

# Desalination of Seawater as a Strategic Option to Enhance Water Security in Algeria: A Case Study of Desalination Plants in Skikda wilaya

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**Abstract:** The Water security is one of the most pressing challenges facing Algeria, given the limited availability of conventional water resources and the increasing demand for water, especially in coastal areas. With the worsening water crisis in many provinces, seawater desalination has emerged as a strategic option to address this shortage and ensure the continuity of water supply.

Accordingly, this study aims to analyze the state of seawater desalination at the national level by focusing on the wilaya of Skikda, which is experiencing increasing water scarcity despite its coastal location. The study found that desalination plants in Skikda have effectively contributed to reducing the deficit in water resources and ensuring the supply of potable water to the population, highlighting their role in strengthening national water security.

**Keywords:** Water Security; Desalination; Water Resources; Drinking Water; Skikda Wilaya.

## 1. Introduction

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The issue of water security is a vital strategic concern for many countries, particularly Algeria, where water scarcity is a significant challenge. This scarcity is exacerbated by

population growth and increased demand for water across various sectors, including industry, agriculture, and household consumption. Algeria has experienced over a decade of drought, and traditional water resources have proven insufficient to meet the needs of the population. As a result, Algerian authorities have sought alternative sources to ensure a reliable supply of drinking water. The most viable solution that mitigates climate risks is the desalination of seawater.

Seawater desalination has emerged as an effective method in recent years to enhance freshwater supplies and alleviate water scarcity in coastal regions. To make seawater suitable for various uses, it must be treated to remove salts and pollutants, resulting in potable water. Desalination projects in Algeria are rapidly expanding to meet the growing demand for clean water. In Algeria, and specifically in Skikda, seawater desalination addresses water security issues, making it a strategic option underlying the country's water resource development policies.

### *1.1. Research problem*

The problem of the study revolves around the following main question:

- To what extent does desalination technology contribute to water security in Algeria?

Accordingly, the following sub-questions can be asked:

- What is Algeria's potential in establishing seawater desalination plants to achieve its water security?
- To what extent do seawater desalination plants in Algeria contribute to the provision of potable water?
- Is seawater desalination technology the best solution to alleviate water scarcity for Skikda?

### *1.2. Study Hypotheses*

In order to answer the previous problem, we put the following hypotheses:

- Seawater desalination plants in Algeria would effectively contribute to the provision of potable water;
- Seawater desalination technology would be the best solution to alleviate water scarcity for Skikda.

### *1.3. Research Aims*

This study aims to highlight the following:

- Rooting theoretical concepts related to seawater desalination technology and water security;
- Recognizing the state of water security in Algeria and its challenges;
- Highlighting the role of seawater desalination technology in solving the problem of water shortage in Algeria;
- Recognizing the efforts of the Algerian government in establishing several desalination plants;
- Determining the contribution of seawater desalination technology to the provision of water to the wilaya of Skikda.

### *1.4. Importance of research*

Seawater desalination is a strategic alternative for many countries, including Algeria. It is an effective technology for alleviating water scarcity and meeting the increasing demand for water, particularly in the wilaya of Skikda. In recent years, seawater desalination technology in Algeria has made significant advancements, driven by the development of various processes related to this method. This approach is one of the successful strategies

implemented within the framework of water governance, aimed at achieving the requirements and goals of sustainable development.

### 1.5. Research methodology

In order to determine the validity of the study hypotheses, we relied on the descriptive approach through with biometrics related to the study from various sources, in addition to the analytical approach that helped us to accurately analyze the data after organizing it.

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## 2. State of water security in Algeria

Water security in Algeria is a strategic challenge due to limited water resources and their expanding usage. The country has faced increasing pressures from climate change and population growth, which necessitates the adoption of sustainable water management policies. This includes government efforts to mobilize unconventional water resources to ensure the future needs are met.

