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Water resources

Water resources are sources of water that are useful to human beings for drinking, recreation, farming, industry, etc. Even though 70% of the Earth's surface is covered with water, a majority of it is salt water. The supply of fresh water is so limited in many parts of the world that the shortage constitutes a serious problem for the human inhabitants. It has been predicted that global scarcity of water resources will occur many decades before the much-heralded depletion of fossil fuel resources. Water scarcity is but one side of the problem; water quality is the other, in as much as a resource can also be lost through its degradation.

The problem

Human populations in some areas are growing a 1 to 3% per year, while fresh water supplies are remaining constant or shrinking.

Most new available water supplies are contaminated with industrial waste, sewage or salt. Aquifers are already being rapidly used, so even ground water is no longer a practical solution.

Most purification plants use large amounts of oil or other fuel. Nuclear purification plants are politically unpopular. Solar purification plants require too much land and are very expensive.

The result

An increasing number of wars and civil disputes are occurring over water rights.

In the U.S.'s western region, this is not news. Water wars in the U.S. date from the western expansion of the 1820s, even though most of them were fought by private landowners. The historic cowboy range wars were over water rights. Land-theft and rustling were usually attempts to get compensation for or access to water. (They weren't kidding when they said 'There isn't room for both of us...')

Civil disputes in the U.S. also have a long history, especially in California, after the population expansion of the 1850s. Both San Francisco, California and Los Angeles, California engaged in lengthy negotiations, property acquisition, and litigation to secure water rights. San Francisco flooded a beautiful glacial valley, Tehachapi, over the bitter protests of conservationists led by the Sierra Club. Los Angeles purchased Mono Lake, and drained it to dust, also over bitter protests.

In the Middle East, many of the wars have been disputes over water. These are expected to escalate as industry and population increase in the region.

Solutions

Conservation

One part of the solution is conservation. People will pay almost any amount for drinking water. However, far less water can sometimes be used for irrigation, wash water and industrial water.

World-wide, crops irrigated by ditches use 70% or more of available water. Changing to dry-land crops and sprinkler or drip irrigation can reduce agricultural water use by 60 to 90%.

About 15% of water use is industrial. Much industrial water is used for cleaning or cooling. Often the water can be settled, filtered and recycled. This reduces pollution of surface water while reducing use. In some cases, it is profitable for water providing authorities to share the costs of pollution control equipment for industries.

Many authorities say that the way to stop these abuses is simply to charge users the true costs of the water they use. Almost all areas subsidize farm and industrial uses of water by over-charging residential uses.

In cities, the largest waste of water is as run off during rainy seasons. Most roofs and storm sewers could preserve the water for use. In heavily urban southern California, some runoff is diverted to swamps in river deltas, to recharge aquifers and keep ocean water out of city wells.

Some areas of California and Israel use greywater systems, in which household wash water is recycled for irrigation and sewage processing.

A number of cities and water districts in California recycle sewage to standards that would make it usable for drinking or washing water. This "reclaimed water" is used for irrigation, recharging aquifers, or discharge into lakes.

Development

Desalination has long been used on ships, submarines and islands, where there is no alternative. It has also been used to supply water to the US military base at Guantanamo Bay, Cuba. History of water supply at Guantanamo Bay: [1].

Desalination of brackish water is already commonplace in the U.S., where it is used to meet treaty obligations for river water entering Mexico.

Desalination of ocean water is common in the Middle East, where a number of countries use oil-fired stills to provide city drinking water.

The price of desalination is rapidly declining. A modern, large, efficient plant is within 20% of the cost of developing a new, local source of fresh water. Desalination stills now control pressure, temperature and brine concentrations to optimize the water extraction expense. Other methods of desalination include reverse osmosis and pressure barrier osmosis. Nuclear-powered desalination could be very economical on a large scale.

Importing water

Water has such a low value per pound that it is not usually profitable to import it.

The most effective way to "import" water is in the form of virtual water; that is, to import products that require large amounts of water to produce. A simple example is grain. It usually takes 1000 pounds of water to grow one pound of grain. Thus, each ton of imported grain saves 1000 tons of domestic water. This method is used by Israel, which imports most grain.

