

Assessment of Ground Water Quality of Sahiwal District of Punjab Province of Pakistan by Using GIS Techniques

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What is Ground Water?

Water located beneath the earth's surface in soil pore spaces and in the fractures of rock formation. A unit of rock or an unconsolidated deposit is called an aquifer when it can yield a usable quantity of water. The depth at which soil pore spaces or fractures and voids in rock become completely saturated with water is called the water table. Groundwater is recharged from, and eventually flows to, the surface naturally; natural discharge often occurs at springs and seeps, and can form Oases or Wetlands. Groundwater is also often withdrawn for agricultural, municipal and industrial use by constructing and operating extraction wells. The study of the distribution and movement of groundwater is hydrogeology, also called groundwater hydrology.

Typically, groundwater is thought of as liquid water flowing through shallow aquifers, but technically it can also include soil moisture and permafrost (frozen soil), immobile water in very low permeability.

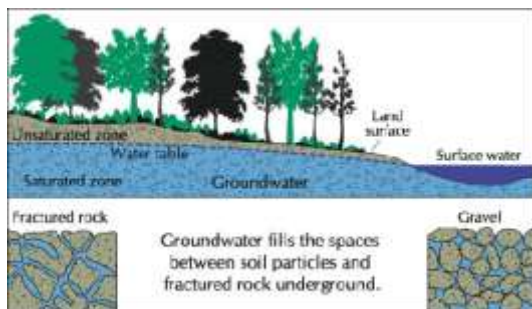


Image compliments of US Geological Survey, adapted by The Groundwater Foundation.

The area where water fills the aquifer is called the saturated zone (or saturation zone). The top of this zone is called the water table. The water table may be located only a foot below the ground's surface or it can sit hundreds of feet down.

Groundwater can be found almost everywhere. The water table may be deep or shallow; and may rise or fall depending on many factors. Heavy rains or melting snow

may cause the water table to rise, or heavy pumping of groundwater supplies may cause the water table to fall.

Water in aquifers is brought to the surface naturally through a spring or can be discharged into lakes and streams. Groundwater can also be extracted through a well drilled into the aquifer. A well is a pipe in the ground that fills with groundwater. This water can be brought to the surface by a pump. Shallow wells may go dry if the water table falls below the bottom of the well. Some wells, called artesian wells, do not need a pump because of natural pressures that force the water up and out of the well.

Groundwater supplies are replenished, or recharged, by rain and snow melt. In some areas of the world, people face serious water shortages because groundwater is used faster than it is naturally replenished. In other areas groundwater is polluted by human activities.

In areas where material above the aquifer is permeable, pollutants can readily sink into groundwater supplies. Groundwater can be polluted by landfills, septic tanks, leaky underground gas tanks, and from overuse of fertilizers and pesticides. If groundwater becomes polluted, it will no longer be safe to drink.

Groundwater is used for drinking water by more than 50 percent of the people in the United States, including almost everyone who lives in rural areas. The largest use for groundwater is to irrigate crops.

It is important for all of us to learn to protect our groundwater because of its importance as a source of water for drinking and irrigation.

Ground Water Always on Move

When rain falls to the ground, the water does not stop moving. Some of it flows along the surface to streams or lakes, some of it is used by plants, some evaporates and returns to the atmosphere, and some sinks into the ground. Imagine pouring a glass of water onto a pile of sand. Where does the water go? The water moves into the spaces between the particles of sand.

Groundwater

Groundwater is water that is found underground in the cracks and spaces in soil, sand and rock. Groundwater is stored in--and moves slowly through--layers of soil, sand and rocks called aquifers. Aquifers typically consist of gravel, sand, sandstone, or fractured rock, like limestone. These materials are permeable because they have large connected spaces that allow water to flow through. The speed at which groundwater flows depends on the size of the spaces in the soil or rock and how well the spaces are connected.

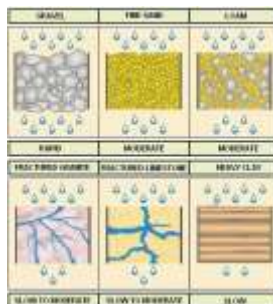


Figure 2. Water moves and is contained at different rates through various geological materials.

