Groundwater

Module 5 • i2P • H2O Tour

"Groundwater has been used for domestic and irrigation needs from time immemorial. Yet its nature and occurrence have always possessed a certain mystery because water below the land surface is invisible and relatively inaccessible. The influence of this mystery lingers in some tenets that govern groundwater law."

- T.N. Narasimhan

THE WELLSPRING

Running across the searing Tunisian Sahara in April, water will be a precious commodity for Ray and the team. As far as the eye can see will be dry dunes of sand virtually free of vegetation. This is a function of the negligible rainfall in the region and the dry soil that does not support plant growth. Yet appearances can be deceiving. Despite the parched surface of the earth the i2P team will in fact be running over a vast subterranean collection of water called the Northwestern Sahara Aquifer System (NWSAS). The NWSAS covers over a million square kilometers in Tunisia, Libya and Algeria. In Tunisia alone water is drawn from the NWSAS by over 1,200 separate wells and sources. Roughly 2.2 billion cubic meters of water is withdrawn from the NWSAS annually (see: NWSAS).

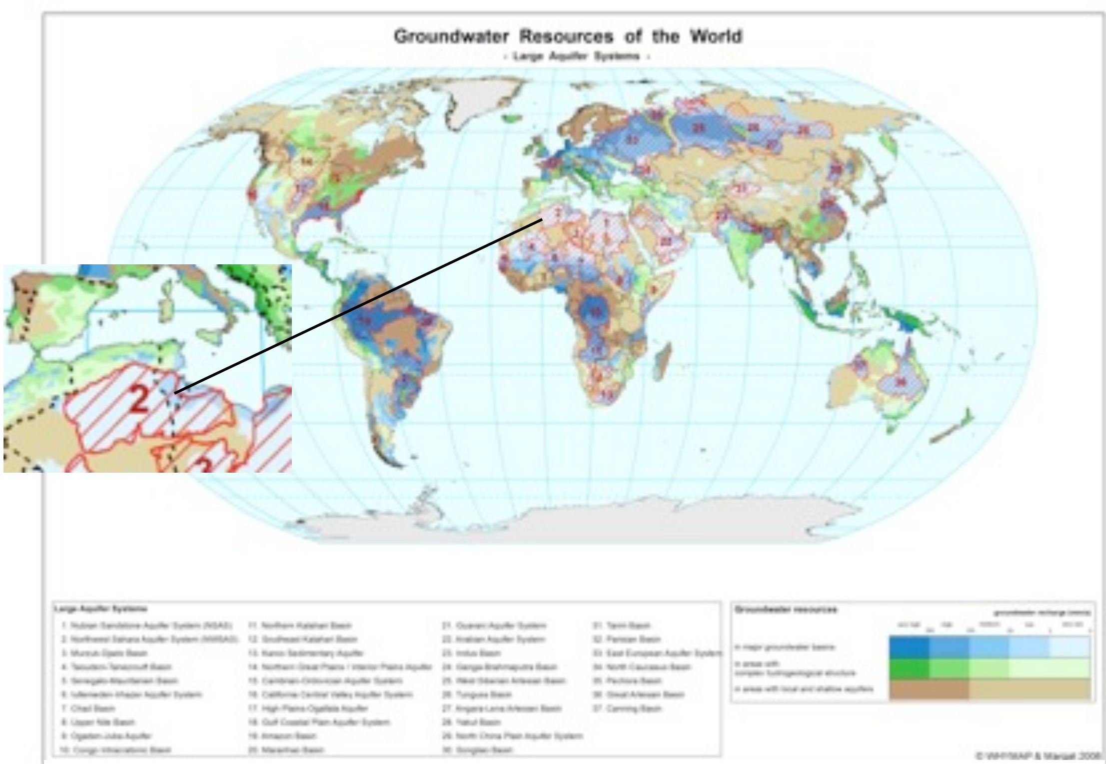

Figure 1: The groundwater resources of the world with the Northwestern Sahara Aquifer System enlarged (source: whymap.org)

If Tunisia is so dry how can it harbor a vast subterranean store of water?

GROUNDWATER

Groundwater is loosely defined as water, found beneath the surface of the earth, which saturates the pores and fractures of sand, gravel, and rock of the earths crust. Groundwater is the underground component of the water cycle and is the largest and most reliable source of freshwater in the world, accounting for about 97% of the worlds freshwater resources. In many regions of the world, including Europe and Russia groundwater is the principle source of drinking water, and in arid countries like Tunisia it supplies well over 80% of drinking water.

