

Effect of Purification on Sodium Chloride produced from Seawater Based on Solar Evaporation

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Abstract

The aims of this study were to evaluate the raw salt (Sodium Chloride (NaCl)) manufactured at Port Sudan and to find the effect of purifying this raw salt to conform with the international and Sudanese standards for table salt. Samples were taken from two factories: Baboud and Rwaia which produce raw salt. The samples were analyzed to determine their quality. The samples were then treated in the laboratory by washing with saturated solution of pure NaCl to remove the impurities i.e. SO_4^{2-} , Ca^{+2} , Mg^{+2} , CO_3^{2-} , Cl^- etc. The treated samples were analyzed and the results revealed that washing of the raw salt with brine must be adapted for the salt produced in Port Sudan at different factories for it is contaminated with elements that make it not conforming with the standard.

Keywords: Sodium chloride; Solar evaporation; Purification; Washing technology.

Introduction:

Sodium chloride (NaCl) was used almost exclusively as food additives and preserving substance for millennia [1-2]. Some table salts or salt premixes contain additives such as iodine, iron, niacin, riboflavin, thiamine hydrochloride or even vitamin A. These additives are meant to address varieties of health concerns and micronutrients deficiencies. Salt production is one of the most

ancient and widely distributed industries in the world. Salt may be produced by mining of solid rock deposits or by evaporation of sea water, lakes, playa and underground brines [2-3].

The physical and chemical composition of salt produced from various sources varies widely depending upon the manufacturing technique and the composition of the raw material [2].

Salt is used for multiple purposes, the chemical industry is the largest salt consumer using about 60% of the total world production. This industry converts the salt mainly into chlorine, caustic soda and soda ash needed for petroleum refining, petro chemistry, organic synthesis, glass production, etc [4-5].

Recently, the annual world production of salt exceeded 200 million tons. More than one third of the total is produced by solar evaporation of sea water or inland brines.

The Sea water having density of 3.85° contains 30.09 kg NaCl / m³ and 998.64 kg of water. 89.9% of this water needs to be evaporated before the first crystals of NaCl can be formed. Further 6.16% of water is evaporated before the brine becomes so concentrated that the evaporation slows down considerably, further evaporation would spoil the salt quality and therefore the brine (bitterns) need to be discarded, still containing 8.37 kg NaCl per original 1 m³ of sea water [4].

Although several solar salt works

exist around the globe that produce excellent salt, many others produce, salt having quality that leaves much to be done. Thus, the general perception is that solar salt is cheap but not clean, impure, containing compounds that are detrimental to most of the uses, whether in the chemical industry, as food or anything else. Particularly in the chemical industry, in chlorine and caustic electrolysis or in soda ash manufacture, impurities in salt are costly and can be even dangerous[5].

In this study aimed to evaluate the raw salt (Sodium Chloride (NaCl)) manufactured at Port Sudan and to find the effect of purifying this raw salt to conform with the international and Sudanese standard for table salt. The samples were then treated in the laboratory by washing with saturated solution of pure NaCl to remove the impurities. Chemical tests for cations, anions and heavy metals were carried out.

2. Materials and Methods:

2.1 Area of Study

Salt factories: Baboud and Rwaia in

Port Sudan: Red Sea State, Sudan.

2.2 Preparation of Samples

Salt samples were taken from two factories: Baboud and Rwaia which produce raw salt. Samples were collected in plastic containers and kept at room temperature, then cracked used for the treatment step.

2.3 Methods of salt treatment:

Baboud produced salt samples were undergone in this study treatment (washed by low concentration NaCl solution (98%) and distilled water, then filtered and after that the samples were dried at room temperature) ready for chemical tests.

2.4 Chemical tests:

2.4.1 Sodium chloride, NaCl test

Sodium chloride percentage was determined according to Mohers method 10 grams of sodium chloride were dissolved in 25 ml of distilled water. Then it titrated against silver nitrate (AgNO_3 , 0.1N) with using potassium chromate as indicator (K_2CrO_4). Percentage of NaCl can be calculated by this equation:

$$\text{Percentage of NaCl} = (A/B) * 100\%$$

Eq. 1

Where:

A: Weight of NaCl from titration.

B: Weight of sample.

2.4.2 CO_3^{-2} test:

Determination of soluble carbonate (CO_3^{-2}) by titration methods, the preparation of sample solution: 10 grams of sodium chloride were dissolved in 50 ml of distilled water. Then it titrated against dilute sulfuric acid (dil H_2SO_4 0.1 N) with Phenolphthalein as indicator (phph). The Percentage of soluble carbonate can be calculated by this equation:

$$\text{Percentage of soluble carbonate} = (((V * N)/W) * 100) \% \quad \text{Eq. 2}$$

Where as

V = volume of acid.

N = normality of acid.

W = weight of sample.

