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Desalination and Agriculture

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ABSTRACT: In arid countries like Tunisia, the need to find new sources of water for irrigation has become imminent. Desalination of seawater can be an alternative to irrigation. Water desalination is a process that makes it possible to obtain fresh water (drinking water or, more rarely, due to the cost, usable for irrigation) from brackish or salt water (seawater in particular). In this article, we take a look at the leading food companies specializing in desalination for irrigation around the world and the prospects for the solar energy desalination potential for irrigation in Tunisia. We have noticed that several companies investmoney to desalinate water for agricultural purposes. However, the cost of a cubic meter of water sometimes remains high to go forward in this new technology.

KEYWORDS: Irrigation/renewableenergy/solar desalination/water cost

I. INTRODUCTION

Since the 1960s, water treatment and water desalination have been the subject of scientific studies in the USA (Gomella, 1967). Among these studies, water specialists have tried to see the performance of thermal desalination plants with thermodynamic cycle plants to have high energy efficiency, large solar plants called Concentrating Solar Power (CSP) can thus be associated with multi-effect distillation (MED) or multi-stage flash distillation (MSF) desalination stations (Thiennot, 1981). These investigations verified the technical feasibility of setting up desalination stations for agricultural purposes. These studies have shown that an irrigated perimeter can have a water supply through desalination plants for sustainable agricultural production. This can help ensure competitive prices on the market for agricultural products (Picard, 1977). Several successful experiences exist in this area.In the Bay Lagoon in the Philippines (Pariset, 1977), the main challenge for agriculture is the salinity of the water, which exceeds 2 g / l. The establishment of a desalination plant for irrigation has enabled the increase in agricultural production for the water supply of 30,000 hectares. In this sense, several countries have chosen desalination for water supply. Arid countries such as Tunisia, Saudi Arabia, Egypt and less arid countries such as Nigeria, China, Indonesia and Cuba have set up drinking water desalination plants (André, 1995). half of Malta's municipal water quantity comes from seawater desalination (Margat, 1993). In Kuwait, there have been years of excess desalinated water over requirements (Detay and Bersillon, 1996).

Nowadays, desalination is a method to obtain good quality water. All desalination processes are energy-intensive and share the common minimum energy required to cause the saline solution to separate into pure water and concentrated brine. It is dependent on the detailed technology used, the exact mechanism or the number of process steps. Furthermore, the overall equivalent power consumption of a Multi-stage flash (MSF) unit is 20 KWhelec / m3to 30 KWhelec / m3, the overall equivalent power consumption of the Multi-effect desalination (MED) unit also varies from 15 KWhelec / m3 to 22 KWhelec / m3 (Shahzad et al. 2019, Shahzad et al. 2018). These thermal processes are energy-intensive because there is a loss of energy efficiency due to phase changes (fossil to thermal or fossil to electric to thermal). According to the same author (Shahzad[a] et al. 2017), for the reverse osmosis (RO) membrane process, the overall equivalent power consumption of the SWRO unit (Seawater RO) reached the lowest specific energy consumption level of SWRO at 2.00 KWhelec / m3. The energy consumed by conventional desalination plants usually comes from combined cycle power plants. They are characterized by the highest efficiency of electricity generation technology from fossil fuels. These units are among the most developed, currently achieving yields above 60%. The CO2 emission is equal to 330 kg - CO2 / MWh (Kotowicz and Brzęczek, 2018). Speaking of agricultural water consumption, according to the United Nations report (United Nations, 2011), agriculture alone uses 70% of the world's water supply. Besides, global food demand is expected to increase by another 70% by 2050. However, according to the report, the main challenge facing the world today is not so much the increase of food production, but rather to provide good quality irrigation water to farmers in sufficient quantities. Shortage of water in arid zones has led to the usage of low-quality irrigation water in agriculture in most arid climate areas (Hamdi, 2011). The water deficit is a problem present in many parts of the world, with lower rainfall and increased salinity of aquifers (Bahir, 2021).
There is another method of desalination that finds success among manufacturers. This is “MEDAD” desalination which is a hybrid of traditional multi-effect distillation (MED) and adsorption cycle (AD)

