

Review Article

# Central Asian and Northern Cyprus Water Desalination Experience

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## Abstract

Water supply in Famagusta, Northern Cyprus, presents a significant challenge, warranting detailed examination of the region's water management practices. Drawing parallels with the desalination experiences in Central Asia and Northern Cyprus, this manuscript explores the intricate relationship between water infrastructure and the multifaceted challenges faced during young researchers experience exchange internship between Kazakhstan and Northern Cyprus. Through a comprehensive analysis of water desalination experiences and the evolution of water supply facilities in both regions, this study provides insights into effective water usage. Central Asia and Northern Cyprus share similar climate conditions and challenges in water management, thus serving as valuable case studies for understanding optimal water resource utilization. This paper emphasizes the significance of adopting a comprehensive approach to address the complexities of water supply. Current research underscores the importance of sustainable practices and innovative solutions in ensuring water security, particularly in the face of climate change. Sharing knowledge and experiences is crucial for addressing the challenges posed by climate change and ensuring the resilience of water management systems. Key terms such as water desalination, water management in Cyprus, and water issues in Central Asia are meticulously explored, offering valuable insights for policymakers, researchers, and practitioners in the field of water resource management.

## Keywords

Water Desalination, Water Management, Water Supply, Northern Cyprus, Central Asia

## 1. Introduction

Freshwater scarcity has become a pressing issue in many parts of the world, with significant implications for both society and the economy. As the global water supply remains relatively constant, the growing human demand for water, already estimated to have reached 50% by some measures, is expected to continue rising [1]. Freshwater is a vital resource that supports a wide range of ecological and societal functions, including food and energy production, waste management, industrial development, transportation, and human health [2].

One region grappling with severe water scarcity is Cyprus, which has experienced recurring droughts over several consecutive years [3]. Against the backdrop of ongoing global climate change and the increasing prevalence of drought in various regions, there is a growing need to foster the exchange of water management expertise among multidisciplinary specialists to promote sustainable environmental development.

As part of an international water management exchange

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initiative, a group of early career hydrologists from Al-Farabi Kazakh National University in Kazakhstan recently visited water treatment facilities in Northern Cyprus. This initiative, conducted in collaboration with the Eastern Mediterranean University in Famagusta, aimed to facilitate knowledge-sharing in water resource management. Through daily seminars, participants gained insights into various aspects of the island's water landscape, including methods for ensuring high-quality drinking water, efficient allocation for domestic and other purposes, and the identification of key challenges facing the water sector, along with potential solutions. The enthusiastic young hydrologists also had the opportunity to explore the core water infrastructure of Northern Cyprus, particularly in the city of Famagusta. This firsthand experience provided them with a deeper understanding of the operational principles and mechanisms behind the water supply and treatment systems in the northern region of Cyprus (see Figure 1).



**Figure 1.** Wastewater treatment plants, Famagusta. Northern Cyprus.

The juxtaposition of escalating global water pressures, exemplified by phenomena such as climate change-induced droughts and increasing demand, alongside Cyprus's acute water scarcity predicament, highlights the urgent need for cross-disciplinary collaboration and knowledge exchange in water resource management [4]. This imperative lays the groundwork for initiatives like the visit of Kazakhstani hydrologists to Northern Cyprus, which serve as tangible demonstrations of the value of international cooperation.

Through this exchange, participants not only gain firsthand insights into the specific water challenges faced by regions like Cyprus but also have the opportunity to share their own expertise and innovative approaches [3]. By leveraging diverse perspectives and experiences, such collaborations foster the development of comprehensive and sustainable solutions to complex water management issues. This initiative also serves as a testament to the importance of fostering partnerships between academic institutions, governmental bodies,

and industry stakeholders [1, 2]. By facilitating dialogue and collaboration across these sectors, initiatives like the one between Al-Farabi Kazakh National University and the Eastern Mediterranean University in Famagusta pave the way for impactful action and positive change in water resource management.

