# INDIAN SOLAR SALTWORKS PRODUCTION PROCESSES AND CHEMICAL COMPOSITION OF SALT

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## EXTENDED ABSTRACT

Salt is manufactured in India from sea water at various places of east and west coast and also from inland brine in Sambhar Lake, Rajasthan state (India). In the case of sea salt, sea water or bore well brine is pumped into the Reservoir and made to flow to reservoirs to condensers and crystallizes for increasing the brine density and salt is harvested. However, in Sambhar Lake, because of the brine already present in the sub-soil due to three consequential processes such as percolation, evaporation and diffusion, the sub-soil dense brine diffuse and surface water also get converted into brine, in turn salt is produced. The chemical composition of the sea salt and salt taken from inland brine is compared. In the case of sea salt, because of Calcium and Magnesium, there is production of Calcium Sulphate as Gypsum and Magnesium Salt as Magnesium Sulphate and Magnesium Chloride. However, in the inland brine, Calcium and Magnesium conspicuously absent and this makes the salt with more Sodium Sulphate, Sodium Carbonate and Sodium Bicarbonate. A comparison between Kyar Salt, Reshta Salt and Pan Salt are also compared with reference to its chemical compositions. However, all these three salt do not have moisture and in the case of marine salt, the moisture content is 3.49% as it is recorded from Gandhidham marine salt. In this, Chlorine combined Magnesium is 0.64%, Calcium 0.22%, Magnesium 0.33% and Sulphate 0.95%. However, Sodium Carbonate and Magnesium Carbonate in Gandhidham marine salt is completely absent suggests the difference in the chemical composition between the marine salt and salt produced from inland brine. With reference to the trace metals, Chromium and Molybdenum are completely absent in marine and inland brine. However, other metals such as Vanadium, iron, Nickel, Copper, Aluminum, and Titanium. The data is discussed with reference to the production processes and origin of brine. However, the total organic carbon in the Reshta Salt, Kyar Salt is 32.59 ppm and 42.70 ppm respectively. It is observed that Total Organic Carbon between washed and unwashed salt at Sambhar Lake varies between 5.42 to 6.8 ppm. The paper highlights the importance of processes in the salt production consequently the quality of salt produced between the sea brine and inland brine.

**Keywords:** Salt chemical composition.

## INTRODUCTION

Salt is manufactured in India from sea water at various places of east and west coast and also from inland brine in Sambhar Lake, Rajasthan state (India). In the case of sea salt, sea water or bore well brine is pumped into the Reservoir and made to flow to reservoirs to condensers and crystallizes for increasing the brine density and salt is harvested. Ecology and rearing *Artemia* in a salt pan near Sambhar Lake were attempted (Bhargava, *et al* 1985, 1985a). Recovery of potassium chloride from sub soil brine of Kharaghoda (India) by solar evaporation was studied Oza and Sanghavi (1993). However, in Sambhar Lake, because of the brine already present in the sub-soil due to three consequential processes such as percolation, evaporation and diffusion, the sub-soil dense brine diffuse and surface water also get converted into brine, in turn salt is produced.

## MATERIAL AND METHOD

The samples were collected in Sambhar salt works and analysed as per conventional methods.

## TECHNICALITY OF SALT MANUFACTURE

The salt manufacture from sea contains various degree of concentration of salts at different temperature. These salts are $MgCl_2$, $MgSo_4$ and $CaSo_4$.Mg $Cl_2$ exercises a potent influence on salt. $MgSo_4$ can be avoided easily in the manufacture of salt, how ever $CaSo_4$ is present in minute quantities.

The solubility of sodium sulphate is extremely sensitive to temperature. At low temperature it breaks up. As temperature raises it gets dissolved again. $CaSo_4$ is so little soluble that it separates long before sodium chloride approaches saturation. Ca $So_4$ is first to separate. It's start separating at 17ºBe. NaCl is the next to separate and start separating from 25ºBe. It separates out as gypsum ($CaSo_4.H_2O$). The separated gypsum first flows out on the surface of the liquid as a thin grey film and when it is sufficiently accumulated it settles down to the bottom on the pan carrying along with it a little salt which just begins to come out when the major portion of the gypsum sheets to separate, the separation of gypsum continues up to 25ºBe. (Rahaman *et al* 1993 Fig.I).

## TECHNOLOGY PROCESS STAGES (SEA WATER)

It comprises four stages.

