

THE HIDDEN GEM OF RAJASTHAN: THROUGH THE PERSPECTIVE OF CHEMISTRY

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ABSTRACT

Sambhar Lake in Rajasthan is the largest saline water lake in India. The saline wet land is elliptical in shape running east northeast to west southwest with length of 35 km and breadth varying between 3 km and 11 km. The circumference of the lake is 90sq miles and is surrounded by Aravalli hills. These are residual hills with several gaps. Aravalli ranges in the northwest and the west of the lake are seen with the highest peak of 500m called Patiala Dungar. At full capacity lake covers an area of 90 sqkms and thus it the largest saline lake of the country. A dam 5.16 km long, made of sand stone divides the lake between Jhapok (in South) and Gudha (in North) It is surrounded by three districts namely Jaipur, Ajmer and Nagaur. Sambhar has been designated as a Ramsar site in the year 1990 at convention at Montreux, Switzerland(1) as thousands of birds migrate in winters from Northern Asia and Siberia.

Keywords: Saline Water Lake, Aravalli Hills, Evaporation, Crystallisation, Percolation.

Introduction

Available historical records suggest that salt extraction from Sambhar lake has been atleast a thousand years old. Prithviraj Chauhan (548 A.D.) ruled over this area (2). There are extensive records of salt revenue during the reign of Mughal emperor Aurangzeb and Akbar. Before the British assumed charge of the lake and salt production, the area was administered, at different times by the Holkars, Scindias, Rajputs and Marathas. It had also been the site of wars between Ali Ahmed and Rajputs in 1765 and between the Rajputs and Marathas in 1847 -48.

Salt or magic mineral is one of the most important industries in India. Sambhar lake plays most important role in the production of salt in the country. It produces 2,10,000 tonnes of salt each year. Sambhar lake is the property of Hindustan Salt Ltd a, public sector unit established in 1958 and is presently working under Ministry of Heavy Industries, New Delhi.

This lake is fed by four main streams having different water volume and salt content (3,4).

- Rupnagarenters lake from south having 77 ppm salinity
- Mendha enters from north having 1395 ppm NaCl
- Kharian from north east having 665 ppm NaCl
- Khandel from east having 11 ppm NaCl.
- Three other streams which flow during heavy rainfall are Ruprail, Bandi and Turatmati.

Origin of Salt

Most widely accepted explanation for the origin of salt in the lake is that chemical weathering of the Aravalli's result in the production of soluble sodium salts which drain into the Sambhar basin. Salt is produced as a result of three consequential processes -percolation, evaporation and crystallisation. The salt produced contains

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Sodium Chloride (NaCl)- 95-97 %

Sodium Sulphide (Na_2SO_4)- 0.2=0.5%

Sodium Carbonate (Na_2CO_3) 0/1-0.2%

Insoluble residue and moisture- 0.7-1.3%

Sodium Sulphate, sodium Carbonate and Bi-Carbonates are present as Inorganic impurities in salt.

Types of Salts

Salts are of three types

- **Kyar Salt**

This is the best quality salt and used as common salt. From October to May a crust of 4" to 6" in the thickness is developed. Then extraction of salt is carried out. Large crystals, white, grey and pink in colour are extracted. This layer has a lot of algae in it. Production of this salt is highest. One Kyar produces almost 2600 tonnes of salt. This salt is also used for making Kala Namak or Rock salt. The composition of kyar salt is as follows –

NaCl- 97.5 to 98.6 %%

Na_2SO_4 as sulphide _ 0.5 to 0.8 %

Alkalies – 0.4 to 0.6 %

Insoluble impurities – 0.3 or 0.5 %

Ca^{+2} - Traces

Mg^{+2} - Traces

Hydrogen Evolution _ 5 to 6 ml

Appearance – Pink in colour

- **Pan Salt**

It develops from subsoil brine. Pan salt has the advantage of being free from algae. It is whiter and finer. Production of this salt is in smaller quantities. One Kyar produces 51-55 tonnes of pan salt, very less in comparison to Kyar salt. Composition of Pan salt is as follows:

- NaCl – 96.5 to 98.0 %

- Na_2SO_4 as sulphate – 0.8 to 1.2 %

- Alkalies - 0.6 to 0.8%

- Insoluble impurities – 0.3 to 0.7%

- Ca^{+2} - Traces

- Mg^{+2} – Traces

- Hydrogen evolution - 4 to 5 ml

- Appearance – Whitish

The crystallization of brine begins at 25°C. The brine of this lake is unique as it has low potassium content. Crystallisation of pure NaCl takes place between 25 °C to 29 °C. As the temperature increases above 29° C specific gravity of the brine increases, resulting in the precipitation of calcium and magnesium. Almost 50% of the brine is discarded to get pure salt.

- **Restha Salt**

It is the most neglected salt. It is crystallized in the form of small crystals. It is a part of Kyar salt. Size is very small. Chemical composition of Reshta salt is

NaCl – 97.3 to 98.2 %

Na_2SO_4 – 0.6 to 0.9 %

Alkalies _ 0.5 to 0.7 %

Insoluble impurities – 0.4 to 0.5 %

Ca^{+2} - Traces

Mg^{+2} - Traces

Hydrogen evolution – Traces

Appearance – Pink

- **Bittern Crust**

This is the hard impure crystalline mass of salt in bittern's area. This can be said as low quality left over salt or sub-standard waste salt. The composition of this crust is-

NaCl – 25 to 60 %

Na₂SO₄ – 35 to 65 %

Alkalies – 2.5 to 4 %

Insoluble impurities – 2.5 to 6.0 %

Shape- hard impurities /crystalline mass

- **By Products**

After iodization some salt is left as by products. It is called Dust and Retention. Dust is the fine powder that is used in soap, detergent and leather industry and Retention is used in Ice factories.

