Effect of Rawsalt Classification and F:S in Salt Purification Using Batch Hydroextraction Method

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Abstract —**Indonesia's coastline is one of the longest in the world. That is why Indonesia has a great potential for salt production and can be one of the world's salt producer. However, Indonesia is still relying on the imported salt, especially from Australia to accommodate the salt demand. Quality of the local salt has to be improved with some purification methods to get the standard quality of industrial salt because the process still using traditional method. In this research, salt purification process is done using the hydroextraction method, where the salt crystals are purified using the pure saturated salt solution in a batch reactor with different classification of salt K1, K2, K3. F:S is varied by 1:30; 1:35; 1:40; 1:45; and 1:50. The quality of the purified salt are determined based on analysis of the levels of Na^+, Ca^{2+}, and Mg^{2+}. This method can reduce 74,36% Ca^{2+} and 91,07% Mg^{2+}.**

***Keywords*—salt, purification, hydroextraction**

I. INTRODUCTION

Salt (NaCl) can be acquired from the sea, lake, ground water, and rock salt. Indonesia as an archipelagic country with a long coastline of 81,000 kilometers is the state of coastal and marine resources that have various biological and non-biological enormous. Areas of sea which is 70% of the total area of the country has a lot of potential to be used, which one of them is salt[1].

As an island nation with a very wide ocean This causes every region has the potential to produce salt. However, the standard of the national salt production still can'taccomplish the national needs. The Government had to import to accomplish the needs of the national salt.

Local salt-making process carried out by the salt farmers are still using traditional method. This kind of salt is not suitable for consumption because it didn't accomplish the quality standards for salt consumption. Local salts still have to be proceed both for household and industrial use.To produce salt with good quality, the compounds of calcium, magnesium, and sulfate must beprecipitated. In the local salt which use the total evaporation process, the highest salt concentration that can be produced relatively reach 90%[1]. These levels are still below the industry standard salt which needs salt with a purity of 98.5%,so it needs special treatment in order to produce high-quality salt

Impurities that exist in salt crystals consist of two categories, which is impurities existing on the surface of the crystal and impurities that exist inside the crystal. Impurities existing on the surface of the crystal comes from the mother liquor carried on the crystal surface during the process of separation of solids from the mother liquor.Impurities on the surface of these crystals can be separated simply by washing. The liquid used for washing must have the nature that can dissolve with impurities but do not dissolve crystalline solid[3].

The impurities inside the crystal can not be removed by washing only. One way to remove impurities in the crystals is byrecrystallization, which is dissolves the crystals and then recrystallize it back[4].This recrystallization process requires substantial heat energy to evaporate any remaining water and re-crystallized salt that has been purified.

KREBBS from Switzerland has start the salt purification technology with hydroexraction method.This technology allows the purification of salt with more efficient mass and energy transfer. This method can produce a salt with a purity of 99.8% [5]. But this technology is not developed yet in Indonesia. So this experiment conducts a preliminary study of salt purification with batch hydroextraction method.

Hydroextraction is a salt purification method which is done by contacting the saturated salt solution with the raw salt. The impurities will be removed and brought by the saturated solution, meanwhile the NaCl crystal will be restrained and settled. This method is good enough to acquire pure salt which are desired.

II. EXPERIMENTAL

In this research, salt purification will be done by batch hydroextraction, where the raw salt crystal washed by saturated pure industrial salt solution in the beaker glass.

The raw material that used in this research is local salts K1, K2, and K3 with size of -2,5+5 mesh. Hydroextraction process is done with extraction stirring of 50, 100, 150, 200, dan 250 rpm. F:S is set at 1:30; 1:35; 1:40; 1:45; dan 1:50.

The quality of raw salt and purified salt will be determined with Na^{+}, Ca^{2+}, and Mg^{2+} content analysis. Ca^{2+}dan Mg^{2+} content analysis refers to ASTM E534-98. This analysis will be done using complexometry titration. Na^{+} content analysis will be calculated by *atomic absorption spectrophotometer* (AAS).

III. RESULT AND DISCUSSION

Na^{+}, Ca^{2+}, dan Mg^{2} content in the K1, K2,K3 local salt and industrial salt must be analyzed first. Table I shows the content of K1, K2,K3 local salt and industrial salt and it's difference with the SNI.

