SOLAR SALTWORKS - AN ENVIRONMENTALLY FRIENDLY INDUSTRY[1]

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ABSTRACT

The solar evaporation process occurs in solar saltworks - a series of connected ponds through which seawater flows, evaporates, and deposits sodium chloride. In sharp contrast to mined salt, most of the energy required to extract sodium chloride from seawater is without cost. The salt is nearly pure, suitable for industry and humans with little further processing, is non toxic and does not change in transit. The waste products from solar saltworks (bitterns) may be used to produce fertilizers and other products, or they may be retained permanently on the property. The ecological value of the saltworks stems from their shallow ponds whose floors produce highly suitable food for birds, shellfish, and other animals. The ponds and surrounding property owned by the installation provides habitat free from human disturbances for bird nesting and animal homes.

INTRODUCTION

A solar saltworks (salina) is a series of connected concentrating ponds through which seawater flows, evaporates by the power of the sun and wind, and deposits sodium chloride (salt) in crystallizing ponds. After 10 to 15 cm of salt accumulates, the sodium chloride is harvested, washed, and stockpiled for a time. Salt produced by this method is 99.7% pure on a dry basis. Solar saltworks range in size from 500 tons per year to more than 6 million tons annually, and they manufacture about one third of the worldwide salt production (about 70

[1] Text of an invited post-conference contribution presented orally at Pythagorion, Samos, Greece, 2 September 1999.

Bottom mat with many layers serves to seal ponds against leakage and lock away phosphates and itrogen

million tons per year). The seaside location of most salinas allows ready access to seawater and use of relatively inexpensive water transport of the salt. When the saltwork's system of concentrating and crystallizing ponds is properly managed, salt production is environmentally friendly, and the saltworks and the environment are mutually benefited.

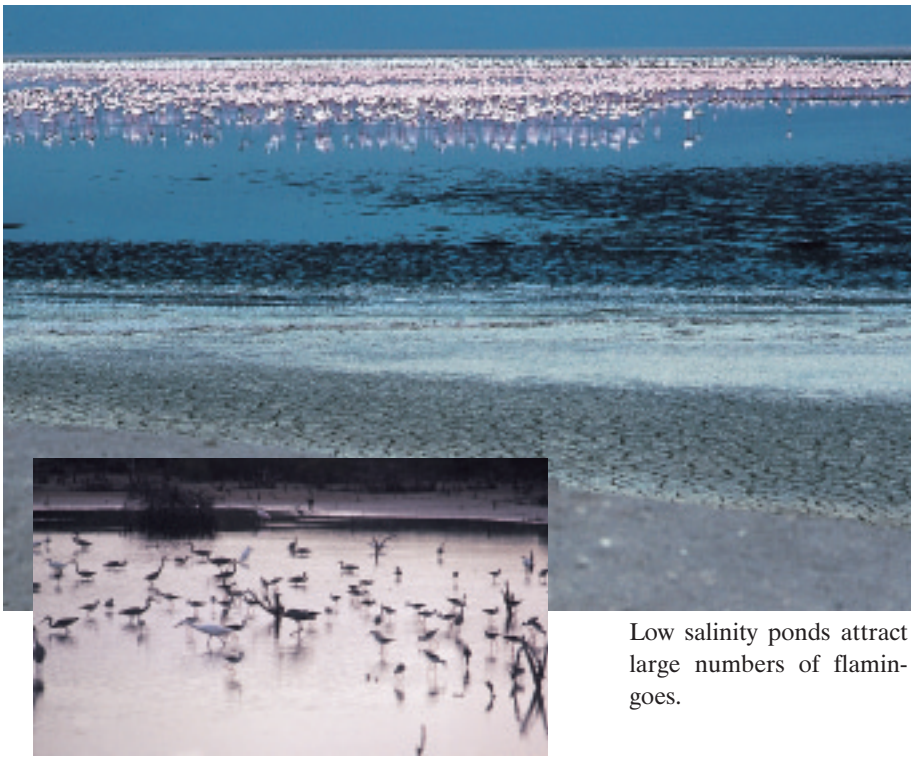
HOW SOLAR SALTWORKS HELP THE ENVIRONMENT

The goal of every solar saltworks - economical and continuous production of high quality[2] salt at design capacity - is highly favorable to the environment. Environment is aided by the physical nature of the ponds, by the proper use of adjacent lands owned by the saltworks, by efforts of saltworks officials to preserve wildlife, appropriate disposal and use of the effluents of the process, and by the highly efficient use of non renewable energy (from petroleum, coal, and gas).

