Fresh water

Rivers, lakes, and marshlands, such as (from top) South America's Amazon River, Russia's Lake Baikal, and the Everglades in Florida of the United States, are types of freshwater systems.

Fresh water (or **freshwater**) is any naturally occurring water except seawater and brackish water. Fresh water is generally characterized by having low concentrations of dissolved salts and other total dissolved solids. Though the term specifically excludes seawater and brackish water, it does include mineral-rich waters such as chalybeate springs. Fresh water may include water in ice sheets, ice caps, glaciers, icebergs, bogs, ponds, lakes, rivers, streams, and even underground water called groundwater.

Water is critical to the survival of all living organisms. Some organisms can thrive on salt water, but the great majority of higher plants and most mammals need fresh water to live.

Fresh water is not always potable water, that is, water safe to drink. Much of the earth's fresh water (on the surface and groundwater) is to a substantial degree unsuitable for human consumption without some treatment. Fresh water can easily become polluted by human activities or due to naturally occurring processes, such as erosion.

Contents

Definitions
- Numerical definition
- Systems

Sources
Water distribution
Aquatic organisms
Problems
- Limited resource
- Minimum streamflow
- Water pollution

Solutions
- Unlimited resources

Human uses
- Agriculture
- Examples

See also
References
External links

Definitions

Numerical definition

Fresh water can be defined as water with less than 500 parts per million (ppm) of dissolved salts.[1]

Other sources give higher upper salinity limits for fresh water, e.g. 1000 ppm[2] or 3000 ppm.[3]

Systems

Fresh water habitats are classified as either lentic systems, which are the stillwaters including ponds, lakes, swamps and mires; lotic which are running-water systems; or groundwaters which flow in rocks and aquifers. There is, in addition, a zone which bridges between groundwater and lotic systems, which is the hyporheic zone, which underlies many larger rivers and can contain substantially more water than is seen in the open channel. It may also be in direct contact with the underlying underground water.

The majority of fresh water on Earth is in ice caps.

Earth seen from Apollo 17 on December 7, 1972. The Antarctic ice sheet at the bottom of the photograph contains 61% of the fresh water, or 1.7% of the total water, on Earth.

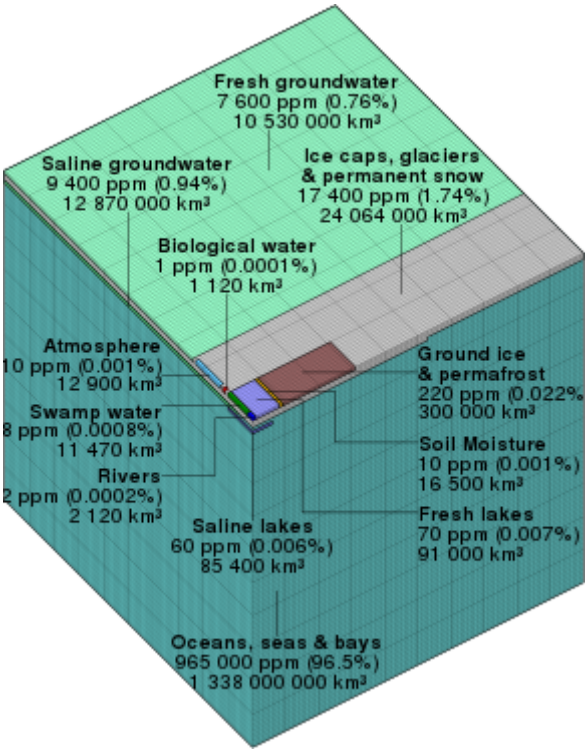
Sources

The source of almost all fresh water is precipitation from the atmosphere, in the form of mist, rain and snow. Fresh water falling as mist, rain or snow contains materials dissolved from the atmosphere and material from the sea and land over which the rain bearing clouds have traveled. In industrialized areas rain is typically acidic because of

dissolved oxides of sulfur and nitrogen formed from burning of fossil fuels in cars, factories, trains and aircraft and from the atmospheric emissions of industry. In some cases this acid rain results in pollution of lakes and rivers.

