

A Global Study About Water Crisis

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ABSTRACT

The article examines the global water crisis, including quantity and quality of fresh water supply around the world. Studies on this issue with examples from different regions of the world are compiled and reviewed. The researcher then aims to identify the key issues in the dire situation and analyze their causes. The scarcity of fresh water is associated with population growth and economic development, including irrigation water for agriculture. Concerns about quality of water included pollution and hard water. Methods including desalination and recycling are evaluated and best practices are shared. Towards the end of the study, the paper presented possible solutions including new processes, metrics, and recommended a combination of these approaches as remedies for the water crisis.

Keywords: *Water crisis, Water quality, Environmental protection, Scarcity of water.*

1. INTRODUCTION

People are facing a water crisis. Water is an essential resource for humans to sustain life, and we should provide an adequate supply for everyone [1]. The term water crisis is widely happening, including both lack of fresh and low quality water [2]. Some factors gradually increase the seriousness of the issue, such as the growth of the population size and pollutions from individuals and industries. With good protection and organization, water can be used for a long time [3]. In the past, many countries and regions have tried several different methods to remedy the situation. This thesis will take a look at case studies from around the world, to determine the measures that governments and citizens can take to solve the problems of freshwater scarcity and pollution that people face today.

This thesis will discuss the causes of the water crisis people face around the world and the consequences, then explain the work people attempt to do in order to resolve the problem, and recommend future studies regarding how to create a sustainable way to treat water resources. Chapter 3 contains information about the major issues of water resources. The problems people are struggling with include the scarcity of water resources, poor water quality, and the effect of hard water. Many regions face water crises, including Beijing, the city the researcher lives in. Similar to Beijing, there are many populated cities around the world facing the same problem—thus it is crucial for us to understand what has been happening worldwide.

2. LITERATURE REVIEW

In the paper, "Water quality assessment and source identification of water pollution in the Banchengzi reservoir, Beijing, China," the author mentioned that surface water in Beijing changed a lot in the past few years, which caused many problems [4]. The study focused on the Banchengzi reservoir in Beijing. During their study, they collected and analyzed six different water samples from different parts of the Banchengzi reservoir and collected the data monthly from 2007 to 2012. Then they used UV-vis spectroscopy, three-dimensional excitation-emission matrix spectroscopy, and nitrogen stable isotope ($\delta^{15}\text{N}$) analysis to find the causes of pollution. The answer was the anthropogenic sources in the upper area or the reservoir. To protect the water, we needed to reduce pollution and focus on upper river ecological restorations.

In "Water Crisis," Sharad K Jain wrote about his understanding of the water crisis [2]. Water is fundamental to social development, justice and welfare. But now, countries all around the world are facing a water crisis which was caused by population and economic growth. Countries all over the world need to find a sustainable solution to this issue. Concluding, he described the water crisis in terms of the quantity and quality of the water, and identified the reasons behind the crisis. As Jain wrote at the beginning of the paper, "A multi-pronged approach involving all sections of the society in all countries – developed, underdeveloped or developing – is

urgently needed to find a lasting solution." [2]. This idea led the researcher to find a synthetical method all around the world. Jain did a detailed analysis of the water crisis, but he did not analyze the methods that could resolve the issues.

In "Global Water Resources: Vulnerability from Climate Change and Population Growth," Charles Vorosmarty used data to describe the water crisis caused by climate change [5]. He mentioned that water quality is a question that can not be evaluated and controlled very easily, but through the growing human activities the situation has definitely grown worse. Through the experiment by using climate model, water budget, and economic information, there occurred two concerns: first, more and more people's lives were affected by the water crisis globally, and secondly, the demand for safe water supply has increased dramatically. The research tried to find the relationship between water crisis and issues like climate change and population growth.

3. MAJOR ISSUES OF WATER RESOURCES

This section will cover the major issues that people face regarding water, including freshwater scarcity and poor water quality. In section 3.1., freshwater scarcity will be discussed and this section will cover the reasons why water became a scarce resource and the major factors leading to this crisis. Section 3.2. discusses water quality. It includes the methods of measuring water quality, and the human and natural behavior that caused a decline of water quality. Section 3.3. contains the effect of hard water for drinking and daily life usage.

