to furnish water during emergencies such as fires and loss of pumping capacity.

Elevated storage may be provided by earthen, steel or concrete reservoirs located on high ground or tanks desired above the ground surface. Water is pumped at a more or loss uniform rate, with flow in excess of consumption being stored in elevated storage tanks distributed throughout the system. During periods of high demand, the stored water arguments the pumped flow, thus helping to equalize the pumping rate and to maintain uniform pressure in the system. It may be economical to pump during off-peak hours.

It should be noted that leakage can occur from the service connections as well as the points.

6.3 THE PIPE SYSTEM

a) **The Primary Feeders (Mains)**

These are sometimes called the arterial main, they form the skeleton of the distribution system. They are so located that they will carry quantities of water from the pumping plant, to and from the storage tanks and to the various parts of the area to be served.

In small cities they should form a loop about 1000m or two – thirds of distance from the centre of the town to the outskirts. They should have valves not over 1.5km apart and mains connecting to them should also be valued so that interruptions of service in them will not require shutting down the feeder main.

In large towns the primary feeders should be constructed as several interlocking coops with the main not over 1000m apart. Looping allow continuous service through the rest of the primary mains even though one portion in shut down temporarily for repairs. Under normal condition looping also allows supply from two directions for large fire flows. Large and long feeders should be equipped with blow offer (was hunt) at low points and air relief relieves at high points.

b) **The Secondary Feeders (Services Pipes)**

They carry large quantities of water from the primary feeder to the various areas to care for normal supply and fire fighting. They form smaller loops within the loops of the primary mains by running from one primary feeder to another. They should be only a few blocks apart and thus serve to allow concentration of large amounts of water for fire fighting without excessive head loss and resulting, low pressure.

c) The Small Distribution Mains

They form a grid over the area to be served and supply water to the fire hydrants and service pipes of the residence and other buildings. Their sizes will usually be determined by fire flow requirements. In residential areas however, particularly where there are heavy water uses for lawn sprinkling, it may be necessary to determine the maximum customer demand.

TYPES OF DISTRIBUTION SYSTEMS FOR BUILDINGS

i) The Direct Feed Type

This is used when the pressure in the municipal main is adequate to supply all the futures inside the building with water for 24 hours each day.

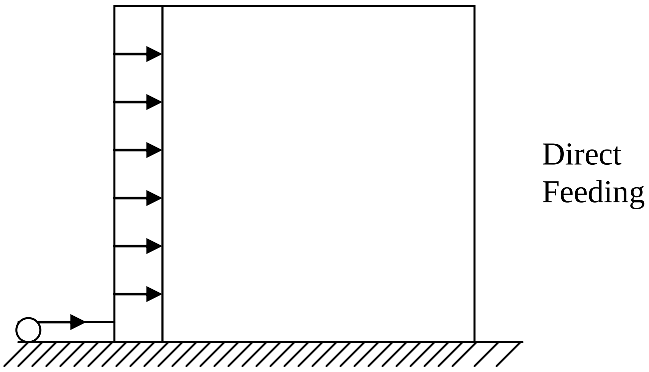


Fig 7.1 Direct Feed type

ii) The Indirect Feed Type

This is used when the pressure in the municipal water main in insufficient to supply water to the fixtures at all times of the day water is supplied to fixtures, inside the building by elevated tank on the top of the building (roof listen).

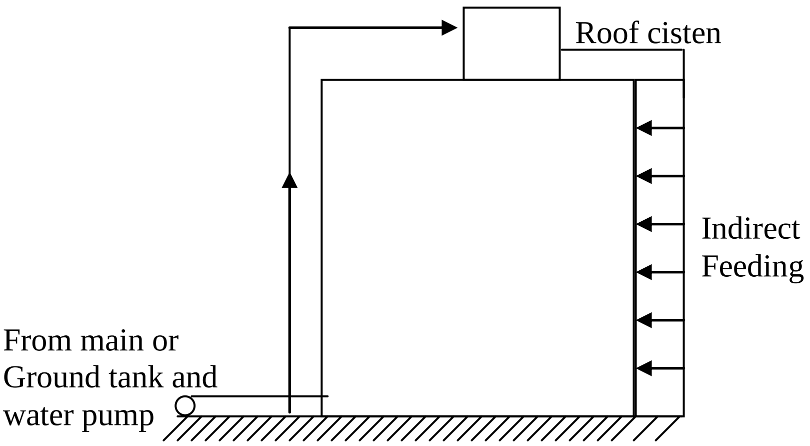


Fig 7.2 The Indirect Feed type

PIPES AND FITTINGS

Requirements and Types of Pipes

There are three requirement for a pipeline

i) It must convey the quantity of water required.

ii) It must resist all external and internal faces coming upon it.

iii) It must be durable and have long life.

Pipelines are classified into three categories:

"Mains" – Pipeline for the conveyance of water over long or short distances for the distribution of water through towns and in general large sized pipeline.

"Service Pipe" – The individual supply line to a house, block of flats, laid underground from a main to the building. The service pipes are fitted with valves and meters.

"Distribution Pipes" (Plumbing pipes) – pipe work within a building for the distribution of water to various appliances. Most water distribution pipes in buildings are made of galvanized iron pipes. They are designed to ensure adequate water supply to the fixtures.

PIPE MATERIAL

The following types of pipes are in use for the construction of mains.

i) Cast iron pipes

ii) Spun iron pipes

iii) Asbestos – cement pipes

iv) Steel pipes

v) Prestressed concrete pipes

vi) P.V.C. pipes pun iron pipe

WEEK EIGHT

6.4 PIPE MATERIALS FOR WATER SUPPLY

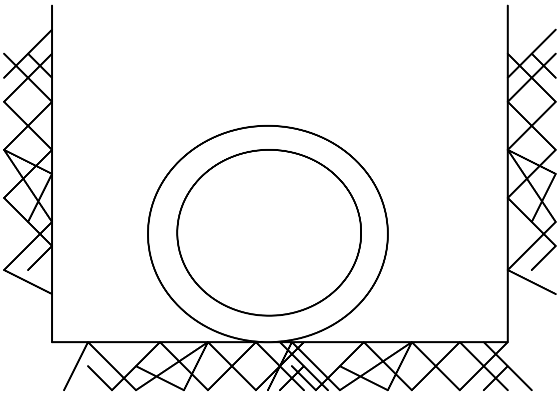
Pipelines are commonly constructed of reinforced concrete, asbestos cement, ductile iron, steel, or plastic and are located below the ground surface only so far as necessary to protect them against freezing and surface loads.

In selecting the type of material and pipe size to be, one should consider carrying capacity, durability, maintenance cost, and first cost. The character of the water and its potential effect upon pipe of different material is an important consideration as well.

6.5 STANDARD BEDDING CONDITIONS FOR LAYING OF PIPES

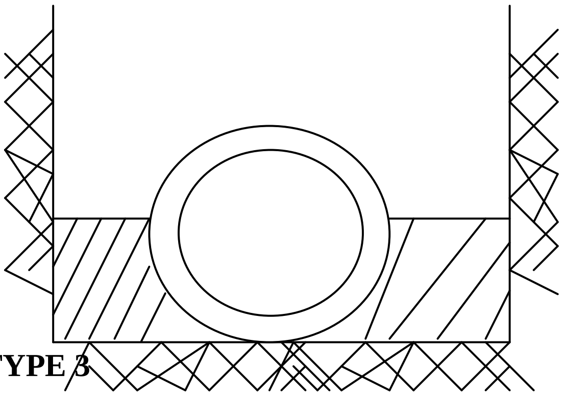
TYPE I

Flat – bottom trench. Loose backfill.



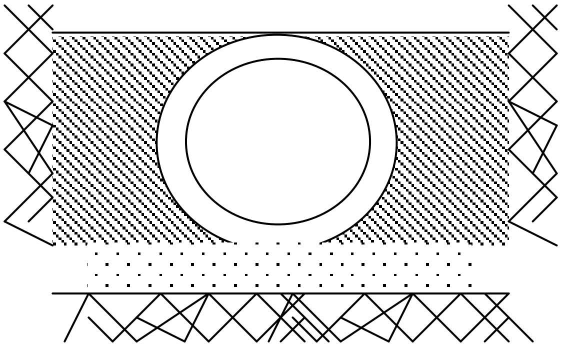
TYPE 2

Flat – bottom French – bock filled lightly consolidated to centerline of the pipe.



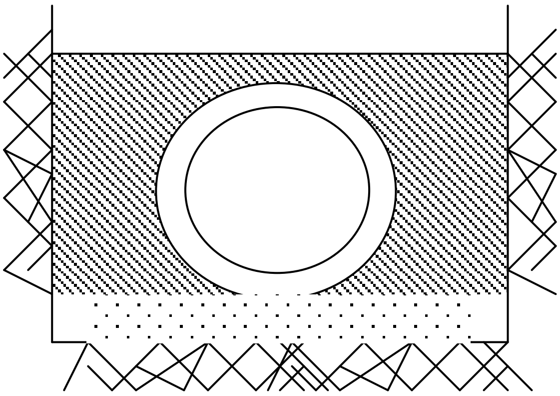
TYPE 3

Pipe bedded in 100mm minimum loose soil. Backfilled lightly consolidated to top of pipe.



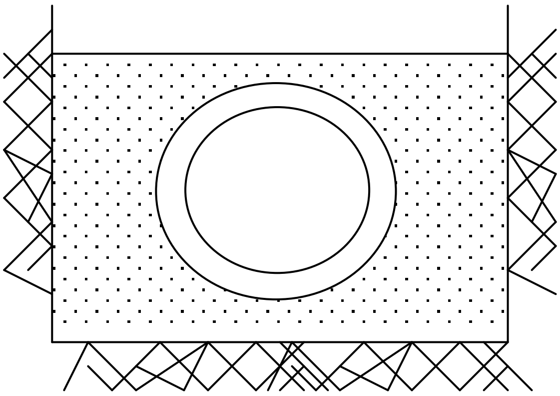
TYPE 4

Pipe embedded in sand. Gravel or crushed stone to depth of 1/8 pipe diameter 100mm min. track filled compacted to top of pope.



TYPE 5

Pipe bedded to its centerline in compacted granular material. 100mm min. under pipe compacted granular or select material to top of pipe.



6.6 VALVES

Valves are devices used for controlling flow through a pipe, especially allowing flow in one direction. A variety of valves are used in water distribution systems. It is desirable to place valves in manholes, although smaller valves may be buried, with access being afforded by a valve box made, or iron or plastic. Valves which are operated frequently, such as those in treatment plants must be designed to be resistant to wear and are often provided with hydraulic or electric operators.

1. **Gate Valves**

   These are commonly used for on – off service since they are relatively inexpensive and offer relatively positive shut off. Gate valves are located at regular intervals throughout distribution systems so that breaks in the system can be readily isolated for repairs or maintenance.

2. **Check Valves**

   These permit water to flow in only one direction and are commonly used to prevent reversal of flow when pumps are shut off check valves installed at the end of a suction line are called FOOT VALVES. These prevent draining of the suction line when the pump is shut down. Check valves are also installed on the discharge and of the pumps to reduce hammer force on the pump mechanism.

3. **Globe and Angle Valves**

   These are seldom used in water distribution system. Their primary application is in house hold plumbing where their low cost outweighs their poor hydraulic characteristics.

4. Air Vacuum and Air Relief Valves

There are provided in long pipeline to permit the release of air which accumulates at high points and prevent negative pressures from building up when the lines are drained. These valves are automatic in operation, opening to release accumulated air and choosing when the pipe is full of water.

5. Pressure-Regulating Valves

These automatically reduce to pressure on the downstream side to any desired level. They function by using the upstream to throttle the flow through an opening similar to that of globe valve.

6.7 FIRE HYDRANTS

Fire hydrants consist of a cast iron barrel with a bell or flange at the bottom which connects to a branch from the water main. The American Water Works Association has developed specifications for hydrants which include the following features:

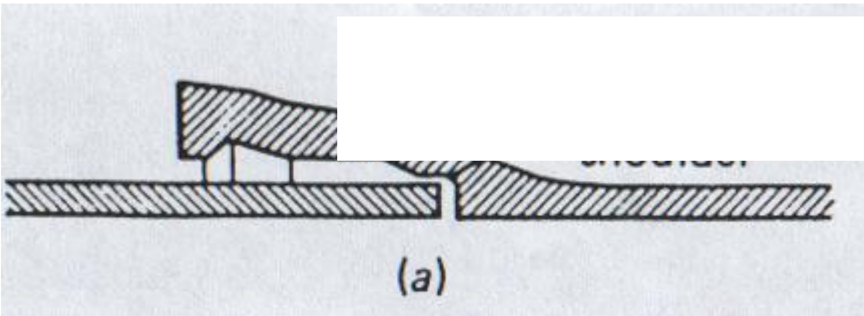
1. The hydrant shall be sufficiently slow in closing that water hammer will not exceed the working pressure or 400kPa, which ever is greater.
2. The hydrant shall be fabricated so that the valve will remain closed if the upper portion of the barrel is broken off.
3. When the discharge is $0.95m^3$/min from each hose outlet, the energy loss in the hydrant will not exceed 10kPa for two – way, 20 kPa for three – way, and 30kPa for four – way designs.
4. To prevent freezing, a drip valve must be provided to drain the barrel when the main valve is closed.
5. Hydrant outlets should conform with the national standard in order to permit interchange of fire – fighting equipment between adjoining communities.

Hydrants are intended to provide fire protection but may also be used to release air at high points and blow off sediment at low points in the system. The hose pumper cap should be not more than 300mm nor less than 150mm from the gutter face of the curb nor closer than 150mm to the sidewalk. The hydrant is connected to the main by a side branch not less than 150mm in diameter and must be buttressed or otherwise restrained. Hydrants are sometimes placed on a concrete base, but must be surrounded by about $0.1m^3$ of gravel or crushed stone in order to permit draining of the hydrant after it has been used. Hydrants which remain closed if the barrel is broken should be used in new construction. A valve in the side branch is also desirable to permit repairs to be made with minimum water loss and minimum interruption of service.

6.8 TYPES OF JOINTS

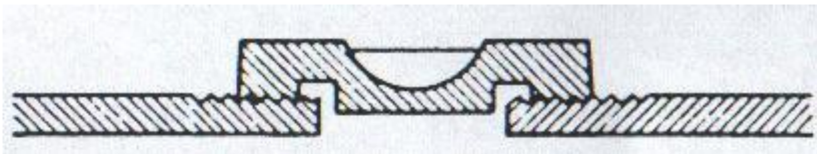
a) Bell (Socket) and Spigot Joint

This is used for both cast iron and steel pipes. The spigot end of the pipe is pushed into the bell end, a tarred gasket made of cotton yarn, or jute is packed into the open space between the bell and spigot. A strap is placed around the joint and molten lead is poured in and tampered.