In coastal areas fresh water may contain significant concentrations of salts derived from the sea if windy conditions have lifted drops of seawater into the rain-bearing clouds. This can give rise to elevated concentrations of sodium, chloride, magnesium and sulfate as well as many other compounds in smaller concentrations.

In desert areas, or areas with impoverished or dusty soils, rain-bearing winds can pick up sand and dust and this can be deposited elsewhere in precipitation and causing the freshwater flow to be measurably contaminated both by insoluble solids but also by the soluble components of those soils. Significant quantities of iron may be transported in this way including the well-documented transfer of iron-rich rainfall falling in Brazil derived from sand-storms in the Sahara in north Africa.



Visualisation of the distribution (by volume) of water on Earth. Each tiny cube (such as the one representing biological water) corresponds to approximately 1400 cubic km of water, with a mass of approximately 1.4 trillion tonnes (235000 times that of the Great Pyramid of Giza or 8 times that of Lake Kariba, arguably the heaviest man-made object). The entire block comprises 1 million tiny cubes.[4]

Water distribution

Saline water in oceans, seas and saline groundwater make up about 97% of all the water on Earth. Only 2.5–2.75% is fresh water, including 1.75–2% frozen in glaciers, ice and snow, 0.5–0.75% as fresh groundwater and soil moisture, and less than 0.01% of it as surface water in lakes, swamps and rivers.[5][6] Freshwater lakes contain about 87% of this fresh surface water, including 29% in the African Great Lakes, 22% in Lake Baikal in Russia, 21% in the North American Great Lakes, and 14% in other lakes. Swamps have most of the balance with only a small amount in rivers, most notably the Amazon River. The atmosphere contains 0.04% water.[7] In areas with no fresh water on the ground surface, fresh water derived from precipitation may, because of its lower density, overlie saline ground water in lenses or layers. Most of the world's fresh water is frozen in ice sheets. Many areas suffer from lack of distribution of fresh water, such as deserts.

Water fountain found in a small Swiss village; used as a drinking water source for people and cattle.

Aquatic organisms

Water is a critical issue for the survival of all living organisms. Some can use salt water but many organisms including the great majority of higher plants and most mammals must have access to fresh water to live. Some terrestrial mammals, especially desert rodents, appear to survive without drinking, but they do generate water through the metabolism of cereal seeds, and they also have mechanisms to conserve water to the maximum degree.

Fresh water creates a hypotonic environment for aquatic organisms. This is problematic for some organisms with pervious skins or with gill membranes, whose cell membranes may burst if excess water is not excreted. Some protists accomplish this using contractile vacuoles, while freshwater fish excrete excess water via the kidney.[8] Although most aquatic organisms have a limited ability to regulate their osmotic balance and therefore can only live within a narrow range of salinity, diadromous fish have the ability to migrate between fresh water and saline water bodies. During these migrations they undergo changes to adapt to the surroundings of the changed salinities; these processes are hormonally controlled. The eel (*Anguilla anguilla*) uses the hormone prolactin,[9] while in salmon (*Salmo salar*) the hormone cortisol plays a key role during this process.[10]

Many sea birds have special glands at the base of the bill through which excess salt is excreted. Similarly the marine iguanas on the Galápagos Islands excrete excess salt through a nasal gland and they sneeze out a very salty excretion.

Freshwater molluscs include freshwater snails and freshwater bivalves. Freshwater crustaceans include freshwater crabs and crayfish.

