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# Brine Movement Management: SEASALT Software

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ABSTRACT

Control of brine circulation in a saltworks makes it necessary to take into account numerous parameters such as climatology, salt characteristics (physical and chemical composition) and topography. Simulations of brine movements are conducted using specific formulae (Riveau–Lambert formulae). The formulae are based on saltworks theory, but also take into account the quality of the soil (infiltration), actual working thicknesses, water catchment area surfaces and the quality of the brines pumped from the sea. These parameters are determined scientifically. The computerized management model has also been tested, by comparing a theoretical situation to a real situation. Experience has shown that the two situations are comparable. These simulations take a great deal of time, and it is necessary to react quickly.

A computer programme has been developed which operates on a PC. This programme provides, on the basis of a given brine situation of a salt marsh, day-to-day management, while enabling simulations to be conducted when exceptional events occur — e.g. a sudden meteorological change. The various possibilities of this software package are mainly used for saltworks operating discontinuously, i.e. those which are inactive in winter. The computerized system enables analysis of all the possibilities for brine movements, and selection of the optimal movement.

For saltworks operating continuously, the programme has another practical use, i.e. the automatic formatting of an evaluation of the evaporating ponds. This evaluation makes it possible to compute such operating parameters as practical evaporation coefficient and mean infiltration coefficient. Other parameters are printed as well, e.g. the daily operational condition of the evaporating ponds, with the references for normal operation. This facilitates checking of brine flow regulation.

## INTRODUCTION

The use of PC technology is particularly suited to the management of brine movements in saltworks — especially the particularly complex management of saltworks whose production is seasonal. For example, the management of the Salin de Giraud saltworks, which produces an average of 1,000,000 tonnes of salt annually in the south of France, involves entering into the database every day the levels and concentrations of the 87 ponds representing the whole area of the concentration ponds. During the salt-producing season, it also involves the levels and concentrations of 70 crystallizers.

In order to process such a volume of data, the personnel responsible for brine movement management have a tool — the SEASALT software package — which enables them to simulate certain situations and to make the right decisions in both everyday management and strategic planning.

## COLLECTION AND ARCHIVING OF DATA

After his rounds, each aygadier* enters into the computer system the brine density and pond level for each pond. For each pump, he also records the number of hours of operation corresponding to a known unit flow, and the various brine movements effected by the pump.

Meteorological data are then entered. These concern the daily evaporation recorded by three evaporimeters and any rainfall recorded by 11 pluviometers. The area of the saltworks is over 10,000 hectares, and rainfall occurs in storm conditions, sometimes very locally. This is why it is necessary to record rainfall on a number of pluviometers distributed over the saltworks.

It should be noted that the first data in the climatological database goes back to 1888.

Brine densities are automatically translated into NaCl concentrations expressed in grams per litre.

* Person responsible for carrying out the manoeuvres which allow brine movement in a salt marsh.

TABLE 1

North area: Initial evaporating ponds. Level and density — 4 September 1991

| Number | Evaporating pond | Level | Density | Day's level / Theoretical level during salt-producing period | Day's density / theoretical density during salt-producing period |
|---|---|---|---|---|---|
| 1 | Val Agricola | 76 | 1.026 | * | d |
| 2 | Galabert 0 | 88 | 1.031 | * | d |
| 3 | Galabert 1 | 77 | 1.030 | * | d |
| 4 | Galabert 2 | 44 | 1.039 | * | d |
| 5 | Galabert 3 | 85 | 1.048 | * | d |
| 6 | Enfore Vignole | 85 | 1.050 | * | d |
| 7 | Pebre | 75 | 1.063 | * | d |
| 8 | Briscon | 66 | 1.104 | * | d |
| 9 | Fangassier 1 | 39 | 1.088 | * | d |
| 10 | Fangassier 2 | 68 | 1.086 | * | d |
| 11 | Vaisseau 1 | 50 | 1.050 | * | d |
| 12 | Vaisseau 2 | 39 | 1.040 | * | d |
| 13 | Quarantaine 1 | 78 | 1.052 | * | d |
| 14 | Quarantaine 2 | 67 | 1.056 | * | d |
| 15 | Vx Rhone Nord | 38 | 1.052 | * | d |
| 16 | Mont d'Arnaud | 88 | 1.056 | * | d |
| 17 | Pourtour 1 | 76 | 1.059 | * | d |
| 18 | Pourtour 2 | 64 | 1.066 | * | d |
| 19 | Quarantaine 3 | 62 | 1.070 | * | d |
| 20 | Rascaillan | 40 | 1.097 | * | d |

Level measurements are expressed in relation to point zero, NGF standard.

