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FRESHWATER RESOURCES ON LAND AND HUMAN DESTINY

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Abstract: This scientific article analyzes the state of freshwater resources on land and their impact on human life and the global ecological environment. Today, the limited availability of freshwater, its environmental pollution, climate change, demographic growth, as well as the increasing demand related to irrigation and industrial needs, pose a serious threat to the fate of humanity. During the study, the socio-economic and ecological consequences of freshwater scarcity, as well as modern approaches to sustainable water resource management, are examined. The article provides conclusions regarding the protection of water resources, the implementation of renewable technologies, and the importance of international cooperation.

Keywords: world ocean, glaciers, rivers, industrial enterprise, mechanical treatment method, electrolysis method, biological treatment method, chemical treatment method

Water is the most widespread substance on Earth and, due to its physical and chemical properties, is an extremely unique and remarkable material. In general, it is difficult to imagine nature and human life without this essential substance. Water participates in almost all processes in nature, specifically in the geographical shell. Water has played an important role in the history of the development of life on Earth. Water is not only a crucial component of nature but also an important material resource that influences the development of the national economy.

In nature, water exists in three aggregate states (liquid, ice, and vapor) and plays an important role in shaping the climate and weather conditions of various regions. The heat capacity of water is twice that of wood, five times that of sand, ten times that of iron, and 3,000 times that of air. This means that 1 m³ of water, when cooled by 1°C, can heat 3,000 m³ of air by 1°C. The high heat capacity of water compared to air and land rocks is significant for moderating local climates and has a strong influence on heat and dynamic processes on Earth. In addition, water vapor in the atmosphere acts almost like a filter for sunlight reaching the surface. Although atmospheric water vapor constitutes only about 0.001% of the total water in the hydrosphere, it plays a significant direct role in the climate conditions of the Earth's surface. The influence of water on climate can be particularly clearly observed through ocean currents. Ocean currents primarily redistribute solar heat on Earth, transferring excess heat from lower latitudes to middle and higher latitudes.

Moreover, large water bodies — seas, lakes, reservoirs, canals, and marshes — also have a direct impact on the climate of surrounding areas. The location of many resorts and recreational areas with mild, healthy climates on the coast is not accidental. The influence of inland water bodies on climate can be clearly illustrated by Lake Baikal. The average temperature in July on the lakeshore is 6°C lower than the temperature only 100 km away from the lake, while the average temperature in December is 12°C higher than areas at the same distance, meaning that the harsh continental climate of Eastern Siberia takes on characteristics of a maritime climate along the shores of Baikal due to the influence of this large water body. Among liquids, water ranks

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second after mercury in terms of upward attraction. Consequently, water moves upward through capillaries in soil and rocks toward plants. This is a necessary condition for soil formation, plant nutrition, and, therefore, agricultural production.

The remarkable properties of capillary water continue to be discovered. For example, it has been found that it does not freeze even at 30°C, though it becomes slightly viscous and heavy. The ability of water to simultaneously exist in gaseous (vapor), liquid, and solid states, along with its extreme mobility, ensures its presence throughout the geographical shell and its participation in various natural processes. There is no place on Earth without water in some form or another.

Water has a certain self-purifying property. When it passes through soil, it is filtered; in addition, clean water evaporates, leaving impurities behind. The flow of rivers and the movement of lake and sea waters also contribute to water purification. Chemically, water is never completely pure in nature because it is a strong solvent. Therefore, it always contains dissolved and suspended substances. Through its interaction with the atmosphere, lithosphere, and biosphere, water affects various substances and forms solutions. Consequently, water is a solution of various gases and salts at different concentrations.

The universal solvent property of water determines the exchange of substances in the geographical shell, including the exchange of materials between organisms and their natural environment, thereby regulating vital processes. It is known that pure water, due to its high solubility, can also harm organic compounds and living tissues. For life, water with a certain degree of mineralization is necessary. It is no coincidence that the composition of salts in the blood is similar to that in seawater. Human economic activity increasingly affects the chemical composition of natural waters. The rapid growth of cities and industrial facilities, the construction of canals, reservoirs, and other structures alter the composition of natural waters and disrupt their hydrochemical regime.

The chemical influence of water on minerals in the Earth's crust plays an extremely important role in the development of continents, the dissolution of rocks, their movement in solution from one place to another, and the exchange of substances between land, oceans, and various landscapes. Due to its high mobility, water is a powerful carrier of substances and energy. It transports various materials from one location to another. This activity of water involves three processes — erosion, the movement of materials, and accumulation. These processes play an important geomorphological role. Water also has a particularly significant role in soil formation and sediment deposition.