(Shahzadb et al., 2014). In general, there are a number of hybridization trends. In RO processes, intake, pre-treatment and brine disposal cost 25% of total desalination cost at 30–35% recovery. Shahzad[b] et al. (2017) proposed a tri-hybrid system to enhance overall recovery up to 81%. The conditioned brine leaving from RO processes supplied to proposed multi-evaporator adsorption cycle driven by low temperature industrial waste heat sources or solar energy. La concentration de rejet de saumure du cycle tri-hybride peut varier de 166 000 ppm à 222 000 ppm si la concentration de rétentat RO varie de 45 000 ppm à 60 000 ppm.Several coastal countries see water desalination as a solution to water scarcity (Wonham, 1995). In Algeria, a neighbouring country of Tunisia, desalination is considered by water experts as the only solution present to avoid a future water shortage (Bessenasse, 2009). The very specific conditions of the Mediterranean Sea (fresh water at 19 ° C and a salinity of 38 g / l (Skliris et al., 2018), while the waters of the golf course are at 30 ° C and a salinity of 40.5 g / l (Ibrahim et al., 2020) will result in lower cost per cubic meter of desalinated water Algeria started building large-scale desalination plants after the 2001 water crisis; with a total capacity of over 2 million m3 / d (Verdier and Viollet, 2015).

Also in Libya, which is Tunisia's second neighbour country, a serious effort has been made to develop additional water sources from desalination (EI-Gheriani, 2003) and the country has about ten desalination stations.There are great advances in the field of membrane and thermal desalination in particular the specific energy consumption (Table 1). According to Shahraz et al. (2019), the performance of desalination plants, conventionally reported on the basis of fossil fuels, can now be transformed fairly on a common platform based on specific energy consumption (SPE). This new factor, called the standard universal performance ratio (SUPR), is calculated on the basis of SPE and presented in table 1. Thermal processes have better efficiency of 2.82 m3 / Kwh and 2.00 m3 / Kwh for MSF and MED respectively with respect to RO. The CSP + MSF or MED configuration should experience a boom in the future.

Table1.SPEandSUPRcalculationofmajordesalinationprocesses (Shahzad et al. 2019, Shahzad et al. 2018)

Specificenergyconsumptionandperformanceratio	Reverseosmosis(SWRO)	Multi-stageflashing(MSF)	Multi-effectdistillation(MED)
Electricity(kWh_{elec}/m^3)	3.54	2.82	2.00
Thermal(kWh_{ther}/m^3)	—	90.0	70.0
Equivalent standard primary energy (SPE) and standard universal performance ratio (SUPR)			
Conversionfactorforelectricity (weightedCF_{elec})	2.012		
Conversionfactorforthermalforlessthan 130°Coperation(CF_{ther})	—	35.33	
Standardprimaryenergy(Q_{SPE}) $Q_{SPE}=[(kWh_{elec}/m^3)(CF_{elec})]+[(kWh_{ther}/m^3)(CF_{ther})]$	7.12	8.22	6.00
Standarduniversalperformanceratio(SUPR) $SUPR=2326/(3.6Q_{SPE})$	90.7	78.6	107.6
SUPR%ofthermodynamiclimit(SUPR=828atTL)	10.9%	9.5%	13.0%

II. EMERGING AGRO-INDUSTRIAL COMPANIES SPECIALIZING IN SOLAR DESALINATION FOR IRRIGATION:

Sundrop Farms is a leading company in high value-added horticulture. It is developing irrigated perimeters in arid areas of Australia with desalinated water from solar energy as the water source (Cleantechnica, 2014). It is an agri-food company with the technological know-how to develop and operate hydroponic greenhouses (Fig. 1).

