Asian Journal of Chemistry Vol. 18, No. 3 (2006), 2413–2416

NOTE

Salt Treatment Methods for the Improvement of Salt Quality

ÖZEN KILIÇ
Department of Mining Engineering, Faculty of Engineering and Architecture
Cukurova University, 01330 Balcali, Adana, Turkey
Fax: (90)(322)3386126; Tel: (90)(322)3386503 E-mail: zenkilic@cu.edu.tr

In this study, the composition of the lake water, salt crust and the salts obtained from salt crust *via* treatment methods were investigated. The salt crust which was initially in the composition of NaCl, $CaSO_4$, $MgSO_4$, $MgCl_2$ and K_2SO_4 was transformed into the composition of NaCl and KCl and that of NaCl by means of mechanical washing-drying-grinding and refining-evaporation methods, respectively. Raw salt is transformed into a processed product of better quality and desired properties after these treatments.

Key Words: Salt Lake, Evaporation, Refinement, Sodium chloride.

INTRODUCTION

In Turkey, salt needs are mostly met by lakes. Especially, the salt obtained from Salt Lake, in Central Anatolia, accounts for 70–80% of Turkey's needs. It has a huge potential for Turkey. In brine extraction for sodium chloride with subsequent lined and unlined solar evaporation pans, concentration takes place on the edge of this lake. On the east, west and north shores of the Salt Lake near Kayacik, Yavsan and Kaldirim respectively, brines are concentrated in the more than 38.86 km^2 solar ponds within a total area of *ca.* 1600 km^2 of the Salt Lake. The annual halite surface reserve of the Salt Lake is approximately 211.2×10^6 ton. The thickness, density of the salt crust and salt production area are 0.08 m, 2.2 ton/m^3 and 1200×10^6 m^2, respectively. During normal summer conditions, 90% of the halite present in the brine is precipitated with little contamination by other salts: sodium salts, potassium salts, sulphate salts, Mg-bearing salts, etc. The salt crust (97–99% NaCl) is precipitated by solar evaporation on the lake basin during May and September. Every year, between August and November, solar salt is harvested by mechanical harvesting equipment. In 2003, the mean annual sodium chloride production was 1,696,000 ton (Kaldirim 551,000 ton, Kayacik 625,314 ton and Yavşan 520,000 ton)[1].

The lake is fed by three major rivers: Peçeneközü, Uluirmak and İnsuyu, with mean annual discharge rates 37×10^6, 41×10^6 and 10×10^6 m^3, respectively. Several ephemeral streams and one man-made agricultural discharge canal with a mean annual discharge rate of 87×10^6 m^3 also feed the lake[2]. Mean annual precipitation averages 353 ± 136 mm and the potential monthly evaporation ranges from 1175–1390 min[3].

Salt crusts are mostly cleaned by mechanical washing-drying-grinding and refined by mechanical evaporation. In the mechanical grinding-washing-drying system, after harvesting, the salt crystals are washed with dilute brine to remove residual bitterns and impurities[4]. As to the refined mechanical evaporation, in this method, the salt is obtained by dehydrating brine using heat alone or in combination with vacuum. The vacuum pan process conserves energy by utilizing multiple effect evaporators connected to vacuum pumps. The final products are of usually typical cubic form.

In this study, it is aimed to determine the chemical composition of the lake water and the change occurring in the components of the precipitated salt on the lake surface and the salts extracted from this salt *via* cleaning methods (mechanical washing-drying-grinding and refined-evaporation).

The lake water was analyzed for the determination of the chemical composition of the Salt Lake. The samples were collected from lined solar evaporation ponds by glass bottles from different areas (Kaldirim Saltpan, Kayacik Saltpan and Yavşan Saltpan) and these were analyzed by using liquid chromatography meter (LCA10A). The salt crust and the salts extracted from this salt *via* cleaning methods (mechanical washing-drying-grinding and refined-evaporation) were analyzed to determine the change in the mineralogical composition of the salts. The analyses were performed with a Shimadzu XRD-6000 and Cu X-ray tube ($\lambda = 1.5405$ Å). Moreover, mechanical washing-drying-grinding salts and refined-evaporation salts were analyzed in the determination of the chemical composition.

The lake water was analyzed in order to determine the major ion composition of the Salt Lake and the analysis results are listed in Table-1.

TABLE-2
CHEMICAL COMPOSITION OF THE SALT LAKE BRINE (mg/L)

Sample place	Cl	SO_4	Ca	Mg	Na	K
Kaldirim Saltpan	192115	8016	1353	47002	71583	38316
Kayacik Saltpan	201338	4055	958	21441	71071	7394
Yavşan Saltpan	201200	5008	976	29950	70050	8010

The Salt Lake water is found to dominate in Na^+ and Cl^-, with lesser amounts of SO_4^{2-}, Mg^{2+}, Ca^{2+} and K^+ (Table-1). The chemical analysis data of the experiments indicate that the chemical compositions of brines vary significantly between the Na-K-Mg-Ca-Cl type and the Na-K-Mg-Cl-SO_4 type according to Eugster and Hardie[6] classification. It could be classified as an Na-Cl-type brine. Also, mean ion concentrations of the Salt Lake brine in a yearly cycle[4] are given in Table-2.