Importing Water to the US from Canada

The situation between Canada and the US illustrates some of the complexities of importing water.

Canada has 20% of the world's fresh water and the US has a great need for additional fresh water supplies. The two nations share bodies of water like the Great Lakes so water could be easily transferred from Canada to the US. Although the US would seem to be a natural market for its water, Canada refuses to export any fresh water to the US, except as bottled water.

Under the terms of the North American Free Trade Agreement (NAFTA), for any commodity that is normally traded between Canada, Mexico and the US, all the nations must be treated the same as the nation that produces the commodity. If Canada were to start bulk water exports to the US, it would lose control of the exports and would be unable to limit American purchases of additional supplies. In effect, Canadians would end up having to compete with the wealthier Americans for access to their own fresh water supply. The only way to avoid this is to stop any attempt to export fresh water in bulk. Even tanker trucks of fresh water are not allowed to cross the Canadian border.

Although Canada has 20% of the world's fresh water, it only receives 7% of the precipitation. Most of Canada consists of rock (the Canadian Shield) or permafrost. Water cannot sink into these impermeable materials but sits on top. The water collects in every hollow to form Canada's innumerable lakes and rivers. Canada's northern latitude means that little water is lost to evaporation before each reaches the sea and this accounts for Canada's vast supply of fresh water. Canadians are afraid that, if allowed, Americans would "mine" Canada's fresh water by taking more than is replaced each year.

The waters shared by the two nations are controlled by the International Boundary Waters Treaty (1909). This treaty prevents the US from, say, just pumping all the water that it wants out of the Great Lakes.

Some vast schemes have been proposed for transferring water about the continent. The Great Recycling and Northern Development (GRAND) Canal scheme proposed damming off James Bay (the southern appendix of Hudson Bay), letting it fill with fresh water and then pumping the water south to the Great Lakes where it could be distributed to the US. The North American Water and Power Alliance (NAWAPA) proposed damming and flooding the Rocky Mountain Trench and then using a vast system of canals to distribute the water across the continent - all the way to northern Mexico and the Great Lakes. One by-product would be a navigable canal connecting the Pacific Ocean with the Great Lakes.

Fresh water

Fresh water (also **freshwater** or **fresh-water**) is water that contains only minimal quantities of dissolved salts, especially sodium chloride, thus distinguishing it from sea water or brackish water. All freshwater ultimately comes from precipitation of atmospheric water vapor, reaching inland lakes, rivers, and groundwater bodies directly, or after melting of snow or ice (see hydrologic cycle).

Access to fresh water is a critical issue for the survival of many species, especially in desert areas. See water resources.

Even on a ship or island, there can be a "water shortage", which means a shortage of fresh water.

For fish it strongly matters how much dissolved sodium chloride the water they live in has. Most species cannot live in both fresh and salt water, though some species move between the two. Salt water fish have access to an abundance of salt, and try to get as much salt out of their body as possible, while trying to keep the water. Fresh water fish do the opposite: They have too much water, and too little salt.

Brackish water

Brackish refers to water that is saltier than fresh water, but not as salty as sea water. It may result from mixing of seawater with fresh water, as in estuaries, or it may occur naturally, as in brackish fossil aquifers.

Technically, brackish water contains between 0.5 and 30 grams of salt per litre — more often expressed as 0.5 to 30 parts per thousand (ppt or °/oo). Thus, *brackish* covers a range of salinity regimes.

Saline water

Sea water is water from a sea or ocean. On average, sea water in the world's oceans has a salinity of ~3.5%. This means that for every 1 liter (1000mL) of sea water there are 35 grams of dissolved salts (mostly, but not entirely, sodium chloride). Water with this level of osmolarity is not potable.

Sea water is not uniformly saline throughout the world. The planet's freshest sea water is in the Gulf of Finland in the Baltic Sea. The most saline sea is the Red Sea, where heat increases the rate of surface evaporation and there is little fresh inflow from rivers.

