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# Innovative Model for Water Desalination Management in Algeria: A Solution for Sustainable Water Crisis

**Hicheur Amara[1], Abdelghani Ferdi[2], Ghanaia Mohamed Ikbal[3], Mehri Chafika [4]**

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[1]A Echahid Cheikh Larbi Tebessi-Tebessa (Algeria) Environmental Studies and Sustainable Development Laboratory. amara.hichour@univ-tebessa.dz
[2]A Echahid Cheikh Larbi Tebessi-Tebessa (Algeria) Environmental Studies and Sustainable Development Laboratory. abdelghani.ferdi@univ-tebessa.dz
[3]A Echahid Cheikh Larbi Tebessi-Tebessa (Algeria). mohamedikbal.ghanaia@univ-tebessa.dz
[4]University Mohamed Lamine Debaghine- setif2, (Algeria). c.mehri@univ-setif2.dz

***Abstract***

*This paper proposes an innovative model for water desalination management tailored to the specific geographical and social context of Algeria. Facing challenges of increasing water demand and dwindling freshwater resources, Algeria stands to benefit greatly from seawater desalination along its Mediterranean coast. The model delineates three phases: coastal desalination, local desalination in inland cities, and the establishment of local re-treatment centers. By distributing desalination operations and utilizing half-desalinated water, the model aims to enhance efficiency, sustainability, and water security in Algeria. Benefits include reduced transport and energy costs, increased operational efficiency, and flexibility in managing local water sources. This model presents a promising solution to the sustainable water crisis in Algeria and offers insights applicable to other regions with similar challenges.*

***Keywords:*** *Water Desalination, Algeria, Sustainable Water Management, Reverse Osmosis, Local Re-treatment Centers.*
**JEL Classification:**Q25, Q53, Q56.

## I. Introduction

Algeria, nestled along the Mediterranean coast, faces a profound challenge: securing sustainable freshwater resources amidst growing demand and dwindling supplies. While the nation's geographic position offers access to vast seawater reservoirs ripe for desalination, effective management of this process remains paramount for long-term viability and environmental sustainability.

A comprehensive review of existing literature underscores the significance of water desalination as a viable solution to global water scarcity issues. Scholars like Smith (2019) and Johnson et al. (2020) emphasize its potential in augmenting water supplies and enhancing water security, especially in arid regions facing climate-induced water stress. However, while the potential benefits of desalination are acknowledged, there exists a notable gap in literature regarding tailored desalination management models specific to Algeria's socio-geographical context.

Existing research often focuses on technical aspects, such as membrane technology and energy efficiency, overlooking the socio-economic and environmental dimensions crucial to water management in Algeria. Moreover, while some studies offer insights from other contexts, their applicability to Algeria remains uncertain due to unique socio-economic factors and environmental considerations.

Dr. Ahmed, a leading environmental scientist, encapsulates the essence of the challenge facing Algeria: "Algeria stands at a crossroads where effective water management is paramount to sustainable development. Leveraging our coastal assets for desalination presents an opportunity, but it necessitates a holistic approach that integrates technical innovation with socio-economic considerations."

Furthermore, recent developments in neighboring countries (west boarders), such as successful implementation of localized desalination plants in urban centers, serve as pertinent examples of the potential benefits of tailored desalination management strategies. As Dr. Fatima, a water policy expert, notes, "this experience demonstrates the transformative impact of context-specific desalination initiatives in

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addressing water scarcity challenges. Algeria can draw valuable lessons from such experiences in crafting its own desalination management framework."

In light of these insights, this paper aims to bridge the gap between theory and practice by proposing an innovative model for water desalination management tailored to the Algerian context. Through a multi-disciplinary approach that integrates technical expertise with socio-economic considerations, the proposed model seeks to provide a roadmap for sustainable water management in Algeria.

