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## **LECTURE NOTES**

Name of the Subject: WATER SUPPLY & WASTE WATER ENGR.

Semester: 5th Year: 3rd

Name of the Faculty: BISWABHARATI NAIK.



## Chapter 1

### Introduction to Water Supply. Quantity and Quality of Water

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#### Necessity of Treated water supply :-

Water is used for drinking. Water production contains water molecules & a large variety of other substances. One of the properties of water is that it is easily dissolves other substances. Water that falls to earth during rain shower dissolves substances, particles & gases, such as oxygen, which can be found in air. Contaminants that are present in air also dissolve in rain water. When surface water flows on earth, it also dissolves several different contamination; such as sand particle, organic matter, micro-organisms & minerals. Water that settled into the ground & becomes ground water often contains large amount of dissolved minerals, as a result of contact with soils & rocks. Human activities, such as agriculture & industrial waste & sewer water discharge cause a number of pollutants to enter into the water.

Water has the capacity to clean itself. Contaminants are removed from water during biological processes. When water settled onto the ground, ground layers will cause filtration to occur. Contaminants are broken down or will stay behind in the ground layers. The self cleaning capacity of water is not strong enough to produce clean drinking

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water. This is a consequence of the quantity & variety of industrial & agricultural contaminants that have entered surface & ground water for many decades. In 1970 it was discovered that industrial discharges & waste water discharges were the cause of water contamination. Immediately after this discovery measures were taken to prevent water pollution. Waste water must meet legal standards before it can be discharged. To meet the standards water is purified before it is discharged.

Despite of these measures water often still needs treatment before it is suitable for use as drinking water. During water purification waste water is treated to become drinking water which meets legal standards in the physical, bacteriological & chemical area. The water may not contain an odour or flavour & it should be bright & chemically stable (non-corrosive). The kind of treatment of water needs strongly depends upon the composition & quality of the water. Water treatment contains 2 processes, (i) physical removal of solid particles, mainly minerals and organic matter & (ii) chemical disinfection, killing or deactivating micro-organisms in

water.

Water requirements for different uses :-

A. Use of water in primary terms :-

- Washing and bathing
- Laundry
- Cleaning (Floor, door, window, etc)
- Watering lawns & gardens
- Heating and cooling system
- Sprinkling & cleaning streets
- Filling swimming & wading pools
- Display in fountains & cascades
- Production of hydraulic & steam power
- Various industrial process.
- Fire fighting (Protecting life/property)
- Removal of offensive & potential dangerous waste.
- From household (sewage) & industry (Industrial waste)

B. Importance of water in broad terms :-

- Agriculture (Irrigation)
- Industrial purpose
- Domestic use
- Recreation
- Commercial
- Hydro-electric power
- Sewer flushing
- Public supply



## Water Demand

### → Domestic demand

This includes the water required in private building for drinking, bathing, gardening, sanitary purpose, etc.

As per IS -

200 litre/day/person (with fully flushing system)

135 litre/day/person (for sewerage section & L&L)

### → Public demand

It represents the water demand for public utility purpose, like washing of public parks, gardening, washing of roads, public fountain. As per IS 20 litre/day/person.

### → Industrial demand

It represents the water demand of industries which are already existing or are likely to be started in future.

As per IS - 50 litre/day/person (for normal industry)

450 litre/day/person (Industrial city)



### \* Commercial demand

Water requirement for institutions, hotels, schools, colleges, offices.

As per is -

20 litre/day/person (For normal commercial area)

50 litre/day/person (highly commercial area)

### \* Fire demand

In populated or industrial area fires generally break out & may lead to serious problem. For control that situation required sufficient quantity of water that is called fire demand.

### \* Water demands require for thefts & wastes

This includes the water lost in leakage & stolen water due to unauthorised water connection.

### \* Water requirement for different use

|                   |           |
|-------------------|-----------|
| * Domestic demand | 135 l/d/p |
| * Public "        | 20 l/d/p  |
| * Industrial "    | 50 l/d/p  |
| * Commercial "    | 20 l/d/p  |
| * Fire "          | 15 l/d/p  |
| * Loss & waste    | 50 l/d/p  |

**270 l/d/p**

### The per capita demand (q)

It is the annual average amount of daily water required by one person & includes the domestic use, industrial use, commercial use, public use, wastage, thefts etc.

It may be expressed as per capita demand (q) in litre per day per head is equal to total yearly water requirement of the city (in litre)

$$q = \frac{\text{Total water requirement}}{365 \times \text{design population}}$$

### Factors affecting per capita demand.

- Size of the city
- Climatic condition
- Habits of people
- Industrial & Commercial activities
- Quality of water supply
- Pressure in the distribution system
- Development of sewerage facilities
- System of supply
- Cost of water
- Method of charging.



### Size of the city

The per capita demand for big cities is generally large as compared to that for small towns. Because in big cities huge quantity of water is required for maintaining clean & healthy environment.

### Climate Condition

At hot & dry places the consumption of water is generally more because more of bathing, cleaning, air cooling, sprinkling in lawn & garden are involved.

### Habits of people

Rich & upper class communities generally consumed more water due to their affluent living standards.

Middle class communities consume average amount while the poor slum dwellers consume very low amount.

### Industrial & Commercial activity

The presence of industrial and commercial activities of a particular place increases the water consumption by large amount.

Many industries require really huge amount of water such as increase the water demand considerably.

### Quality of water supply

If the quality and test of the supplied water is good, it will be consumed more. Because in that case people will not use the other sources such as private wells, hand pump etc.

### Pressure in distribution system

If the pressure in the distribution pipe is high and sufficient to make the water consumption shall definitely be more.

This water consumption increases because of two reasons.

- People living in upper storey will use water freely as compared to the case when water is available scantily to them.
- The losses and wastage due to leakage are considerably increased if this pressure is high.

### Development of sewerage facility

As pointed out earlier the water consumption will be more, if the city is provided with flush system and shall be less if the old conservation system of

toilets are provided.

### System of Supply

The water may be supplied either continuously for all the 24 hours of the day or may be supplied only for peak periods during the morning and evening.

### Cost of Water

If the water rates are high less quantity of water may be consumed by the people.

### Method of Charging

Water tax is generally charged in two different ways.

- On the basis of meter reading
- Certain fixed monthly flat rate.

In the second case, i.e. when the supplies are unmetered and the charges are fixed, people generally don't practice economy in the use of water because they think that they have to pay only a fixed amount irrespective of the quantity of water used by them.



## Variation in rate of demand

$$\text{Average daily per capita demand} = \frac{\text{Quantity required in 12 months}}{365 \times \text{design population}}$$

In this, average demand is supplied at all the times.

It will not be sufficient to meet the variation.

Variations may be of following types.

### Seasonal Variation

The demand deals during summer, fire breakouts are generally more in summer, increasing the demands that is seasonal variation.

