Development of Hydrology Science

The science of hydrology began with the concept of the hydrologic cycle. From ancient times, many have speculated about the circulation of water, including the poet Homer (about 1000 B.C.), and philosophers Thales, Plato, and Aristotle in Greece; Lucretius, Seneca, and Pliny in Rome; and many medieval scholars. Much of this speculation was scientifically unsound; however, the Greek philosopher Anaxagoras of Clazomenae (50CM-28 B.C.) formed a primitive version of the hydrologic cycle. He believed that the sun lifted water from the sea into the atmosphere, from which it fell as rain, and that rainwater was then collected in underground reservoirs, which fed the river flows. An improvement of this theory was made by another Greek philosopher, Theophrastus (c. 372-287 B.C.), who correctly described the hydrologic cycle in the atmosphere; he gave a sound explanation of the formation of precipitation by condensation and freezing. After studying the works of Theophrastus, the Roman architect and engineer Marcus Vitruvius, who lived about the time of Christ, conceived the theory that is now generally accepted: he extended Theophrastus' explanation, claiming that groundwater was largely derived from rain and snow through infiltration from the ground surface. This may be considered a forerunner of the modern version of the hydrologic cycle.

Independent thinking occurred in ancient Asian civilizations (UNESCO, 1974). The Chinese recorded observations of rain, sleet, snow, and wind on Anyang oracle bones as early as 1200 B.C. They probably used rain gages around 1000 B.C., and established systematic rain gaging about 200 B.C. In India, the first quantitative measurements of rainfall date back to the latter part of the fourth century B.C. The concept of a dynamic hydrologic cycle may have arisen in China by 900 B.C., in India by 400 B.C., and in Persia by the tenth century, but these ideas had little impact on Western thought.

During the Renaissance, a gradual change occurred from purely philosophical concepts of hydrology toward observational science. Leonardo da Vinci (1452-1519) made the first systematic studies of velocity distribution in streams, using a weighted rod held afloat by an inflated animal bladder. The rod would be released at a point in the stream, and Leonardo would walk along the bank marking its progress with an odometer (Fig. 1.5.1) and judging the difference between the surface and bottom velocities by the angle of the rod. By releasing the rod at different points in the stream's cross section, Leonardo traced the velocity distribution across the channel.

According to Frazier (1974), the 8000 existing pages of Leonardo's notes contain more entries concerning hydraulics than about any other subject. Concerning the velocity distribution in streams, he wrote, "Of water of uniform weight, depth, breadth and declivity [slope], that portion is swifter which is nearest to the surface; and this occurs because the water that is uppermost is contiguous to the air, which offers but little resistance through its being lighter than water; the water that is below is contiguous to the earth, which offers great resistance through being immovable and heavier than water" (MacCurdy, 1939). Prior to Leonardo, it was thought that water flowed more rapidly at the bottom of a stream, because if two holes were pierced in a wall holding back a body of water, the flow from the lower hole was more rapid than the flow from the upper one.

The French Huguenot scientist Bernard Rilissy (1510-1589) showed that rivers and springs originate from rainfall, thus refuting an age-old theory that streams were supplied directly by the sea. The French naturalist Pierre Perrault (1608-1680) measured runoff and found it to be only a fraction of rainfall. He recognized that rainfall is a source for runoff and correctly concluded that the remainder of the precipitation was lost by transpiration, evaporation, and diversion.

Hydraulic measurements and experiments flourished during the eighteenth century. New hydraulic principles were discovered such as the Bernoulli equation and Chezy's formula, and better instruments were developed, including the tipping bucket rain gage and the current meter. Hydrology advanced more rapidly during the nineteenth century. Dalton established a principle for evaporation (1802), the theory of capillary flow was described by the Hagen-Poiseuille equation (1839), and the rational method for determining peak flood flows was proposed by Mulvaney (1850). Darcy developed his law of porous media flow (1856), Rippl presented his diagram for determining storage requirements (1883), and Manning proposed his open-channel flow formula (1891).

However, quantitative hydrology was still immature at the beginning of the twentieth century. Empirical approaches were employed to solve practical hydrological problems. Gradually hydrologists replaced empiricism with rational analysis of observed data. Green and Ampt (1911) developed a physically based model for infiltration, Hazen (1914) introduced frequency analysis of flood peaks and water storage requirements, Richards (1931) derived the governing equation for unsaturated flow, Sherman devised the unit hydrograph method to transform effective rainfall to direct runoff (1932), Horton developed infiltration theory (1933) and a description of drainage basin form (1945), Gumbel proposed the extreme value law for hydrologic studies (1941), and Hurst (1951) demonstrated that hydrologic observations may exhibit sequences of low or high values that persist over many years.

Like many sciences, hydrology was recognized only recently as a separate discipline. About 1965, the United States Civil Service Commission recognized hydrologist as a job classification. The "hydrology series" of positions in the Commission list of occupations was described as follows:

This series includes professional scientific positions that have as their objective the study of the interrelationship and reaction between water and its environment in the hydrologic cycle. These positions have the functions of investigation, analysis, and interpretation of the phenomena of occurrence, circulation, distribution, and quality of water in the Earth's atmosphere, on the Earth's surface, and in the soil and rock strata. Such work requires the application of basic principles drawn from and supplemented by fields such as meteorology, geology, soil science, plant physiology, hydraulics, and higher mathematics.

The advent of the computer revolutionized hydrology and made hydrologic analysis possible on a larger scale. Complex theories describing hydrologic processes are now applied using computer simulations, and vast quantities of observed data are reduced to summary statistics for better understanding of hydrologic phenomena and for establishing hydrologic design levels. More recently, developments in electronics and data transmission have made possible instantaneous data retrieval from remote recorders and the development of "real-time" programs for forecasting floods and other water operations. Microcomputers and spreadsheet programs now provide many hydrologists with new computational convenience and power. The evolution of hydrologic knowledge and methods brings about continual improvement in the scope and accuracy of solutions to hydrologic problems.

Hydrologic problems directly affect the life and activities of large numbers of people. An element of risk is always present — a more extreme event than any historically known can occur at any time. A corresponding responsibility rests upon the hydrologist to provide the best analysis that knowledge and data will permit.