UNCONVENTIONAL METHODS OF OBTAINING FRESH WATER

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ABSTRACT

This article provides an overview of the currently available methods for obtaining fresh water. The possibilities of using each of them in the arid zones of Central Asia are evaluated. One of the most acceptable methods of electro dialysis for these zones, the method of obtaining fresh water by its active condensation from atmospheric water vapor, is considered.

In the context of a global freshwater shortage, where traditional sources (rivers, lakes, and groundwater) are dwindling due to climate change, urbanization, and pollution, humanity is seeking alternative solutions. According to the United Nations, by 2030, approximately 40% of the global population will face severe water scarcity. Unconventional methods involve innovative technologies, often energy-intensive or experimental, that have the potential to make a significant impact. During the 20th century, humanity's consumption of fresh water increased sixfold and continues to grow. It is expected that the demand for fresh water will increase by 35-40% in the next 25 years, and the demand for drinking water will double, while the world's water resources are declining. As a result, one-third of the world's population already lives in countries with limited water resources, and by 2025, two-thirds of the world's population will live in such countries. These include some Central Asian countries (Uzbekistan, Turkmenistan, and Kazakhstan), as well as the southern part of European Russia.

Of the total amount of water on Earth, only about 2.5% is fresh water, and two-thirds of this (68.7%) is in the form of ice in mountain glaciers and the ice sheets of Antarctica, Greenland, and Alaska. As an alternative method of obtaining fresh water, some researchers propose extracting it from icebergs transported from Antarctica using specialized ice-breaking vessels.

Special calculations have shown that a country like Saudi Arabia would need to transport about 1 km3 of ice annually, which is a minor loss for Antarctica [Hamidov, 1999].

The total cost of the project for the Arabian Peninsula countries would be around \$3.2 billion. According to the same estimate, the project would be profitable if it could meet the half-yearly demand for ice water at a selling price of 20 cents per liter. At the same time, the cost of high-quality fresh water will be much lower than that of water produced by nuclear desalination plants.

One of the disadvantages of the project is the construction of special vessels capable of transporting large blocks of ice and having environmentally friendly ship propulsion systems to prevent possible pollution of the Antarctic and Arctic seas.

Another method of obtaining fresh water is the widespread use of desalination of saltwater. The production of fresh water using this method is continuously growing at a rapid pace. In 1960, 0.09 km3 was produced using this method, in 1985 – 3.63 km3, in 2000 15.3 km3. The distribution of the amount of water obtained by region is uneven: the Middle East accounts for 60%, North America – 13%, Europe – 10%, Africa – 7% and the rest of the world 10%. The CIS countries account for only 0.6% of the total global volume of freshwater production.

Three methods are used for large-scale production of fresh water from seawater: distillation, electrodialysis, and reverse osmosis.

Distillation is the oldest method of producing fresh water. The essence of the method is to convert seawater into steam by heating it, which is then condensed. It takes approximately 2700 kJ of energy to evaporate 1 kg of water, making distillation a relatively energy-intensive process. However, in recent years, significant advancements have been made in reducing energy consumption in large-scale water production facilities by utilizing the heat generated during steam condensation. For this purpose, multi-shell desalination plants are being built, with the number of stages reaching up to 30.

Multi-shell flash boiling plants and vapor compression plants have also been developed, allowing for more efficient use of the heat generated during steam condensation, resulting in significant reductions in energy consumption, particularly in high-capacity plants. However, the cost of heat and electricity in distillation plants accounts for 50-70% of the total cost.

The electrodialysis method involves passing an electric current through seawater to remove the salts present in it. To prevent reverse reactions, semi-permeable ion-selective membranes are placed in front of the electrodes. This method is primarily used for desalination of low-salinity waters, as the energy consumption increases significantly with higher salinity levels. For example, the cost of desalinating seawater with a mineralization of 20-25 g/L increases fivefold compared to the cost of desalinating water with a mineralization of 4 g/L.

The essence of the reverse osmosis desalination method is that when a higher pressure is applied to a container separated by a semi-permeable membrane, fresh water passes through the membrane while the salts are retained. However, the selectivity of the membranes depends on the charge of the ion. They retain multi-charged ions but allow 15% of single-charged ions, which make up the majority of the ionic composition of seawater. To desalinate seawater, it must be passed through the membranes multiple times. The efficiency of membranes depends on the temperature of the water and its contamination, so pre-treatment is required.

The price of 1 m3 (US dollar - $) of fresh water on large distillation plants is 0.5-2 $/m3, depending on the plant capacity, and 0.2-0.3 $/m3 for electrodialysis and reverse osmosis at a salinity of 2-4 g/L.