Pumping a well changes the amount and direction of movement of groundwater within the subsurface. Movement of water in the atmosphere and on the land surface is relatively easy to visualize, but the movement of ground water is not. Concepts related to ground water and the movement of ground water are introduced in Box A. As illustrated in Figure 3, ground water moves along flow paths of varying lengths from areas of recharge to areas of discharge. The generalized flow paths in Figure 3 start at the water table, continue through the ground-water system, and terminate at the stream or at the pumped well. The source of water to the water table (ground-water recharge) is infiltration of precipitation through the unsaturated zone. In the uppermost, unconfined aquifer, flow paths near the stream can be tens to hundreds of feet in length and have corresponding travel times of days to a few years. The longest and deepest flow paths in Figure 3 may be thousands of feet to tens of miles in length, and travel times may range from decades to millennia. In general, shallow ground water is more susceptible to contamination from human sources and activities because of its close proximity to the land surface. Therefore, shallow, local patterns of ground-water flow near surface water are emphasized in this Circular.

Ground water moves along flow paths of varying lengths in transmitting water from areas of recharge to areas of discharge

Small-scale geologic features in beds of surface-water bodies affect seepage patterns at scales too small to be shown in Figure 3. For example, the size, shape, and orientation of the sediment grains in surface-water beds affect seepage patterns. If a surface-water bed consists of one sediment type, such as sand, inflow seepage is greatest at the shoreline, and it decreases in a nonlinear pattern away from the shoreline (Figure 4). Geologic units having different permeability's also affect seepage distribution in surface-water beds. For example, a highly permeable sand layer within a surface-water bed consisting largely of silt will transmit water preferentially into the surface water as a spring (Figure 5).

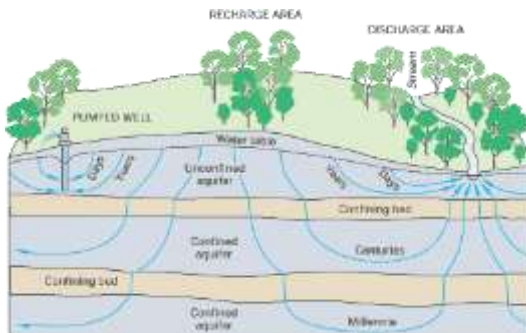


Figure 3. Ground-water flow paths vary greatly in length, depth, and travel time from points of recharge to points of discharge in the ground-water system.

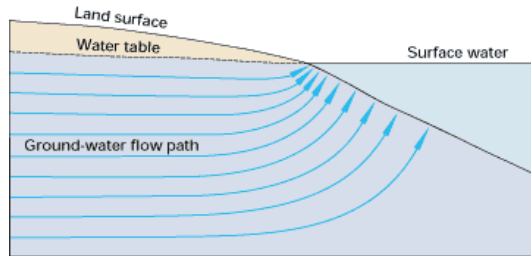


Figure 4. Ground-water seepage into surface water usually is greatest near shore.
In flow diagrams such as that shown here, the quantity of discharge is equal between any two flow lines; therefore, the closer flow lines indicate greater discharge per unit of bottom area.

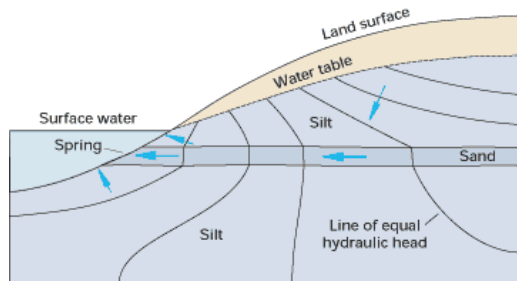


Figure 5. Subaqueous springs can result from preferred paths of ground-water flow through highly permeable sediments.