The Pond System. Shallow depths (40 to 70 cm) and carefully maintained salinity gradients throughout the ponds allow development of a variety of environments and growth of many kinds of microorganisms in the water and on pond floors. When located along rocky shores without beaches, saltworks may provide the only environment for aquatic and terrestrial organisms that require shallow water. The microscopic pond life supplies food for flamingoes, stilts, ibis, and other wading and floating birds. Vegetated dikes and islands within large ponds furnish birds with nesting and resting sites, and they also exclude predators, such as jackals, foxes, feral cats, mongooses, and humans.

Adjacent Lands. When fenced off to deny access to humans and domestic animals, the property owned by a saltworks develops and maintains a natural terrestrial ecosystem providing sanctuary for bird nesting and homes for native animals. Sanctuaries for large and small animals have been implemented world-

[2] Most salt crystals are large, clear and solid; contaminants in salt remain within world standards.



Low salinity ponds attract large numbers of flamingoes.

Dawn at a medium salinity pond attracts many species of plankton- and bottom-feeding birds.

wide. In western Australia, special fencing keeps out introduced animals and allows the less aggressive native creatures to flourish. In saltworks near large human populations (e.g., San Diego, San Francisco Bay, Tanggu in China, Bay of Izmir in Turkey), fenced off areas may be one of the very few wildlife sanctuaries of the area. Furthermore, saltworks with beaches not open to humans provide undisturbed areas for sea turtles, seaside plants, fish nurseries, and sea grasses.

Waste Disposal. Many manufacturing processes develop large quantities of wastes, but solar saltworks produce only small amounts of effluent. The only waste product, the bittern (supernatant liquid above the deposited salt in the crystallizers), is less than five percent of the volume of the intake seawater. When the effluents of small saltworks are gradually released at appropriate times, little damage to the environment is evident. Many large solar saltworks never discharge their bitterns into the sea. Instead, the effluents may be placed in special crystallizers to extract the remaining salt, they may remain permanently on the property in deep lagoons, or they may be processed on the site or sold to obtain $MgSO_4$, $MgCl_2$, and K_2SO_4.

Energy Usage. Nearly all the energy required for water evaporation (wind and sunlight) and light energy needed to power the biological system, are free of cost. The fraction of the total energy necessary for salt production derived from

Table 1: Salt manufacture aids the environment by having a low energy input, minimal industrial impact on the environment compared to other land use, providing sanctuary for birds and animals.

Salt Manufacture Aids the Environment

- **Low energy input by humans (fuel, power)**
- Minimal impact on the marine environment
  - Ponds occupying the largest surface area have organisms similar to estuarine biota
- **Impact of waste product (bitterns) is mimimal**
  - – when gradually released
  - – when retained on the saltworkds
  - – when used for extraction of magnesium, potassium, etc.
  - – has medicinal value (thalassiotherapy)
- **Product is**
  - – essential to life
  - – does not change in transit
  - – is non-toxic to environment
- **Sanctuary of wildfife, particularly birds**
  - – food during entire year
  - – free of tide influences
  - – free of hunting pressure
  - – some saltworks construct of install
    - – nestin sites
    - – islands to exclude predators
    - – fencing to exclude introdued animals
    - – pumps to keep water levels from changing

Table 2: Biological products whose harvest aids salt production are also environmentally friendly: fish, oysters, shrimp, brine shrimp, Dunaliella salina.

Biological Products Whose Harvest Aids Salt Production

- **Low Salinity Ponds**
  - Fish
  - Oysters
  - Shrimp
- **Intermediate Salinity Ponds**
  - Artemia
    - Cysts
    - Adults
- **High Salinity Ponds**
  - Dunaliella salina

Solar salt manufacture uses bacteria occurring in nature to improve evaporation, decrease organic substances, and improve salt quality.

HOW THE ENVIRONMENT AIDS SOLAR SALT PRODUCTION

For a solar saltworks to be successful, a biological system favorable to salt production must be established and maintained in the ponds. The environment provides the physical requirements and genetic information for the biological system-water with appropriate nutrients (e.g., combined nitrogen and phosphate), energy from sunlight and wind, and appropriate microorganisms in each community at each salinity level.