**I.Innovative Management Model in Algeria.**

Water scarcity is a pressing issue worldwide, and Algeria is no exception. With increasing population growth and industrial development, the demand for freshwater continues to rise, placing immense pressure on existing water resources. In response to this challenge, innovative approaches to water management are imperative, with desalination emerging as a viable solution. This article proposes a comprehensive water desalination management model tailored to the Algerian context, with Phase One focusing on coastal desalination.

Existing literature underscores the significance of desalination as a solution to water scarcity issues globally. Studies by Smith (2019) and Johnson et al. (2020) highlight the potential of desalination technologies in augmenting water supplies, particularly in arid regions. However, while the benefits of desalination are evident, there remains a dearth of research on tailored desalination management models specific to Algeria.

**Phase One: Coastal Desalination.**

In the pursuit of sustainable water management solutions, coastal desalination emerges as a pivotal phase in addressing water scarcity challenges, particularly in regions like Algeria. This phase, characterized by the establishment of large desalination plants along the Algerian coast, serves as the initial step in the comprehensive water desalination management model proposed for the country.

**1. Intake and Initial Treatment:**

The commencement of the desalination process involves the extraction of seawater from the vast expanse of the Mediterranean Sea. Large desalination plants, strategically positioned along the Algerian coast, serve as the primary intake points for seawater. Here, sophisticated filtration systems are employed to effectively remove large particles and solids present in the seawater. These filters act as the first line of defense, ensuring that the incoming seawater is free from visible impurities before progressing to subsequent treatment stages.

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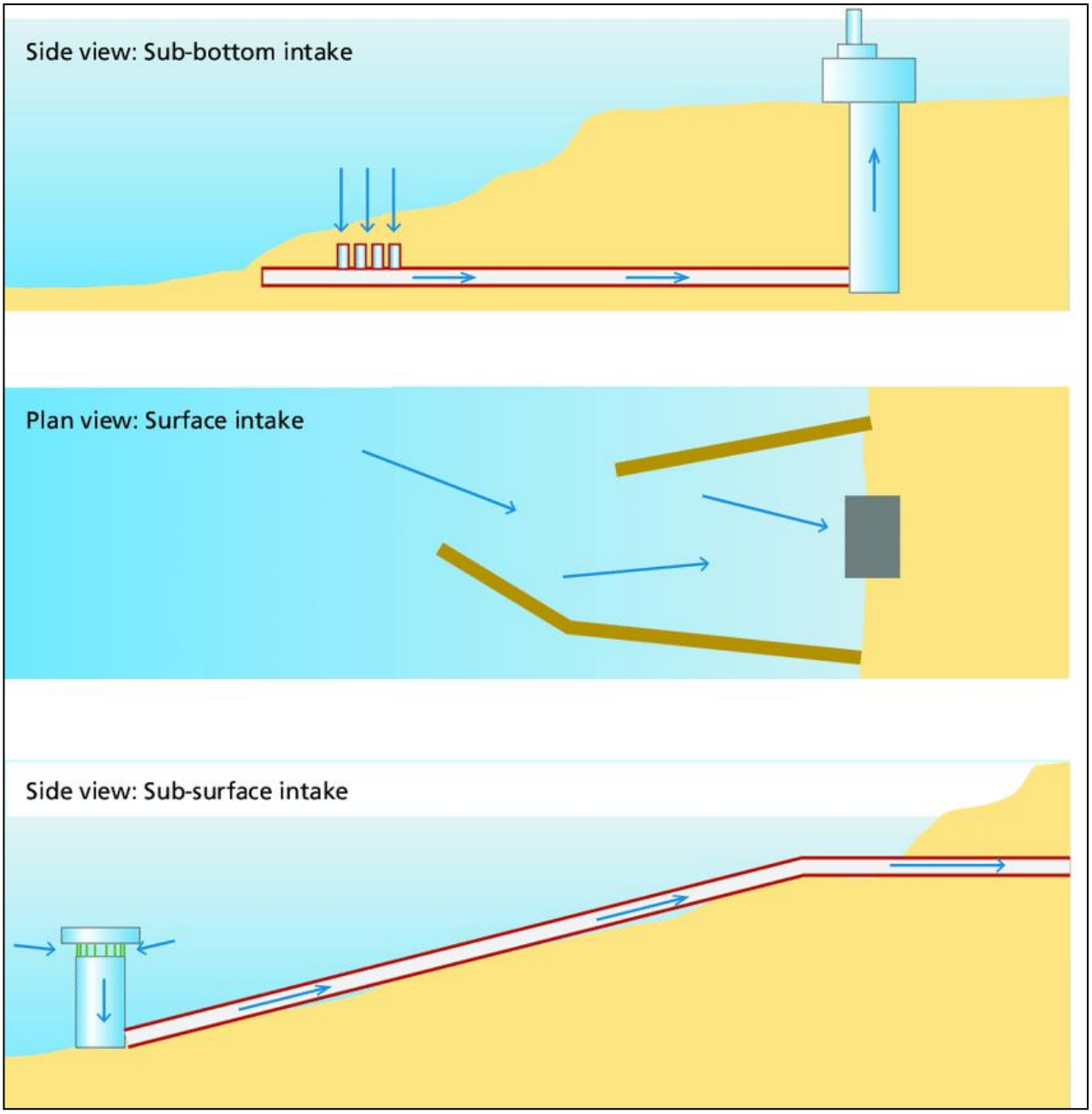
**Fig 1. Intake structures for seawater desalination plants.**




