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Desalination techniques — A review of the opportunities for desalination in agriculture

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HIGHLIGHTS

- Water from reverse osmosis/electrodialysis technologies is suitable for agriculture.
- Water from these technologies is more expensive than normal agricultural water.
- The use of desalination for agriculture may currently be justified for high value crops.
- Wider technology application is viable where fit for purpose water is limited.
- Technology development requires cost reduction and improved agricultural practices.

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ABSTRACT

The adoption of desalination for agricultural purposes in countries such as Australia has been very limited, with only a small number of cases available to demonstrate its suitability. This can be compared to countries such as Spain where the uptake has been significant. A number of suitable technologies such as reverse osmosis and electrodialysis are available to provide desalinated water, but not at a cost comparable to that for water commonly utilised for agricultural purposes. The use of blended waters, where the quality of the water is tailored to the crop may go part way to addressing this cost differential. However, if the overall efficiency of the combined production of water and food, as well as opportunities for better soil management is considered, then desalination's applicability to agriculture becomes more viable. The use of state of the art technologies for the provision of desalinated water for agriculture is most likely to be cost effective in a tightly controlled environment, using agricultural practices with the most-effective water use and crops with high productivity. Such conditions are often associated with greenhouses and the production of high-value irrigated crops, where the cost of water is small compared to the infrastructure investment.

Contents

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1. Introduction

Population growth, food security concerns, climate change impacts on agriculture, freshwater resource overuse and land degradation worldwide are forcing international scientific communities to look for alternative approaches to our current resource management approach for agricultural purposes. This includes all aspects associated with water resources and their availability to support ever-growing demands for both agricultural and potable water demands. Desalination technologies may provide one opportunity for generating cost-effective and potentially climate-independent water resources of controlled quality for agriculture applications.

As shown in Fig. 1, seawater desalination is the most used solution to address water shortage especially for potable water applications. In this respect the number of desalination plants around the world, both planned and under construction, has increased significantly in recent years, as shown in Fig. 2, especially in Australia where they have been targeted for providing additional sources of potable water [25]. It is estimated that about 69% of available water resources around the world are used for irrigation [110] and as water demands increase the number of desalination plants for irrigation for agriculture has also increased. Consequently there is increased emphasis on enabling cost effective desalination technologies to provide water of suitable quantity and quality for agricultural applications.

Drier countries such as Australia and Spain have a long history with desalination technologies. In the past, the high capital and operating costs of desalination and the energy required have been major constraints to large-scale production of freshwater from brackish waters and seawater. However, desalinated water is becoming more competitive for urban use because desalinating costs are declining associated with increasing demand from population growth and reduced security of supply from surface water and usable groundwater and it is expected that these increases in efficiency will flow through to the agricultural sector. However, in spite of these developments, currently the cost of desalinated water is still too high for the use of this resource in broad-scale irrigated agriculture. An exception appears to be intensive horticulture for high-value cash crops, such as vegetables and flowers (mainly in greenhouses) grown in coastal areas where safe disposal of brines is easier than in inland areas [11]. For example Sundrop farms (Sundrop-Farms, Personal communication), uses 860,000 m^3 of fresh water yearly to irrigate 2000 m^2 of greenhouses. If the costs for providing desalinated water continue to reduce, its use is expected to become more viable because desalination for agricultural purposes has a number of significant advantages including:

- Tailored conductivity for irrigation water
- Assured supply
- Enables agricultural products of consistent quality
- Production may be increased compared to other water sources.
- The water may attain a higher resale price due to quality and supply assurance.
- It allows recovery of saline soils by irrigation with high quality water.

2. Integrated water and food production: desalination and agriculture

Desalination allows a widening in utilisation of available water resources by producing freshwater from saline or brackish natural water sources. Over the past decade conventional water production costs have been rising in many parts of the world and costs for desalination have been declining, consequently desalination has become more economically attractive and competitive. Lattemann et al. [58] estimated that by 2015 the costs of freshwater treatment, wastewater reuse and desalination are likely to be similar, at least in USA. However, currently desalinated water produced worldwide (77.4 million m^3/day, IDA, 2012) still comprises less than 1% of total worldwide water use, with only 2% of total desalinated water production currently used for agriculture (Fig. 3).

According to Desaldata [29] many countries are beginning to use desalinated water in agriculture, albeit at varying rates. The highest proportion of desalinated water use in agriculture occurs in Spain, where the current installed capacity is 1.4 million m^3/day and 22% is used in agriculture for high value crops, such as vegetables, fruits including tomatoes and peppers, and vineyards for table grape production. In Kuwait, where the current installed capacity is in excess of 1 million m^3/day, 13% is used for agriculture and in Saudi Arabia, the world's largest single producer of desalinated water; only 0.5% of its desalination capacity is used for agricultural purposes. Other countries which use desalinated water for food production are Italy (desalination capacity 64,700 m^3/day — 1.5% for agriculture), Bahrain (620,000 m^3/day — 0.4%), Qatar (0.1%), USA (1.3%) and Israel. The wider application of desalination technologies for agriculture is limited by its relatively higher cost, as well as by the need for agriculture to be close to saline and brackish feedwater resources as well as a safe and cost effective disposal option for brines. National assessments of the applicability of desalination technologies to support agricultural water supply are currently under way in Chile, China and Australia [49].

The overall efficiency of the combined production of water and food, energy use as well as an opportunity for better soil management, should be the basis for an assessment of desalination's applicability to

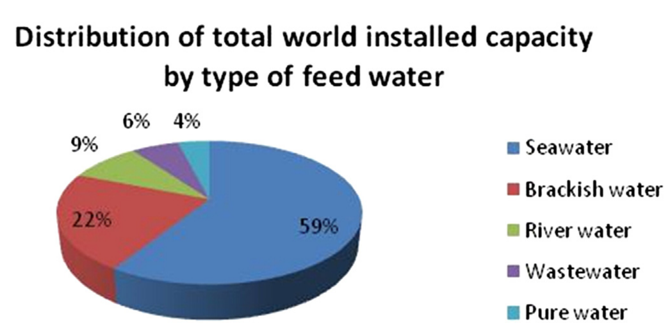

Fig. 1. Total capacity installed in the world (IDA Desalination Yearbook 2013–2014).

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