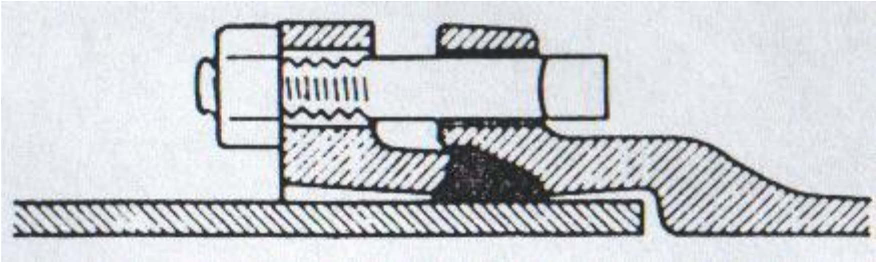
b) Threaded Joints

There are strong in pipes. A rubber gasket is used to make the joint water tight. The bell end is threaded on the inside to fit with an outside threaded ring. This ring presses against the rubber gasket making the joint water tight.



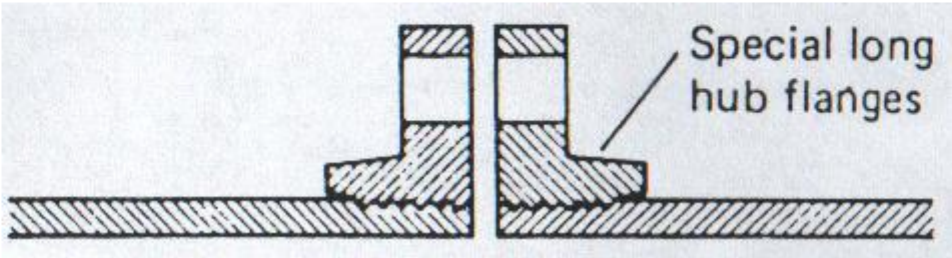
c) Mechanical Joint

A rubber gasket of trapezoidal cross – section is prossed against the spigot and. A cast iron follower ring is connected to the bell making the joint water tight.



d) Flange Joint

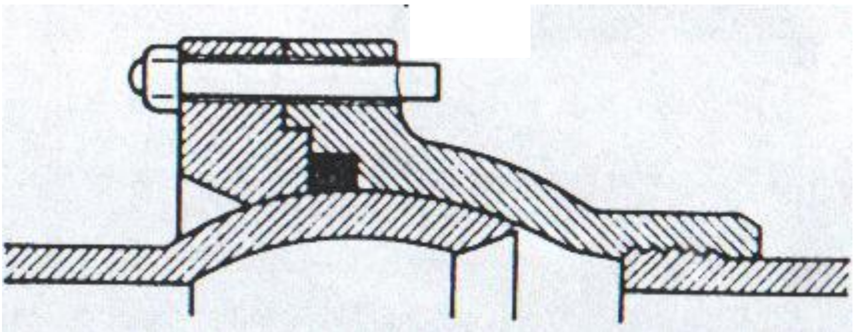
This is suitable for pipes under high pressure and for pipes subjected to variations in temperature. Various fittings in a pump house are connected by flange



joints. Rubber of similar material gasket 3- 5mm thick are placed between flanges which are connected by bolts and nuts.

e) Flexible Joint

The direction and the slope of pipes connected by a flexible joint can be varied up to a maximum of 20^o. This joint is especially suitable for pipes being under water.



f) **Welded Joint**

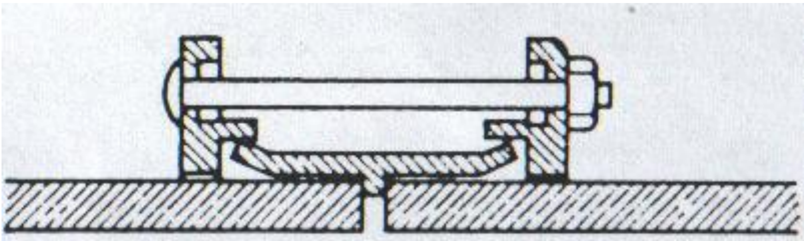
Large and small diameter steel pipes are generally and frequently welded together. Welded joint require greater skill than the ones mentioned above and careful quality control in required.

g) **Concrete Pipe Joint**

Concrete pipes with bell and spigot joints. Are generally used with a rubber ring to make the joints water tight. Such joints are used for water pipes not under pressure.

h) **Asbestos Cement Pipe Joint**

This consist of a steel or cast iron sleeve which fits over the ends of the pipes, it is made water tight with two rubber rings placed between the sleeve and pipes. Sleeves are frequently constructed of the same material as the pipe.



6.9 BASIC PIPE NETWORK

1. Branching System (Pattern) with dead ends

This comprises of the primary feeders, the secondary feeders and small distribution mains. They are otherwise known as the truck line, the main and the submains respectively. The flow of water is the branching pattern with deed end is in one direction. It is simple system but with so may dead ends and maintenance is difficult.

Advantages

(i) It is a simple method of water distribution

(ii) The design is also simple

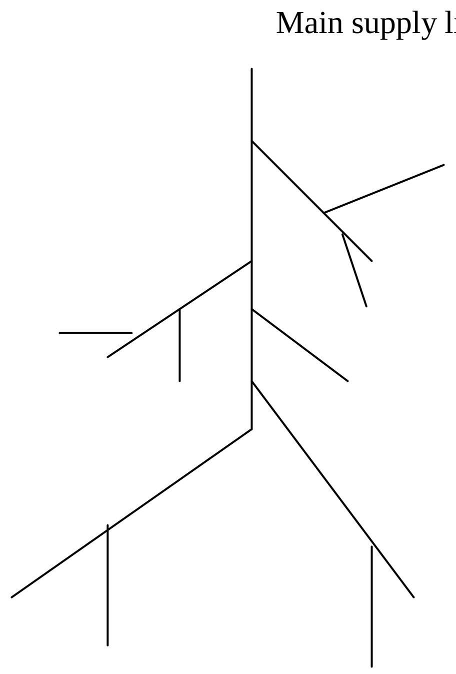
(iii) the pipe dimensions are economical

Disadvantages

(j) In view of the existence of dead ends, sediments accumulates causing taste and odour problems if the pipe is not flushed regularly,

(ii) During repair work, water supply to the area receiving water from the pipe is cut of.

(iii) Insufficient water pressure occurs frequently



2. Grid System (Pattern)

No dead ends exist in grid systems and the pipes are interconnected. The direction is always interchangeable. It is an expensive system, has many connections and valves for isolated maintenance.

Advantages

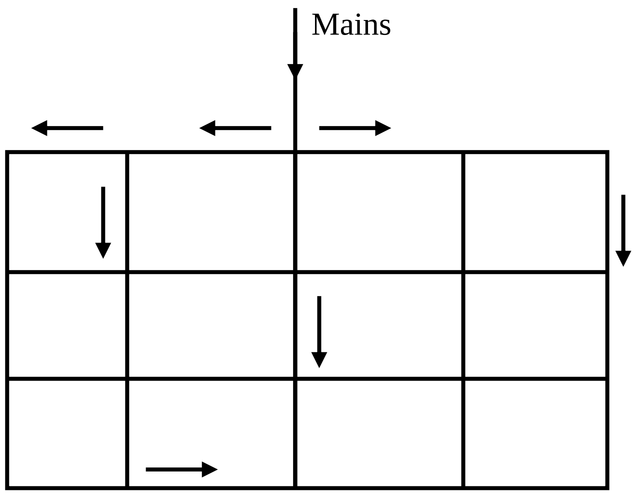
(i) No stagnation occurs, and water flour in different direction.

(ii) During repairs, water is not disrupted.

Disadvantages

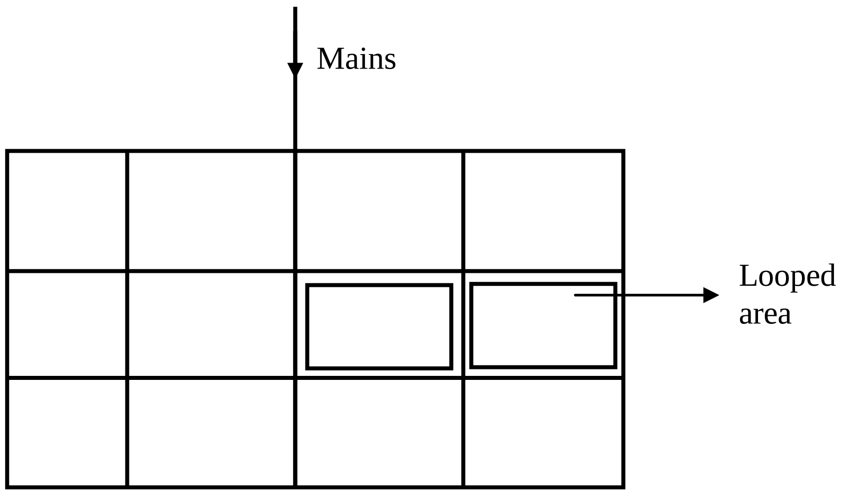
(i) More pipe fittings are required

(ii) The calculation of pipe sizes is more complicated.



3. Grid System (Pattern) With Loops

Where demand is higher is some areas than others, the area is looped with large diameter pipes. This improve the pressure in areas where they are introduced their advantages are similar to that of the grid system.



WEEK NINE

7.0 GENERAL PRINCIPLES INVOLVED IN RURAL WATER SUPPLY

RURAL WATER SUPPLY

The availability of potable water plays a key role in the realization of health improvement measures in any community. Water supply contributes to the reduction is infant mortality and mobility rate and increase the children's life expectancy. In addition to health benefit, improved water supply produces high productivity and socio-economic

7.1 SOURCES OF RURAL WATER SUPPLY

The principal main sources of water are surface and ground water.

The surface water includes water from streams, natural water, artificial reservoirs, rivers, estuary, precipitation etc.

The groundwater sources are upland springs, artesian springs, infiltration galleries, shallow or deep wells.

7.2 TYPES OF WELLS

The commonest sources of water farms and rural homes are wells. A well can be defined as a hole sunk into the earth's crust to a depth below the water table or into deep aquifer (water bearing strata) for the purpose of abstracting groundwater.

Wells are classified according to their methods of construction. There are four common types of well construction for rural water supplies; hand dug, driven, jetted, bored or drilled wells. The selection of any of the methods depends on the depth of the aquifer, soil type, available construction equipment and financial resources. All wells have four basic parts; casing, in-take area, well-head or cap and lifting device.

(a) **Hand-dug wells:-** These are usually 1 to 1.3m in diameter and rarely more than 10m deep. A hole is dug into the earth by hand until a flow is obtained. a the casing can be made with brick, stone, masonry or concrete. The yield depends on the permeability of the acquifer and the well depth below the water table. A large diameter well only increases the well storage and not the yield. The top of the well must be protected against contamination by water tight cap as cover. After completion the well must be disinfected with chlorine at regular intervals.

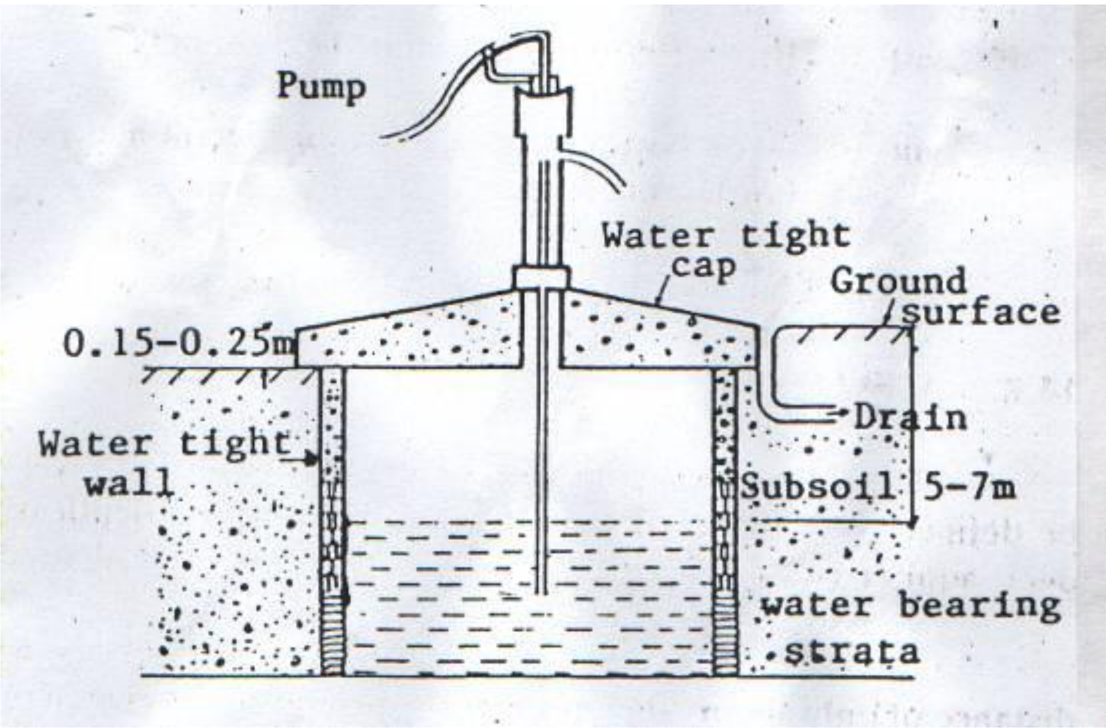


Fig 9.1 A Shallow Dug well with pump on the top

(b) **Driven wells:** There are feasible where the acquifers are not below bedrock or where area is free of stones. Driven wells are constructed by driving a well point into the ground until it encounters an acquiefer. A specially designed well point is driven into the ground either by hammer or sliding weight which transmits the driving force over the casing or by a drive pipe inside the casing with its casing being pulled into the ground.

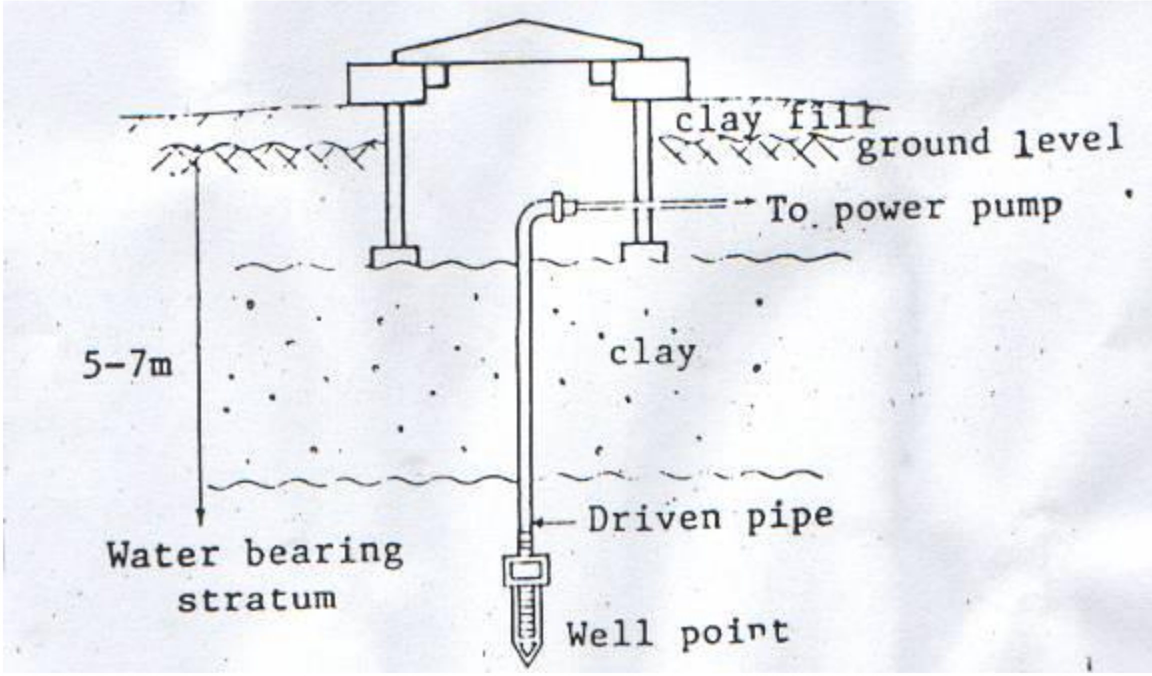


Fig 9.2 A Driven well with the pump located at a distance from the well

(c) **Jetted Wells:** These are constructed by the erosive action of a stream of water jetted from the well point. The diameter of the jetting pipes ranges from 30 – 50mm. the well screen is relatively free of clogging. To improve the rate of sinking the well, rotary drill bit may be used simultaneously. However, jetted drilling is limited to unconsolidated soil formations. The yield of the well vary from 5 to $100m^3$/ day.

