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Aquifers

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Aquifers, often referred to as nature's underground water storage, play a crucial role in sustaining life on our planet. These hidden reservoirs hold vast quantities of groundwater, providing water for drinking, agriculture, and industry. In this article, we'll explore the fascinating world of aquifers, their importance, challenges, and preservation efforts. An aquifer is essentially a subterranean sponge—a layer of porous rock or sediment that stores water. When rainwater or snowmelt infiltrates the ground, it percolates through soil and eventually reaches these underground reservoirs. In certain areas, water could pass through the soil of the aquifer while in other areas it enters through joints and cracks in rocks where it moves downwards until it encounters rocks that are less permeable.

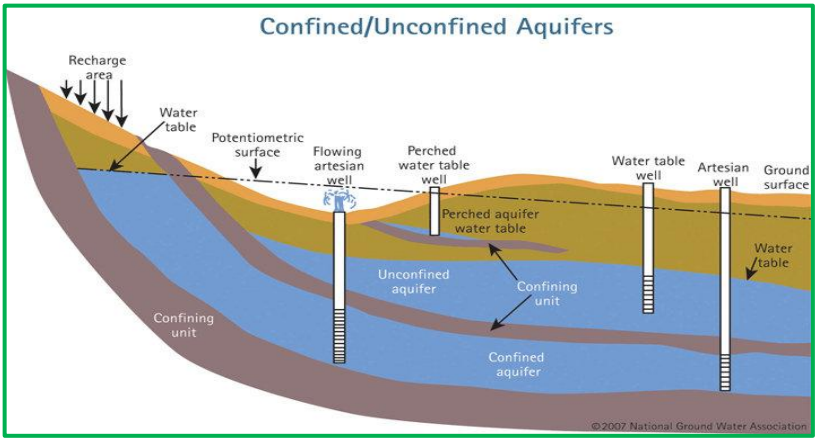
What Are Aquifers?

Aquifers in geological terms are referred to as bodies of saturated rocks or geological formations through which volumes of water find their way (permeability) into wells and springs. The top of the water level in an aquifer is called the water table.Aquifers generally are known to serve as reservoirs and could dry up when people drain them faster than they are been refilled by nature. Aquifers can be found beneath deserts, forests, and even urban areas. Aquifers must not only be permeable but must also be porous and are found to include rock types such as sandstones, conglomerates, fractured limestone and unconsolidated sand, gravels and fractured volcanic rocks (columnar basalts). Those with high porosity and low permeability are referred to as poor aquifers and include rocks or geological formation such as granites and schist while those with high porosity and high permeability are regarded as excellent aquifers and include rocks like fractured volcanic rocks.

Types of Aquifers

1. **Confined Aquifers**:

- These aquifers are sandwiched between impermeable layers of rock or clay.
- The water within confined aquifers is under pressure, making it more challenging to access.



- Wells drilled into confined aquifers tap into this pressurized water.
- Contains confining layers, having very low permeability, typically less than about 10^{-2} Darcy.
- Ground water may move through confining layers, but the rate of movement is usually very slow.
- Confining layers can be subdivided into aquitards, aquicludes and aquifuges.
    - An aquitard is a leaky confining layer of low permeability that can store ground water and transmit it sluggishly from one aquifer to another.
    - An aquiclude also has low permeability but is situated in position to form the upper or lower boundary of a ground water flow system.
    - An aquifuge is an almost totally impermeable body of rock or unconsolidated material.
- Confined aquifers could also be referred to as "Artesian aquifers" which could be found most above the base of confined rock layers.
- Artesian water is confined ground water that is under high hydrostatic pressure.
- In terms of storage coefficient, confined aquifers have very low storage coefficient values of 0.01 to 0.0001.

