HOW TO MAKE SALT

FROM SEA-WATER.

BY

PROFESSOR JOHN LECONTE.

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GOVERNOR AND COUNCIL OF SOUTH CAROLINA.

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MANUFACTURE OF SALT FROM SEA-WATER.

FIRST METHOD.

BY THE SPONTANEOUS EVAPORATION OF SEA-WATER IN LARGE SHALLOW BASINS, CALLED "SALT GARDENS," OR "SALINES."

The process is simple, and requires but little apparatus of any kind. The first condition for the establishment of a "saline" is a low, broad, level ground on the border of the sea, bay, or inlet, which can be protected by dykes or dams from the action of the tides. A shallow *artificial pond*, or *reservoir*, is made near the sea, and, if possible, *below* the level of high tides: so that it may receive water from the sea at high tides, by means of flood-gates. When, however, it is *above* the sea-level, the water may be elevated by means of hydraulic machines. The bottom of the *pond* or *reservoir* must be laid out perfectly *even*, the soil must be *clayey*, to retain the water, and should be beaten hard and smooth. Its outline may be irregular, and its depth should be from three to six feet. Of course its size must depend on the extent of the "saline" which is to be established. In this reservoir the sea-water deposits its sediments, becomes warmed by the sun's rays, and begins to evaporate.

From this reservoir the partially concentrated brine is led by a canal to a series of "rectangular basins," No. 1, from ten to sixteen inches in depth. These "basins" are divided into a series of compartments, by means of little cross banks, through which the brine flows successively, in a slow current, which can be regulated at pleasure. These "basins" should be carefully prepared like the "reservoir," so as to retain water. Here, by the action of the sun and wind, the water is rapidly evaporated, and deposits a portion of its *lime*, in the form of sulphate. When the concentrated brine marks 15° to 18° of Baumé's hydrometer, it deposits a considerable quantity of sulphate of lime; and when it marks 25°, the *whole* of the lime is deposited.

From "basins" No. 1 the brine passes, in like manner, to another series of similar "rectangular basins," No. 2, larger and more shallow, but more carefully constructed. In these "basins," No. 2, the remainder of the sulphate of lime is deposited, and the evaporation is carried to such a point that the water becomes a *saturated brine* by the time it reaches the *lower* side of them. At this period the volume of the concentrated brine is greatly diminished, and, marking 25° of Baumé's hydrometer, is ready to be transferred to the "salting tables."

From "basins" No. 2 the concentrated brine passes, in like manner, to a *third* and *last* series of similar "rectangular basins," No. 3, called "*salting tables.*" These are smaller and shallower "basins," carefully constructed, and divided into compartments communicating with each other, and the layer of water should not be more than three inches in depth. The point at which the brine has reached a sufficient degree of concentration to be introduced into the "salting tables," is sometimes judged of by the water becoming RED, but the hydrometer is, perhaps, a more reliable indicator—it should mark 25° of Baumé. In the "salting tables" the brine soon begins to deposit salt, in the form of crystalline crusts, which are either collected with rakes as soon as they form, or allowed to accumulate at the bottom, until they form masses of several inches in thickness. The brine on the "tables" is renewed daily, or every two days, according to the evaporation; whilst the "reservoir," as well as "basins" No. 1 and No. 2, are constantly supplied with fresh brine. The concentration of the brines in the "salting tables" must be carefully watched, and their density never allowed to *exceed* 28½° of Baumé's hydrometer, otherwise a deposit of sulphate of magnesia (Epsom salts) would be formed, rendering the salt impure. The *mother-liquors*, as they are called, are run off as soon as they have reached the above density: it is usually necessary to draw them off three or four times during the season. When the salt has attained a sufficient thickness, it is broken up and piled upon the sides of the "tables" in large pyramids, which are covered with clay. In these heaps the salt undergoes a process of *purification*—the moisture from the clay, or from occasional rains, penetrates slowly through the mass, removing the more soluble foreign matters, and leaving the salt much purer than before. If the salt in these heaps is too much soiled to be sent into market, it requires a process of *refining*. For this purpose *two* methods are employed; the *one* consists in simply *washing* the crude salt with a concentrated brine, which removes the foreign salts, and a large portion of the earthy impurities. The *other*, more perfect, but more *costly* process, consists in dissolving the impure salt in water, and adding a little lime to precipitate the salts of magnesia, always present, after which the filtered brine is slowly evaporated, to obtain the large-grained salt used for salting provisions. When the "salines" yield the *coarsely crystalline "bay-salt," there is no need of these refining processes.*

At some of the French "salines" the concentration of the brines is carried as far as 32° of Baumé's hydrometer, and the *salt separated into three* *qualities.* Between 25° and 26° of Baumé, the brine deposits 25 per cent. of the salt extracted, which is kept apart, on account of its great purity, and sold at a higher price than the rest. In passing from a density of 26° to 28½° of Baumé, 60 per cent. more of salt of second quality is deposited, and from this point to 32° the remaining 15 per cent. is obtained, somewhat impure and deliquescent, from the magnesian salts which it contains, but preferred for the salting of fish, on account of its tendency to keep them moist.