TABLE I.
Na^{+}, Ca^{2+}, Mg^{2+} CONTENT RATIO FROM K3, K2, K1, and INDUSTRIAL SALT WITH THE SNI

Parameter	Salt Quality	Result	Industrial Salt SNI
Na^{+} (%w)*	K1	93,62	min. 98,5
	K2	92,11	
	K3	91,5	
	Industrial	98,9	
Ca^{2+} (%w)**	K1	0,84	max. 0,1
	K2	1,06	
	K3	1,8	
	Industrial	0,09	
Mg^{2+} (%w)**	K1	1,09	max. 0,06
	K2	1,73	
	K3	4,37	
	Industrial	0,06	

*) Analysis using *atomic absorption spectroscopy* (AAS)
**) Analysis using complexometry titration method

According to Table I, it shows that pure industrial salt that will used as solvent in hydroextraction process has meet the SNI, meanwhile K1, K2, and K3 salt has not meet the SNI yet according to the compared parameters. In principle, the ultimate goal to be achieved is a salt crystal of the three raw materials that have been hydroextracted would have approached the quality standards of this pure industrial salt.

Preliminary Experiment

From the variation of stirring speed (50, 100,150, 200 and 250), obtained that there is no significant diference from the content of Ca^{2+}andMg^{2+}. According to Fig. 1, the content difference of $Ca^{2+}$and Mg^{2+} is only at 0,01%. At stirring sepped of 50 rpm, the highest Ca^{2+} content is 0,29%, meanwhile at stirring speed of 250 rpm, the highest $Mg^{2+}$is 0,51%.