In the observation, cubic chevron type halite minerals in the upper levels of the salt crust was seemed to have dimensions of < 0.5 mm–1 cm, and they were easily recognized and distinguished from the underlying halites by their clean colours in the Salt Lake.

The precipitated salt crust on the lake surface and recovery salts (mechanical washing-drying-grinding and refined evaporation salts) of salt lake crust were analyzed in determination of the mineralogical composition. The salt crust which was initially in the composition of NaCl (98.30%), $CaSO_4$, $MgSO_4$, $MgCl_2$ and K_2SO_4 was transformed into the composition of NaCl (98.75%) and KCl and that of NaCl (99.70%) by means of mechanical washing-drying-grinding and refining-evaporation methods, respectively. It is determined that the salt extracted via refined-evoparation was purer (Table 3).

TABLE-2
MEAN ION CONCENTRATIONS (mg/L) OF THE SALT LAKE BRINE IN A YEARLY CYCLE

Month	K	Na	Ca	Mg	SO_4	Cl	pH
Jan.	1610	115625	617	4445	9675	188812	7.42
Feb.	800	107500	870	2100	6100	161100	7.50
Mar.							
Apr.	800	106300	1000	2200	6600	173100	7.10
May	944	101980	925	2860	7371	167438	7.34
Jun.	1458	114717	772	3963	8838	185454	7.30
Jul.	3358	106667	429	10591	19097	172710	7.33
Aug.	6300	113000	380	10932	20809	184104	7.45
Sep.	9400	89625	273	20686	37018	196448	7.15
Oct.	9900	69750	192	36667	67785	171159	6.95
Nov.	9950	105417	621	61194	13646	176523	7.33
Dec.	10000	102083	600	5095	10885	168018	7.55

TABLE-3
CHEMICAL COMPOSITION OF SALT PRODUCTS

Properties	Mechanical washing-drying-grinding	Refining-evaporation
Appearance	White crystal	White crystal
Humidity (%)	0.45 ± 0.10	0.30 ± 0.05
Purity (% NaCl)	98.6 ± 0.7	99.7 ± 0.2
Insoluble solids in water (%)	0.33 ± 0.2	0.15 ± 0.02
Insoluble solids in acid (%)	0.15 ± 0.1	0.06 ± 0.01
Total calcium (%)	0.14 ± 0.04	0.06 ± 0.01
Total magnesium (%)	0.05 ± 0.01	0.031 ± 0.005
Alkalinity (%) ($CaCO_3$)	0.26 ± 0.05	0.2 ± 0.03
Sulfate (mg/kg)	37 ± 3	32 ± 1
Coliform (EMS/g)	22 ± 4	3 ± 1
E. coli (EMS/g)	6 ± 1	3 ± 1

Conclusion

The Salt Lake (Tuz Gölü) water has been classified as Na-Cl type brine whose NaCl rate is over 98%. The salt obtained from this lake accounts for 70–80% of Turkey's need. It also has considerable salt (NaCl) and salt co-product potential for industries and human activities. According to previous study[5], pure halite, sodium sulphate salts, halite + carnalite, halite + langbėinite + sylvite and halite + bischofite + kieserite are approximately obtained 162.5, 41.9, 99.2, 41.4 and 26 g per litre of brine water (Salt Lake), respectively.

The salts prepared for food industry are consumed after they have undergone mechanical washing and/or refining process. As the process gets more complex, the salt becomes purer and more convenient for consumption according to the food standards (TS 933[25]) since unwanted impurities are removed. Table-3 indicates that raw salt is transformed into a processed product of better quality and desired properties after these treatments.

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(*Received*: 11 November 2005; *Accepted*: 6 March 2006) AJC-4737

ERRATUM

Asian Journal of Chemistry Vol. 17, No. 4 (2005), 2851–2852

Development of Apparatus for the Instant Production of Dry Gases or Fumigants

VINAY PRABHA SHARMA
Department of Chemistry, J.V. College, Baraut-250611, India
E-mail: shambhavisharma98@hotmail.com

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Asian Journal of Chemistry Vol. 18, No. 2 (2006), 1231–1235

Effect of Potassium on Yield and Quality of Tomato

GHOLAMALI PEYVAST
Department of Chemistry, Guilan University, Rasht, Iran
Fax: (98)(131)7757261; Tel: (98)(131)7725326;
E-mail: peyvast@guilan.ac.ir, gpeyvast@yahoo.com

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Asian Journal of Chemistry Vol. 18, No. 1 (2006), 601–607

Effects of Some Drugs on Enzyme Activity of Catalase from Bovine Liver

SALIH ALKAN*, ALI SAVRAN, HALIT DEMIR and HASAN CEYLAN
Department of Chemistry, Science and Arts Faculty, Yuzuncu Yil University, Van, Turkey
Fax: (90)(432)2251114; Tel: (90)(432)2251026; E-mail: halitdemir@hotmail.com

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