Eco-Link

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Water

A precious film of water, most of it salt water, covers about 71% of the Earth's surface. Earth's organisms are made up mostly of water. As an example people and trees are both about 65% water-by-weight. We can live without most things for an extended period of time, however, we can only live a few days without water. Biological processes simply won't work without it. Water is more than just H2O. Water's unique combination of qualities seems almost magical. The more you know about water, the more fascinated you'll be!

This will get you started: About 97% of the world's water is found in the oceans, and is too salty for drinking, irrigation, or industry (except as a coolant). The remaining 3% is fresh water. Most of this is locked up in ice caps or glaciers, or is buried so deep that it costs too much to extract. Only about .003% of the Earth's total volume of water is easily available to us in soil moisture, exploitable ground water, water vapor, and lakes and streams. There is 40 times as much ground water as surface water. However, ground water is unequally distributed, and only a small amount of it is economically exploitable.

Of the total water available on Earth, only a small fraction is fresh, and only a tiny portion of that is available to support human populations. Human civilizations have risen and fallen depending on how well they managed their basic natural resources, such as soils and water. Past wars have been fought over oil. Future wars will be fought over water, a finite and increasingly scarce renewable resource. Water is our most precious resource, yet it may be our least understood and most poorly managed one. The United States is now in a period of transition from constantly developing supply sources, at which it has been marvelously successful, to improving the conservation and utilization of the water it has.

It might be easier to look at these numbers in the following data table. Notice of the world's total water supply of about 326 million cubic miles of water, surface-water sources (such as rivers) only constitute about 300 cubic miles (about 1/10,000th of one percent), yet rivers are the source of most of the water we use.

Water source	Water volume, in cubic miles	Percent of total water
Oceans	317,000,000	97.24%
Icecaps, Glaciers	7,000,000	2.14%
Ground water	2,000,000	0.61%
Fresh-water lakes	30,000	0.009%
Inland seas	25,000	0.008%
Soil moisture	16,000	0.005%
Atmosphere	3,100	0.001%
Rivers	300	0.0001%
Total water volume	**326,000,000**	**100%**

Source: Nace, U.S. Geological Survey, 1967 and
The Hydrologic Cycle (Pamphlet), U.S. Geological Survey, 1984

[Source: http://ga.water.usgs.gov/edu/earthwherewater.html]

Hydrology

Water is continuously collected, purified, and distributed in the hydrological cycle. This natural recycling and purification process provides plenty of fresh water as long as we don't overload it with slowly degradable and non-degradable wastes or withdraw water from underground supplies faster than it is being replenished. The hydrologic cycle takes water from the ocean or land surfaces by evaporation, transports it by winds across large distances during which condensation occurs, and deposits the water on the Earth's surfaces in the form of precipitation. Once here, the water gravitates to lower levels, everything being discharged into the oceans or being returned to the atmosphere by evaporation and transpiration. The processes within this cycle happen concurrently, supplied with energy from the sun and gravitational forces.

Water Demand

Since 1950 the rate of global water withdrawal has increased almost fivefold and per capita use has tripled, largely to meet the food and other resource needs of the world's rapidly growing population. The United States has the highest per capita water withdrawal rate in the world, followed by Canada, Australia, the CIS (Confederation of Independent States, former USSR), Japan and Mexico. If every country were to withdraw as much water per person as the United States, fresh water demand globally would exceed water supply.

Competition between cities and farmers for scarce water is escalating in regions such as the western United States and China. Dozens of major cities in Northern China, including Beijing, already face acute water shortages, and chronic water shortages are expected in 450 of China's 644 cities by the turn of the century. Potential for Conflict

The next wars in the Middle East will probably be fought over water not oil. Most of the water in this region comes from three shared river basins: the Jordan (Jordan, Syria, Israel), the Tigris-Euphrates (Iraq, Syria, Turkey), and the Nile (Ethiopia, Sudan, Egypt). Clearly, distribution of water resources will be a key issue in this volatile region.