### 2.1. Water potential in Algeria

Water resources in Algeria include natural or traditional water resources and non-natural or non-conventional water resources. These are:

#### 2.1.1. Natural water resources:

A. Rainfall: Algeria covers an area of approximately 2,381,741 km<sup>2</sup>, with more than 85% of this area being desert. This region experiences a scarcity of rainfall, with an average annual volume estimated at 12.4 billion m<sup>3</sup>. About 90% of this rainfall is concentrated in the northern part of the country, particularly in the mountainous regions, while the water basins in the plateaus account for only 10% of the total rainfall. (Zerrarqa & Issa, 2021, p. 155)

B. Surface water: Surface water resources make up 65% of Algeria's total water resources and are primarily found in the form of rivers and valleys. Their levels rise due to rainfall and snowfall. The most significant surface water basins are the northern Mediterranean basins, which account for 10.1 billion m<sup>3</sup>, approximately 90% of the country's total surface water resources. (Messadia & Louafi, 2022, p. 70)

C. Groundwater: Groundwater in Algeria is estimated at 7 billion m<sup>3</sup> per year, while groundwater that can be exploited in the north of the country is estimated at 2 billion m<sup>3</sup> per year. It is exploited at 90% and is replenished annually by rainwater. Groundwater reserves in the south of the country are estimated at 5 billion m<sup>3</sup> per year, but its filling and use is limited by several factors. (Ahmed, 2015, p. 79)

#### 2.1.2. Non-natural water resources:

A. Desalination of seawater: Algeria began its desalination journey in the 1960s, specifically in 1964, with the establishment of the first plant on the western coast of the city of Arzew. (Hamza, 2022, p. 145) With a 1,200 km coastline, Algeria benefits from an abundant source of desalinated water. Currently, the country operates 12 small plants with an estimated production capacity of 20 million m<sup>3</sup>, sufficient to meet the needs of 380,000 people. Additionally, there are 13 large plants with an estimated annual capacity of 825 million m<sup>3</sup>, which can serve 11.87 million people. (Belkacem & Hamida, 2023, p. 05)

B. Wastewater treatment: Wastewater treatment is estimated at 1.5 billion m<sup>3</sup>. The Algerian state has focused on this type of water by implementing a series of projects, the most significant of which is the completion of 138 purification plants. These plants have a total

capacity of 700,000 m<sup>3</sup> and can process up to 150,000 m<sup>3</sup> per hour annually. (Bentrad, Souad, & Benhalima, 2023, p. 03)

## 2.2. Uses of Water Resources

**2.2.1 Household sector:** Providing the population with an adequate supply of potable water, both in quantity and quality, is a fundamental aspect of the national water policy. Currently, 98% of the population is connected to potable water supply networks, with a daily quota of 180 liters per person. Of these, 80% receive water daily, with 40% having access over a 24-hour period. The annual demand for potable water is estimated to be 3.3 billion m<sup>3</sup>.

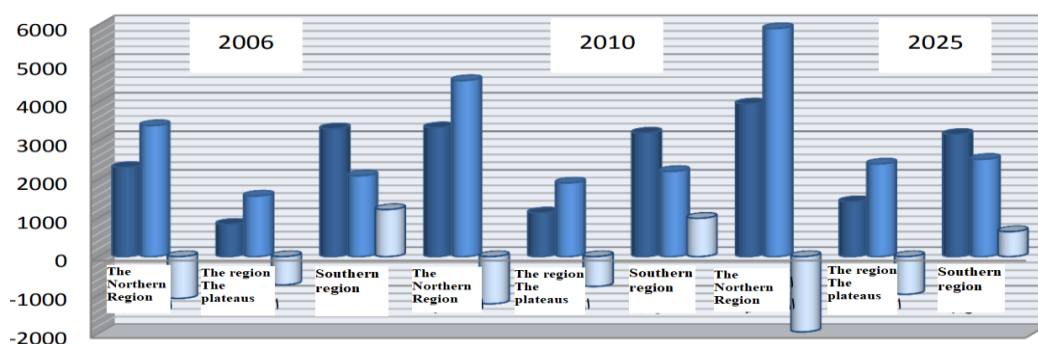
**2.2.2 Agriculture sector:** Arable land in Algeria constitutes 3.44% of the country's total area of 238 million hectares. Harsh climatic conditions and irregular rainfall, which varies from region to region, have prompted local authorities to mobilize additional water resources and increase reliance on irrigated agriculture. Since 2000, the volume of water resources allocated for irrigation and agricultural activities has more than tripled, reaching 6.8 billion m<sup>3</sup> per year nowadays.

