SURFACE WATERS: RIVERS, STREAMS, LAKES, AND WETLANDS

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Keywords: Rivers, lakes, reservoirs, wetlands, bogs, river channel, hydrograph.

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Summary

Surface waters could be regarded as including all inland waters permanently or intermittently occurring on the Earth surface in either liquid (rivers, temporary streams, lakes, reservoirs, bogs) or solid (glaciers, snow cover) condition but this article does not attempt to cover the latter. All types of liquid surface waters are considered—rivers, reservoirs, lakes, bogs. The basic terms used to describe these water bodies are defined. Their types and classifications are given, and data are presented on the largest rivers, lakes and reservoirs.

Surface waters play a very important role in economics and the functioning of ecosystems. According to their topographic and morphological peculiarities, and hydrological regime, lakes can be subdivided in three different ways:

- into lowland, foothill and mountain rivers, depending on relief;
- into large, medium and small, depending on river size;
- into snow-fed, rain-fed, glacier-fed and groundwater-fed, depending on sources of supply.

Lakes can be also divided according to their size, the origin of their depressions, their water regime, degree of river channel stability, water exchange character, water balance structure, temperature regime, dissolved load, etc. Data on the largest rivers and reservoirs are cited.

About 3.5 million km^2 of the Earth are covered with wetlands and mires, or peatlands. The article provides a general classification of peatland landscapes and microlandscapes, based on ecological characteristics and vegetation.

1. Rivers

Natural water flows moving under the force of gravity along their channels and fed by surface and underground runoff are called rivers. Rivers can be divided into **mountain**, which have rapid flows and narrow valleys, or **lowland** rivers, which have slower flows and wider, often terraced, valleys.

The rivers of polar regions and high mountain areas can be mainly supplied by glacier melting. A network of tributaries usually supplies the main river, which can flow into the ocean, an interior (partially enclosed) sea, an endorheic (drainless) lake, or it can disappear into an arid desert. A main (trunk) river and all its tributaries constitute a river system. A lake (or lakes) may be present within a main (or tributary) river.

Rivers are classified according to their topographic/morphological features and their hydrological regime. These in turn are influenced by climate, soils, relief, and vegetation.

Topographic/morphological types of rivers:

1. Mountain rivers with large channel gradients and rapid flow.
2. Rivers of glaciated areas, the channels of which have been considerably transformed by glaciers, at least in former times.
3. Lowland rivers with small slopes and slow flow in meandering channels.

The hydrological types of rivers are fairly diverse. The main criterion for their evaluation is the dependence of runoff variation on seasonal variation in rainfall and air temperature.

Classification of rivers, especially large ones, according to their hydrological features, is rather difficult. The variety of geographical and climatic conditions is very wide. Water regime is therefore taken as a basis for river classification.

River types are determined according to various criteria, such as river size, flow conditions, sources of feeding, water regime, degree of channel stability, ice regime, etc.

According to their size, rivers are divided into large, medium, and small. Large rivers are characterized by a basin area of more than 50 000 km^2; medium rivers, by basin area of 2000 - 50 000 km^2, and small rivers, by basin area less than 2000 km^2. The lower boundary of the basin area (50 km^2) separating small rivers from creeks is ambiguous.

Large river basins are usually located in several geographical zones. The hydrological regime of a large river is not typical of any specific zone and is therefore polyzonal. The basin of a medium size river is usually situated within the limits of one geographical zone. The hydrological regime of rivers of this group is zonal since it is typical of the majority of rivers in each specific zone.

A small river basin is always located in one geographical zone. But its hydrological regime is strongly influenced by local conditions and can differ significantly from the water regime of the majority of rivers in the same zone. Thus the regime becomes azonal.

