HYDROLOGICAL REGIONS AND WATER BALANCE

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Contents

Summary

The major part of the Earth (361.3 mln sq. km) is occupied by the World Ocean. The land area equals 149 mln sq. km. The land includes six continents and numerous islands. The whole land area can be regarded as consisting of two slopes, i.e. from the first slope rivers flow to the Atlantic and Arctic Oceans; the rivers from the second slope flow to the Pacific and Indian Oceans. These slopes are separated into large regions (or areas of external runoff) by the watershed—the divides of the oceans. The total area of external runoff occupies 80% of the whole land area of the Earth. The other 20% of the land area contains regions without runoff to the World Ocean. These endorheic areas are areas of internal runoff. Water balances of the areas of external and internal runoff differ greatly. The integral water balance index of land i.e. runoff coefficient, is low within the areas of internal runoff. Areas of external and internal runoff in Nature are limited by orographic features. Physiographic zones are other areal units, dependent on orography and climate. They may be characterised by aridity and moistening indices.

Areas of external and internal runoff and physiographic zones occupying large areas of the Earth are not homogeneous with regard to many hydrological features. Different conditions of runoff formation and hydrological regime of rivers are observed within these areas.

Discovery of objectively existing territorial units that are homogeneous in hydrological features is the main objective of hydrological regionalization. Separation of

homogenous hydrological regions on a map is possible with the use of geographic, water-balance and probabilistic-statistical methods. Different methods for hydrological regionalization have been considered, including the multi-purpose approach based on the account of zonal and azonal conditions and ratios between water balance components.

1. Introduction

The Earth's surface is remarkable for its variability. It may be subdivided into territories each characterised by historically formed types of relations between landscape components and relative similarity of physiographic features. The specific features of the largest territories have resulted from various effects of the inner forces of the Earth or from different quantities of solar radiation onto separate surfaces of the planet. The inner forces caused a separation of the Earth's surface into territories identifiable by physiographic features, i.e. continents, oceans, seas, mountains and plains. Specific distribution of heat and moisture over the Earth explains soil and vegetative cover, and trends in many geomorphological processes and river regimes, i.e. a variety of zonal specific features.

Each territory on the planet is unique; it has a unique combination of geographic specific features. Some specific features, however, and even a combination of such features, may be observed in several territories. Regionalization should be based on repeated and individual features of separate territories.

Depending on the geographic position of the large water areas on the Earth, the World Ocean is subdivided into four independent oceans: the Pacific, Atlantic, Indian and Arctic. According to various features (surface water temperature, salinity, density, etc.) these oceans may be subdivided into separate regions.

Continents and islands consist of external and internal runoff areas. These areas are not homogeneous. They differ in their evolution and, as a result, in topography, climate and geology.

Discovery of objectively existing territories in Nature, pre-determined by natural and historical evolution of the Earth's surface, is the basic objective of regionalization for most geo-sciences. Hydrology is an integral part of physiography. Therefore, it is based on the principal laws of Nature and it uses approaches and methods originated in physiography, including regionalization of territories. It is very important for hydrology to determine homogeneous territoriesprimary that are essentially similar in their hydrological features. Hydrological regionalization is possible only in a definite stage of hydrological development after much observation data has been collected and when a further development of hydrology inter-related with the geographical environment is recognised. If hydrological regionalization of the Earth is connected with the processes of the global hydrological cycle, it is necessary to take account of the available hydrological macro-territories (macroregions), i.e. oceans and continents. On the continents the regions of external and internal runoff, and other types of physiographic zones, should be taken into account. Separation of hydrological regions within the territories is an extremely difficult problem and it is usually made using a number of features, depending on the specified problems.

2. World Ocean and Continents of the Earth

The structure of the Earth, its revolution around the Sun and around its axis, and the origin and history of the hydrosphere explain the differentiation of our planet into macroterritories: continents, oceans, seas, islands and other physiographic and areal units.

At present, the surface of our planet occupies 510 mln sq.km. The World Ocean occupies 361.3 mln sq.km and land area equals 149 mln sq.km. The major portion of the land area (100 mln sq.km) is located in the northern hemisphere and only 49 mln sq.km is in the southern hemisphere. The water surface area in the northern hemisphere occupies 155 mln sq.km, and the water area in the southern hemisphere equals 206 mln sq.km.