Water Supply

Some countries have enough annual precipitation, but get it all at one time of the year. In India, for example, 90% of the annual precipitation falls between June and September, the monsoon season. This downpour causes floods and waterlogged soils, leaches soil nutrients, and washes away topsoil and crops. Floods, like droughts, are usually called natural disasters, but human activities have contributed to the sharp rise in flood deaths and damage since the 1960's. Cultivation of land, deforestation, overgrazing, and mining have removed water-absorbing vegetation and soil. Urbanization also increases flooding, even with moderate rainfall, by replacing vegetation and soil with highways, parking lots and buildings that lead to rapid runoff of rainwater.

Droughts, periods in which precipitation is much lower than normal and evaporation much higher, cause more damage and suffering worldwide than any other natural hazard. At least 80 arid and semiarid countries where 40% of the world's people live, experience droughts that span many years.

In many parts of the world water is contaminated. Many rivers are severely polluted and aquifers used for drinking water in many moderately or lesser-developed countries are becoming contaminated with pesticides, fertilizers, and hazardous organic chemicals. In China, for example, 41 cities get their drinking water from polluted groundwater. In its passage through the hydrologic cycle, water is polluted by: sediment, excess nutrients, pathogens, and hazardous chemicals. All four categories of waste are increasing because of rapid population growth, poverty, and industrialization.

The United States has plenty of fresh water, but much of it is in the wrong place at the wrong time. In the East the largest uses for water are energy production, cooling, and manufacturing. In the arid West by far the largest use is irrigation. Many major urban centers, especially those in the West, are in areas that don't have enough water or are projected to have water shortages by the year 2000.

Tapping groundwater is another way to increase water supply. In the United States 25% of all fresh water used is groundwater. About half of the country's drinking water and 40% of the irrigation water is pumped from aquifers. Currently about 40% of the groundwater withdrawn in the United States is not replenished. The most serious overdraft is in parts of the Ogallala Aquifer, extending from northern Nebraska to northwestern Texas. Aquifer depletion is also a serious problem in Saudi Arabia, northern China, Mexico City, Bangkok, and parts of India. For example, the demands of Mexico City's 24 million people is lowering the water table of their main aquifer as much as 11 feet (3.4 m) per year. Saudi Arabia's remarkable increase in agricultural productivity is based on withdrawing water from fossil aquifers, with essentially negligible recharge rates, to irrigate crops in the desert. At the current rate this country's fossil groundwater will be exhausted by 2007.

Desalinization, the removal of salt from ocean water or brackish (slightly salty groundwater), is another way to increase fresh water supplies. Distillation and reverse osmosis are the two most common methods. Distillation involves heating salt water and collecting the vapor. In reverse osmosis salt water is pumped at very high pressure through a thin membrane whose pores allow water molecules, but not dissolved salts, to pass through. Although about 7,500 desalinization plants are operating in about 120 countries, these plants provide less than 0.1% of the world's water. Desalinization uses vast amounts of electricity and therefore costs three to five times more than water from conventional sources. Distributing the water from coastal desalinization plants costs even more in terms of energy needed to pump the water inland and uphill. Desalinated water will probably never be cheap enough to use for irrigating conventional crops or to meet much of the world's demand for fresh water, unless efficient solar-powered methods can be developed.

Watershed transfers can move stream runoff from rich watersheds to water-poor areas. Two of the world's largest watershed transfer projects are the California Water Project and the diversion of water from rivers feeding the Aral Sea in the CIS (Confederation of Independent States, former USSR) to irrigate cropland. In California 75% of the population lives south of Sacramento, but 75% of the rain falls north of it. Southern Californians want more water from the North to support cities like Los Angeles, San Diego, and to grow crops. Agriculture uses 72% of all the water withdrawn in California. Irrigation for just two crops, alfalfa and cotton, uses as much water as the residential needs of all 30 million Californians! Northern Californians argue that sending more water South would further degrade the Sacramento River, threaten fisheries, and reduce the flushing action that helps clean San Francisco Bay of pollutants. They also argue that much of the water already sent South is wasted and that making irrigation just 10% more efficient would provide enough water for domestic and industrial uses in Southern California.