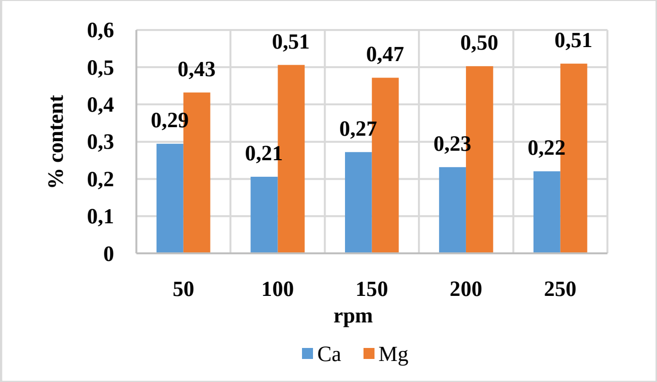

Fig. 1 Effect of stirring speed on content of Ca^{2+} and Mg^{2+}

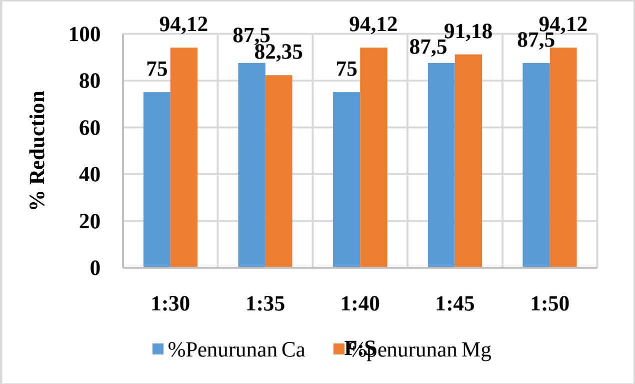

Fig. 2 Reduction of Ca^{2+} and Mg^{2+} in K1salt at various F:S

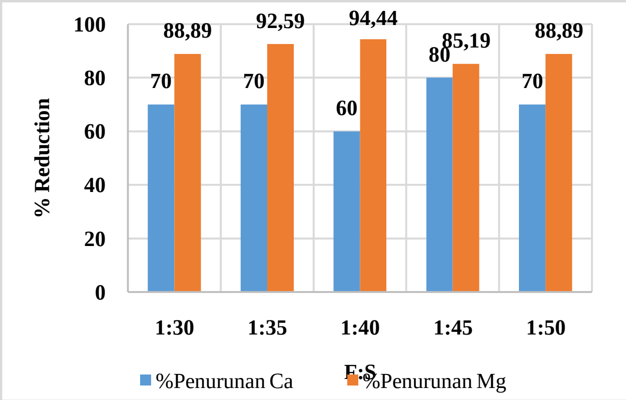

Fig. 3 Reduction of Ca^{2+} and Mg^{2+} in K2 salt at various F:S

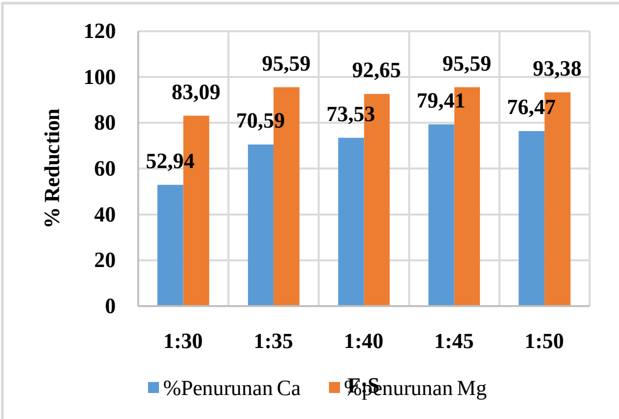

Fig. 4 Reduction of Ca^{2+} and Mg^{2+} in K3salt at various F:S

Effect of F:S on hydroextracted salt quality

Based on Fig. 2 and Fig. 3,reduction of Ca^{2+}in K1 and K2 salt after hydroextraction process can reach about 82,5% for salt K1 and 70% for salt K2. And the reduction of $Mg^{2+}$is 91,17% for salt K1 and 90% for salt K2. At Fig. 4, reduction of Ca^{2+} and Mg^{2+} in salt K3 after hydroextractionprocess is 70,58% and 92,05 %.

The content of Mg^{2+} in the raw salt is higher than Ca^{2+}. Therefore, in this series of experiments, reduction of Mg^{2+} was higher than Ca^{2+}. The higher difference content between Mg^{2+} concentration in raw salt and the pure industrial salt increased the driving force, so the easier Mg^{2+} can be removed from the raw salt. Also, the solubility Mg^{2+}that is greater than Ca^{2+} caused Mg^{2+} more soluble in thepure industrial salt.

Na^{+}in K1 and K2 salt after hydroextractionprocess reachedthe minimum value of pure industrial salt appropriate SNI (min. 98,5%). At F:S was 1:40, Na^{+} in K1 salt reached 98.64% and at F:S was 1:45, Na^{+} in K2 salt reached 98.89%

At Fig. 7, the larger F:Swas used, the higher Na^{+}will be obtained. With increasing F:S, the pure industrial salt solution that are used in hydoextraction will increase too. Therefore, more Ca^{2+} and Mg^{2+} in the raw salt can be removed and the salt after the hydroextraction process had higher purity.

