HYDROLOGY

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Contents

Summary

Hydrology is the science that deals with the waters of the Earth, their occurrence, circulation and distribution, their chemical and physical properties, and their reaction with their environment, including their relation to living things. Hydrology can be seen as the scientific examination and appraisal of the whole continuum of a water cycle, which takes place at the three parts of the total Earth system: atmosphere, hydrosphere, and lithosphere.

The study of main components of the hydrological cycle includes precipitation, interception, infiltration, evapotranspiration, soil moisture, subsurface flow, groundwater, runoff and stream discharge.

From a geographer's point of view, the main hydrological interest are the increasing pressures on available water resources related to today's rising populations and improving living standards. There is, in general, no shortage of water on the Earth's land surface, but the areas of surplus water are often located far from major centres of population.

1. Definitions

Hydrology in its broadest sense is the science that relates to water. It is an Earth science because it deals with water primarily on Earth.

Hydrology can be defined as:

a) "a science dealing with the occurrence, circulation, distribution and properties of the waters of the Earth and in its atmosphere".
b) "the science that treats the waters of the Earth, their occurrence, circulation and distribution, their chemical and physical properties, and their reaction with their environment, including their relation to living things; in that way the domain of hydrology embraces the full life history of water on the Earth".
c) "the science that deals with the processes governing the depletion and replenishment of the water resources of the land areas of the Earth; it is concerned with the transportation of water through the air, over the ground surface, and through the strata of the Earth; it is the science that examines the various phases of the hydrologic cycle".

Water is the most abundant substance on Earth and is the principal constituent of all living things. Water in the atmosphere plays a major role in maintaining a habitable environment for human life. The occurrence of surface waters has played a significant role in the rise and decline of the major civilisations in world story.

In many societies the importance of water to humankind is reflected in the legal and political structures. At the present time rising populations and improving living standards are placing increasing pressures on available water resources. There is, in general, no shortage of water on the Earth's land surface, but the areas of surplus water are often located far from major centres of population. Moreover, in many cases these centres prove to be sources of water pollution. Thus, the availability and quality of water are becoming an ever-increasing constraint on human activities, notwithstanding the great technological advances that have been made in the control of water surfaces.

2. Scope of hydrology

In practice hydrologists usually restrict their study to waters close to the land surface of the Earth. Water in the atmosphere is usually studied as part of meteorology; water in the oceans and seas is studied within the science of oceanography; water in lakes and island seas within limnology; and ice on the land surface within glaciology. All are linked by the fundamental concept of the hydrological cycle.

In view of the extensiveness of the hydrologic cycle, hydrology is a very broad science. It is an interdisciplinary science because it borrows heavily from many other branches of science and integrates them for its own interpretation and uses. The supporting sciences required for hydrologic investigations are physics, chemistry, biology, geology, fluid mechanics, mathematics and statistics.

Table 1 lists the sciences related to hydrology in the different domains of atmosphere, hydrosphere, lithosphere and flora and fauna.

ATMOSPHERE	HYDROSPHERE	LITHOSPHERE	FLORA AND FAUNA
Hydrometeorology	Potamology	Agronomy	Ecology
Meteorology	Limnology	Hydrogeology	Silviculture
Climatology	Cryology	Geohydrology	Biohydrology
	Glaciology	Geomorphology	
	Oceanology		

Table 1. Sciences related to hydrology.

Since hydrology is a science that underlies the development and control of water resources, it has its influence in several sciences (Figure 1) and it has practical applications (Figure 2).

