Evolution of Harvesting Methods and Mechanization in Small Saltworks

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ABSTRACT

Harvesting solar saltworks is carried out in several different stages. A number of mechanical approaches developed by producers are described which have been used depending on the historical evolution of the systems and local conditions. In modern times, several systems have been employed which involve high-power machines. These were especially studied with respect to the enlargement of saltworks. On the other hand, solutions are being sought which are adaptable to small units where one can work with light machinery with polivalent characteristics. These are important in making small saltworks competitive, especially in countries where there are only scattered areas available for such works. The modernization of traditional saltworks is favored because their adaptation to modern techniques of harvesting requires only simple changes in the layout and low investment. Experience gathered in making these changes is described from southern Portugal where 100.000 tons per year is being produced from 30 separate units.

INTRODUCTION

The evaporation of brines by action of the solar energy is a very old process to produce salt. Many human communities created methods to solve the problems brought about by this type of production. From the solutions found, there developed saltworks with diverse outlines and varied procedures, according to the different ecological conditions.

When the primitive salt workers realized that it was practical to distribute their brines on thin sheets, they verified that the salt thus obtained formed a fragile layer unable, in these conditions, to withstand the effects of weather. This reason led to the operation known as harvesting, which consists of removing the crystals from the local of their precipitation, to piles of an adequate size to be preserved and stored. The salters soon verified that this operation was one of the most significant in the productive process. Later on, they would learn it was the hardest and the most expensive one.

The salt workers of past centuries had at their disposal just their bare arms and the plain implements they could grasp. Only much later would the industrial revolution reach the salt ponds by the introduction of mechanical procedures, able to perform the operations with a minimum of human effort.

When the salt workers were compelled to walk barefooted on salt, to drag it with their simple rakes, to carry it on their shoulders to the storing piles, then, small salt ponds were convenient, because the work was easier and relatively less tiring. With the introduction of machinery, these limitations disappeared and salt pans became bigger and bigger and finally reached huge sizes.

These were the main features of the technical evolution of this industry. However, harvesting still holds an important position because a great percentage of the expenses are incurred during its completion.

STAGES OF HARVESTING

Whether the method chosen is manual or mechanical, the following stages may be observed, although with a variable sequence, in conventional salterns. 1) Residual brines are drained, 2) the salt layer is extracted, broken up and separated from the bottom, and 3) elevated. The salt is then 4) first removed (lateralization), 5) loaded on containers or

vehicles, 6) moved again or transported to 7) washing, 8) moved again and 9) finally piled. Each of these steps is described in this paper.

Residual brine drainage. This initial stage of harvesting consists in draining the ponds by opening the sluices and tracing furrows on the salt layer. This procedure was unknown in some of the primitive technologies. In other traditional schemes, the residual brines were kept in the reservoirs, allowing, during the raking, a kind of salt washing, which partially eliminates the insoluble impurities.

The residual brines drainage is followed by drip drying carried out during the several operations, removals and finally in the pile.

Salt layer preparation. This is the most characteristic stage of the harvesting. The salt cannot be removed from the local where it was precipitated, unless the respective layer is broken up and the resulting portions separated from the subjacent bottom.

When these two operations are carried out by the same implement or part of machine, in the same movement, it is difficult to distinguish one from the other. There are, however, methods where they are independent.

Breaking the salt layer. This process aims to divide the salt layer in portions of adequate size to be removed. In modern methods, where a harvesting machine is utilized, portions are cut with the width of the attacking blade. The harvesting is made by parallel stripes. In manual methods, the bands had the same width as the tools employed. The dragging harvesting methods require a fractioning using a harrow or an adapted rotary cultivator.

Separation from the bottom. This operation is carried out by an attacking blade. The applied force is the result of two components, a horizontal one, causing a dragging of the salt and a vertical one, which causes its separation from the bottom, lifting it.

In manual methods, when the salt layer is shoveled, the horizontal component is minimized, the main component is lift. On the contrary, when the rake is used, it is the vertical component that is minimized and the horizontal dragging emphasized.

In mechanical methods, both applied, the first is most employed. The attacking blade and conveyors of the harvesting machine perform a lifting and loading caused by the shovel movement. However, other types of mechanical solutions originated from the dragging method are based on the rake action.

After being broken up and separated from the bottom, the salt is carried to the piling place. Theoretically, this movement takes three steps.

First removal or "lateralization". This phase takes place in the crystallizer, between the precipitation place and the border of the pond—this is what we call lateralization.

This operation may be carried out by dragging or by the utilization of containers (baskets, hampers, basins, buckets), vehicles (trailers, trucks, lorries, dumpers) or belt conveyors.

When containers or vehicles are used, this first removal is immediately followed by the second. The salt, then, is carried directly from the extraction place to the pile, or washing machine. In other cases, the salt is dragged or raked to the borders of the pans, accumulated there and stays there some time.

