



NSW DEPARTMENT OF
PRIMARY INDUSTRIES

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Photograph 18. Raw salt stockpile, Mourquong Basin salt remediation scheme, northeast of Mildura. This salt was obtained by solar evaporation of highly saline groundwater pumped from shallow aquifers in the Murray Basin during salt remediation work. (Photographer J. Whitehouse.)

Potential and Outlook

There is excellent potential for commercial salt extraction from salt interception schemes in the Murray Basin (or the Murray–Darling drainage basin) (Figure 1). These schemes are designed to ameliorate salinisation of land and water resources by diverting saline groundwater flows, or irrigation effluent, into natural or artificial basins for retention and solar evaporation. Salt extraction makes use of a waste product, extends scheme life, offsets costs, and benefits the local region.

Salt is commercially extracted from groundwater pumped from Murray Basin aquifers near the Mourquong Basin salt remediation scheme in New South Wales (Photograph 18), and at Hattah and Pyramid Hill, Victoria. In these operations, raw salt produced by solar evaporation is excavated by mechanical scrapers for additional processing. Current

production of sodium chloride and magnesium chloride at these localities is about 30 000 tpa. These products are used in applications which include stockfeed; metal recycling; gourmet table salt; swimming pool chlorination; hide curing; food processing; and dust suppression on unsealed roads.

The long-term viability of commercial salt production in the Murray Basin may depend largely on the ability of salt producers to develop and supply products for niche and local markets. Downstream processing to produce a range of valuable chemical products could improve the economic viability of salt extraction from salt disposal basins in the Murray Basin. Potential products include chlorine, hydrochloric acid, sodium hydroxide, soda ash, sodium bicarbonate, magnesium sulphate and magnesium hydroxide. The development of a mineral sands industry of major capacity in the

Murray Basin, and the likely consequent development of processing facilities in the region, may create an additional market for raw materials from salt disposal schemes (see chapter on Mineral Sands).

Nature and Occurrence

Salt (sodium chloride, NaCl) is the most abundant source of sodium and chlorine. Salt occurs in the solid state as the mineral halite. Rock salt consists of 95% to 99% halite, the main impurity being anhydrite (CaSO₄). Pure halite is a completely soluble, soft (H = 2.5), vitreous mineral that is usually colourless or white but may be tinted red, yellow, blue or purple. Salt is an evaporative mineral and therefore occurs in association with other minerals such as gypsum, calcite and dolomite. It also occurs together with clastic sedimentary materials, such as clay or sand.

Deposit Types

Vast amounts of salt occur in solution in the world's oceans, playas or lakes and groundwater. Seawater has an average total salt content of about 3.5%, especially NaCl (2.7%). Salt also occurs as solid deposits in salt lakes, salt beds or layers, and salt domes.

Laterally extensive bedded deposits of salt several hundred metres or more in thickness are found in sedimentary sequences with shale, limestone and other evaporites (Warren 1999). These deposits range in age from Precambrian to Quaternary and occur throughout the world. Bedded rock salt deposits and salt domes, such as those associated with Permian rocks extending from England to Poland, and in various sedimentary basins of the USA, are major sources of salt (Harben & Kužvart 1996). Such types of deposits are, however, not mined in Australia.

Salt can be categorised into four types on the basis of the method of recovery (Kostick 2005).

Evaporated salt (or vacuum pan salt)

A fine-grained, high-purity sodium chloride produced by mechanical evaporation of brine using heat, generally in combination with a vacuum. The most widely used method is boiling saturated brine under a partial vacuum in steam-heated enclosed vessels called vacuum pans.

Solar salt

Solar salt is produced by evaporation of shallow ponds, or natural salt lakes, by sun and wind. Salt water is pumped through a series of concentrating ponds, becoming progressively more saline as the water evaporates. When the brine becomes

saturated it is transferred to crystallisation ponds where salt is deposited as evaporation proceeds. The residual brine is then drained and the salt harvested. The process takes up to five years.

Rock salt

Rock salt is produced by mining, crushing and screening natural salt deposits.

