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Overview of irrigation water salinity and desalination methods in the Adrar region

HADIDI Abdelkader[#1], GAHGAH Mourad [#2], SABA Djamel [#3],YOUCEF Ahmed[#4], KORTI Mohammed Choukri[#5], KHELAFI Mostefa[#6].

[#] *Unité de recherche en Energie Renouvelables en milieu saharien, URERMS, Centre de Développement des Energies Renouvelables, CDER, 01000, Adrar, Algeria.*

hadidiabdelkader@gmail.com

mourad.gahgah@gmail.com

saba_djamel@yahoo.fr

a_youcef83@yahoo.fr

kortichoukri@yahoo.fr

e_khelafi@yahoo.fr

Abstract—
The Adrar region is located in the southern part of Algeria and is considered the The southern limit of groundwater networks is the northern Sahara, which is often salty. This topic aims to study the salinity of the Adrar region, identify the saline areas in the state, identify modern desalination methods, and provide recommendations for water desalination. To solve this problem, various new technologies have been invented to desalinate saltwater and seawater. Old water treatment processes suffer from disadvantages that generate costs for the manufacturer. On the other hand, new water treatment technologies, particularly magnetization or capacitive ionization treatment, offer many advantages proven by scientific research. Water by magnetization technology, its applications in the economic sector, and its impact on plants, soil and water were discussed. Studies have shown that magnetization prevents water distribution and industrial pipes from clogging and allows good plant development. Capacitive deionization technology is also discussed as an innovative desalination technology that uses porous electrodes that absorb ionic molecules in the water once they are electrically charged. Capacitive deionization technology removes various suspended impurities in water and consumes less energy than reverse osmosis technology, and is expected to play an important role in the freshwater supply in the future.
Keywords: salinity, desalination and water treatment, magnetization, capacitive deionization.

I. INTRODUCTION

Algeria has experienced more than a decade of drought and traditional water resources were not sufficient to meet the needs of the population [1]. which prompted the Algerian authorities to seek other resources to ensure the supply of drinking water to the population. The most appropriate solution was desalination. Desalination of Mediterranean Sea water, which has a salinity of 35 mg/liter, was used to supply drinking water to cities in the coastal region, and desalination (removal of minerals) of brackish water with a salinity not exceeding 0.35 mg/l was used to supply landlocked and desert areas. Among the many proven water desalination methods, Algeria overwhelmingly chose the technique known as "reverse osmosis." This is a mature and technologically mastered membrane method with import rates exceeding 60%. Its major drawback is its energy consumption. If our country has invested massively in water desalination, the objective is to meet the needs of the population, since the needs of agriculture are covered by water from dams. Even though there are currently 84 dams available with an estimated storage capacity of 8 billion m^3, there is still a need to improve irrigation methods [2].

To overcome this problem, a new technology based on water magnetization could provide an alternative solution for using this water in agriculture.

This work therefore aims to understand the standards and characteristics of approved irrigation water and to understand the salinity of water in the Adrar region for agriculture, providing recommendations for irrigation with water that can produce the highest agricultural yields. Highlight the impact of this water on various components of the environment, including the physical and chemical properties of the soil. Wastewater and the physical, morphological and chemical behavior of species

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II. Presentation of the Study Area

The province of Adrar is located in southwestern Algeria; it extends between the following geographic coordinates:

- Longitudes between 0°30` and 0°30` in the West
- Latitudes between 26°30` and 28°30` in the North
- With an average altitude of 222 m (HIDAOUI A, 2015).

The province covers a total area of 443,782 km², representing 17.97% of the total area of Algeria (MOUSSAOUI D, 2016). It is bordered to the north by the provinces of El Bayedh and Ghardaïa, to the west by the provinces of Béchar and Tindouf, to the east by the province of Tamanrasset, and to the south by Mauritania and Mali (MOUSSAOUI D, 2016).

It is bordered (geomorphological boundary):

- To the north by the great Western Erg.
- To the south by the Tanezrouft Plateau.
- To the east by the Tademaït Plateau.
- To the west by the Chech Erg (BENHAMZA M, 2013).