The "salines" are usually cultivated from March to September, so that the process is suspended during a large part of the year. But the French have recently introduced improvements, by which the works are carried on throughout the whole year, with an increase of the produce by about 50 per cent. During the months of autumn the evaporation is still carried on, though more slowly, and brine is furnished marking from 10° to 20° of Baumé. This is stored away in pits or large wells, where the diluting effect of the winter and spring rains is but little felt, and at the commencement of the warm season this brine is elevated into the evaporating "basins," so that the summer's labors are commenced with *concentrated brine*, and the salt is all harvested in the months of August and September.

The foregoing method, when conducted on a large scale, constitutes the most *economical* means of making salt from sea-water. But the nature of our climate offers serious obstacles to the manufacture of salt by this process: *first*, on account of the large quantity of rain which falls; and *secondly*, from the great *uncertainty* of having *dry weather* after mid-summer, which is necessary during the deposition of salt on the "salting tables." In the moist and rainy climate of Venice these difficulties are in a measure overcome, by so arranging the "salting tables" that in case of heavy rains the concentrated brines are rapidly run off into deep reservoirs or large wells, from which they are again elevated when the weather becomes fine.

The marsh lands, provided they have an *underlying stratum of clay*, might be prepared for extensive "salines." In using sea-water of full strength, the proportionate area of the several evaporating "basins" may be as follows:

Area of reservoir, ⅓ of total evaporating surfaces.
Basins No. 1, ⅙ of total evaporating surfaces.
Basins No. 2, ⅓ of total evaporating surfaces.
Basins No. 3, ⅙ of total evaporating surfaces.

When the water used is *one-half* the strength of that in the open ocean, the area of basins No. 3, the "salting tables," need not be more than *one-tenth* of the aggregate evaporating surfaces. Whenever it is practicable, the different basins should be nearly on the *same plane*, so that the brine may flow from one series to the other, as its level is reduced by evaporation.

But when it is necessary to construct the basins at *different levels,* the brines may be raised from one series to another by means of wooden drums, from eight to sixteen feet in diameter, moved by steam or horse power.

The "saline" at Baynas, in the South of France, covers an aggregate area of nearly 371 acres, and yields per annum 2,125 bushels (56 pounds to the bushel) of salt to *each acre of evaporating surface.* At other French "salines" the average yearly produce is about 1,594 bushels to each acre of evaporating surface. At the salt works of the Lake of Berre, near Marseilles, the brine is scarcely *half the strength* of sea-water, and yet the annual yield is 966 bushels of salt to each acre of evaporating surface. The *average price* of salt at the last-named "salines" *is only five cents per bushel*, but an outrageous *impost* upon it, amounting to *ten times that sum*, enhances the price to about fifty-five cents per bushel. At these works the "mother-liquors" are used for the production of large quantities of sulphate of soda (from which soda is manufactured), as also the salts of potash and magnesia.

SECOND METHOD.

BY "SALINES" AND ARTIFICIAL EVAPORATION COMBINED.

In this method, the evaporating basins are constructed as before indicated, *excepting* that basins No. 3 (salting tables) *are omitted.* In fact, by *enlarging* the area of basins No. 1, we might likewise dispense with basins No. 2, thus retaining only the reservoir and the series of basins No. 1 as the aggregate evaporating surfaces. The sea-water is *first* concentrated in these basins by spontaneous evaporation, and the brine thus obtained is *boiled down*, and the salt extracted. For this purpose furnaces, evaporating-pans, and a store-house must be provided. The pan is a shallow four-sided vessel of sheet-iron, from nine to twelve inches deep, with flat bottom, somewhat deepened towards the middle, and from ten to twenty feet or more in length and breadth, according to the extent of the salt-works. The bottom of the pan is supported by small pillars of brick-work, built from the foundation of the furnace, so as to form, at the same time, *flues* for the distribution of the heat. These flues are calculated to disseminate the flame as uniformly as possible over the bottom of the pan, after which it is made to pass out behind, to one of the rooms of the store-house, called the drying-chamber, which it heats, and then escapes by the chimney.