### Daily Variation

It depends on the activity, people draw out more water on Sunday & festival days, thus increasing demand on these days.

## Hourly Variation

Hourly variations are very important as they have a wide range. During active house hold working hours (i.e. from 6-10 am in the morning & 4-8 pm in the evening) the bulk of the daily requirement is taken. During other hours the requirement is less.

So an adequate quantity of water must be available to meet peak demand. To meet all the variation the supply pipes, service reservoirs & distribution pipes must be designed to meet the peak demand. The effect of monthly variation influences the design of storage reservoirs & hourly variation influences the design of pumps & service reservoirs.

As the population decreases the variation rate increases.

$$\text{Maximum daily demand} = 1.8 \times \text{average daily demand}$$

$$\begin{aligned} \text{Maximum hourly demand of max}^m \text{ day i.e. peak demand} \\ = 1.5 \times \text{average hourly demand} = \\ = 1.5 \times \text{maximum daily demand} \end{aligned}$$



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$$= \frac{1.5 \times (1.8 \times \text{average daily demand})}{24}$$

⇒ Maximum daily consumption is generally taken as 180% of the average daily consumption.

$$\begin{aligned}\text{Maximum daily demand} &= 180\% \times \text{average daily demand} \\ &= \frac{180}{100} \times \text{average daily demand} \\ &= 1.8 \times \text{average daily demand}.\end{aligned}$$

⇒ Maximum hourly consumption is generally taken as 150% of its average hourly consumption. Therefore maximum hourly consumption of maximum day, i.e. peak demand

$$\begin{aligned}\text{Maximum hourly consumption} &= \\ &= 150\% \times \text{average hourly consumption}\end{aligned}$$

$$= \frac{150}{100} \times \text{average hourly consumption}$$

$$= 1.5 \times \frac{\text{max}^m \text{ daily demand}}{24}$$

$$= 1.5 \times \frac{1.8 \times \text{average daily demand}}{24}$$

$$= \frac{2.7}{24}$$



$= 2.7 \times \text{Annual average hourly demand.}$

## Design periods & Population Forecast

This quantity should be worked out with due provision for the estimated requirements of the future.

The future period for which a provision is made in the water supply scheme is known as the design period.

Design period is estimated based on the following:

- Useful life of the component.
- Expandability aspect
- Anticipated rate of growth of population including industrial, commercial development
- Available resources.
- Performance of the system during initial period.

## Population Forecasting Method

The various methods adopted for estimating future population are given below.

The particular method to be adopted for a particular case or for a particular city depends largely on the factors discussed in the methods & the selection is left to the discretion & intelligence of the designer.



- Arithmetic increase method
- Geometric increase method
- Incremental increase method
- Decreasing rate of growth method
- Simple graphical method
- Comparative graphical method
- Ratio method
- Logistic curve method.

### Arithmetic Increase Method

This method is based upon the assumption that the population increases at a constant rate (i.e. the rate of change of population with time,  $\frac{dP}{dt}$  is constant).

$$\frac{dP}{dt} = k$$

$$\Rightarrow dP = k \cdot dt$$

$$\Rightarrow \int_{P_1}^{P_2} dP = k \cdot \int_{t_1}^{t_2} dt$$

$$\Rightarrow \boxed{P_2 - P_1 = k(t_2 - t_1)}$$

Where suffix 1 & 2 represent the last & first decades respectively.

$t_2 - t_1$  = number of decades.

The population data for the last 4-5 decades is therefore obtained & the population

increase for decade ( $\bar{x}$ ) is calculated & the average of which  $\bar{x}$  is then used as the design growth rate for computing future population. Thus

$P_1$  = Population after 1 decade from present

$$P_1 = P_0 + 1 \cdot \bar{x}$$

$$P_2 = P_1 + 2 \cdot \bar{x}$$

$$P_3 = P_2 + 3 \cdot \bar{x}$$

$$P_n = P_0 + n \bar{x}$$

Where,

$P_n$  = forecasted population after 'n' decades from the present.

$P_0$  = population of present.

$n$  = no. of decades bet<sup>n</sup> now & future

$\bar{x}$  = Average of population increases in the non-decade.

Ex The population of 5 decades from 1930-1970 are given below in the table find out the population after 1, 2, & 3 decade beyond the last non-decade by using arithmetic increase method.





| <u>Year</u> | <u>Population</u> | <u>Increase in population</u> |
|-------------|-------------------|-------------------------------|
| 1930        | 25,000            | 3000                          |
| 1940        | 28,000            | 6000                          |
| 1950        | 34,000            | 8000                          |
| 1960        | 42,000            | 5000 = $\bar{x}$              |
| 1970        | 47,000            |                               |

Soln

$$\begin{aligned}P_{1980} &= P_{1970} + 1 \times \bar{x} \\&= 47000 + 1 \times 5000 \\&= 52,000\end{aligned}$$

$$\begin{aligned}P_{1990} &= P_{1970} + 2 \times \bar{x} \\&= 47000 + 2 \times 5000 \\&= 57,000\end{aligned}$$

$$\begin{aligned}P_{2000} &= P_{1970} + 3 \times \bar{x} \\&= 47000 + 3 \times 5000 \\&= 62,000\end{aligned}$$

## Geometric Increase Method

In this method the per decade percentage increase or percentage growth rate ( $r$ ) is assumed to be constant & the increase is compounded over the existing population every decade. This method is therefore known as uniform increase method.

The basic difference bet<sup>n</sup> arithmetic & geometric progressive method for forecasting future population is that - In arithmetic method no compounding is done & in geometric method compounding is done every decade.

The above geometric increase can be expressed as

$P_1$  = population after 1 decade.

$$P_1 = P_0 + \frac{r}{100} \times P_0$$

$$P_2 = P_1 + \frac{r}{100} \times P_1$$

$$\begin{aligned} P_1 \left(1 + \frac{r}{100}\right) &= \left(P_0 + \frac{r}{100} \times P_0\right) \cdot \left(1 + \frac{r}{100}\right) \\ &= P_0 \left(1 + \frac{r}{100}\right)^2 \end{aligned}$$

$$P_n = P_0 \left(1 + \frac{r}{100}\right)^n$$

Where,

- $P_n$  = future population after n decades.
- $P_0$  = Initial population
- $re$  = Assume growth rate in percentage.

The assume growth rate ( $re$ ) can be computed in several ways.

$$re = \left( \frac{P_2}{P_1} \right)^{\frac{1}{n}} - 1$$

$$= \frac{\text{increasing population}}{\text{original population}} \times 100$$

The geometric average  $= re = \sqrt[n]{re_1 \times re_2 \times re_3 \dots re_n}$

### Incremental Increase Method

In this method the perc. decade growth rate is not assume to be constant as in the arithmetic or geometric progression method but progressively increasing or decreasing depending upon weather the average of the incremental increases in the past data is positive or negative.

$$P_n = P_0 + n\bar{x} + \frac{n(n+1)}{2} \cdot \bar{y}$$



Where,

$P_n$  = population after  $n$  decades from present.  
 $\bar{x}$  = average increase of population of known decade.

