Conduits for transporting water

Conduit

A conduit is a channel for conveying waters or other fluids from one location to another or between persons. Examples pipes and aqueducts

Types of Conduits

Depending upon the conditions and characteristic of flow, the conduits may be divided into

1. Gravity conduits and
2. Pressure conduits

Gravity conduits

Gravity conduits are those in which the water flows under the action of gravity. Gravity conduits can be in the following form of canals, flumes, or aqueducts.

1. Canals

Canals are the open channels which are constructed by cutting high grounds and constructing banks on low grounds.

2. Flumes

Open channels supported above the ground over trestle are called flumes. They are used to convey water across valleys and minor depression or over drains and other obstructions in their path. They may be made of masonry. R.C.C, metal or wood and are usually circular or rectangular in cross-section.

3. Aqueducts

An aqueduct is a water supply or navigable covered or closed conduits constructed to convey water. They may be made of masonry. R.C.C, metal or wood and are usually circular, rectangular or horse shoe in cross-section.

Pressure conduits

In Pressure conduits which are closed conduits and as such no air can enter into them, the water flows under pressure above the atmospheric pressure.

Hydraulics of flow and design of pressure pipes

1. Darcy- weisbach formula

$$H_L = \frac{f'LV^2}{2gd}$$

2. Manning's formula:

$$H_L = \frac{n^2V^2L}{R^{\frac{4}{3}}}$$

3. Hazen- Williams formula

$$V = 0.85\, C_H R^{0.63} S^{0.54}$$

Where

H_L = Head loss (m)
L = Length of pipe (m)
d = Diameter of the pipe (m)
V = Velocity of flow through the pipe (m/s)
g = Acceleration due to gravity (m/s2)

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f = Dimensionless friction factor (0.02 ~ 0.075)
n = Manning's coefficient

R = Hydraulic mean depth of pipe = $\frac{A}{P} = \frac{\Pi d^2}{4\Pi d} = \frac{d}{4}$

C_H = Coefficient of hydraulic capacity
S = slope of the energy lone

Pipe material	Value of CH (Depending upon the smoothness of the pipe material)
Concrete	130
Cast iron	
New	130
5 years old	120
20 years old	100
Welded steel(new)	120
Riveted steel (new)	110
Vitrified clay	110
Brick Sewers	100
Asbestos Cement	140

Forces acting on Pressure Conduits

The structural design of the pressure pipes should be carried out, so as to enable them to withstand the various forces likely to come on them. The following forces generally come into play in the pressure pipes:

(1) Internal pressure of water including water hammer pressure to be resisted by using materials strong in tension.

(2) Pressure due to external loads in the form of backfill, traffic loads, etc. to be resisted by using material strong in compression.

(3) Longitudinal temperature stresses created when pipes are laid above the ground to be resisted by providing expansion joints.

(4) Longitudinal stresses created due to unbalanced pressures at bends, or at points of changes of cross-section to be resisted by holding the pipe firmly by anchoring it in massive blocks of concrete or stone masonry.

(5) Flexural stresses produced when pipes are supported over trestles, etc.

Various Types of Pressure Pipes

Depending upon the construction material, the pressure pipes are of the following types:

(1) Cast iron pipes
(2) Steel pipes
(3) Reinforced cement concrete pipes
(4) Hume steel pipes
(5) Vitrified clay pipes
(6) Asbestos cement pipes
(7) Miscellaneous types of pipes.

Selection of a particular type of material for a pipe depends mainly upon

1. Relative economy
2. Pressures likely to come and the working pressures
3. Maximum permissible sizes and capacities
4. Availability of materials and
5. Labour for their construction, etc.

1. Cast Iron Pipes

Cast iron pipes are widely used for city water supply. They are sufficiently resistant to corrosion and may last as long as 100 years or so. They are generally manufactured in lengths of about 3.5 metres, but may be manufactured up to 6m or so, on special orders.

The **advantages of cast iron** pipes are:

(i) Moderate in cost
(ii) Easy to join
(iii) Strong and durable
(iv) Corrosion resistant
(v) Long life up to 100 years or so
(vi) Service connections can be easily made.