Salt brine (or salt in brine)

Salt brine is natural brine; brine produced from solution mining of rock salt; or, less commonly, from dissolution of solar salt or natural playa lake deposits. It may be used directly as a feedstock for chemical manufacture or processed in an evaporating plant.

Salt has had a profound impact on human history and, though its social influence has to some extent declined, it is still of major industrial and economic importance. There are thousands of uses for salt (Kostick 2005). Chemical industries use salt in huge quantities to manufacture sodium and chlorine products, most importantly chlorine and sodium hydroxide. Salt is also used: to manufacture hydrochloric acid; in metallurgical processing; in plastics manufacture; food processing; and in agriculture.

Global production of salt in 2004 was at a rate of 215 Mt a year (Kostick 2005). The USA and China are the largest producers, accounting for over 70 Mt annually. Salt production by solar evaporation from seawater and saline lakes tends to be the dominant means of salt production in coastal regimes with favourable location and climate. Unsuitable climate and lack of available coastal land restricts solar salt production in some countries.

Main Australian Deposits

Australian salt production is currently about 9 Mt per annum, about one million tonnes of which is consumed domestically (Fetherston 2002). Nearly all production is from seawater, with relatively minor amounts obtained from playa lake deposits and saline groundwater. Western Australia is the major producer, accounting for around 80% of Australian production. South Australia is the source of most of the remainder, with minor amounts produced in Victoria and Queensland.

The Murray Basin, which extends across much of South Australia, New South Wales (Figure 1) and Victoria, has major potential for groundwater-hosted industrial minerals, notably sodium chloride and magnesium chloride. Groundwater quality in the Murray Basin is

quite variable in salinity, ranging from fresh to highly saline with over 300 000 mg/L of salts (Evans & Kellet 1989). Over the past half a million years, large amounts of salt from the Southern Ocean have been transported into the Murray Basin as aerosols and leached into basin-wide shallow groundwater systems (Jones et al. 1994). Surface and subsurface waters of the Murray Basin thus have a pronounced 'marine' composition (Warren 1999). The groundwater stored in the Murray Basin aquifers, however, represents a vast water resource. Evans and Kellet (1989) estimated the total volume of water in storage at 4600 million megalitres, which is some 1500 times the capacity of the Hume Reservoir on the headwaters of the Murray River.

Salt is commercially extracted from groundwater pumped from Murray Basin (Photograph 18) aquifers near the Mourquong Basin salt disposal basin (SunSalt) in New South Wales, and at Hattah (SunSalt) and Pyramid Hill (Geo-Processors Pty Ltd), in Victoria.

New South Wales Occurrences

Coastal New South Wales lacks favourable climatic conditions (low rainfall and high evaporation rates) for the large-scale production of salt from seawater by solar evaporation technology. While playa lake deposits occur in the arid western part of New South Wales, such deposits are relatively small and have little potential for salt production. There are no known occurrences of bedded rock salt or salt domes of commercial potential in the state.

In New South Wales, salt is commercially extracted from the Mourquong Basin salt disposal basin, which is about 10 km northeast of Mildura. There are more than 150 salt disposal basins in the Murray–Darling (Drainage) Basin (Hostetler & Radke 1995), twelve of which are in New South Wales, and it is likely that more will be constructed in the future. Some 40 million cubic metres per year of saline water, representing about one million tonnes of raw salt, are pumped into salt disposal basins in the Murray–Darling (Drainage) Basin annually (Aral & Norgate 2002). These schemes are designed to ameliorate salinisation of land caused by rising water tables and to limit the invasion of salt into rivers and streams. Saline water is pumped or piped into closed basins which may be natural depressions, modified natural depressions or artificial structures, where the water is removed by solar evaporation and/or leakage.

Salt disposal basins thus provide significant opportunities for commercial salt harvesting and some schemes, such as the Sub-Surface Drainage Scheme, near Deniliquin, have been specifically designed

with salt harvesting as an integral component of the process. Other saline detention basins in New South Wales that may have potential for future salt harvesting operations include the Mallee Cliffs Salt Interception Scheme, Rufus River Saline Water Disposal Basins and Fletchers Lake (Hostetler & Radke 1995).

