

SOLAR DESALINATION, BRINE AND FINE CHEMICALS — A PRELIMINARY REPORT

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ABSTRACT

Solar stills put into operation by taking known quantities of sea water of different salinities varying from $27.75 - 36.27 \times 10^3$ during April-May 1990, indicated fresh water yield of 55-68% (av. 64). The volumes of brine as well as those of biterms, obtained by further concentration of brine samples varied from 30 to 350 ml and indicated large volumes of brine recoverable from high salinity waters ($>30 \times 10^3$).

The analyses of boron in water samples of different salinities showed concentrations to range from 3.65 - 4.63 ppm. The definite volumes of seawater samples (3.7 litres) taken in stills for desalination correspond to 13.08 - 31.36 mg of net boron content. Analyses on the recovery of the total content of boron in brines as well as in the biterms of these waters indicated 57 - 83% recovery. The highest recovered boron in brine was 25.96 mg as against the total expected 31.36 mg in the total quantity of seawater in still. So also, the highest recovered boron in the biterm was 15.02 mg as against the total expected 23.73 mg. The observed lowest recoveries of boron below 65% in the concentrated samples indicated the possible loss of boron due to the removal by adsorption onto the preformed salts.

Key-words: Solar desalination, freshwater yield, brine, boron.

The changing climatic/ weather conditions affecting almost every part of the world have given rise to the arid and semi-arid zones which face acute shortage of good quality water (Berger, 1981). In India, the increasing population, the growing industrialization and the usage of water for agricultural purposes have aggravated the water shortage still further (Anonymous, 1989). One of the biggest consumers of fresh water appears to be the industrial sector as often times, for the manufacture of one ton of the finished product, the industry uses 200 tons of fresh water (Anonymous, 1964).

Though the country is influenced both by NE and SW monsoons the wide arid desert regions of Gujarat and Rajasthan receive only scanty rainfall and in some years there is none (Anonymous, 1964). Similarly, Madras, north Kerala and West Bengal where serious problems exist with respect to salinisation face acute shortage of water many a times. Though India receives annually on an average 1000 mm of rainfall it varies from place to place and a major portion of it flows out to the sea. Also no let up can be expected in fresh water demand in the years to come. This has necessitated the desalination of largely available brackish or seawater to meet the increasing demand for fresh water. Moreover, the present escalating cost of the conventional energy has opened way for the exploitation of non-conventional energy sources in

order to produce desalinated water and energy. In areas of drought as well as in many other villages which do not have any source of fresh water but where brackish or seawater is available in plenty, solar desalination seems to be the only alternative and economic way of getting potable water that is of good quality, free from bacteria and dissolved salts (Chaturvedi, 1984). However, this can be achieved by solar stills which serve the dual purpose providing fresh water and brine that can also be used economically.

The widespread use of multisurface solar stills in the developing countries has proved economically very satisfactory to meet the increasing demand for fresh water (Porteous, 1983).

The by-product of solar desalination, salt, brine and the bittern, can be used as raw material in chemical industries for the extraction of economically important chemical elements. The bittern can be obtained after the separation of sodium chloride from brine. The economic importance of chemical element depends upon their demand in industry, the nuclear reactors, medicines etc. e.g. uranium being fissionable is used as a nuclear fuel; so also boron being a neutron absorber is used in neutron shielding in nuclear reactors. Such elements of importance apart from many others can be recovered from brine by applying suitable modern techniques.

The extraction and isolation of most of the major elements and their salts is being carried out at the Central Salts and Marine Chemicals Research Institute, Bhavnagar. However, the extraction of minor/trace elements as well as some economically important elements like boron, uranium, lithium etc. from seawater is not carried out much, due to the tedious methodology involved. An attempt was, therefore, made at NIO to study in detail the process of solar desalination in relation to its fresh water yield and the recovery of brine, bittern and their boron contents.