The **disadvantages of cast iron** pipes are:

(i) Water carrying capacity decreases with time, as the value of friction factor increases due tc tuberculation in certain waters.
(ii) They cannot be used for high pressures. Generally, not used for pressures above 700 kN/m^2.
(iii) When large, they are very heavy and uneconomical.
(iv) They are likely to break during transportation or while making connections.

2. Steel pipe

Steel plates of varying thickness for withstanding different pressures are generally bent and welded so as to manufacture steel pipes.

Advantages

i) Strong in tension
ii) Used for high internal pressure
iii) Very in length and diameter
iv) Long life upto 40 years or so

Disadvantage

i) Get rusted quickly
ii) Cannot withstand high negative pressures or vacuums.
iii) Easily affected by acidic or alkaline waters
iv) Required coating both side of the pipe.

3. Cement Concrete Pipes

Plain cement concrete pipes are manufactured in small sizes (i.e. upto a maximum of about 0.6 m diameter); while they are reinforced with steel for large diameter pipes. They are easily available in sizes upto diameters say about 1.8 metres and may be got manufactured for larger diameters say upto about 4.5 metres, on special orders.

These pipes may either be prepared at site by transporting various ingredients (i.e. cement, steel, aggregates water etc.) or can be manufactured in factories and then transported to site. They are known as cast in situ pipes in the former case, and precast pipes in the latter case. Cast in situ pipes are useful when the site conditions are difficult an where it may be difficult to carry the pipes. But when pipes are cast at site, lesser supervision and check is possible a compared to the case of precast pipes which are cast in factories and thus subjected to greater quality control.

Advantages of R.C.C. Pipes are given below:

(i) They can resist external compressive loads and do not collapse under nominal vacuums and loads.

(ii) They are not corroded from inside by normal potable waters and from outside by ordinary soils.

(iii) They are quite strong and their useful life is of the order of 75 years or so.

(iv) They are easy to construct either at site or at factories and with local ingredients.

(v) The coefficient of expansion being low, expansion joints may not be needed when laid above the ground.

(vi) If laid under water, the empty pipes do not float because of their heavy weights.

Disadvantages of R.C.C. Pipes are given below:

(i)They are likely to corrode by ground waters due to the presence of acids, alkalis or sulphur compounds.

(ii) They are difficult to be repaired.

(iii) They cannot withstand very high pressures.

(iv) They are heavy and bulky, and hence difficult to transport.

4. Hume Steel Pipes

As pointed out earlier, hume steel pipes are R.C.C. spun pipes patented under this name. They consist of thin steel shell coated from inside with cement mortar by centrifugal process. The thickness of the inside coating varies from 1.2 to 3.75 cm depending upon the size of the pipe. They are also coated from outside, so as to protect the steel from external weather or soil action. The thickness of external coating is 2.5 cm for pipes upto 1 metre in diameter, and is 3.75 cm for pipes of larger diameters. The thickness of steel shell depends upon the size of the pipe and also upon the pressure to be borne by the pipe. Like all R.C.C. pipes, they are heavy and difficult to handle.

5. Vitrified Clay Pipes

They are generally not used as pressure pipes for carrying waters, but are extensively used for carrying sewage and drainage at partial depths. These pipes are free from corrosion and provide a smooth hydraulically efficient surface. They are not used as pressure pipes because clay is very weak in tension, and formation of watertight joints becomes difficult on them. Clay pipes are commonly made in lengths of about 0.6 to 1.2 m or so.

6. Asbestos Pipes

Asbestos, silica and cement are converted under pressure to a dense homogeneous material possessing high strength, called asbestos cement. This material is used for casting these pipes. The asbestos fibre which is thoroughly mixed with cement, serves as reinforcement. These pipes are generally available in different sizes, say from 10 to 9[illegible] cm in diameters in about 4 meters lengths.

Advantages of asbestos pipes are given below:

(i) They are light and hence easy to transport.

(ii) They can be easily assembled without skilled labour.

(iii) They are highly resistant to corrosion.

