

CHARACTERISTICS OF RIVER SYSTEMS

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Summary

Characteristics of river systems are introduced under different headings such as river morphology, chemical characteristics, biological characteristics, type of riverine ecosystems and biogeochemical characteristics. The historical relation between human communities and river systems is emphasized, as is sustainability of river systems.

1. Introduction

Characteristics of river systems were originally defined by morphological and channel processes that took place over a long historical period. The differences between regions and countries has also been clear. After the ascendancy of the human race, the characteristic of river systems were heavily influenced by human activity. Especially after the industrial revolution, the characteristics changed as the relationship between humans and rivers changed conspicuously. Furthermore, since the latter half of twentieth century, the relationship became seriously affected owing to active economic development throughout the world. Therefore the historical processes of interaction between human activity and river systems should be emphasized. River improvement works such as the construction of dams, barriers, canals, etc, have caused changes of the hydrological cycle within river basins.

Development based on science and technological progress raised the standard-of-living of humankind, but brought about an environmental crisis in water quality and ecosystems. This caused changes of chemical, biological and biochemical characteristics of river systems, as well as severe influence on riverine ecosystems. A river itself should be regarded as a single system, from headwaters to outlet. In view of the active development after eighteenth century, river systems which became complex may each be considered, in principle, as one system, including the whole river basin. The longitudinal gradient has to be viewed as a continuum, though it is intercepted by geomorphological discontinuities. The lateral gradient records the exchanges between the original river course and inundated areas, even in seasonally or occasionally flowing rivers. The vertical gradient describes the exchanges between the river and the alluvial aquifer in the alluvial plains.

2. History of relations between human societies and rivers

Human civilizations developed near rivers that could supply enough water for domestic purposes, agriculture, fisheries and navigation. In due course, water was needed for industry and water-power. In arid and semi-arid regions, from very early times, people developed systems to utilize groundwater by wells and qanats. On the other hand, rivers have brought major hazards to inhabitants in river basins. These include floods, water-shortage, malaria and other water-associated diseases, and recently new types of diseases caused by polluted water. Vast inundations in river basins have caused serious damage throughout history everywhere in the world.

In order to alleviate flood damage, the river regulation has been an important undertaking since work on the river Nile, the Tigris-Euphrates and the Yellow River, etc, took place about 4000 years ago. In addition, drainage of flood plains was very important in developing agriculture and accommodating urbanization. Thus, today almost all large rivers in the world are regulated by means of advanced technology developed for such purposes. These kinds of human activity in relation to the rivers and the drainage basin altered, to a greater or lesser extent, the characteristics of river systems. Generally speaking, modification by modern technological advancement first appeared in western Europe. Historical events in the development of river regulation are as presented in Table 1.

1475~60	Ship canal connecting Milan with the River Adda constructed
Approximately 1580	Gravity dam at Alicante (Spain) constructed
Approximately 1620	Rhine-Meuse Ship canal constructed between Rheinberg and Venlo
1667~81	Canal du Languedoc constructed
1861~66	Furens dam built by Groeff and Delocre
1822	The Caledonian Canal completed (Scotland)
1869	Suez Canal completed

1913	Panama Canal completed
1936	Hoover Dam (the Colorado river) completed
1933	Tennessee Valley Authority established the first comprehensive river development project –a group of multipurpose reservoirs
1970	Aswan High Dam (the Nile River) completed
1992	Canal connecting Danube and Rhine completed

Table 1. Main historical development of river works after the fifteenth century

Almost all large alluvial rivers in Europe and USA, except in desert and semi-arid areas, as well as nearly all rivers in Japan, have experienced a history of severe modification by engineering works. By the end of the twentieth century only a few reaches of wholly natural rivers remained in these developed countries. Morphological characteristics of river systems have been affected by several climatic changes, particularly, repeated warming and cooling phases over the last 20 000 years. But important changes of river systems appeared in the latter half of twentieth century in chemical, biological and bio-chemical characteristics of river systems. In Egypt, Mesopotamia, China, etc, high and long embankments had been constructed more than four thousands years ago, but the areas covered were limited. After the thirteenth century, weirs and aqueducts begun to be constructed in order to control the natural discharge for waterpower in Germany, France, Italy, and England, etc. In advanced countries in Europe, there were river improvement works for flood control, land reclamation, and navigation constructed by embankment, weir and regulation of river course. Since the middle of the fifteenth century, in the Netherlands, dredging technology, designs for floodgates, retaining walls, etc, developed rapidly. Also, in Italy, the technology of land reclamation, river training and regulation made it possible to arrange rational management of very large areas of river basin, including the planned control of rivers. By the end of the seventeenth century, new methodologies were established based on modern science and technology, for example the hydraulics advanced by Benedetto Castelli (1577-1644), Evangelista Torricelli (1608-1647), Blaise Pascal (1623-1662), Henri de Pitot (1695-1771), Daniel Bernoulli (1700-1782), Leonhard Euler (1707-1783), Antoine Chézy (1718-1798) and others.

In the eighteenth and nineteenth century in Europe, river engineering works became large scale and widespread. The main objectives of these works were to reclaim more agricultural land, to control floods, and to supply water to the increasing population. In addition, the invention of hydroelectric power generation and the development of large dam construction progressed rapidly after the end of nineteenth century.

In North America, since the eighteenth century, canals and water supply works were carried out on a large scale. Especially in the early twentieth century, huge river engineering projects astonished the world. The Hoover Dam, completed in 1936 on the Colorado River, was 215 m in height, the highest in the world at that time. The construction was called the great pyramid of the American West, a symbol for twentieth century oasis civilization. The Tennessee Valley Authority, established in 1933, resulted in a typical comprehensive development in the Tennessee Valley of the

Mississippi River System, incorporating more than 20 multi-purpose dams. After the Second World War, river systems all over the world have been changed remarkably by the huge scale of river works, such as a large number of big dams, canals for navigation, transport of irrigation water etc, not only in the developed countries but also in the developing countries.

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Biographical Sketch

Yutaka Takahasi was a Professor of Civil Engineering at the University of Tokyo from 1978 to 1987 (now Professor Emeritus) and a Professor of Civil Engineering at Shibaura Institute of Technology in Tokyo from 1987 to 1998. He is now a Senior Programme Advisor (Environment and Sustainable Development) at United Nations University. His research and teaching interests are focused on fluvial hydrology, water resources planning and history of civil engineering. He has been a member, Board of Governors, World Water Council since 1996, and Vice-President, International Water Resources Association from 2000 to 2003.