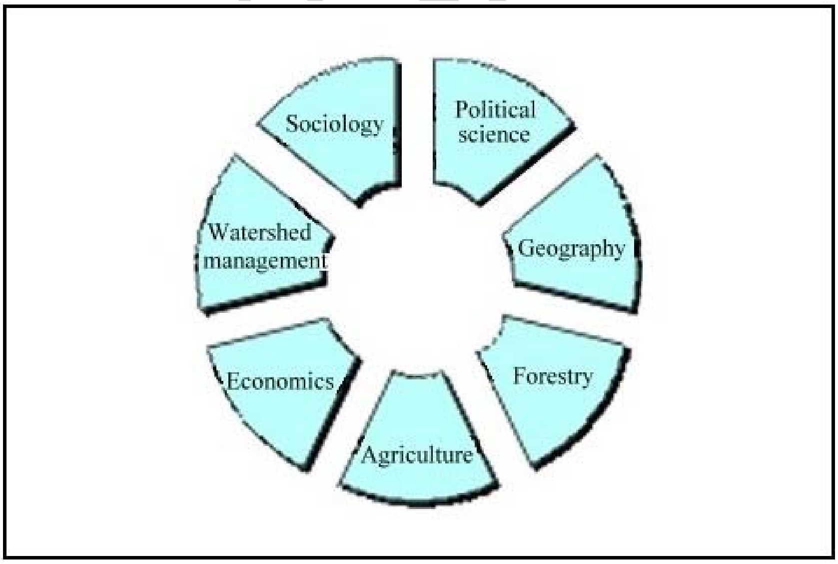

Figure 1. Sciences influenced by Hydrology.

For a geographer, whose interest is focused in human development and integration, knowledge of water resource constitutes the fundamental element for regional planning, where man and environment combine to allow the integrity of policy, economy and society.

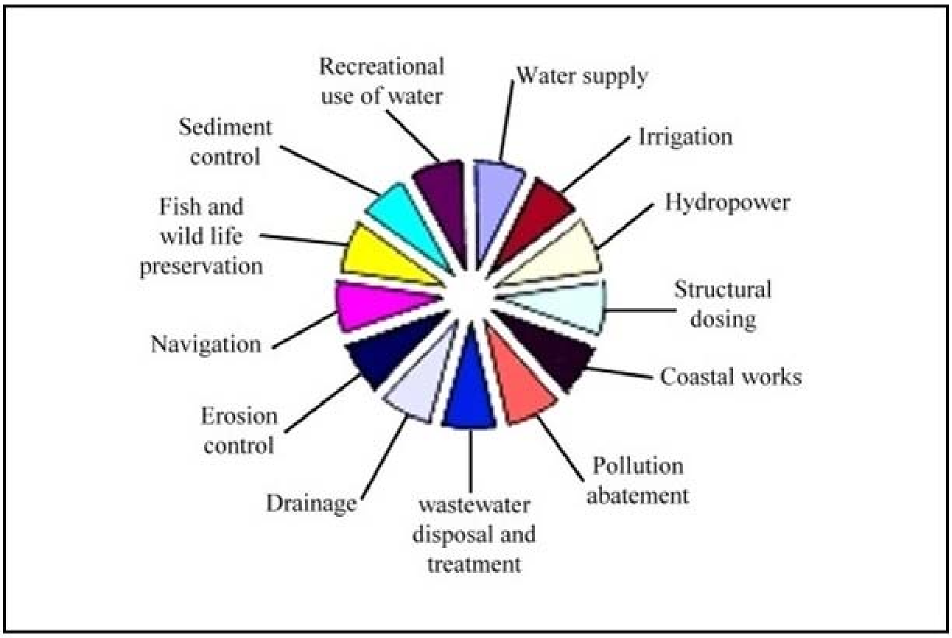

Figure 2. Hydrology practical applications.

3. The hydrological cycle

Hydrology can be seen as the scientific examination and appraisal of the whole continuum of a *hydrologic*, or *water cycle*.

The hydrologic cycle, as can be seen in Figure 3, takes place in the three parts of the total Earth system: atmosphere, hydrosphere, and lithosphere. The *atmosphere* is a gaseous envelope above the hydrosphere; the *hydrosphere* is the bodies of water that cover the surface of the Earth; and the *lithosphere* is the solid rock below the hydrosphere. The activities of water through these three parts of the Earth system, from an average depth of about a half mile in the lithosphere to a height of about ten miles in the atmosphere. They create a gigantic system of great complexity and intricacy.

The hydrologic cycle has no beginning or end, as water evaporates from the oceans and the land and becomes a part of the atmosphere. It can be seen as a system. The evaporated moisture is lifted and carried in the atmosphere until it finally precipitates to Earth, either on land or in the oceans. The precipitated water may be intercepted or transpired by plants, may run over the ground surface and into streams, or may infiltrate into the ground. Much of the intercepted and transpired water and the surface runoff returns to the air through evaporation. The infiltrated water may percolate to deeper zones to be stored as groundwater which may later flow out as springs or seep into streams as runoff, or evaporate into the atmosphere to complete the hydrologic cycle. Thus, the hydrologic cycle undergoes various complicated processes of evaporation, precipitation, interception, transpiration, infiltration, percolation, storage and runoff. Many diagrams have been designed to illustrate the hydrologic cycle; some are qualitative, some descriptive, and some quantitative.