Divided into four natural Saharan regions represented by:

- Gourara: Its administrative center is the Timimoune district, which includes all the palm groves and ksars of this district.
- Touat: It extends from Brinkane to Reggane; this is the largest of the regions, and the most interesting, as it contains a large number of foggaras.
- Tidikelt: This region extends from Aoulef to Ain Saleh, which is the center of the region.
- Tanezrouft: The region of Bordj Badji Mokhtar (DAHALI S, 2013).

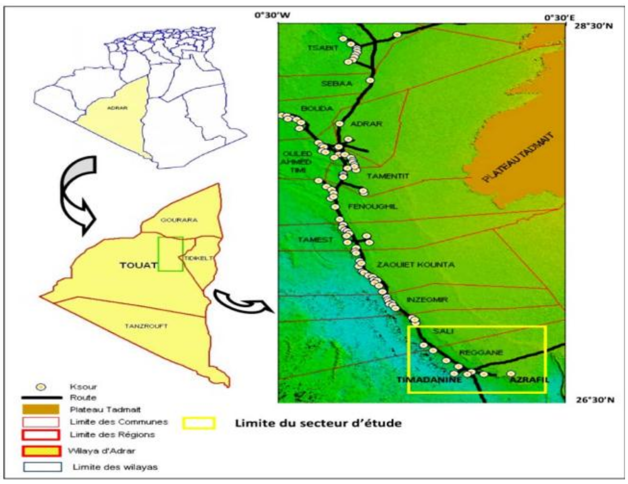

Fig. 1 The map represents the study region (BOUTADARA Y., 2009).

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III. Materials and Methods

Our work is primarily based on investigations.

We have collected data, information, and documents from technical departments.

There are essentially two families of desalination technologies used in the world today. These include thermal technologies and membrane technologies [4] ,[5].

The two types of processes used for desalination in Algeria are thermal distillation by successive expansion or Multi Stage Flash (MSF) and reverse osmosis (RO)[11].

Desalination in Algeria

In the coming years, Algeria's total freshwater production capacity will reach approximately 3.5 million cubic meters per day, to meet the needs of the population living within 50 km of the Mediterranean coast(Fig1).

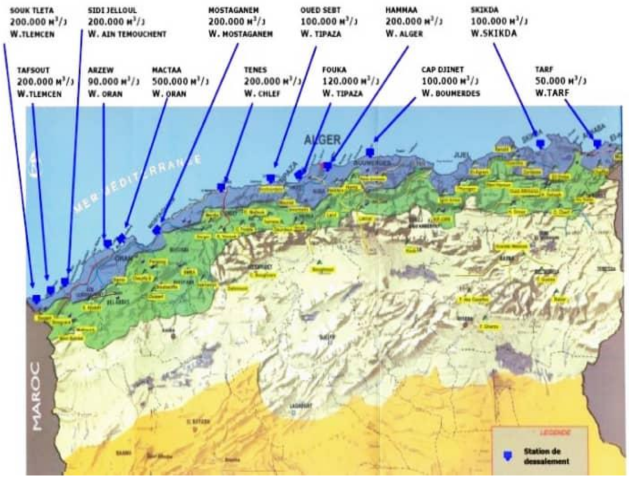

Fig. 2 Location of large seawater desalination plants [7].

III.1. Thermal distillation by expansion

The Kahrama (Arzew) desalination unit, in service since the end of 2006 (production capacity: 90,000 m3 / day) is of the MSF type. In addition, it is the only one operating in cogeneration with a power station [7], [9].

III.1.1. Operating principle

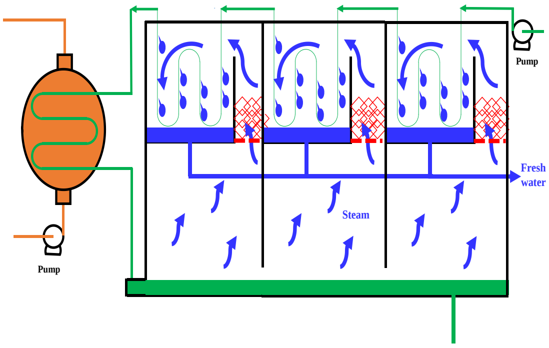

Fig. 3 operating principle of a 3-stage successive expansion system (MSF) [10].