(iv) They are highly flexible and may permit as much as 12° deflection in laying them around curves.

(v) Expansion joints are not required as the coefficient of expansion is low and the joints are also flexible.

(vi) They are very smooth and thus provide a hydraulically efficient pipe. Their carrying capacities do not reduce with time.

(vii) They are very suitable to be used as small size distribution pipes.

Disadvantages of asbestos pipes are given below:

(i) They are costly.

(ii) These pipes do not have much strength and are brittle and soft. They are liable to get damaged by excavating tools or during transportation transits.

(iii) The rubber joint seals may deteriorate if exposed to gasoline or other petroleum products, and hence cannot be used for transporting petroleum products.

Miscellaneous Types of Conduits

Various other materials which may be used for manufacturing pipe conduits are: copper, wrought iron, plastics, etc.

Copper pipes are very costly although they are highly resistant to acidic as well as alkaline waters. They can be bent easily and do not sag due to heat. They are, therefore, very useful for carrying hot water in, the interior of th buildings.

Wrought iron pipes are lighter than cast iron pipes and can be more easily cut, threaded and worked. They are more costly but neat in appearance. They are generally manufactured in small' sizes and are very useful for indoor works. However, they corrode quickly and are less durable. They are, therefore, generally protected by galvanizing them with zinc coatings, and they are then known as Galvanized iron pipes.

Plastic pipes are lighter and free from corrosion. But they are of low strengths and less durable. Moreover, they cannot withstand high temperatures exceeding 60°C or so. They may, however, be used for minor works in house connections, etc. ; in which they are finding extensive use these days.

Laying of Water Supply Pipes

Pipes are laid either above the ground or below the ground. Generally, the pipes bringing water from the source to the city, are laid on the ground, whereas the distributing mains taking the water within the localities, are laid below the roads and streets. The pipe lines, in general, should follow the profile of the ground, and that location is chosen which is most favorable with respect to the resulting construction costs and pressures.

When pipes are laid on the ground (or above the ground), they must be laid on a well compacted formation of suitable width so as to avoid future settlements. They may be laid directly over the compacted soil formation or may be laid over small masonry or cement concrete supports at 6 to 12 metres apart. This arrangement, though costly, facilitates inspection, maintenance, repairs, etc., and is generally adopted these days.

When pipes are buried under the ground, they are laid in trenches excavated up to the required depths. The top of the pipe is generally kept about 1 metre below the road surface, so as to minimize the impact and traffic loads transmitted to the pipes. The width of the trench is generally kept 30 to 50 cm more than the outside diameter of the pipe, subjected to a minimum of about 75 cm, which is required for conveniently laying the pipe.

Pipe Appurtenances

The following are the important appurtenances in pipe lines:-

1. Air valves
2. Reflux valves
3. Relief valves
4. Sluice valves or gate valves
5. Scour valves or Blow off valves or drain valves
6. Stop cocks
7. Bib cocks
8. Fire hydrants
9. Ferrule
10. Water meter

Pipe apparatus is needed due to

1. Control the flow of water
2. Release the excessive pressure in the pipe line
3. Eliminate the accumulation of air in the summits of the pipe line.

1. Air valves

Air valves are also known as air relief valves. The water flowing through the pipe line always carries some air with it. This air tends to accumulate at the summits of the pipe line. Due to the accumulation of the air, a backward pressure is created which causes a blockage to the flow of water. Thus the discharge through the pipe is suddenly decreased and ultimately it may be stopped. So air relief valve is provided at the summit to release the air pressure.

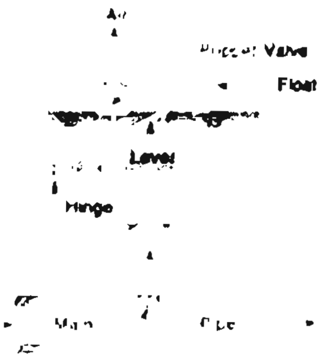
The **function of air valve** is as follows:

a. In normal condition, the chamber remains full of water. The float touches the roof of the chamber and the poppet valve remains in closes position.

