OCCURRENCE AND ORIGIN OF GROUNDWATER

Abstract

One may consider almost all groundwater to be a type of water. Sometimes referred to as broad kinds of groundwater, such as magmatic water, connate water, juvenile water, and metamorphic water, a negligibly small amount of groundwater from various sources might join the water cycle. A critical natural resource, groundwater is essential for supporting many human endeavours and maintaining life. For efficient administration and long-term use, it is crucial to comprehend its incidence and genesis. The current level of knowledge on the occurrence and origin of groundwater is thoroughly reviewed in this abstract. Groundwater is a result of intricate geological, hydrological, and climatic variables. This paper discusses the distribution and storage capabilities of several aquifer types, including as confined, unconfined, and perched aquifers. The paper explains the interaction between precipitation, infiltration, and subsurface flow as it digs into the dynamics of groundwater recharge and discharge processes.

Keywords: Groundwater, Sustainability, Aquifer, Near surface features, Geological formations.

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I. INTRODUCTION

The groundwater is primarily obtained through a process known as "recharge," which includes water moving from the surface into the subsurface. Here is a step-by-step breakdown of the formation of groundwater:

1. **Precipitation:** Whether rain or snow, precipitation is the main source of groundwater. Water that falls on the Earth's surface during rain or snowfall either seeps into the soil or runs off into rivers and streams.

2. **Infiltration:** Water seeps into the earth through porous rock layers and the soil in a process known as infiltration. Not all precipitation-related water seeps in; some is lost to evaporation and surface runoff. Through the pore spaces and fissures in the underlying materials, the water that permeates the soil travels downhill.

3. **Soil Zone:** In the pore spaces of the uppermost subsurface layer, often referred to as the "unsaturated zone" or "vadose zone," there is both water and air. The water in this region, which is typically above the water table, is kept in place by capillary and molecular forces.

4. **Water Table:** Water progressively flows down to a point when it fills all of the pore spaces. The "water table" is the line separating the saturated zone from the unsaturated zone. Below the water table, water entirely fills up every pore space.

5. **Saturated Zone:** The region below the water table is known as the "saturated zone," sometimes known as the "phreatic zone." Groundwater is stored in this zone where the connecting pore spaces and cracks are flooded with water.

6. **Aquifers:** Geologic formations known as aquifers have great permeability, allowing water to flow through them at rates sufficient to support wells and springs. These formations serve as subsurface reservoirs that store and convey groundwater, such as porous rock layers or unconsolidated deposits like sand and gravel.

II. VERTICAL DISTRIBUTION OF SUBSURFACE WATER

To understand the presence of groundwater and its vertical distribution, let's first consider the hydrological zones that exist below the surface. The area between the top of the capillary fringe and the ground's surface is referred to as the unsaturated zone or zone of aeration. It is made up of pores or interstices that contain both air and water in some portions. Water is kept at a pressure lower than air pressure in the unsaturated zone. The area where the majority of voids are filled with water, but the water is kept at a lower pressure than atmospheric pressure is referred to as the "capillary zone" and is located between the bottom of the unsaturated zone and the top of the water table. The saturated zone (or zone of saturation) is the area between the water table and an impermeable layer when all spaces are entirely filled with water. Water is retained at a pressure in this zone that is higher than atmospheric pressure; therefore it travels in a direction determined by the surrounding hydraulic condition.

