Beneficiation of Salts Crystallized from Lake Katwe Brine

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Abstract

A salt extraction process to enhance the quality and quantity of salt produced at Lake Katwe in Uganda is presented. To validate the designed process, laboratory experiments were conducted. The techno-economic analysis of the process flow sheet was modeled and simulated by SuperPro Designer. Halite of purity >98% was obtained by floating burkeite and trona which co-precipitate with it during evaporation. The other feasible products of the process are soda ash and sodium sulfate. With a net present value of US$25,077,817, the proposed process is economically viable.

Keywords: Salt Extraction, Lake Katwe, Sodium Chloride, Soda Ash, Sodium Sulfate, SuperPro Designer

Introduction

In Uganda, Lake Katwe is the major source of brine containing valuable minerals (Kirabira et al. 2013). The reserve contains about 22.5 million tonnes of crystalline salts (UDC 1997). At the deposit, salt mining has been taking place since precolonial times using rudimentary methods. As a result, the mined salt is of low quality (55.8 – 94.8% halite content) (Kasedde et al. 2014) and quantity thus, fetching small prices on the market. Due to this, Uganda imports over 90% of the salt from neighbouring countries (Chopra 2020).

The government of Uganda in the 1970's established a salt processing plant which failed within a few months without posting any results (UDC 1997). The process involved heating brine by steam in a series of evaporators operating at different temperatures. Additionally, cyclones, centrifuges, and filters were employed to separate crystals from the mother liquor. The expected primary product of this process was halite with potassium chloride as the secondary product. The failure of this process could be attributed to lack of the requisite phase chemistry knowledge of the raw material that resulted in severe corrosion of the plant equipment.

Kasedde et al. (2014) characterised the raw material and determined that the brine constituted mainly Na^+, Cl^-, SO_4^{2-} , CO_3^{2-}, HCO_{3^-} with lesser amounts of K^+, Mg^{2+}, Ca^{2+}, Br^-, and F^- ions. Several thermodynamic studies followed (Kasedde et al. 2013; Lwanyaga et al. 2018, 2019b,a)with a rich source of mineral salts. The present work aims at evaluating possibilities of future salt extraction from the lake deposit. An isothermal evaporation experiment was conducted on the lake brines. The precipitated salts were characterized by X-ray diffraction (XRD that established the major evaporites as halite, burkeite, trona, and thenardite. These phase equilibrium studies have reported the mineral crystallization sequence as generally sulfate, halides and lastly carbonates. Furthermore, the evaporites co-precipitate with each other (Lwanyaga et al. 2019b,a) 40, 50, 60 and 70 and therefore, cannot be separated by simple techniques. From the above-mentioned studies, it was found that Lake Katwe brine composition is different from sea water and other notable salt lakes (e.g. Magadi, Dead