Allocation of A Finite Resource

In the years ahead the debate over water allocation will intensify dramatically. While much of the developing world will continue to build dams and irrigation projects, the developed world will turn to conservation and efficiency. Ways to slow depletion of water include: slowing population- growth, reducing consumption, improving efficiency, growing less water-thirsty crops in dry areas, reuse and recycling. Less water will be available for agriculture as it is diverted to meet the needs of municipalities, industry, and the environment. However, even small gains in irrigation efficiency can offset this loss. Israel now boasts the most water efficient agricultural economy in the world. Half desert, this Connecticut sized nation has brought about what is widely perceived as an agricultural miracle over the last three decades. This has included perfecting drip irrigation, which is 95% efficient. With 69% of the world's water going to agriculture, this is clearly the place where the greatest gains in conservation can be made.

Water Conservation Techniques

A number of techniques and technologies can be used to make agricultural, industrial and domestic water use more efficient. Reductions can easily occur in the following areas.

Reducing Agricultural Waste - Irrigation accounts for about 70 % of the world's water use. Most irrigation systems deliver water to crops by flooding the land surface, diverting water to fields via open channels, or by sprinkler systems that apply water to the field surface. In general, these methods are very inefficient as the plants absorb only 50 % of the water applied. The rest is lost to the atmosphere by evaporation. **Micro-irrigation** techniques can reduce the amount of water applied to crops by 40 to 60 %. Other strategies that can be used to reduce agricultural water use include:

- The cultivation of food crops that require less water for growth.
- The use of lined or covered irrigation canals to reduce infiltration and evaporation losses.
- Irrigating crops at night or early morning when evaporation potentials are low.
- Reduce water subsidies and encourage the proper pricing of this resource.

Reducing Industrial Waste - Industry is the second largest user of water supplies. Reducing the amount of water used in industry not only makes more water available for other purposes but it can also reduce the volume of pollution. Industry reductions can be achieved by:

- Designing industrial processes to recycle water. For example, water used for industrial cooling purposes can be cooled down in a cooling tower and then reused.
- Increasing the cost of water to industries to encourage water recycling.
- Recycling materials themselves can also greatly reduce water demand. For example, manufacturing a ton of aluminum from scrap rather than from virgin ore can reduce the volume of water used by 97 %.

Reducing Domestic Waste - Some strategies for reducing domestic consumption include:

- Replace lawns in semiarid and arid urban areas with xeriscaped surfaces.
- Encourage the use of efficient irrigation systems for home garden and lawn use.
- Manufacture and legislate the use of more efficient dishwashers, washing machines, and bathroom showers and toilets.
- Encourage leak detection and repair for distribution systems. Distribution systems in many of the world's urban areas are losing between 25 and 50 % of their water supplies due to leaks in pipes.
- Properly price water for domestic use. This price must reflect the environmental cost of over consumption and resource degradation. Many studies have shown that higher prices for water provide motivation for people to conserve. The introduction of water meters in Boulder, Colorado reduced water use by about 30 %. In Canada, water is metered in approximately two-thirds of the municipalities.
- Education can encourage people to reduce the amount of personal consumption.

[Source: http://www.geog.ouc.bc.ca/conted/onlinecourses/geog_210/210_8_6.html%5D

Ecological Restoration

The world's largest ecological restoration project is an attempt to undo and redo an engineering project that is destroying Florida's Everglades. The Florida Everglades is a slow-flowing river 50 miles (80 km) wide and generally only 6 inches (15 cm) deep. It begins south of Orlando in a series of spring-fed lakes that drain into the Kissemmee River, which until the 1960's meandered approximately 100 miles (160 km) through marshlands to the vast, shallow Lake Okeechobee. From there it flows south through Everglades National Park to the estuary of Florida Bay. Without the Everglade's rain distribution and aquifer recharge system, Miami and the rest of South Florida would be uninhabitable.