3.1. Freshwater scarcity

Fresh water scarcity happens all around the world, which affected people in many countries and regions. Although the total amount of fresh water on Earth is enough for population in the world, the distribution of water spread unequally, so the water scarcity happened [6]. In some areas such as Amazon, water has a huge surplus which no one care about water crisis, but for other places such as Saudi Arabia, the water is really limited. The fresh water scarcity will discuss following on four aspects, problem caused by increasing of global population, water used agriculture, water sources influenced by human, and the effects of water shortage.

3.1.1. Demand of water and the increasing population of humans

There are many kinds of water shortages, but the main two causes are less rainfall and the insufficient water quantity. Less rain affects the hydrological cycle and causes damage to the environment [7]. The lack of water affects a lot of areas resulting in severe shortage and increasing demand. It is a problem difficult to solve since it is hard to work against nature, thus the water resource is an important issue for demand of water.

The population in the world increased dramatically in recent years and the increasing in the human population caused some problems, such as reducing the degree of surface sealing as well as infiltration area. Furthermore, the demand on water as well as water pollution increases [8]. Everyday people need to use 3 to 5L of water for drinking, 200 to 300 liters for household use, 300 liters of water for refining every liter of gasoline and irrigation is 2000 to 5000 liters per capita [7]. That was a huge amount of water for everyone, and due to the growth of population, this issue becomes more important.

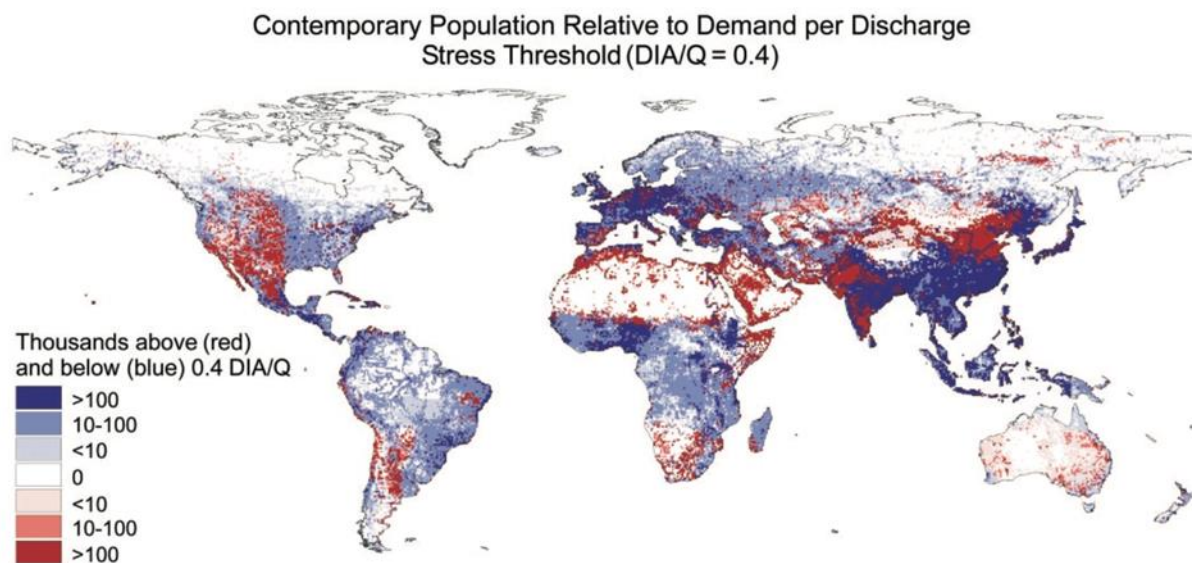


Figure 1. Population and water storage [7]

3.1.2. Agriculture uses

Just as water is essential for life, so is food an essential resource for human survival. Agriculture is one of the most significant parts of the food production process. Agriculture drains the largest amount of freshwater resources, since irrigation uses 65-75% of water [6]. The usage of water for land irrigating is unavoidable, since people need to produce food. However, the amount of water used for irrigation could be reduced with improved efficiency and better management.

3.1.3. Human impact

The effects of human on the water resource involves two parts, the development of society and its economy, and bad water habits wasting resources. Social and economic development resulted in uneven distribution of resources and caused industrial pollution.