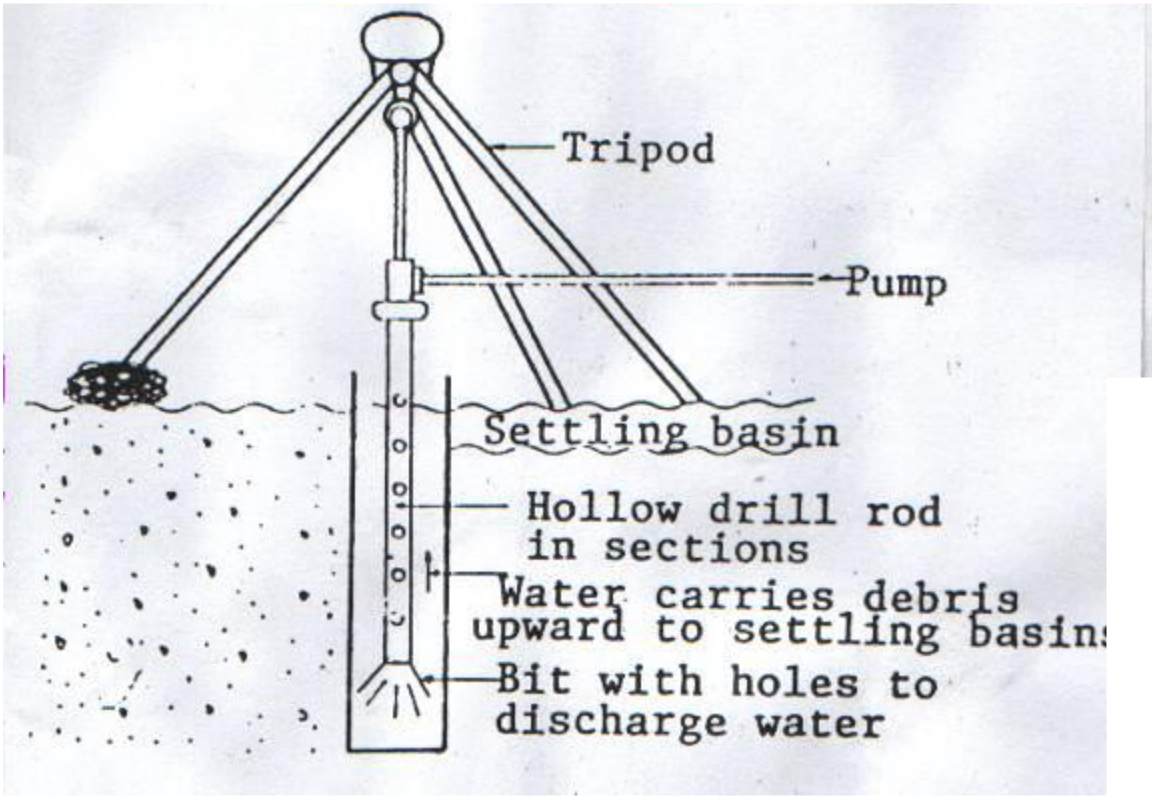
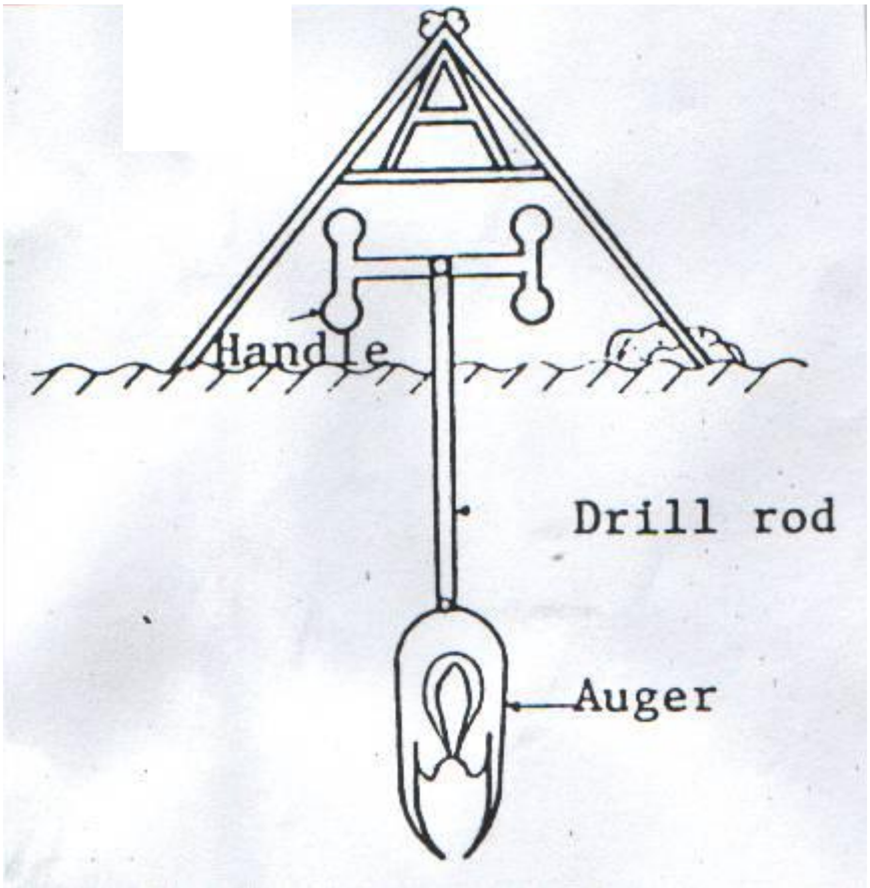


Fig 9.3 A Jetted well

(d) **Bored wells:** They are constructed by manually rotating an earth anger which penetrates the ground that is free from stones and boulders. A depth of 15m may be possible in clay, silt and sand formations. A diameter may reach 20cm to permit the installation of submersible pumps. The well can be lined for support.



(e) **Drilled wells:** these are constructed using engine powered mechanical drilling rigs. Two methods are used; the cable tool (percussion) method and the rotary method.

The cable- tool methods are for small-diameter wells (8-21cm) commonly used for farms and homes. The method employs the principle of a free falling heavy bit delivering bellows against the bottom of the well hole forcing its way into the ground. The mixture of water and loose soil is periodically removed by sand pumps. The yield vary from 100 to several thousand cubic metre per day.

The rotary drilling methods are for large water supply for irrigation and cities. This method requires the use of rotating bit for drilling the bore hole. The drilled material is continuously removed by a circulating mixture of water and clay. The clay clogs the wells preventing collapse of the borehole. This drilling methods is suitable in any soil or rock formation and the acquisition of equipment are high. Drilled wells have maximum protection from contamination and pollution, but often have objectionable minerals like salts, sulphur etc.

7.3 TREATMENT METHODS FOR RURAL WATER SUPPLIES.

Residual chlorine is one of the indicators commonly used to assess the degree of treatment. The residual chlorine standards, 0.3mg/l after 30mins at normal pH produce fewer coliform count than most standards recommend. It is generally desirable to monitor chlorine residuals after treatment and in the distribution system to assure a bacterial quality which is simplier and cheaper than bacteriological setting. Coliform in the raw water should not average more than 1000/liters where the only treatment desired is disinfection and should not be great than 10,000/liters when full treatment is to be provided.

Heavy metals are toxic to health and their accumulation in human body could cause neurological damage in children leading to intellectual and psychological impairment. Among the most dangerous heavy metal is lead. Though there is no safe threshold for leas as any little exposure to it is very dangerous, the lead concentration in water should be as low as possible. The association of aluminium with problems of the central nervous system now attracts attention worldwide, residual aluminium should not exceed 0.2mg/l.

A major problem in many rural water supplies is excess or insufficient fluorides. The concentration of fluorides should be low enough to prevent fluorosis, dental disease in children. Excessive fluorides can lead to severe bone damage. The recommended standard of fluorides is 1.5 – 2.0mg/l. As many of the foods taken by rural community contains fluorides, care should be taken when adding fluorides to water so as not to exceed the recommended value.

Most synthetic organic compounds which enter ground and surface water sources have been found to be carcinogenic, mutagenic and tetragenic. Though they are rarely found in most rural water supply, they should be excluded in sanitary survey if the source is close to industrial areas or urban centres.

The reaction of chlorine used for disinfection of water with organic matter such as humous material produces a category of organic compound called trihalomethanes (THM). A recommended value for THMs is 0.1mg/l but because of the difficulty in meeting this standard, it only applies to communities with population of over 100,000 people. In the regions where water – borne diseases are predominant, the treatment of water with chlorine should be more important than THMs. It is important to note that THMs can be reduced to minimum by removing colour and turbidity to low levels which reduces the potential for the formation of THMs.

7.3.1 Rural Water Treatment

In the planning and development of rural water supply scheme, the guiding principle is to select best quality souce that is economically feasible in order to minimize dependence on chemical treatment. Where treatment is unavoidable, the selection and treatment processes should be as simple as possible to assure proper operation with a minimum attention.

Table 9 provide the minimum treatment possible with the example of source

Table 7.3.1: Classification of Raw Waters

Class	Iron (mg/l)	Turbidity (NTU)	Average Coliform MPN/100ml	Colour (platinum Cobalt Scale)	Total Solids (mg/l)	Chlorides (mg/l)	Hardness
I	< 1	< 25	< 1	< 50	< 1,500	< 600	< 250
II	< 1	< 25	< 1	< 50	< 1,500	< 600	< 250
III	< 1	< 25	< 1	< 50	< 1,500	< 600	< 250
IV	< 1	< 25	< 1	< 50	< 1,500	< 600	< 250
V	< 1	< 25	< 1	< 50	< 1,500	< 600	< 250
VI	< 2.5	< 50	< 1000	< 70	< 1,500	< 600	< 250
VII	< 2.5	< 75	< 5000	–	< 1,500	< 600	< 250
VIII	< 2.5	< 250	< 20000	–	< 1,500	< 600	< 250
IX	< 2.5	< 250	< 20000	–	< 1,500	< 600	< 250
X	< 2.5	> 250	< 20000	–	< 1,500	< 600	< 250

XI	< 2.5	< 250	< 2000	–	< 1,500	< 600	< 250

Table 7.3.2: Classification of Raw Waters with Regard to Treatment Processes

Classes	Minimum Treatment Possible	Example of source	Remark
I	None	Protected gravity springs and protected deep wells	Requires affirmation by sanitary and bacteriological examination
II	Chlorination	Spring, river	Use calcium hypochlorite or bleaching powder
III	Chemical pretreatment and chlorination	Impounded reservoir	
IV	Iron removal and chlorination	Groundwater	
V	Hardness reduction and chlorination	Groundwater	
VI	Slow sand filtration and chlorination	Mountain stream	Turbidity < 50NTU slow sand filter clogs too quickly
VII	Pretreatment – slow sand filtration – chlorination; upflow – downflow filtration and chlorination	Water from lakes or reservoirs	
VIII	Coagulation – sedimentation – filtration – chlorination	River	
IX	Aeration – coagulation – sedimentation – filtration – chlorination	River or lake low in oxygen groundwater with iron/manganese	Prechlorination can assist in manganese removal
X	Pretreatment – coagulation - sedimentation – filtration – chlorination	Very turbid river	
XI	Coagulation – Sedimentation – Filtration – hardness reduction – chlorination	River	
XII	Defluoridation by bone colour filters or coagulation with alum	Groundwater	Very expensive and not always effective
XIII	Activated carbon	Heavily polluted source	Used during periods of troublesome odour and taste

WEEK TEN

8.0 WASTE WATER

8.1 SOURCES OF WASTEWATER

- Sanitary (Domestic) Sewage

This is spent water supply of the community. The waste water from kitchen, bathroom, lavatory, toilet and laundry. In addition to these are human excrement paper, soap, dirt, food waste (garbage) etc. domestic sewage is unstable, biodegrable, and may generate offensive odors. Some of the waste & matters remain in suspension, and some go into solution.

- Industrial Waste Waters

These vary in composition with industrial operations. Some are clear rinse water; others are heavily laden with organic or mineral mater, or with corrosive, poisonous, flammable, or explosive substances. Some are objectionable other are not, and are it is safe to discharge into drains or water triodes. Fat, lime, hair and fibres adhere and clog to sewers. Acid and H_2S destroys cement, concrete and metals poisonous chemicals. Disrupt biological treatment, rill aquatic life and endanger water supplies.