Composition of Earth's ocean water by element

Element	Percent	Element	Percent
Oxygen	85.7	Sulfur	0.0885
Hydrogen	10.8	Calcium	0.04
Chlorine	1.9	Potassium	0.0380
Sodium	1.05	Bromine	0.0065
Magnesium	0.1350	Carbon	0.0026

Aquifer

An **aquifer** is a layer of water-bearing permeable rock, sand, or gravel capable of providing significant amounts of water (see also groundwater). The upper boundary of the topmost aquifer is known as the water table. Some areas have several aquifers, each capped on top by an impervious layer. If the recharge area is elevated higher that the capping layer, the water may be under considerable pressure, and flowing or Artesian wells may be likely. Most land areas on Earth have some form of aquifer underlying them, though often at significant depth. Aquifers in coastal regions do not necessarily contain fresh water, especially when they have been pumped at rates exceeding the input of fresh water from the recharge area. Such reversal of normal flow toward the ocean leads to intrusion of sea water backward into the aquifer, which is a serious problem in many coastal areas.

Aquifers are critically important in human habitation and agriculture. Deep aquifers in arid areas have long been water sources for irrigation. Many villages and even large cities draw their water supply from wells in aquifers.

The most sustainable aquifers, and those most often used for city water supplies, are **riparian aquifers**. These are present in unconsolidated deposits of sand and gravel along river corridors, and are usually rapidly replenished.

Aquifer depletion is a global problem, and is especially critical in northern Africa.

The Ogallala Aquifer of the central United States is one of the world's great aquifers, but is being rapidly depleted. This huge aquifer, present in around eight states, comprises fossil water from the time of the last glaciation.

Groundwater

Groundwater is any water found below the land surface, including water found in aquifers, in the pore spaces of rocks, unconsolidated sediments, permafrost, and soil moisture. Groundwater flows to the surface naturally at springs, seeps and often forms oases or swamps. It may also be tapped artificially by the digging of wells. The top of an unconfined aquifer is the water table, where water pressure is equal to atmospheric pressure.

Groundwater is a long residence time 'reservoir' in the natural water cycle (as compared to the atmosphere or surface water), which is naturally replenished from above, as surface water from rain, rivers or lakes sinks into the ground. The region between the land surface and the water table is the vadose zone (latin for shallow); in this region, water is under pressure less than atmospheric pressure (suction).

Problems with groundwater

Groundwater is a highly useful and abundant resource, but it does not renew itself rapidly. If groundwater is extracted intensively, as for irrigation in arid regions, it may become depleted. The most evident problem that may result from this is a lowering of the water table beyond the reach of existing wells. Wells must consequently be deepened to reach the groundwater; in places like India, the water table has dropped hundreds of feet due to over-extraction. A lowered water table may, in turn, cause other problems.

The film of ground water around particles of an aquifer of unconsolidated sediment actually holds the particles apart, and the removal of this water will compact the sediment. Thus the aquifer is permanently reduced in capacity, and the surface of the ground may also subside. The city of New Orleans, Louisiana is actually below sea level today, and its subsidence is partly caused by removal of ground water under it.

Generally (but not always) ground water flows in the same direction as the slope of the surface. The *recharge zone* of an aquifer near the seacoast is likely to be inland, often at considerable distance. In these coastal areas, a lowered water table may induce seawater to reverse the flow toward the sea. Sea water moving inland is called a saltwater intrusion. Alternatively, salt from mineral beds may leach into the groundwater of its own accord.

Sometimes the water movement from the recharge zone to the place where it is withdrawn may take centuries. When the usage of water is greater than the recharge, it is referred to as *mining* water. Under those circumstances it is not a renewable resource.

In India, a drop in the water table has been associated with arsenic contamination. It is thought that irrigation for rice production since late 1970s resulted in the withdrawal of large quantities of groundwater, which caused the local water table to drop, allowing oxygen to enter the ground and touching off a reaction that leaches out arsenic from pyrite in the soil. The actual mechanism, however, is yet to be identified with certainty.

Not all groundwater problems are caused by over-extraction. Pollutants dumped on the ground may leach into the soil, and work their way down into aquifers. Movement of water within the aquifer is then likely to spread the pollutant over a wide area, making the groundwater unusable.