The process of boiling consists of *two* distinct operations: *First*, the purification and evaporation of the brine up to the point of *saturation*, which is called *sludging;* and *second*, the crystallization of the salt, which is called *soccage.*

Sludging.—The pans are rather more than half filled with clear concentrated brine, which is brought rapidly to a state of violent boiling, the evaporated portion being replaced from time to time by *fresh brine*. The surface soon becomes covered with a dirty brown scum, which, with the salts precipitated at the same time, collects as a thick mud. As far as possible, this must be removed by means of rakes, but some attaches itself to the bottom of the pans, forming the *pan scale*. After twelve or fifteen boilings, it often increases to the thickness of an inch, and must then be broken up by the chisel and removed. In the meantime the solution of salt becomes more concentrated by the constant evaporation and renewal of the brine, until at last it begins to *crystallize*. This process lasts from 20 to 24 hours. When the scum of crystals begins to form on the surface, the fire is *lessened*, until the temperature of the brine falls to 194° or 167° Fahrenheit, when, with *slow evaporation*, the *soccage* begins, and lasts *several days*.

Soccage.—During this time the small floating crystals gradually increase in size and sink to the bottom. When the pan is kept at 194° the crystals have no time for growing, and fine-grained salt falls to the bottom; at 167° they remain floating a longer time, and produce salt of a coarser grain. The temperature must not be *too much* reduced, otherwise the chloride of magnesium is a source of obstruction to the process, unless removed by the addition of sulphate of soda or slaked lime; and, better still, of *both*. To remedy the *crusting* of the surface of the brine, which sometimes occurs, a half an ounce of *butter*, or a small quantity of *powdered rosin*, may, if necessary, be added to the pan. Sometimes the *sludging* and *soccage* are conducted in *separate* pans, the brine being transferred at the proper time.

The *purity* of the salt diminishes towards the end of the process of *soccage*; for this reason it must be stopped before all the salt is deposited. It need not, however, be rejected at the end of each boiling; a *second*, and sometimes even a *third*, charge may be boiled down before the residue—the mother-liquor—is removed.

During the whole process of *soccage* the salt is raked up from the bottom with long *cullender-shovels*, to the edge of the pan, and placed either in wicker-baskets of peeled willow, or heaped upon boards which are thrown back for the purpose, when, in both cases, the brine runs back to the pan. The moist salt, either in the same baskets or spread out upon *hurdles*, is then placed in the drying-chamber, where it is exposed to a heat of 120° or 130° Fahrenheit as long as it loses moisture, when it is packed up for sale.

At Lymington, in Hampshire, England, the process of obtaining salt from sea-water is similar to the foregoing, but somewhat *simpler*. The sea-water is concentrated, by spontaneous evaporation, in shallow basins, to about *one-sixth its bulk*, before admitting it into the boilers. The salt is not *fished* out of the pan and drained in baskets, but the water is almost entirely evaporated, and the whole mass of salt taken out at once, and removed to troughs with holes in the bottom: through these it drains into pits under ground, which receive the mother-liquor. Under the troughs, and in a line with the holes, are fixed upright stakes (old broom-handles), and on these the salt concretes and forms, in the course of ten or twelve days, on each stake a mass of sixty or eighty pounds. These lumps are called *salt-cats*. They bear the proportion to the salt made from the same brine of one to one hundred. The mother-liquor is reserved for the manufacture of Epsom salt during the winter season.

Cost of Boiling.—This will, of course, depend on the extent to which the brine has been concentrated by the process of natural evaporation in the basins. If practicable, the brine should mark about 20° of Baumé before it is introduced into the boilers. To do this, ordinary sea-water must be evaporated to about *one-eighth* of its bulk. Calculation shows that 10,000 gallons (of 231 cubic inches *each*) of this concentrated brine contains 305½ bushels (of 56 pounds) of salt. Assuming that only *eighty-five per cent.* of it can be conveniently extracted, this quantity of brine should yield nearly 260 bushels of salt. With tolerably good arrangements for boiling, *each pound of wood should evaporate 3½ pounds of water*. Taking the weight of a cord of *dry pine* to be equal to 3,200 pounds (a *low* estimate), it will require about 7⅓ cords to boil down the 10,000 gallons so as to extract the 260 bushels of salt; that is, it will require the burning of *one cord* of wood to every 35½ bushels of salt manufactured.

Supposing the concentration of the sea-water to be carried only as far as at Lymington, viz: to *one-sixth* of its bulk, or marking 15° of Baumé, 10,000 gallons will contain about 194½ bushels of salt capable of being extracted. In this case about 26½ bushels of salt ought to be made for each cord of wood burnt.

THIRD METHOD.

BY SPONTANEOUS EVAPORATION IN GRADUATION-HOUSES AND BOILING COMBINED.

The advantages of this method are: 1. That all the processes are conducted *under shelter*, so that the operations are independent of *rainy weather*. 2. That the *space* required for the works is comparatively *small*. 3. That the arrangements are *not costly*, and may be put up on any desired scale.