1. Elimination of $S0_4^{2-}$ ions then formation of gypsum.
2. Precipitation Mg (OH)2 and formation of MgO.
3. Precipitation of KCl, NaCl and Ca $Cl_2$.
4. Conversion of gypsum into Ca $Co_3$ and $Na_2S0_4$ $10H_2O$


**Figure 1:** Showing the area of the Sambhar lake(foreground) and Salt extraction and view point of Sambhar lake.

## RESULT AND DISCUSSION

The chemical composition of the sea salt and salt taken from inland brine is compared. In the case of sea salt, because of Calcium and Magnesium, there is a production of Calcium Sulphate as Gypsum and Magnesium Salt as Magnesium Sulphate and Magnesium Chloride. However, in the inland brine, Calcium and Magnesium conspicuously absent and this makes the salt with more Sodium Sulphate, Sodium Carbonate and sodium Bicarbonate. The most important source of lake brine is the Sambhar lake. The salt works are laid out on the banks of the lake and are called kyars. Each kyar has its own reservoirs, condensers and pans. In addition to kyar salt, two more varieties are manufactured, namely reshta and pan salts. Reshta salt is the wind swept salt formed when the salt crystalling on the surface of the brine is blown to the edges where it collects as tiny crystals (Aggarwal 1956).It is also formed in the bittern area where the salt separates out from the brine formed by the dissolution of bittern salt in the rain water. This constitutes most important source of salt. Pan salt is obtained from well brine by a method conventionally followed.

**Table 1**: % of chemical composition between Kyar, Reshta, Pan Salts

| | Kyar salt % | Reshta salt % | Pan salt % |
|---|---|---|---|
| Sodiumchloride | 96.36 | 97.59 | 95.48 |
| Sodiumsulphate | 2.39 | 1.03 | 1.63 |
| Sodiumcarbonate | 0.46 | 0.40 | 0.72 |
| S. bicarbonate | 0.08 | 0.36 | 0.93 |
| Insoluble | 0.26 | 0.42 | 0.89 |
| Undetermined | 0.45 | 0.20 | 0.35 |

However, all these three kind of salts do not have moisture and in the case of sea salt, the moisture content is 3.49% as it is recorded from Gandhidham sea salt. In this, Chloride combined Magnesium is 0.64%, Calcium 0.22%, Magnesium 0.33% and Sulphate 0.95%. However, Sodium Carbonate and Magnesium Carbonate in Gandhidham sea salt is completely absent suggests the difference in the chemical composition between the sea salt and salt produced from inland brine. With reference to the trace metals, Chromium and Molybdenum are completely absent in sea and inland brine. However, other metals such as Vanadium, iron, Nickel, Copper, Aluminum, and Titanium are present. (Table 2)

**Table.2:** Tthe test report of salt sample and the result is as per requirement of industrial grade II salt

| S. No | | Gandhidam Marine salt (ppm) | Sambhar Kyar salt (ppm) | Sambhar Pan salt (ppm) | Sambhar Reshta salt (ppm) |
|---|---|---|---|---|---|
| 1 | Chromium Cr | 0 | 0 | 0 | 0 |
| 2 | Vanadium V | 0.007 | 0.008 | 0.007 | |
| 3 | Iron Fe | 10 | 40 | 50 | 100 |
| 4 | Nickel Ni | Nil | Nil | Nil | Nil |
| 5 | Copper Cu | 4 | 5 | 3 | 5 |
| 6 | Aluminium Al | 5 | 6 | 4 | 5 |
| 7 | Titanium Ti | Nil | 0.08 | 1 | 20 |
| 8 | Molybdenum Mo | Nil | Nil | Nil | Nil |

However, the total organic carbon in the Reshta Salt, Kyar Salt is 32.59 ppm and 42.70 ppm respectively. It is observed that Total Organic Carbon between washed and unwashed salt at Sambhar Lake varies between 5.4 to 6.8 ppm.The organic content in the different kinds of salts suggest that there is enough organic content in the brine used in the manufacture of salt. The presence of blue green algae have been recorded the Sambhar lake (Subbaramanian, 1972) and due to this quality of salt has decreased (Lall, 1987). During the course of condensation algae appear in the brine and impart different courses like light green, yellow, dark brown and pink. Finally the algae appear on the surface as scum which suggests that at higher concentrations the algae have been destroyed.(Lall, 1987).

