Improvement of seawater salt quality by hydro-extraction and re-crystallization methods

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Abstract. Indonesia is one of the salt producing countries that use sea water as a source of raw materials, the quality of salt produced is influenced by the quality of sea water. The resulting average salt quality contains 85-90% NaCl. The Indonesian National Standard (SNI) for human salt’s consumption sodium chloride content is 94.7 % (dry base) and for industrial salt 98.5 %. In this study developed the re-crystallization without chemical and hydro-extraction method. The objective of this research to choose the best methods based on efficiency. The results showed that re-crystallization method can produce salt with NaCl content 99.21%, while hydro-extraction method content 99.34 % NaCl. The salt produced through both methods can be used as a consumption and industrial salt, Hydro-extraction method is more efficient than re-crystallization method because re-crystallization method requires heat energy.

1. Introduction

Indonesia is one of the salt producing countries that use sea water as a source of raw materials, Generally the salt production process through various stages of the process is the first evaporation process, the second evaporation process, the concentration process and the crystallization process. In salt production process, besides producing salt also produced the liquid remaining crystallization called bittern. The quality of the salt produced is influenced by the quality of seawater, process and technology applied. The salt produced in Indonesia has quality average contains 85-90% NaCl. Those salt quality are still below of the Indonesian National Standard (SNI) for human salt’s consumption sodium chloride content is 94.7 % (dry base) [1] and for industrial salt 98.5 % [2]. Based on the quality of the resulting salt and the salt requirements for human salt’s consumption and the industrial salt, a process is required for the salt produced to occupy the requirements. There are several methods for improving the quality of salt included physical and chemical methods, physical method is a method for improving the quality of salt without addition of chemicals such as hydro-extraction and evaporation (re-crystallization) methods [3] and chemical method is added chemicals such as sodium carbonate (Na2CO3), sodium hydroxide (NaOH), barium chloride (BaCl2), calcium hydroxide (Ca(OH)2), calcium chloride (CaCl2) and other [4].

The hydro-extraction process is an extraction process or a separation of a component which is in a solid phase by a liquid phase as a solvent. In this case, the salt is the solid phase and the salt solution as the solvent. The performance of the hydro-extraction process is influenced by the size of the salt, the concentration of the salt solution as a solvent and extraction time [9]. The re-crystallization process is a process of salt quality improvement through re-crystallization, in this case the salt is dissolved with water and crystallized. The performance of the re-crystallization process is affected by the temperature, and the re-crystallization time, and the re-crystallization stages [11]
Application of hydro-extraction method on improving the quality of salt can eliminate insoluble materials such as dust, soil and sand also soluble materials such as magnesium (Mg), calcium (Ca) and sulfate (SO₄), but difficult for material inner of salt because salt diameter too large, the hydro-extraction process more effective if the size of salt very small but not dissolved, size of salt in the market about 30 – 50 mesh. The re-crystallization process can eliminate soluble materials such as magnesium, sulfate, calcium and other because crystal formation and leaving little liquid containing sulfate ions such as magnesium sulfate, this is because magnesium sulfate is difficult to form crystals.

The Standard concentration for consumption salt is min 94.7% NaCl while for industrial salt is min 98.5% NaCl, SO₄ max 0.2%, Mg max 0.06, Ca max 0.1 and H₂O max 3%.

2. Materials and Method

There are 2 (two) types of seawater salt that used in this research as raw research material namely the salt type A, and type B, with difference qualities. (1) The hydro-extraction process, salt is crusher until, 5, 10, 20 and 30 mesh, extracted by saturated salt solution (360 g salt/liter), salt and saturated salt solution ratio is 1 : 3 (w/w) and mixing for 15 minutes. The salt is separated by filtration and drying. (2) The re-crystallization process, salt dissolved with water (360 g/1 liter water) and evaporated at 115 C. The evaporating process is done by one stages, salt crystal is separated by filtration. Sulfate is analyzed by gravimetric method calcium and magnesium are analyzed by titrimetric method and sodium chloride by stoichiometry.

The Improving quality of seawater salt by hydro-extraction and re-crystallization methods is presented in Figure 1.