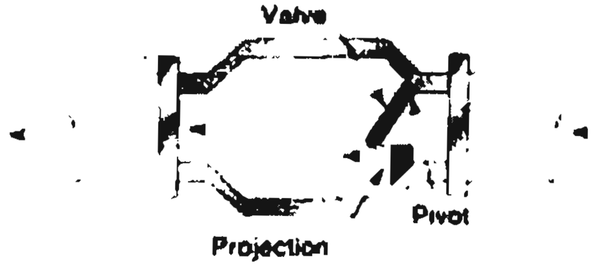
b. As the air goes on accumulating on the top of the chamber, a pressure goes on developing there.

c. This pressure causes the water level to go down and hence the float moves downward which pulls the lever down. Thus the poppet valve is opened and the air is allowed to escape.

d. When the air is released completely, the water level raises again the normal working conditions revives.



Air valve



Reflux valve

2. Reflux valves or cheek valve

Reflux valves are also known as cheek valves or non-return valves. These possess some automatic device which allows the water to flow in one direction only. These are made of brass or gun metal. As shown in the figure, a valve is pivoted at one end and it can rest on a projection on the other end. This valve is provided in the pipe line which draws water from pump. When the pump is operated, the valve is opened and the water flows through the pipe (as indicated by arrow). But, when the pump is suddenly stopped or it fails due to power failure, the valve is automatically closed and the water is prevented from returning to the pump

3. Relief valves

A pressure relief valve is a safety device that relieve in case of overpressure in vessel or piping. The relief valves are also known as pressure relief valves or cut-off valves or safety valve. The power of the spring of the valve is so adjusted that the valve always remains in closed position upto some permissible water pressure in the pipe line. When the pressure of the water suddenly exceeds the permissible due to water hammer phenomenon, then the valve is opened automatically and the excess pressure is released instantaneously. Thus the pipe line is protected from bursting. These valves are provided along the pipe lines at some specific points when the pressure is likely to increase.

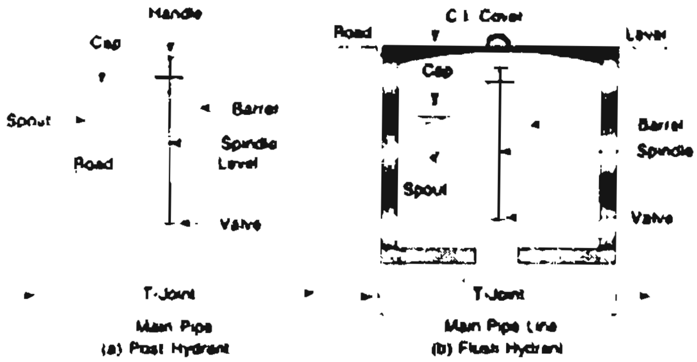
Relief valves are typically used for incompressible fluids such as water or oil. Safety valves are typically used for compressible fluids such as steam or other gases. Safety valves can often be distinguished by the presence of an external lever at the top of the valve body, which is used as an operational check.

8. Fire Hydrants

A Fire Hydrant is a pipe that allows water to flow from a water main with the control of a order to put out a fire. A firefighter connects a fire hose to the fire hydrant and releases a valve to get water the water main. The different valves on a fire hydrant allow it to be attached to different water sources that ma be either pressurized or not pressurized. Most fire hydrants are designed to allow not less that 250 gallons (950 liters) of water to flow through the hydrant per minute.

A hydrant is an outlet provided in a water distribution main or a sub-main (i.e. at least 15 cm di pipe) for tapping water, mainly during fires. They may sometimes, however, be used for withdrawing water for filling the municipal water tankers.

During a fire breakout, a nearby hydrant is connected to the fire hose, and the water obtained from the hydrant is used for extinguishing the fire. For fire fighting, as was mentioned earlier, the water is generally required at much higher pressure than that required for ordinary domestic uses, so as to obtain the water at large rates and also to make it reach several storeyed high buildings. Such high pressures are generally developed by attaching the fire hydrant outlet to the fire engine. The fire engine will draw water from the hydrant, boost its pressure within the engine, and the high pressure water will come out from the outlet of the engine, to which the hose pipe will be connected.



