WATER SUPPLY SOURCES

Groundwater

The water which is available in the saturation zone (pores completely filled with water) is known as groundwater. Groundwater is water located beneath the ground surface in soil pore spaces. Groundwater, as mentioned above, is available in large quantities in shallow depths and constitutes the most important source of fresh water supply.

The volume of water contained in the ground water reservoir is dependent upon

(i) The porosity and permeability of the rocks

(ii) The rate at which water is added to it by infiltration; and

(iii) The rate at which water is lost from it by evaporation, transpiration, seepage to surface courses, and withdrawal by man.

Pores

The spaces between particles within geological material (rock or sediment) occupied by water and or air is known as pores

Porosity:

Porosity is defined as the ratio of the volume of voids to the volume of aquifer material. It refers to the degree to which the aquifer material possesses pores or cavities which contain air or water.

$$\text{Porosity (n)} = \frac{\text{Volume of voids } (V_v)}{\text{Total volume } (V_t)}$$

Porosity Values of a few Rock Formations

Sl. No.	Types of rock formation	Porosity
1	Granite, Quartzite	1.5 %
2	Slate, Shale	4 %
3	Limestone	5 to 10 %
4	Sandstone	10 to 15%
5	Sand and Gravel	20 to 30%
6	Only Gravel	25%
7	Only Sand	35%
8	Clay and soil	45%

Permeability

The capacity of a porous rock, sediment, or soil to transmit ground water is known as Permeability. It is a measure of the inter-connectedness of a material's pore spaces and the relative ease of fluid flow under unequal pressure.

Coefficient of permeability / Hydraulic conductivity

Coefficient of permeability is the rate of flow of water through a unit cross-sectional area of the water bearing material under a unit hydraulic gradient and at a temperature of 20^0 C

$$K = \frac{V}{i}$$

Where K = Coefficient of permeability

V = Velocity of flow

i = hydraulic gradient

Coefficient of permeability of a few Rock Formations

Sl. No.	Types of rock formation	App. Avg. value of K (cm/sec)
1	Granite, Quartzite	0.6×10^{-4}
2	Slate, Shale	4×10^{-5}
3	Limestone	4×10^{-5}
4	Sandstone	0.004
5	Sand and Gravel	0.4
6	Only Gravel	4.0
7	Only Sand	0.04
8	Clay and soil	0.04×10^{-5}

Specific yield

The volume of ground-water extracted by gravity-drainage from a saturated water bearing material is known as the yield, and when it is expressed as the ratio of the volume of the total material drained, then it is known as specific yield.

$$\text{specific yield} = \frac{\text{Volume of water obtained by gravity drainage}}{\text{Total volume of the material drained or dewatered}} \times 100$$

$$S_y = \frac{V_d}{V_t}$$

Specific retention

The quantity of water retained by the material against the pull of gravity is termed as the specific retention or the field capacity, and this is also expressed as percentage of the total volume of the material drained.

$$\text{Specific retention or Field capacity} = \frac{\text{Volume of the water held against gravity drainage}}{\text{Total volume of the material drained}} \times 100$$

$$S_r = \frac{V_r}{V_t}$$

It is evident that the sum of the specific yield and the specific retention is equal to its porosity.

Aquifer

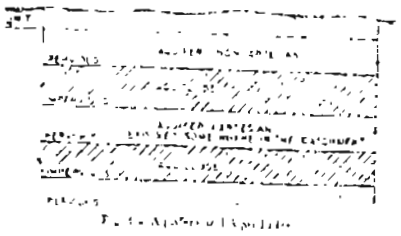
An **aquifer** is an underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, silt, or clay) from which groundwater can be usefully extracted using a water well. The study of water flow in aquifers and the characterization of aquifers are called hydrogeology.

The quantity of ground water that an aquifer will yield to wells depends partly on its thickness, extent, continuity, and homogeneity, and partly on its physical properties of permeability and porosity

Aquitard

An aquitard is that geological formation, which does not yield water freely to wells due to its lesser permeability, although seepage is possible through it. The yield from such a formation is, thus, insignificant. Sandy clay is an example of aquitard.