Unfortunately freshwater biodiversity faces many threats.[11] The World Wide Fund for Nature's Living Planet Index noted an 83% decline in the populations of freshwater vertebrates between 1970 and 2014.[12] These declines continue to outpace contemporaneous declines in marine or terrestrial systems. The causes of these declines are varied but are related to what Reid et al. call the "dirty dozen".[13][14] The dirty dozen are:

1. A rapidly changing climate
2. Online wildlife trade and invasive species
3. Infectious disease
4. Toxic algae blooms
5. Hydropower damming and fragmenting of half the world's rivers
6. Emerging contaminants, such as hormones
7. Engineered nanomaterials
8. Microplastic pollution
9. Light and noise interference
10. Saltier coastal freshwaters due to sea level rise
11. Calcium concentrations falling below the needs of some freshwater organisms
12. The additive—and possibly synergistic—effects of these threats

Problems

Limited resource

Fresh water is a renewable and variable, but finite natural resource. Fresh water can only be replenished through the process of the water cycle, in which water from seas, lakes, forests, land, rivers, and reservoirs evaporates, forms clouds, and returns as precipitation. Locally, however, if more fresh water is consumed through human activities than is naturally restored, this may result in reduced fresh water availability from surface and underground sources and can cause serious damage to surrounding and associated environments.

Fresh and unpolluted water accounts for 0.003% of total water available globally.[15]

The increase in the world population and the increase in per capita water use puts increasing strains on the finite resources availability of clean fresh water. The World Bank adds that the response by freshwater ecosystems to a changing climate can be described in terms of three interrelated components: water quality, water quantity or volume, and water timing. A change in one often leads to shifts in the others as well.[16] Water pollution and subsequent eutrophication also reduces the availability of fresh water.[17]

Many areas of the world are already experiencing stress on water availability (or water scarcity). Due to the accelerated pace of population growth and an increase in the amount of water a single person uses, it is expected that this situation will continue to get worse. A shortage of water in the future would be detrimental to the human population as it would affect everything from sanitation, to overall health and the production of grain.[18]

Minimum streamflow

An important concern for hydrological ecosystems is securing minimum streamflow, especially preserving and restoring instream water allocations.[19] Fresh water is an important natural resource necessary for the survival of all ecosystems. The use of water by humans for activities such as irrigation and industrial applications can have adverse impacts on down-stream ecosystems.

Fresh water withdrawal is the quantity of water removed from available sources for use in any purpose, excluding evaporation losses. Water drawn off is not necessarily entirely consumed and some portion may be returned for further use downstream.

Water pollution

Pollution from human activity, including oil spills and also presents a problem for freshwater resources. The largest petroleum spill that has ever occurred in fresh water was caused by a Royal Dutch Shell tank ship in Magdalena, Argentina, on 15 January 1999, polluting the environment, drinkable water, plants and animals.[20] Chemical contamination of fresh water can also seriously damage eco-systems.

Solutions

Unlimited resources

Closed water cycles, reclaimed water, atmospheric water generation and desalination can all be considered unlimited water resources. These artificial resources are based on the use of energy, infrastructure and human expertise, but are potential solutions to the various water crisis. Currently, as energy is limited the coefficient of resource input to output, thus process efficiency is the determinant. An example is the IBTS Greenhouse which uses 0.45kwh of energy for the production of 1.0 m3 of distilled water. The other important determinant is the occurrence of negative side effects of the technologies. The Integrated Biotectural System is an example for a low-tech solution, based on a natural wetland, without the use of toxic anti-sealants used in industrial desalination plants and without the discharge of brine into the source water body as it is common in the desalination industry.

Human uses

Agriculture

Water used for agriculture is called *agricultural water* or *farm water*.[21] Changing landscape for the use of agriculture has a great effect on the flow of fresh water. Changes in landscape by the removal of trees and soils changes the flow of fresh water in the local environment and also affects the cycle of fresh water. As a result, more fresh water is stored in the soil which benefits the agriculture. However, since agriculture is the human activity that consumes the most fresh water,[22] this can put a severe strain on local freshwater resources resulting in the destruction of local ecosystems.

In Australia, over-abstraction of fresh water for intensive irrigation activities has caused 33% of the land area to be at risk of salination.[22] With regards to agriculture, the World Bank targets food production and water management as an increasingly global issue that will foster debate.[23]

Examples

One in eight people in the world do not have access to safe water.[24][25] Inappropriate use of water may contribute to this problem. The following tables provide some indicators of water use.