Fig.1.Anintegrateddesalinationfacilitydrawingitsmainelectricityfromanadjacentconcentratingsolarpowerplant (Inhabitat, 2016).

Desalination is a long-term solution. But the high energy requirements of desalination are a drawback (Lafforgue, 2016). This is why Sundrops farms use solar desalination. The technology has given satisfactory technical results. In 2015, Sundrop Farms built a 20-hectare solar greenhouse in Port Augusta. A concentrated solar power plant (CSP) desalinates seawater taken from the Spencer Gulf to irrigate agricultural products (Conseil Development Assessment Panel Agenda Meeting # 123, 2014). Tomato yields reached 850 tonnes/ha in hydroponic greenhouses (The Guardian, 2017). A quantity of desalinated water of 335 103 m^3 is used in the greenhouses. The financial cost of the project is estimated at the US $ 205 million (Government of South Australia, 2015).In the same context, a study carried out in 2017 in Spain showed that the supply of drinking water and irrigation water via a desalination plant increased resilience in the face of water shortages (Barraque et al., 2017).Another similar project was built in 2012 as part of the Norwegian agro-industry called the Sahara Forest Project in Qatar on an area of 300 hectares. The Qatari installation can provide desalinated water for all crop irrigation needs (Renew Economy, 2013) for a yield of 633 tonnes/ha of tomatoes and melons. This same agro-industrial project in the Sahara Forest will initiate numerous activities in Tunisia over 10 hectares (Inhabitat, 2016).In addition, an American blog called “sustainable business” specializing in sustainable development projects described a solar thermal project launched in 2014 in California (Sustainable business, 2014).A Californian start-up called WaterFX has set up a 14-hectare solar thermal desalination plant. It supplied 3.8 million m3 of water in 2014 from the saline drainage water of the San Joaquin Valley and turns it into fresh water for irrigation. The desalination unit recycles drainage water over an area of 2,800 hectares into a source of fresh water for nearby irrigated areas. The success of the project convinced the Panoche Water District, in an arid agricultural region of California, to build a desalination plant (Earthtechling, 2015). WaterFX's operating cost is US $ 450 for 1.2103 m3 (Forbes, 2014). The price was deemed acceptable by the Panoche Water District. A current price of US $ 1 / m3 is considered acceptable in some countries for domestic and industrial uses (Babillot and Le Lourd, 2000).

III. SOLAR DESALINATION IN TUNISIA: PERSPECTIVES

Several coastal countries see water desalination as a solution to water scarcity (Wonham, 1995). In Algeria, a neighbouring country of Tunisia, desalination is considered by water experts as the only solution present to avoid a future water shortage (Bessenasse, 2009). The very specific conditions of the Mediterranean Sea (fresh water at 19 ° C and a salinity of 38 g / l (Skliris et al., 2018), while the waters of the golf course are at 30 ° C and a salinity of 40.5 g / l (Ibrahim et al., 2020) will result in lower cost per cubic meter of desalinated water Algeria started building large-scale desalination plants after the 2001 water crisis; with a total capacity of over 2 million m3 /d (Verdier and Viollet, 2015).Also in Libya, which is Tunisia's second neighbour country, a serious effort has been made to develop additional water sources from desalination (EI-Gheriani, 2003) and the country has about ten desalination stations. The German Institute for Space Research carried out a study on the problem of water scarcity in the Arab region. The main conclusion is that this shortage can be alleviated by resorting to water desalination by solar energy. Solar desalination can provide more than 85 billion m3 / year in some areas when the direct normal irradiance (DNI) exceeds 1800 KWh / m2 / year (Fig. 2). The x-axis represents the DNI and the y-axis represents the quantity of desalinated water obtained (in billions of m3 /year).