This programme for entering daily meteorological conditions is structured so that data from a fully automated weather station can be integrated automatically. The reading can be made through a French MINITEL and VIDEOTEXTE system. Moreover, the system will in the near future be connected to the central pumping control station which monitors the operation of the pumps on the basis of meteorological data.

All of this data is stored on a personal computer with the following characteristics: 1 Mb, on-line, DOS; 4 Mb hard disk; 1 conventional printer.

## AUTOMATIC USE OF DATA

### Daily management

Management of brine movements involves two main categories of programmes: one of which concerns evaporating ponds and the other crystallizers.

*The evaporating ponds*

The role of the evaporating ponds is to supply the crystallizers with the saturated brine, according to requirements. The operating characteristics of these ponds are given by the Riveau–Lambert computation formula. They concern the operating levels and concentrations of each evaporating pond.

Once data for all ponds have been recorded the programme gives the profile of saltworks' operation, characterized by the distribution of brine volumes in accordance with densities.

The evaporating ponds operating profile is characterized by the superimposition of day's deposity and day's level on the theoretical vertical straight lines, represented in Table 1. For the months during the salt-producing period when the saltworks operate normally, the level (*) and density (d) of the evaporating pond are most closely situated on these two vertical references (see Table 1). From this table, which shows the situation on 4th September 1991, it can be seen that the levels of the 20 ponds shown are lower than the average levels for normal operation and the densities are above the average densities for normal operation; the table displays the decision taken to lower the water surface in preparation for the winter movements.

SEASALT also computes, in relation to the previous day's situation, all the volumes of brines

moved, in terms of both quantity and quality. The values are to be compared to the "PUMP" programme, which gives the operating reading for each pumping station as well as the different movements effected (Table 2).

These two programmes also make it possible to estimate the volume of brine infiltrated into the saltworks, as well as the volume of water evaporated.

*The salt-depositing surfaces*

During the salt-producing period from April to September, the readings from the 70 crystallizers are recorded each day (Table 3). Each reading includes the thickness of the brine cover as well as density. Each day, SEASALT computes the weight of the salt deposited, the magnesium (Mg) content of the covering brine, as well as the average production of each crystallizer.

**Short-term management (1 week to 1 month)**

From the daily readings, the programme effects weekly and monthly evaluations of the evaporating ponds. For a defined operating period, the evaluations calculate the principal parameters of both the evaporating ponds and the crystallizers. Thus, SEASALT evaluates the circulation and operating performances of brine movements.

Each week during the production period and each month during winter, the model calculates, by pond sector and for all of the evaporating ponds:

– the mean infiltration coefficient,
– the mean evaporation coefficient,
– the useful evaporation coefficient,

taking into account the infiltration losses recorded.

For salt-producing surfaces, it computes the quantities of brine necessary for depositing a tonne of salt, along with the NaCl and Mg content of the brines contained in the crystallizers.

TABLE 2

Daily pumping journal on evaporating ponds. Central area — 4 September 1991

| Name of pump | Hours | Density | Movement |
|---|---|---|---|
| Pavias | 2.5 | 1.040 | Normal |
| Car. Mer 1 | 6.0 | 1.024 | Discharge of brine to the sea |
| Car. Mer 2 | 2.0 | 1.024 | Dicharge of brine to the sea |
| Etoile 1 | 8.0 | 1.057 | Backward |
| Etoile 2 | 0.0 | 0.0 | |
| Etoile 3 | 0.0 | 0.0 | |
| Jeu de Mail | 15.0 | 1.080 | Normal |
| Grau d'Enfer 1 | 0.0 | 0.0 | |
| Grau d'Enfer 2 | 24.0 | 1.170 | Normal |
| St. Genest | 0.0 | 0.0 | |
| Carrefour A | 0.0 | 0.0 | |
| Carrefour B | 0.0 | 0.0 | |
| Carrefour C | 0.0 | 0.0 | |

SEASALT is a tool for the management of saltworks. The model makes it possible to simulate brine evolution based on the variations of different factors such as, for example, rainfall and sea pumping. Thus, at all times, the decision-maker is able to judge the timeliness of brine movement in accordance with different hypotheses.

**Long-term management — management policy**

The "EVI" software package enables the evolution of levels and concentrations for each pond over a period of several months to be visualized. This makes it possible to detect operating anomalies in

TABLE 3

Crystallizers. Sector: Mas des Crottes. Feedings by gravity — 9 July 1991

| | | | | |
|---|---|---|---|---|
| ↓ | ↓ | Å | Å | Å |
| t = 23.0 | t = 14.0 | t = 26.0 | t = 15.0 | t = 20.5 |
| d = 1.217 | d = 1.221 | d = 1.220 | d = 1.219 | d = 1.219 |
| ↓ | Å | Å | Å | Å |
| t = 21.0 | t = 14.0 | t = 18.5 | t = 14.0 | t = 19.0 |
| d = 1.223 | d = 1.225 | d = 1.224 | d = 1.223 | d = 1.224 |
| ↓ | Å | Å | Å | Å |
| t = 22.5 | t = 16.0 | t = 13.0 | t = 16.5 | t = 21.5 |
| d = 1.233 | d = 1.261 | d = 1.231 | d = 1.229 | d = 1.230 |
| ↓ | Å | Å | Å | Å |
| t = 11.5 | t = 13.0 | t = 13.5 | t = 16.0 | t = 11.0 |
| d = 1.255 | d = 1.245 | d = 1.242 | d = 1.240 | d = 1.255 |

t = brine thickness (cm); d = density.

