

INTRODUCTION

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DEFINITION

The hydrology deals with the water of the earth: their distribution and circulation, their physical and chemical properties, and their interaction with the environment, including interaction with living things and, in particular, human beings. Hydrology may be considered to encompass all the hydrosociences, or defined more strictly as the study of the hydrologic cycle, that is, the endless circulation of water between the earth and its atmosphere. Hydrologic knowledge is applied to the use and control of water resources on the land areas of the earth; ocean waters are the domain of ocean engineering and the marine sciences.

IMPORTANCE OF HYDROLOGY

Water is the most abundant substance on earth, the principal constituent of all living things, and a major force constantly shaping the surface of the earth. It is also a key factor in air-conditioning the earth for human existence and influencing the progress of civilization. Hydrology, which treats all phases of the earth's water, is a subject of great importance for people and their environment. Practical applications of hydrology are found in such tasks as the design and operation of hydraulic structures, water supply, wastewater treatment and disposal, irrigation, drainage, hydropower generation, flood control, navigation, erosion and sediment control, salinity control, pollution abatement, recreational use of water, and fish and wildlife protection. The role of applied hydrology is to help analyze the problems involved in these tasks and to provide guidance for the planning and management of water resources.

SUBJECT MATTER OF HYDROLOGY

Surface water hydrology is the focus of this course which can be divided into three sections:

- Hydrologic Processes
- Hydrologic Analysis and
- Hydrologic Design.

Hydrologic processes describe the scientific principles governing hydrologic phenomena, such as hydrologic cycle, atmospheric water (atmospheric circulation, precipitation, rainfall, evaporation, transpiration, evapotranspiration), subsurface water (unsaturated flow, infiltration, etc.) surface water (sources of streamflow, streamflow hydrographic, excess rainfall and direct runoff), and hydrologic measurement (measurement of atmospheric water, surface water, subsurface water).

Hydrologic analysis emphasizes computational methods in hydrology for specific tasks such as rainfall-runoff modeling, flow routing, and analysis of extreme events.

Hydrologic design focuses on the risks inherent in hydrologic design, the selection of design storms including probable maximum precipitation, and the calculation of design flows for various problems including the design of storm sewers, flood control works, and water supply reservoirs.

HYDROLOGIC CYCLE

Water on earth exists in a space called the hydrosphere which extends about 15 km up into the atmosphere and about 1 km down into the lithosphere, the crust of the earth. Water circulates in the hydrosphere through the maze of paths constituting the hydrologic cycle.

The hydrologic cycle is the central focus of hydrology. The cycle has no beginning or end, and its many processes occur continuously. As shown schematically in fig. 1.1.1, water evaporates from the oceans and the land surface to become part of the atmosphere; water vapor is transported and lifted in the atmosphere until it condenses and precipitates on the land or the oceans; precipitated water may be intercepted by vegetation, become overland flow over the ground surface, infiltrate into the ground flow through the soil as subsurface flow, and discharge



into streams as surface runoff. Much of the intercepted water and surface runoff returns to the atmosphere through evaporation. The infiltrated water may percolate deeper to recharge ground water, later emerging in springs or seeping into streams to form surface runoff, and finally flowing out to the sea or evaporating into the atmosphere as the hydrologic cycle continues.