This uneven distribution of water and land areas is very important for all processes of the hydrological cycle, climate difference and water balance on the planet.

The World Ocean covers the waters of the four oceans together: the Pacific, Atlantic, Indian and Arctic oceans. The main morphometric characteristics of the oceans are given in Table 1.

Ocean	Area, mln sq.km			Depth, m	
	Total	Water area	Islands	Mean	maximum
Pacific	182.6	178.7	3.9	3,957	11,034
Atlantic	92.7	91.7	1.0	3,602	9,219
Indian	77.0	76.2	0.8	3,736	7,450
Arctic	18.5	14.7	3.8	1,131	5,220
World	370.8	361.3	9.5	3,704	11,034

Table 1. Main morphometric characteristics of the oceans

There are six continents on the planet, i.e. Eurasia, Africa, North America, South America, Australia and Antarctica. Eurasia is often considered as two continents—Europe and Asia. The main morphometric information about the continents is given in Table 2.

A main watershed-divide separates the whole land area into two slopes: from the first slope rivers flow to the Atlantic and Arctic oceans; from the second slope rivers flow to the Pacific and Indian oceans. In turn, these slopes are subdivided into large regions (areas of external runoff) by the watershed-divides of the ocean drainage areas. The drainage area of the Arctic Ocean is 15% of the whole land area; 34% of the land drains to the Atlantic Ocean, 17% to the Pacific Ocean, and 14% to the Indian Ocean. The remaining 20% of the land area contains regions of internal runoff (endorheic areas), i.e. the regions without water flow to the World Ocean.

In Europe the Caspian Sea drainage area is an area of internal runoff. In Asia the endorheic areas are as follows: the Tura Lowland, the drainage areas of the Aral Sea, Lake Balkhash and Lake Issyk-Kul, the central part of Asia, the major part of the Arabian Peninsula, the Thar Desert, Central Anatolia, the Dead Sea drainage area, Seistan depression, and a part of the Plateau of Iran.

Continent	**Area, mln sq.km**		**Elevation above sea level, m.**		
	total	**islands**	**mean**	**maximum**	**minimum**
Europe	10.5	0.7	300	5,642	-28
Asia	43.5	2.7	950	8,848	-392
Africa	30.1	0.6	650	5,895	-150
North America	24.2	4.1	700	6,193	-85
South America	17.8	0.1	580	7,014	-35
Australia & Oceania	8.9	1.3	350	5,029	-12
Antarctica	14.0	0.0	2,040	5,140	-
The whole land area	149.0	9.5	825	8,848	-392

Table 2. Main morphometric characteristics of the continents

In Africa vast desert areas belong to endorheic areas, i.e. the Sahara, Libyan Desert, Kalahari Desert, Namib Desert, as well as the drainage areas of Lakes Rukwa, Chad and Rudolf.

In North America the endorheic areas are as follows: the Great Basin Desert, deserts of the Mexican Plateau, the Colorado river plateau, the right-hand bank area of the Rio Grande.

In South America the endorheic areas cover Lake Titicaca and Lake Poopo drainage areas, Puna de Atacama Desert, and semi-desert plateaus of Patagonia.

In Australia the endorheic territories are: the Great Sandy Desert, Gibson Desert, Great Victoria Desert and the drainage areas of Lakes Eyre, Amadeus, Torrens and Frome.

Land distribution within drainage areas of the oceans and distribution of areas of internal runoff on the continents are shown in Figure 1.

Oceans, continents and regions differ greatly in physiography where water balance components are formed (see *World Water Balance*). Runoff coefficient—the ratio of runoff to precipitation—is an integral index of water balance. Its value varies from 0.09 (in Australia) to 0.46 (in Asia). The runoff coefficient in Africa equals 0.21; on the other inhabited continents it varies within a narrow range of 0.40 to 0.44.