Manufacturing Process

Of the total area of 90 sq miles of Sambhar Lake, the area under salt manufacturing is about 2.82 sq miles. The production of salt depends on the rainfall and water brought by the four feeder streams. The salt producers now use ground water to reduce this period thus reducing water table of this area.

The process of salt production is very simple. During the monsoon rains, the water entering the lake brings some salt with it from the catchment and more salt is dissolved from the lake sediments, this saline water called brine contains sodium chloride and several other sodium salts like sulphates, carbonates and bicarbonates. The brine had P^H value of 9.502 and a total salt content ranging from 7% (w/v) to more than 30% {w/v}. The water is at 2-3° Be. The water is then left in the kyars for evaporation after rainy season. There are six kyars

- Main line kyar
- Deodhani kyar
- New kyar
- Gudha kyar
- Jhapog kyar
- Nawa kyar

The process of concentrating salt from the lake brine involves a number of steps. The lake water is pumped into the main reservoir of the salt production area through sluice gates in the dam. Extraction work commences at high temperature during summers. Crystallisation of sodium chloride begins while sulphates and carbonates still remain in the solution. Wind movement sprays water on the margin of the reservoir where salt dries out and accumulate in the form of a fine white powder (Fig 1).



The brine is then pumped into crystallizer pans where the salt starts crystallizing. The concentration increases up to 15-20 ° Be. 28.5 ° Be is the optimum degree where we get maximum extraction of salt. If this value increases sulphate formation occurs. Now the brine is removed and the salt formed is periodically removed, allowed to dry and transported to the main plant. The salt department has laid its own track from the kyars to central store/plant (Fig 2).



The discarded brine is also sold as it contains sodium sulphide, sodium sulphate, calcium sulphate and gypsum. Sambhar Lake does not have Bromine in it. Generally, salts produced from sea water has magnesium bromide in its brine but here it is not so. HSL at Khara Ghoda, Gujrat produces 900 tonnes bromine per year.

This impure salt brought from the kyars is put in washery to remove all the impurities. Small stones, wooden particles are handpicked before moving it to washery on a conveyor belt (Fig 3).



Picture 3 is showing a lady picking up stones. One can see a lot of algae and other impurities being washed away (Fig 4).



This has many varieties of algae of Chlorophyceae family but *Dunaliella Salina* is the most common. Washing tank or Cellory tank (fig5) is the place where washing of salt takes place removing all the impurities the salt thus obtained is sent through screw conveyor belt (Fig6) and put in a Hopper to crush and reduce the size of the particle(Fig7).



The wet and washed salt now is centrifuged in large centrifugal machine at 3200 rpm. This process removes all the moisture and the purity of the salt increases from 94-95 % to 98 %. Now the whole material is passed through the settle tank to recover the salt. After this the salt is free flow i.e., completely dry in nature. This free flow salt now obtained is then passed through cyclone unit where hot air having around 250 °C is passed through it. Dust gets separated here. This by product is sold by the unit to detergent industry. Salt from Hooper after complete drying is moved to iodization unit (Fig8). The salt thus produced is tested in the laboratory and then packed as per requirement (Fig9). Sambhar salt is first in the country to have iodization plant with UNICEF (5).



Climate

The catchment of Sambhar is called the gateway of the arid climatic zone. Summers being hot, dry and windy (30-36km/h), temperature in summer varying from 40 -47° C causing evaporation of shallow lake water. The temperature in winters is almost 8-19° C and sometimes fall upto 4°C. Rainfall is very less (100-500mm). In monsoon season lake water is fresh, so less saline. During winters salinity increases partly due to evaporation of water and partly due to generation of salts from the lake sediments. During summer salinity increases sharply leading to crystallization. Salinity is highest from April till mid-June. Salt concentration in Lake varies from season to season. The colour of brine varies from green, orange, pink, purple and red due to haloalkaliphilic microorganisms.

A lot of factors like temperature and rains affect salt formation. Concentration of dissolved salt vary in summer or rainy season. During early summer the water is alkaline, P^H ranging from 7.5 to 9.5 %. Carbonate concentration also rises from 35 ppm to 135 ppm, sodium sulphate from 232mppt to 66 ppt. sodium carbonate from 6.6 to 39.4 ppt. sodium chloride from 8.6 ppt to 146 ppt. The oxygen concentration decreases during summer season. Calcium varies from 16 to 80 mg/l, magnesium, from 10-117 mg/l, potassium from nil to 51 KCl/100 ml brine, nitrogen 30 µg/l to 240 µg/l, phosphate nearly 4 µg/l throughout the year and Sulphate varies from 250 mg/l to 320 mg/l. Sulphur is mostly in the form of sodium sulphate in the sediments. Under anaerobic conditions it produces hydrogen sulphide having characteristic smell, which one can come across at Sambhar.

Threats it is Facing

Over the years the salinity is increasing thus increasing barren land area. The barren land has increased from 50-90% due to scarcity of water. The scarcity of rainfall is leading to lowering of ground water level, increasing salinity thus lowering the salt production. This in turn is reducing job opportunities to local people. Illegal salt production and ground water extraction is leading to drying of lake area. Northern periphery of the lake is the most abused salt making area. After 1980 almost 18500 salt pans have been established apart from Sambhar Salt Limited. Before 1980 this no was limited to 600-700 including SSL (6).

Almost 901000 metric tonnes salt is being produced by private salt production units now. Before 1980 it was just 500 tons. Sand mining and stone mining are another practice which is causing threat to salt production.

Acknowledgement

Dr Jaya Rai is grateful to Sambhar Salts Limited for extending full cooperation and support and to Mr Gaurav Sharma for the photographs.

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