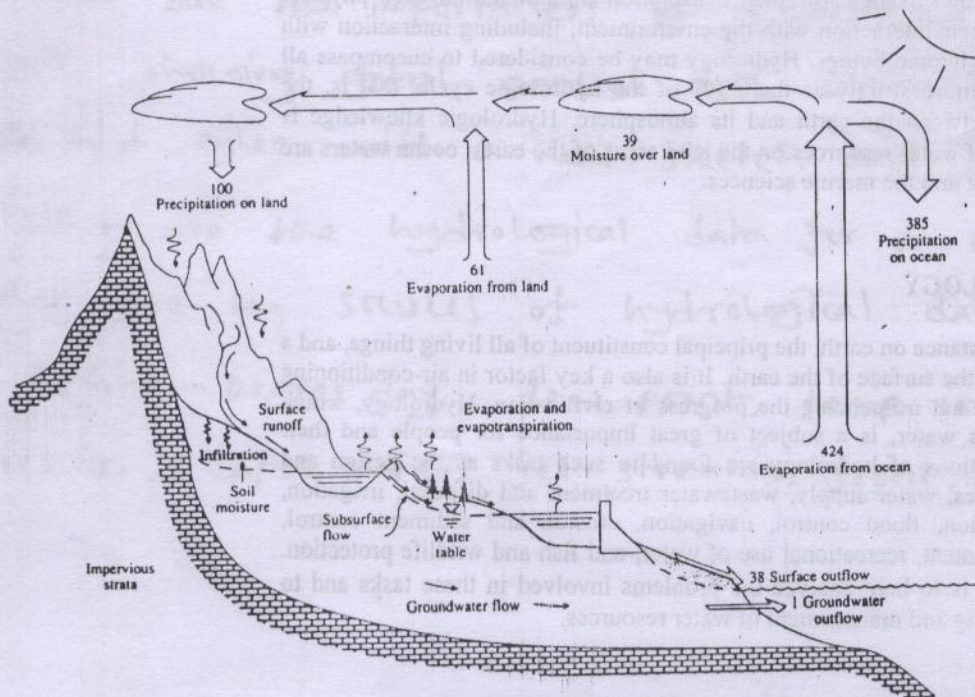


FIGURE 1.1.1 Hydrologic cycle with global annual average water balance given in units relative to a value of 100 for the rate of precipitation on land.

Table 1.1.1 lists estimated quantities of water in various forms on the earth. About 96.5 % of all the earth's water is in the oceans. Of the remainder 1.7% is in the polar ice, 1.7 % in groundwater and only 0.1 % in the surface and atmospheric water systems.

Of the earth's fresh water, about two-thirds is polar ice and most of the remainder is groundwater. Only 0.006 % of fresh water is contained in rivers. The global annual water balance is shown in Table 1.1.2.

The residence time T_r is the average duration for a water molecule to pass through a subsystem of the hydrologic cycle. It is calculated by dividing the volume of water S in storage by the flow

$$T_r = \frac{S}{Q}$$

rate Q .

Problem: Estimate the residence time of global atmospheric moisture.

Solution: The volume of atmospheric moisture = 12,900 km³ (Table 1.1.1)

The flow rate of moisture from the atmosphere as precipitation
= 458,000 + 119,000 = 577,000 km³/yr (Table 1.1.2)

So, the average residence time for moisture in the atmosphere is

$$T_r = \frac{S}{Q} = \frac{12,900}{577,000} = 0.022 \text{ yr} = 8.2 \text{ days}$$

The very short residence time for moisture in the atmosphere is one reason why weather cannot be forecast accurately more than a few days ahead.

TABLE 1.1.1 Estimated world water quantities

Item	Area (10 ⁶ km ²)	Volume (km ³)	Percent of total water	Percent of fresh water
Oceans	361.3	1,338,000,000	96.5	
Groundwater				
Fresh	134.8	10,530,000	0.76	30.1
Saline	134.8	12,870,000	0.93	
Soil Moisture	82.0	16,500	0.0012	0.05
Polar ice	16.0	24,023,500	1.7	68.6
Other ice and snow	0.3	340,600	0.025	1.0
Lakes				
Fresh	1.2	91,000	0.007	0.26
Saline	0.8	85,400	0.006	
Marshes	2.7	11,470	0.0008	0.03
Rivers	148.8	2,120	0.0002	0.006
Biological water	510.0	1,120	0.0001	0.003
Atmospheric water	510.0	12,900	0.001	0.04
Total water	510.0	1,385,984,610	100	
Fresh water	148.8	35,029,210	2.5	100

Table from World Water Balance and Water Resources of the Earth, Copyright, UNESCO, 1978.

TABLE 1.1.2 Global annual water balance

		Ocean	Land
Area (km ²)		361,300,000	148,800,000
Precipitation	(km ³ /yr)	458,000	119,000
	(mm/yr)	1270	800
	(in/yr)	50	31
Evaporation	(km ³ /yr)	505,000	72,000
	(mm/yr)	1400	484
	(in/yr)	55	19
Runoff to ocean			
Rivers	(km ³ /yr)	—	44,700
Groundwater	(km ³ /yr)	—	2200
Total runoff	(km ³ /yr)	—	47,000
	(mm/yr)	—	316
	(in/yr)	—	12

Table from World Water Balance and Water Resources of the Earth, Copyright, UNESCO, 1978

APPLICATION OF HYDROLOGY TO ENVIRONMENTAL PROBLEMS

It is true that humans cannot exist without water; it is also true that water, mismanaged, or during times of deficiency (droughts), or times of surplus (floods), can be life threatening. Furthermore, there is no aspect of environmental concern that does not relate in some way to water. Land, air, and water are all interrelated as are water and all life forms. Accordingly, the spectrum of issues requiring an understanding of hydrologic processes is almost unlimited.