Shallow basin solar stills of 1 m² area, designed and developed at the Institute (Anand, 1982), were provided with a fresh coating of black paint and with rubber packings to prevent the leakage of water vapour so as to increase its efficiency. These stills were then put in operation during the summer months of April and May, 1990 by taking known quantities of seawater of varying salinities from 27.75 - 36.27 × 10³. The volumes of fresh water recovered and those of the brine and the bittern collected were noted. Boron was analysed by the spectrophotometric method of Hulthe, Uppstrom and Ostling (1970) in the initial seawater, in brine and in bittern so as to calculate its rate of recovery. The salinity was estimated by the argentometric method (Strickland and Parsons (1976); Grasshoff, Ehrhardt and Kremling (1983)).

As seen from the results in Table I, the observations indicate an average fresh water yield on volume basis to be 64%. This can be considered to be fairly satisfactory. In some cases the yield was 68% while in others it was 55%. The yield was dependent

Table I - The freshwater yield, the expected boron content and the recovery of boron in brine.

| Salinity $S \times 10^3$ | Seawater in still ml | Temperature $^{\circ}\text{C}$ | Yield % | Brine Bittern ml | Seawater ppm | Brine/ Bittern ppm | Concentration of Boron | | | |
|-----------------------------|----------------------------|-----------------------------------|------------|------------------------|-----------------|--------------------------|-------------------------------------|---|---------------|------|
| | | | | | | | Expected boron in seawater mg | Recovery of Boron in Brine/Bittern mg | % recovery | |
| | | | | | | | | | | |
| | Brine | | | | | | | | | |
| 36.27 | 3000 | 32-33 | 63 | 210 | 4.63 | 48.7 | 13.89 | 10.23 | | 73.6 |
| 34.95 | 7000 | 30-31.5 | 68 | 350 | 4.48 | 74.18 | 31.36 | 25.96 | | 82.8 |
| 33.47 | 3000 | 30-30.7 | 60 | 165 | 4.45 | 52.59 | 13.35 | 8.77 | | 65.0 |
| | Bittern | | | | | | | | | |
| 35.74 | 3000 | 32-33.5 | 68 | 40 | 4.36 | 206.00 | 13.08 | 8.24 | | 63.0 |
| 30.63 | 4000 | 30-32 | 67.5 | 30 | 3.96 | 300.00 | 15.84 | 9.10 | | 57.0 |
| 27.75 | 6500 | 30-31.5 | 55 | 45 | 3.65 | 333.73 | 23.73 | 15.02 | | 63.3 |

on the availability and intensity of sunlight at the time of desalination. The volumes of brine collected were 165, 210 and 350 ml for the seawater of 3 litres and 7 litres while the volumes of bittern obtained by further concentration of brine and salt separation were 30, 40 and 45 ml for 3 litres to 6.5 litres (\approx 7 litres) of seawater (Table 1). The observed densities of brine samples were found to vary from 1.203 to 1.249 while those of the bittern samples varied from 1.27 to 1.35. Larger volumes of brine could be obtained from high salinity samples and the amount of salt recovered during further concentration of brine to bittern was also high in high salinity samples.

Though the boron in seawater samples ranges from 3.65 - 4.63 ppm indicating high values in high salinity samples, its concentration in brine and the bittern were found to range from 8.77 to 26 mg and from 8.24 to 15.02 mg respectively indicating low values in bittern as compared to the brine. The fairly good percentage recovery of boron was shown by brine from 65 to 83% while bittern showed relatively low percentage recovery from 57 to 63%.

In Table 1, the sample No. 3 that was concentrated 20 times indicated good recovery of 82.8% giving 25.96 mg of boron in still. Similarly, sample No.1 indicated 73.6% recovery thereby giving 10.28 mg of boron as against the expected 13.89 mg of boron. The samples of bittern showed less than 65% recovery with lowest 57% in sample No.4 which gave 9.1 mg as against the expected 15.84 mg in the seawater in still. Such low recoveries of boron were attributed to the removal of boron by the precipitated salt. This was confirmed by the analyses of boron in the precipitated salt which gave 10 - 18% of the boron.

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