Fire Hydrants

The **requirements of a good hydrant** are:

(a) It should be such as to connect the hose or the motor pump easily to it.
(b) It should be cheap.
(c) It should be easily detectable during the panicky atmosphere of fire.
(d) If should not get out of order during operation.
(e) On being fully opened, it should allow undisturbed water flow.

Types of fire hydrant

(i) Post fire hydrant and
(ii) Flush fire hydrant

The essential difference between these two types of hydrants is that whereas the Post fire hydrar remains standing above the ground like a post by about 0.9 to 1.2 m ; the flush hydrant is installed underground in a brick or a cast iron chamber with its top cover slightly above the street level.

The method of functioning is the same for both the types.

(i) Post fire hydrant

The post fire hydrant consists of a barrel of cast iron with connection to the street main. There is a valve stem having good leather valve at its lower end. The fire hydrants may be provided with one, two,

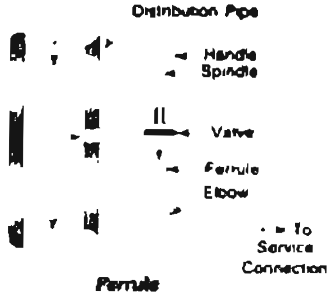
.ree or four outlet openings, depending upon which, they may be classified as one way, two way, three way, or four way hydrants. These outlets are spaced around the periphery of the hydrant barrel.

(ii) Flush fire hydrant

In case flush hydrants, there is generally only one outlet opening on the side of the moving stem. The same opening may be directly connected to the hose pipe (when no. lift is required) or may be connected to the fire engine.

9. Ferrule

Ferrule is a device by which connection is given to the consumers. It is connected between the distribution pipe and service connection. It controls the quantities of water to be supplied to the consumers. In case of any dispute, the water supply to a house is disconnected by operating the ferrule. It is manufactured of brass or gun metal in shape of a 'T'. As shown in the figure, the open ends of the ferrule are threaded. One end is connected to the distribution pipe by making hole and the other end is connected to the service connection pipe with the help of an 'Elbow'. The valve is moved up and down by rotating the handle.



Ferrule

Rotary water meter

10. Water Meters

Water meters are the devices which are used for measuring the quantity of water flowing under pressure through a pressure conduit. This measurement of the quantity of water supplied to the general public (far industrial, commercial or dames tic use) is necessary, in order to charge the consumers according to the quantity of water supplied to them. The question as to whether the consumers should be charged a per the quantity of water supplied to them or at a flat rate, is highly debatable.

Requirements of a good water meter are given below.

(i) It must record the entire water passing through it, and should therefore, be capable of recording even slight discharges.

(ii) Its maintenance and repair should be easy.

(iii) It should measure the discharges within the maximum limit of 20% error.

(iv) It should be able to work efficiently at all the pressures in the mains.

(v) It should cause minimum hindrance to the flow and, therefore, cause minimum head lass in its working.

(vi) Its parts should not be affected easily by the chemicals present in the water passing through it.

(vii) It should prevent the back flaw passing through it and should not be liable to clogging.

Manholes

Manholes are provided at suitable intervals along the pipe line, so as to help its "laying, and to serve for inspections and repairs. They are generally provided on large pipe lines bringing water from the source to the city at intervals of about 300 to 600 metres or so. They are usually provided in case of steel, hume steel, or R.C.C. pipes (which are commonly used for conveyance of water from the source to the city) and are less common pipes.

Testing of Pipe Lines

After a pipe line has been laid, fitted with all appurtenances and accessories, painted both from inside as well as outside by means of protective paints, etc., the pipe line will be tested for the soundness in its construction. The step by step procedure adopted for testing the pipes is described below:

(i) The pipe line is tested from section to section. Thus, at a time, only one particular section lying between two sluice valves is taken up for testing.

(ii) The downstream sluice valve is closed, and water is admitted into the pipe through the upstream sluice valve. The air valves will be properly operated during filling up of the pipe.