An aquitard can sometimes, if **completely impermeable**, be called an **aquiclude or aquifuge.**



Aquiclude

Aquiclude is **highly porous**, containing large quantities of water, but essentially impervious, as not to yield water. **A clay layer** is an example of aquiclude.

Aquifuge

Aquifuge is that geological formation, which is, neither porous nor permeable; and hence it neither contains nor yields ground water. **Granite rock** is an example of aquifuge.

Water table

The surface of saturated material in an aquifer is known as the water table

Classification of aquifer

Aquifer may be classified as follow

1. Confined Aquifer /artesian aquifer/ pressure aquifers
2. Unconfined aquifer / Non-artesian aquifers/ water table or phreatic aquifer
3. Parched aquifer

Confined Aquifer

When an aquifer is confined on its upper and under surface, by impervious rock formations (i.e., aquicludes), and is also broadly inclined so as to expose the aquifer somewhere to the catchments area at a higher level for the creation of sufficient hydraulic head, it is called a confined aquifer or an artesian aquifer.

Unconfined aquifer / Non-artesian aquifers

The top most water bearing stratum having no confined impermeable over burden (i.e., aquiclude) lying over it, is known as an unconfined aquifer or non-artesian aquifer. The water level in a well constructed in a water table aquifer will be at the same level as the water table

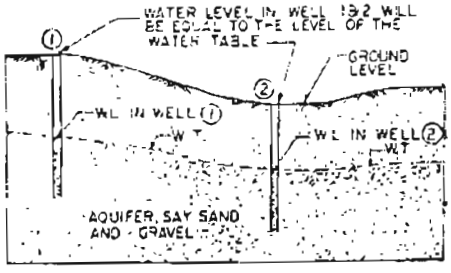


Fig.: Unconfined aquifer

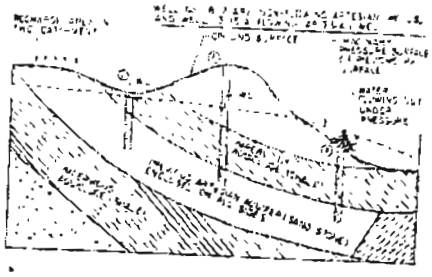
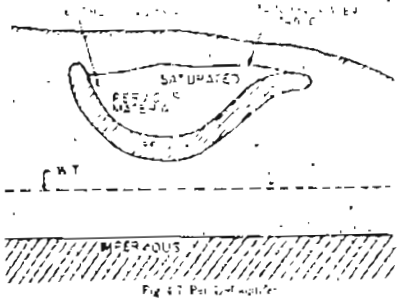


Fig.: confined aquifer

Parched aquifer

Perched aquifer is a special case which is sometimes found to occur within an unconfined aquifer

If within the zone of saturation, an impervious deposit below a pervious deposit is found to support a body of saturated material, and then this body of saturated material which is a kind of aquifer is known as perched aquifer. The top surface of the water held in the perched aquifer is known as the perched watertable



Problems in groundwater development

Groundwater is the main source of water supply in urban and rural areas of Bangladesh. Groundwater in Bangladesh is available abundantly, but the availability of groundwater for drinking purposes has become a problem for the following reasons:

1. arsenic in groundwater;
2. excessive dissolved iron;
3. salinity in the coastal areas;
4. lowering of groundwater level;
5. Rock/stony layers in hilly areas.

Arsenic in groundwater:

The concentration of arsenic in drinking water in excess of permissible limit is toxic to human body. According to the WHO guideline value the desirable maximum concentration of arsenic in drinking water should be 0.01 mg/l. In Bangladesh the maximum acceptable concentration in drinking water is considered to be 0.05 mg/l. symptoms of arsenic toxicity leading to cancer may occur due to excessive intake of arsenic in the human body over a longer period of time. In Bangladesh the presence of arsenic in groundwater was first detected in 1993 at Barogharia union of Chapai

Nawabganj district appreciating the gravity of the problem water sample testing activities started in 1995 by various organizations and agencies. The samples were collected from different parts of the country and examined for arsenic content. It has been observed that about one in every three shallow tubewells is producing water with arsenic in excess of acceptable limits.