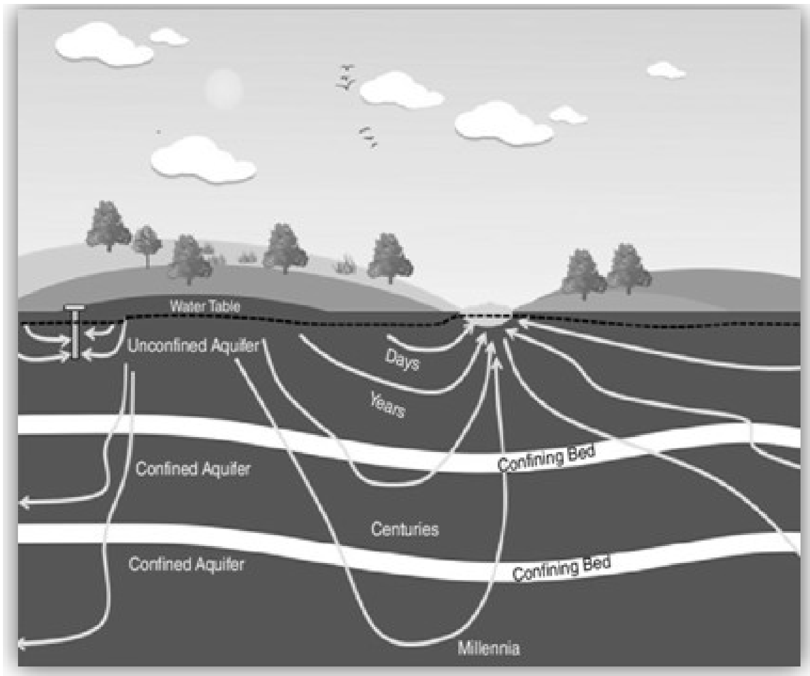

Figure 1: Groundwater Flow System.

The "soil-water zone" and "intermediate zone" are further divisions of the unsaturated zone (Todd, 1980). The area between the top of the water table and the ground's surface is known as the vadose zone. The vadose zone is composed of the unsaturated zone and the capillary zone, sometimes known as "capillary fringe". Vadose water is the water that occurs in the vadose zone and is maintained at a pressure lower than atmospheric pressure. Because of the matric potential and gravity, this water can still travel inside the vadose zone, but it cannot exit the zone into alternative water collection methods that are exposed to air pressure, such as wells, pits, or wells. It should be noted that the word vadose zone is technically more accurate than the phrase unsaturated zone.

This is due to the possibility of saturation in some vadose zone regions, despite the fact that water pressure is lower than atmospheric pressure. As a result, the term "vadose zone" has gained popularity and is often used in the domains of soil physics and groundwater hydrology today. Groundwater is the general term for the water that is kept in the saturation zone. Only free water or gravitational water—water that freely flows into wells under the effect of gravity—is considered to be groundwater, which is not all underground water. A precise and practical definition of groundwater is thus, in the words of Bouwer (1978), "that portion of the water beneath the earth's surface, which can be collected through wells, tunnels, or drainage galleries, or which naturally flows to the earth's surface via seeps, or springs." At depths of 1 m or more to 1000 m or more, groundwater can be discovered. There are some places where there is absolutely no groundwater.

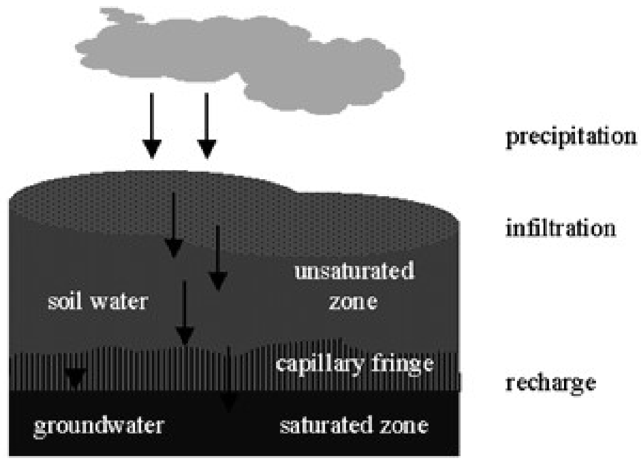

Figure 2: (Source: Ideo.columbia.edu)

III. TYPES OF SUBSURFACE FORMATIONS

The substance found below the surface of the earth is typically referred to as subsurface formation or subsurface deposit in subsurface hydrology. *Soil* and *geologic formations* make up the first and second major categories of subsurface formations, respectively. Soil is produced through the weathering of rocks, as is widely known. Geologic formations, however, can be divided into three categories: consolidated, semi-consolidated, and unconsolidated. Geologic formations that have undergone cementation, compaction, and recrystallization result in rocks with tightly packed grains. They are also referred to as "hard rock's". Consolidated geologic formations include indurated sedimentary rocks like sandstone, shale, and limestone, as well as igneous and metamorphic rocks like granite, basalt, and schist.

Sedimentary rocks with partial induration and various degrees of intergranular porosity preservation are classified as semi-consolidated geologic formations. Because of its high primary porosity and early cementation, sandstone is thought to be the most prolific of the semi-consolidated sedimentary rocks. On the other hand, non-indurated colluvial, alluvial, aeolian (wind-borne sediments), lacustrine, marine (coastal), and glacial deposits make up unconsolidated geologic formations. These deposits/formations are made up of pebbles, gravel, clay, silt, and sand.