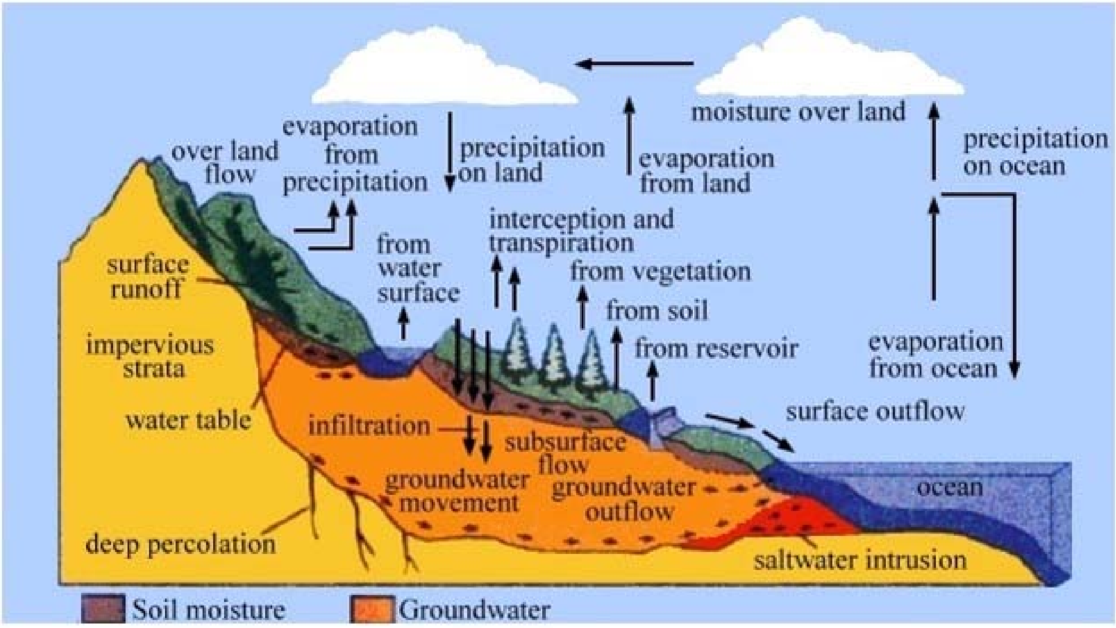

Figure 3. Hydrological cycle.

Although the concept of the hydrologic cycle is simple, the phenomenon is very complex. It is not only a large cycle, it is a compound of a lot of inter related cycles of continental, regional and local extent. Even so the total quantity of Earth's water resources is constant, though its distribution is changing continuously, in continents, regions and local basins.

The total quantity of water on Earth and the different parts of the hydrological cycle have been studied since the second half of the nineteenth century. However, quantitative information is scarce, particularly in the oceans, and many components of the hydrological cycle are not known with precision.

Oceans contain 97% of all the water in the world, or one quadrillion (10^{15}) acre-ft. This quantity would be sufficient to cover the world to a depth of 800 ft, if we assume it were a uniform sphere. The total amount of fresh water is estimated at about 33 trillion acre-ft. These are, however, stationary estimates of distribution. While the water content of the atmosphere is relatively small at any given moment, immense quantities of water pass through it annually. The annual precipitation on the land surface alone is 7.7 times as great as the moisture contained in the entire atmosphere at any time, i.e. about 30 times as great as the moisture in the air over the land. Table 2 shows the estimated quantities of the waters of the world.

Water ´s states	**Surface (km^2)**	**Volume (km^3)**	**Width (m)**	**Proportional parts in world reservoirs**	
				In total water reservoirs	**In sweet reservoirs**
Oceans	361,300,000	1,338,000,000	3,700	96.5	-
Underground water	134,800,000	23,400,000	174	1.7	-