2.4.3 Determination Ca^{+2} , Mg^{+2}

In order to determine Ca^{+2} , Mg^{+2} ions: Firstly, determination moles number of Ethylene diamine tetra acetate (EDTA) which equivalent moles number of calcium and magnesium, by titration method (titrated 100 ml of sample which prepared by (20 grams of sodium chloride were dissolved

in 500 ml of distilled water.) against EDTA (0.1M) with Erochrom black T indicator. The molarity of EDTA calculated by this equation:

$$\text{Molarity of EDTA} = (\text{M/V}) * 1000$$

$$= \text{Number of calcium} + \text{Number of magnesium} \quad \text{Eq 3}$$

Where:

M: Molarity of EDTA.

V: Volume of EDTA.

Secondly, determination moles number of calcium and magnesium by gravimetric analysis, prepared sample (100 ml of sample added drops from conc. hydrochloric acid (HCl) then add ammonium oxalate ((NH₄)₂C₂O₄), after that leaving the sediment in water bath, finally it filtrated, separated and burn at a temperature 1000 °C, to turn into calcium oxide (CaO). The weight of calcium (CaO) calculated by this equation:

$$\text{weight of calcium (CaO)} = \text{Ws} * 40/56$$

Eq 4

From Eq.4 determined number of calcium moles and magnesium as in Eq.5 and Eq.6, respectively.
number of calcium moles at 1000 ml

$$= (\text{W ca} / 40) * 10 \quad \text{Eq 5}$$

$$\text{Moles of magnesium} = \text{moles of EDTA} - \text{moles of calcium} \quad \text{Eq.6}$$

Where:

Ws: Weight of sediment.

Wca: Weight of calcium.

2.4.4 SO₄-2 test:

Preparation of sample: 20 grams of sodium chloride were dissolved in 200 ml of dilute hydrochloric acid (dil HCl) (4N). Then the sample was undergone to burning process (used furnace at 800 – 900 °C for 2h). The Percentage of SO₄-2 calculated by this equation:

$$\text{Percentage of SO}_4\text{-2} = ((\text{Wr}/\text{Ws}) * (\text{Mw SO}_4\text{-2} / \text{Mw BaSO}_4)) \%$$

Eq. 3

Where:

Wr: weight of residue.

Ws: weight of sample.

Mw: Molecular weight. [6]

2.4.5 Heavy metals test:

Was determined percentage of lead (Pb) and copper (Cu) by Atomic Absorption Spectroscopy (A A S)

Shimadzu flame atomic absorption model; A.A.A 160 [7].

Results and Discussion

The results of chemical test such as: percentage of cation and anion ions (Ca^{+2} , Mg^{+2} , CO_3^{-2} , SO_4^{-2}) for raw salt (Baboud and Rwaia samples) as shown in Fig.1. Noticed variable percentage of cation and anion ions between raw salt (Baboud and Rwaia samples) compared with Sudanese standard [8]. The percentage of Ca^{+2} is higher in Baboud raw salt than Rwaia raw

salt, due to the separated part of calcium element as calcium sulfate (Gypsum) in precipitation step [9], but in Rwaia raw salt in production step the quantities of calcium mixed with table salt [10]. And also The percentage of Mg^{+2} is higher in Baboud raw salt than Rwaia raw salt, due to the production step in Baboud: the salt produced by dry method, but in Rwaia samples by wet method so probably the magnesium may be in high concentration in water which lead to rise concentration in salt.

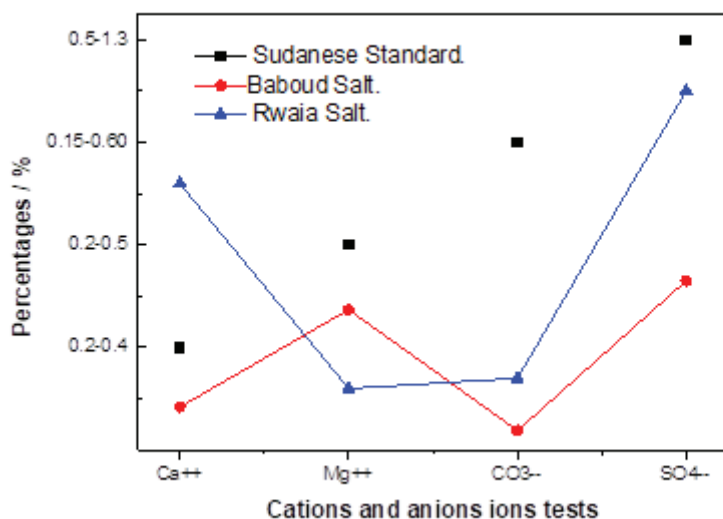


Fig.1 The percentages of cations and anions in raw salt compared with Sudanese standard.