$\bar{y}$  = average of incremental increases of the known decades.

| <u>Year</u> | <u>Population</u> | <u>Increase in population</u> | <u>Incremental increases</u> |
|-------------|-------------------|-------------------------------|------------------------------|
| 1930        | 25,000            |                               |                              |
| 1940        | 28,000            | 3000.                         |                              |
| 1950        | 34,000            | 6000.                         | + 3000                       |
| 1960        | 42,000            | 8000.                         | + 2000                       |
| 1970        | 47,000            | 5000.                         | - 3000                       |
|             |                   | $\bar{x} = \frac{22000}{4}$   | $\bar{y} = \frac{2000}{3}$   |
|             |                   | = 5500                        | = 667                        |

1st decade

$$P_{1980} = 47000 + 1 \times 5500 + \frac{1(1+1)}{2} \times 667$$

$$= 53,167$$

2nd decade

$$P_{1990} = 47000 + 2 \times 5500 + \frac{2(2+1)}{2} \times 667$$

$$= 60,001$$

3rd decade

$$P_{2000} = 47000 + 3 \times 5500 + \frac{3(3+1)}{2} \times 667$$

$$= 67,502$$

## Decreasing rate of growth method

Since the rate of increase in population goes on reducing as the city reach towards saturation. A method which makes use of the decreases in the percentage increase is many a time used & gives quite rational results.

In this method the average decrease in the percent increase is worked out & is then subtracted from the latest percentage increase for each successive decades.

$$P_n = P_0 + \left( \frac{r_n - t}{100} \right) P_0$$

$$r_n = \frac{P_1 - P_0}{P_0} \times 100$$

$$t = (r_1 - r_2) + (r_2 - r_3) + (r_3 - r_4) + \dots$$

Ex

| <u>Year</u> | <u>Population</u> | <u>Increase in population (X)</u> | <u>Percentage increase in population</u>  |
|-------------|-------------------|-----------------------------------|-------------------------------------------|
| 1930        | 25,000            |                                   |                                           |
| 1940        | 28,000            | 3,000                             | $\frac{3000}{25000} \times 100 = 12\%$    |
| 1950        | 34,000            | 6,000                             | $\frac{6000}{28000} \times 100 = 21.42\%$ |
| 1960        | 42,000            | 8,000                             | $\frac{8000}{34000} \times 100 = 23.52\%$ |
| 1970        | 47,000            | 5,000                             | $\frac{5000}{42000} \times 100 = 11.9\%$  |

Decrease in the percent increase

$$12 - 21.4 = -9.4\%$$

$$21.4 - 23.5 = -2.1\%$$

$$23.5 - 11.9 = +11.6\%$$

$$\frac{-9.4 - 2.1 + 11.6}{3} = 0.03\% \text{ (decreases)}$$

The expected population at the end of year (1980) first decade.

$$\begin{aligned} P_{1980} &= P_{1970} + \frac{rc - t}{100} \times P_{1970} \\ &= 47000 + \frac{11.9 - 0.03}{100} \times 47000 \\ &= 52,579 \end{aligned}$$

The expected population at the end of year (1990)

$$\begin{aligned} P_{1990} &= P_{1980} + \frac{rc - t}{100} \times P_{1980} & rc &= \frac{5,579}{47,000} \times 100 \\ &= 52,579 + \frac{11.87 - 0.03}{100} \times 52,579 = 11.87 \\ &= 58,804 \end{aligned}$$

The expected population at the end of year (2000)

$$\begin{aligned} P_{2000} &= P_{1990} + \frac{rc - t}{100} \times P_{1990} & rc &= \frac{6225}{52,579} \times 100 \\ &= 58,804 + \frac{11.84 - 0.03}{100} \times 58,804 = 11.84 \\ &= 65,748 \end{aligned}$$



### Simple graphical method

In this method a graph is plotted from the available data (between time & population). The curve is then smoothly extended upto the desired year. The method however gives very approximate results as the extension of the curve is done by the intelligence of the designer.

### Comparative graphical method

In this method the cities having conditioned & characteristics similar to the city, whose future population is to be estimated as, first of all selected. It is then assume that the city under consideration will develop as the selected similar cities have developed in the past.

This method has a logical background & its statistics of development of similar cities are available, quite precise & reliable results can be obtained.

However it is rather difficult to find identical cities with respect to population growth.

## Factors for source selection

→ Purity of the raw water

This is with respect to the possibility of treatment (cost).

→ Volume of water

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

→ Permanency of the source

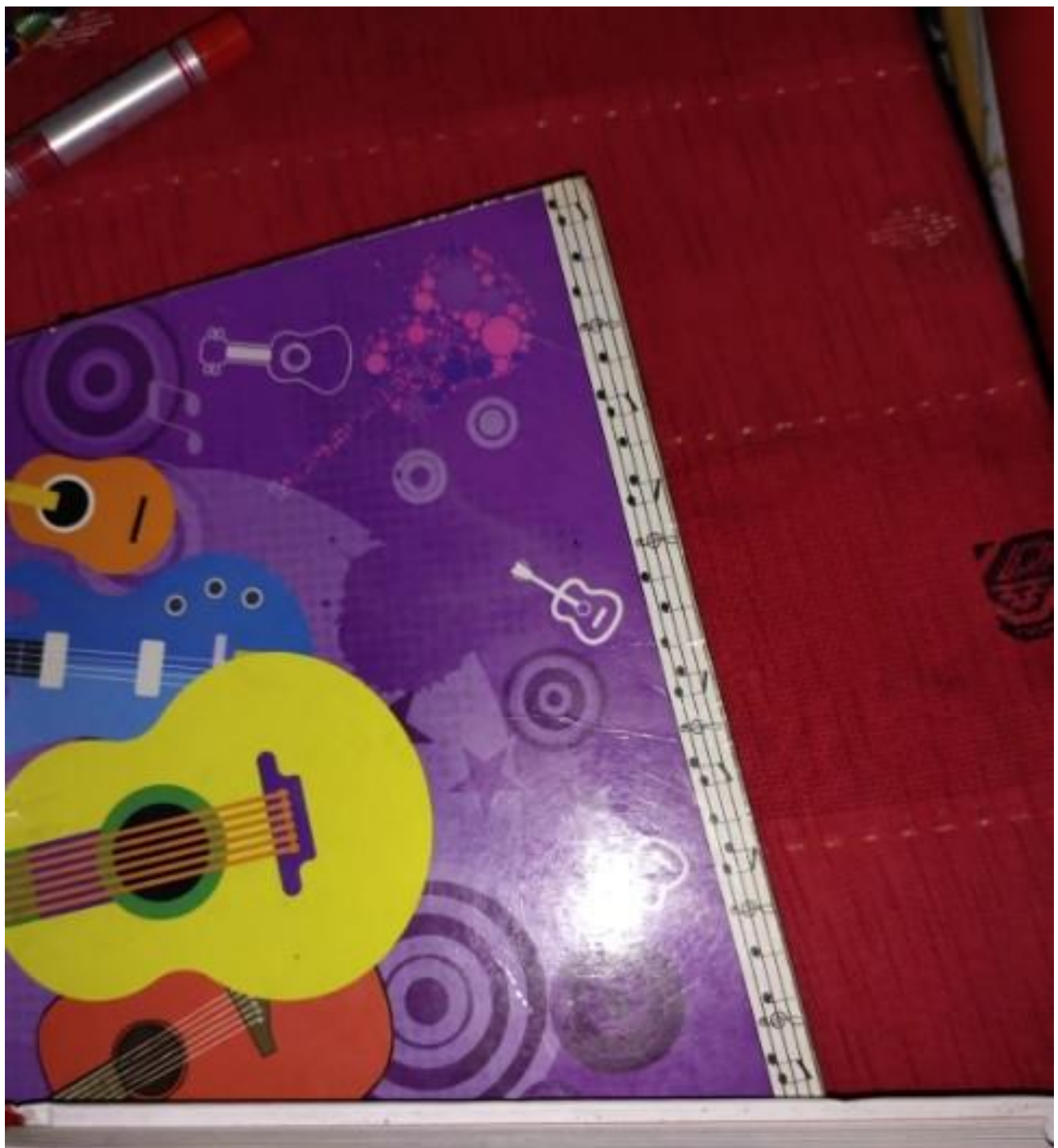
Available in large quantity with a continuous discharge.