Unfortunately, the uneven distribution of resources mostly affected the underprivileged population, especially those in rural areas. Unlike the city, in some rural regions, people do not have water taps installed at home. From the data we can tell that, for homes containing multiple taps the water consumption is 100-200L per day; when the source of water is within 1km the water

consumption is 20L per day; and when the source of water is more than 1km away from home, the water consumption drops to 5L per day [2]. To travel a distance to get water takes time and energy. This proves that the underdeveloped regions face the problem of water crisis more than anyone else.

Of course, in highly developed regions, water resources are guaranteed but often squandered. We also need to raise the awareness of saving water in metropolitan cities around the world.

3.1.4. Effects of scarcity

Water scarcity has its consequences in many different regions, affecting economic and social development and the daily lives of ordinary citizens. More severely, it could affect institutional efforts like medical services, agricultural efforts, and urbanization.

In some regions, to solve the problem of surface water shortage, people use a great amount of groundwater. The quantity of surface water in cities is small, compared to the total amount of fresh water underground. In places with a shortage of water, you might be able to find that there is a water supply underground. Thus, there is tremendous pressure on land usage, and this causes land disputes [7].

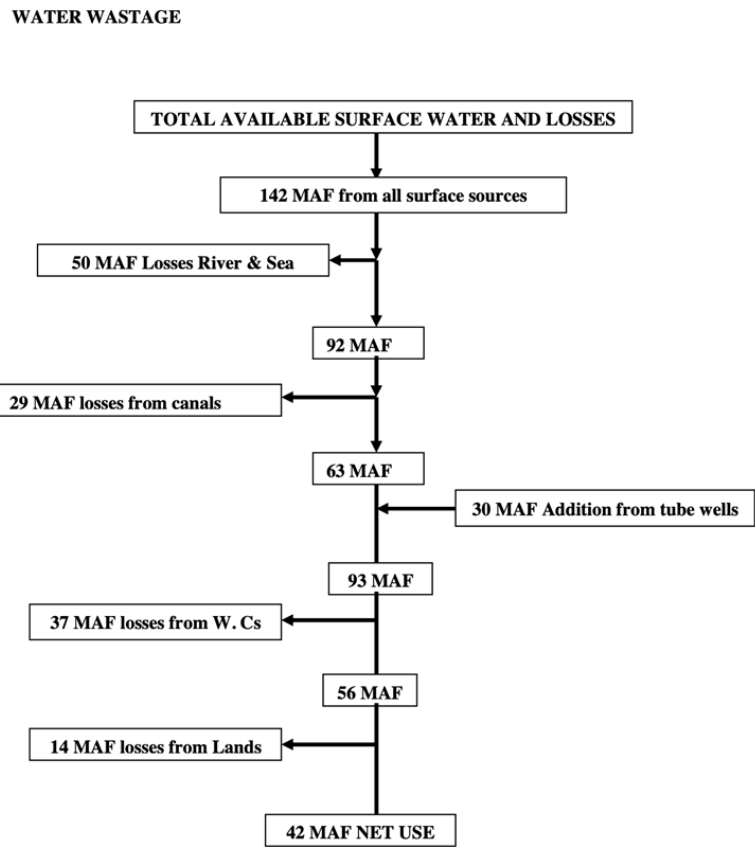


Figure 2. Water wastage [7]

3.2. Low quality of water

The quality of water is a trickier question. The situation has grown worse in areas with fast development and industrialization. In a research project using a climate change model, many factors were examined, including water quality, economic development, and population. The researchers confirmed that more people are facing the water crisis and the demand for reliable water supply has increased dramatically [5]. The researchers used many methods in order to identify the relationship between the water crisis and climate change and population growth. In the following sections, we will analyze these two aspects. The impact from human behavior is described in 3.2.1. and the problem of hard water, or water that has high mineral content, is mentioned in 3.2.2.

3.2.1. Human impact

During the past years, surface water has encountered many problems due to pollutions. Human factors caused the decline of biodiversity, harming humans' health and worsening the ecosystems [4]. For example, the Banchengzi reservoir in Beijing, is facing a water pollution issue, and the main pollutant in the Banchengzi reservoir is nitrogen which is produced by upper river human activities. The nitrogen stays in the water and produces Soluble Microbial Products (SMP), affecting the water quality [4].