**2.2.3 Industry Sector:** It is challenging to determine the actual volume of water consumed in the industrial sector, as it is often connected to the public potable water network. In 1995, water resources allocated for the industrial sector were estimated at 120 million m<sup>3</sup>. Currently, this figure has risen to 300 million m<sup>3</sup> and is projected to reach 600 million m<sup>3</sup> by 2030. (Abutair & Abdelwahab, 2023, p. 870)

## 2.3 Overall water balance

The gap between water supply and demand can be illustrated in the following figure:

Figure 1. Algeria's total water balance



Source: (Alliout, 2020, p. 196)

The above figure shows that the total water balance experienced a deficit in the northern region and the upper plateaux region in 2006 and 2010. This deficit is expected to continue until 2025, with an anticipated increase each year. In contrast, the water balance in the southern region remained positive during the three years; however, it is noteworthy that its the volumes declines annually.

## 3. Desalination of seawater in Algeria

### 3.1. Concept of Desalination

Desalination, also known as brackish water purification, is a process that allows fresh water (potable, or occasionally usable for irrigation due to cost) to be obtained from brackish water, particularly seawater. Despite its name, desalination is not merely the removal of salt from water; rather, it involves extracting fresh water from saline sources. The salinity of seawater generally ranges from about 35 g/L, while in areas such as the Persian Gulf, it can reach up to 42 g/L. To separate salt from water, theoretically and without energy loss (in an isentropic desalination process), approximately 563 watts per cubic meter is required. (Djoher &

Chaouki, 2019, p. 362)

Desalination is defined as "a set of industrial processes aimed at removing part or all of the excess minerals and salts from water, making it suitable for daily use in areas such as agriculture, drinking, and industry." The goal of desalination is to remove or reduce the salts dissolved in marine, groundwater, or saline surface water. Additionally, desalination is a branch of science that studies and explores various methods to obtain water at reasonable prices and in sufficient quantities. (Amal, 2019, p. 59)

Reverse osmosis (R.O), multi-effect distillation (M.E.D.) and multi-stage flash evaporation (M.S.F.) are among the most sought-after key desalination technologies on the market.

- Reverse osmosis (R.O.) is a process that enables fresh water to flow from a region of lower solute concentration to a region of higher solute concentration, using semi-permeable membranes. Such a maneuver creates a pressure difference across the membrane, known as osmotic pressure. When pressure is applied to the brine that exceeds the osmotic pressure, fresh water begins to flow from the brine to the opposite side of the membrane; (Bouadam & Yennoune, 2016, p. 325)
- Multi-Effect Distillation (M.E.D) is similar in principle to multi-stage flash evaporation. In M.E.D, steam is used to heat seawater in the first stage. The steam produced in subsequent stages is then used to evaporate water, while seawater or brine cools and condenses the steam in each subsequent stage. This process allows the temperature to gradually decrease through each stage, just as in multi-stage flash evaporation; (Hetal & Upadhyay, 2014, p. 640)
- Multi-stage flash evaporation (M.S.F) involves heating salt water to high temperatures and then passing it through decreasing pressures. This process maximizes water vapor production, ultimately resulting in fresh water. (Bahar & Nurul Alam Hawlader , 2013, p. 02)

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### 3.2. *Motives for Algeria's resort to seawater desalination*

Algeria's resort to desalination of seawater stemmed from a combination of motives related to both the characteristics of this unconventional solution and the country's water reality. (Bouadam & Yennoune, 2016, p. 324)