Loading of containers or vehicles. In traditional methods, hand or head carried containers were loaded with special implements. In other methods, transportable containers were carried on donkeyback or in vehicles pulled by animals.

At one time, small wagons, spade filled, were used a lot. This technique, however, was almost abandoned. Now several mechanical methods are used to load the vehicles, such as conveyor belts, mechanical paddles and helicoidal screws. The loading of containers or vehicles is made in the crystallizer or on its border, whether or not there has been previous lateral dragging.

Second removal or transport and washing. In this stage, salt is carried from the borders to the washing machine. If there is none, it ends at the piling location. The containers and the vehicles in which this phase is carried out are the same as used in the first removal.

Washing as a technological innovation, is rather recent and was unknown in the primitive saltworks. It seeks a better quality of the product.

Third removal and piling. After being washed, salt is carried to the pile, generally by conveying belts. Stacking the salt is the purpose of harvesting and its last stage.

In manual methods, the containers were emptied in a systematic order, as to form a pile of adequate size. In mechanical methods, most arrangements are based on conveying belts. In big units, these are a remarkable equipment.

GENERAL FEATURES OF SEVERAL METHODS

The methods of harvesting utilized in the conventional saltworks, are divided by the type of equipment and the importance of the physical work, into 1) manual, 2) with animal traction, 3) semi-mechanized and 4) mechanized.

Manual methods. These correspond to traditional schemes, some of them from great antiquity, with a considerable historical, artistical and ethnographical value.

The equipment is limited to plain tools made mostly from vegetable (wood, fiber, etc.) materials. Each traditional salt region had, usually, its own procedure.

Methods with animal traction. There are few instances in which animals were adapted to the work in salterns.

Some Andalusian saltworks, on the borders of the Guadalquivir River, represent a typical case in which the transport of salt to the pile still is made in saddlebags on don-

keyback. In the Cadiz saltworks, the same animals pull wagons in which the salt is transported.

Semi-mechanized methods. The term is applied to those cases in which mechanical transporting equipment was introduced in saltworks, but not to break up the salt layer.

The first decisive step to semi-mechanize the salterns has been the small wagon of the "decauville" system which for many years solved the problem of moving salt to the pile.

Mechanized methods. The mechanized solutions utilized more frequently may be grouped in the following types: 1) dragging, and 2) lifting where the harvesting machine is coupled to the lateralization system, and 3) lifting with an autonomous harvesting machine. This latter case may involve accumulation on crystallizer borders, or no accumulation on crystallizer borders (conventional method).

The lifting methods, based on a blade which attacks the salt layer, breaks it up, lifts and puts it in a transport unit, are the most reported and proved to be adaptable to saltworks of bigger sizes.

When the harvesting machine is coupled to the lateralization system, the attacking blade belongs to a mechanical set, provided with a conveyor, which moves the salt out.

In other methods, the attacking set is independent from the lateralizer. Together they constitute the harvesting machine, now very widely used. Generally, these machines work with transporting vehicles which move themselves at their side. In other cases, the harvesting machines deliver the salt to conveyors which temporarily put it in small heaps on the borders of the crystallizers.

All lifting methods have been proven in big units. However, their adaptation to small saltworks has been not so easy, due to the type of equipment required and its relatively high cost.

The dragging methods are solutions specially adaptable to small saltworks and to those where the bottoms have low traffic possibilities.

They consist in lateralizing the salt, employing a drag set pulled by a cable run by a winch on the pond border. The drag set may be provided with a motor, which operates the rear movement to the crystallizer interior. In apparatus of smaller sizes, this rear movement is manual.

Small producers are availing themselves of these methods to compete with big salterns.

SMALL SALTWORKS MECHANIZATION. PORTUGUESE EXPERIENCE.

Precedents. Portugal is a country of a long saline tradition. Salt exports about 1920 exceeded 100,000 tons a year.

The Portuguese salt workers did not begin a timely modernization of their salterns until very late, they remained thoroughly faithful to manual processes.

The soils are not favorable for the concentration of the small saltworks. These are spread alongside estuaries, in (very clayish) fluviomarine alluvial soils, cut by small streams and, sometimes, forming islets. In these conditions, the sizes of saltworks have to be reduced, although, when this is feasible, tentatives of concentration may appear.

Up to recent times, the production of the biggest saltwork in the country, in favorable years was over 10,000 tons. There were 1,200 salterns all together producing 300,000 tons, or an average production per unit of 250 tons. Almost 51% of the salterns were unable to produce more than 250 tons and 93% never exceeded 500 tons.

