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The Selective Extraction of Magnesium Components from Bittern Using NaOH: Experimental and Pilot Scale Studies

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ABSTRACT: Due to the world rapid depletion of mineral reserves, extraction of major elements (such as magnesium, potassium, sodium and etc.) from brines and bitterns has been a matter of discussion. Although sea salts applications in diverse branches of arts and sciences, industrial and economic factors has been limiting their production. In recent work, we represented affordable extraction method for magnesium hydroxide using sodium hydroxide (NaOH) in experimental (1000 ml) and pilot (5000 L) scale studied. The laboratory research aimed to optimization critical parameters as washing time with mixed sea and fresh water, and excellent bittern density for the dosage adding NaOH. High grade and recovery can be attained in 15 min time consumption 5 ml NaOH (12/5 M), stripping rate 180 RPM, 5 level washing combining 2 liter fresh water mixing 9 liter sea water respectively, 99/7% and 46/87%. Washing process indicated classifier had unsatisfied the cycle results, but applying 3 similar polyethylene ponds Outcomes acquired very close to laboratory scale. Furthermore, pilot assessments emphasized that design of salt work effluents for 7 days conditioning is urgent and unavoidable. Also, XRD analysis in conformity with increase concentration Kainite and schoenite during the certain time.

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1- Introduction

In the not too distant future mineral reserves will be depleted. The salt work complex and brines from distillation plants have most of the components. This has led to such reserves as a potential economic valuable source taken into account. Besides of economic subject, it can dramatically reduce environmental problems. Nowadays these effluents known destructive factors for environment despite the fact that in the past were given back to the sea without any additional process. It stresses on treatment and filtration bitterns. It should be noted, due to the presence of large desalination plants and natural beaches, much of this wastewater (bittern) is produced in Persian Gulf states. In particular, magnesium is the second most abundant element in brines and, concentrated up to 40 kilograms per cubic meter. Nevertheless, little efforts for aids mineral extraction from the brine and bittern has been run out except solar salt [1-6]. On the other hand, consumption of magnesium is growing up after decades of stagnation [6]. Main reason can be found in physical and chemical properties of the element. Magnesium is in group 2 (alkaline earth metals) and it delivers the lightest structural used in industry. The metal has application in various industrial sectors such as metallurgy and automobile industries, basic refractory materials, pharmaceuticals, paper and pulp, and water and wastewater treatment industry [7-9].

Dolomite, lime, and ammonia are well-known chemical agents employed in industrial scale with spread application in the electrolysis process. However, use of these chemicals causing a serious risk of explosion or calcined in the process [2, 6]. In recent decades, sodium hydroxide (NaOH) as an alternative alkalizing agent has a wide interest for precipitation of magnesium hydroxide. It seems, the agent has a promising route despite of slow precipitation the concentrate on experimental observation [10-14].

Few data are available for optimization parameters such as retention time, the density of bittern, stripping rate, and effect of mixed washing with sea water and drinking in spite of extensive research in laboratory scale. The purpose of this study was to optimization of these parameters in the production of magnesium hydroxide process using NaOH. Identify and optimize these parameters in addition to providing fundamental data of the process, clear the way for increased scale. Furthermore, we examined a promising route in pilot scale. With this act, the accuracy of laboratory practice is tested and sketch of the process in industrial scale prepared. Besides, this research enables basis information about the improved recovery of the process.

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2- Methodology

In this section, the study area and the process of production of bittern studied first. After that, laboratory studies are carried out on sodium hydroxide. At the end, the method of conducting pilot studies is expressed. The study area located 12 km from Abadan-Mahshahr Road in the Persian Gulf.

Figure 1. The salt ponds of study area

3- Results and Discussion

In 1.26 grams per cubic centimeter, the concentration of magnesium and potassium ions increased significantly by 17.68 and 4.13 (this number is related to potassium salt), respectively while the calcium concentration decreased, which can be ignored (0.0001%). Also, the high salt content of magnesium and sodium chloride salts was 36.33 and 35.35%, respectively. These numbers were obtained based on the weight of dry precipitates of the pond basin bed. The concentration of these salts increased more than 3 times for magnesium chloride salts and more than 2 times for sodium chloride.

4- Conclusions

The brines and bitterns containing valuable minerals. Although recovery of the related minerals can be valuable, releasing these materials can cause severe environmental pollution without any special precautions. The purpose of this study was to develop a process for the extraction of solutes from bittern with a special look at the production of magnesium hydroxide. Due to 50 percent evaporation of effluent under ambient temperature, the process was valuable and reduced environment problems. The research was carried out in the laboratory and semi-industrial scales using sodium hydroxide (12.5 molar). The results of experimental included: 1) The best amount of magnesium hydroxide was obtained at 47.57 g in 15 minutes at pH 10.5. 2) The most convenient time was the addition of sodium hydroxide at a density of 1.28 grams per cubic centimeter. However, the concentration proportional to this density was not always available and increased concentrations outside this range caused the loss of soluble salts; Therefore, the economical start time of the process at a density of 1.26 grams per cubic centimeter was considered acceptable at the initial discharge state of the real state. It should be noted that the bittern in this density had a good volume of soluble ions. 3) The process was optimized with sodium hydroxide in 5 ml, which had the highest selectivity. Also, during the washing, low-stirrer stirred was useful, but the agitator should be kept within the range of 180-200 rpm. The speed of the 180 rpm was so close to propose of process, and this speed was used for mixing. 4) The use of seawater in the washing stage, in addition to easy and economical access, reduces fresh water consumption by one-third. As the optimal mode, the fourth phase was ideal and the most economical state. The recovery and grade was 99.7% and 46.87%, respectively. In addition, the results showed that the washing time has critical role and should be kept at least 10 minutes at each step. We recommended the purification steps should be 15 minutes at least.

On the other hand, the pilot scale results indicate that we must constructed additional evaporation ponds which it could containing effluents capability for one-week retention time. The reason for choosing one-week retention time was reducing the sodium concentration in bittern. Under these conditions, the magnesium concentration increased. This was perfectly compatible with the XRD results obtained from natural emulsions in the natural process, which showed an increase in the concentration of kainite and schoenite. Additionally, the evaporite minerals on the floor could increase durability of the pond. Based on conditions and the volume of bittern, we designed and constructed container with characterization: Sodium hydroxide tank (1000 ml), Bittern container reactor (5000 L), Dewatering time (5 min), retention time (5 min).

It is worth noting, the classifier system showed lower recovery (33%) than pilot reservoirs washing step (45.23%), however, no change was observed in concentrate grade in the washing stages.

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