Since the Civil war half the original Everglades has been lost to development. The most devastating blow came in the 1960's when the U.S. Army Corps of Engineers transformed the meandering 100 mile long Kissemmee River into a straight 56 mile (84 km) canal. By the 1960's the park had lost 80% of its marshlands. In 1976 the Florida legislature passed a bill calling for the restoration of the Kissemmee River. Now a $1 billion restoration project is underway with the Federal Government picking up 75% of the tab. This project will not restore the Everglades to its original state, but it will fix some of what was broken.

Waste

It is estimated that the world wastes about 65% of its water and the United States, which uses 30% of the world's fresh water, wastes 50%. If we could reduce water waste to 15% or less we could meet most of the world's water needs for the foreseeable future. Of course there must be incentives to encourage conservation. In many parts of the world farmers pay based on the amount of land they irrigate rather than the amount of water they use. A prime source of water waste is artificially low prices. Cheap water is the only reason farmers in southern California or Arizona can grow water-thirsty crops like alfalfa in the middle of the desert.

Water subsidies are paid for by taxpayers in higher taxes. Because these external costs don't show up on monthly water bills, consumers have little incentive to use less water or to install water-conserving devices or processes. The Federal Bureau of reclamation supplies 25% of all the water used to irrigate land in the western United States under long term contracts (typically 40 years) at greatly subsidized prices. Another reason for water waste in the United States is that the responsibility for water resource management in a particular watershed may be divided among many state and local governments rather than being handled by one authority.

U.S. Water Policy

River Basin Planning is a holistic way to ensure that the whole river basin is looked at. Before the Corps of Engineers could turn a lower river basin into a freeway for barges, it would have to look at the Bureau of Reclamation's need for irrigation water in the upper river basin.

River Basin Accounting is a way to take all the revenues from projects in any basin and toss them in a common fund. This is one way the Bureau of Reclamation justified more money, by making dams, which would subsidize money losing irrigation projects.

While conceptually appealing, most of the attempts at water management by river basin have been failures, because our society is not hydrologically organized. Human endeavors tend to follow other lines, legal or political boundaries, historical, economic or service areas. Often water ownership will extend to the center of the stream, a circumstance that virtually guarantees fragmentation of the water resource.

Three major surface water rights hold sway in the United States: riparian rights, prior appropriation, and hybrid systems. Currently, 29 states utilize riparian rights system, whereby a landowner receives limited rights of water use (not possession) for water bordering on his or her property. The prior appropriation doctrine followed by 19 states and strictly by nine, arose out of the mining camps in the American west in the 1840's. In the absence of law enforcement they devised their own rough and ready rule of first in time, first in right. The prior appropriation doctrine continues to function on the basis that the first entity to use a water source claims sole rights to its use. The third major doctrine, the hybrid system, is a combination of the other two doctrines.

Groundwater rights are more complex than surface water because of the common pool nature of most groundwater sources. Five groundwater doctrines are currently in use across the United States: absolute ownership, prior appropriation, groundwater as a public resource, reasonable use, and correlative rights.

The Unfinished Business of U.S. Water Policy

Groundwater serves as the principal source of drinking water for 50% of all Americans, and for an estimated 97% of those living in rural areas. Groundwater is largely unregulated and increasingly polluted.

Non-Point Pollutants are typically dispersed substances like pesticides, fertilizers, and other agricultural chemicals associated with the use of rural or suburban lands; sediments from mining or construction activity; and, in urban areas the wide range of pollutants from storm water runoff from city streets.

Wetlands have been declining at an alarming rate. Since the arrival of the first European settlers more than half the original 215 million acres of wetlands of the United States have been drained and converted to other uses. Beyond the stated goal of "no net loss" there is now a widespread perception that the total area of wetlands needs to be increased. This may become the new mission for the Corps of Engineers. Wetlands are being seen as the essential link between terrestrial and aquatic ecosystems.

Basic Laws Relating to Water
[Source: http://www.epa.gov/win/law.html]

- Reclamation Act of 1902
- Clean Water Act (Started as Water Pollution Control Act) of 1948, 1987 - (CWA) establishes a sewage treatment construction grants program, and a regulatory and enforcement program for discharges of wastes into U.S. waters.