For more information on global water pressures and initiatives promoting sustainable water resource management, you can explore resources such as the United Nations Water website and reports from organizations like the World Bank and the World Water Council. Additionally, information on specific water scarcity challenges in Cyprus and ongoing efforts to address them can be found through sources such as the Cyprus Department of Water Resources and academic research publications on the topic.

## 2. Research Area and Methods

### 2.1. Water Resource Conditions in Northern Cyprus

Northern Cyprus, occupying the northeastern part of the Mediterranean basin, possesses unique water resource characteristics within the third largest Mediterranean island. Covering 9,251 km<sup>2</sup>, this region plays a pivotal role, stretching 240 km from east to west and 100 km from north to south. Positioned 380 km north of Egypt, 105 km west of Syria, and 65 km south of Turkey, its geographical location is significant. Cyprus, known for its arid climate and hot, dry summers, faces considerable challenges in meeting its agricultural and domestic water needs. To address water scarcity challenges, the region has strategically invested in reservoirs, wastewater treatment systems, and desalination facilities for seawater treatment [5]. In recent decades, there has been increasing adoption of brackish and seawater desalination, especially in arid, semi-arid, or water-scarce regions, catering to both municipal and industrial water requirements. This trend is driven by the rising global population and limited freshwater availability.

In Northern Cyprus's water supply landscape, surface water collected in dams predominates, fulfilling around 70% of domestic and industrial water needs and 40% of agricultural requirements [6]. The region's climatic variations, with mild and rainy winters influenced by westward-moving cyclones [7]. Contrast sharply with long, hot, and arid summers due to persistent atmospheric subsidence driven by the Asian monsoon and the Hadley circulation [8]. Average daytime temperatures range between 12–15 °C during winters and reach 32 °C along the coast in summer, while inland areas often experience temperatures of up to 40 °C. Rainfall, concentrated between November and March, with about 60% occurring from December to February [9], shapes the region's hydrological patterns.

The hydrological landscape of Northern Cyprus features

seasonal rivers originating from the Troodos Mountains. The Pedieos River, the largest of these watercourses, flows through the capital city of Nicosia, exhibiting distinct seasonal dynamics from a vital water source in winter to a dry channel in summer. Spanning approximately 100 km, the Pedieos River mirrors the seasonal patterns of other significant rivers like the Kouris, Serakhis, and Yialias, which flow eastward toward Famagusta. The Yialias, originating in the Troodos Mountains, ultimately reaches the Mediterranean Sea, contributing to Northern Cyprus's hydrological complexity [10]. In summary, Northern Cyprus's water resources reflect a blend of climatic nuances, seasonal river fluctuations, and hydrological patterns, shaping water management and resource utilization strategies.

Furthermore, faced with hot, dry summers and limited freshwater sources, Cyprus has strategically utilized its dam and reservoir resources while adopting innovative solutions like desalination to bridge the gap in water supply demand. The success of projects such as the Dhekelia Desalination Plant underscores the importance of technological advancements in addressing water scarcity issues and highlights the continued reliance on desalination as a critical tool in combating global water shortages.

## 2.2. Water Resource Conditions in Central Asia

With a Focus on Kazakhstan Central Asia stands out as one of the globe's most severely afflicted regions by water scarcity, posing significant obstacles to achieving sustainable development goals (SDGs) in the area [11]. It epitomizes an inland arid zone characterized by parched climates, where deserts encompass over a quarter of the landmass, rendering water a precious and strategic asset [12]. The region's profound aridity necessitates intensive transboundary water management, with Kazakhstan being particularly reliant on it. Within Kazakhstan, surface water resources are notably irregularly distributed, displaying significant fluctuations both seasonally and perennially.