2. **Unconfined Aquifers**:

- These aquifers lie below permeable layers of soil.
- Water in unconfined aquifers is not under pressure, allowing it to rise and fall with seasonal changes.
- These aquifers receive recharge from rainfall and melting snow; they are not overlain by a lower permeability unit that confines the movement of water within the aquifer.
- The elevation of the water table changes in response to smaller or larger amounts of recharge, changes in rates of discharge, and the introduction or extraction of water. For example, infiltration of surface irrigation water and pumping.
- When a borehole is advanced into the earth, the first groundwater encountered will be part of an unconfined aquifer.
- The groundwater in an unconfined aquifer is more vulnerable to contamination from surface pollution as compared to that in confined aquifers this been so due to easy groundwater infiltration by land pollutants.
- Unconfined aquifers have a storage coefficient value greater than 0.01.
- The water table may be many 10s to 100s of meters below the ground surface, especially in upland areas and arid regions. In lower areas, the water table will be near the surface where springs, rivers, wetlands and lakes occur.
- "Perched aquifers" are special cases of unconfined aquifers occurring in situation where groundwater bodies are separated from their main groundwater source by relatively impermeable rock layers of small areal extents and zones of aeration above the main body of groundwater.
- The quantity of water found available in this type of aquifer is usually minute and available for short periods of time.
- Shallow wells often draw water from unconfined aquifers.

3. **Saturated Aquifer:**

- Saturated aquifers are those aquifers that are filled with water and have no space to store more water.
- These aquifers store water with high-pressure heads.

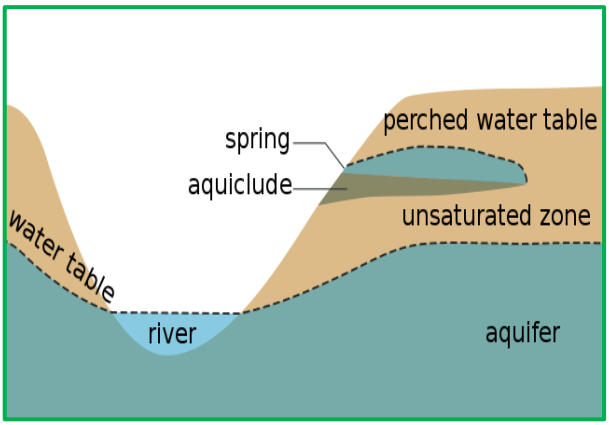
4. **Unsaturated Aquifer:**

- Unsaturated aquifers are those aquifers that contain water but still have some space filled with air and can store more water.

- These aquifers generally occur above the water table, and their pressure head is negative or less than a saturated aquifer.

5. **Perched Aquifer:**

- An unconfined aquifer can also occur as a perched aquifer.
- Perched aquifer is a type of aquifer that occurs over unsaturated rock formations.
- These aquifers develop as a result of discontinuous impermeable layers of rock or sand.
- Perched ground-water sources are generally small.
- A line along which water pressure equals atmospheric pressure forms within, or at the base of the lens resulting in an inverted water table so the entire perched system is surrounded by a water table.
- Where perched groundwater systems intersect the land surface, groundwater discharges as spring flow.



6. **Leaky Aquifer:**

- In nature, truly confined aquifers are rare because the confining layers are not hundred per cent impervious.
- An aquifer which is overlain or underlain by a semi- pervious layer (aquitard) through which vertical leakage takes place due to head difference is called leaky aquifer or semi-confined aquifer.
- The permeability of the semi-confining layer is usually very small as compared to the permeability of the main aquifer.
- Thus, the water which seeps vertically through the semi-confining layer is diverted internally to proceed horizontally in the main aquifer.

Common Misconceptions

1. **Aquifers Are Not Underground Rivers**:

- Despite popular imagery, aquifers are not flowing rivers or lakes beneath the surface.
- Groundwater moves slowly through the porous rock, following the laws of physics rather than the meandering paths of rivers.

2. **The Importance of Aquifers**:

- Most of our freshwater comes from aquifers.
- Wells provide access to this hidden resource, supplying water for households, agriculture, and industries.

3. **Aquifers once depleted stay depleted:**

- This is not true. Aquifers can be replenished or "recharged" through the process of infiltration, where water from precipitation seeps back into the ground.

4. **Groundwater is an everlasting source of water:**

- Groundwater levels can decrease if we use it at a faster rate than it can replenish itself.

5. **Groundwater is pure and hence a very safe source:**

- While groundwater is often cleaner than surface water because the soil acts as a natural filter, it can still become contaminated. For example, pesticides and herbicides from agricultural fields, leaks from septic tanks, or improperly managed landfills can contaminate groundwater.