8.2 SEWER, SEWAGE AND SEWERAGE

- SEWARAGE

Sewarage refers to the collection of waste water from occupied areas and conveying them to some point of disposal. The liquid waste usually, will require treatment before they can be discharged into a body of water or so as not to endanger the public health or causing offensive conditions. Sewerage (Sewage) works include all the physical structures required for that collection, treatment and disposal

- SEWAGE

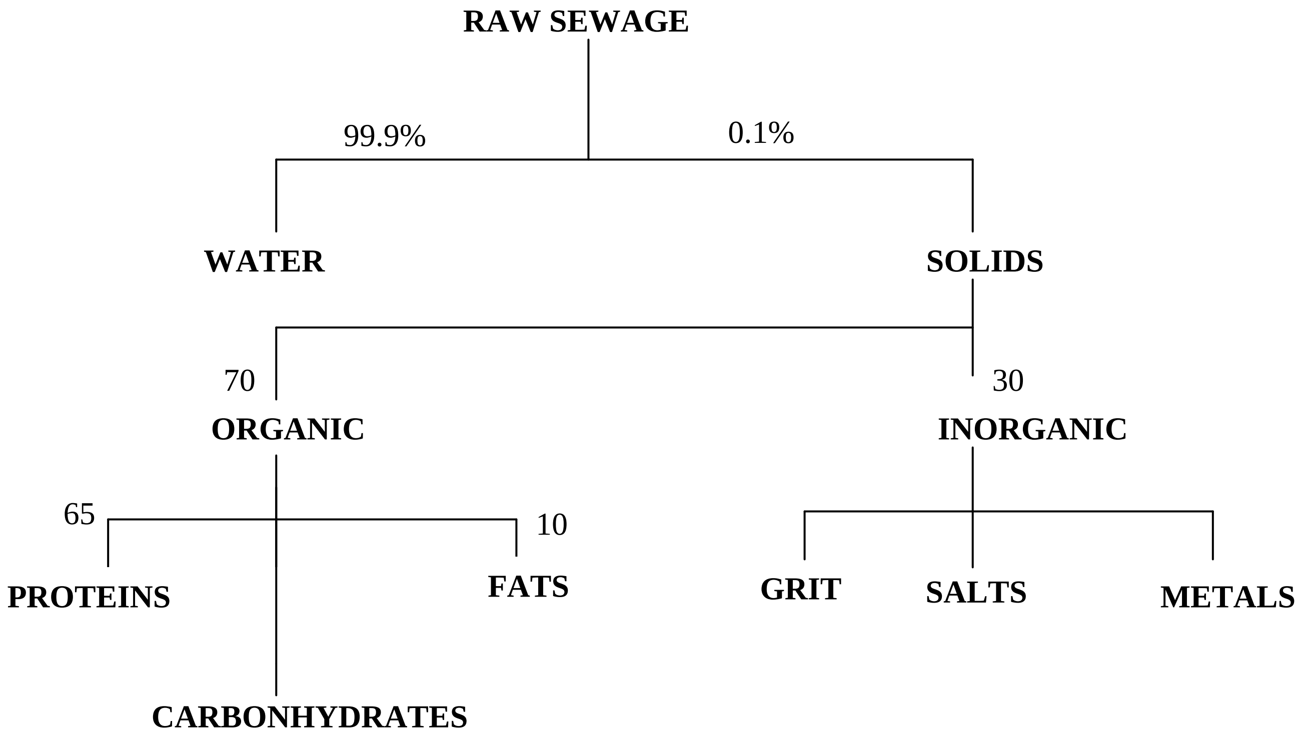
Sewage is the liquid waste conveyed by a sewer and may include domestic and industrial discharges as well as storm sewage, infiltration and inflow.

- SEWER

A sewer is a pipe or conduit, generally closed, but not normally no flowing full, which caries sewage.

8.3 CHARACTERISTICS AND COMPOSITION OF SEWAGE

Sewage is the wastewater of a community. It may be purely domestic or may contain some industrial or agricultural wastewater. Domestic sewage composed of human body wastes. (faeces and urine) and sullage which is the wastewater resulting from personal washing,, laundry, food preparation and the cleaning of kitchen utensils.



8.4 POLLUTION AND CONTAMINATION

The planning, design, construction, and supervision of water and waste water systems have long been the responsibilities of civil Engineers. Needed skills in water resource development are possessed in largest measure by this oldest group of engineering practitioners.

The cholera, typhoid fever, and other enteric infection could be transmitted through drinking water and that sewage often contained the causative agents of disease were not discovered until the middle of the 19^{th} century of scientifically confirmed until the end of that century. Eventually, too, the evolving physical and natural sciences suggested ways of preventing transmission of common waterborne diseases and otherwise ensuring the safety, palatability and economic usefulness of water. At the same time, the behaviour of wastewater flowing from communities and industries was explored, and it became possible to protect receiving bodies of water against contamination and pollution. Therefore by convention, **Water contamination** is considered to be the introduction or release into water of pathogenic organisms or toxic substances that render it unfit for human consumption or domestic use. In like sense, **Water pollution** is held to be the introduction into water of substances that impair its usefulness or make it offensive to the sense of sight, taste, or smell. Contamination may and often accompany pollution.

10.7 METHODS AND PROCESSES OF SEWAGE TREATMENT

10.7.1 PHYSICAL TREATMENT

Physical treatment methods include screening, communition, grit removal, sedimentation and filtration. Except for filtration each of these units operations will be incorporated in most modern treatment plants.

- Screening: Coarse screens or racks with 50mm openings or large are used to remove large floating objects from wastewaters. They are installed ahead of pumps to prevent clogging. These materials consists of wood, rags, and paper which will not putrefy and may be disposed by incineration, burial, or dumping.

- **Comminution:** Comminutor or (Shredders) are devices that are used to grid or cut waste solids to about 6mm size. Comminutors eliminate the problem of disposal of screenings by reducing the solids to a size that can be processed elsewhere in the plant.

- **Grit Removal:** Specially designed grit chambers are used to remove inorganic particles such as sand, gravel, eggshells, and bone to prevent damage to pumps and to prevent the accumulation of this material in sludge digesters. Grit may be used for fill or handled away and dumped if it does not contain too much organic material. Detention Time is 3 to 5minutes.

-Sedimentation: Plain sedimentation basic in wastewater treatment is used to remove the larger suspended material from the incoming wastewater. The material to be removed is high in organic content (50 – 70%) and has a specific gravity of less than 1.2. A slopping bottom facilitates removal of the sludge.

-Filters: Filters are used as final or advanced treatment following secondary or other treatment processes, such as lagoons and stabilization ponds. Wastewater is applied continuously at about 0.4m/day and the straining action of the sand is relied upon the remove most of the remaining suspended solid in the wastewater.

10.7.2 CHEMICAL TREATMENT

The main unit processes used for wastewater treatment are chemical precipitation and chlorination. A number of treatment plants use a combination of chemical processes (usually precipitation) and physical operations to achieve complete treatment. Such processes are known as physical – chemical treatment processes.

- Chemical Precipitation: Is used to increase the removal of suspended solids to 90%. It can also be used to remove phosphates for the control of entrophication. Alum and ferric chloride are two commonly used coagulants. Lime is often added to improve the action of the coagulant.. chemicals are introduced and mixed by rapid mechanical agitation, this is followed by gentle agitation in a flocculating basin before the wastewater is introduced to the sedimentation basin. Suitable for large seasonal variation in wastewater flow, but is costly and with increase in sludge volume.

- **Chlorination**: Chlorination may be used as a final step in the treatment of wastewater when an effluent low is bacterial content is required (Post chlorination) to reduce the BOD. Pre-chlorination before sedimentation helps to control odors, may prevent flies in trickling filters; and assists in grease removal. Its relatively expensive, hence many treatment plants have no chlorination facilities.

10.7.3 BIOLOGICAL TREATMENT

These are basic components of almost all secondary treatment schemes, this treatment involves the conversion of the dissolved and colloidal organic matter in wastewater to biological cell tissue and to end products and subsequent removal of the cell tissue, usually by gravity settling. The biological conversion can be accomplished both aerobically (presence of O_2) and a aerobically (absence of O_2) the aerobic conversion is significantly more rapid. The microorganisms responsible for the conversion can be maintained in suspension or attached to a fixed or moving medium. Such biological treatment processes are known as aerobic suspended growth or attached growth processes**.** The activated sludge process, which is used extensively, is the best known example of aerobic suspended-growth process. The trickling filter, is the most common attached – growth process.

10.8 PRIMARY SEDIMENTATION

Primary sedimentation is a unit operation designed to concentrate and remove suspended organic solids form wastewater. As a total treatment then, it was the most important operation in plants. Its design and operation were critical in reducing waste loads to receiving streams. With the current universal requirement for secondary treatment, primary sedimentation plays a lesser role. Indeed many of the secondary wastewater. Treatment unit processes are capable of handling the organic solids if good frit and scum removal are provided for in preliminary treatment. In primary sedimentation the organic material slightly heavier than water settles slowly. Lighter materials primarily oil and grease, float to the surface and must be skimmed off.

Primary sedimentation is accomplished in either long rectangular tanks or circular tanks. Scum removal in rectangular tanks is achieved by having the sludge scrapers penetrate through the surface as they return to the effluent end of the tank. Circular tanks have a skimmer arm attached to the sludge-scraper drive mechanisms. The scum is nipped up an inclined apron and into scum trough for removal. Sludge should be removed from the tank before anaerobic condition develops. If this happens gas bubbles will be produced and will adhere to solid particles and lit them towards the surface.

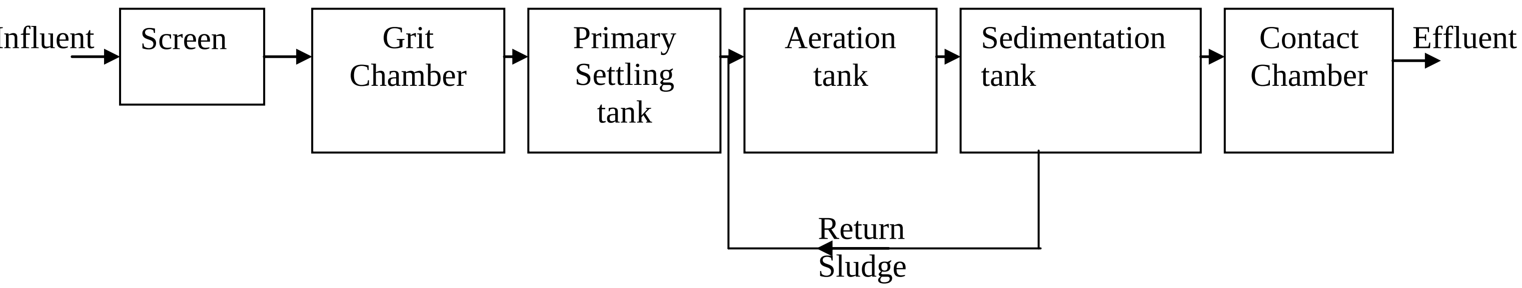
WEEK ELEVEN

9.0 METHODS OF SEWAGE/WASTE WATER TREATMENT

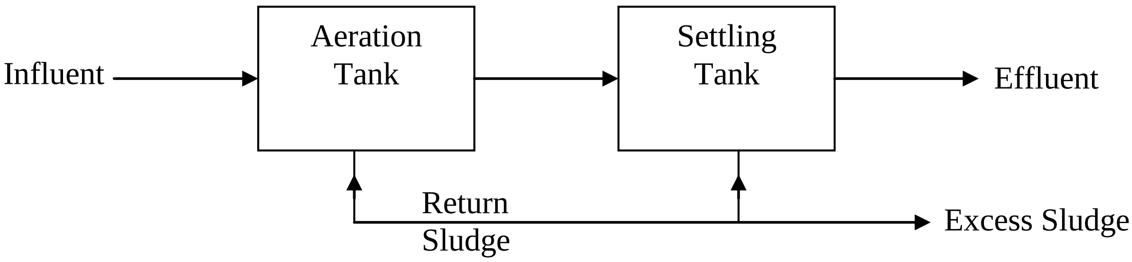
9.1 ACTIVATED SLUDGE

This is used for cities with very high populations.

Flow diagram.



Experiments have indicated that blowing of air in wastewater results in the formation of flocs. Examination of these under microscope indicated the presence of a variety of microorganisms. When the blowing of air stopped, the flocs settled. This floc, when added to fresh wastewater causes its digestion and therefore is called activated sludge. This process is so named because it involves the production of an activated waste. Activated sludge processes are used for both secondary treatment and complete aerobic treatment without primary sedimentation.



Wastewater is fed continuously into an aerated tank where the microorganism metabolises and biologically flocculates the organics. Microorganisms are settled from the aerated mixed liquor in the final clarifier and returned to the aeration tank. Clean supernatant from the final settling tank now becomes the plant effluent. A portion of the settled biological solid is recycled and the remaining mass is wasted. The level at which biological mass is returned depends on the quantity of wastewater and degree of treatment required. Usually this quantity varies from 20-30% of the waste water volume. Aeration units are the made unit of the activated sludge system, the main aim of which are to supply oxygen to the sewage to keep the return sludge aerobic and to mix up the return sludge with the sewage thoroughly.

ADVANTAGES

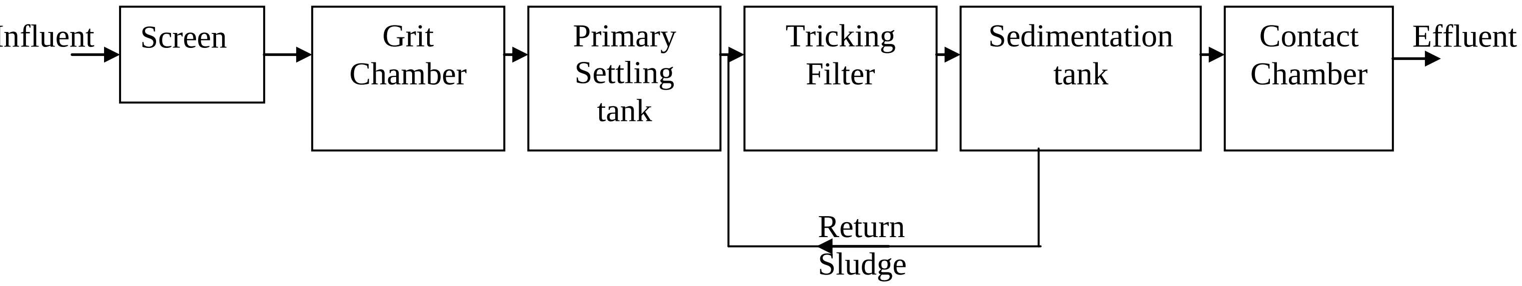
1. It gives clear effluent
2. The operation is free from offensive odour
3. The degree of purity of effluent can be varied according to the nature and quality of diluting water.
4. Cost of installation is low compared to trickling fitters.
5. BOD, Solids and bacteria are removed up to 90%.

DISADVANTAGE

1. It is sensitive to certain types of industrial wastes especially the toxic wastes.
2. The process required skilled attention.
3. Operating cost is high
4. High volume of sludge and problem of sludge disposal.

9.2 TRICKLING FILTERS

This is employed in cities with low populations. Flow diagram.



These are also known as sprinkling or percolating filters in these filters sewage trickles over the filter media which are continuous in operation. These filters may be rectangular or circular in plan coarse aggregates of impervious nature are used as filter media. The size of the filter media should be between 5-7.5cm. an under drainage system is provided in the filter bed to collect the effluent. As sewage passes through the filter ring media an organic film known as zoogleal film is formed around the particles of filtering media. A large number of aerobic bacteria present in this film carry out oxidation of organic matters. As the applied sewage trickles through this film final suspended solids are removed and held by the film and colloidal particles are absorbed by its.

9.3 OPERATIONAL PROBLEMS AND REMEDY IN FILTERS

The following are various types of troubles associated with the operation of trickling filters.

a) **Odour Nuisance**: Caused by anaerobic decomposition, sludging and undesirable growth of micro-organisms. It can be eliminated to some extent by recirculation of filter effluent.

b) **Ponding Nuisance:-** When all the voids of filter are filled due to choking by fungus or other suspended matter, the sewage cannot pass through the filter bed and is accumulated at the surface a pond. This can be prevented by the following methods;

 (i) By drying the filter media for 15-48 hours, exposing it to the sun and loosening the aggregate with steel bar.

 (ii) By washing and flushing the filter media with high velocity water jets.

c) **Fly Nuisance:** Is a major problem in sewage treatment plants. The filter fly interfere with the working of the filter as it reaches the filter media and chokes it up. The following are used to prevent fly nuisance;

 (i) By spraying insecticide such DDT on the ground and surrounding.

 (ii) By sprinkling lime at the sides of treatment plants.

Advantages

1. It does not upset for the variation of hydraulic or organic loading.
2. BOD removal is 70-90% , while the solid matter removal is 70-92%.