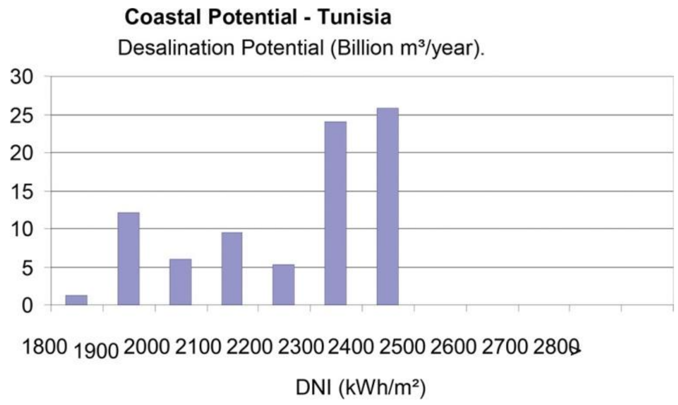

Fig.2.StatisticalanalysisoftheDirectNormalIrradiance (DNI) mapforCSP-desalination in Tunisia, (20 mabovesealevel)(Fichtner,2011).

This is the distribution of surfaces according to the radiation expressed in the production of desalinated water. Considering the increase in population in most countries of the South and particularly those which are arid like Tunisia, the desalination of sea water will be an important source of water in the water supply (La Société Hydrotechnique de France, 1998). In addition, with the development of seawater desalination and the expected progress in terms of access to drinking water and sanitation (United Nations Sustainable Development Goal SDG 6), this sector could reduce its consumption. in energy by 15% by 2040 (Loudière and Gourbesville, 2020) Everywhere, when political decision-makers wanted it, deserts were irrigated in several cities of the Middle East with desalinated seawater (Dunglas, 2000).

IV. MAJOR CHALLENGES FOR THE CONSTRUCTION OF SOLAR DESALINATION PLANTS FOR IRRIGATION

The launch of desalination plants presents many major challenges.A well-detailed expertise file must be drawn up on the technical requirements (Ghaffour et al., 2013).There is a need to collect a lot of data for the construction of these stations. These data concern the distribution of water and its use for irrigation for better agricultural efficiency. Also, the data concern resources, both in their quantitative and qualitative aspect (rain, infiltration, flows, recharge, water quality).This idea is shared by Margat (2000) who says that desalination operations bring together a complex chain of water development and control for better energy efficiency. Indeed, when the occupation of the coast poses a problem for the installation of desalination units, the problem is "energy efficiency", which must be fully taken into account for these units coupled with thermal power stations. (Esmailion, 2020).The second major challenge is that the cost per cubic meter of water is expensive in some areas (Wiesman, 2003). Indeed, the desalination of certain brackish water requires a fairly significant pre-treatment which can affect this cost. Since reverse osmosis desalination plants can be set up in isolated sites.Another existing challenge is that these stations could significantly affect marine life and fauna (Miri and Chouikhi, 2005) leading to ecological variations. For example, thermal discharges can seriously harm the marine ecosystem. There are also steps to be taken to change consumers' perception of desalinated water, which will enable the supply of sufficient quantities of water and in fact constitute new water insurance (Cabrera et al., 2019).In Tunisia, water desalination is technically feasible but at excessively high costs (Daghari and Zarroug, 2020). Indeed, there is a transfer of water from dams that mixes in aquifers to fight against seawater intrusion in coastal regions and not with desalinated water (Daghari et al., 2020).

V. CONCLUSION

Agri-food companies are emerging in countries suffering from increasing water stress. The goal is to develop agricultural production through solar water desalination. This will be one of the alternatives on which Tunisia can count for the supply of irrigation water. The economy will flourish with the irrigation water needed for millions of hectares of arable land. However, the first and main concern is the cost of these factories which pose a problem for poor or emerging countries. Second, emissions of gas, hot water and salinity create environmental problems. Third, using chlorine to clean membranes (reverse osmosis) creates chemical water that cannot be discharged into the sea.

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