3.2.2. Hard water

Hard water contains high mineral content such as calcium and magnesium [9]. Recently, hard water has been a controversial topic, resulting in debates on its benefit to human health. According to WHO, there is no evidence of health indication regarding hard water [9], but the relationship between hard water and cardiovascular diseases is still unclear. A study in 1975 by a Japanese scientist, Kobayachi, shows that when the water is harder, the death rate caused by cardiovascular diseases will go down [10]. The scientist concluded that the special elements in hard water may be related and that Magnesium and Calcium play an important role. Against conventional thinking, this study shows that Magnesium and Calcium could reduce the risk of cardiovascular diseases [10]. Magnesium is a component of muscle cells that are connected to the functioning of the human heart, and it is an essential catalyst in life reaction which participates in several processes of producing energy [10].

In summary, there is no indication that we need to be worried about the issue of hard water. It is a minor issue compared to the quality and quantity of freshwater resources. But researchers should continue to monitor this issue, not just the effect on human health but also on animals, plants, and the environment overall.

4. POTENTIAL SOLUTIONS

By knowing the causes and the consequences of the water crisis, people need to look for solutions. Many have attempted to use various methods to alleviate the crisis. In 4.1., two processes, water desalination and wastewater recycling are described; and in 4.2., two measurements, water footprint and the trinomial approach, are also presented.

4.1. Improvement Methods

In addition to measuring and limiting consumption, some methods could help increase the supply of water, which is very essential for solving the water crisis. Methods such as water desalination and wastewater recycling are explained in this section.

4.1.1 Desalination

Desalination of seawater is a method known widely in the world. This method has its pros and cons. Since ocean water is the largest water resource in the world, thus by the desalination method, theoretically we can take advantage of ocean water as an unlimited type of fresh water supply. Unfortunately, this process is expensive, and it may cause environmental problems by burning fossil fuels [11]. Countries practicing desalination methods include the Kingdom of Saudi Arabia (KSA). KSA is a country in the middle east with a serious water scarcity issue caused by climate change and population growth [11]. Since KSA is occupied by desert and has abundant oil reserves, the ocean water desalination method has become its most important option and has been providing water resource for the country for a long time. According to research data, 70% of water resources used in KSA are produced by water desalination, but this practice has resulted in a usage of 1.5 million barrels of crude oil need [11]. Thus, the usage of desalination could solve the water crisis but the users need to be aware of the financial and environmental cost involved.

4.1.2. Wastewater recycling

Reuse of water is one of the most effective ways in regions with a water shortage. This process is practiced well in Europe, where a project called AQUAREC was created to manage the recycling of water. The AQUAREC project established a new recycling procedure to treat the polluted water in a way that could boost the overall freshwater supply in Europe [12]. Water recycling provides several benefits including the reduction of eutrophication in water and saving energy [12], but for a long time many concerns remain regarding the effectiveness and the efficiency of the recycling technology. The AQUAREC project created a model that could recycle a huge amount of water, as shown above in Figure 3. In 2014 alone, 700 Mm³ of water was reused in Europe,

and this is not the full potential of this method. It could work better in the future [12].