Disadvantages

1. The filter is subjected to different types of nuisance e.g. odour and flies.
2. The cost of construction is high
3. Large volume of filter media is required.

9.4 AERATION

The rate at which oxygen is consumed by the microorganism is the biological reactor is called the oxygen utilization rate. The oxygen utilization rate will always exceed the rate of natural replenishment, thus some artificial means of adding oxygen must be used. When depletion of oxygen occurs, the sewage becomes sick and lifeless, resulting in sludge bulking.

Oxygen addition should be sufficient to match the oxygen utilization rate and still maintain a small excess in the mixed liquor at all times to ensure aerobic metabolism

Aeration techniques consists of using air diffusers to inject compressed air into the biological reactor and / or using mechanical mixers to stir the stir the contents violently enough to entrain and distribute air through the liquid.

9.5 SECONDARY SEDIMENTATION/CLARIFICATION

The effluent from primary treatment still contains 40 to 50% of the original suspended solids and virtually all of the original dissolved organics and inorganics. To meet the minimum EPA standards for discharge, the organic fraction both suspended and dissolved, must be significantly reduced. This organic removal, referred to as secondary treatment may consist of chemical-physical processes or biological process. The biomass generated by secondary treatment represents a substantial organic load and must be removed to also meet acceptable effluent standards. These solids are removed in secondary clarifiers.

Clarification is the removal of solids from the liquid phase and thickening the removal of liquid from the solid or sludge phase. A high degree of clarification is required to reduce the load on the secondary biological treatment plant.

9.6 STABILIZATION POND

This consists of a large, shallow earthen basin where wastewater is retained long enough for natural purification process to provide the necessary degree of treatment. Part of the system must aerobic to produce an acceptable effluent. Some oxygen is provided by diffusion from the air, but the bulk of the oxygen in ponds is provided by photosynthesis. Shallow ponds in which dissolved oxygen is present at all depths are called **Aerobic Ponds** (Polishing or tertiary ponds). Deep ponds in which oxygen is absent except for a relatively thin surface layer are called **Anaerobic Ponds**. Under favourable conditions facultative ponds in which both aerobic and anaerobic zones exist may be used as the total treatment system for municipal wastewater.

Advantages

1. Purifies wastes at low cost and minimum maintenance by unskilled operative
2. Removal of pathogens in considerably greater than other methods

3. It withstands both organic and hydraulic shock load
4. effectively treat a variety of industrial and agricultural wastes.
5. The algae produced are potential source of high protein food for fish farming, duck farming and crop irrigation.
6. It is flexible in design and operation.

Disadvantages

1. Assimilative capacity for some industrial waste is poor
2. Potential odor problems
3. Extensive land for sitting

9.7 AERATED LAGOONS

These are distinguished from ponds in that oxygen for lagoons is provided by artificial aeration. Lagoons are classified by the degree of mechanical mixing provided when sufficient energy is supplied to keep the entire contents, including the sewage solids, mixed and aerated, the reactor is called an **Aerobic Lagoon**. The effluent from an aerobic lagoon requires solids removal in order to meet suspended – solids effluent standards. When only enough energy is supplied to mix the liquid portion of the lagoon, solid settle to the bottom in areas of low velocity gradients and proceed to degrade an aerobically. This facility is called a Facultative Lagoon, it differs from that in the facultative pond only in the method by which oxygen is supplied.

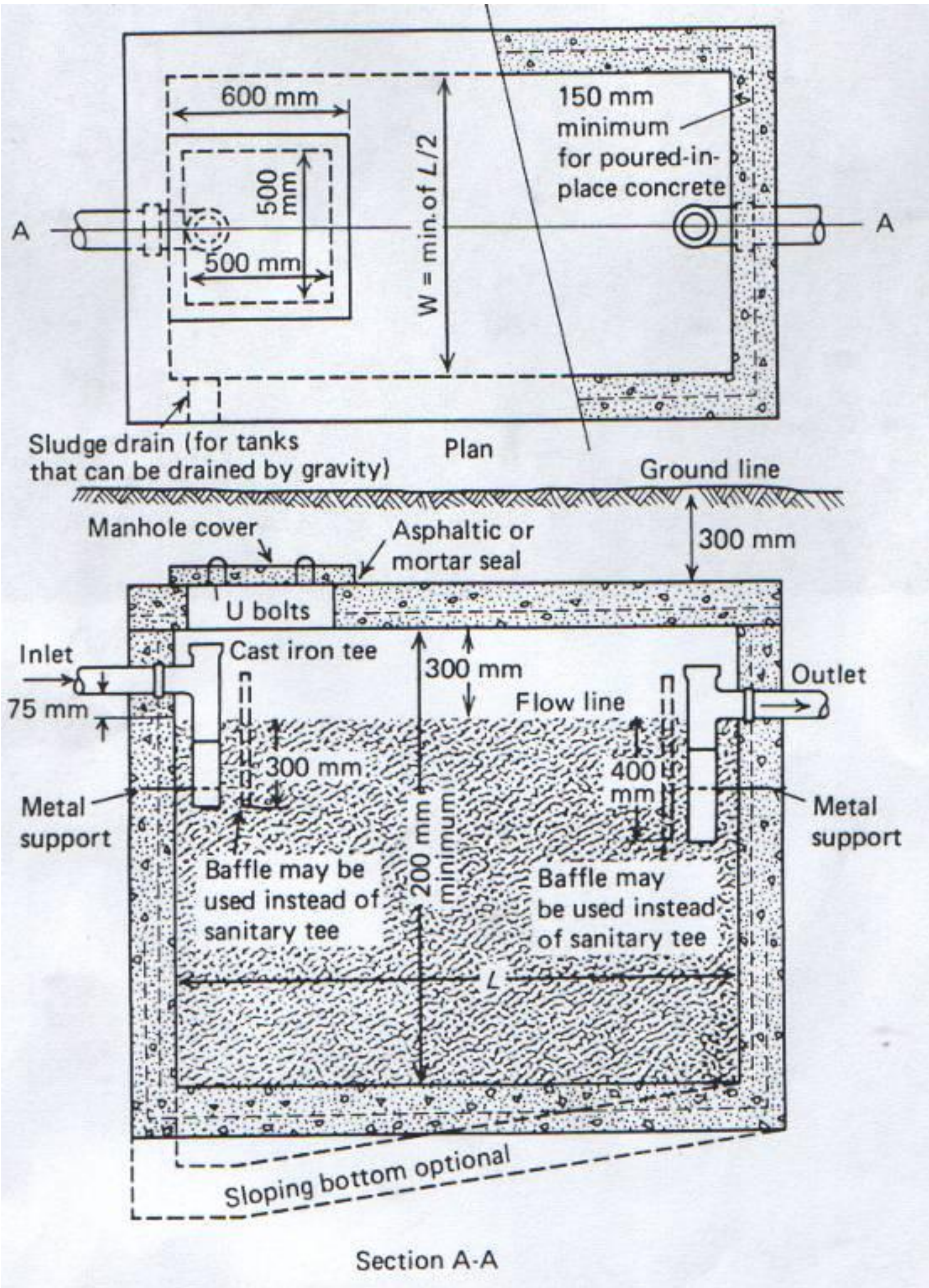
WEEK TWELVE

9.11 ON-SITE DISPOSAL SYSTEMS

9.12 SEPTIC TANKS

Septic tanks are small, rectangular chambers, usually sited just below ground level, in which sewage is retained for 1-3d. During this time the solids settle to the bottom of the tank where they are digested anaerobically. A thick crust of scum is formed at the surface and this helps to maintain anaerobic conditions. Although digestion of the settled solids is reasonably good some sludge accumulates and he tank must be desludged at regular intervals, usually once every 1-5 years. The effluent from septic tanks is from a public health point of view, as dangerous as raw sewage and so required further treatment before disposal. Although septic tanks are most commonly used to treat the sewage from individual households, they can be used as a communal facility for populations up to about 300. All the household wastewater should be led to the septic tank. In some older installations sullage is discharged directly to soak aways or open seepage channels; this is no longer recommended practice.

A two-compartment septic tank (Figure 12.1) is now generally preferred to



Two compartment septic tank: a scum clear space (75mm minimum: b sludge clear space (300mm minimum;) c=40 percent of liquid depth (from cotteral and norris[3])

One with only a single compartment as the suspended solid concentration in its effluent is considerably lower. The first compartment is usually twice the size of the second. The liquid depth is 1-2m and the overall length to breadth ratio 2-3 to 1.

Experience has shown that in order to provide sufficiently quiescent condition for effective sedimentation of the sewage solids, the liquid retention time should be at least 24h. two-thirds of the tank volume is normally reserved for the storage of accumulated sludge and scum, so that the size of the septic tank should be based on 3 d retention at start-up; this ensures that there is at least 1 d retention just prior to each desludging operation.

9.13 SUBSURFACE IRRIGATION

Overland flow is not a true disposal system, since most of the flow must be collected after it has passed over the soil. The process consists of applying wastewater along the upper edges of sloping, grass – covered fields and collecting it at the bottom in ditches which intercept the surface flow. This method is typically applied in areas with soils of low permeability, although it can also be used effectively under other conditions. Some percolation and evapotranspiration occurs and some nutrients are removed by the plant growth. Effluent quality is reasonably good – somewhat better than is normall attainable in secondary treatment systems. Advantages of overland flow systems include reduced requirements for pretreatment and storage. Disadvantages include somewhat reduced effluent quality, potential contamination of rainwater on the treatment site, and the need for more extensive site preparation.

Wetlands, either natural or artificial, have a substantial capacity for wastewater renovation. Organic material is oxidized by bacteria in suspension or on the surface of aquatic plants, while nutrients and many heavy metals and other contaminants may be taken up by the plants themselves. The aquatic plants must be harvested if the removal which they provide is to be taken advantage of since their constituents would otherwise be released to the water when they die. Even then, the bulk of the plant mass is below the ground so most of the nutrient material will still be recycled. Wetland systems are similar to overland flow systems in that they are primarily treatment processes with typically slightly better than that obtained in secondary systems.

Subsurface application is an alternative which is widely used in small scale systems employing septic tanks in areas of permeable soils. The method has been extended to areas with unfavorable soil conditions by construction of earthen mounds containing permeable materials which provide a locus for bacterial stabilization of organic material and plant uptake of nutrients. If the mound is underlain by impermeable soils, the product water must be collected by underdrains. If the subsurface consists of fractured rock, the effluent may be allowed to flow to the groundwater if no adverse impact will result form this discharge.

The major activity in soil systems occurs in the upper 300mm of the soil mantle. Adsorption of phosphates and heavy metals may occur deeper levels as the capacity of the upper layer is exhausted. Readily bio – degradable compounds are oxidized in the upper few millimeters of the soil. From 0.45 to $1kg/m^2$ of organic material is required each year for general soil equilibrium, and such levels are seldom approached in land treatment systems. Other organic compounds such as pesticides, cellulose, polysaccharides, and humic materials which may be present in wastewater are adsorbed to the soil matric and are slowly degraded.

Nitrogen may be present as organic nitrogen, ammonia, nitrate, or a combination of two or more species. Nitrate can percolate to the groundwater if it is not removed by plant uptake or reduced to nitrogen by bacterial action. Ammonia may be adsorbed on the soil or be fixed in clays. It is removed by plants and oxidized to nitrate by soil bacteria in an aerobic environment. The oxidation is slow, and the delay in passage through the soil increases the likelihood of plant utilization. Organic nitrogen is released as ammonia on the oxidation of the organic material of which it is part.

Phosphorus is utilized by plants as a nutrient and is fixed by adsorption and by exchange reactions with compounds in the soil which contain aluminum or iron. The adsorptive capacity of fine – textured soils is high (up to $2.25kg/m^2$) and offers a useful site life of as much as 100 years under favorable conditions. Overland runoff and wetland systems do not provide much phosphorus removal, since little interaction with the soil is involved.

Inorganic compounds which may be harmful include heavy metals and monovalent cations. Heavy metals are removed by adsorption on soil particles. While no clear limit to capacity is evident, the adsorption capacity is thought to exceed the tolerance level of plants, hence the first effect would be on the crop, not on the groundwater. It should be noted, however, that the agricultural use of land may be destroyed by heavy metal poisoning. Under acid conditions, heavy metals may be leached from the soil.

Monovalent ions tend to exchange for divalent ions in the soil matrix. In some clays, such exchange leads to swelling and loss of permeability. Additionally, high salinity decreases the ease of water utilization by plants. Water which has an ionic composition suitable for general agricultural use will not cause swelling of clay materials.

9.14 DRAINFIELD

Land disposal is often socially and politically desirable, and may be economical in water – poor areas where suitable land is available and streams standards are restrictive. Land systems may also require somewhat less skill in operation, which can be a significant factor in ensuring protection of the environment. Viewed simply as a disposal technique in areas where substantial storage is required, land disposal is generally quite expensive in comparison to discharge to surface waters.

Evaporation is practicable only in limited areas, and in those areas the water might be more profitably used to recharge groundwater or irrigate crops. The designer in such a case must weigh the cost of the more expensive land disposal system against the value of the benefit obtained.

WEEK THIRTEEN

9.15 METHODS OF EXCRETA DISPOSAL

In many rural communities, human wastes are disposed of in some kinds of latrine system. The latrine system is either built for individual household use or as public latrines. Individual latrines are preferable because public latrines are subject to abuse, poor maintenance or neglect. In some communities, might soil buckets are used to dispose human wastes but the labour for this system is increasingly difficult to obtain.

The location of sanitation facilities is very important as they affect the quality of drinking water sources. This problem needs special attention if the water table in the vicinity of the latrine is high sanitation facilities should not be located close to shallow wells or springs.

a) Conservancy system (disposal of excreta without water)

In this system the human excreta is collected in various types of privies, few of which are

i) Pit privy
ii) Aqua privy
iii) Bore hole privy
iv) Cesspools
v) Concrete vault privy
vi) Chemical toilet
vii) Removable receptacle privy
viii) V.I.P. latrine (ventilated invert pit toilet by proof Wright

b) Water carriage system (disposal of excreta with the use of water)

- Septic tank and soak away

i) Pit Privy: This is very economical with no operation. It essentially consists of manually dug pit 1.3m x 1.0m in plan and 1.5 to 2.8m deep. Or a hole of usually greater than 2.5m deep and of about 1.0m in diameter. At the top of this pit the squatting seat is provided in a compartment. When the pit is filled it is closed from the top and a new are in excavated by its side. Pit privy should be located at a distance not less than 200m from the position of local water sources; should be close to dwellings but not less than 5m.