This disparity poses a substantial challenge as the spatial distribution of transboundary water resources does not align with demand patterns for resources or with economic and social development. Kazakhstan's renewable freshwater resources average around 100.6 km<sup>3</sup> per year, with approximately 55.94 km<sup>3</sup> originating within the country, while the remainder—44.64 km<sup>3</sup>—flows from neighboring nations such as China (19.2 km<sup>3</sup>), Uzbekistan (14.7 km<sup>3</sup>), Kyrgyzstan (3.1 km<sup>3</sup>), and Russia (7.6 km<sup>3</sup>) [13]. The nation's climate typifies a continental climate with harsh, dry winters and scorching, dry summers. Southern regions experience temperatures ranging from minus 3 °C in January to 30 °C in July, with precipitation levels being negligible except for mountainous areas. Annual precipitation averages around 250 mm, dipping below 100 mm in certain regions like the Balkhash-Alakol depression in the central-east or near the Aral Sea in the south. Both Central Asia and Cyprus confront

arid or semi-arid climates, characterized by sparse precipitation and elevated evaporation rates, exacerbating water scarcity issues. The continental climate's high evaporation levels, coupled with meager rainfall, render irrigation imperative across vast swathes of Kazakhstan, particularly in the southern regions [14]. Efforts have been made to ensure sustainable access to drinking water for rural Kazakhstanis, with 77.2% of the rural population receiving quality drinking water in sufficient quantities by 2010. Nevertheless, challenges persist, as freshwater availability per inhabitant (1,000m<sup>3</sup>) remains significantly below international standards [15]. While water supply systems cover approximately 78% of the urban population, only 80% of those supplied receive potable water conforming to sanitary norms round the clock. Additionally, 6.3% of urban populations rely on alternative water sources, including courtyard wells and public water pits, highlighting the need for improved water infrastructure [16].

**Water Scarcity:** In both regions, water scarcity is a pressing concern, with freshwater availability often falling short of demand, particularly in arid environments. This shortfall necessitates a reevaluation of water usage principles and the exploration of innovative approaches to water conservation and augmentation. Notably, one key distinction in water resource management between Cyprus and Kazakhstan lies in the widespread practice of seawater desalination in Cyprus, driven by its hot climate and the complete drying up of rivers during summer.

## 3. Methodology

### 3.1. Seawater Desalination Experience in Famagusta (Northern Cyprus)

In the coastal region of Northern Cyprus, specifically in Famagusta, the endeavor to secure a sustainable freshwater supply has led to the establishment of five operational seawater desalination plants. These plants, strategically located in Dhekelia, Limassol, Vassilikos, Larnaca, and Paphos, contribute substantially to the region's water security, yielding an impressive total of approximately 65 million cubic meters of freshwater annually [17].

Among these facilities, the Dhekelia Desalination Plant stands out as a pioneering infrastructure. Commencing its operations on April 1, 1997, with a modest capacity of 20,000 cubic meters per day, it quickly scaled up its production, doubling its output to 40,000 cubic meters per day by May 18, 1998 [18]. This rapid expansion exemplifies the region's commitment to addressing its water needs with technological innovation and resourcefulness.