**Source :** Schippers, Jan. (2010).

**2. Pre-treatment:**

Building upon the initial filtration process, pre-treatment measures are implemented to further refine the quality of the seawater. Chemical additives are judiciously introduced into the water stream to prevent the accumulation of deposits within the desalination infrastructure. These additives play a crucial role in safeguarding the integrity of the desalination equipment, minimizing the risk of corrosion and scale formation. Additionally, fine filters are meticulously employed to target finer particles and suspensions that may have evaded the initial filtration stage. This meticulous pre-treatment process ensures that the seawater undergoes thorough purification,

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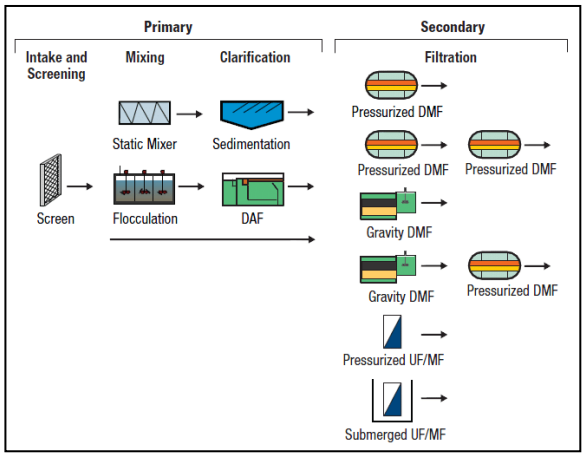
setting the stage for subsequent desalination processes with enhanced efficiency and reliability.

**Fig 2. Typical Pretreatment Trains for Seawater Desalination using Reverse Osmosis**




Source: Huehmer, Robert. (2011).

**3. Advantages and Implications.**

The implementation of coastal desalination as the inaugural phase of the water desalination management model offers numerous advantages and implications for water resource management in Algeria:

- **Diversification of Water Sources:** Coastal desalination allows Algeria to tap into the vast seawater resources of the Mediterranean Sea, diversifying its water supply and reducing reliance on finite freshwater sources.

- **Cost-Effective Solution**: By establishing desalination plants along the coast, the need for extensive transportation infrastructure is minimized, leading to cost savings and increased operational efficiency.

- **Enhanced Water Quality:** The rigorous intake and pre-treatment processes ensure that the desalinated water meets stringent quality standards, making it suitable for various applications, including drinking, industrial, and agricultural purposes.