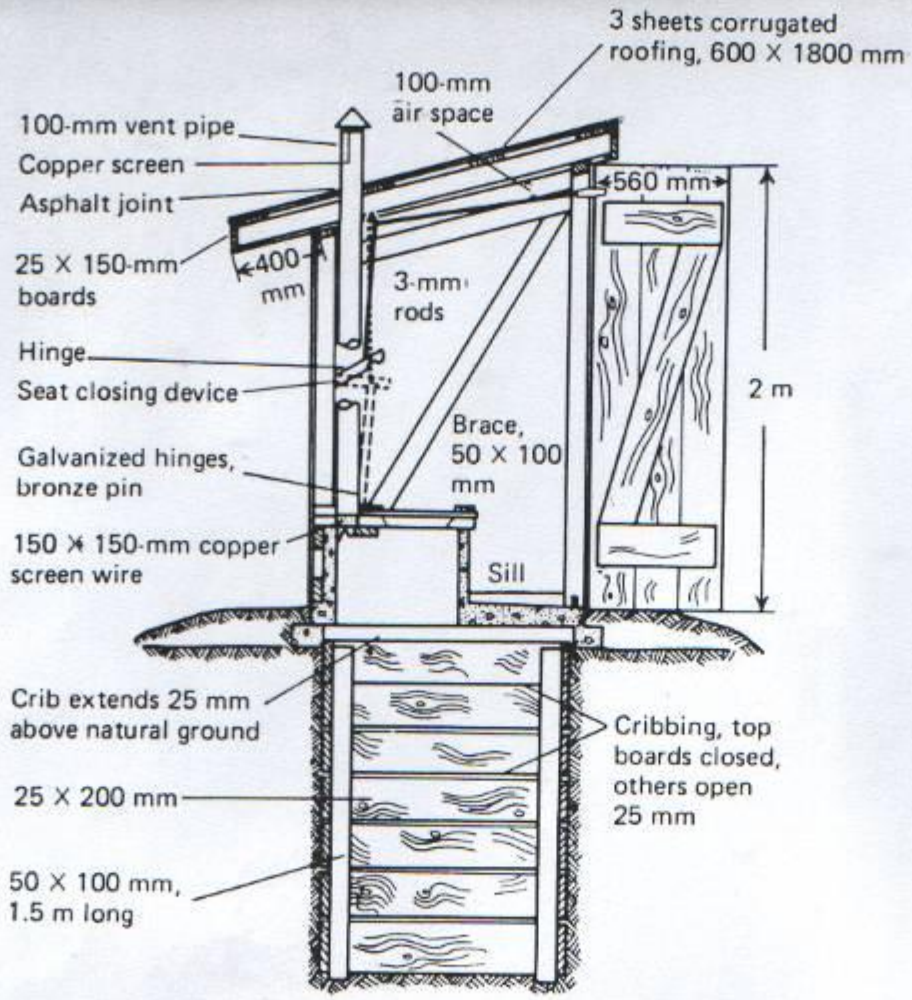


FIGURE 25-1
Concrete-slab pit privy.

ii) **Bore-Hole Privy**: This is similar to pit privy, the only difference is that in place of a pit it has a deep 40cm diameter borehole. The depth of the borehole should be 1.0m less than ground water table so that the waste may not pollute the underground water.

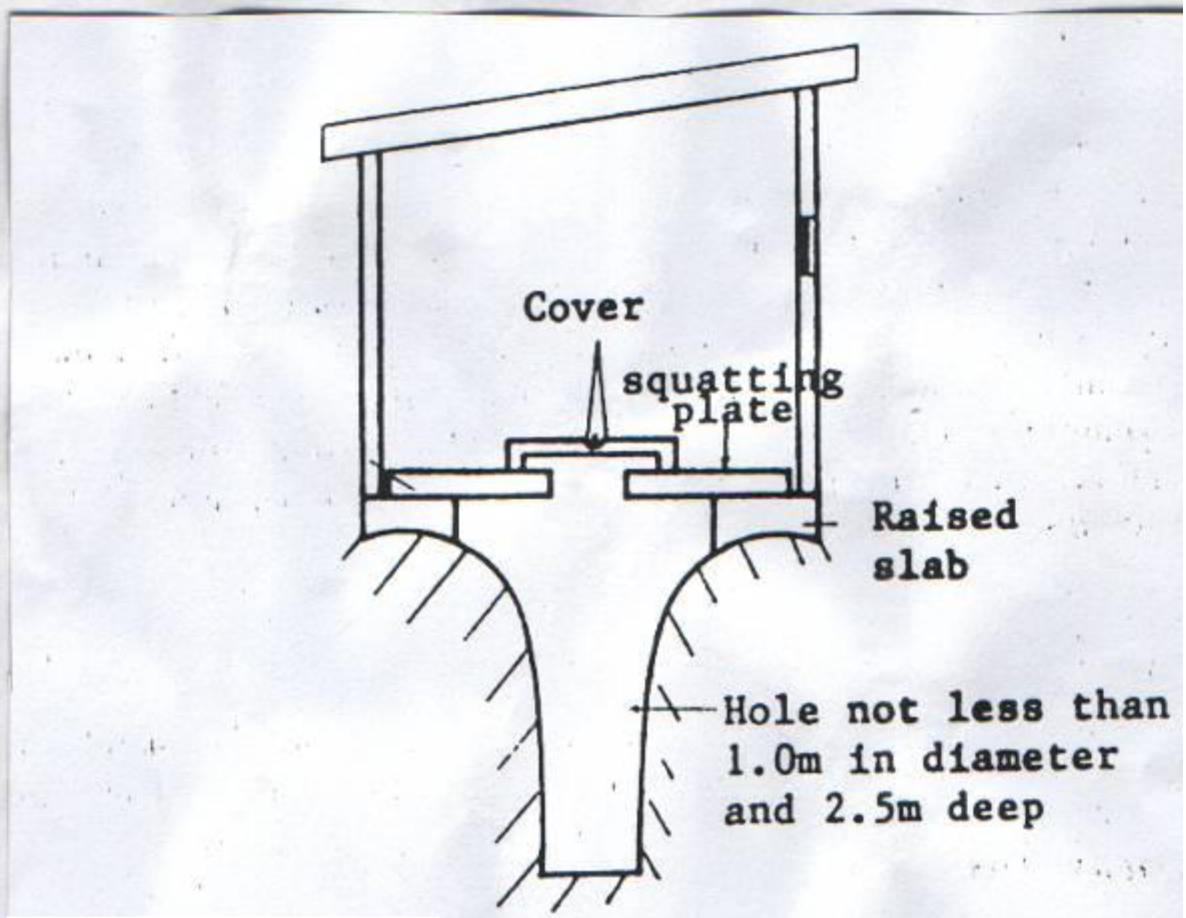


Fig 12.2 Bore Hole Privy

iii) **Agua Privy**: Most privies are of temporary nature. Aqua privy is an improved type of privy which makes it possible to provide a permanent structure. The aqua privy consist of water tight tank in which wastes are anaerobically digested, the design is shown below. The effluent produced can be disposed off in soak away pits. The accumulated solids in the tank need to be removed regularly. Wastes from the squatting hole are conveyed through drop pipe aperture, 12-15cm to the tank, for easy clearing of blockages, the pipe should not be firmly connected in position. In commercial toilets tanks of adequate size may be fitted with a number of pipes. The settlements of solids from the effluent may be improved by adopting a two-tank design

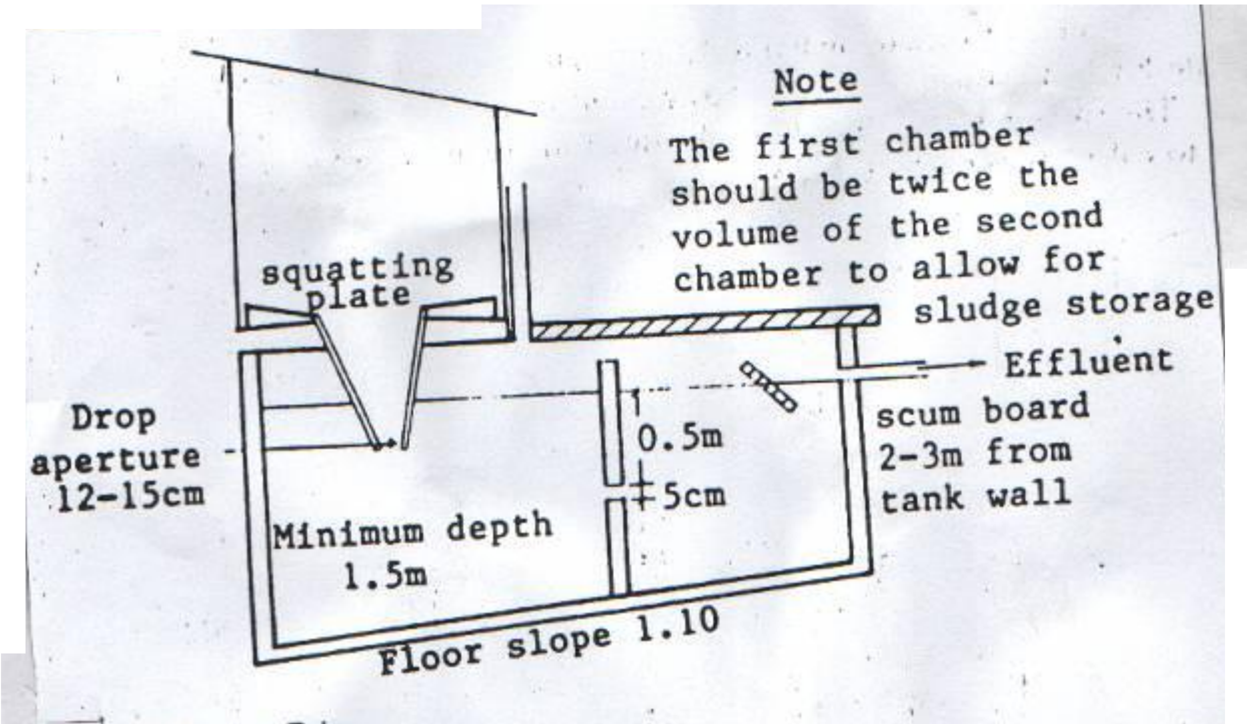


Fig 12.3 The Aqua Privy

Note: The first chamber should be twice the volume of the second chamber to allow for sludge storage.

The total capacity of the privy can be calculated from.

$$V = P (Q + S)$$

Where

P = Number of users

Q = Volume of liquid discharged per person per day of -12 litres

S = Volume of sludge storage space allowed per person, a reasonable factor is 120 – 150 litres.

The minimum recommended volume for about 10 people is 1,500 litres. The privy should be dislodged when the sludge reaches within 10 -15cm o the connecting aperture between the two tanks the de-sludging can be carried out once in 5years for a property designed privy.

iv) **Cesspool**: This essentially consists of a pit or chamber lined with dry bricks or stones. The excremental matter flow through pipe from the water close to the pool, when the cesspool is filled up it emptied and cleaned.

v) **Concrete Vault Privy**: When water table is very close to the ground surface it becomes difficult to construct pit privy and bore-hole privy because the excremental matter will pollute the underground water. Under such circumstances concrete vault privy is most suitable. It essentially consists of water tight vault constructed in the ground.

vi) **Chemical Toilets:** This is the most satisfactory method of disposal of excreta without water. In this method, a metal tank filled with the solution of concentrated caustic soda is placed below the squatting seat. The excreta is totally liquefied when it comes in contact with caustic soda. The main advantage is that it eliminates odour.

vii) **Removable Receptacle Privy:** This is a cheap type of privy. It essentially consists of a metal box placed below the squatting seat. The excreta is collected daily from this removable privy by sweepers.

WEEK FOURTEEN

10.0 SEWER APPURTENANCES

10.1 MANHOLES

Manholes provide access to sewers for inspection and cleaning and are located at changes in direction, changes in pipe size, substantial change in grade, and at intervals of 90 to 150m in straight lines. Sewers larger than 1.5m in diameter can be entered readily and thus need fewer manholes.

The design of manholes is fairly well standardized in most cities. A typical brick manhole, illustrated in Fig 10.1, has a cast iron frame and cover with a 500 to 600mm opening. The frame rests on brick work which is corbeled as shown to form a cylinder from 1 to 1.25m in diameter which extends downward to the lowest sewer. The walls are typically 200mm thick for depths up to 4m and increase by 100mm for each additional 2m of depth. The interior of brick manholes is often plastered with portland cement or mortar.

The bottom of the manhole is normally concrete, sloping toward an open channel which is an extension of the lowest sewer. The open channel is sometimes line with half – round or split sections of sewer pipe. The channel should be sufficiently well – defined and deep enough to prevent sewage from spreading over the bottom of the manhole. Changes in direction in the lower sewer are made by deflecting the open and channel as shown in Fig 13-2, which represents a cast – in – place reinforced – concrete manhole.

Figure 13-3 illustrates a precast reinforced – concrete manhole which, with the exception of the tapered section, is fabricated of tongue – and – groove concrete pipe. This figure also shows a common technique of matching the grades of sewers without requiring all the lines to be placed at the same elevation. Such a structure is called a drop manhole and is usually provided when the sewage falls through the vertical line, but the sewer itself is open for inspection and cleaning through the horizontal extension. When large sewage flows must fall long distances in order to reach a lower sewer, the fall is generally interrupted by staggered horizontal plates within the shaft or by a steplike arrangement. These devices prevent excessive kinetic energy from damaging the bottom of the structure. Manholes for large sewers may be constructed as shown in Fig. 15-4 or as a separate structure connected to the sewer by a short tunnel.

Manhole covers and frames are manufactured in several standard weights for different traffic conditions. The heaviest covers and frames weigh about 340 kg , those intended for city streets about 245 kg and the lightest about 70 kg (150-46). Light and heavy frames are illustrated in Fig. Covers are generally cast with a raised pattern on their surface to make them less slippery when wet. Openings through the cover should not be allowed, since these contribute to infiltration during rainfall events.

Manholes may be provided with metal rungs inserted in the walls, as shown in Figs. 15-1 and 15-4. Such rungs and the manholes themselves are subject to corrosion and may present a danger to workers in older sewers. It may be safer to lower a ladder into the manholes than to depend on such rungs.

Fiber-glass-reinforced plastic manhole structures have been manufactured and used since about 1975. These are, of course, much lighter than concrete and thus much easier to install. Fiber glass is also more resistant than concrete to the mechanism of sewer corrosion. The drawbacks to fiber glass lie in its uncertain design life and its susceptibility to structural failure if it is improperly installed. Very careful placing and compaction of backfill is required to ensure structural stability.

Cleanouts are sometimes used to permit cleaning of small sewers, particularly at the upper end of laterals. A standard cleanout used in Dallas is illustrated in Fig. 15-6. A light cast iron cover provides access to a line of pipe leading to the sewer. The connection to the sewer is made through a special wye with its side outlet making an angle of 27° with the main rather than the standard 60°. When the sewer is fairly deep, as in the illustration, a 1/16 bend is installed above the wye to bring the cleanout to the surface at a 45° angle. The sewer may be rodded or flushed with water through such structures and small television cameras can be inserted to permit inspection of the condition of the pipe and joints.