→ 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 lower elevation & may require the use of pumps.

→ Availability of finance

To carry out the design,



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Construction, running & maintenance. This is related  
to the kind of structures.



## Sources of Water



There are 2 sources of water.

- Surface source
- Underground source

Natural sources of water

### Natural Sources

#### Streams

In mountainous region streams are formed by the runoff. The discharge in streams is much in rainy season than other season.

#### Ponds

These are depressions in planes like base of mountains, in which water is collected during rainy season.

#### Rivers

Rivers are born in the hills, when the discharge of large number of springs and streams combine together. In mountains the quantity of water in rivers remains small, so it is known as small river.

### Artificial Sources

#### Impounded reservoirs

In summer season, the discharge of some river is insufficient to meet the water requirement. In such cases it becomes essential to store the water for summer.



season. The water can be stored in the river by constructing a weir or dam across the river. It is known as impounded reservoir.

### Underground source of water

→ Springs  
Sometimes ground water reappears at the ground surface in the form of springs. Generally springs can supply small quantity of water. Hence these cannot be used as source of water to big towns.

→ Infiltration gallery  
We have seen that ground water travels towards lakes, rivers or streams.

This water which is travelling can be intercepted by digging a trench or by constructing a tunnel with holes on sides at right angle to the direction of flow of underground water.

These underground tunnel used for tapping underground water near rivers, lakes or streams are known as infiltration gallery.

## → Infiltration well

The shallow wells constructed under the beds of rivers and nallas is known as infiltration well.

These wells are very suitable for Indian conditions where there are deposits of sand & porous material at least 3m deep in river beds.

In order to obtain large quantity of water infiltration well are sunk in series in the bank of river.

### Types of well

There are 2 types of well.

→ open well.

→ Tube well

### Open well

The well which is constructed by digging earth, whose diameter varies from 1m to 2m & depth varies from 1m to 20m. is known as open well.

There are 2 types of open well.

### → Shallow open well

The well which is constructed in the top permeable strata is known as shallow open well.

This well is likely to get dried up in summer.



### Deep Open Well

The well which is constructed in the deeper permeable strata is known as deep open well.

This well is ~~likely~~ not dried up in summer.

### Tubewell

The well which is constructed by using G.I pipes of diameters varying from 3.75cm to 15cm & length varying from 7m to 8m is known as tube well.

There are 2 types of tubewell.

#### Shallow tube well

The tubewell in which the diameter varies from ~~3.75cm~~ <sup>3.75cm</sup> to ~~4cm~~ <sup>5cm</sup> and depth varies from 30m to 40m is known as shallow tubewell.

It draws water from the top most aquifer, hence the water of the well may be dried up in summer.

#### Deep tubewell

The tubewell in which the diameter varies from 10cm to 15cm & depth varies from 200m to 300m is known as deep tubewell.

It draws water from the

deeper most aquifer, hence the water is available through out the year.

## → Aquifer

A permeable stratum which is capable of yielding appreciable quantities of ground water under gravity is known as aquifer.

### Types of Aquifer

There are three types of aquifer.

→ Perched aquifer

→ Confined "

→ Unconfined "

### Perched aquifer

The aquifer which contains water but can't pass water is known as perched aquifer.