- The droughts that Algeria has experienced in recent decades, particularly in the 1980s and 1990s, have significantly impacted water resources, both for recharging groundwater reservoirs and filling dams;
- The northern region of the country faces water scarcity, characterized by high population density, which has negatively affected the volume of water resources. Groundwater, in particular, has been over-pumped, reaching critical levels in some areas. This over-extraction poses a significant risk to both the quantity and quality of water reserves;
- Over the past decade, signs of climate change have begun to manifest in certain areas of the country, marked by sharp fluctuations in rainfall and snowfall. These changes, in terms of timing and location, have adversely affected investment opportunities in traditional water resources;
- Algeria has a coastline of 1,200 km, comprising 14 wilaya with high urban concentration, leading to increased demand for drinking water. This demand cannot be fully met by traditional resources;
- Algeria possesses abundant financial and energy resources necessary for the desalination industry;
- The desalination industry is not subject to climatic fluctuations, as desalination plants can be established near consumption centers. This proximity reduces the cost of pumping groundwater and laying pipes to deliver water to remote areas;
- The desalination industry requires a lower capital cost per unit of capacity compared to the cost of establishing and operating traditional facilities like dams; however, it incurs

significantly higher operating costs;

- Desalination plants contain mechanical equipment, such as pumps, so the development of their efficiency and economic value is expected to continue;
- The desalination industry operates without significant political, social, or legal obstacles;
- Investing in the desalination industry is more feasible than financing traditional water projects, and the construction period is shorter than that required for establishing water transmission lines from remote areas.

### 3.3. Reality of desalination in Algeria

With the worsening water crisis in Algiers and the western regions, where water has become increasingly scarce, desalination of seawater has emerged as a preferred option. In response, public authorities have developed a plan that includes a comprehensive study on desalination in Algeria, aimed at defining the general framework for this strategy, advancing technology, and preparing feasibility studies for priority sites.

It is important to note that Algeria's experience in this field spans three industrial zones: arzew, Skikda, and Annaba. This experience dates back to the early 1960s; however, the existing desalination plants can produce only 18 million m<sup>3</sup> per year under extreme conditions, which is insufficient to meet the needs other sectors' needs the two value. For instance, the Arzew Industrial Area has 26 desalination plants with a total production capacity of about 23,600 m<sup>3</sup> per day, with individual plant capacity ranging from 192 m<sup>3</sup> per day to 1,920 m<sup>3</sup> per day. Later, production capacity was expanded to 33,000 m<sup>3</sup> per day.

In February 2002, the Algerian government approved the first phase of construction for four desalination plants in Arzew, Algiers, Oran, and Skikda. This initiative is expected to increase the water supply by 400,000 to 500,000 m<sup>3</sup> per day, which is equivalent to the daily water consumption in the capital. (Belghali, 2012, pp. 39-40)

Algeria boasts the largest desalination plant in Africa, which is a hot water desalination facility, as well as the largest Oscosy-type desalination plant in the world, located in the Oran region. As for 2011, there were a total of 10 desalination plants operating in the country, with a combined capacity of 1,610,000 m<sup>3</sup> per day. The most significant of these is the Oran plant, which has a production capacity of 55,000 m<sup>3</sup> per day. Overall, these plants produce approximately 2.26 million m<sup>3</sup> of water per day. Operations began from 2005 to 2008 with the establishment of the first two stations, Arzew and Algeria. Additionally, there are 23 integrated monobloc plants already in operation, distributed across coastal cities. The advancement of seawater desalination technology can ensure a reliable supply of drinking water to major cities and facilitate the transfer of available resources from dams in the northern region to areas facing water shortages. Furthermore, it supports the development of irrigation systems in hilly areas.

Algeria has begun developing the production of drinking water from seawater, utilizing multiple desalination plants to supply water to its population. Currently, the 11 desalination plants in Algeria produce 17% of the total drinking water consumed nationwide. According to the Minister, this percentage is expected to rise to 25% once the new plants become operational. The production capacity of these plants is equivalent to 770 million m<sup>3</sup> annually, providing drinking water to 7,189,904 people across various wilayat. (Daas, 2020, p. 101)

The Algerian government plans to expand the total count of desalination plants to 19 by the year 2024. Currently, 11 desalination plants have been established in coastal areas. In addition, under the emergency plan, authorities have successfully constructed three additional plants, each capable of producing 70,000 m<sup>3</sup> of water every day. These achievements are important steps in favor of securing a more stable supply and dispensing clear water to the country.