**Table 3:** Average chemical composition of salt produced at sambhar lake

| Chemical Composition | Kyar Salt (on dry basis) | Reshta Salt (on dry basis) | Pan salt (Deptt K.7-8, M.L. Pan) (on dry basis) | | Pan Salt Bundewals( Deo & M.L. Pan) ( On dry basis) | |
|---|---|---|---|---|---|---|
| | | | Summer Crop | Winter crop | Summer Crop | Winter crop |
| Nacl | 97.5% -98.5% | 97.3%-98.2% | 96.5%-98.0% | 97.5%-98.8% | 96.0%-98.0% | 97.0%-98.5% |
| $Na_2So_4$ | 0.5% -0.8% | 0.6 % - 0.9 % | 0.8% -1.2% | 0.5% - 0.8% | 0.8% - 2.5% | 0.8% - 1.0% |
| (as $So_4$ ) | 0.3 % - 0.5% | 0.4% - 0.6% | 0.5% - 0.8% | 0.3% - 0.5% | 0.5% -1.68% | 0.5% -0.67% |
| Alkalies | 0.4% - 0.6% | 0.5% - 0.7% | 0.6% - 0.8% | 0.4% - 0.7% | 0.6% - 0.9 % | 0.5% - 0.8% |
| Insolubles | 0.35 - 0.5% | 0.5% - 0.5% | 0.3% - 0.7% | 0.2% - 0.5% | 0.5% - 0.7% | 0.3% to 0.7% |
| $Ca^{+2}$ * | Traces | Traces | Traces | Traces | Traces | Traces |
| $Mg^{+2}$ * | Traces | Traces | Traces | Traces | Traces | Traces |
| Hydrogen Evolution | 5 to 6 ml | 5 to 6 ml | 4 to 5 ml | 4 to 5 ml | 4 to 5 ml | 4 to 5 ml |
| Appearance | Inherently Pink Colour | Pink colour | Whitish colour | Whitish colour | Off- white with Greenish Tinch | Off-white with Greenish Tinch |

* in general the ration of Calcium & Magnesium are reverse.

**Table 4:**Showing the chemical composition of super wased iodised and non-iodised industrial salt using in dying industries.

| | Super washed Iodised Salt 1 Kg P.P. / 75 kg Pkg (On dry basis) | Superwashed Non-Iodised Industrial Salt 50 kg / 75 kg Pkg (Using in dying Industries) |
|---|---|---|
| Nacl | 98.0% - 98.5% | 98.0% - 98.5% |
| $Na_2So_4$ | 0.2% - 0.5% | 0.2% - 0.5% |
| (As $So_4$ | 0.13% - 0.27% | 0.15% - 0.3% |
| Alkalies | 0.3% - 0.5% | 0.3% - 0.5% |
| Insolubles | 0.15% - 0.15% | 0.1% - 0.2% |
| Hardness | 30ppm - 40ppm | 30ppm - 40 ppm |
| Iodine level | 30 - 35 ppm | |
| Appearance | White powder contains some inherently black particles | Some inherently black particles but confirming IS–797–1982 Grade-II |

The chemical composition of salt produced at Sambhar lake between different kinds of salt indicates that calcium and Magnesium are only in traces whereas sodium chloride content falls between 96% to 98.8%.The appearances of colour varies. The insolubles 0.2 % to 0.7 % a variation between summer and winter crops (Table 3). The presence of inherent black particles are of organic in origin which could be managed biologically managing the solar salt works.

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**REFERENCE:**

Aggarwal,S.C., (1956), *Salt Industry in India*.,195:272

Bhargava S.C; Jakher. G.R, Saxena .M.M. and Sinha .R.K. (1985), Ecology of Artemia in Didwana salt lake ,India, *2n International Symposium on the brine shrimp Artemia* Antwerpen(Belgium).

Bhargava *et al*., (1985) a Rearing, *Artemia* in a salt pan near Sambhar Lake India, *2nd International Symposium on the brine shrimp* Artemia *,* Antwerpen(Belgium).

Lall, S.B. (1987), Note on Sambhar salt works and algae problem. In Sorgeloos .P (Editor) *Artemia news letter*, 5:5-6.

Oza, M.R. and Sanghavi, S.R. (1993), Recovery of potassium chloride from sub soil brine of Kharaghoda, India by solar evaporation, *7th International Symposium on salt*, Vol.1 589-592.

Rahaman,A.Abdul, Ambikadevi .M and Sosamma-Esso (1993), Biological management of Indian Solar Saltworks, *7th Symposium on salt*, Vol.1:633-643.

Subbaramanian, K (1972), The biology of the blue-green algae of the Sambhar lake salt works. In: Desikachary,T.V (Editor) Taxonomy and biology of blue green algae,1st *International Symposium on Taxonomy* and biology of blue green algae held at Madras, January 8-13, 1970.University of Madras, Madras 339-441.