Excessive dissolved iron:

In Bangladesh, the permissible limit of iron in groundwater is 1 mg/l but iron content up to to 5 mg/l is acceptable for rural water supply. It has been observed that iron content exceeds this limit in many handpump tubewells. People are reluctant to drink this water mainly due to its bad taste. Water with high iron content is not used for cooking, washing and other domestic purposes.

It has been observed from a survey in 1993 that 1,230 unions in Bangladesh have an iron content of more than 5 mg/l. It may be observed that dissolved iron in shallow tubewell water in about 67% areas of Bangladesh is in excess of 2 mg/l. However, iron content in deep tubewell water is comparatively lower. In urban areas iron removal plants have been

constructed and in rural areas community-type iron removal units attached to handpumps are provided.

Salinity in coastal areas:

The concentration of dissolved minerals in groundwater is higher then that in surface water. The coastal belt of Bangladesh, extended over 86 upazilas, is identified as a problem area where complex Hydrogeological conditions and adverse water quality make water supply difficult as compared to other parts of the country. Unlike other areas of Bangladesh, groundwater of acceptable quality at relatively shallow depths, which can be easily withdrawn by conventional handpump tubewells is not available in most parts of the coastal area. In some places low salinity water has been found in deep aquifers. Exploratory drillings with borehole logging have been conducted in many places to locate sweet water aquifers. However, there are still many areas in coastal belts where low salinity groundwater is not available within a depth of 1,100 ft. In rural water supply chloride content up to 1,000 ppm is acceptable for coastal belts where the normal acceptable limit is 250 ppm)

Lowering of groundwater level:

Although groundwater in Bangladesh is said to be abundant, a considerable area of the country faces scarcity of groundwater within suction limit in the dry season. Due to the over-exploitation of groundwater for irrigation purposes, the water level declines, rendering thousands of suction mode no.6 tubewells inoperable. These areas are increasing with abstraction of more groundwater for Irrigation in the dry season.

Rock/stony layers in hilly areas:

In Chittagong Hill Tracts Districts of Bangladesh, drilling of tubewells for rural water supply is difficult due to the presence of hard formations in the subsurface. In most cases conventional drilling methods for the installation of handpumps cannot penetrate these hard rock formations. This situation also prevails in some parts of Chittagong, Cox's Bazar, Sylhet, in the north of Mymensingh, Netrokona and in Panchagar Districts. To overcome the situation and provide potable water through handpump tubewells, mechanical drilling rigs are used

RAINWATER

Bangladesh is a tropical country and receives heavy rainfall due to north-easterly winds during the rainy season. Rainwater can be a potential source of water supply in Bangladesh. In the coastal districts, particularly in the offshore islands of Bangladesh, rainwater has been used for drinking purposes since time immemorial. The protected ponds annually replenished by rainwater are a main source of water supply in the coastal area. Since various uses and unhygienic practices pollute these ponds, rainwater harvesting can be an alternative option for good quality water supply. In some areas having a high salinity problem, as many as 36% of households have been found to harvest rainwater in the rainy season for drinking purposes. But the collection, storage and use of rainwater are not organized and need development through adoption of appropriate technologies.

The average yearly rainfall in Bangladesh varies from 2,200 to 2,800mm, 75% of which occurs between May and September. The high rainfall occurs in the eastern part of Bangladesh, including the eastern part of the coastal. area, and highest rainfall occurs in the north-eastern region of the country. The low rainfall, less than 1,500 mm, occurs in the western part of Bangladesh. The coastal and hilly areas with high source problem intensity lie in the high rainfall areas. The high rainfall intensity in these difficult areas provides good opportunity for rainwater harvesting.