The Mourquong Basin salt disposal scheme involves pumping groundwater from six bores near the Murray River and discharging into a natural lakebed via a single outlet. Saline water is then pumped into nearby evaporation ponds. An estimated 80 000 tonnes of salt has been pumped into the basin annually since 1979, and about two million tonnes of salt has been disposed of so far (Sunraysia Environmental 2001). Development consent was granted in 2002 for commercial salt production from this site to SunSalt, which proposes to produce a total of up to 50 000 tonnes of salts, principally sodium chloride and magnesium chloride, annually.

The Wakool Tullakool Sub-Surface Drainage Scheme, which is about 70 km west of Deniliquin, pumps saline groundwater from beneath an area of 25 000 hectares of irrigated farmland into two artificial basins (referred to as Stages 1 and 2). Each basin consists of a number of rectangular concentrating bays and includes crystallisation ponds for salt production. There has been minor production of salt from Stage 1 by Cheetham Salt since 1984. The quality of the salt produced to date has restricted commercial sales, apart from small quantities of magnesium chloride bitterns sold for use as a dust suppressant. Trial extraction has recently been undertaken from Stage 2 by SunSalt, which is working with Murray Irrigation Ltd to determine the potential for salt extraction in this area.

Applications

Globally, over half of the salt produced is used by chemical industries to manufacture sodium and chlorine chemicals, the most important of which are chlorine and sodium hydroxide (Harben & Kužvart 1996). Salt is used with lime (CaO) in the Solvay process to produce soda ash (Na_2CO_3), an important ingredient of applications, such as glass, pulp and paper, pesticides and dye manufacture. Salt is also used with sulphuric acid in the production of hydrochloric acid and low-grade sodium sulphate. High-value salts, fertilisers and soil additives include the following:

- quality feedstock for manufacture of magnesium metals and alloys
- inorganic fire retardants
- light-weight compounds for the manufacture of plasterboards and other building products

- dust suppressants and stabilisers
 - sealants for reduction of drainage leakage.
- The preservative and colour development and taste properties of salt enable it to be used in food processing, medical applications and the tanning/hide industries (Kostick 2005). Salt is also used as a freezing-point depressant; in metallurgical processing; plastics manufacture; and in agriculture. In the Northern Hemisphere, large quantities of salt are used in ice removal from highways. Salt is used in water treatment to recharge water-softening units to replenish depleted sodium ions, which undergo cationic exchange with magnesium and calcium ions.

Economic Factors

Globally, most salt produced is consumed domestically, principally in chemical industries, though low-cost, large-scale producing countries such as Australia and Mexico export significant amounts large distances. The ability of salt producers in the Murray Basin to compete with low-cost producers, such as those in South Australia and Western Australia that process seawater, may depend on their capacity to satisfy niche and local markets. Downstream processing could produce a range of valuable chemical products and improve the economic viability of salt production from salt disposal basins in the Murray Basin. Additional investigations, however, are needed to determine the extent to which this may be commercially viable. Potential products include chlorine, hydrochloric acid; sodium hydroxide, soda ash and sodium bicarbonate; and magnesium sulphate and magnesium hydroxide.

Major investigations of the industrial mineral potential of Murray Basin groundwater are being conducted by Geo-Processors Pty Ltd and the CSIRO. SAL-PROC™ technology involves the sequential extraction of salt and a range of commercially valuable chemical products from saline effluent (Geo-Processors Pty Ltd 2005). This technology has been the subject of trials to assess its potential for enhancing the operation of salt interception schemes in the Murray–Darling Basin. The SAL-PROC™ process involves multiple stages of evaporation and/or cooling of concentrated saline water supplemented by mineral and chemical processing. Geo-Processors have also developed another process technology called ROSP, which involves using Reverse Osmosis (RO) desalination

and SAL-PROC™ processes for integrated recovery of freshwater, and potentially useful mineral and chemical by-products. The CSIRO is also currently investigating the potential for downstream chemical processing of salt and bitterns from evaporation basins in the Murray–Darling Basin (Aral & Norgate 2002; CSIRO Minerals et al. 2004).

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