Only in the last 10 years, have the salt workers realized the necessity of the technical evolution and mechanization of their plants. However, they had to find a suitable way to solve deficient ecological conditions, depending on the salt ponds dimensions and to their economical possibilities.

At this stage of evolution, the dragging harvesting methods proved to be efficient, for they are adaptable to the extant conditions and required just slight modifications of the layout of the crystallization surface.

Dragging methods. In Portugal there are operating 30 plants, with an annual total of about 100,000 tons, working with dragging systems. These are in addition to a saltern (9,000 tons/year) employing the conventional method and another one, at the starting point (25,000 tons/year).

The typical system has the following steps. The surface is broken by a harrow coupled to an agricultural tractor, moving itself on the salt layer; a drag set pulled by a tractor placed on the crystallizer border moves the salt to the side. Transport vehicles are loaded with a retroescavator and pulled on trailers attached to farming tractors. The salt is piled by conveyor belt.

This system allows variations in size and characteristics of the salterns. In breaking up the surface other tools are also utilized, such as hoes (manual method), harrow pulled by winches and rotary cultivators with special teeth, moving on the salt layer.

Lateralization and loading. The basic systems of dragging utilizes either a metallic plate or a kind of bucket. The latter is not yet widespread in Portugal. The dragging plates have several shapes and are made from different materials. The most common sizes are 2.30 × 0.50 meters.

Besides the system which uses a retroescavator bucket, a helicoidal screw and conveyor belt are also used.

To load vehicles with salt heaped on borders, the helicoidal screw and small conveyor belts are employed. These are fed, when necessary, with shovel operators. This last system can be used only in small salt pans.

The quickest method is when the heaping of salt on borders is eliminated and the salt is directly dragged up to a platform, where a conveyor belt, with a horseneck form, immediately loads the transporting vehicle.

Transport and piling. Removal can be achieved by dump trucks of various types, such as tractor trailers, lorries

and dumpers. Piling usually is carried out by conveyor belts, with reception hopper.

The timing and the number of required operators for each of these stages, including some variants, are shown in Table 1.

General characteristics of dragging systems. The dragging-harvesting methods have the following favorable characteristics: 1) relatively moderate investments and labor costs, 2) satisfactory output for investment, 3) suitability to small and medium size salterns, 4) utilization of equipment, most of it polivalent, easily found in the market, which may be employed in other operations, in/or outside the plant, 5) adaptation to low traffic bearing bottoms, 6) easy adaptation of the salt workers because the methods are similar to the manual ones, 7) reduced requirements to alter the traditional salt ponds layouts.

One-man saltworks. In Figueira da Foz salt region one finds a curious case of small unit mechanization. There one sees the smallest salterns at work where a total of 210 salt ponds produce 25,000 tons/year, with an average individual production of about 120 tons. These small units were worked part-time by small farmers using manual methods. Now however, there is a lack of hands for that activity.

Remembering that salt is produced in crystallizers of very small sizes (usually 12 m × 3.5 m) with weekly harvestings, the possibility of mechanical extraction has not yet been contemplated. In this case, provided transport mechanization were available, the manual method of extraction seems liable to be kept a few more years.

At this scope, there is already under way a system utilizing dumpers of 800 kg (either of solely own property or in cooperative regime) which assures the transport. One dumper may carry out the work on four saltworks a day.

Another system is being adopted which uses a kind of special "palettes" that are placed on the borders, to which salt is manually dragged with a rake. A small "porte-palettes" will gather them and will transport the salt to warehouses.

In a cooperative regime one "porte-palettes" may serve 6 saltworks. With this equipment it is believed that a salt worker may operate all the work of one of these mini-salt ponds alone.

CONCLUSIONS

In the agriculture, mechanization began with big units. At the present time, with the increasing expanse of small machinery and new methods, it also reaches small farms, horticulture and gardening.

There is a parallel evolution under way in salt ponds. New methods, more suitable to small units are sought which may allow them to survive and compete with bigger ones. The aim of technological methods suitable to small saltworks still has to be considered in an experimental phase. New adaptable solutions are foreseen.

In the transition stage from manual to mechanized methods, the dragging systems have revealed themselves practical. They already have prevented the closing of some saltworks.

The Portuguese experience shows that such methods may become more general in countries undergoing development.

TABLE 1

Performance Characteristics

System	Number of Operators	Daily Performances (Day = 8 Working Hrs.)
Fractionation (breaking of salt layer) (15 cm thick layer)		
Manual	1	25–30 tons
Harrow (winch run)	2	0,5 ha
Coupled harrow to tractor	1	3–4 ha
Lateralization (movement to edge)		
Dragging plate	3	80 tons
Loading		
Retroescavator (136 l bucket)	1	180 tons
Helicoidal screw	2	25–30 tons
Conveyor belt	2	70–80 tons
Piling		
Conveyor belt	3	200 tons