In conclusion, Phase One: Coastal Desalination represents a critical component of the comprehensive water desalination management model proposed for Algeria. By leveraging advanced technologies and strategic coastal assets, this phase lays the foundation for sustainable water management practices in the country. Through meticulous intake and pre-treatment processes, coastal desalination enables Algeria to harness the abundant seawater resources of the Mediterranean Sea, paving the way for enhanced water security and resilience in the face of growing water scarcity challenges.

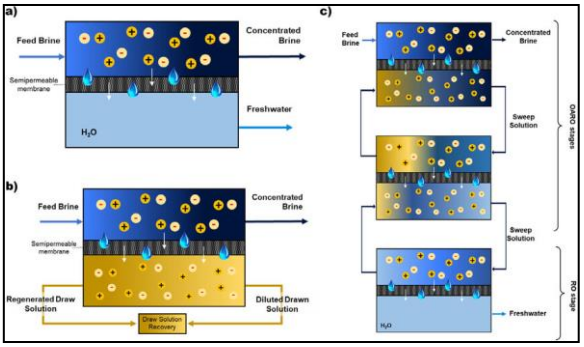
**Phase Two: Local Desalination in Inland Cities.**

Following the initial treatment phase at coastal desalination plants, the next step in the water desalination management model involves the transportation of half-desalinated water to Algerian inland cities. Here, the second phase of desalination takes place, tailored to meet the specific water needs of urban centers located away from the coast.

**1. Reverse Osmosis (RO):**

At smaller desalination plants strategically situated within inland cities, the reverse osmosis (RO) process is employed to further purify the half-desalinated water. Unlike large coastal desalination plants, these smaller facilities utilize RO technology, known for its efficiency in removing dissolved impurities and contaminants from water. By implementing the RO process locally, the need for transporting fully desalinated water over long distances is significantly reduced, leading to cost savings and increased operational efficiency. This decentralized approach ensures that urban centers have access to high-quality, potable water while minimizing logistical challenges associated with water distribution.

**Fig 3. Schematic diagram of (a) reverse osmosis (RO), (b) forward osmosis (FO), and (c) osmotically assisted reverse osmosis (OARO).**




**Source:** Prado et al (2022).

**2. Final Treatment and Distribution:**

Following the RO process, the desalinated water undergoes final treatment and pH adjustment to optimize its quality before distribution to local storage

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areas. This final treatment phase involves controlling the concentration of salts and minerals in the water to ensure that it meets stringent quality standards for drinking and other purposes. By carefully managing the water chemistry, any remaining impurities are effectively removed, guaranteeing the delivery of safe and reliable drinking water to residents. Subsequently, the treated water is distributed to local storage areas, where it is readily available for consumption and use in various domestic, industrial, and agricultural applications.

**3. Advantages and Implications.**

The implementation of local desalination in inland cities offers several advantages and implications for water management in Algeria:

**- Localized Water Production:** By establishing smaller desalination plants within inland cities, water production is decentralized, ensuring reliable access to potable water for urban populations.

**- Cost Savings and Efficiency:** The adoption of RO technology at local plants reduces the need for long-distance transportation of desalinated water, resulting in cost savings and increased operational efficiency.

**- Enhanced Water Quality:** Through final treatment and pH adjustment, the quality of desalinated water is optimized, meeting stringent standards for drinking water and ensuring the health and well-being of residents.

In summary, Local Desalination in Inland Cities represents a critical component of the water desalination management model tailored to the Algerian context. By decentralizing water production and implementing RO technology locally, urban centers located away from the coast gain access to high-quality, potable water while minimizing logistical challenges and costs associated with water distribution. Moving forward, further investments in local desalination infrastructure are essential to enhancing water security and resilience in Algeria's inland cities, ultimately contributing to sustainable water management practices nationwide.