Early in 2021, the government of Algeria started the construction of chief desalination plants in the important wilayas of Al-Tarf, Bejaia, Boumerdes, Tipaza, and Oran. On a daily

basis, a singular plant is designed to produce 300,000 m<sup>3</sup> of water. This acute action targets water shortages in these spheres, particularly in densely populated urban regions and main industrial regions, by premeditatedly positioning the plants to secure the nation’s water supply and meet both present-day and subsequent needs. These efforts reflect the government's engagement to ensuring clean water for its people.

The primary goal of the National Water Strategy is to significantly invest in projects of desalination. Accredited statistics reveal that 17% of the country's water needs are currently met through desalinated sources. nevertheless, the intricate project outlined by the government in the National Water Strategy (2021-2030) includes a roadmap that aims to increase this figure to 22% by 2022, indicating a rapid expansion of desalination infrastructure.

Desalination, which was once considered a new solution, has now become a fundamental component of Algeria's water security strategy. As the country approaches 2024, it is estimated that 42% of its water needs will be supplied through desalination, indicating a significant transformation in water accessibility and availability. By 2030, Algeria aims to meet up to 60% of its drinking water requirements, relying on desalination. This ambitious conduct not only demonstrates the government's commitment to ensuring water security for its citizens but also addresses the urgent challenges posed by change in climate, populace growth, and increasing urbanization. This plan of action represents a comprehensive engagement to adopt advanced technology and sustainable proceedings while taking into account the environmental implications. (Amine, 2023, pp. 142-144)

3.3.1. *Large Desalination Plants:* Today, Algeria counts 11 major desalination plants in service, and the following table shows these plants along the coastline

Table .1. Major Seawater Desalination Plants in the Algerian Coast

Stations Name	Ténès Dessert - Souk Tlata Dessert - Honaine Dessert - Mostaganem Dessert - Beni Saf Dessert	Fouka	Dessert Skikda - Dessert Cap Djinet - Dessert Oued Sebt
Capacity to produce	200 000 m <sup>3</sup> /day	120 000 m <sup>3</sup> /day	100 000 m <sup>3</sup> /day
Capacity to produce	200 000 m <sup>3</sup> /day	120 000 m <sup>3</sup> /day	100 000 m <sup>3</sup> /day

Source: Prepared by researchers based on: (Mebarek & Ferhat, 2021, p. 307)

(Algerian Energy Company (AEC), 2024)

3.3.2. *Small-scale desalination plants (2000-5500) m<sup>3</sup>/day:* They are transportable stations from one place to another, which were started within the framework of the emergency program in 2002, and are managed by the various institutions responsible for the distribution of drinking water, as shown in the following table:

Table. 2. Small Seawater Desalination Plants

ADE-managed plants	desalination	Desalination plants operated by SEAAL in Algiers	Desalination plants operated by SEOR Oran
Stations	Installed capacity (m <sup>3</sup> /day)	Stations	Stations
			Installed capacity (m <sup>3</sup> /day)
Invasions 01	2500	Zeralda 01	2500
Invasions 02	2500		
Bousmail	5000		
Takzirat	2500	Zeralda 02	2500
Skikda 01	2000	Ain Al-Bunyan 01	2500
'Skikda 02	5000	Ain Al-Bunyan 02	2500

<b>Bozgar</b>	5000			<b>Sand anchor</b>	5000
<b>Shatt Al Ward</b>	5000	<b>Al Beach Nakheel</b>	2500		
<b>Tènès</b>	5000				
<b>Total</b>	34500	<b>Total</b>	12500	<b>Total</b>	10500

Source : (Tahar, 2023, p. 138)

#### 4. Field study of the desalination plant of the wilaya of Skikda

Skikda wilaya is a coastal region with a coastline of 1,400 km. It has a population of 1,135,450 people distributed across 38 municipalities, Located in the northeast of Algeria, Skikda covers an area of 4,138 km<sup>2</sup>, It is bordered to the north by the Mediterranean Sea, to the east by Annaba wilaya, to the west by Jijel wilaya, and to the south by the wilayat of Mila, Constantine, and Guelma. The climate is moderately humid Mediterranean, with average annual rainfall not exceeding 1,000 mm.