> Definition: Aquifer
>
> A permeable body of rock capable of yielding quantities of groundwater to wells and springs.

There is groundwater underlying all the Earths continents with the exception of Antarctica, however the extent and character of this water differs according to a variety of factors, principally the nature of the Earth's crust and the amount of precipitation in a given region. About half of the Earth's continental surface holds groundwater that is very shallow and of limited supply, whereas about 20% of the Earth's continental area holds major water reserves consolidated in big collections or aquifers (see: Groundwater). The Northwestern Sahara Aquifer System is one of 37 major Aquifer systems found in the world.

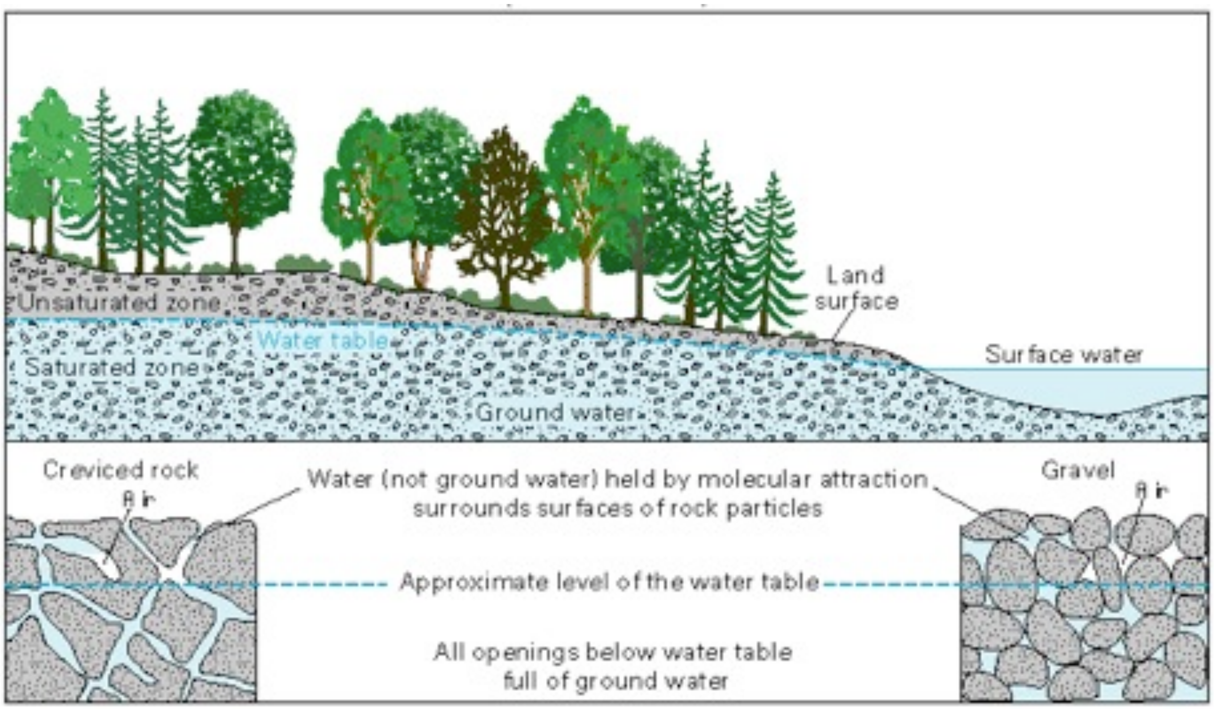

Figure 2: How groundwater occurs in rocks (source: US Geological Survey)

Groundwater Recharge

The Earth's total resources of fresh groundwater are estimated to be about 10,000,000 cubic kilometers, which is almost 200 times the annual global renewable fresh water provided by the water cycle through *precipitation*. Groundwater is created or replenished by precipitation in a process called groundwater recharge.

When fresh water falls as rain to Earth it either *seeps* into the soil or runs along the surface of the ground collecting in rivers that then run into lakes forming a component of the surface water system. The water that *seeps* into the soil forms part of the groundwater. Some of this is taken up by plants, some is *discharged* into rivers and lakes and the ocean as springs and some percolates down where it replenishes aquifers and other groundwater stores. A proportion of groundwater is *evaporated* when the sun heats the soil, and when it is transpired by plants that have taken it up. Thus the 4 main components of the groundwater cycle are *precipitation, seepage, discharge and evaporation*.