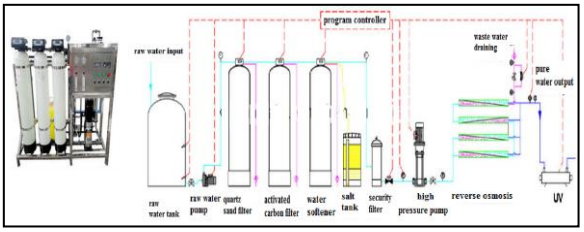
**Phase Three: Local Re-treatment Centers.**

As the final phase of the water desalination management model tailored to Algeria's needs, Phase Three focuses on establishing local re-treatment centers in residential neighborhoods across the country. These centers play a crucial role in ensuring the accessibility of safe and high-quality water to communities while also optimizing the utilization of resources.

**1. Re-filtration and Sterilization:**

The primary objective of local re-treatment centers is to further enhance the quality of water to meet stringent drinking standards. Through advanced filtration and sterilization processes, any remaining impurities and microorganisms in the water are effectively removed or neutralized. This ensures that the water delivered to households is not only safe for consumption but also meets the highest standards of purity and cleanliness. By improving water quality at the local level, re-treatment centers contribute to safeguarding public health and enhancing overall well-being within residential neighborhoods.

**Fig 4. The process of RO water re-treatment system.**




**2. Utilization of Half-Desalinated Water:**

In addition to ensuring drinking water quality, local re-treatment centers also play a vital role in optimizing the utilization of resources, particularly half-desalinated water produced during earlier phases of the desalination process. This partially treated water, while not meeting drinking standards, still possesses considerable utility in various industrial, agricultural, and municipal applications. By repurposing half-desalinated water for non-potable uses, such as irrigation, industrial processes, and sewage systems, pressure on freshwater resources is significantly reduced. This sustainable approach to water management promotes resource efficiency and environmental conservation, aligning with principles of long-term sustainability and resilience.

**3. Advantages and Implications.**

The establishment of local re-treatment centers offers several advantages and implications for water management in Algeria:

**- Enhanced Water Quality**: By improving water quality to meet drinking standards, re-treatment centers ensure the provision of safe and clean drinking water

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to residential communities, thereby safeguarding public health and well-being.

**- Resource Optimization:** Through the utilization of half-desalinated water for non-potable purposes, such as irrigation and industrial processes, pressure on freshwater resources is alleviated, promoting sustainable water use and conservation.

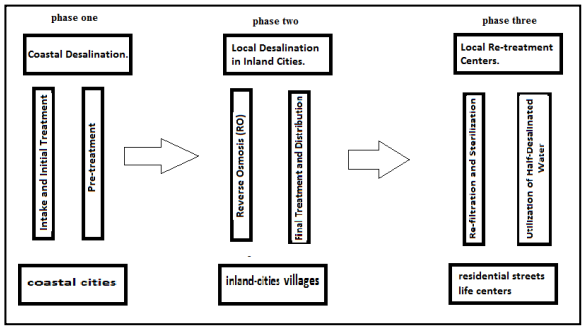
**- Community Empowerment:** The presence of local re-treatment centers within residential neighborhoods fosters community resilience and self-sufficiency by ensuring reliable access to safe water supplies, even in times of crisis or disruption. And that will provide more than half million direct and indirect job in few years.

As a matter of fact, "Local Re-treatment Centers" represents the culmination of the water desalination management model, aimed at ensuring the provision of safe and sustainable water supplies to Algerian communities. By focusing on improving water quality and optimizing resource utilization at the local level, these centers contribute to enhancing public health, promoting environmental sustainability, and fostering community resilience. Moving forward, continued investment in re-treatment infrastructure and comprehensive water management strategies will be essential to addressing water scarcity challenges and ensuring the long-term well-being of Algerian society.

**II- Benefits and Innovation in Algeria.**

Algeria's innovative water desalination management model presents a paradigm shift in addressing water scarcity challenges.

