When was desalination invented

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This paper describes advances toward more sustainable desalination and exciting directions that could make this technology more accessible, energy efficient, and versatile. It reviews the emergence of membranes as the preferred technology for desalination, recent advances, challenges to its sustainable implementation, and needs for further research.

Desalination represents a promise of near unlimited water supply and is an attractive potential solution to the age-old conundrum of seawater abundance and practical inaccessibility for potable use. It now encompasses the removal of both salts and dissolved contaminants from various sources such as seawater, brackish surface and groundwater, and industrial and municipal wastewaters.

The primary descriptor of importance for desalination processes is the amount of dissolved solids (primarily inorganic salts) represented by the total dissolved solids (TDS; the solids left over after water is evaporated from particle-free water). Table 1 lists the typical range of TDS levels in waters subjected to desalination-based water treatment processes (Australian NWC 2008). Table 1

The growing pressure on limited freshwater sources has focused the world’s attention on seawater and the recovery of water from marginal sources such as brackish ground- and surface water as well as recycled wastewater. It has also raised awareness and catalyzed the implementation of wastewater reuse, where wastewater is treated to a high quality and in some cases used for direct or indirect potable reuse. Desalination is thus a critical technology for humanity to allow for sustainable development.

Desalination has a long history in both mythology and practice. An early and illustrative reference appears in the Bible (Exodus 15:22–26) and is widely considered to be about desalination.

When they came to Marah, they could not drink the water of Marah because it was bitter; therefore it was named Marah. And the people grumbled against Moses, saying, “What shall we drink?” And he cried to the LORD, and the LORD showed him a log, and he threw it into the water, and the water became sweet.

Early scientific descriptions of desalination centered around the application of distillation. In his Meteorologica, Aristotle wrote that “Salt water when it turns into vapour becomes sweet and the vapour does not form salt water again when it condenses” (Forbes 1948, p. 383). This is the definition of distillation, a process used to create fresh water from seawater at larger scales starting in the 1930s (NRC 2008). Distillation-based technologies remained a major approach to water desalination until the development of membranes.

The most common distillation-based desalination methods are thermally driven technologies, including multistage flash distillation, multiple-effect distillation, and mechanical vapor compression processes. In these processes water is evaporated by the addition of heat and in many cases assisted by the use of vacuum. The evaporated water is then condensed to recover desalinated water. Several large plants, primarily in the Middle East, have used thermal distillation since the 1930s (NRC 2008). Figure 1

But thermal desalination has very high energy consumption and is increasingly being replaced by the use of membranes, specifically reverse osmosis (RO) membranes. Figure 1 shows the energy consumption per unit volume of water for several commonly used water desalination techniques (Al-Karaghouli and Kazmerski 2013). As is evident from this figure, RO is a substantially more energy efficient technology for water desalination.

Membrane technologies arose as a result of a breakthrough in the use of polymer films for separating salt from water in the late 1950s/early 1960s. A brief history of the development of RO membranes is shown in figure2, based on Baker (2004). Figure 2

Reid and Breton (1959) first demonstrated the possibility of desalination using polymeric cellulose films and thus the first polymeric RO membranes were created. Loeb and Sourirajan (1963) then showed that an asymmetric cellulose acetate membrane can be used for desalination. The permeabilities of these early membranes were low and RO membranes were considered a novelty separation technique rather than a solution to desalination.

A major advance in membrane chemistry that has made possible the application of RO membranes is the development of the thin film composite (TFC) architecture. Previously, membranes were either several-micron-thick polymer layers with a uniform architecture or similar-size polymer layers with an “asymmetric” structure with a nonporous salt-rejecting top surface opening up to a more porous support.

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