IV. TYPES OF AQUIFERS

1. Unconfined Aquifer

- An aquifer with a confining layer at its bottom but no confining layer overlying it is referred to as an unconfined aquifer. Since it is often exposed to the environment; water is partially saturated in its top region.
- The water table, which is the top surface of saturation and is subject to air pressure, is another name for this aquifer.

2. **Perched Aquifers**
   - Perched aquifers are a particular type of unconfined aquifer that develops when a lens-shaped layer of impermeable or somewhat impervious material is found inside the water-bearing unconfined aquifer.
   - The perched aquifer, whose top layer is known as the perched water table, is the water storage generated above the lens.

3. **Artesian Aquifer**, also known as Confined Aquifer.
   - It is a particular kind of aquifer that is enclosed by strata both above and below.
   - As a result, the water in the aquifer is kept under pressure. It is sometimes referred to as a pressure aquifer.
   - Positive hydrostatic pressure will result in circumstances for a flowing well if the aquifer has a high outcrop laterally above the ground surface. Water from such a well rises to the surface naturally without the need for pumping. Piezometric surface is the imagined level to which the water will ascend.

4. **Leaky Aquifer**: Because the confining layers are not completely impermeable, genuinely contained aquifers are uncommon in nature.
   - A leaky aquifer or semi confined aquifer is one that is overlain or underlain by a semi-pervious layer (aquitard) 16 through which vertical leakage occurs due to head difference.
   - The semi-confining layer's permeability is typically very low in comparison to the main aquifer's permeability, so any water that seeps vertically through it is internally diverted to move horizontally in the main aquifer.

Aquifers come in many different geologic formation types. While consolidated geologic formations (hard rock’s) function as aquifers primarily because of secondary porosity brought on by fractures, fissures, solution cavities/channels, lava tubes, shrinkage cracks, etc., unconsolidated geologic formations (alluvial deposits, for example) and semi-consolidated geologic formations (sandstones, for example) function as aquifers because of primary porosity (i.e. The geologic formations that might include aquifers include alluvial deposits, limestone, volcanic rocks, sandstone, and weathered igneous and metamorphic rocks. On the other hand, igneous and metamorphic rocks that is solid and conglomerates, which are often used as bedrock or confining strata. Although clay, silt, and coarser particles combined with clay and/or silt are often porous, most of the time their pores are so tiny that they can be considered impermeable or semi-permeable. They work better as restricting layers, whether they are leaky or not. Keep in mind that the lithology, stratigraphy, and structure of rock formations determine the aquifers' or confining layers' composition, extent, and vertical distribution. Confining layers are the geologic formations that aren't aquifers in hydrogeology. According to Fetter (2000: "A geologic formation having little or no intrinsic permeability"), a restricting layer is such. According to whether they may significantly contribute to leakage through them or not, confining layers can be classified as either "leaky confining layers" or "non-leaky confining layers" (Fetter, 2000).

The inherent permeability (k) of confining layers is less than 10 Darcy; this limit is arbitrary and dependent on regional factors (Fetter, 2000). For instance, a layer of silt 10 Darcy thick may be used to fill a tiny well in clay (k–10 Darcy) locations. On the other hand, if the same silty layer was discovered in a region of coarse gravels with k = 100 Darcy, it may be regarded as a restricting layer. Although it travels extremely slowly, groundwater does pass through the majority of limiting strata. Confining layers are often divided into aquitards, aquicludes, and aquifuges.In subsurface hydrology, however, the words "non-leaky confining layer" and "leaky confining layer" are becoming used to describe whether a confining layer is leaky or not.

A geologic structure known as an aquiclude is one that can hold a substantial amount of water but cannot transport a comparable amount of water. An excellent illustration of aquiclude is clay. A geologic feature known as an aquitard is capable of both storing some water and transmitting it at a pace that is lower than that of an aquifer. An aquitard may contain a considerable volume of water even though it may not generate water profitably. Aquitard is best exemplified by sandy clay. Aquifuge, on the other hand, is a geologic feature that is unable of either storing or transmitting water.

An ideal illustration of aquifuge is solid stone. Aquitards and aquicludes are basically leaky confining layers, in contrast to aquifuge, which is essentially a non-leaky confining layer. The fact that leakage through aquicludes is typically very tiny and may be regarded as practically unimportant means that in practise, aquiclude is frequently thought of as a non-leaky confining layer.

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