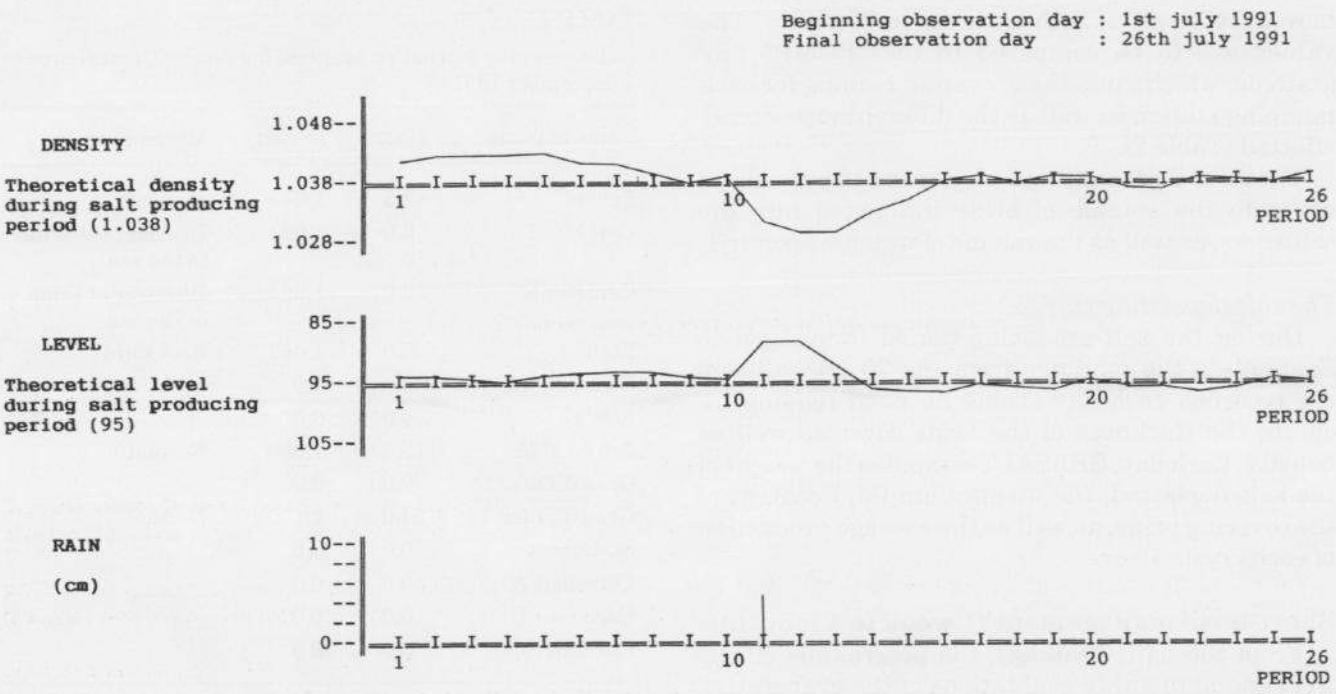


Fig. 1. Evaporating pond Galabert 2.

the ponds. In particular, it is possible to identify the ponds where infiltrations are unusually high, where intake or evacuation is too irregular, where there is a large water catchment area, or where there is significant inclination of the water surface due to wind.

Figure 1 shows the evolution of the Galabert 2 Pond between 1st and 26th July 1991 (one division corresponds to one day). The upper graph gives the evolution of density, and the lower graph the evolution of NGF level of the pond. Rainfall levels are shown at the bottom. The effect of the rainfall on 11th July 1991 can clearly be seen, i.e. decreased concentration and increased level.

## CONCLUSIONS

The computer programme SEASALT is a tool for the management of saltworks. It provides invaluable assistance to saltworks personnel, especially where climatological factors impose a wintering phase.

SEASALT also provides assistance in taking decisions, especially during storm-prone periods.

Used in saltworks in the south of France — the Salin de Giraud saltworks in particular — SEASALT is designed in such a way as to be easily transferrable to other saltworks, even those where work is carried out under other specific conditions.

## ACKNOWLEDGEMENT

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