WATER RESOURCES FOR SUSTAINABLE DEVELOPMENT, WITH PARTICULAR REFERENCE TO RUSSIA

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Summary

The concept of “water resources” is defined. Their global characteristics and distribution among continents are described, and particular attention is paid to the water resources of Russia. The total water reserves in lakes in Russia are evaluated at 24 100 km^3, and annual river runoff in an average year is estimated to be 4043 km^3 $year^{-1}$. Natural groundwater resources in Russia are evaluated at 725 km^3 $year^{-1}$. In recent years, annual water consumption in Russia has not exceeded 90 km^3 $year^{-1}$; water from surface and subsurface sources accounted for not more than 75 and 13–14 km^3 $year^{-1}$ of consumed water, respectively.

Quantitative and qualitative indices of water resources are presented and their use for different purposes is described. Water quality in most Russian surface water bodies fails to meet the standards, on average by an excess of 68% above permissible concentrations. The conditions of groundwater are described. As at 1998, the explored and approved fresh groundwater reserves in Russia are shown to amount to 30.1 km^3 $year^{-1}$, and groundwater quality is shown to comply with the standards. The large annual and long-term variations in river runoff have necessitated construction of reservoirs, and, in some cases, systems for water transfer, aimed at providing people and economic enterprises with the required amounts of water. More than 2000 reservoirs with total active storage of 338.65 km^3 have been constructed in Russia. The amount of transferred water has reached 16.6 km^3 $year^{-1}$. The principal regions, river basins, and large lakes in Russia are considered.

1. Introduction

As a natural resource and component of the biosphere, water is a decisive life-providing and environment-conserving factor on Earth. It is used in almost all spheres of production. But ultimately water is a bearer and accumulator of all pollutants, along with soil.

The concept of “sustainable development,” approved at the UN Conference on Environment and Development in Rio de Janeiro in 1992, has become a major strategy for most countries. It is aimed at improving human life while preserving the environmental potential and allowing careful use of natural resources. Sustainable development can be achieved by introducing progressive nature and energy preserving technologies, while not depleting resources and not polluting the environment.

At the start of the new millennium the most highly developed countries have succeeded in stabilizing the ecological situation. This has been achieved through intense promotion of scientific and technical advances, new resource-retaining technologies, and significant investments into industrial reconstruction and nature protecting measures. Most other countries are proceeding with their wasteful extensive exploitation and sale of natural resources.

In the Russian Federation the strategy of “sustainable development” presents a very complex problem under current conditions of recession in industrial and agricultural production, with foreign debt constantly increasing, and many economic and social problems requiring urgent solution.

The transition of Russia to a model of sustainable development primarily requires the creation of a new legal base, improving the current legislation, and introducing new resource saving and nature protecting technologies. The previous and to some extent the current structure of federal management of natural resources, particularly water, was characterized by fragmentation, confused distribution of functions between numerous departments, and distinct lack of coordination. Correction of all these measures requires time and, particularly, considerable administrative reconstruction.

It is not helpful to consider water resources in isolation from Russia’s other problems. They are closely interconnected. Previous lack of attention to water protecting measures in Russia resulted in loss of self-purification capacity in most water bodies and them turning into waste water collectors.

Economic development in Russia proceeded rapidly in Russia without much thought for natural resources. The most ecologically dangerous industrial complexes were mainly located in the upper and middle reaches of rivers or in vulnerable parts of floodplains and deltas.

The current environmental situation in Russia requires many measures for regeneration, protection and rational use of water resources. There is a need for safe and effective water engineering structures to provide a reliable supply for the population, and for industrial and agricultural enterprises. Such ‘hydro-economic complexes’ must provide water of sufficient quantity and quality without violating nature protecting legislation. It can be confidently asserted that the water factor is the most useful indicator of the state of environment.

The total volume of the hydrosphere is about 1.5 billion km^3. It is distributed over the globe in the following way: 94% in the ocean, 4% as groundwater (mostly deep brines - fresh groundwater being only 4000 km^3), and 1.6% being glaciers and ice sheets. Surface fresh water is about 0.25% and atmosphere vapor is 0.001%. Isochronous (at one point in time) water volume in riverbeds, according to different estimations, ranges from 2000 to 2120 km^3 that is less than 0.01% of the total freshwater reserve on the Earth. World freshwater reserves in lakes are 91 000 km^3 and total river runoff is 46 800 km^3.

There are data on regenerated fresh river water resources and dependable water supply of different continents, of the Earth in Table 1 and Table 2. As for the world total water consumption, there is no clear answer.

Continents	**Area** mln.km^2	**Water resources,** km^3/year			**Water availability,** thous.m^3/km^2
		Long-term mean	**Maximum**	**Minimum**	
1	**2**	**3**	**4**	**5**	**6**
Europe	10.46	2,900	3,410	2,254	277
North America	24.3	7,890	8,917	6,895	324
South America	17.9	12,030	14,350	10,620	672
Asia	43.5	13,510	15,008	11,80	311
Africa	30.1	4,050	5,082	3,073	134
Australia and Oceania	8.95	2,405	2,880	1,891	269
Land as a whole	135	42,785	44,751	39,775	317

Table 1. Resources of river freshwaters and potential availability of water on different continents

Year	**Population, billions**	**Potential water availability per capita, thousand m^3/year**
1970	3.3	12.9
1980	4.4	9.7
2000	6.083	7.0
2003	6.314	6.78
2025	8.0	5.4
2050	8.9	4.81

Table 2. The dynamics of world population and water availability

It is sensible to give a definition of the term "water resources "before discussing water resources formation, their quality and dependable water supply in Russia. Water resources are the available fresh and natural or transformed water (desalinized, purified, etc.) of sufficient quality and quantity to be used for present and future economic purposes. This includes all types of water, on the land surface, in the atmosphere, and underground: all the components of the hydrosphere that are suitable for use.