According to their flow conditions, rivers are also classified as lowland, piedmont, and mountain. The criterion for this classification is, in particular, is the Froude number (*Fr*)

$$Fr = \frac{v^2}{gh}, \tag{1}$$

where v is flow velocity, h is flow depth and g is gravitational acceleration. Lowland rivers are characterized by a Froude number less than 0.1; piedmont rivers have a Froude number in the range of 0.1 to 1.0; and mountain rivers have a Froude number of more than 1.0. Thus, lowland and piedmont rivers have a relatively calm flow character, while mountain river flows are violent.

According to the sources of supply, rivers are divided into rivers with snowmelt, rain, glacial, underground, or mixed feeding.

According to their water regime, i.e. the character of annual runoff distribution, rivers are divided into those with spring high-water period, warm-season high-water period, and rivers with short-term floods.

According to the degree of channel stability, rivers can be regarded as stable or unstable. Depending on their ice regime, rivers can be classed as freezing and non-freezing.

Some information on the Earth's largest rivers is given in Table 1. The Amazon basin area is the largest in the world, and the Nile is the longest river; the Amazon also ranks first in the world in terms of runoff (it accounts for 16.6% of global river runoff). The largest rivers flow in Africa, South America, and Asia. The largest rivers in Russia are the Ob', Yenisei, Lena, Amur, and Volga.

River	**Basin area, (thousand km^2)**	**Length, (km)**	**Average year runoff, (km^3)**
Amazon[1]	6915	6280	6930
Congo (Zaire)	3820	4370	1414
Mississippi[2]	3220	5985	580
La Plata[3]	3100	4700	725
Ob'[4]	2920	3650	395
Nile[5]	2870	6670	73
Yenisei	2580	3490	610
Lena	2490	4400	532
Niger	2090	4160	270
Amur	1855	2820	355
Yangtze	1800	5520	995
Mackenzie[6]	1800	4240	350
Ganges[7]	1730	3000	1230
Volga	1360	350	239

Zambezi	1330	2660	106
St. Lawrence	1290	3060	439
Nelson[8]	1070	2600	86
Orange	1020	1860	15.3
Orinoco	1000	2740	914

(1) – with Ucayali; (2) – with Missouri; (3) – with Parana and Uruguay;
(4) - with Irtysh; (5) – Kagera; (6) – with Athabaska; (7) - with Brahmaputra;
(8) – with Saskatchewan.

Table 1. The largest rivers of the world

River runoff and regime depend on precipitation, evaporation, water accumulation in soils, land use, vegetation, basin slope, etc. River water forms at the expense of precipitation onto the land surface. The sources of river alimentation include snow, rain, ground water, and glaciers.

Variation in the amount of water entering a river channel lead to changes in the water level, i.e. the elevation of water surface relative to a certain conventional surface. The following types of water level regime can be distinguished:

1. level variations connected with variation in the amount of water in the stream;
2. level variations caused by changing channel resistance;
3. level variations caused by setups and tides, and
4. level variations caused by natural and anthropogenic backwater phenomena.

According to the character of slope distribution along the river, four main types of longitudinal profiles are recognized:

1. Equilibrium: a slightly concave profile. This, the most common type, represents a concave curve of a hyperbolic kind. The gradient is steeper near the source of the river and less near the river mouth.
2. Linear profile characterized by a relatively uniform slope distribution along the whole river. This is common for small rivers.
3. Fault-line or convex profiles occur in rivers with small slopes at the upper and steep slopes in the lower parts of the river (i.e. a saddle-shaped landform).
4. Stepped profiles are characteristic of rivers in areas with much variation in their erosion bases.

Peculiar processes take place in river mouths because of sedimentation of river-borne materials and interaction between the river and the receiving water body (often the ocean).

For rivers of regions with a warm climate, the main source of nourishment is rainwater. Runoff of large rivers such as the Amazon, Ganges/Brahmaputra, and Mekong is mainly formed due to rainwater. This kind of river nourishment is the predominant one on the Earth. Snowmelt nourishment ranks second in the formation of river runoff, and is typical of temperate climatic regions. Groundwater accounts for about 1/3 of the total river runoff. Glacial nourishment plays an insignificant role in river runoff formation (as low as 1% of global runoff). Quantitative evaluation of the role of different types of nourishment in runoff formation is carried out with the help of graphically splitting the hydrograph according to the nourishment regimes. In this case, the role of each nourishment type is proportional to the areas of the appropriate parts of the hydrograph.