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The seawater to be treated is heated and maintained under pressure [6]. when it reaches a temperature of the order of 120 ° C, it is introduced into an enclosure (or stage) in which a reduced pressure prevails (Fig2). This result in instantaneous vaporization by expansion called "Flash", a fraction of the water evaporates and will condense on the condenser tubes placed at the top of the enclosure[8], [9]... Liquid water is collected in receptacles placed under the tubes. It is the warm seawater, which cools down to provide the heat of vaporization, boiling stops when the seawater has reached the boiling temperature corresponding to the pressure in the stage considered [12].The flash phenomenon is then reproduced in a second stage where a lower pressure prevails. The water vaporization is thus carried out by successive expansion in a series of stages where increasingly reduced pressures prevail.

We obtain pure water, unfit for consumption. To make it drinkable, it is re-mineralized in the production unit before supply to ADE.

To heat seawater up to 120°C, it is circulated in the condenser tubes of the different stages starting with the last stage where the lowest temperature prevails, it is preheated by recovering the heat of vaporization from water vapor, then brought to 120 ° C by means of steam brought to a temperature above 120°C produced by a boiler or coming from an electricity production plant.

III.2 Magnetisation of water

Effect of Magnetism on Water

Water is a polar material whose molecules tend to bond together by hydrogen bonds to form clusters. Normally, each water cluster contains about 100 molecules. When water is passed through an electromagnetic field or a permanent magnetic field, it becomes magnetized and is known as magnetic field-treated water (MFTW). The magnetic field breaks the hydrogen bonds, reducing the clumping of water molecules into a cluster, and, as shown in (Fig. 4), it spreads the water molecules. Magnetized water differs from tap water in terms of its mechanical, electromagnetic, and thermodynamic properties. These properties make magnetized water suitable for many industrial, medical, and agricultural applications.

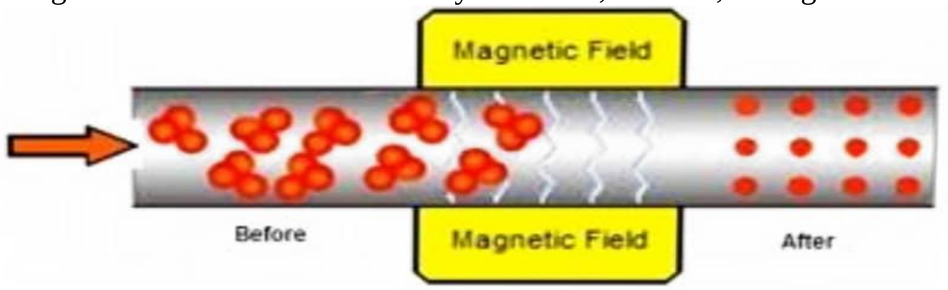

Fig. 4 Effect of magnetic field on water clusters [8].

Magnetic water treatment works on the principle that water passes through a magnetic water softener, and the Lorentz force acts on each ion, which is in the opposite direction to the other. The forward movement of the molecules increases the frequency of collisions between the ions on opposite sides, combining to form an insoluble precipitate of metal or composite.

III.3 Principle of desalination by electrosorption

CDI (Capacitive De-Ionization) is an emerging technology for desalination and water treatment that uses electrophoretic driving forces. Attractive in its simplicity, CDI is based on the following demineralization principle: placed between two carbon electrodes and subjected to a ddp, the electrolytic solution allows the migration of its ions towards the electrodes where they will accumulate, thus promoting the deionization of the solution. The technique is mainly applicable to brackish waters with low dissolved salt concentrations between 1 and 10 g/l.

The CDI cycle occurs in two stages: ion adsorption and desorption. These two stages proceed as follows:

- In the adsorption phase (a): a small potential difference is applied to a pair of porous electrodes to cause the salt ions to migrate into the electric double layer (EDL) of the electrode-water interface (Suss et al.,

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2015). Cations (+) move to the cathode (-) and anions (-) move to the anode (+): this promotes the storage of ions in the various pores of the electrode (ion adsorption). When the electrode is saturated with salt (having reached its maximum electrosorption capacity), the solution is deionized.