Microorganisms (e.g., algae, bacteria, copepods, molluscs, worms) develop into biological systems favorable to both salt production and bird life. Microorganisms suspended in the water (planktonic communities) aid salt production by coloring the water to improve solar energy absorption and water evaporation, and by creating and maintaining appropriate quantities of organic substances that power the entire biological system at a desired condition. Microorganisms living on pond floors (benthic communities) seal ponds against water leakage and infiltration, permanently remove important quantities of combined nitrogen and phosphate from the overlying water, remain permanently attached to pond floors, and maintain desired thicknesses in all ponds. A biological system maintained at a desired condition allows economic and continuous production of high quality salt at design capacity.

Most nutrients required by communities in the ponds of a solar saltworks are abundant in the intake seawater. However, combined nitrogen and phosphate can be present in quantities insufficient to establish and maintain communities favorable to salt production, or these nutrients may be present in excessive concentrations. In ponds with inadequate nutrients, floating and wading birds of several species may provide combined sufficient nitrogen and phosphate for community development and maintenance. Microorganisms that furnish combined nitrogen (species of nitrogen-fixing bacteria and blue-green algae) make the use of artificial fertilizers unnecessary to establish favorable biological systems. In ponds with excessive concentrations of combined nitrogen and phosphate, shallow areas through which the intake water flows before entering the salina, and appropriate water depths can aid nutrient-sequestering by the benthic communities.

The Environment Aids Salt Manufacture

– Provides cost-free energy for water evaporation

– Allows development of biological systems essential to salt production

– An array of appropriate organisms at each salinity range provides
- Light for photosynthesis
- Nutrients
  - dissolved in the intake water
  - from birds
  - from nitrogen-fixing microorganisms

Harvest of biological products can remove important quantities of combined nitrogen and phosphate. These products include medicinal muds for skin diseases (black sediments in saltworks of the Dead Sea and Balkan States); food for human consumption, e.g. fish (Izmir), brine shrimp (San Francisco Bay), pinaeid shrimp (China), and shellfish (Australia, Namibia), and chemicals (beta carotene, glycerol) from Dunaliella salina. When compared to the usual methods of obtaining these products, harvest from saltworks constitutes a large saving of energy and provides extra monetary income to the slatworks.

Tourists may be valuable for extra income and public relations. Officials of some saltworks regularly conduct groups of tourists around their ponds, adjacent property, and processing facilities. Emphasis on ecologically friendly interaction of nature and industry, habitat conservation for native animals, conservation of natural resources and energy, and historical aspects of the salt-producing process invariably results in improved public relations.

Many people use concentrated brine and black muds from high salinity ponds to soothe skin diseases.

REFERENCES

Baas-Becking, L.G.M. 1931. Historical notes on salt and salt manufacture. Scientific Monthly, 1931.

Baha Al-Deen, B. and A.H. Baha Al-Deen. 1972. Posible effecto de microalgas en la forma de cristalizacion del cloruro de sodio en la salina de Araya, *Bol. Inst. Oceanogr. Univ. Oriente* 11:35-38.

Davis, J.S. 1993. Biological management for problem solving and biological concepts for a new generation of solar saltworks. Seventh Symposium on Salt 1:611-616.

Krumbein, W.E. 1985. Applied and economic aspects of Sabkha systems-genesis of salt and hydrocarbon deposits and biotechnology. In: *Hypersaline Ecosystems the Gavish Sabkha,* G.M. Friedman and W.E. Krumbein, eds., Springer-Verlag, Berlin, pp. 426-436.

Perthuisot, J.P. 1982. Introduction generale a l'etude des marais salants de Salin-de-Giraud (Sud de la France): la cadre geographique et le milieu, *Geol. Mediterr.* 9:309-327. [The reader is referred to the entire group of papers in Number 4 of Volume 9.]

Petanidou, T. 1977. Salt in European History and Civilisation, Hellenic Saltworks S.A., Athens.

Tressler, D.K. 1923. Marine Products of Commerce, Reinhold Publishing Corp., New York.

Tressler, D.K. and J.M. Lemon. 1951. Marine Products of Commerce, Reinhold Publishing Corp., New York.