For biological, biochemical, biophysical, and other processes in continental and ocean waters, the dissolution of gases in water, especially oxygen and carbon dioxide, is of great importance. Dissolved carbon dioxide further enhances the solvent properties of water. However, the most important role of water in nature is its participation in photosynthesis, the process that forms the basis of organic life. During this process, water is split into oxygen and hydrogen under the influence of sunlight. The released oxygen enters the atmosphere, while hydrogen combines with carbon dioxide to form organic compounds. Thus, water is the sole source of oxygen released into the atmosphere during photosynthesis.

Water is also of special importance in the biochemical and biophysical processes within organisms, as well as serving as their habitat. No living organism on Earth can survive without water, as it is an integral part of the cells and tissues of all animals and plants. Naturally, water is abundant in aquatic organisms. For example, the body of a jellyfish consists of 99.7% water. Terrestrial organisms also contain large amounts of water; for instance, grasses contain 85%, and large mammals contain more than 60% water in their bodies. Food consumed by humans contains more than 50% water. Vegetables contain 80–90% water, meat 50%, and milk 87–89%. Water plays a major role in human growth and physiological functions. About 70% of the human body in middle age consists of water. Water actively participates in nutrient absorption and metabolic processes. At the same time, water is an ideal object for relaxation and recreation. Many springs and water bodies are widely used for recreational purposes. These examples clearly demonstrate the enormous importance of water in nature and human life.

The largest reserves of freshwater are stored in natural glaciers. According to the table above, the volume of polar and mountain glaciers amounts to 24 million km³. The volume of other glaciers is 250 thousand km³, of which approximately 200 thousand km³ corresponds to ground ice in permanently frozen areas. The following data clearly illustrate the volume of glacial waters. If all the glaciers on Earth were to melt, the level of the World Ocean would rise by 64 meters, its area would increase by 1.5 million km², and the land area would decrease by approximately 1%. Glaciers occupy a special place in the cyclical movement of water on Earth because they store water in solid form for many years. On average, snow that falls on a glacier remains there for 8,000 years before it turns back into water and joins the active water cycle.

The water resources of the Earth are recognized and confirmed by many scientists and specialists in geography and hydrology around the world. We present the information according to M.I. Lvovich (1974).

Table 1
Distribution of Water Reserves

Hydrosphere Components	**Total Water Volume, thousand km³**	**Percentage of Total Volume (%)**	**Water Exchange Activity, years**
World Ocean	1,307,323	93.96	3,000
Groundwater	60,000	4.12	5,000
— including active exchange zones	40,000	0.27	330
Glaciers	24,000	1.65	8,000
Lakes	2,801	0.019	7
Soil Moisture	85	0.006	1
Atmospheric Water Vapor	14	0.001	0.027

River Water	1.2	0.0001	0.031
Total	1,454,193	100	2,800

Of these, water in reservoirs amounts to 5.5 thousand km³, while water in canals accounts for 2 thousand km³. As can be seen from Table 1, the main part of the Earth's water reserves (94%) corresponds to the saline waters of the World Ocean. These waters are very rarely used in the national economy. In industry, agriculture, and domestic services, primarily freshwater is used.

In general, the volume of surface waters on land constitutes only 0.07% of the total water on Earth. Soil moisture reserves amount to 85 thousand km³. Approximately 280 thousand km³ of water is stored in lakes, half of which corresponds to flowing freshwater lakes, while the remainder is found in enclosed lakes (non-flowing lakes) with varying salinity. The smallest water reserves are in the river component of the hydrosphere, with a volume of approximately 1.2 thousand km³, which is only 0.0001% of the total hydrosphere water reserves. Another form of water reserve in the hydrosphere is water in the form of vapor in the atmosphere. The volume of water vapor in the troposphere, if converted to water, is 14 thousand km³ (Lvovich, 1974). Although the volume of this part of the hydrosphere is small, its significance in the formation of freshwater on Earth is extremely large. Information on freshwater reserves that can meet the needs of humanity is presented in Table 2.

Table 2
Freshwater Reserves on Earth

Hydrosphere Component	**Total Freshwater Volume, km³**	**Percentage of Total Freshwater (%)**
Glaciers	24,000,000	85
Groundwater	4,000,000	14
Lakes and Reservoirs	155,000	0.6
Soil Moisture	83,000	0.3
Atmospheric Water Vapor	14,000	0.06
River Water	1,200	0.04
Total	28,253,200	100

The total volume of freshwater on Earth is 28.25 million km³, which constitutes nearly 2% of the total volume of the hydrosphere. The largest reserves of freshwater are stored in natural glaciers. The volume of glaciers in the polar regions and mountains is 24 million km³, accounting for 85% of all freshwater reserves on Earth. The majority of freshwater is concentrated in remote and difficult-to-access areas such as Antarctica, the Arctic, and high mountain regions.