Areas of external runoff, i.e. large regions of continents, are characterised by runoff coefficients close to the values for the appropriate continents. Areas of internal runoff are the most arid regions of land. In fact, the whole quantity of precipitation is lost to evaporation. Runoff coefficients for rivers and streams flowing to endorheic water bodies are small i.e. from 0.01 in Australia to 0.09 in South America. In North America and Africa runoff coefficients are 0.05 to 0.06. In the endorheic regions of Asia the overall runoff coefficient is 0.16. Only the Caspian Sea basin has a runoff coefficient of 0.25 which is the highest runoff coefficient for any endorheic area. This is related to the fact that runoff formation occurs in a well-watered zone of the temperate belt, a long way from the Caspian Sea.

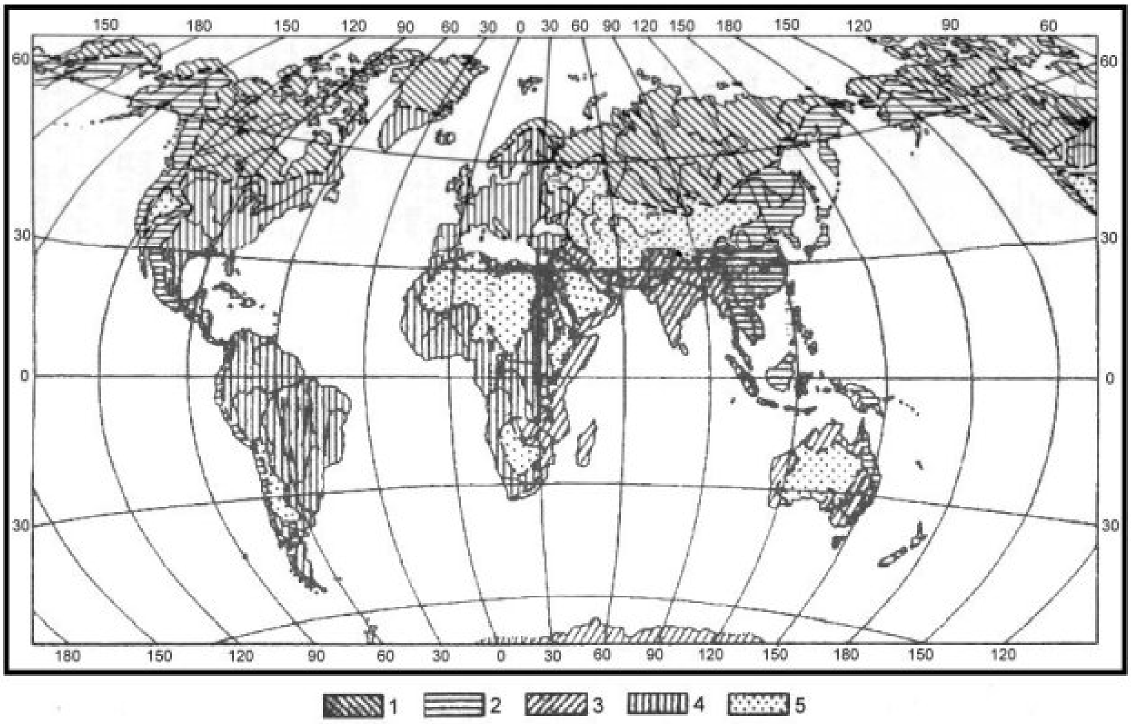

Figure 1. Distribution of dry land relative to the ocean drainage basins
1 – Arctic Ocean; 2 – Pacific Ocean; 3 – Indian Ocean; 4 – Atlantic Ocean; 5 – areas of internal runoff

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Biographical Sketch

Vladimir Ivanovitch Babkin was born in 1941. In 1965, he graduated from the Voronrzh State University. Since 1969 he has worked at the State Hydrological Institute. In 1970, he defended a thesis for the degree of candidate of geographical sciences, and in 1984 a doctor thesis in geography.

Since 1982, Babkin has been the head of the laboratory “Water Resources and Water Balance” at the State Hydrological Institute, St. Petersburg.

V.I. Babkin is the author of 130 scientific papers including seven monographs on hydrology, hydrophysics, and water balance and water resources. Most of his studies deal with hydrological cycle processes (evaporation, runoff, precipitation, and infiltration), developing methods for their estimation, and discovering global mechanisms of land moisturizing on the continents.