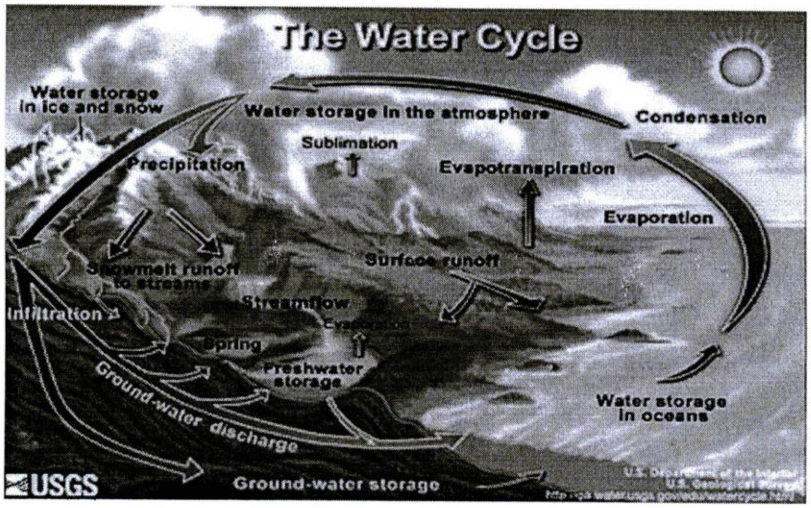
Water table conditions are frequently of importance to agricultural irrigation, waste disposal (including nuclear waste), and other ecological issues.

Water table

The **water table** is the upper limit of abundant groundwater. A large amount of water below the ground table is called an aquifer. Springs and oases occur when the water table reaches the surface.

The practice of drilling wells to extract groundwater is dependent on the water table. Because wells must reach it, the depth of the water table determines the minimum depth of any viable well, and thus the feasibility of drilling it.

Water cycle



The **water cycle**—technically known as the **hydrologic cycle**—is the circulation of water within the earth's hydrosphere, involving changes in the physical state of water between liquid, solid, and gas phases. The *hydrologic* cycle refers to the continuous exchange of water between atmosphere, land, surface and subsurface waters, and organisms. In addition to storage in various compartments (the ocean is one such "compartment"), the multiple cycles that make up the earth's water cycle involve five main physical actions: evaporation, precipitation, infiltration, runoff, and subsurface flow:

- **Evaporation** is the transfer of water from bodies of surface water into the atmosphere. This transfer entails a change in the physical nature of water from liquid to gaseous phases. Along with evaporation can be counted transpiration from plants, as well as, to a lesser degree, perspiration from land mammals and marsupials. Thus, this transfer is sometimes referred to as **evapotranspiration**. 90% of atmospheric water comes from evaporation, while the remaining 10% is from transpiration.
- **Precipitation** is atmospheric moisture that has previously condensed to form clouds (changed from the gas phases to a liquid or solid phase), falling to the

surface of the earth. This mostly occurs as rainfall, but snow, hail, fog drip, and other forms participate as well.

- **Interception** is precipitation trapped by vegetation instead of falling directly onto the soil.
- **Infiltration** into the ground is the transition from surface water to groundwater. The infiltration rate will depend upon soil or rock permeability as well as other factors. Infiltrated water may reach another compartment known as groundwater (i.e., an aquifer). Groundwaters tend to move slowly, so the water may return as surface water after storage within an aquifer for a period of time that can amount to thousands of years in some cases. Water returns to the land surface at lower elevation than where it infiltrated, under the force of gravity or gravity induced pressures.
- **Runoff** includes the variety of ways by which land surface water moves down slope to the oceans. Water flowing in streams and rivers may be delayed for a time in lakes. Not all precipitated water returns to the sea as runoff; much of it evaporates before reaching the ocean or reaching an aquifer.
- **Subsurface flow** incorporates movement of water within the earth, either within the vadose zone or aquifers. After infiltrating, subsurface water may return to the surface or eventually seep into the ocean.