### Unconfined aquifer

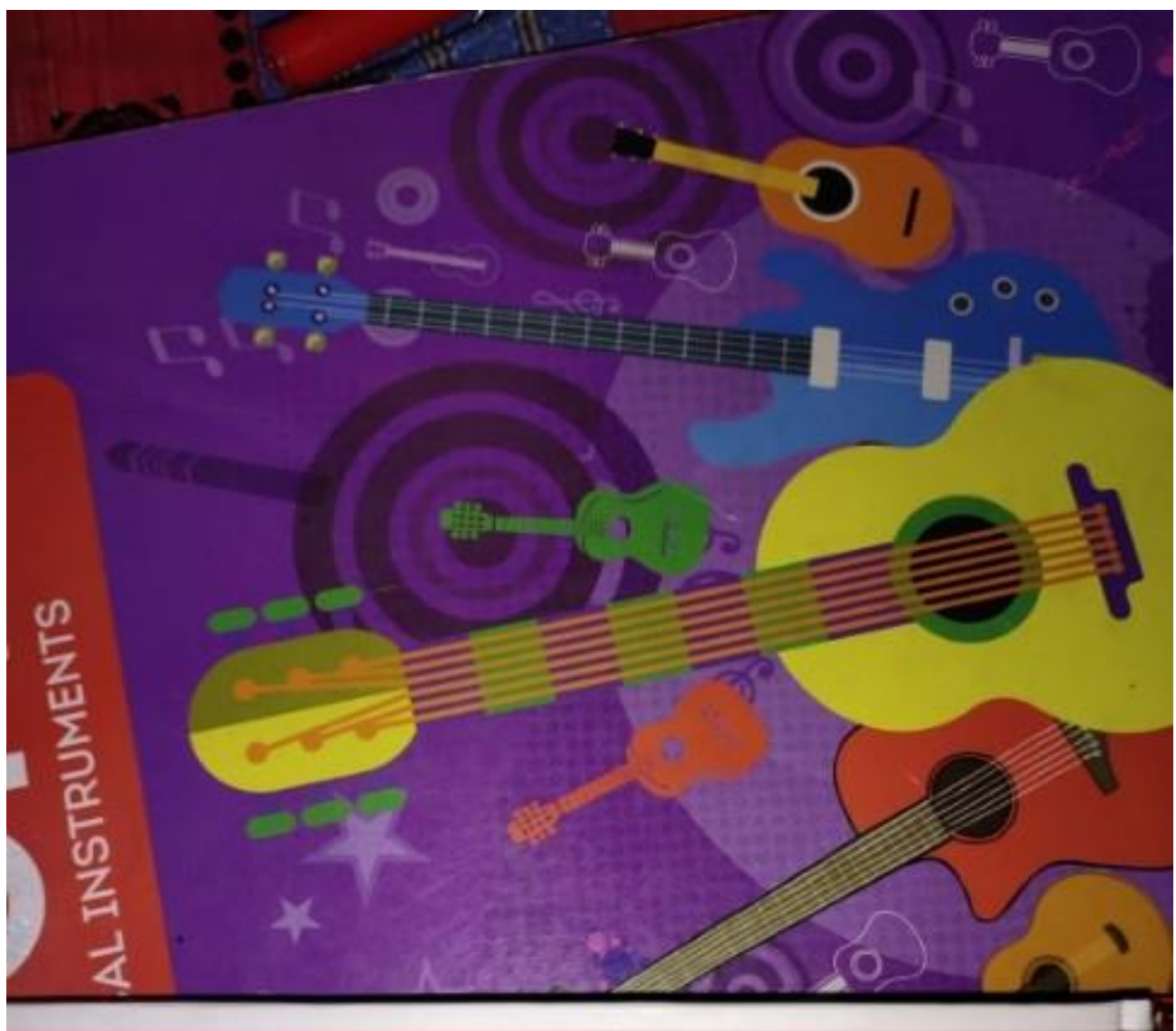
The top most layer water bearing stratum, is known as unconfined aquifer.

### Confined aquifer

The aquifer which is sandwiched between two impervious layers is known as confined aquifer.

### Yield of Well

The rate of pumping of water from the well without causing the failure of the well is known as yield of well.



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## Methods of determination of yield of well

The yield of open well can be determined by the following test.

- Constant level test
- Recuperation test.



to the kind of structures.  
Sinking of well

The tubewells are generally sunk by two methods.

→ Wash boring method

→ Water jet "

Wash boring method

In this method, a pit of depth about 1m and diameter 10cm is first excavated at the position where the well is proposed to be sunk.

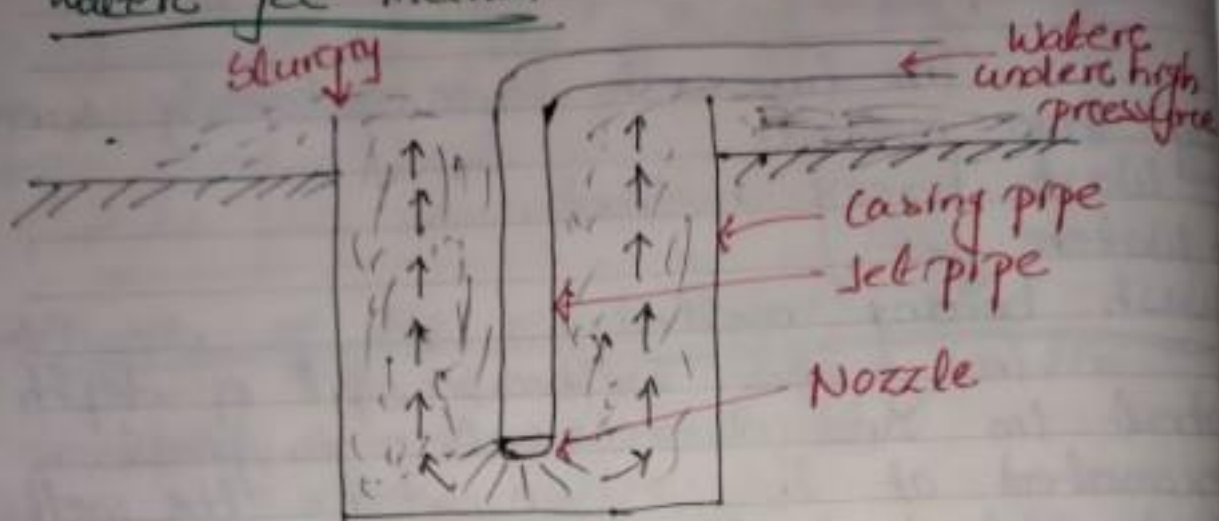
A GI pipe of diameter 3.75cm & length 6m is held vertically in the pit by the lever.

The pipe is completely filled with water & an operator standing on the bamboo frame covers the upper end of the pipe with palm of his hand. Sufficient quantity of water is poured continuously on the pit.

Now the pipe is removed up & down with the lever which is operated by a group of labourers.

The washing of the pipe is done until the clear water comes out.

This method is suitable for sandy & clayey soil.  
Water jet method



### Components of well

Following are the components of well.

- Suction pipe
- Drainage channel
- Pump
- Rock lining
- Concrete seal
- Well cover.

### Development of well

The method of extracting and removing the fine sand particles from the soil around the strainer is termed as development.

The development is done for the following reasons.

- To prevent the sand particles from entering the well.
- To increase the specific capacity of well.
- To increase the life of well.

### Sanitary protection of well

The most important features missing from most private wells are sanitary protection. The sanitary protections are required by most states because they help protect ground waters by sealing the well from potential contamination.

There are two types of sanitary protection.

- Sanitary well cap
- Grout cap.

#### Sanitary well cap

A sanitary well cap is a rubber gasket, hole for electrical conduit & screen holes for ventilation.

#### Grout cap

Grout cap is a neat cement (no aggregate) that is pumped into the space between the drilled hole & the casing.





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## Maintenance of well

The method of cleaning or replacing the strainers or tubewells pipes to make it workable for longer period is known as maintenance of well.

The following measures are generally taken.

- If the yield of well is reduced due to the clogging strainer, then the strainer may be cleaned by surging with the help of a plunger.
- Compressed air also forced through the well pipe to remove the clogging.
- The internal corrosion of the well pipe or strainer may be removed by sulphuric acid.

## Pump

The mechanism by which the water is lifted from the under ground sources to some height or some place is known as pump.

There are 4 types of pump.

- Reciprocating pump
- Centrifugal pump
- Air lift pump
- Rotary pump.

## Reciprocating pump

This consist of a close cylindere in which a piston moves to and from by connecting rod.

The connecting rod is again hinged with a wheel which is rotated by a motore.

During the suction stroke the suction valve is opened and delivery valve remains closed & water entered the cylindere.