River runoff includes water runoff, sediment runoff, dissolved materials runoff, and heat runoff. The main characteristic of river runoff is the rate of flow, i.e., the volume of water flowing through the cross-section per unit time (m^3/sec).

There are several kinds of flow rate: maximum flow rate during high-water periods, minimum flow rate during low-water periods, flow rate at the beginning of spring ice drift, etc.

The main sources of sediments entering rivers are basin surfaces and river channels eroded by water flow.

Sediments are characterized by geometric size, i.e. the diameter of sediment particles (d, mm), particles settling velocity in standing water (w, mm/sec, mm/min), and water turbidity (S, g/m^3, kg/m^3),

$$S = m/V \,, \qquad (2)$$

where m is the mass of the sediments in water sample, and V the volume of water sample.

Variations in water temperature affect ice phenomena, chemical and biological processes, etc. The main cause of temperature variations in the river is the changing meteorological situation. Variations in river water temperature are seasonal and daily.

According to their ice regime, rivers are divided into three groups: freezing, with unstable ice cover, and non-freezing.

Usually river waters contain low dissolved loads and are classed as fresh waters. According to their dissolved load, river water can be of low dissolved load (up to 200 mg/l), medium dissolved load (200-500 mg/l), high dissolved load (500-1000 mg/l), or very high dissolved load (more than 1000 mg/l).

As regards their chemistry, most river waters belong to the bicarbonate class, and the calcium group. Other types of river occur in areas of base-poor rocks, particularly where the surface water drains from peatland with a low pH.

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Biographical Sketch

Academician **Martin G. Khublaryan** was born in March 1935 in Georgia. He is married with two daughters. *Details of Education:*

1958 - Armenian Agricultural Institute, Department of Hydrotechniques and Reclamation;
1964 - Candidate of Sciences (Physics and Mathematics), Institute of Mechanics, USSR Academy of Sciences;
1975 - Doctor of Engineering, All-Union Scientific Research Institute for Hydrotechniques and Reclamation.
1992 – Professor.

Career to date:

1988 - present - Director Water Problems Institute of Russian Academy of Sciences;
1989 - Chief of the Laboratory of Theoretical Problems of Water Protection;
1979 - 1988 - Deputy Director, Chief of the Laboratory of Modeling Hydrophysical Processes;
1968 - 1979 - Chief of the laboratory at the All-Union Scientific Research Institute for Hydrotechniques and Reclamation;
1963 - 1968 - Senior Scientist at the All-Union Scientific Research Institute for Natural Gas;
1961 - 1964 - Post Graduate courses at the Institute of Mechanics, USSR Academy of Sciences;
1959 - 1961 - Junior Scientist at the Institute for Power and Hydraulics of the Academy of Sciences of Armenian Republic;
1958-1959 - Engineer at the Erevanproekt Institute (Armenia).

Publications:

"Water streams: models of flow and quality surface water", Moscow, Nauka, 1991;
"Water pollution and its consequences in the former USSR". Pollution knows no frontiers, A PWPA Book, N.-Y., 1992;
"Basic problems in protection of natural waters", Water management and protection, AIH, 1993;
"Volga river Remediation is – the step to save Russia". (Khublaryan et all). Book 1, 1996; Book 2, 1997. Moscow - Nigniy Novgorod; Book 3, part I, 1999; part II, 2000. Moscow,
and more than 150 other publications.

Memberships of Associations:

Full Member of the Russian Academy of Sciences - 1994;
Member of the Working Group of the International Hydrological Program (IHP) - 1989;
Member of Russian National Committee for International Association of Hydraulic Research (IAHR) - 1987;
Member of American Institute of Hydrology and President of its Russian section - 1991.

Hobbies and interests: painting, classical music, chess, and memoirs.