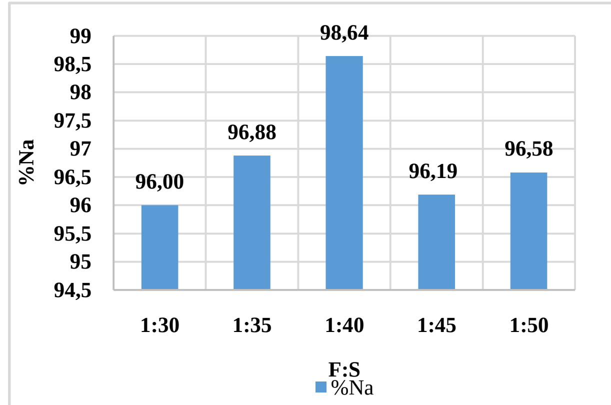

Fig. 5 Na^{+} in K1 salt after hydroextraction

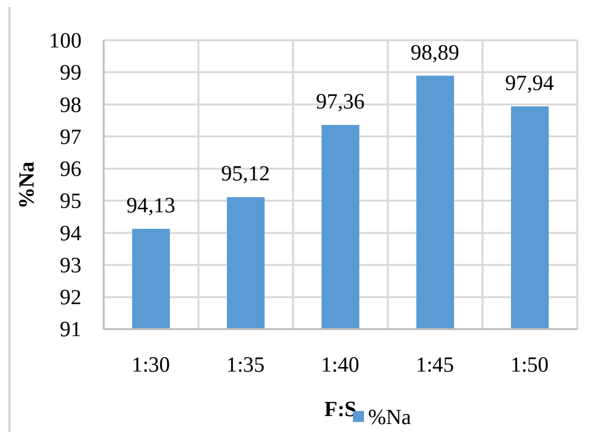

Fig. 6 Na^{+} in K2 salt after hydroextraction

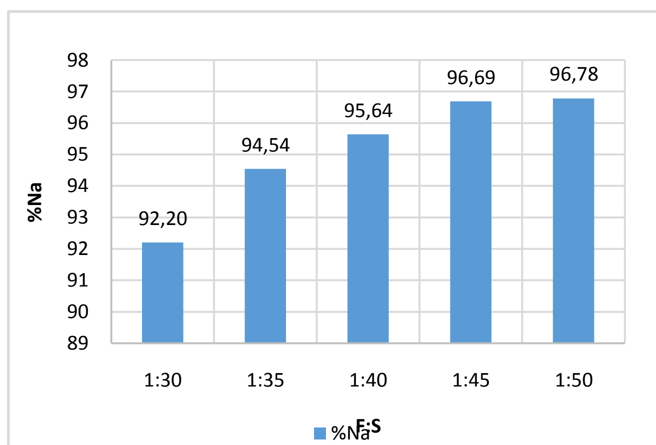

Fig. 7 Na^{+} in K3 salt after hydroextraction

Effect of Raw salt classification (K1, K2, and K3) on hydroextracted salt quality

The raw salt classified by the content of the Na^{+}, Ca^{2+}, and Mg^{2+}. The best one is the K1 salt which have the highest content of Na^+. Based on Fig. 5, Fig. 6, and Fig. 7, the highest Na^+ (98.64%) in the K1 salt after hydroextraction reached at F:S 1:40, in the K2 salt (98.89% Na^+) reached at F:S 1:45, and in the K3 salt (96.78% Na^+)reached at F:S 1:50. With increasing of quality of raw salt will decrease the pure industrial salt solution that is used to hydroextraction process.

The average reduction of Mg^{2+}in K1 salt is 91,17%, K2 salt is 90%, and K3 salt is 92,05%. K3 salt has the highest reduction of Mg^{2+} content. Mg^{2+} content in the K3 salt is the highest compared with K2 and K1, so the difference concentration between Mg^{2+} concentration in raw salt and the pure industrial salt increased the driving force. It caused Mg^{2+} can be removed more easier from K3 salt compared with K2 and K1. Also, Ca^{2+} in the K3 salt can be removed more easier from K3 salt compared with K2 and K1.

But as results, the average reduction of Ca^{2+}in K1 salt is 82,5%, K2 salt is 70%, and K3 salt is 70,58%. This shows that K1 salt has the highest reduction of Ca^{2+} content. Asit was reviewed, Ca^{2+} reduction for K3 salt should be the highest. This can be caused by the uneven impurities at each raw salt crystal.

Quality of Hydroextracted Salt

The quality of the hydroextracted salt determined with the content of Na^+, Ca^{2+}, and Mg^{2+}. Overall, the quality of the hydroextracted salt show at Table II. The highest Na^+ content (98.89%) reached at the hydroextraction process using K2 salt with F:S 1:45.

TABLE II.
Ca^{2+},Mg^{2+},and Na^+ content

Salt	**F:S**	**Ca^{2+} (%w)**	**Mg^{2+}(% w)**	**Na^+(%w)**
K1	1:30	0,21	0,06	96,00
K1	1:35	0,11	0,19	96,88
K1	1:40	0,21	0,06	98,64
K1	1:45	0,11	0,01	96,20
K1	1:50	0,11	0,06	96,58
K2	1:30	0,32	0,19	94,13
K2	1:35	0,32	0,13	95,12
K2	1:40	0,43	0,09	97,36
K2	1:45	0,21	0,26	98,89
K2	1:50	0,32	0,19	97,94
K3	1:30	0,85	0,74	92,27
K3	1:35	0,53	0,19	94,60
K3	1:40	0,48	0,32	95,36
K3	1:45	0,37	0,19	96,53
K3	1:50	0,42	0,29	96,60

From Table II, there are some Ca^{2+}dan Mg^{2+}content that has met the SNI, but all of Na^+ content has not met the SNI yet. This thing is caused by some impurities that haven't been detected at the salt crystal. Thers are two Na^+content that has met the SNI which are, Na^+ content in K1 salt at 98,64% and Na^+content at K2 salt at 98,89%.

IV. CONCLUSION

Overall, F:S effects to the salt quality. Hydroextraction process can reduce74,36% $Ca^{2+}$and 91,07% Mg^{2+}. The highest Na^+content (98,89%) acquired with the K2 salt using F:S 1:45. In the advanced experiments, multistage hydroextraction can be tried to produce better quality of hydroextracted salt. Also, the study and another research to utilize or recycle the saturated industrial salt solution.

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