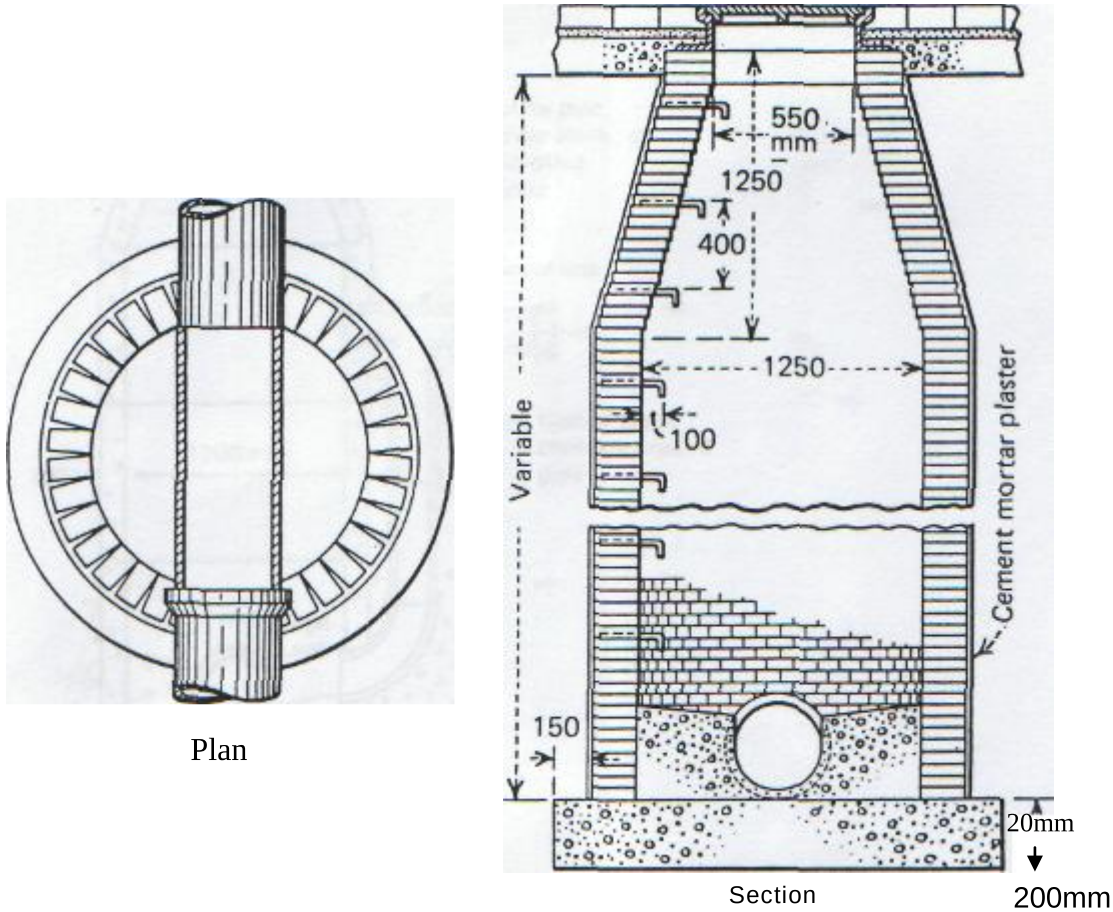


FIGURE 15-1
Brick manhole

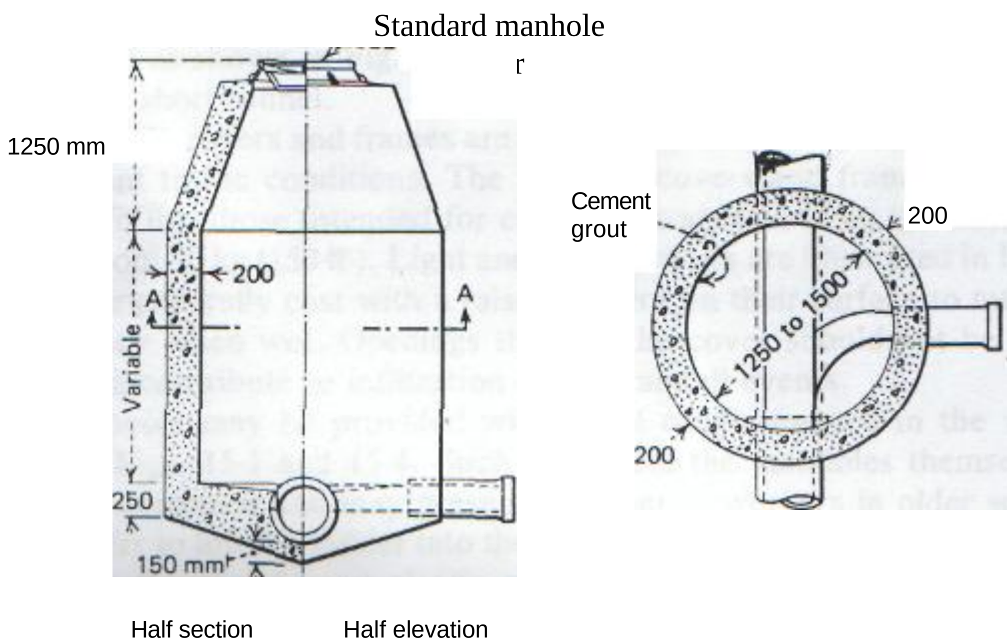


Fig 15 – 2 Concrete Manhole with junction of branch sewer

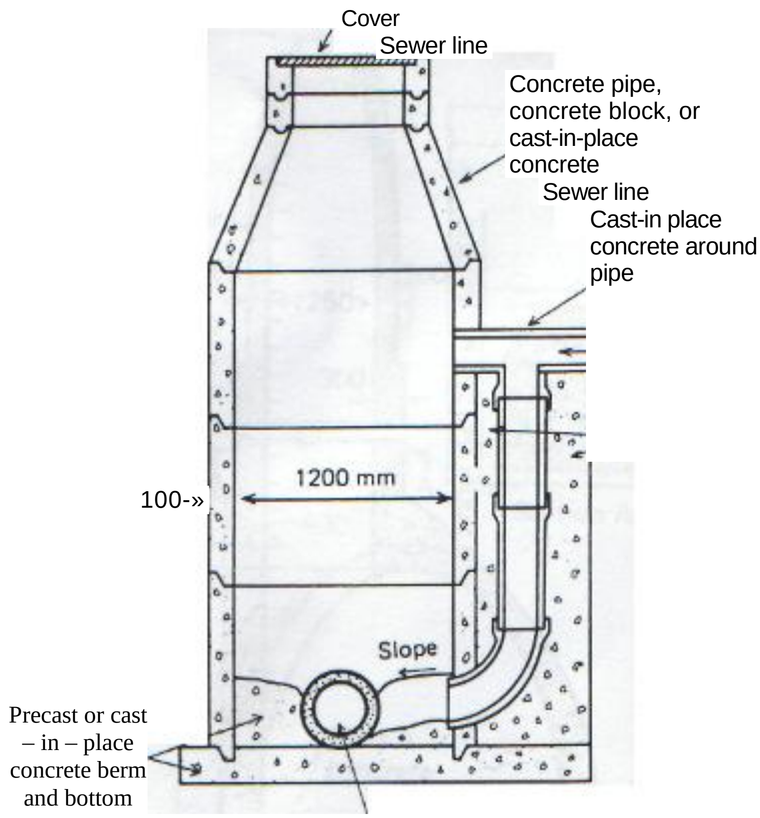


FIGURE 15-3
Precast concrete manhole with drop inlet.

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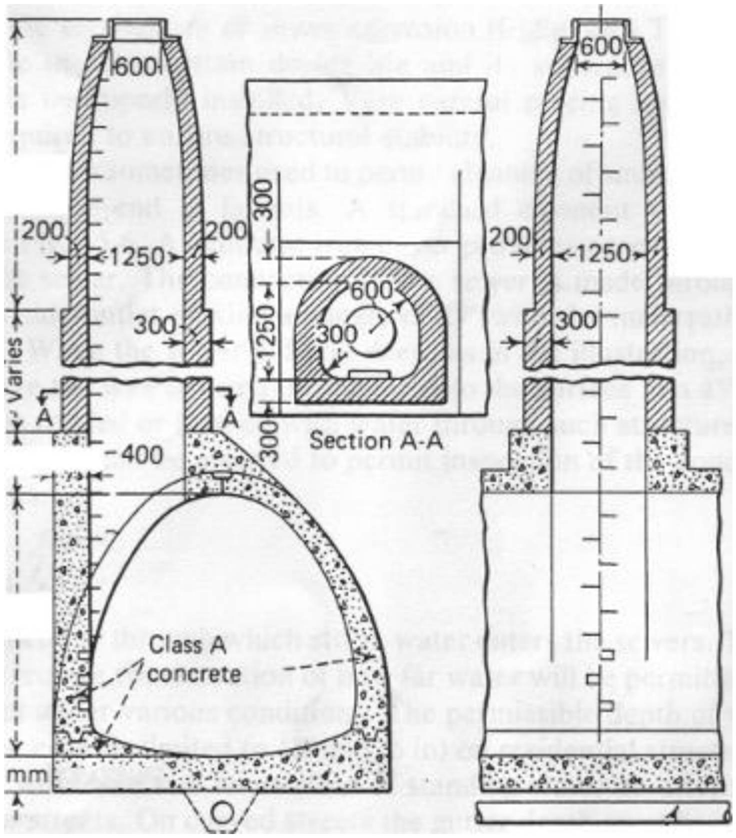

FIGURE 15-4
Manhole access to large sewer

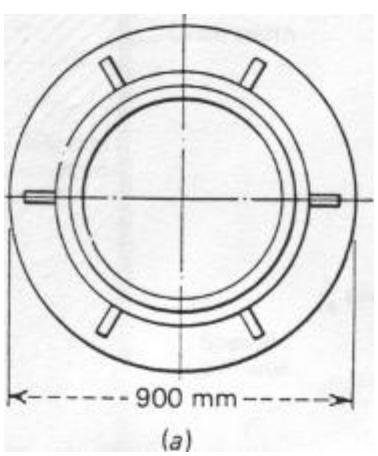

FIGURE 15-5
Manhole frames, *(a)* Plan; *(b)* section of heavy frame; (c) section of light frame.

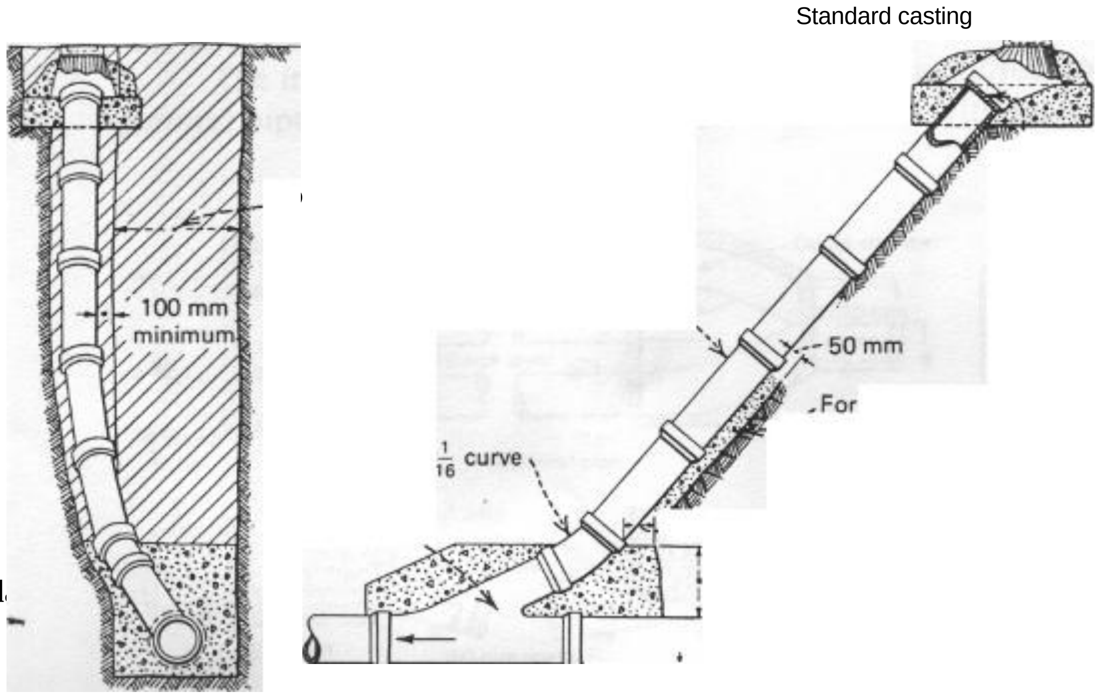

Fig 15 – 6 Stand
Sewer Cleanout

10.2 INLETS

Inlets are structures through which storm water enters the sewers. Their design and location require consideration of how far water will be permitted to extend into the street under various conditions. The permissible depth of water in the gutter in most cities is limited to 150mm (6 in) on residential streets and to that depth which will leave two lanes clear of standing water on arterials and one lane on major streets. On curved streets the gutter depth must be decreased to with grades which are adequate to maintain self – cleaning velocities and to employ simple drop inlets.

10.3 INVERTED SIPHONS

An inverted siphon is a section of sewer which is dropped below the hydraulic grade line in order to avoid an obstacle such as a railway or highway cut, a subway, or a stream. Such sewers will flow full and will be under some pressure, hence they must be designed to resist low internal pressures as well as external loads. It is also important that the velocity be kept relatively high (at least 0.9 m/s) to prevent deposition of solids in locations which would be very difficult or impossible to clean.

Since sewage flow is subject to large variations, a single pipe will not serve adequately in this application. If it is small enough to maintain a velocity of 0.9 m/s at minimum flow, the velocity at peak flow will produce very high head losses and may actually damage the pipe. Inverted siphons normally include multiple pipes and an entrance structure designed to divide the flow among them so that the velocity in those pipes in use will be adequate to prevent deposition of solids.

Figure 15-10 illustrates an inverted siphon designed to avoid an obstacle. The three pipes are designed to carry, respectively, the minimum flow, the difference between minimum flow and average flow, and the difference between average and maximum flow. The difference in elevation from one end to the other is dictated by maintaining self-cleansing velocity (0.9 m/s) in the smallest sewer. At the same differential head, the velocities will be greater in the larger sewers.

The inlet structure has two side flow weirs which direct low flows to the central pipe. As the depth in the structure increases with increasing flow, the

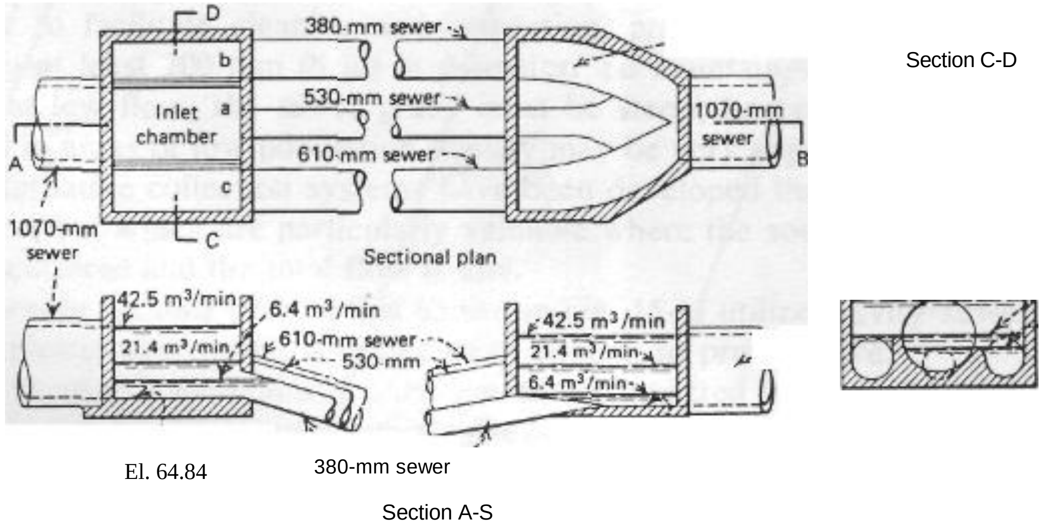

FIGURE 15-10
Inverted **siphon.**

Excess flow will spill over the lower weir and enter the second pipe. Further increases in flow and depth will cause flow to be diverted to the third pipe. Inlet and outlet structures for inverted siphons should be installed in manholes or other access should be provided for maintenance and cleaning.