- In the desorption phase (b): A current reversal causes the electrodes to regenerate (ion desorption). The adsorbed ions are rapidly released into the water stream as a concentrate (Fig.5)

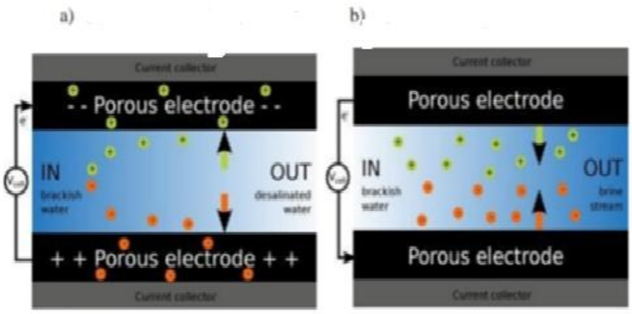

Fig. 5 Illustration of the CDI process.

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III.RESULTS AND DISCUSSION

- Using Magnetization to Treat Saline Irrigation Water

Salt water has a negative effect on plant growth due to the presence of sodium ions and high osmotic potential. Various methods have been used to mitigate the stress of salt water on plant growth and crop production, the most recent of which is the use of magnetic fields (ALAVI et al., 2020).

The effects of magnetic fields on improving the properties of salt water depend on:

1. Exposure time.
2. Magnetic field amplitude.
3. Plant species.
4. Environmental conditions.
5. Salt properties and concentration (ALAVI et al., 2020).

Treating irrigation water with magnetic fields:

- Improves seed germination.
- Improves plant growth.
- Also increases soil moisture in the root zone of the plant compared to unmagnetized water (SUCHITRA and BABU, 2011).

Saline soil cannot be reclaimed with chemicals, conditioners, or fertilizers. Reclamation of these types of soil is only possible by applying a sufficient quantity of high-quality water to completely leach the soil. The water applied must be low in sodium but still be sufficiently saline.

Recently, magnetizing saline irrigation water using a suitable magnetic field has been introduced as an effective method for soil desalination.

- Electrosorption desalination offers numerous advantages, such as low energy consumption and ease of use. Indeed, at low salinity, CDI consumes less energy compared to conventional methods such as reverse osmosis and distillation (Oren, 2008; Porada et al., 2013). Furthermore, CDI has no pressure/heat requirements and no secondary contamination

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(Gabelich et al., 2002; Park et al., 2007a). It is a process that reduces the environmental costs and economic impact of desalination (Qu et al., 2016). However, during ion regeneration, strong adsorption of unwanted co-ions can occur during the desorption phase, limiting treatment efficiency (Foo and Hameed, 2009; Goh et al., 2016; Hassanvand et al., 2018). Additionally, a pH fluctuation is observed by (Lee et al, 2010) at potentials above 1.0 V due to the reduction of dissolved oxygen at the cathode during electrosorption. According to (He et al, 2016), this pH fluctuation reveals that faradaic (oxidation-reduction) reactions occur in tandem with ionic electrosorption (non-faradaic effect). Therefore, this could lead to salt precipitation and subsequent fouling of electrodes in industrial applications; which is not desirable. To overcome some limitations of the CDI desalination process, Membrane Capacitive Deionization (MCDI) has been explored.

IV .CONCLUSIONS

In this study, we provide a bibliographic overview of the salinity phenomenon in the Adrar region, as well as modern water desalination technologies and their principles in general. Salinity is a natural phenomenon that affects water containing a high percentage of dissolved salts, making it unfit for consumption and agriculture due to its effect on plants. Many countries around the world suffer from a shortage of fresh water. This has led to the search for technical solutions for the desalination of seawater and saltwater. Water desalination technologies have undergone significant development over the past few decades, leading to the emergence of numerous methods offering high productivity and excellent efficiency. To solve the salinity problem, we have proposed new methods based on high-level desalination of water, making it suitable for agricultural and industrial use.

Magnetic water treatment is an innovative technology that has begun to be applied in several water-using fields due to its numerous effects and advantages. Despite its drawbacks, it is a more efficient technology and remains the ideal solution to many problems, including:

- Increasing plant growth.
- Improving agricultural yields.
- Reducing soil salinity and increasing productivity.

Capacitive deionization technology is an electrochemical technology that allows soil to be extracted from water through the electrolytic absorption of ions.

This technology is considered efficient and low-cost for water desalination. It is also used in the manufacture of electronic devices and food products, as well as in wastewater treatment and pollutant removal.

One of its most important features:

- Consumes less energy compared to conventional methods such as reverse osmosis and distillation.
- Has no pressure/heat requirements and no secondary contamination.

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