Both of the described methods of obtaining fresh water can only be carried out in coastal areas. However, the method of desalination of sea water requires the use of large amounts of sea water, which means that the desalination plants must be located near a body of water, as operating large plants far from a body of water increases the cost of water, and operating individual-use plants is almost impossible. In addition, the need to locate the desalination plants near a body of water is due to the fact that concentrated brine is discharged into the body of water during desalination, which has an adverse effect on the ecology of coastal waters due to the high concentration of harmful substances.

One of the methods of obtaining fresh water that is currently being developed is the method of collecting water from fog. A number of papers on this topic were presented at the Second International Conference on Fog and Fog Water Collection.

Most studies on fog harvesting are conducted in South Africa, where the climate contributes to the formation of fog. South Africa has a distinctly arid climate. Most of the country receives less than 500 mm of annual rainfall. The few permanent rivers that cross the country and the limited underground water reserves are often insufficient or contaminated. The severe droughts and limited surface and groundwater resources in South Africa have led to research into the feasibility of using alternative water sources.

One of the experiments was conducted at the Southpansberg School in Wenda, an area where water is particularly scarce. In March 1999, a 18x4 m fog collector was installed. Since then, the average daily water collection rate has exceeded 3 L/m2, with a maximum of 3,800 L/day. The amount of water collected was influenced by rainfall and the speed of fog-bearing winds perpendicular to the collector. With the exception of light impurities, the water quality was determined to be acceptable and suitable for consumption.

Since ancient times, humanity has been trying to intensify the process of atmospheric water vapor precipitation. It is known that in the desert regions of Central and South Asia, including along the "Silk Road" caravan route, people have been trying to obtain drinking water from atmospheric moisture using primitive condensation devices [Kamalov, 1999]. For this purpose, they built stone pyramids on a ceramic (or wooden) base. At night, dew would precipitate on the stones and collect in vessels.

Another type of large structure designed to improve water supply is called a "kariz" (underground tunnel). Its depth could reach 10-30 m and in some places even more. The length of such tunnels reached 3 km or more, height 1.5-1.8 m, width 0.8-1.0 m, the average slope of the tunnel was about 1-2 m and increased for every 10 m length. Along the entire length of the tunnel, vertical wells were dug every 10-15 m, which were used to raise the ground. Over time, the tunnel's air quality improved.

Shepherds raising cattle built so-called (breathing wells) on the Ustyurt river. Their walls were covered with porous limestone, and moisture, condensed into many holes inside the wall, collected at the bottom of the well in the form of water. The water in these wells was cold and clean.

More than a hundred years ago, in Feodosia (Crimea), archaeologists excavated a network of pipelines extending into the mountains. In the mountains, the network ended not at a mountain stream or any other body of water, but at a pile of crushed stone on a hill. It was the crushed stone, placed on hills in the windiest areas, that served as a kind of condenser, extracting moisture from the humid air. According to experts, the capacity of such installations reached 700,000 liters of water per day.

Interest in this type of atmospheric moisture condensation method was revived at the end of the 20th century. The method of obtaining fresh water from humid air, described in [Alekseev, Chekarev, 1996], is based on natural processes occurring in nature and does not contribute to environmental pollution. In this method, fresh water is obtained from humid air by condensing the water vapor present in it.

Obtaining fresh water with this method is carried out by collecting the smallest droplets that form in the air as a result of its natural cooling due to radiation from both the air mass and the surface. To control the droplets, obstacles are placed in the path of air movement, into which the droplets strike and settle on them. Large networks with cells of the order of 1 cm are used as collectors. Experiments on obtaining water using this method are carried out in many parts of the world (in 47 locations, in 22 countries on 5 continents). In 1989-1990, a large-scale experiment was conducted in the northern part of Chile to collect fresh water using 50 collectors in the form of 48 m2 nets, each installed vertically [Alekseev, Chekarev, 1996]. The experiment was conducted during three dry years in an extra-arid zone (10-80 mm of precipitation per year), and the installation produced an average of 7,200 liters per day. The cost of producing water using this method depends on various factors, including the location of the installation.

Despite the simplicity of this method for obtaining fresh water, it cannot be considered as a permanent source of water supply. This is due to the fact that the conditions under which the smallest water droplets are formed in the air significantly depend on the location and climatic features of the area.

For this reason, active methods of water vapor condensation are more promising, as they allow for the creation of nuclear condensation plants of any capacity. The essence of active methods is the forced cooling of the condensation surface to the dew point temperature. In this regard, the most advanced method, in our opinion, is the condensation method using so-called solar tubes [Wolfgang Schiel, 1996]. Initially, these tubes were designed to generate electrical energy. We believe that the generated electrical energy can be partially used to cool the condensation surface by appropriately reconstructing the solar tube.

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