10.4 PARSHALL FLUME

The parshall flume is frequently used to measure open – channel flow. Typical details of such flumes are presented in fig . it is often necessary to raise the channel bottom at the flume in order to ensure that upstream depth will be adequate. The required depth of the step may be determined from the energy and momentum equations. The flow through a parshall flume is given by

$$Q = 2.23 \text{ X } 10^{-5} W \left(\frac{Ha.}{0.305} \right)^{1.57W^{0.026}}$$

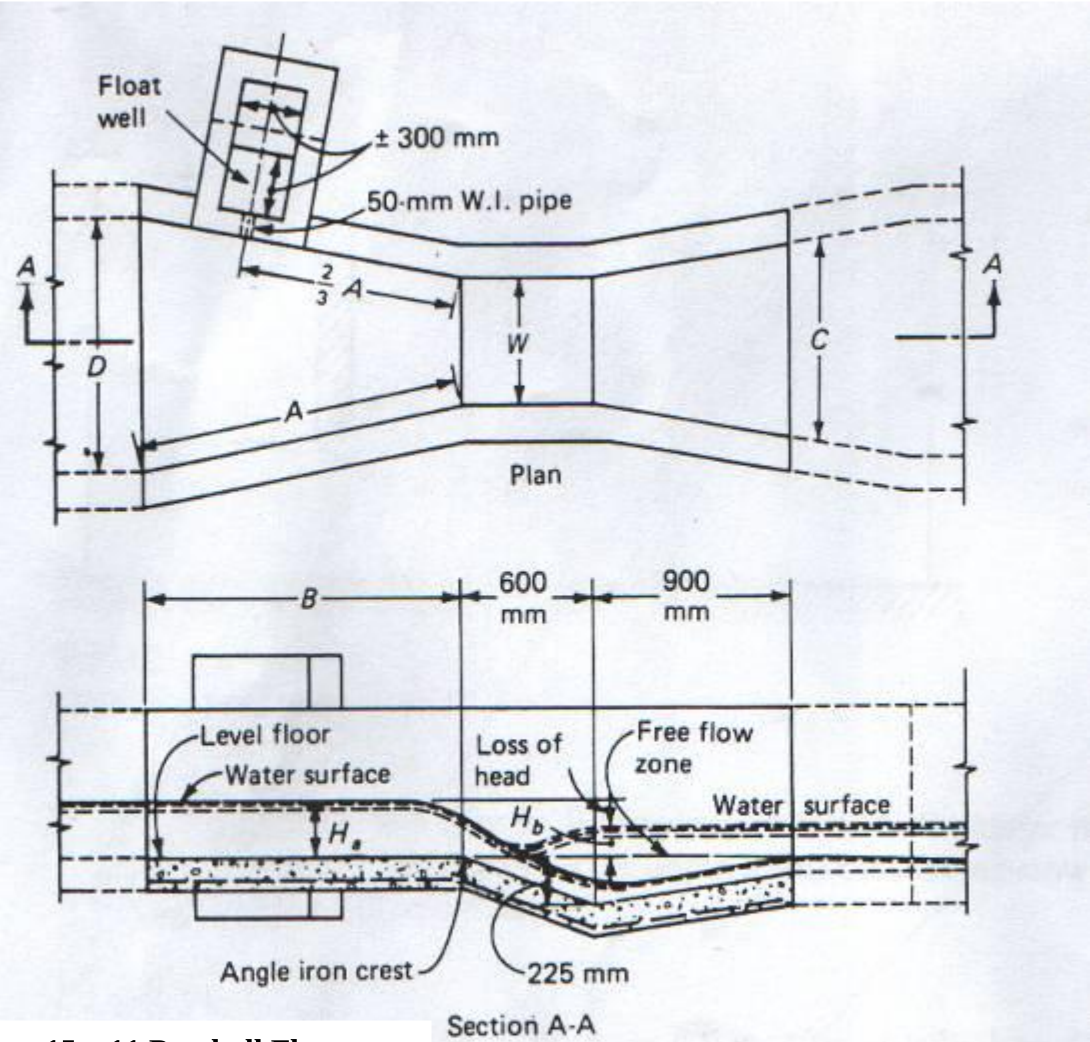

Figure 15 – 11 Parshall Flumes

WEEK FIFTEEN

11.0 POLLUTION AND METHODS OF CONTROL

11.1 WATER POLLUTION

Domestic and industrial wastewaters may be disposed in various ways, e.g. into the sea, on to land, into underground strata, etc. but the commonest method of disposal is into surface waters, directly or via a local authority drainage system. Any body of fresh water can assimilate a certain amount of pollution without serious effects because of the biological cycle which adjusts itself to the greater supply of food or other changed conditions (fig. 6.1). in a low organic content stream there is little nutrient material to support life so that although many types of organisms will be present, there are only relatively low numbers. In streams with high organic content

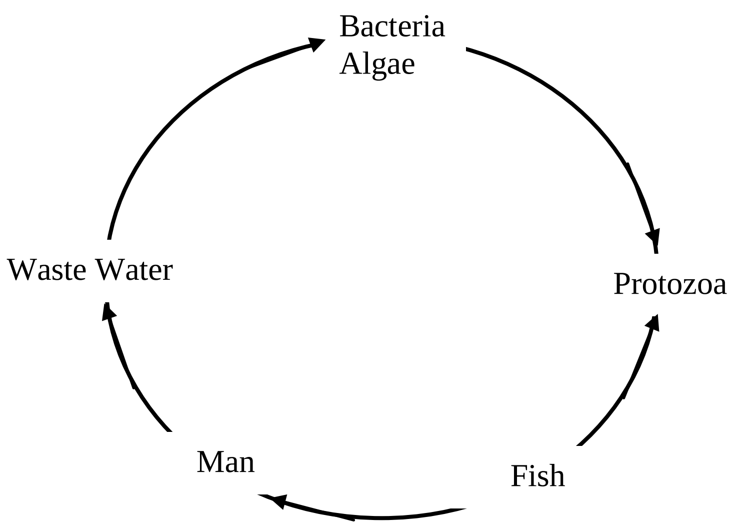

Fig. 15.1 The self-purification cycle

11.2 TASTE AND ODOUR

The terms taste and odor are themselves definitive of this parameter. Because the sensations of taste and smell are closely related and often confused, a wide variety of tastes and odors may be attributed to water by consumers. Substances that produce an odor in water will almost invariably impart a taste as well. The converse is not true, as there are many mineral substances that produce taste but no odor.

Sources

Many substances with which water comes into contact in nature of during human use may impart perceptible taste and odor. These include minerals, metals, and salts from the soil, end products from biological reactions, and constituents of wastewater. Inorganic substances are more likely to produced tastes unaccompanied by odor. Alkaline material imparts a bitter taste to water, while metallic salts may give a salty or bitter taste.

Organic material, on the other hand, is likely to produce both taste and odor. A multitude of organic chemicals may cause taste and odor problems in water, with petroleum-based products being prime offenders. Biological decomposition of organics may also result in taste-and odor-producing liquids and gases in water. Principal among these are the reduced products of sulfur that impart a “rotten egg” taste and odor. Also, certain species of algae secrete an oily substance that may result in both taste and odor. The combination of two or more substances, neither of which would produce taste or odor by itself, may sometimes result in taste and odor problems. This synergistic effect was noted earlier in the case of organics and chlorine.

Impacts

Consumers find taste and odor aesthetically displeasing for obvious reasons. Because water is thought of as tasteless and odorless, the consumer associates taste and odor with contamination and may prefer to us a tasteless, odorless water that might actually pose more of a health threat. And odors produced by organic substances may pose more than a problem of simple aesthetics, since some of those substances may be carcinogenic.

11.3 OVERALL EFFECTS OF POLLUTION

(a) River pollution is clearly undesirable for many reasons;

1. Contamination of water supplies –additional load o treatment plants.
2. Restriction of recreational use.
3. Effect on fish life.
4. Creation of nuisances –appearance and odour.
5. Hindrance to navigation by banks of deposited solids.

A typical water use classification might thus be (in decreasing order of quality requirements).

1. Domestic water supply.
2. Industrial water supply.
3. Commercial fishing

4. Irrigation
5. Recreation and amenity
6. Transportation
7. Waste disposal.

(b) Ground water Pollution

Although ground waters are normally effectively purified, as far as suspended matter is concerned, by the straining action of the rock as water percolates through it, soluble impurities are not so readily removed, although thee is the possibility of ion-exchange reactions.

Nitrogen compounds in agricultural drainage and in effluents discharged to soakaways are responsible for high nitrate levels in some groundwaters. The use of soakaways for the disposal of domestic and industrial effluents may impair groundwater quality unless thee is an impermeable stratum between the disposal area and the acquifer. Similar considerations apply to the sitting of refuse tips for both domestic and industrial solid wastes. These potential hazards are much increased if the strata is fissured, since polluted water may then rapidly reach the aquifer.

Organic matter entering groundwater reservoirs will only be stabilized slowly because the oxygen demand rapidly deoxygenates the water and there is no source of replacement oxygen. Anaerobic conditions then ensure and constituents of the aquifer, e.g. iron, may then readily dissolve in the water, causing further quality problems.

It is also important to note that although rocks may strain out suspended matter, this process is likely to have a deleterious effect on the permeability of the strata. Such considerations are clearly of considerable importance in the case of recharge operations.

Although most water pollution control measures are based on parameters such as BOD, SS, Amm. N. etc. other pollutants may be of importance in some cases. As a measure of water quality, identification

11.4 EUTROPHICATION AND SELF – PURIFICATION

(a) Eutrophication

A water quality concern with lakes and reservoirs is eutrophication, a natural aging process in which the water becomes organically enriched, leading to increasing domination by aquatic weeds, transformation to march land, and eventually to dry land. Eutrophication can be accelerated by human input of nutrients. Die-off and settling of plant growth results in sediment oxygen demand, which tend to decrease dissolved-oxygen levels. The effects of entrophication, which may be detrimental to aquatic life, are compounded by large day-night excursions in dissolved oxygen due to photosynthesis and respiration.

(b) Self-purification

The assimilation of organic mater in surface water is a natural activity which may even have beneficial effects on fishing. It is only when the self-purification capacity of the water is exceeded that serious trouble occurs.

Self-purification involves one or more of the following processes;

1. Sedimentation assisted by biological or mechanical flocculation. This may, however, result in formation of anaerobic bottom deposits which if re-suspended can exert high oxygen demands.
2. Chemical oxidation of reducing agents.
3. Bacterial decay – due to inhospitable conditions there is normally a rapid die-off of enteric and pathogenic organisms.
4. Biochemical oxidation- the most important process. to prevent serious pollution it is essential that aerobic conditions be maintained, thus the amount of DO in the water becomes of vital importance. The DO content is controlled by various factors such as, temperature, BOD, salinity and most important, reaeration.

(c) Self-purification in a river

If an effluents is discharged into a river it exerts a demand on the oxygen resources of the river. The removal of DO for waste stabilization must be balanced by an addition of oxygen. The most important source of oxygen for reoxygenation o the river is the atmosphere: there is a mass transfer of oxygen from the atmosphere across the water surface to the bulk water below. The rate of this transfer is proportional to the oxygen deficit in the water (i.e the difference between the saturation concentration and the actual DO concentration). Thus the DO removal that occurs below the point of discharge of an effluent actually stimulates an increased rate of supply of oxygen from the atmosphere. This competition between deoxygenation and reoxygenation results in a DO profile which typically shows a distinct sag some distance below the point of discharge (Figure 3.4). In order to prevent the river becoming offensive there must be an adequate DO reserve at all points along the river. Analysis of the oxygen sag curve provides a convenient method of determining the degree of treatment that should be given to the effluent before it is discharged, so as to ensure that the lowest DO concentration that occurs is greater than the minimum required to maintain the river water equality at the desired level.

11.5 OXYGEN DEPLETION IN STREAMS

The description of the cause of oxygen depletion in stream, when bacterial decomposition of the organic matter on the floor of the reservoir is accompanied by a depletion of the dissolved oxygen in the water and the formation of carbon dioxide. The corrosiveness of the water is increased by the carbon dioxide, and N also causes the solution of deleterious minerals such as iron and manganese and the hardness –producing minerals calcium and magnesium from the soil of the reservoir floor. The extent to which these changes take place depend upon the amount of organic matter available for decomposition on the reservoir floor and the character of the mineral matter in the soil and rock

11.6 STRATIFICATION

Almost all lakes and reservoirs with a depth of 15ft (5m) or more stratify during a substantial part of the year. The exception is run-of-the-river reservoirs with a residence time of a month or less. Stratification develops during the spring due to surface heating by solar and atmospheric radiation. Because the density of water decreases with temperature, a hydrodynamically stable situation develops with lighter fluid overlying heavier fluid. If, for example, a parcel of fluid is moved downward into denser fluid, a buoyant upward restoring force results with the net effect of resisting vertical mixing.

Stratification-vertical structure or layering within a terrestrial or aquatic environment, or the layering in sedimentary locks due to chemical physical or biological changes in the sediment.

Lake – A body of water lying on the surface of a continent and unconnected (except indirectly by rivers) with the Ocean. Lakes acts ad natural setting tanks, in which sediment carried down by rivers is deposited, contaning the shells of molluses etc. the lakes of farmer geological periods may thus be recognized by the nature of the sediments deposited in them and the fossils they contain.

Reservoir – any volume in an isotope separation plant which is for the purpose of storing material or ensure smooth operation.

Stratification of lakes reservoir

Difference in temperature of water at various locations and depths in a reservoir will occur with changing ambient temperatures. The difference in temperature, resulting in differences in density will cause stratification within the reservoir, as well as exchange of water between areas of different densities; the use of desities current to pass through a reservoir the fine sediment which tend to remain in suspension has been suggested on any occasions as a means of reducing deposition.

11.7 THE EFFECT OF STRATIFICATION ON WATER QUALITY

The quality of water is determined by its content of living organisms and by its content of living organisms and by its content of mineral and organic matter.

Water that percolates through the soil or rocks dissolves the more soluble of the minerals with which it carries in contact. The quality such minerals held in solution depends upon their abundance in the soil and the amount of carbon dioxide dissolved in the water. Most of the carbon dioxide in ground water is obtained from the top soils in which this gas is continuously being generated by bacterial action. Ground water is practically free from suspended matter, for such material is effectively strained out in the pores of the soil, ground water is usually free from sewage and industrial wastes out may contain traces of wastes and some bacteria if they are free to percolate through crevices or large soil pores to he ground water near wells or spring. The quality of ground water is affected by its abundance.