During the delivery stroke, the delivery valve is open & the suction valve remain closed & water is forced through the delivery pipe.

## Centrifugal pump

The centrifugal pump involve the principle of centrifugal force.

When the water in the casing of a pump is rotated by the impelleres about the central point, the centrifugal force develop which forces the water towards the periphery of the casing.

Thus the velocity head is converted to pressure head & this head forces the water through the delivery pipe.

## Air lift pump

It consists of a casing pipe in which an educator pipe is introduced.

An air pipe is also introduced into the casing pipe.

The bottom end of the air pipe carries an air diffuser which is introduced into the educator pipe in upward direction.

When the compressed air is forced through the air pipe, a mixture of air & water is formed & rises up in the form of bubbles.

Then the pressure of the water in the educator pipe becomes less than the pressure of water in the casing pipe.

The efficient working of the pump depends on the air pipe's submergence depth.

## Rotary pump

It consists of two cams which are pivoted in a casing.

These cams rotate in opposite direction and hence by the suction takes place through the suction pipe.

The rotation of the cams



pushes the water in upward direction through the delivery pipe.

### Site Selection

While selecting the site for pumps following points are kept to be remembered.

→ The location of the pumps should be above HFL.

→ Required quantity of water should be available at the site.

→ The pumping station should be at higher level above all the sources of contamination.

→ The location site should be such that future growth & expansion may be possible.

→ The source of water should be permanent.



## Conveyance of Water

### Intake

An intake is a structure which is constructed across the surface of water so as to permit the withdrawal of water from the source.

The structure may be of stone masonry, brick masonry, RCC or concrete block.

### Types of Intake

River intake

Reservoir intake

Canal intake.

### River Intake

→ It is circular masonry tower of 4 to 7 metres in diameter constructed along the bank of the river at the place from where required quantity of water can be obtained even in the dry period.

→ The water enters in the lower portion of the intake known as sump well from penstocks.

→ The penstocks are fitted with screens to check the entry of the suspended solids may only enter sump well. The penstocks with screens are provided with streamers at its lower end.

→ The water from Jackwell is pumped & sent to the treatment plant.

→ To prevent the back flow of water due to gravity, a valve should also be providing on the rising main leading to the treatment plant.

→ To reach upto the bottom of intake from the floor of pump room, the ladders or steps in zigzag manner should be provided.

### Reservoir Intake

→ Reservoir intakes which is mostly used to draw the water from earthen dam reservoir.

→ It essentially consists of an intake tower constructed on the slope of the dam at such from where intake can draw sufficient quantity of water even in the driest period.

→ Intake pipes are located levels with a common vertical pipe. The valves of intake pipes are operated from the top & they are installed in a valve room.

→ Screens are provided at the mouth of all intake pipes to prevent the floating & suspended matter in them.

→ The water which enters the vertical pipe is taken to the other side of the dam by means of an outlet pipe.

→ At the top of the sluice valves are





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provided to control the flow of water.

→ The valve tower is connected to the top of the dam.

### Canal Intake

→ An intake chamber is constructed in the canal section. This results in the reduction of waterway which increases the velocity of flow.

→ The entry of water in the intake chamber takes through the coarse screen & the top of outlet pipe is providing with fine screen.

→ The inlet to outlet pipe is of bell-mouth shape with fine screen on its surface.

→ The outlet valve is operated from the top and it controls the entry of water into the outlet pipe from where it is taken to the treatment plant.

→ As the water level in the canal section partially remains constant, it is not necessary to provide intake pipes at various levels.

## Pipe Material (Necessity)

- Carrying capacity of the pipe.
- Durability & life of the pipe.
- Types of water to be conveyed & its corrosive effect on the pipe material.
- Availability of fund
- Easy maintenance & repair.

## Types of Pipes

- \* Cast iron pipes
- \* Wrought iron pipes
- \* Steel pipes
- \* Concrete pipes
- \* Cement lined pipes
- \* Asbestos cement pipes
- \* Copper & lead pipes
- \* Wooden pipes
- \* Vitricified clay pipes.

### Cast iron pipes

#### Merits

- \* The cost is moderate.
- \* The pipes are strong & durable.

#### Demerits

- \* The breakage of these pipes are large.
- \* The pipes are heavier & uneconomical.

## Wrought iron pipes

### Merit

- These pipes are light in weight.
- They can be easily cut, threaded & welded.

### Demerit

- They are found to be costly.
- The pipes are less durable as compare to the cast iron.

## Steel pipes

### Merit

- The pipes are available in long length & hence, the number of joints becomes less.

- The pipes are light in weight.

### Demerit

- The maintenance cost is high.
- The pipes are required more time for repairs.

## Concrete pipes

### Merit

- The maintenance cost is low.
- These are not corroded by the water.

### Demerit

- They are heavy & difficult to handle & transport.



→ They can not withstand high pressure.  
Cement lined cast iron pipe

Merits

- Their life is more about 75 years.
- They can be easily constructed in the factories.

Demerits

- They are affected by acids, salty waters.
- Their repairs are very difficult.

Wooden pipes

Merits

- The pipes are light in weight.

Demerits

- They can not bear high pressure.

Plastic pipes

Merits

- The pipes are cheap.
- The pipes are free from corrosion.

Demerits

- The pipes are less resistance to heat.
- The coefficient of expansion for plastic is high.

Pipe Joints

- For the facilities in handling, transporting & placing in position, pipes are manufactured in small lengths of

the amazing

2 to 6 meters.

→ These small pieces of pipes are then joined together after placing in position, to make one continuous line.

### Types of joints

- Spigot & socket joint
- Expansion joint
- Flanged joint
- Mechanical joint
- Flexible joint
- Screwed joint
- Collare joint
- A.C. pipe joint.

### Spigot & Socket joint

Methods of jointing - For the construction of this joint the spigot or normal end of one pipe is slipped in socket or bell end of ~~and one pipe is slipped in socket~~ other pipe until contact is made at the base of the bell.

After this yarn of hemp is wrapped around the spigot end of the pipe & tightly filled in the joint by means of yarning iron upto 5cm length depth.

The hemp is tightly packed to maintain regular annular space & for preventing jointing material from falling inside the pipe.

After packing of hemp a joint runner is clamped in place round the joint so that it fits tightly against the outer edge of the bell.

### Flanged joint

The pipe in this case has flange on its both ends, cast, welded or screwed with the pipe.

The 2 ends of the pipes which are to be joined together are brought in perfect level near one another & after placing one hard rubber, washer, copper or lead between flanges are bolted. Placing of washer or gasket of rubber between the 2 ends of flanges is very necessary for securing a perfect water tight joint.

### Flexible joint

This is a special type of joint. The socket end is cast in a spherical shape. The spigot end is plane but has a bead at the end.

For the assembling of this joint



The spigot end of one pipe is kept in the spherical end of the other pipe. After this retainere ring is slipped which is stretched over the bead.