Recommended basic water requirements for human needs (per person)[26]

Activity	Minimum, litres / day	Range / day
Drinking Water	5	2–5
Sanitation Services	20	20–75
Bathing	15	5–70
Cooking and Kitchen	10	10–50

Water requirements of different classes of livestock[27]

Animal	Average / day	Range / day
Dairy cow	76 L (20 US gal)	57 to 95 L (15 to 25 US gal)
Cow-calf pair	57 L (15 US gal)	8 to 76 L (2 to 20 US gal)
Yearling cattle	38 L (10 US gal)	23 to 53 L (6 to 14 US gal)
Horse	38 L (10 US gal)	30 to 53 L (8 to 14 US gal)
Sheep	8 L (2 US gal)	8 to 11 L (2 to 3 US gal)

Approximate values of seasonal crop water needs[28]

Crop	Crop water needs mm / total growing period
Sugar Cane	1500–2500
Banana	1200–2200
Citrus	900–1200
Potato	500–700
Tomato	400–800
Barley/Oats/Wheat	450–650
Cabbage	350–500
Onions	350–550
Pea	350–500

See also

- African Great Lakes – Series of lakes in the Rift Valley
- Aral Sea – Lake between Kazakhstan and Uzbekistan
- Desalination – Removal of salts and minerals from a substance
- Drought – Extended period of deficiency in a region's water supply
- Freshwater ecology
- Limnology – The science of inland aquatic ecosystems
- List of countries by freshwater withdrawal
- List of countries by total renewable water resources – list of countries by total renewable water resources mostly based on The World Factbook
- Properties of water – Physical and chemical properties of pure water
- Water cycle – Continuous movement of water on, above and below the surface of the Earth

References

1. "Groundwater Glossary" (https://web.archive.org/web/20060428102341/http://www.groundwater.org/gi/gwglossary.html#F). 27 March 2006. Archived from the original (http://www.groundwater.org/gi/gwglossary.html#F) on 28 April 2006. Retrieved 14 May 2006.
2. "Freshwater" (https://web.archive.org/web/20110606104533/http://amsglossary.allenpress.com/glossary/search?p=1&query=freshwater). *Glossary of Meteorology*. American Meteorological Society. June 2000. Archived from the original (http://amsglossary.allenpress.com/glossary/search?p=1&query=freshwater) on 6 June 2011. Retrieved 27 November 2009.
3. "Freshwater" (https://web.archive.org/web/20060511182717/http://www.practicalfishkeeping.co.uk/pfk/pages/glossary.php?entry_name=Freshwater). *Fishkeeping glossary*. Practical Fishkeeping. Archived from the original (http://www.practicalfishkeeping.co.uk/pfk/pages/glossary.php?entry_name=Freshwater) on 11 May 2006. Retrieved 27 November 2009.
4. USGS – Earth's water distribution (http://ga.water.usgs.gov/edu/waterdistribution.html) Archived (https://web.archive.org/web/20120629055146/http://ga.water.usgs.gov/edu/waterdistribution.html) 29 June 2012 at the Wayback Machine. Ga.water.usgs.gov (11 December 2012). Retrieved on 29 December 2012.
5. Where is Earth's water? (http://ga.water.usgs.gov/edu/earthwherewater.html) Archived (https://web.archive.org/web/20131214091601/http://ga.water.usgs.gov/edu/earthwherewater.html) 14 December 2013 at the Wayback Machine, United States Geological Survey.