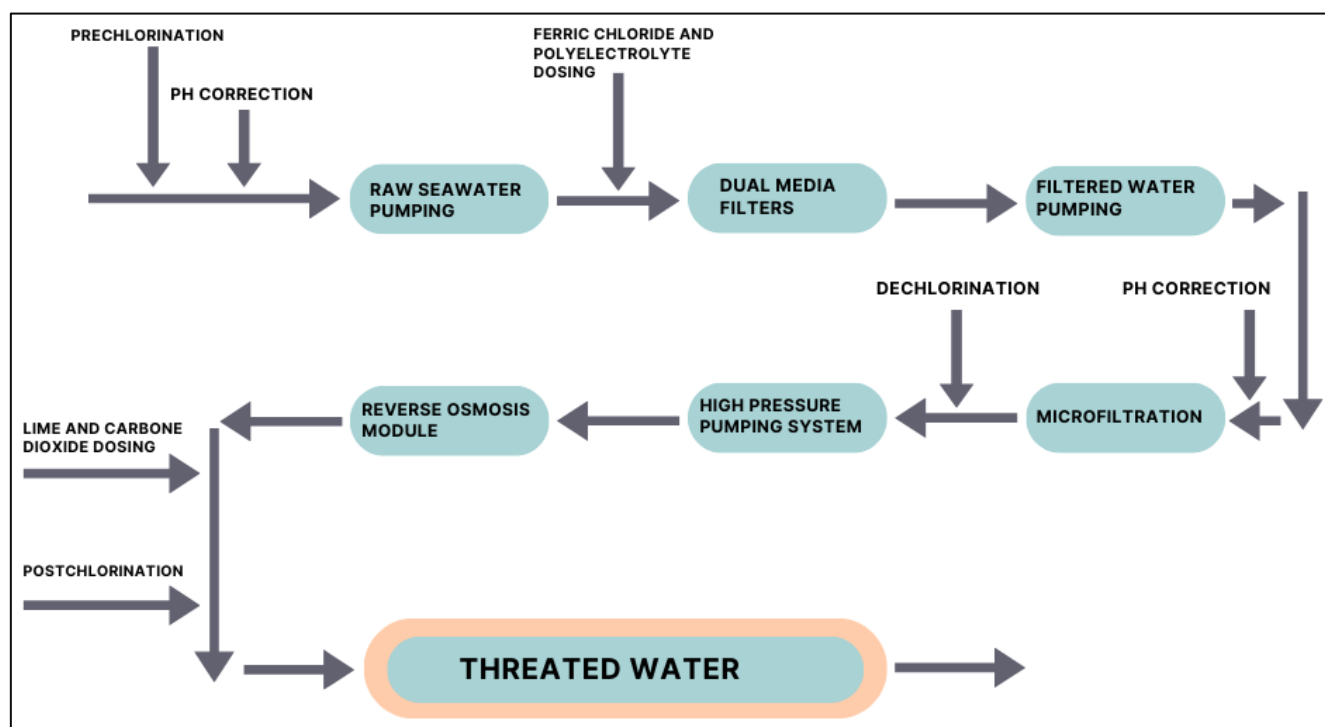
Desalination, the process of extracting salts from seawater to obtain fresh, potable water, employs various methods, each with its unique advantages and applications.

### 3.2. Thermal Distillation Method

1. *Multi-stage Flash Distillation*: This technique involves heating saline water until it reaches its boiling point, producing vapor that is then condensed to yield fresh water. The Dhekelia Desalination Plant, among others, utilizes this method to meet the demands of the Famagusta region.
2. *Multiple Effect Distillation*: Another thermal distillation approach, this method utilizes multiple stages of evaporation and condensation to enhance efficiency and freshwater output.
3. *Vapor Compression Distillation*: By utilizing mechanical compression to increase the vapor pressure, this method optimizes energy efficiency in the distillation process.
4. *Solar Distillation*: Leveraging the abundant solar energy in the region, solar distillation offers a sustainable approach to freshwater production, particularly in remote or off-grid locations.

### 3.3. Membrane Processes

1. *Electrodialysis*: This process involves the selective movement of ions through ion-exchange membranes under the influence of an electric field, effectively removing salt from the water.
2. *Reverse Osmosis*: A widely adopted method, reverse osmosis utilizes semi-permeable membranes to separate water from saline solutions under high pressure. With advancements in membrane technology and energy recovery systems, reverse osmosis has become a cornerstone of seawater desalination in Northern Cyprus [19]. Unlike traditional distillation and electrodialysis methods, which have been utilized for decades, reverse osmosis emerged as a game-changer in desalination technology since the early 1970s. Its effectiveness and versatility have made it the preferred choice for many desalination plants in the region.



**Figure 2.** Schematic of the reverse osmosis desalination method.

Numerous methods utilized in the technological purification of water often come with significant expenses. The economic landscape surrounding the production of drinkable water in Northern Cyprus (Figure 3) fails to adequately meet the increasing demand in the region. Consequently, Northern Cyprus relies on importing additional freshwater from the mainland part of the island. For instance, during the severe drought of 2007, Northern Cyprus was compelled to import freshwater from Greece, incurring a substantial cost of around

39 million euros to maintain its water supply. In this particular scenario, the procurement of water itself amounted to 4.4 million Euros, with the remaining expenses attributed to transportation. The decision to import water at such steep prices was influenced by various factors: delayed completion of desalination plant construction, consistent use of reservoir and groundwater for golf course irrigation, significant water losses during distribution, and inefficient water usage in agriculture and horticulture [20].