Then a rubber gasket is moved which touches the retainere ring.

After a split cast iron gland is placed, the outer surface of which has the same shape as inner of socket end.

Over this finally cast iron follower ring is moved.

### Screwed joint

This joint is mostly used for connecting small diameter, cast iron, wrought iron, & galvanized pipes.

The ends of the pipes have threads on outside, while socket has threads on the inner side.

The same socket is screwed on both the ends of the pipes to join them.

### Collar joint

This type of joint is mostly used for joining big diameter concrete & asbestos cement pipes.

The ends of the 2 pipes are

brought in one level before each other. Then proper gasket between steel ring & jute rope soaked in cement is kept in the groove & the collar is placed at the joint so that it should have the same lap on both the pipes. Now 1:1 cement mortar is filled in the space between the pipes.

### A.C. pipe joint

For joining small diameters A.C. pipes, the 2 end of pipe are butted against each other, & then 2 rubber rings will be slipped over the pipes.

The rubber rings make the joint water proof.

### Laying of water supply pipes

#### Methods

First of all detailed map showing all roads, streets, lanes etc. is prepared. On this map the proposed pipe line with its sizes & length will be marked. The position of existing pipe line, curb lines, sewer lines etc. will also be marked on it. In addition to this position of valves & other pipe specials, stand post etc. will also be made so that at the time of laying there should be no difficulty in

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this connection.

→ After the general planning the centre line of the pipe line will be transferred on the ground from the detailed plan. The centre line will be marked by means of stakes driven at 30m. interval on straight lines on curves the stakes will be driven at 7m to 15m spacing. If the roads or streets have curbs, the distance of centre pipe line from the curb will be marked.

→ When the centre line has been marked on the ground the excavation for the trenches will be started.

→ After the excavation of trenches the pipe are lowered in it.

→ After laying the pipes in position, they are tested for water leakage & pressure.

→ When the pipe line is tested, the back filling of the excavated material will be done.

### Tests

#### Pressure test

At a pressure of at least durable the maximum working pressure pipe & joints shall be absolutely water-



light under the test.

### Leakage test

Leakage is defined as the quantity of water to be supplied into the newly laid pipe. It is ~~also~~ necessary to maintain the specified leakage test pressure after the pipe has been filled with water & the air is expelled.

### Pipe Corrosion

The pipe corrosion is used to indicate the loss of pipe material due to the action of water.

#### Cause

##### ~~Alka~~ Acidity

This is rather than the most important factor in corrosion & the water having low pH value due to the presence of carbonic acid or other acids is invariably corrosive.

##### Alkalinity

The water possessing sufficient calcium bicarbonate alkalinity is anti-corrosive in nature.

##### Biological action

The growth of iron bacteria & sulphur bacteria may develop aerobic & anaerobic corrosion respectively.



### Chlorination

The presence of free chlorine or chloramines makes the water corrosive.

### Mineral or organic constituents

The presence of high total solid in water accelerates the process of corrosion. The calcium & magnesium chlorides are particularly active in hot water system.

### Oxygen

The presence of oxygen is found in both the corrosive & non-corrosive water & under ordinary conditions, it is not the sole or primary cause of pipe corrosion.

### Prevention of pipe corrosion

~~Cathode~~

#### Cathodic protection

It is found that if entire pipe lines acts as cathode, the pipe corrosion may be minimized.

#### Proper pipe material

The pipe material, if metallic, should be able to resist the dissolving effect of water. The alloys of iron or steel with chromium, copper or nickel

are found to be more resistant to the corrosion.

### Protective lining

The pipe surfaces should be coated with anti-corrosive linings. The usual coatings employed are those of asphalt, bitumen, cement mortar, paints etc. The degree of prevention achieved will depend on the individual properties of the coating material.

### Treatment of water

The water should be given proper treatment to prevent pipe corrosion. The usual treatments employed are adjustment of pH value, control of calcium carbonate, removal of dissolved oxygen and dioxide, addition of sodium silicate, etc.



## Quality of Water

### Water quality standards for different uses

Absolutely pure water is never found in nature. The rain water which is originally pure also absorbs various gases (dust & other impurities while falling & this water when moves on the ground (for the carries silt, organic & inorganic impurities).

Now this water before supplying to the public should be treated & purified.

Complete purification is very difficult & absolutely purified water is not good for health.

So before supplying the water to public it goes for some type of testing & then it shows the quality of water.

### Impurities in Water

There are basically three types of impurities in water.

- Suspended impurities
- Colloidal "
- Dissolved "

#### Suspended impurities

The suspended particles which have the same specific gravity as that of water are mixed in the water.

Just like clay, fungi, organic & inorganic matters & mineral matter etc.

These all impurities are microscopic & the size of these impurities ranges from 0-0001mm.

### Dissolved impurities

Some impurities are dissolved in water when it moves over the rocks soil etc. These dissolved impurities may contain organic compounds, inorganic salts & gases etc.

### Colloidal impurities

It is very finely divided dispersion of particles in water. All the colloidal impurities are electrically charged & remain in continuous motion.

The electric charge is due to the presence of ions, acid materials, like silica glass, acquire negative charge whereas basic materials such as metallic oxide, aluminium oxide, ferrous oxide are positively charged.

Due to the electric charge action all the colloidal particles remain in motion & don't settle, that's why their removal is very difficult.

Most of colour of water is due to colloidal impurities the size of colloidal particles is between 1 micron to 1 millimicron.

## Harmful effects of impurities

- Bacterias - Cause disease
- Protozoa - Cause odour
- Clay, Silt - Cause turbidity
- Carbonate - Cause hardness
- Sulphate - Cause hardness
- Bicarbonate - Cause alkalinity & hardness.
- Fluorides - Cause mottled enamel of teeth.
- Chlorides - Taste & salinity
- Manganese - Cause black & brown colour.
- Iron Oxide - Cause taste, corrosiveness, hardness & colour.
- Metal lead - Cause lead poisoning.

## Analysis of Water

The analysis of water of the source is determined the various impurities present in it on the basis of these impurities the treatment plant will be designed for treated water before supplying to the public is checked for its quality whether it fulfills the requirement of the standards laid down by the public health department.

The following tests which are done during water analysis.

- ⇒ Physical test
- ⇒ Chemical test
- ⇒ Bacteriological test.



## Physical test

The physical test include the following test.

- Temperature test
- Colour test
- Turbidity test
- Taste & odour test
- Specific conductivity of water.

### Temperature Test

The temperature of water is measured by means of ordinary thermometers from the temperature the density, viscosity, vapour pressure & surface tension of water can be determined.

The most desirable temperature for public supply is between  $4.4^{\circ}\text{C}$  to  $10^{\circ}\text{C}$ .

### Colour Test

Before testing the colour of the water first of all suspended matter should be removed from the water by centrifugal force in a special apparatus.