(deep and capillaries)					
Underground water	134,800,000	10,530,000	78	0.76	30.1
Soil water	82,000,000	16,500	0.2	0.001	0.05
Glaciers and snow	16,227,500	20,064,100	1,463	1.74	68.7
Antarctica	13,980,000	21,600,000	1,546	1.56	61.7
Greenland	1,802,400	2,340,000	1,298	0.17	6.68
Arctic Islands	226,100	83,500	369	0.006	0.24
Mountain regions	224,000	40,600	181	0.003	0.12
Underground ice	21,000,000	300,000	14	0.022	0.86
Water reserve in lakes	2,058,700	176,400	85.7	0.013	-
Sweet water	1,236,400	91,000	73.6	0.007	0.26
Salad water	822,300	85,400	103.8	0.006	-
Water reserve in marshes	2,682,600	11,470	4.28	0.0008	0.03
Rivers	148,800,000	2,120	0.014	0.0002	0.006
Biologic water	510,000,000	1,120	0.002	0.0001	0.003
Water in the atmosphere	510,000,000	12,900	0.025	0.001	0.04
Total water reservoirs	510,000,000	1,385,984,610	2,718	100	-
Sweet water	148,800,000	35,029,210	235	2.53	100

Table 2. World water resources. Source: UNESCO, 1978.

The availability of World Water Resources is shown in Figure 4, where it can be seen that South America and Asia are the continents with greatest water resources world-wide, with 12 030 and 13 510 km^3 respectively, with inter-annual variations ranging between ± 15-25 %.

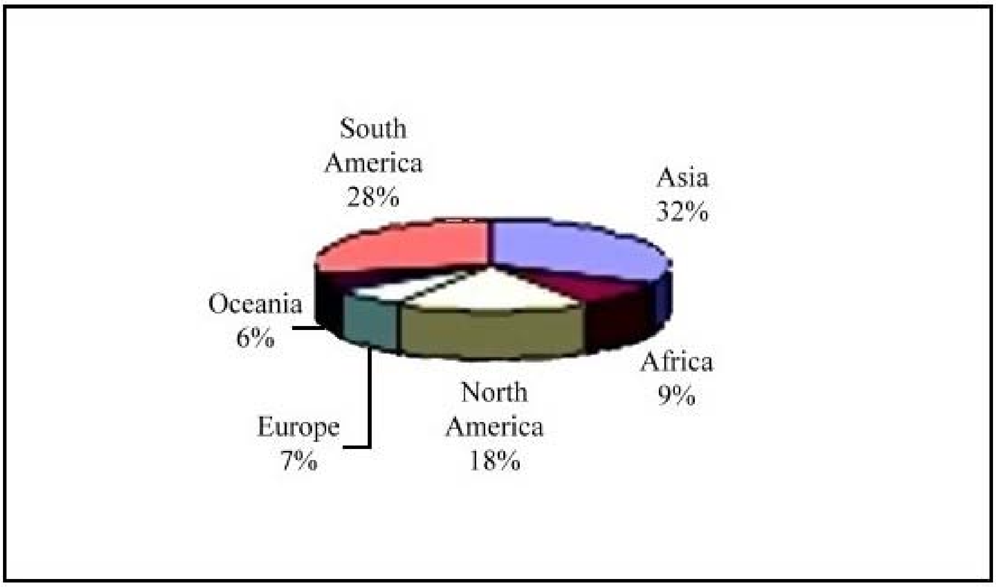

Figure 4. World water resources availability. Source: Global Water Partnership, 2000.

The mean annual precipitation for the entire Earth is about 86 cm y^{-1} (34 inches y^{-1}). Under stationary conditions this is balanced by an equally large evaporation amount. Thus, the average evaporation for the whole Earth amounts to 2.37 mm (c. 0.1 inch) of water per day.

The amounts of evaporation, precipitation, runoff, and other hydrologic quantities are not evenly distributed on the Earth, either geographically or temporally. About 70 to 75% of the precipitation is returned to the atmosphere by evapotranspiration and direct evaporation, while the remaining 30% becomes runoff. About one-fourth is diverted. About two-thirds of that diverted water is fed back into the stream and eventually goes to oceans for storage and evaporation, and the remaining one-third is consumed and returns to the atmosphere directly.

The quantities of water going to another component of the hydrological cycle can be evaluated usually by the so called *hydrologic equation*, which simple states as

$$I - O = \Delta S \qquad (1)$$

where:

- I is the inflow during a given period to a problem area including, for instance, the total inflow of the channel and overland runoff to the area above the ground surface and of the groundwater across the boundaries of the area plus the total precipitation over the area during the period.
- O is the outflow during the given period to the area including, for instance, total evaporation, transpiration, and outflow of surface runoff in channel and overland from the area above the surface plus the outflow of groundwater across the boundaries of the area.
- ΔS is the change in storage in various forms of retention, depression, and interception.

This equation (1) is essentially a form of continuity equation.

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Biographical Sketch

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