**Figure 3.** Desalination plant. Famagusta, Northern Cyprus.

## 4. Results and Discussion

The importance of desalination in tackling water scarcity cannot be overstated, yet it comes with complex challenges, particularly regarding its energy usage. Desalination plants heavily rely on fuel and electricity inputs, raising environmental concerns, especially when heavy fuel oil is used. In response, the Government of Cyprus has taken strategic steps to promote sustainable water management, notably by establishing seawater desalination plants. The roots of seawater desalination in Cyprus trace back to April 1997 when the pioneering Dhekelia desalination plant began operations. Another significant milestone occurred on March 4, 1999, with the start of a second desalination facility near Larnaca Airport. Expanding on this progress, on August 25, 1999, the Council of Ministers approved the construction of another desalination plant at Zakaki, Limassol, with a notable capacity of 20,000 cubic meters per day.

An innovative approach in this field is the utilization of solar energy by a standout desalination plant, tapping into the region's abundant solar irradiance for sustainable and energy-efficient solutions. Recent progress includes the launch of two crucial plants, Vasiliko and Episkopi, in 2012. The Vasiliko plant, in particular, is a significant contributor, producing 60,000m<sup>3</sup> of high-quality water daily, effectively meeting the water needs of Paphos and Peyia municipalities. Cyprus maintains a vigilant approach to drinking water quality, ensuring adherence to established standards. Dual pipelines separate drinking water from household supplies. However, many residents opt for bottled water and filtration solutions. Additionally, Cyprus's water management strategy includes the reuse of treated wastewater for agricultural irrigation.

Although Kazakhstan currently lacks operational desalination plants, the country has gained valuable experience in seawater desalination to address water management needs. The Aktau Desalination Plant, located along the Caspian Sea, played a crucial role in providing freshwater to the Mangystau region, which has long faced water scarcity challenges. [21].

Moreover, Kazakhstan is in the planning stages for an environmentally sustainable desalination plant in the Caspian

Sea region, emphasizing the country's commitment to leveraging advanced technologies and sustainable practices for water management.

## 5. Conclusion

The pressing issues of climate change, desertification, human impact, and escalating global water stress highlight the critical need to address water scarcity in Kazakhstan. To tackle this challenge effectively, it's vital to explore successful strategies worldwide, with a close eye on Cyprus's example.

Kazakhstan is actively engaged in partnerships with other nations to pioneer innovative water treatment methods, enhance desalination technologies, and optimize water distribution systems. This reflects a dedicated effort to confront this crucial issue head-on. A crucial aspect is Kazakhstan's recognition of the interconnectedness of its water resources with the broader international landscape. With nearly half of its water originating from beyond its borders, ensuring water security demands coordinated action with neighboring countries to ensure equitable distribution. The universal nature of water challenges underscores the imperative for Kazakhstan to transcend national borders in managing its water resources, echoing sentiments expressed in the 2014 UNDP Report.

This analysis underscores the significance of effective water resource management amidst mounting global challenges. By delving into the specific case of Famagusta, it emphasizes the pressing need for proactive measures to ensure the sustainability of water supply systems. As the world grapples with the complexities of water scarcity exacerbated by climate change, Kazakhstan's proactive stance in learning from and incorporating international experiences, particularly from Cyprus, showcases its dedication to a sustainable water future. Through collaboration and innovative approaches, Kazakhstan stands ready to navigate the challenges of the 21st century, safeguarding its ecological equilibrium and fostering regional cooperation in managing shared water resources.

## Abbreviations

FAO	Food and Agriculture Organization
GWP	Global Water Partnership
UNDP	United Nations Lead Agency on International Development
UN	United Nations

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## Author Contributions

Maxim Leman is the sole author. The author read and ap-

proved the final manuscript.

## Conflicts of Interest

The author declares no conflicts of interest.

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