Decreased percentage of heavy metals for raw salt (Baboud and metals in samples comparison with Rwaia samples) as shown in Fig.2 other elements. The results of heavy

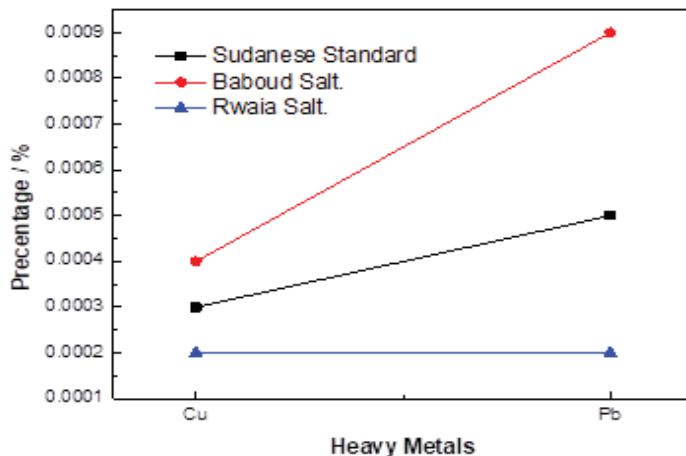


Fig.2 The percentage of heavy metals in raw salt of Baboud and Rwaia samples compared with Sudanese standard.

The percentage of NaCl for Baboud raw salt higher than Rwaia raw salt as shown in Fig.3.

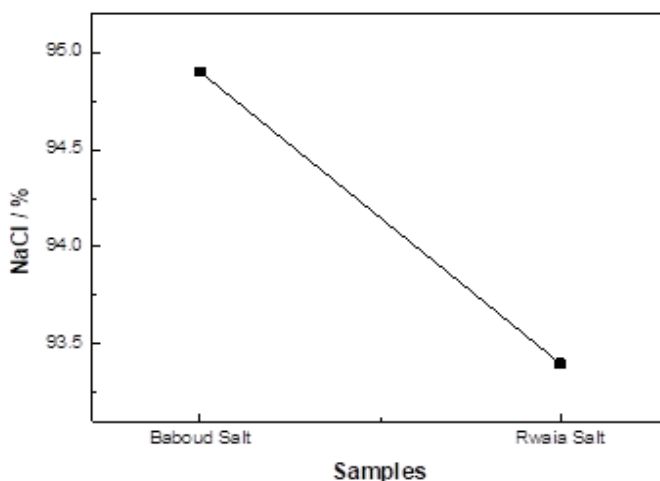


Fig.3 The percentage of NaCl for raw salt (Baboud and Rwaia samples).

Baboud produced salt samples were undergone in this study to treat (washed by low concentration of NaCl solution (98%) and distill water. The results before and after

treatment shown in Fig.4. Noticed that all cation and anion ions were decreased after treatment, due the successful treatment method.

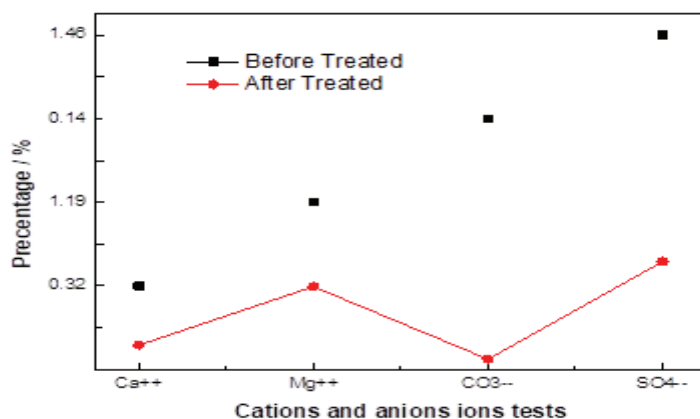


Fig.4 The percentage of cations and anions for Baboud salt before and after treatment. And also the heavy metals decreased in Baboud produced salt samples after treatment.

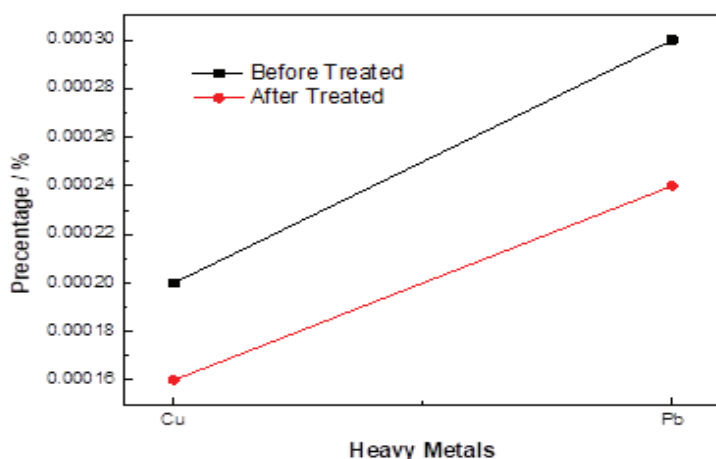


Fig.5 The percentage of heavy metals for Baboud salt before and after treatment.

Conclusion:

In order to ensure getting to pure raw salt. This study aimed to evaluate the process of purification on raw salt and compare it with international and Sudanese standards. The samples were then treated in the laboratory by washing with saturated solution of pure NaCl to remove the impurities. The results showed that washing of the raw salt with brine must be adapted for the salt produced in Port Sudan at different

factories for it is contaminated with elements that make it not conforming with the standard. Should be made salt purification before utilizing for multiple purposes.

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