6. **Groundwater is not connected to rivers and lakes:**

- In reality, there is often a connection between surface water (like rivers and lakes) and groundwater.

7. Contaminants from oil that is poured on the ground will be filtered by soil and gravel before reaching groundwater:

- While soil can act as a natural filter for some contaminants, it cannot filter out all potential contaminants.

8. Groundwater flows mainly in underground rivers:

- Groundwater does move, but it does so slowly through the tiny spaces between rocks and sediment. It doesn't flow in the same way that water does in a river.

9. "The diviner said I have strong groundwater on my farm"

- The myth mentioned has vexed the professional groundwater industry for many years.
- The practice of water divining dates back centuries and entails a diviner or "water witch" using a random inanimate object, such as a forked branch, metal rods, a pendulum, a coconut, a plastic cold drink bottle to perform an arbitrary action whereby a "suitable" drilling site is selected.
- A diviner will often claim that "this farm has strong water" or "there are many breaks here, you won't have to drill deep".
- These claims are unfortunately not supported by any quantifiable scientific evidence.
- This is mostly because of a lack of exposure to the additional benefits of having a trained professional assist in the development of a groundwater resource.
- A good hydrogeological assessment should consider the regional and local setting of the planned development, the presence of any known aquifers within the development area, risks related to drilling into the underlying aquifers, the groundwater recharge, storage, availability and potential of the underlying aquifer, and other users or ecosystems that also rely on the groundwater resource.

Problems to Aquifers

- Non-renewable aquifer water threatens life on earth.
- 97% of freshwater is in aquifers, soil, swamps and permafrost.
- Aquifers supply 35% of freshwater demands.
- Depleted aquifers threaten 2 billion people.
- Over half the world's largest aquifers are threatened.
- Aquifers supply 50% of us drinking water.

- 40% of sea level rise is from displaced aquifer water.
- Drinking water levels fall by two thirds since 1950.
- Water insecurity costs $94 billion annually.

(worldpreservationfoundation.org)

Causes

- Agriculture uses 70% of water withdrawals, & 90% in developing countries.
- Livestock consumes 56% of freshwater in the US.
- 1kg of animal protein uses 100x the water of plant protein.
- 1kg beef uses 43k litres of water.
- Annual showers for 4 people use 90k litres water, the same required to produce 2kg of beef.

Challenges and Preservation

1. **Depletion**:

- Over-pumping of groundwater can lead to aquifer depletion.
- Recharging aquifers through natural processes (like rainwater infiltration) is essential to maintain their levels.

2. **Contamination**:

- Aquifers act as natural filters, removing impurities from groundwater.
- However, excessive pesticide use, septic tank leaks, and poor waste management can contaminate aquifers.
- Protecting aquifers from pollution is critical.

3. The relative cost of groundwater development and management:

- One of the main reasons for the reluctance of groundwater users to seek professional help, is the perceived cost of groundwater resource development.
- Drilling a borehole is a costly endeavour at present rates.
- This cost, however, is generally far lower compared to other water supply options for industrial processes, irrigation or bulk supply.
- If developed, operated, monitored, and maintained as recommended by a professional hydrogeologist, a borehole can provide groundwater sustainably for several generations.

4. Sustainable groundwater use:

- Groundwater sustainability is the development and use of groundwater to meet both current and future beneficial purposes without causing unacceptable consequences.
- It is important that we understand the factors that contribute to local, regional, or state wise groundwater shortages, the strategies that can be implemented to promote a sustainable groundwater supply, and what resources or tools are needed to implement these strategies successfully.
- Factors affecting groundwater supplies and use:
  1. Methods that promote the wise use of groundwater supplies
  2. Need to determine strategies that promote groundwater sustainability
  3. Need for cooperative efforts to fill data gaps and undertake priority research
  4. Need for increased collaborative educational efforts.

Conclusion

Aquifers are vital sources of groundwater that can be used for various purposes, such as irrigation, drinking, and industrial activities. Aquifers are formed by different types of porous or permeable rocks and sediments that can store and transmit water underground. Next time you turn on the tap or water your garden, remember that the water might have journeyed through layers of rock and sediment, hidden deep within the Earth. Aquifers are silent heroes,

quietly sustaining life above ground. Let's appreciate and protect these invaluable reservoirs for generations to come .

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