A large reservoir is constructed at some point conveniently situated for receiving the brine from the sea. From this the sea-water is pumped up into a large wooden cistern on the top of a tower 25 or 30 feet in height, from whence it is conducted to the graduation-house, to be concentrated.

Graduation-House.—This is a long, open frame building, the longest side of which is exposed to the prevailing wind of the locality. The floor of the building is made of a large clay basin, or of strong wooden planks, intended to collect the brine which has been concentrated by evaporation. The spaces between the frame of the shed are filled with bundles of twigs or fagots, so that the building looks like a vast wall of *brush,* 20 or 30 feet high, and from 100 to 1,000 feet in length. The pyramid of fagots should be ten feet thick at its base and six feet at its upper part. Under the ridge of the graduation-house, and consequently *over* the middle of the long wall of fagots, is a long wooden trough or spout, perforated with holes at small intervals, through which the sea-water flows from the large cistern on the tower. In this manner the weak brine is made to fall like a perpetual shower over the vastly extended surface of the fagots into the basin below, during which it is rapidly concentrated by evaporation. This partially concentrated brine is again pumped up, and undergoes the same operation successively, until it is sufficiently concentrated for boiling. The same brine is usually passed four or five times through the fagots before it is fit for boiling; it is then passed into a reservoir, and kept for the boiling operations. During these successive concentrations the fagots gradually become coated with a *crust* of the salts of lime, but one set will last about eight or ten years.

Of course it is best that this operation should be conducted during the warm season; in fact, when the temperature is below 27° Fahrenheit, a portion of salt is *lost* by the reaction of the sulphate of magnesia. But the boiling may be carried on at any season. In general, the *brine fit for boiling* should contain about 20 per cent. of salt, that is, should mark 20° of Baumé. The boiling process is the same as that indicated in the *second method,* and its *cost* will be as there estimated. By adding *slaked lime* to the reservoir of brine fit for boiling, the magnesia might be precipitated, and a purer salt obtained.

FOURTH METHOD.

BY LIXIVIATING SALINE SAND AND THEN BOILING THE BRINE.

This method is employed in Lower Normandy, and is used for making salt on a *small scale.* A level shore with a clean sand is selected, and the necessary buildings are erected (covered sheds, evaporating-pans, store-houses, &c.), and an area of three or four acres is chosen, a little *below* the level of spring tides. The surface is carefully levelled, and rolled smooth and hard. It is then filled with sand taken from the shore at low water, to the depth of several inches, and the sand is also drenched with sea-water at high tide. It then lies exposed to the sun and wind, which soon evaporate the water, and the surface is covered with a white efflorescence of salt. It is then turned over frequently with the shovel, changing the surface several times a day, till the whole is perfectly dry. This saline sand is carried to the sheds, and the process repeated with fresh sand, till a large quantity is collected.

To make the brine, the dry saline sand is taken out of the sheds and thrown into small round pits, 2½ feet in diameter and 12 inches deep, the bottoms of which are lined with hard rammed clay, mixed with straw. The sand is then covered with sea-water, or with the weaker ley of former operations, and, after standing some hours, is drawn off into reservoirs or barrels, whence the evaporating-pans are supplied. The sand is lixiviated a second time, and this ley is reserved for a fresh portion of saline sand. The boilers used on the western coast of France are about 3½ feet square, and 4 or 6 inches in depth—a charge is worked off in from 2 to 3 hours. Three pans of this size yield together about 50 pounds of salt, but it is of rather inferior quality for preserving meat.

FIFTH METHOD.

BY BOILING SEA-WATER.

This method cannot be made *economical* except where fuel is very cheap. In Scotland a very good quality of salt is made in this manner. The boiling processes are identical with those detailed under the *second method*, excepting that, on account of the weakness of the brine, the *first* operation (sludging) is very much prolonged.

Cost of Boiling.—Ordinary sea-water contains about 2½ per cent. of its weight of pure salt. Hence, it follows that 10,000 gallons contain a little more than 38 bushels of salt, of 56 pounds each. Assuming that 85 per cent. of this can be extracted by boiling, 10,000 gallons of sea-water will yield nearly 32½ bushels of salt. To boil down this quantity of sea-water will require the combustion of 7⅓ cords of wood; that is, not quite 4½ bushels of salt to each cord of wood burnt. When the brine is *weaker* than ordinary sea-water, of course the yield will be proportionally *smaller*, and the operations more expensive. To obtain a *good quality* of salt, all the precautions in boiling indicated under the *second method* must be observed.

The foregoing abstract of the several processes of manufacturing salt from sea-water has been prepared at the request of a member of the Executive Council of the State of South Carolina.