Changing meteorological conditions also strongly affect seepage patterns in surface-water beds, especially near the shoreline. The water table commonly intersects land surface at the shoreline, resulting in no unsaturated zone at this point. Infiltrating precipitation passes rapidly through a thin unsaturated zone adjacent to the shoreline, which causes water-table mounds to form quickly adjacent to the surface water (Figure 6). This process, termed focused recharge, can result in increased ground-water inflow to surface-water bodies, or it can cause inflow to surface-water bodies that normally have seepage to ground water. Each precipitation event has the potential to cause this highly transient flow condition near shorelines as well as at depressions in uplands (Figure 6).

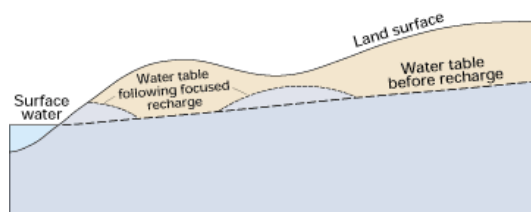


Figure 6. Ground-water recharge commonly is focused initially where the unsaturated zone is relatively thin at the edges of surface-water bodies and beneath depressions in the land surface.

Transpiration by near shore plants has the opposite effect of focused recharge. Again, because the water table is near land surface at edges of surface-water bodies, plant roots can penetrate into the saturated zone, allowing the plants to transpire water directly

from the ground-water system (Figure 7). Transpiration of ground water commonly results in a drawdown of the water table much like the effect of a pumped well. This highly variable daily and seasonal transpiration of ground water may significantly reduce ground-water discharge to a surface-water body or even cause movement of surface water into the subsurface. In many places it is possible to measure diurnal changes in the direction of flow during seasons of active plant growth; that is, ground water moves into the surface water during the night, and surface water moves into shallow ground water during the day.

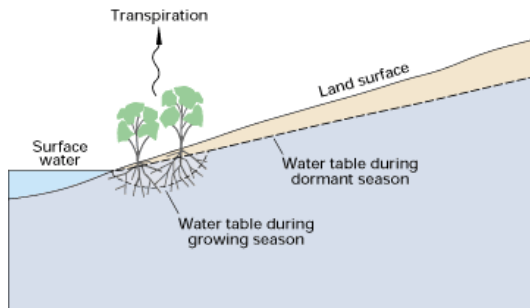


Figure 7. Where the depth to the water table is small adjacent to surface-water bodies, transpiration directly from ground water can cause cones of depression similar to those caused by pumping wells. This sometimes draws water directly from the surface water into the subsurface.

These periodic changes in the direction of flow also take place on longer time scales: focused recharge from precipitation predominates during wet periods and drawdown by transpiration predominates during dry periods. As a result, the two processes, together with the geologic controls on seepage distribution, can cause flow conditions at the edges of surface-water bodies to be extremely variable. These "edge effects" probably affect small surface-water bodies more than large surface-water bodies because the ratio of edge length to total volume is greater for small water bodies than it is for large ones.

NATURAL PROCESSES OF GROUND-WATER AND SURFACE-WATER INTERACTION

The Hydrologic Cycle and Interactions of Ground Water and Surface Water

The hydrologic cycle describes the continuous movement of water above, on, and below the surface of the Earth. The water on the Earth's surface--surface water--occurs as streams, lakes, and wetlands, as well as bays and oceans. Surface water also includes the solid forms of water-- snow and ice. The water below the surface of the Earth primarily is ground water, but it also includes soil water.

The hydrologic cycle commonly is portrayed by a very simplified diagram that shows only major transfers of water between continents and oceans, as in Figure 1. However, for understanding hydrologic processes and managing water resources, the hydrologic cycle needs to be viewed at a wide range of scales and as having a great deal of variability in time and space. Precipitation, which is the source of virtually all freshwater in the hydrologic cycle, falls nearly everywhere, but its distribution is highly variable. Similarly, evaporation and transpiration return water to the atmosphere nearly everywhere, but evaporation and transpiration rates vary considerably according to

climatic conditions. As a result, much of the precipitation never reaches the oceans as surface and subsurface runoff before the water is returned to the atmosphere. The relative magnitudes of the individual components of the hydrologic cycle, such as evapotranspiration, may differ significantly even at small scales, as between an agricultural field and a nearby woodland.