The primary source of freshwater that meets human needs is rivers, whose total volume is only 47 thousand km³. Most of this water flows through sparsely populated regions in the northern and equatorial zones, making its utilization quite challenging. Equatorial and temperate regions of the Earth are relatively better supplied with freshwater. Countries best supplied with freshwater include Brazil, Russia, Canada, the United States, Venezuela, Peru, Colombia, and the Democratic Republic of the Congo, among others.

In arid regions, which constitute one-third of the land, water scarcity is particularly severe. Moreover, agriculture in these areas largely relies on artificial irrigation. Countries in North Africa and Southwest Asia are among such regions.

To use river water more efficiently, numerous reservoirs have been constructed. Currently, the number of reservoirs worldwide exceeds 40,000. The volume of water consumed in production processes at large modern enterprises is hundreds to thousands of times greater than the weight of the products produced. For example, producing 1 ton of steel or paper requires 250 tons of freshwater, 1 ton of aluminum requires 1,500 tons, 1 ton of synthetic fiber requires 5,000 tons, 1 ton of ammonia requires 1,000 tons, 1 ton of nickel requires 4,000 tons, 1 ton of sugar requires 100 tons, and 1 kg of rubber requires 3,500 tons of freshwater.

Freshwater is especially widely used for cooling aggregates and components. If current methods of utilizing freshwater resources continue to be applied in the future, its depletion will become a reality, resulting in a “water crisis.”

At present, the demand for the quality of water used for household and industrial needs is steadily increasing. In the future, the location of new enterprises will be determined not by energy or raw materials, but by water resources. Therefore, ensuring the supply of freshwater has become one of the critical issues for human society and its development.

Among the many tasks facing humanity, the problem of water resource conservation occupies a special place. It is well known that the Earth has large water resources due to the cyclical movement of water. This cyclical movement continuously renews water resources. The circulation of water is important not only in terms of quantity but also in terms of quality. However, discharging polluted water into rivers and reservoirs disrupts this process and contaminates continental freshwater. In the near future, if significant changes are not made in water management and strict control over the quality of water resources is not established, serious negative consequences will inevitably be observed in both the quantity and quality of freshwater.

To prevent this, particular attention must be paid to new principles of water use and to protecting water resources from pollution. It should also be noted that the experience accumulated in global water management so far provides a basis for an optimistic view of the future of water resources. Various measures exist for successfully addressing the water problem.

One of these measures includes technical interventions as follows. The first approach involves reducing the amount of polluted (waste) water in all possible ways to prevent the deterioration of water quality, and subsequently stopping its discharge into rivers and reservoirs. This requires industrial enterprises to transition to a closed-loop water supply system. This is a complex but feasible task. Many enterprises in Russia, the USA, Germany, and Japan are increasingly moving in this direction. The large metallurgical plant in Chelyabinsk, Russia, has already switched to a closed-loop process. To eliminate bacterial contamination, wastewater is disinfected. The method used is determined by the type and degree of contamination of the wastewater.

Mechanical purification method. In this method, insoluble impurities in wastewater are retained using mechanical devices. Mechanical purification allows the removal of up to 60% of insoluble impurities from domestic wastewater and up to 95% from industrial wastewater.

Chemical purification method. In this method, reagents are added to wastewater that react with harmful compounds, causing them to precipitate or become neutralized. Chemical purification reduces insoluble compounds in polluted wastewater by up to 95% and dissolved compounds by up to 25%.

Electrolysis method. Recently, the electrolysis method has been widely used to purify polluted water. This method involves passing an electric current through the contaminated water. The electric current decomposes harmful organic substances in the water and separates metals, acids, and other inorganic compounds from the water.

Mechanical, chemical, and electrolysis methods are used either as complete purification methods before discharging water into reservoirs or as initial treatment steps, after which water undergoes biological purification.

Biological purification method. This method uses the biochemical and physiological self-purification properties of a river or other water body. The biological method is based on mineralizing organic pollutants in wastewater under aerobic conditions through biochemical processes. Biological purification is mainly applied to domestic wastewater and partially to industrial wastewater.

Conclusion

Freshwater reserves on land are one of the crucial factors for human life, social development, and ecological stability. Today, due to global warming, industrialization, population growth, and improper use of water, freshwater sources are under serious threat. This problem leads not only to the depletion of natural resources but also to the intensification of socio-economic issues. The fate of humanity depends on the rational management, conservation, and equitable distribution of freshwater resources. Therefore, within the framework of sustainable development strategies, it is of vital importance to protect water resources, restore them, and manage them effectively using innovative technologies. Only through global cooperation and conscious actions at the local level can humanity ensure a safe and sustainable future.

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