##### 4.1. Water Resources in Skikda

The status of the public service for potable water at the state level is as follows:

- **Water potential of Skikda:** The hydraulic potential of Skikda consists of three types:

- **Groundwater resources:** The groundwater resources, which are estimated at 87 115 m<sup>3</sup>, are represented in the water deposits of the valleys (Al-Wad Al-Kabeer, Wad Al-Safsaf, Al-Wad Al-Qibli, Wad Bibi Coastal, Filfila and Bouqaroun Coast).

- **Surface resources:** The rainfall and terrain of the state contribute to increasing the water supply, as it allowed the storage infrastructure (Zerdaza Dam , Quneitra, zit emba and Beni zid), as the state includes a significant group of valleys, including main valleys (oued el-Kebir el-Gharbi, oued Safsaf, oued Qubi), and secondary valleys (oued Bibi, oued zhor, oued Qira), and the annual size of these valleys is estimated at 1070 m<sup>3</sup>/year.

- The state has 04 large dams, with an estimated capacity of 317 million m<sup>3</sup>, as follows:
- Zardaza with a capacity of 32 million m<sup>3</sup>per year, covering El-Harrouch, Ain Bouziane, Zerdaza and Emdjez Edchich;
- Quneitra is about 125 million m<sup>3</sup>per year, covering Skikda, Elhadaik, Hamadi Karouma, Oum toun and Sidi Mezghiche;
- Beni Zid with a capacity of up to 40 million m<sup>3</sup>per year, covering collo, Beni Zid, Kerkeria and cheraia;
- Zit emba with 120 million m<sup>3</sup> per year, covering azzaba, Ain charchar, Djendel and Es sebt. (Ibtisam & Riad, 2019, p. 500)

- **Non-conventional water sources:** Many initiatives have been launched to increase the availability of water resources, including the desalination of seawater through two desalination units—one located in the marina and the other in the industrial zone. Together, these two stations produce 103,500 cubic meters of water per day, currently supplying the city of Skikda and its surrounding areas with drinking water.

The salt water is demineralized to supply the industrial area, and this water is produced by demineralization plants at a rate of 4000 cubic meters per day. (Ministry of the Interior, Local Authorities, and Urban Planning, 2024)

Wastewater treatment is conducted through wastewater treatment plants dedicated exclusively to agriculture in the Safsaf Plain, aimed at mobilizing and exploiting water resources. Skikda has recently completed a wastewater treatment plant with an estimated capacity of 42,000 m<sup>3</sup>. This treated water is used to irrigate 1,500 hectares of land in the first sector, utilizing the irrigation infrastructure of Safsaf.

- **Mobilization indicators:** The state is supplied with 27% of surface water, 40% of desalinated water, and 33% of groundwater. The current water production of the state is: 158.678 m<sup>3</sup>/day, including surface water: 51,310 m<sup>3</sup>/day, groundwater: 34,289 m<sup>3</sup>/day and desalinated water: 73,079 m<sup>3</sup>/day

4.2. *Distribution of seawater desalination plants in Skikda*

4.2.1. *Desaladora Industrial Area Station:* Located on the coast of Skikda, 5 km northeast of the city and within the Sonatrach industrial zone, the desalination plant has been in operation since June 2009. It is one of the first plants built in the country and, thanks to its production capacity of 100,000 m<sup>3</sup> per day and reverse osmosis technology, it provides drinking water to the city of Skikda and the Sonatrach petrochemical complex. This facility delivers potable water of the highest quality standards to a population of approximately 1,000,000 people.

The desalination plant is part of a program launched by the Algerian government in 2005 aimed at alleviating water shortages in the country by providing one million cubic meters of water per day, setting a benchmark in this sector.

The operational data for the Skikda desalination plant can be summarized as follows:

- **Entry into force:** June 2009 ;
- **Daily production capacity:** 100,000 m<sup>3</sup>/day;
- **Annual capacity:** 36,500,000 m<sup>3</sup>/year;
- **Population needs:** 34,000,000 m<sup>3</sup>/year;
- **Sonatrach needs:** 2,500,000 m<sup>3</sup>/year.