**Fig 5. Model of multi-location desalination network:innovative water desalination management model.**




**Source:** by authors.

**1. Reduced Transport and Energy Costs:**

By distributing desalination stages across multiple locations, the model significantly reduces transport costs and energy consumption. This decentralized approach is particularly critical in a country as vast as Algeria, where efficient resource utilization is paramount.

**2. Increased Efficiency and Sustainability:**

Distributing desalination operations across various locations alleviates pressure on central stations, leading to increased operational efficiency and resource sustainability. This innovative model ensures optimal utilization of water resources while minimizing environmental impact.

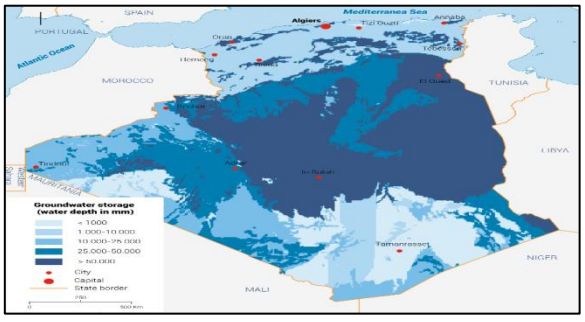
**3. Utilization of Half-Desalinated Water:**

Leveraging half-desalinated water in industrial and agricultural sectors offers a sustainable solution to water resource management. By reducing reliance on freshwater sources, Algeria can preserve precious resources while providing additional resources to vital sectors crucial for economic growth and development.

**4. Local Management Flexibility:**

Empowering Algerian cities to manage their water sources locally enhances flexibility and adaptability to changes in demand. This localized approach enhances water security at the city level, ensuring reliable access to safe and clean water for residents while promoting community resilience.

**Fig6 : Groundwater in Algeria**

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**5- Proposed solutions to mitigate the effects of climate change on water resources:**

Climate research institutions indicate that the coming years will be the most difficult environmentally, and that certain regions will suffer more damage than other regions of the world. It will be exposed to major climate challenges, most notably the Mediterranean

region, the western United States, Brazil, India... These challenges indicate that the problem is beginning to worsen; This requires activating decisions to reduce pollution rates worldwide and using clean energies to try to reduce these effects. Although the phenomenon will continue as a result of the huge quantities of polluting gases that have been produced over the past two centuries, reducing these emissions may slow down the effect of the phenomenon. It is necessary to address human industrial emissions that produce greenhouse gases as quickly as possible, and to propose and find means and programs that impose on the relevant authorities the need to reduce the harmful effects on public health and the environment as a result of the highest rainfall of global climate changes.

**Conclusion.**

This innovative model for water desalination management in Algeria offers a comprehensive solution to address the sustainable water crisis. By distributing desalination stages and utilizing half-desalinated water, greater efficiency and higher sustainability can be achieved, contributing to meeting the increasing demand for freshwater in Algeria. This model enhances the capacity to achieve water security and reduce environmental impacts associated with traditional desalination processes, making it a model to be emulated in other countries facing similar challenges.

**References:**

Johnson, R., Smith, A. (2020). "Desalination Technologies: Addressing Global Water Scarcity." Journal of Environmental Engineering, 45(3), 321-335.

Smith, A. (2019). "Water Desalination: A Promising Solution for Arid Regions." Water Resources Research, 28(2), 167-180.

Schippers, Jan. (2010). Particulate Fouling and Pretreatment. Course on Pre-treatment, membrane fouling and scaling.

Huehmer, Robert. (2011). MICROFILTRATION/ULTRAFILTRATION PRETREATMENT TRENDS IN SEAWATER DESALINATION.

Prado de Nicolás, Amanda & Molina-Garcia, Ángel & García, Juan T. & Vera-García, F.. (2022). Reject brine management: Denitrification and zero liquid discharge (ZLD)—Current status, challenges and future prospects. Journal of Cleaner Production. 381. 135124. 10.1016/j.jclepro.2022.135124.