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Effects of Desalination Processes on the Water Circulation and Earth System

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Abstract

Desalination is emerging as a promising alternative among various technologies to resolve water shortage. However, desalination requires a sufficient energy and cooling device and therefore poses limitations for its installation and application. In particular, many countries suffering water deficits are economically underdeveloped and cannot afford the technology. As this technology, which changes seawater into freshwater, has little environmental impact, developed countries will need to assist less developed countries to introduce this technology as a humanitarian effort. This will help reduce the number of countries that have experienced difficulty with development.

Keywords

Desalination, Earth System, Humanitarian Effort, Water Shortage

1. Appropriateness of Desalination

Water is the most basic element for humans in maintaining their livelihoods and building civilization [1]. The four cradles of ancient civilizations were each located near a large river that formed the basis for their development. However, urbanization and industrialization have led to the pollution and depletion of water sources, and people in an increasing number of regions suffer from water poverty [2] [3]. Almost one billion people living in developing countries do not have access to clean water. Water is an essential nutrient for life. Among the 10 countries with the worst water shortages, where polluted water must be used for drinking, the severity of water shortage is correlated with the average lifespan (Table 1). In comparison, South Korea, with an average lifespan of 84.1 years, is not yet a water-stressed country but has the potential to become one.

Table 1. Average lifespans in the top 10 water-stressed countries of the world.

Rank	Country	Average life span (year) [9]
1	Somalia	57.35
2	Mauritania	75.69
3	Sudan	66.10
4	Niger	62.93
5	Iraq	72.05
6	Uzbekistan	71.78
7	Pakistan	67.34
8	Egypt	70.81
9	Turkmenistan	69.54
10	Syria	72.45

Water shortage may appear to be unlikely when the earth is viewed from space. Despite the fact that 70% of the planet's surface is covered with water, water shortage is considered one of the greatest threats to many countries. The most important reason is that humans cannot drink saltwater. While the salinity of seawater is approximately 3%, that of the human body is less than 1%. Therefore, when humans drink seawater, the solute concentration in the blood becomes higher than in the cytosol and water leaves the cell and enters the blood or lymph. This increases the volume of blood. The kidney eliminates salts and water from the body to maintain the blood concentration, but only approximately 2% of salts can be eliminated from the human body by the kidneys. Therefore, to remove excessive salts from the body, a greater volume of urine must be removed than that of the seawater that was consumed, and this can cause fatal dehydration.

However, we have a technology that can change saltwater to freshwater. Desalination turns non-potable seawater into potable freshwater by removing salts and various other minerals.

Why, then, do so many countries still suffer from water shortages despite this technology? The answer is related to economic power. Just as our civilizations have been established based on water, our industrial and cultural development are also closely linked to it. Few countries suffering water shortages are sufficiently economically developed to afford desalination, a technology that requires the consumption of a large quantity of energy.

Around the world, advanced water treatment industries are expanding due to aggravated water shortage and pollution. By 2030, the water treatment market is expected to exceed US$536.4 billion [4]. Recently, China, India, and other countries have increased their investment in relevant infrastructure. However, this issue cannot be approached this issue from the economic or commercial viewpoint to help the aforementioned countries suffering from water shortage. Economically developed countries must collaborate to help solve this problem.

One must then consider the environmental effects of implementing desalina-

tion technology in these 10 countries suffering from water shortage. To examine this question, the likely environmental effects were predicted based on the following assumptions.

The minimum amount of water a person needs for survival per day is 3L in an environment with an average temperature of 25 degrees Celsius. As of January 2024, the total population of the 10 countries mentioned earlier was 574,135,696, if these people use only the minimum amount of water for 365 days, they need approximately 628.7 billion liters of freshwater. If such a large amount of seawater is turned into fresh water and returned to terrestrial environments, stagnation of freshwater in the land and blocked inflow of seawater can be expected.

When a substantial amount of seawater flows into the land, how does it change the sea level? We need to consider the change of sea level caused by climate change. The melting of glaciers and ice caps caused by climate change generates 267 ± 16 billion tons of freshwater each year [5] [6]. Seawater introduced to terrestrial systems by desalination due to increased freshwater from melting glaciers increases every year. As a result, the sea level still rises, but this can be slightly reduced through the seawater desalination process (**Figure 1**).

Based on this assumption, the sea level will continue to increase, which will cause continental uplift according to the theory of isostasy. As a result of continental uplift, through the Benioff zone located on the active continental margin, the interior substances of the upper mantle will flow into seawater. Associated outgassing processes, including volcanism, as well as an increase in rates of chemical weathering on the continental margin will increase the amounts of dissolved components in seawater [7] [8]. In other words, continental uplift may offset the salinity decrease associated with the introduction of freshwater due to the melting of glaciers. Additionally, maintaining salts in the sea can contribute to the maintenance of the thermal balance of the earth by maintaining the thermohaline circulation.

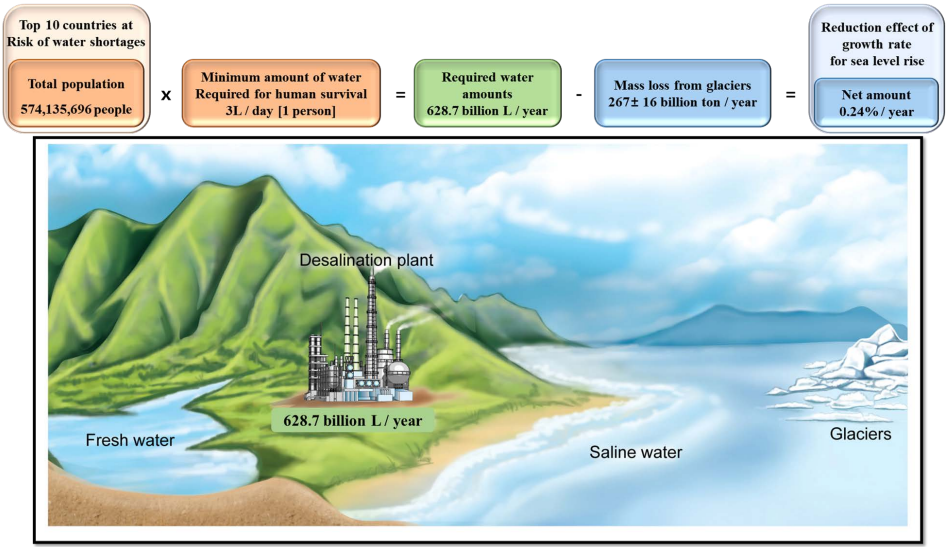

Figure 1. Reduction rate of sea level rise by desalination.

2. Conclusion

The theory above was based on a combination of assumptions. However, the author hopes that desalination will be more actively carried out based on this study. Additionally, the development and implementation of desalination technology can help people around the world who are living in countries with insufficient water resources and will surely contribute to balanced development and growth worldwide.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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