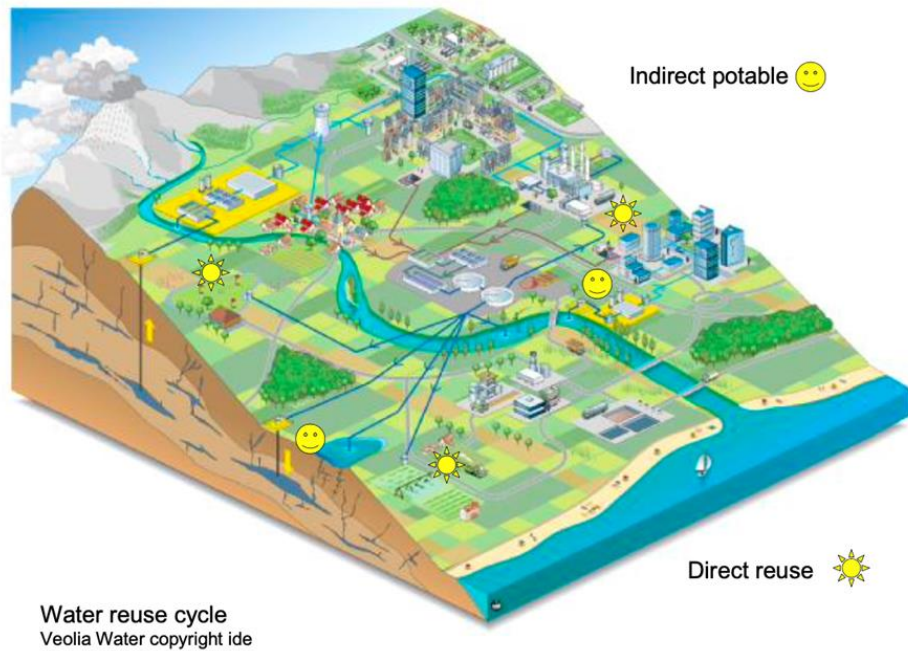


Figure 3. Reuse of water diagram [12]

4.2. New Methods of Analysis

New metrics have been developed to manage the situation. People also have launched new ways to evaluate the quality and quantity of water, which is important for identifying solutions for the water crisis. By measuring the water quality and the efficiency of a water system, we could recommend potential solutions and create policies to improve the situation [13].

4.2.1. Footprint

Water footprint, similar to carbon footprint, is a useful indication of the total volume of water consumption [14]. With this measurement, individuals, organizations and governments can measure their consumption patterns and try to minimize the usage. The water footprint can measure the quantity of fresh water a country uses, which could be effectively used to raise awareness and change behaviors. Everyone could use this metrics to monitor the water situation, from individuals to organizations and communities.

4.2.2. Trinomial approach

A trinomial approach is a concept in algebra, and this method allows us to measure water consumption from a micro and macro level. We could break down a piece of urban water consumption data into small elements to help analyze the water usage behavior of a region and provide insight for long-term policy-making. [15]. The trinomial approach can help us identify patterns in water

consumption and create policies that improved the efficiency of water management.

5. FUTURE STUDY

There are still unsolved issues regarding these new processes and new metrics. We should also look into synthetical methods that could play an important role in helping us treat and manage water. This new approach will be discussed in 5.1.

5.1. A synthetic method

To find a better solution for the water crisis, we need a comprehensive method, which could leverage the above measures and take everything into consideration, including climate change, water resource, and social impact [5]. In this synthetic method, it is important to address the shortcomings of water production processes, such as the expensive water desalination process and the inefficiency of the water recycling process. Furthermore, we should also incorporate the new evaluation metrics into this holistic approach so we can stay on top of the development and management of the water resources. By combining water footprint and trigonal metrics with new processes, policy-makers could help people understand the situation in a specific area and identify the key solution to tackle the issue. For example, in Saudi Arabia, the method wildly used is water desalination which was described in 4.1.1. Through better analysis methods, the government identified areas to improve and started to recycle water in some regions and transport them to help other regions in need. This resulted in less desalination

and helped save energy, reduce cost, and alleviate the pollution problem.

6. CONCLUSION

Policy-makers, researchers, scientists, and environmental protectionists have been working on the issues of the water crisis for a long time. This phenomenon has its roots in both natural and human causes, and could not be solved easily by one country or in a short time. The common goal should be to treasure the limited water supply and implement policies to reverse the trend of pollution and reduction.

Only by trying new processes, metrics, or combining both, can the crisis be managed in a more effective and efficient manner. First of all, different regions need to tailor their water policy to local needs. For examples, large cities should promote the awareness of saving water, while urban areas need to measure and improve penetration of water tap installment. Secondly, countries around the world need to work together to share best practices of methods like desalination and wastewater recycling. We need to continue to improve the effectiveness and efficiency of these commonly used methods. Last but not least, better measurements lead to better results. New metrics need to be developed to better monitor the situation, including Water Footprint, A trinomial approach to measure water consumption. Most importantly, we need to combine the above procedures and initiatives in order to achieve a satisfactory result.

The solutions we discuss today might not fully resolve the problem, and there are some geological issues that we have not been able to discuss today, such as the difference between a plateau or tundra terrain. But this study aims to inspire other studies and new ideas or technologies that could become solutions for the global water crisis.

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