- Wild and Scenic Rivers Act of 1968 protects certain selected rivers of the Nation which, "with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations."
- National Environmental Policy Act of 1969 (NEPA) requires, in part, EPA to review environmental impact statements.
- Endangered Species Act of 1973
- Safe Drinking Water Act of 1974, 1986 (SDWA) establishes primary drinking water standards, regulates underground injection disposal practices, and establishes a groundwater control program.
- Toxic Substance Control Act of 1976 (TSCA) regulates the testing of chemicals and their use
- Resource Conservation and Recovery Act of 1976 (RCRA**)** provide regulation of solid and hazardous waste
- Comprehensive Environmental Response, Compensation, and Liability Act of 1980
- Food Security Act of 1985
- Water Resources Development Act of 1986, 1992
- Reclamation Projects Authorization and Adjustment Act of 1992
- Energy Policy of 1992

[Source: http://www.cnie.org/nle/crsreports/briefingbooks/laws/a.cfm]

Conclusions

Sustainable development means meeting the needs of the present without sacrificing the ability of future generations to meet their own needs. Perhaps the best test of how well we are doing is to look at how well we are conserving and managing our water resources. There are some choices we can make:

- Get a handle on runaway growth of human populations and per capita consumption.
- Dramatically reduce the wasting of water in agriculture, industry and municipalities.
- Correct water policies (e.g. use-it or lose-it) and subsidies that encourage waste. People only make sound decisions when prices reflect the true cost and value of a product or service. Many water costs are externalized and absorbed by the general public in the form of higher taxes
- Put incentives in place to encourage water conservation. This means ensuring that Best Available Technology (BAT) is being used along with the Best Management Practices (BMPs).
- Look critically at federal government mega-projects that ignore long-term cumulative effects. More authority has to be delegated downward, and smaller scale projects encouraged.
- Reform government water agencies and committees to eliminate inefficiency, redundancy, and inconsistency.
- Establish a central focus for water policy in the federal government and the corresponding accountability.
- Begin to treat groundwater and surface water in an integrated manner.
- Upgrade or at least maintain the aging water infrastructure in the United States.
- Recognize the value of in-stream water, and aquatic ecosystems.
- Teach our children about water, the resource that connects ecology, history, economics, politics, navigation, health, economic development and human progress.
- Conserve water by producing more with less: less input, less waste, and less pollution.
- Use ecosystem management at the watershed level to manage forests sustainably.

Summary

We are all riding through space on this tiny blue dot together. We live on the water planet, which is precisely the right distance from the sun so that all the water doesn't boil away or freeze. All life on earth depends on water for its existence. Grasping the connection between our own destiny and that of water is integral to the challenge of meeting human needs while protecting the ecological functions that all life depends upon. People and water are part of a greater whole. While water is a renewable resource it is a finite resource, and is not evenly distributed around the world. How water is distributed among existing generations and passed on from one generation to the next is the issue of our time. How we handle this challenge will determine our future on this planet, and good planets are very hard to find. That's Amazing!

Russia's Lake Baikal contains one fifth of all the fresh surface water on the planet. It is 372 miles long, 31 miles wide, and one mile deep. It harbors over 1800 species of plants and animals found nowhere else in the world. The Russian boreal forest, the taiga, is the critical resource maintaining the lake. The Siberian portion of the watershed is 80.5 million acres or 32.6 million hectares.

The world's longest rivers in order are:

- Nile (Africa) - 4,160 mi/6,690 km
- Amazon (South America) - 4,080 mi/6,570 km
- Mississippi-Missouri (North America) - 3,740 mi/6,020 km
- Yangtze (Asia) - 3,720 mi/5,980 km

In area, the largest natural lake in the world is the Caspian Sea in Asia, which covers 143,240 square miles (371,000 square kilometers). By comparison the largest lake in North America is Lake Superior, which covers 31,760 square miles (82,260 square kilometers).