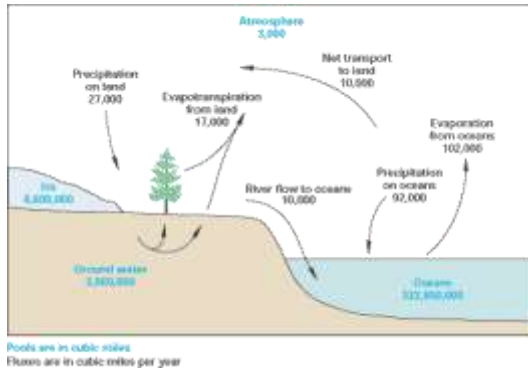
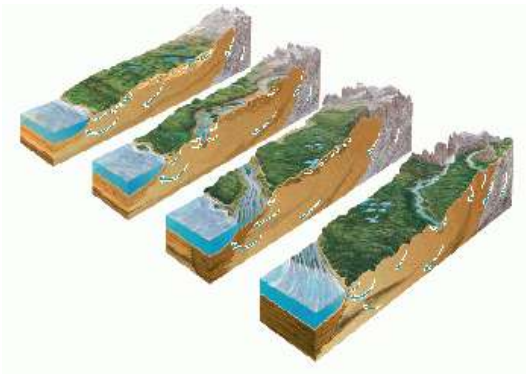


Figure 1. Ground water is the second smallest of the four main pools of water on Earth, and river flow to the oceans is one of the smallest fluxes, yet ground water and surface water are the components of the hydrologic system that humans use most. (Modified from Schlesinger, W.H., 1991, *Biogeochemistry-An analysis of global change*: Academic Press, San Diego, California.) (Used with permission.)

To present the concepts and many facets of the interaction of ground water and surface water in a unified way, a conceptual landscape is used (Figure 2). The conceptual landscape shows in a very general and simplified way the interaction of ground water with all types of surface water, such as streams, lakes, and wetlands, in many different terrains from the mountains to the oceans. The intent of Figure 2 is to emphasize that ground water and surface water interact at many places throughout the landscape.



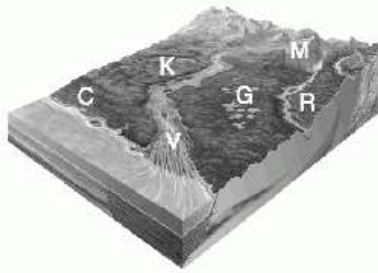


Figure 2. Ground water and surface water interact throughout all landscapes from the mountains to the oceans, as depicted in this diagram of a conceptual landscape. M, mountainous; K, karst; G, glacial; R, riverine (small); V, riverine (large); C, coastal.

Groundwater Contamination

What kind of contaminations it?

Groundwater is rain water or water from surface water bodies, like lakes or streams, that soaks into the soil and bedrock and is stored underground in the tiny spaces between rocks and particles of soil. Groundwater pollution occurs when hazardous substances come into contact and dissolve in the water that has soaked into the soil.

How did it get there?

Groundwater can become contaminated in many ways. If rain water or surface water comes into contact with contaminated soil while seeping into the ground, it can become polluted and can carry the pollution from the soil to the groundwater. Groundwater can also become contaminated when liquid hazardous substances themselves soak down through the soil or rock into the groundwater. Some liquid hazardous substances do not mix with the groundwater but remain pooled within the soil or bedrock. These pooled substances can act as long-term sources of groundwater contamination as the ground water flows through the soil or rock and comes into contact with them.

How does it hurt animals, plants or humans?

Contaminated groundwater can hurt animals, plants, or humans only if it is first removed from the ground by manmade or natural processes. In many parts of the world, ground water is pumped out of the ground so it can be used as a source of water for drinking, bathing, other household uses, agriculture, and industry. In addition, groundwater can reach the surface through natural pathways such as springs. Contaminated groundwater can affect the quality of drinking and other types of water supplies when it reaches the surface. Contaminated groundwater can affect the health of animals and humans when they drink or baths in water contaminated by the groundwater or when they eat organisms that have themselves been affected by groundwater contamination.

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