The municipalities served by the plant include Skikda, Hammadi Karouma, Filfila, el hadaik, bouchtata, Beni Bachir, Ramdane djamel, salah bouchaour, emdjez edchich, Ain Bouziane, and el-Harrouch, in addition to the Sonatrach industrial zone.

4.2.2. *Marsa Seawater Desalination Plant:* Located 66 km east of the municipality of Skikda, the desalination plant began operations on March 19, 2023. It has a production capacity of 5,000 m<sup>3</sup> per day, providing drinking water as follows: 3,800 m<sup>3</sup> per day for the residents of Marsa and neighboring areas, and 1,200 m<sup>3</sup> per day for the residents of chetaibi in the wilaya of Annaba.

Both desalination plants use Reverse Osmosis technology.

4.3 *Evolution of the volume of domestic water production in the wilaya of Skikda during the period (2015-2024)*

With the entry into force of the first major desalination plant for the industrial area of Sonatrach in 2009, which has a production capacity of 100,000 m<sup>3</sup> per day, the production of desalinated water commenced. This was followed by the second plant, el Marsa, which began operations in 2023 with a production capacity of 5,000 m<sup>3</sup> per day. Of this, 3,800 m<sup>3</sup> per day is allocated to the residents of the municipality of Marsa and its neighboring areas, while 1,200 m<sup>3</sup> per day is directed to the residents of the municipality of chetaibi, which is part of the wilaya of Annaba. Although the two stations do not operate at full capacity, they have contributed significantly to providing water to the city of Skikda amidst the scarcity of traditional resources. The following table tracks the development of desalinated water production from 2015 to 2024.

Table .3. The volume of domestic water production in the wilaya of Skikda during the period (2015-2024)

SDEM 100000 M <sup>3</sup> /J (Skikda Industrial Area)					
Years	2015	2016	2017	2018	2020
<b>Volume of desalinated water</b>	33943000	35413000	34962760	35533000	35223000

Years	202&	2022	2023	2024 (until 30 June)
<b>Volume of desalinated water</b>	35184000	35288000	35288000	17264700
<b>SDEM 5000 M<sup>3</sup>/J (el marsa)</b>				
Years	2023		2024 (until 30 June)	
<b>Volume of desalinated water</b>	506751		332174	

Source : (Directorate of Water Resources of Skikda wilaya, 2024)

We note from the table data the annual development of desalinated water from 2015 to mid-2024. During this period, domestic water production grew at a pace nearly equivalent to that of the industrial zone plant. The average production of desalinated water at the Skikda industrial zone plant reached approximately 35,000,000 m<sup>3</sup>. In contrast, the Marsa plant recorded production of 5,067,751 m<sup>3</sup> in 2023, its first year of operation. Given the scarcity of traditional resources, the expansion of the second plant became inevitable.

Between 2015 and mid-2024, the two desalination plants in Skikda wilaya generated a total of 298, 938,386 cubic meters of water. Despite the considerable volume produced, it is noteworthy that the plants have not been operating at their full design capacity.

#### 4.4. Contribution of desalinated water to the provision of drinking water to the wilaya of Skikda

The importance of desalinated water in Skikda has emerged in recent years. Due to the high cost of its production, it is primarily intended for human consumption. Desalinated seawater is now considered the main source of drinking water in Skikda, which has a high population density of approximately 1,135,450 people distributed across 38 municipalities. This source of water has played a key role in alleviating the state's water deficit and is now available daily to residents in many of the state's municipalities.

Table .4. Share of the beneficiary population of desalinated water according to each station during the years 2022, 2023 and 2024

Station Name	Beneficiary Municipalities	Number of population benefiting from desalinated water		
		2022	2023	2024
<b>S dem 100000 M<sup>3</sup>/J (Skikda Industrial Area)</b>	<b>Skikda</b>	202567	206210	213699
	<b>Hamadi Karouma</b>	37367	38314	37650
	<b>el hadaik</b>	16218	16580	17111
	<b>Filfila</b>	33617	34222	35466
	<b>bouchtata</b>	-	8319	8621
	<b>el-Harrouch</b>	52973	53754	55883
	<b>Ain Bouziane</b>	9017	9180	9513
	<b>salah bouchaour</b>	25744	26145	27161
	<b>emdjez edchich</b>	18952	18952	19993
	<b>Beni Bachir</b>	5655	5757	5967
	<b>Ramdane djamel</b>	26447	26923	27901