3. Results and Discussions

The chemical composition of seawater solar salt that used in this research as raw research material are presented in the following table 1.
Table 1. Chemical composition of seawater salt

| Types of Salts | Chemical Composition of seawater salt (%) |
|---------------|-------------------------------------------|
|               | NaCl | Mg  | SO₄ | Ca  |
| Salt A        | 92.24| 0.036 | 0.465| 0.220 |
| Salt B        | 89.86| 0.35 | 0.890| 0.210 |

Table 2 shows that the seawater salt product that used as a study has a quality below the standard for consumption and industry salt. Sodium chloride (NaCl) content lower than consumption and industrial standard, sulfate (SO₄), magnesium (Mg) and calcium contents are higher than industrial standard.

**a. The effect of particle size of salt on the quality of seawater salt product**

The objective hydro-extraction method is to extract (remove) sulfate (SO₄), magnesium (Mg) and calcium contents of salt by saturated salt solution. The particle size of salt effect on the quality of seawater salt for hydro-extraction method are presented in the following figure 2, 3 dan 4.

![Figure 2](image)

**Figure 2. The effect of particle size of salt on NaCl content of the salt**

Figure 2 shows that particle size of salt affects the NaCl content of salt, for salt type A can produce salt quality could be enhanced up to consumption and industrial standard for 20 and 30 mesh particle size of salt, but for salt type B can produce salt quality could be enhanced up to consumption standard only. For salt type A has sodium chloride content 99.26 – 99.46 %.

Figure 3 shows the effect of particle size of salt on impurities for type A salt and type B salt. The result showed that particle size affects the sulfate (SO₄), magnesium (Mg), and calcium (Ca) content of salt product for both salts. The salt type A product could be enhanced up to consumption and industrial standard for 20 and 30 mesh salt size. Sulfate content 0.12%, magnesium (Mg) 0.01% and calcium 0.07%. Salt type B product could be enhanced up to consumption only because sulfate content is reached 0.31%, magnesium (Mg) 0.09% and calcium content 0.10% that are higher than industrial salt standard.
Figure 3. The effect of the particle size of salt on impurities content on (a) salt type A, and (b) type B

Figure 4 showed the effect of washing stage on NaCl concentration for particle size in the range of 5 to 30 mesh. The results of salt leaching from stage I to stage V using saturated solution repeatedly showed no significant change in NaCl concentration. However, the smallest particle size of 30 mesh produces the highest salt concentration of about 99.5%.

Figure 4. Effect of washing stage on NaCl concentration for particle size in the range of 5 to 30 mesh.

b. The effect of recrystallization on the quality of seawater salt product
The objective recrystallization method is to remove sulfate (SO₄), magnesium (Mg) and calcium contents of salt by dissolved and crystallization again or evaporation. Recrystallization in this study is proved to be able to remove impurities along with increasing NaCl concentrations from 92.24% to 99.24% for type A of salts while for type B of salts increased from 89.86% to 98.67%.

4. Conclusion
Based on the data of research results obtained from this study can be concluded several things including:
1. The quality of seawater salt as research materials has different quality, the two seawater salt samples has concentration 92.24% for salt type A and 89.86% for salt type B of sodium chloride content, including size and color.

2. The hydro-extraction method for salt type A can produce salt with the purity of sodium chloride could be enhanced up to 99.26% for particle size of salt 20 mesh and 99.53% for 30 mesh and sulfate content 0.12%, magnesium (Mg) 0.01% and calcium 0.07%. Base on NaCl and impurities content, salt product from salt type A can be used as consumption and industry salt.

3. The hydro-extraction method for salt type B can produce salt with the purity of sodium chloride could be enhanced up to 96.64% for particle size of salt 20 mesh and 97.53% for 30 mesh and sulfate content 0.31%, magnesium (Mg) 0.09% and calcium content 0.10%. Base on NaCl and impurities content, salt product from salt type B can be used as consumption salt only.

4. The evaporation or re-crystallization method for salt type A and B can improve the quality of salt. The purity of sodium chloride could be enhanced up to 99.21% for salt type A and 98.67% for salt type B. Base on NaCl and impurities content, the salt product from salt type A can be used as consumption and industry salt, and for salt type B just for consumption salt only.

5. The hydro-extraction method more efficient than re-crystallization because the hydro-extraction not need energy.

6. The solvent (saturated solution) can be used for extraction until five times before discharge.

7. Industrial salt can produced by seawater salt that has sodium chloride content more than 90%.

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5. References

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