The creation of groundwater is not equal around the globe but varies according to precipitation. Significant regions of the world receive very little precipitation and therefore have limited capacity to recharge their groundwater. In humid regions with a great deal of rainfall, the soil becomes saturated with water and there is a significant amount of seepage deep into the ground resulting in significant groundwater recharge.

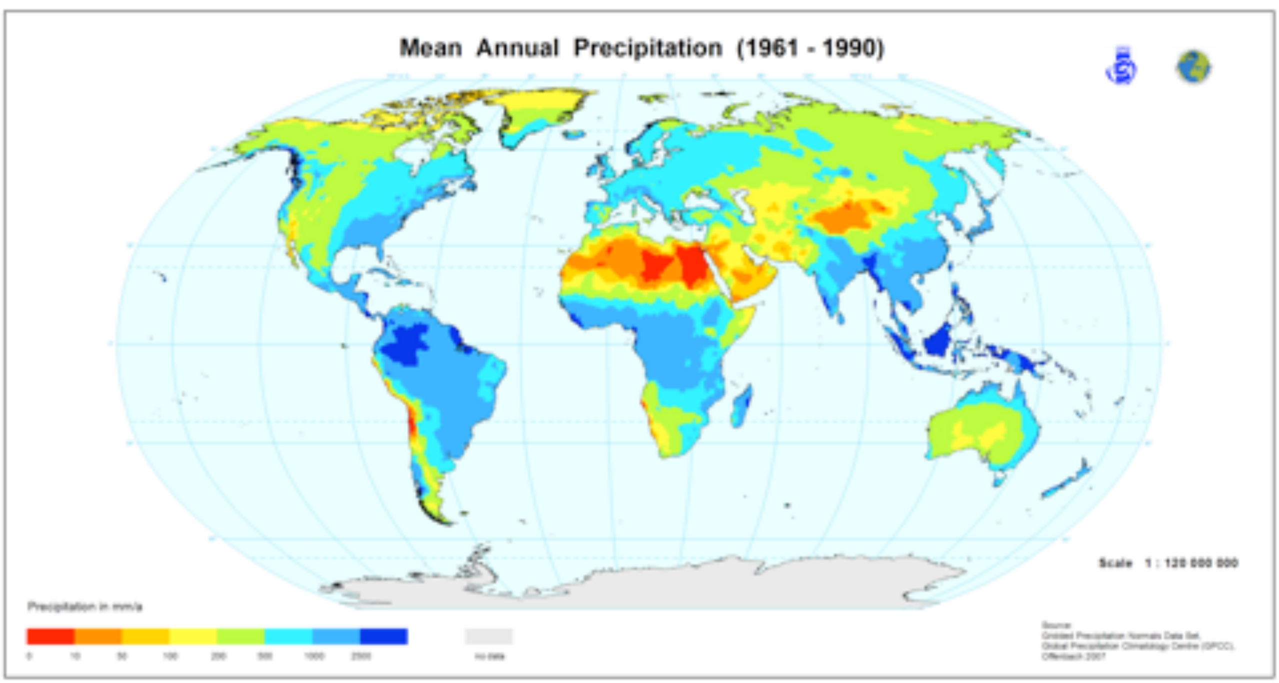

Figure 3: Mean Annual Precipitation (source: whymaps.org)

In dry regions the soil is parched and of low humidity. Consequently most of the rain that falls does not penetrate the unsaturated soil to seep into and replenish the groundwater stores (this is the case in Tunisia).

Nonetheless groundwater reserves may be very significant in dry areas of the globe because it has collected over thousands of years, and was established when the local climate differed. Such is the case in the Sahara Desert. Although it has very little annual rainfall, and consequently has limited capacity for groundwater recharge, the Sahara is still home to a series of huge and abundant aquifer systems.

Groundwater Mining

Provided it is replenished adequately groundwater can be abstracted indefinitely. However the concern facing people living in low rainfall areas of the world that are dependent on groundwater - like the Sahara Desert - is that the groundwater they use is not being renewed. The practice of abstracting groundwater that is not being renewed by the water cycle is called *groundwater mining.*

In Tunisia and many other countries groundwater mining has become common practice. A combination of low precipitation, limited surface freshwater resources, growing populations, and growing standards of living that demand more intensive agriculture and industry are all factors promoting the practice of groundwater mining.

Groundwater Pollution

> Did You Know?
>
> In most cases groundwater is cleaner than surface water.