(iii) The upstream valve, through which water was admitted, is closed, so as to completely isolate the pipe section from the rest of the pipe.

(iv) Pressure gauges are then fitted along the length of the pipe section at suitable intervals (say 1 km or so) on the crown, through holes left for this purpose.

(v) The pipe section is then connected to the delivery side of a pump through a small by-pass valve, and the pump is started, so as to develop pressure in the pipe. The operation is continued till the pressure inside the pipe reaches the designed value, which can be read from the pressure gauges fixed on the pipe.

(vi) The by-pass valve is then closed, and the pumping is discontinued.

(vii) The pipe is thus kept under pressure for 24 hours, and inspected for possible defects, leakages at the joints, etc. This completes the pressure-test.

The pipe is finally emptied through drain valves, and the observed defects (in the test) are rectified, so as to make the line fit for use. The pipe is again tested by repeating the test, so as to ensure proper rectification of defects already done.

Disinfection Pipe Lines before Use

After the pipe line has been tested and corrected for defects, it is ready for transporting untreated water to the city from the source. However, when the pipe lines are carrying treated water, they must be disinfected before use. The pipes are disinfected by keeping them full with water and adding chlorine in amounts, as to maintain a residue of 50 mg/l (i.e. 50 ppm). This residue is maintained for 12 hours and the pipe is emptied and flushed with fresh treated water, thus making the pipe ready for carrying potable water to the consumers or to the storage tanks.

Disinfection of Tube well:

1. About 50 L of chlorine solution with a chlorine concentration of 50 mg/L is prepared.
2. The chlorine solution is poured through the base of the tube well in the pipe.
3. Tube well components are washed in chlorine solution.
4. After at least six hours, the water is pumped out until traces of chlorine can be smelled.

Disinfection of dug wells/pond water

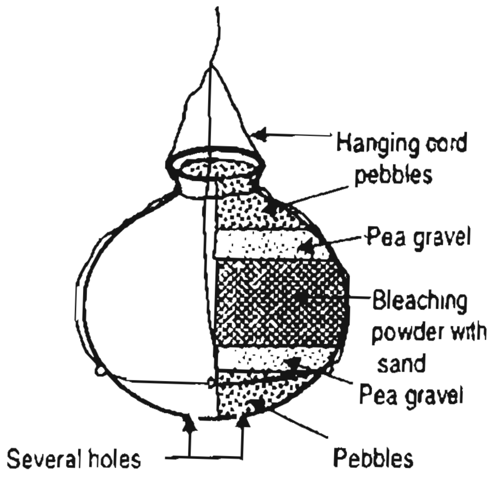
Dug wells and protected ponds are sources of water supply to many rural households. These water sources are frequently contaminated and need some form of treatment, at least disinfection, in order to protect public health. Disinfection by chlorination can give satisfactory protection of these traditional sources for rural and small community water supplies. It is desirable that the process of chlorination of these sources is simple for adoption in rural settings. Single and double pot chlorinators have been found suitable for disinfection of open wells and protected ponds.

Single pot chlorination

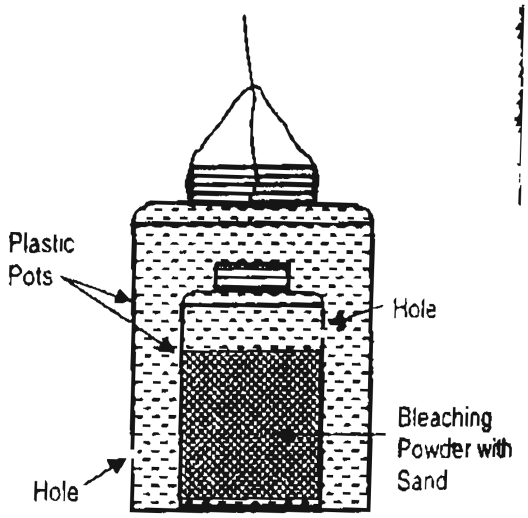
An earthen pot with few holes at the bottom can be used as a chlorinator. The pot is half filled with pebbles and Pea gravel of 20-40 mm size. Bleaching powder and sand in 1:2 proportions are mixed and placed on the pea gravel. The pot is then filled with pea gravel and pebbles up to the neck. The pot is suspended with some strings as

.own in Figure and lowered into the well or pond with its mouth open. Chlorine from the bleaching powder is slowly released in water. A single chlorination pot in a household well may give too high a chlorine content in water during the first few days.