The deepest point in the ocean is the Milwaukee Depth (Puerto Rico Trench) in the Atlantic at 30,238 feet (9,219 m) and the world's tallest point is Mt. Everest at 29,028 feet (8,848 m).

Each year the United States uses over 500,000 gallons (2,075 tons) of water for every man, woman and child. The average price of this water for uses is 19 cents per 1,000 gallons. The United States uses twice as much water per capita as any other country in the world.

About 38% of the global grain harvest becomes food for livestock. Animal agriculture is highly water intensive, especially where feed grain is irrigated. A kilogram (2.2 lbs) of hamburger or steak produced by a typical California beef cattle operation uses 5,432 gallons of water.

Properties of Water

Water has many properties, which make it truly unique when compared with other molecules of similar weight. For example:

- Water's high boiling point 212 degrees F (100 degrees C) and low freezing point 32 degrees F (0 degrees C), means that it remains in a liquid state in most climates on earth.
- Water's high heat capacity, means it can store a large amount of heat without a large change in temperature. This helps to protect living organisms, like people and trees, from the shock of abrupt temperature change. Water moderates the Earth's climate and is an effective coolant for car engines, power plants, and other heat producing industrial processes.
- Liquid water has a very high heat of vaporization, meaning that it takes a lot of heat to evaporate liquid water. Water's ability to absorb large amounts of heat as it changes into water vapor, and to release this heat as it condenses back into liquid is a primary factor in distributing heat throughout the world.

- Liquid water dissolves a variety of compounds. This enables water to dissolve nutrients throughout the tissues of living organisms, to serve as an all-purpose cleanser, and to help remove and dilute the water-soluble wastes of civilization. However, water's superiority as a solvent means that it is easily polluted by water-soluble wastes. Water is also a carrier of disease causing bacteria and viruses.
- Liquid water has extremely high surface tension and even higher wetting ability, which is its capacity to adhere to and coat a solid. Together, these properties help water to rise through a plant from roots to leaves.
- Liquid water is the only common substance that expands rather than contracts when it freezes. Consequently ice has a lower density (i.e. weight per unit of volume) than liquid water. Thus, ice floats on water and bodies of water freeze from the top down. Without this property, lakes and streams in cold climates would freeze solid, and most current forms of aquatic life would not exist. Because water expands on freezing, it can break pipes, crack engine blocks, and fracture rocks and pavement.

[Also see: http://www.geog.ouc.bc.ca/conted/onlinecourses/geog_210/210_8_1.html]

Glossary

Agroforestry: The combined production of both crops and trees to maximize water efficiency.

Aquifers: Porous, water-saturated layers of sand, gravel or bedrock through which groundwater flows that can yield an economically significant amount of water.

Common Law: Most groundwater use is based on common law, which holds that the subsurface water belongs to whoever owns the land above it. This means landowners can withdraw as much as they want to use on their land.

Groundwater: Precipitation that infiltrates the ground and fills the pores in rocks and soil.

Prior Appropriation: The first-come first-serve approach to water use, most common in the western United States. The first user of water from a stream establishes a legal right for the continued use of the amount originally withdrawn. This use-it or lose-it approach offers no efficiency incentive.

Public Trust Doctrine: Asserts that governments hold certain rights in trust for the public benefit and can take action to protect these rights from private interest.

Riparian Rights: A system of water rights that gives anyone whose land adjoins a flowing stream the right to use water from the stream as long as some is left for downstream landowners. This system is most common in the Eastern United States.

Surface Water: Precipitation that does not soak into the ground or return to the atmosphere by evaporation.

Transpiration: The process by which plants pull water up from their roots to leaves to be evaporated in the atmosphere.

Water: A compound consisting of two parts hydrogen and one part oxygen, H2O. Pure water is a colorless, odorless, transparent liquid.

Water Marketing: An idea that farmers and other users with water rights who save through conservation or growing less water-thirsty crops should be able to sell or lease the water they save to industries and cities rather than losing their rights to the water.

Watershed: The sloping land that collects, directs, and controls the flow of rainwater in a river basin.

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