6. Physicalgeography.net (http://www.physicalgeography.net/fundamentals/8b.html) Archived (https://web.archive.org/web/20160126072955/http://www.physicalgeography.net/fundamentals/8b.html) 26 January 2016 at the Wayback Machine. Physicalgeography.net. Retrieved on 29 December 2012.
7. Gleick, Peter; et al. (1996). Stephen H. Schneider (ed.). *Encyclopedia of Climate and Weather* (https://archive.org/details/encyclopediaofcl02schn). Oxford University Press.
8. "Vertebrate Kidneys" (http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/V/VertebrateKidneys.html). 3 November 2002. Archived (https://web.archive.org/web/20060429045409/http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/V/VertebrateKidneys.html) from the original on 29 April 2006. Retrieved 14 May 2006.
9. Kalujnaia, S.; et al. (2007). "Salinity adaptation and gene profiling analysis in the European eel (Anguilla anguilla) using microarray technology". *Gen. Comp. Endocrinol*. **152** (2007): 274–80. doi:10.1016/j.ygcen.2006.12.025 (https://doi.org/10.1016%2Fj.ygcen.2006.12.025). PMID 17324422 (https://pubmed.ncbi.nlm.nih.gov/17324422).
10. Bisal, G.A.; Specker, J.L. (24 January 2006). "Cortisol stimulates hypo-osmoregulatory ability in Atlantic salmon, Salmo salar L". *Journal of Fish Biology*. **39** (3): 421–432. doi:10.1111/j.1095-8649.1991.tb04373.x (https://doi.org/10.1111%2Fj.1095-8649.1991.tb04373.x).
11. Reid, AJ; et al. (2019). "Emerging threats and persistent conservation challenges for freshwater biodiversity" (https://doi.org/10.1111%2Fbrv.12480). *Biological Reviews*. **94** (3): 849–873. doi:10.1111/brv.12480 (https://doi.org/10.1111%2Fbrv.12480). PMID 30467930 (https://pubmed.ncbi.nlm.nih.gov/30467930).
12. "Living Planet Report 2018 | WWF" (https://wwf.panda.org/knowledge_hub/all_publications/living_planet_report_2018/). *wwf.panda.org*. Retrieved 9 April 2019.
13. Reid, Andrea J.; Carlson, Andrew K.; Creed, Irena F.; Eliason, Erika J.; Gell, Peter A.; Johnson, Pieter T. J.; Kidd, Karen A.; MacCormack, Tyson J.; Olden, Julian D. (2019). "Emerging threats and persistent conservation challenges for freshwater biodiversity" (https://doi.org/10.1111%2Fbrv.12480). *Biological Reviews*. **0** (3): 849–873. doi:10.1111/brv.12480 (https://doi.org/10.1111%2Fbrv.12480). ISSN 1469-185X (https://www.worldcat.org/issn/1469-185X). PMID 30467930 (https://pubmed.ncbi.nlm.nih.gov/30467930).
14. Reid, Andrea Jane; Cooke, Steven J. "Freshwater wildlife face an uncertain future" (https://theconversation.com/freshwater-wildlife-face-an-uncertain-future-108863). *The Conversation*. Retrieved 9 April 2019.
15. Nitti, Gianfranco (May 2011). "Water is not an infinite resource and the world is thirsty". *The Italian Insider*. Rome. p. 8.
16. The World Bank, 2009 "Water and Climate Change: Understanding the Risks and Making Climate-Smart Investment Decisions" (https://web.archive.org/web/20120407105752/http://water.worldbank.org/water/publications/water-and-climate-change-understanding-risks-and-making-climate-smart-investment-decisi/). pp. 19–22. Archived from the original (http://water.worldbank.org/water/publications/water-and-climate-change-understanding-risks-and-making-climate-smart-investment-decisi) on 7 April 2012. Retrieved 24 October 2011.
17. "Nutrients in fresh water" (https://www.eea.europa.eu/data-and-maps/indicators/nutrients-in-freshwater/nutrients-in-freshwater-assessment-published-6)
18. "Fresh Water in the Future" (https://www.un.org/waterforlifedecade/water_cities.shtml) Archived (https://web.archive.org/web/20161230010235/http://www.un.org/waterforlifedecade/water_cities.shtml) 30 December 2016 at the Wayback Machine. Un.org (17 December 2010). Retrieved on 29 December 2012.
19. Peter Gleick; Heather Cooley; David Katz (2006). *The world's water, 2006–2007: the biennial report on freshwater resources* (https://books.google.com/books?id=Lttb1qPh4Z8C). Island Press. pp. 29–31. ISBN 978-1-59726-106-7. Retrieved 12 September 2009.
20. Petroleomagdalena.com (http://www.petroleomagdalena.com) Archived (https://web.archive.org/web/20100514095121/http://www.petroleomagdalena.com/) 14 May 2010 at the Wayback Machine. Petroleomagdalena.com (15 January 1999). Retrieved on 29 December 2012.