One kg of bleaching powder can disinfect about 200-300 m3 of water in the well or pond. A fresh mixture c bleaching power and sand is to be filled in the pot when' no smell of chlorine is traced in the water.



Single Pot Chlorinator



Double Pot Chlorinator

Double pot chlorination

A unit consisting of two cylindrical earthen or plastic pots, one inside the other can be used as a very good chlorination device. The inner pot with a small hole at the upper level is filled with a mixture of bleaching powder anc coarse sand in 1:2 ratio to a level below the hole. The inner pot is then placed inside the larger ~t with a hole slightly above the bottom level. The mouth of the outer pot is closed with a lid or polythene sheet and tied with string. The po are then lowered into the Water with the help of a rope as shown in Figure. Chlorine from the inner pot lowly leache out into the outer pot and then into the water of the well due to difference In Concentrations. The double pot system i better than the single pot system with respect to controlled release of chlorine. The unit can provide effective disinfection of a household well for several weeks.

Wastage of water

The wastage of water has a great impact on the water supply scheme. if the wastage exceeds the permissible limit, then the supply of water to the consumers decreases and they have to suffer for that. So, the cause of wastage should always be investigated and proper steps should be taken accordingly.
The following are some of the reasons for water wastage.

a. Carelessness of consumers

i) A tap in the bathroom or basin or kitchen or any other place may be kept open unnecessarily.
ii) A damaged tape may not be replaced in time.
iii) The small reservoir in bathroom or any other place may be allowed to overflow unnecessarily.
iv) The street taps may be kept open or damaged and the water flows out unnecessarily.

b. Leakage in pipe line

i) There may be leakage of water through the pipe joints
ii) There may be leakage through the pipe line which was damaged at the time of excavation trenches for telephone line, drainage line, sewer line etc.

Detection of Leakage of water

The point of leakage of water can be detected by the following tests

1. By Hydraulic Gradient

The pressure of water measured at a regular interval along the pipeline by a pressure gauge. Then, a graph is prepared with the recorded pressure. The graph will show the hydraulic gradient of the flow of water along the pipe line. By studying the nature of hydraulic gradient, the point or leakage can be detected. This is very effective method.

2. By compressed air

If compressed air is blown through the water pipe, then bubbles will be formed at the point of leakage and ultimately the water will come out by loosing the soil above the pipe line.

3. By direct observation

The point of leakage can be detected by observation. The ground surface of leakage will be moist and soft and green spot will appear at the surface.

4. By sound test

A metal rod may be inserted into the ground is such a ways that it may touch the pipe line. The 'hissing sound' of the escaping water may be heard through the metal rod by some hearing device.

Preventive measures to control wastage of water

To control the wastage of water the following measures should be taken:

1. Zoning system

The layout of distribution should be done by dividing the area into a number of small zones. The water is supplied to each zone by a branch line. This will help to locate the point of leakage easily.

2. Pipe joints

There are different types of pipe joints. So, the proper joint should be done by considering the pipe materials. Again, the joints should be done perfectly and leakage test should be carried out before filling up the trench.

3. Installation of water meter for each zone

Water meter should be installed at the entry of each zone. At mid night, there is practically no consumption of water. If such meter indicates the flow of water during this period, then the leakage of water can be detected.

4. Water tax

If some water tax is imposed on consumers on the basis of the volume of water consumptions, then they will be cautions about the wastage of water within their house.

5. Vigilance Team

A vigilance team should be formed by the water supply authority to look after the road side taps and the pipe lines. This team will walk along th roads daily and inspect the conditions of taps. They will also observe the ground surface along the route of pipe line to detect any sign of leakage.