The colour produced by one any of platinum in a litre of distilled water has been fixed as the unit of colour.

The permissible colour for domestic water is 20 ppm. on platinum cobalt scale.



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## Turbidity Test

It is caused due to presence of suspended & colloidal matters in the water. The character & amount of turbidity depends on type of soil over which the water has ~~move~~ moved.

Turbidity is a measure of resistance of water to the passage of light through it.

Turbidity is measured by Jackson candle Turbidity units.

## Taste & Odour test

Taste & odour in water may be due to the presence of dead or live micro-organisms, dissolved gases, mineral substances, etc.

The water having bad smell or odour is objectionable & should not supply to the public.

The intensities of the odours are measured in terms of the threshold odour numbers.

First we take the odourless water sample when the sample giving typical smell. The quantity of sample is done first at  $20^{\circ}\text{C}$  & then at  $80^{\circ}\text{C}$ . The increase in temperature is done to liberate the dissolved gases which cause odours.

### Specific Conductivity test

The total amount of dissolved salts present in water can be easily estimated by measuring the specific conductivity of water.

The specific conductivity of water in micro-mhoes per cm. at  $25^{\circ}\text{C}$  is multiplied by a co-efficient (generally 0.05) so as to directly obtain the dissolved salt content in ppm.

### Chemical Test

The following are the methods of doing various chemical tests.

- Total Solids test
- Hardness test
- Chloride test
- Chlorine test
- Iron & manganese test
- pH value test
- Dissolved gases test.

### Total Solid Test

Total solids include the solids in suspension, colloidal & in dissolved form.

The quantity of suspended solids is determined by filtering the sample of water through a fine filter, drying & weighing.



The quantity of dissolved & colloidal solids is determined by evaporating the filtered water & weighing the residue.

The total solids in a water sample can be directly determined by evaporating the water & weighing the residue.

### Hardness test

It is the property of water which prevents the lather of the soap. It is caused due to the presence of carbonate & sulphate of calcium & magnesium in the water.

Hardness is generally determined by soap test, in which the standard soap solution was added in the water & it was vigorously shaken to see the formation of lather for 5 min. The hardness of water was calculated on the basis of soap solution added & the lather factor.

### Chloride test

Sodium chloride is the main substances in chloride water. The natural water near the mines & sea has dissolve sodium chloride.

Excess of chlorides is dangerous & unfit for use. The chloride can be

reduced by diluting water. Chlorides above 250ppm are not permissible in water.

The chloride can be determined by titrating the water with silver nitrate & potassium chromate. In this titration process reddish colour will be formed if chlorides present.

### Chlorine test

Dissolved free chlorine is never found in natural water.

Residue chlorine is determined by the starch-iodide test. In this test, potassium iodide & starch solution are added to the sample of water due to which blue colour is formed. This blue colour is then removed by titrating with N/100 sodium thiosulphate solution & the quantity of chlorine is calculated.

The residue chlorine should remain between 0.5ppm in the water so that it remains safe against bacteria.

### Iron & Manganese test

These are generally found in ground water. If it present in water then the water is not suitable for domestic, bleaching, dyeing & laundering purposes.

The presence of iron & manganese in water makes brownish red colour in it, leads to the growth micro-organism & corrodes the water pipes.



The quantity of iron & manganese is determined by colorimetric methods. In this method some colouring agents are added in the water & colour so formed are compared with standard colour solution.

It is generally in 0.3ppm.

### pH value test

Depending upon the nature of dissolved salts in minerals, the water found in natural sources may be acidic or alkaline.

For the pure water pH is 7. The pH value of water is generally determined by colorimetric method or electrometric method.

In colorimetric method some indicator is added in the sample of water & colour so formed is compared with standard colour discs or solutions. The standard colour discs & solutions are supplied by the manufacturers, on comparing with them pH value of water can be determined.

If the pH value of water comes less than 7 then it is acid & if the pH value comes greater than 7 then the water is alkaline.



## Dissolved gases test

Oxygen Surface waters contain large amount of dissolved oxygen, because they absorb it from the atmosphere. The presence of oxygen in water is necessary to keep it fresh & sparkling, but more quantity of oxygen causes corrosion to the pipe materials.

### Carbon dioxide

The water absorbs carbon-dioxide from the atmosphere. It causes hardness in water.

The presence of carbon-dioxide can be easily determined by mixing of the lime solution in the water. If it gives milky white colour then carbon-dioxide is present in the water.

### Nitrogen

The presence of nitrogen in the water indicates the presence of organic matters in the water.

The presence of nitrates is not so harmful, but in no case its quantity should increase 45ppm, because excess presence of nitrate will cause disease to the children.

It is determined by colour matching methods. In this method the colour is obtained if phenol-di-sulphonic acid & potassium hydroxide are added. The colours so developed are compared

with standard colours.

### Bacteriological test

In bacteriological analysis the following two tests are done.

→ Total count of bacteria

→ Bacteria coli test

#### Total Count of bacteria

In this method total numbers of bacteria present in a millilitre of water is counted. The sample of water is diluted. 1ml of sample water is diluted in 99ml of sterilized water. Then 1ml of diluted water is mixed with 10 millilitre of agar or gelatin.

This mixture is then kept in incubator at 37 degree centigrade for 24 hours or at 20°C for 48 hours. After the sample will be taken out from the incubator & colonies of bacteria are counted by means of microscope.

#### Bacteria coli test

Now a day a new technique of finding out the B-coli is developed which is called "membrane filter technique".

In this method the sample of water is filtered through a sterilized membrane of special design due to which all the bacteria are retained on

the membrane.

The membrane is then put in contact of culture medium - M-Endos medium in the incubator for 24 hours at  $37^{\circ}\text{C}$ . The membrane after incubating is taken out & the colonies of bacteria are counted by means of microscope.

For drinking water it is necessary that it must be free from pathogenic bacteria.

Water quality standard  
The following are the standards of water to be used for domestic purposes.

|                      |                             |
|----------------------|-----------------------------|
| Temperature          | - $10-15.6^{\circ}\text{C}$ |
| Odour                | - 0-4                       |
| Colour               | - 10-20 ppm                 |
| Turbidity            | - 5-10 ppm                  |
| Taste                | - no objectionable taste    |
| Total Solids         | - upto 500 ppm.             |
| Hardness             | - 75-115 ppm.               |
| Chlorides            | - upto 250 ppm.             |
| Iron & manganese     | - upto 0.3 ppm.             |
| pH value             | - 6.5-8                     |
| Lead                 | - 0.1 ppm.                  |
| Arsenic              | - 0.05 ppm.                 |
| Sulphate             | - upto 250 ppm.             |
| Carbonate alkalinity | - upto 120 ppm.             |
| dissolve oxygen      | - 5-6 ppm                   |
| BOD                  | - Nil                       |
| B-Coli               | - no B-Coli in 100 ml.      |