<b>SDEM 5000 M<sup>3</sup>/J</b> (el marsa)	<b>El marsa</b>	-	3948	4092
<b>Total</b>		428827	448304	463057

Source : (Directorate of Water Resources of Skikda wilaya, 2024)

The table shows that the two seawater desalination plants in Skikda wilaya potable water to approximately 460,000 people in 2024, distributed across 12 out of the province's 38 municipalities, representing around 40% of Skikda's population. The data also indicate a gradual annual increase in the number of beneficiaries. Accordingly, the seawater desalination option adopted by the wilaya since 2009 has effectively contributed to easing the pressure on traditional water resources and has proven to be a practical solution to the region's water crisis.

## 5. Conclusion

Water is one of important scarce economic resources, and water scarcity is a significant challenge facing the economic development in Algeria. This issue is exacerbated by limited natural water resources and the high costs associated with obtaining water from non-traditional sources. As a result, traditional water resources have become insufficient to meet the population's needs for drinking water. Therefore, it is essential to find more sustainable solutions to provide this vital resource.

The Algerian government has primarily relied on exploiting available water resources in the water sector. Consequently, resorting to seawater desalination has become an urgent necessity and a strategic solution, as it represents a forward-looking technology to address water scarcity. The state has developed a strategy to provide drinking water through desalination, prioritizing this initiative within its economic recovery plan. A financial envelope of approximately 12 billion dollars has been allocated for this purpose.

To achieve water security, the government has established several seawater desalinations plants along the coastal strip. Currently, 11 major desalination plants in Algeria produce about 767 million cubic meters of water per year, meeting the needs of approximately 8,232,305 people. The Algerian government also plans to increase the number of desalination plants to 19 by 2025. Notably, Skikda is among the leading regions in seawater desalination, with a production capacity of 135,000 cubic meters per day, contributing 40% of the total water resources for the state.

Among the most important results reached in this study:

- Algeria has explored new alternatives and established several projects to ensure the sustainability of water resources;
- Seawater desalination technology is a strategic option for supplying cities with drinking water in Algeria;
- Since 2001, public authorities have prioritized the supply of drinking water through seawater desalination as part of the Economic Recovery Plan, which has allocated an estimated financial envelope of \$12 billion;
- Algeria aims to meet up to 60% of its drinking water needs through desalination by 2030;
- Eleven desalination plants in Algeria produce approximately 767 million m<sup>3</sup> per year, meeting the needs of about 8,232,305 inhabitants;
- The Algerian government plans to increase the number of desalination plants from 11 to 19 by 2025;
- Skikda has two seawater desalination plants: the first with a production capacity of 100,000 m<sup>3</sup> per day and the second with a production capacity of 5,000 m<sup>3</sup> per day, along with two additional plants under construction;
- Seawater desalination technology contributes to the water security and economic growth of Skikda; 75% of the production from the Skikda plant is directed to the population, while 25% is allocated to the industrial zone of Sonatrach;

- The wilaya of Skikda has pursued seawater desalination to alleviate pressure on traditional water resources, with desalinated water accounting for about 40% of the total water resources in the region.

*\*Recommendations*

- The study findings gives insights of the following recommendations:
- Research modern and sophisticated technologies to reduce desalination costs;
- Rationalize water resource use in industrial, tourist, and urban areas through citizen education;
- Integrate AI technologies to find ways to treat and reuse wastewater;
- Promote modern technologies such as remote sensing and GIS in water management;
- Adopt advanced water-saving methods in agriculture, focusing on low-water-consuming practices;
- Increase attention to studies and research in this field, particularly those proposing optimal solutions and management strategies;
- Work on wastewater reuse by introducing necessary techniques and technologies, within the framework of rational water resource management and environmental protection;
- Innovate new methods to rationalize water consumption and enhance water awareness among all users;
- Encourage investment in research within the water resources sector to develop solutions for the water crisis.

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