Another factor that threatens groundwater supplies is pollution. By nature groundwater is very clean, however industrialization, agricultural practices and groundwater mining all threaten the cleanliness of the water. Groundwater can be contaminated by both manmade and natural materials. For instance, when aquifers adjacent to the ocean are mined, their lowered fresh water level can lead to the invasion of sea water. Similarly, other natural substances like arsenic, fluorine, nitrate or sulphate can also contaminate groundwater. Although groundwater is usually protected by soils and covering rock layers, industrial pollutants can also seep deep into the ground and contaminate fresh water resources.

Back to the Well

The state of groundwater resources are particularly troubling in a variety of locations in the world. India has seen significant declines in groundwater resources that have resulted in water shortages and rationing. The Irrigation Management Institute suggests that India is using its underground water reserves at least twice as fast as they are being

> Did you Know?
>
> Groundwater is used by about two billion people worldwide; making it the single most used natural resource. The estimated annual production of groundwater is between 600 and 700 cubic kilometers (billion cubic meters, or billion tones). In comparison, the worldwide annual consumption of sand and gravel is about 18 billion tones, while worldwide oil consumption is a mere 3.5 billion tones. see: groundwater production

replenished (see: groundwater India). Similar issues are arising in China, with over-tapping of aquifers driven by population growth. According to the World Health Organization Arsenic poisoning of ground water supplies has been identified in many countries, including Argentina, Bangladesh, Chile, China, India, Mexico, Thailand and the United States (see: WHO water sanitation).

The mining of aquifers is not unique to the Middle and Far East. The United States has been mining the massive High Plains Aquifer for years and recent studies demonstrate that water levels have declined over 150 feet in some areas (see: Ogallalla). The High Plains Aquifer, also known as the Ogallalla Aquifer, underlies 111.4 million acres (174,000 square miles) in parts of eight States - Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming. The principle use of water drawn from this aquifer is for the purposes of irrigation to support farming for a increasingly hungry population.

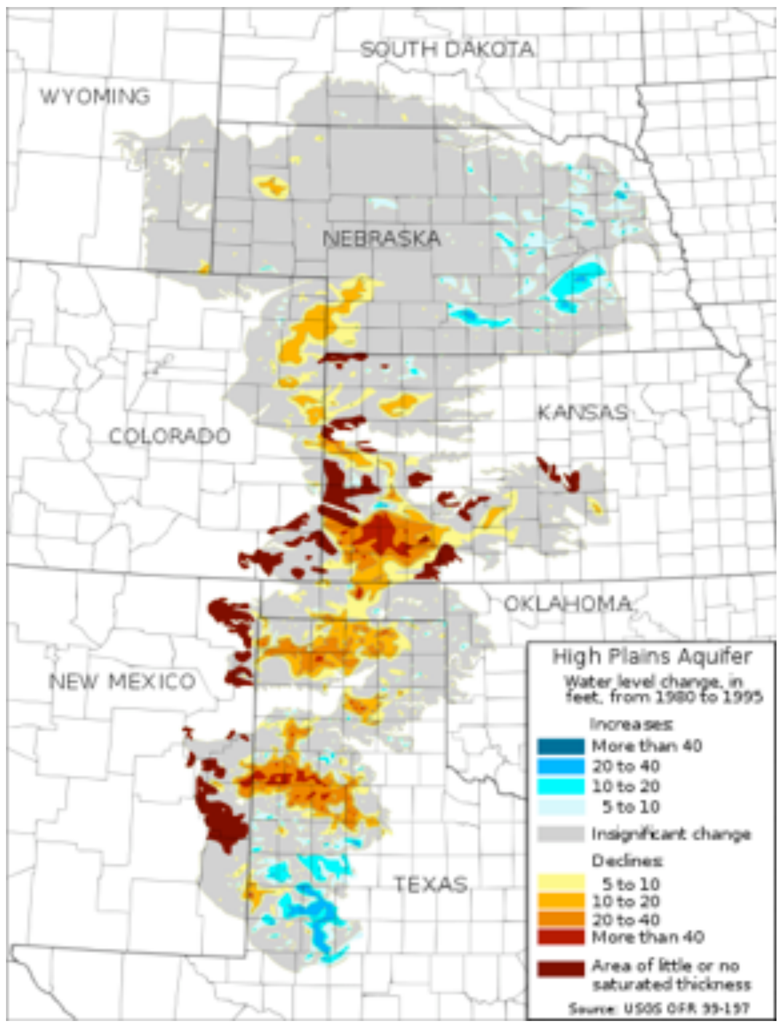

Figure 4: High Plains (Ogallalla) Aquifer change in water level - 1980 - 95 (source: US Geological Survey)