21. "USDA Economic Research Service - Irrigation & Water Use" (http://www.ers.usda.gov/topics/farm-practices-management/irrigation-water-use.aspx). *www.ers.usda.gov*. Archived (https://web.archive.org/web/20151115155026/http://www.ers.usda.gov/topics/farm-practices-management/irrigation-water-use.aspx) from the original on 15 November 2015. Retrieved 17 November 2015.
22. Gordon L., D. M. (2003). "Land cover change and water vapour flows: learning from Australia" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1693281). *Philosophical Transactions of the Royal Society B: Biological Sciences*. **358** (1440): 1973–1984. doi:10.1098/rstb.2003.1381 (https://doi.org/10.1098%2Frstb.2003.1381). JSTOR 3558315 (https://www.jstor.org/stable/3558315). PMC 1693281 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1693281). PMID 14728792 (https://pubmed.ncbi.nlm.nih.gov/14728792).
23. *Reengaging in Agricultural Water Management: Challenges and Options* (http://water.worldbank.org/water/publications/reengaging-agricultural-water-management-challenges-and-options), The World Bank, pp. 4–5, archived (https://web.archive.org/web/20120105012930/http://water.worldbank.org/water/publications/reengaging-agricultural-water-management-challenges-and-options/) from the original on 5 January 2012, retrieved 30 October 2011
24. "Global WASH Fast Facts | Global Water, Sanitation and Hygiene | Healthy Water | CDC" (https://www.cdc.gov/healthywater/global/wash_statistics.html). *www.cdc.gov*. 9 November 2018. Retrieved 9 April 2019.
25. Water Aid. "Water" (https://archive.today/20130416024534/http://www.wateraid.org/uk/what_we_do/the_need/5899.asp?gclid=CMvwnO7B164CFUcRfAodFkdffg). Archived from the original (http://www.wateraid.org/uk/what_we_do/the_need/5899.asp?gclid=CMvwnO7B164CFUcRfAodFkdffg) on 16 April 2013. Retrieved 17 March 2012.
26. Gleick, Peter. "Basic Water Requirements for Human Activities" (http://www.bvsde.paho.org/bvsacd/cd17/basic_wate.pdf) (PDF). Archived (https://web.archive.org/web/20130629113313/http://www.bvsde.paho.org/bvsacd/cd17/basic_wate.pdf) (PDF) from the original on 29 June 2013. Retrieved 17 March 2012.
27. Filley, S. "How much does a cow need ?" (https://web.archive.org/web/20120512155949/http://extension.oregonstate.edu/douglas/sites/default/files/documents/lf/WATERLF0503.pdf) (PDF). Archived from the original (http://extension.oregonstate.edu/douglas/sites/default/files/documents/lf/WATERLF0503.pdf) (PDF) on 12 May 2012. Retrieved 17 March 2012.
28. Natural Resource Management and Environmental Dept. "Crops Need Water" (http://www.fao.org/docrep/S2022E/s2022e02.htm). Archived (https://web.archive.org/web/20120116073927/http://www.fao.org/docrep/S2022E/s2022e02.htm) from the original on 16 January 2012. Retrieved 17 March 2012.

External links

- The World Bank's work and publications on water resources (http://water.worldbank.org/water/)
- U.S. Geological Survey (http://ga.water.usgs.gov/edu/mearth.html)
- Fresh Water National Geographic (http://environment.nationalgeographic.com/environment/freshwater/)