As water becomes more scarce and as competition for its use expands, the need for improved water management will grow. And to provide water for the world's expanding population, new industrial developments, food production, recreational demands, and for the preservation and protection of natural systems and other purposes, it will become increasingly important for us to achieve a thorough understanding of the underlying hydrologic processes with which we must contend. This is the challenge to hydrologists, water resources engineers, planners, policymakers, lawyers, economists, and others who must strive to see that future allocations of water are sufficient to meet the needs of human and natural systems.

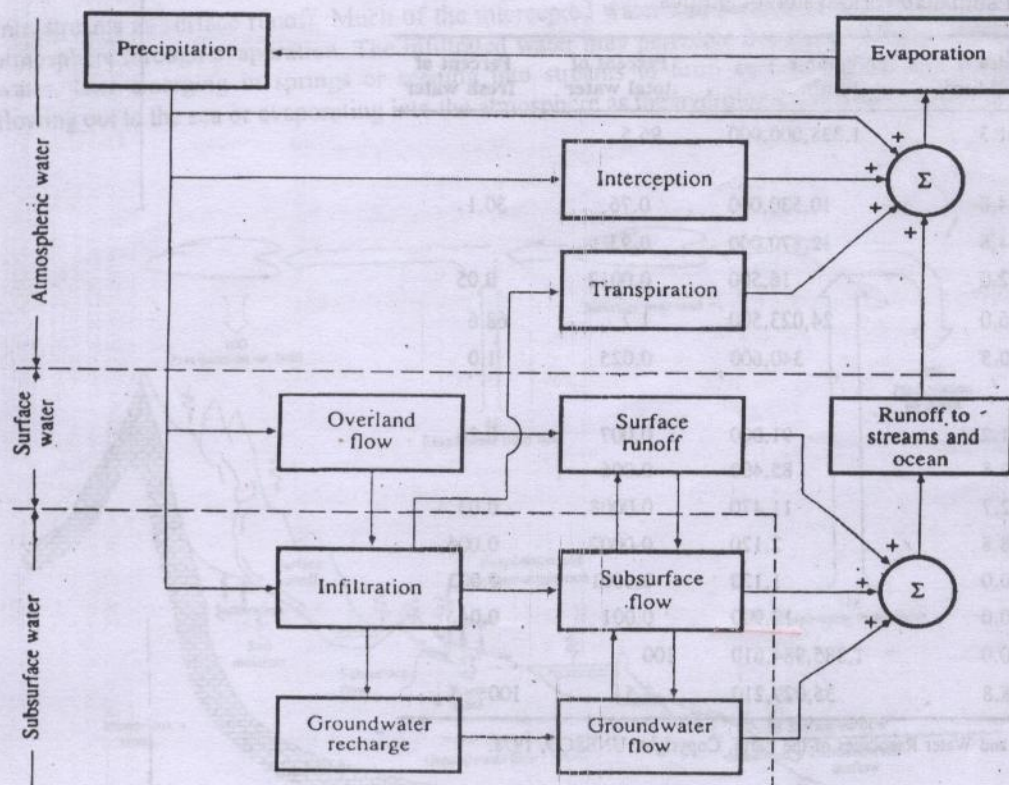


FIGURE 1.2.1 Block-diagram representation of the global hydrologic system.

HYDROLOGICAL DATA

For the analysis and design of any hydrological project adequate data and length of records are necessary.

The basic hydrological data required are

- Climatological data
- Hydrometeorological data (temperature, wind velocity, humidity etc.)
- Precipitation data
- Stream flow data
- Seasonal fluctuation of ground water table
- Evaporation data
- Cropping pattern, crops and their consumptive use
- Water quality data of surface stream and ground water
- Geomorphological studies of the basin like area, shape and slope of the basin, mean and median elevation, mean temperature and other physiographic characteristics of the basin, stream density and drainage density, tanks and reservoir
- Hydrometeorological characteristics of the basin

Sources of data are numerous, with the Surface Water Hydrology Directorate (SWHD) of BWDB being the main one for precipitation, stream flow and ground water facts. The Meteorological Department is the major collector of meteorological data. Many other organizations like BARI, IWM (former SWMC), WARPO, EGIS etc. also compile hydrologic data.

BWDB	Bangladesh Water Development Board
BARI	Bangladesh Agricultural Research Institute
IWM	Institute of Water Modeling
SWMC	Surface Water Modeling Centre
WARPO	Water Resources Project Organization