From another point of view, water resources are the water that is available, or capable of being made available, for use in sufficient quantity and quality at a location and over a time period appropriate for an identifiable demand.

2. Surface Water Resources of Russia

The total volume of the age-old water reserves in the lakes of Russia is 24 100 km^3. River runoff in an average year is 4043 km^3 per year or 237 000 m^3 per year per square kilometer, and 27 820 m^3 per year per capita (1997). There are about 40 000 km^3 of fresh water in glaciers.

There are more than two million fresh and saline lakes in Russia, of which Lakes Baikal, Ladoga, and Onega are particularly notable. Lake Baikal holds the greatest store of clean fresh water. Its area is 31 500 km^2; the mean depth is about 730 m, and maximum depth is 1637 m.

Lake Baikal contains 23 000 km^3 or more than 95% of water storage in the lakes of Russia. After construction of a dam in the Irkutsk hydroelectric power plant, the level of Lake Baikal rose by 1 m. The largest river flowing into Lake Baikal is the Selenga; its annual flow of 58.75 $km^{.3}$ is about half of the total supply of all the rivers flowing into the lake.

The only river flowing out of Baikal Lake is the Angara, its mean runoff being about 60 km^3 per year, and its mineralization—96.7 mg l^{-1}.

Zooplankton is of considerable importance for maintaining clean water in Lake Baikal. The mean biomass in the lake is 46 200 ton. About 90% of zooplankton biomass consists of epishura, a species endemic to Lake Baikal. During a year epishura filters more than 30% of the lake water from the surface layer to a depth of 50 m.

Despite this natural purification process, intensification of human activities on the shores and in the lake catchment has caused a disturbance to the hydro-physical and hydro-chemical regimes. Annually about 8 million tons of dissolved materials and 2.6 million tons of solid sediments enter Lake Baikal. The normal water mineralization in the Baikal is 120 mg l^{-1}.

The main sources of pollution in the lake are wastewater from industrial enterprises (particularly Selenga cardboard and pulp, and Baikal paper and pulp plants), timber rafting, petroleum products, atmospheric dust and gaseous emissions from industries, and road traffic.

Disturbance of soil and vegetation cover in the basin and particularly in the BAM zone (Baikal–Amur Main Road) has caused a great increase in the turbidity of the lake.

A complex land use and nature protection scheme has recently been developed. Capital investment is being directed at modernizing and re-equipping industrial plants in the catchment area, conversion of some industrial enterprises to ecologically pure technologies and deep processing of raw materials, and limitation of the area of arable land in areas affected by wind and water erosion.

The catchment area of Lake Ladoga is 258 600 km^2; it incorporates the basins of three lakes—the Ladoga, the Onega and the Ilmen. One reason for changing regime elements of the lakes is the large amount of economic activity in the catchment connected with using different kinds of natural resources.

The basin is rich in water resources. On average about 71 km^3 of water flow into Lake Ladoga during a year (the range is from 68 km^3 per year (in the low water phase) to 80 km^3 per year (in the high water phase). The seasonal distribution of inflow into Lake Ladoga is not greatly affected by the water content phase, but in some areas the water quality is poor because the flow becomes insufficient to dilute it. The most serious threat to the lake is inflow of organic matter, causing eutrophication: its annual inflow into the lake is 7 to 7.5 thousand tons. Most of this is phosphorus—one calculation of the annual quantity of phosphorus transported into the lake is 7.2 thousand tons. Under these conditions the lake biomes eutrophic, equivalent to a concentration of 0.03 mg l^{-1} of phosphorus in the lake water. The concentration of phosphorus in the lake is currently 0.027 mg l^{-1}. Lake Ladoga accumulates about 5% of the incoming iron, manganese and cobalt, and 20% of the aluminum. The rest of these metals and almost all of the lead and copper leaves the lake in the flow of the Neva River. Annually 9900 tons of iron, 7400 tons of manganese, 20 500 tons of aluminum, 300 tons of copper, 350 tons of cobalt, and 225 tons of lead get into the lake each year.

Total transport of organic matter into the lake by river runoff is about one million tons per year. Suspended matter is irregularly distributed in Lake Ladoga. Three main zones are singled out: the southern zone where maximum water turbidity is 5 to 8 g m^{-3}), the central zone (1 to 2 gm^{-3}) and the northern part of the lake (2 to 3 g m^{-3}).

The mass and quality of water in the lake is of great importance for the River Neva. The inflowing water in the tributaries, the Svir, Burnaya, Volkhov, and Syas rivers, has a significant affect on the quality of the River Neva, the perennial outflow of which is 78.5 km^3. As a result of the input from the tributaries, the water in the river above St. Petersburg is of reasonable quality. The content of suspended matters ranges from 5 to 10 mg l^{-1}.

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Biographical Sketch

Dr Martin Gaykovich Khublaryan was born in 1935 in Georgia. He is married with two daughters. A hydrologist, he was educated as follows: 1958—Armenian Agricultural Institute, Department of Hydro Techniques and Reclamation; 1968—Candidate of Sciences (Physics and Mathematics), Institute of Problems of Mechanics, USSR Academy of Sciences; 1975—Doctor of Engineering, All-Union Scientific Research Institute for Hydro techniques and Reclamation. Career to date: 1988—present time—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 Hydro physical Processes; 1968–1979—Chief of the laboratory at the All-Union Scientific Research Institute for Hydro techniques and Reclamation; 1963–1968—Senior Scientist at the All-Union Scientific Research Institute for Natural Gas; 1961–1964—postgraduate 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 the 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; 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.