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Simple processing technology for the production of consumption salt in Indonesia

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ABSTRACT

As an archipelagic country, Indonesia has a concentrated deposit of salt in Java and Madura Island. Furthermore, the total demand for the mineral in 2017, 2018, and 2019 were 3.9, 4, and 4.2 million tons, respectively. This study was carried out in 4 stages, namely identification of raw materials, crystallization, mechanical, and re-crystallization. The salt crystallization and purification process is beneficial to the aquaculture, fishery, and health sectors. The results showed that the raw materials obtained from the coastal areas of East Java and Bali Island have an average NaCl interval estimation range of 80.31% to 92.37%, which indicates that they are suitable for salt production. The product obtained from the processes have the potential to initiate diversification of business development in the country with an estimation range of 95.38% to 97.25%.

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1 Introduction

Natural salt contains Magnesium chloride, Magnesium Sulphate, Magnesium Bromide, and other trace compounds, hence, its crystal is transparent and the color ranges from yellow, red, and blue to purple. Furthermore, there is a high demand for the mineral because it is needed for survival. It is also used to increase the palatability of food as well as for preservation [1]. Salt plays an essential role in the production of foods, such as bread, cheese, sausages, meat, and fish products [2]. Several studies revealed that it is often used to reduce water activity, remove moisture [3], as well as to cure meats, cheeses, and olives [4].

[5] stated that 2.84 million tons of salt was manufactured in 2015, of which 2.5 million tons were produced from folk, while others were obtained in the form of industrial salt from PT. Garam. Meanwhile, a total of 1.09 million tons was manufactured in 2013 and, Indonesia was ranked as the 36th major producer. Furthermore, the top 3 producing countries, include the People's Republic of China (PRC), United States, and India with market shares of 25%, 15%, and 6%, respectively [6].

As an archipelagic country, Indonesia has a land area with salt deposits of 4,305,210 Ha, of which only 25.702,06 Ha (59.7%) are used as production site, as shown in Figure 1. These areas are located in 10 provinces, namely Nanggroe Aceh Darussalam, West Java, Central Java, East Java, Bali, East Nusa Tenggara, West Nusa Tenggara, South Sulawesi, North Sulawesi and Southeast Sulawesi.

2 Data and Method

2.1 Raw Material

Based on the utilization of land, only 2,570,206 Ha are used for the production of salt. The raw material of seawater and folk salt were collected randomly from six cities, including: (01) Pati, (02) Tuban, (03) Lamongan,

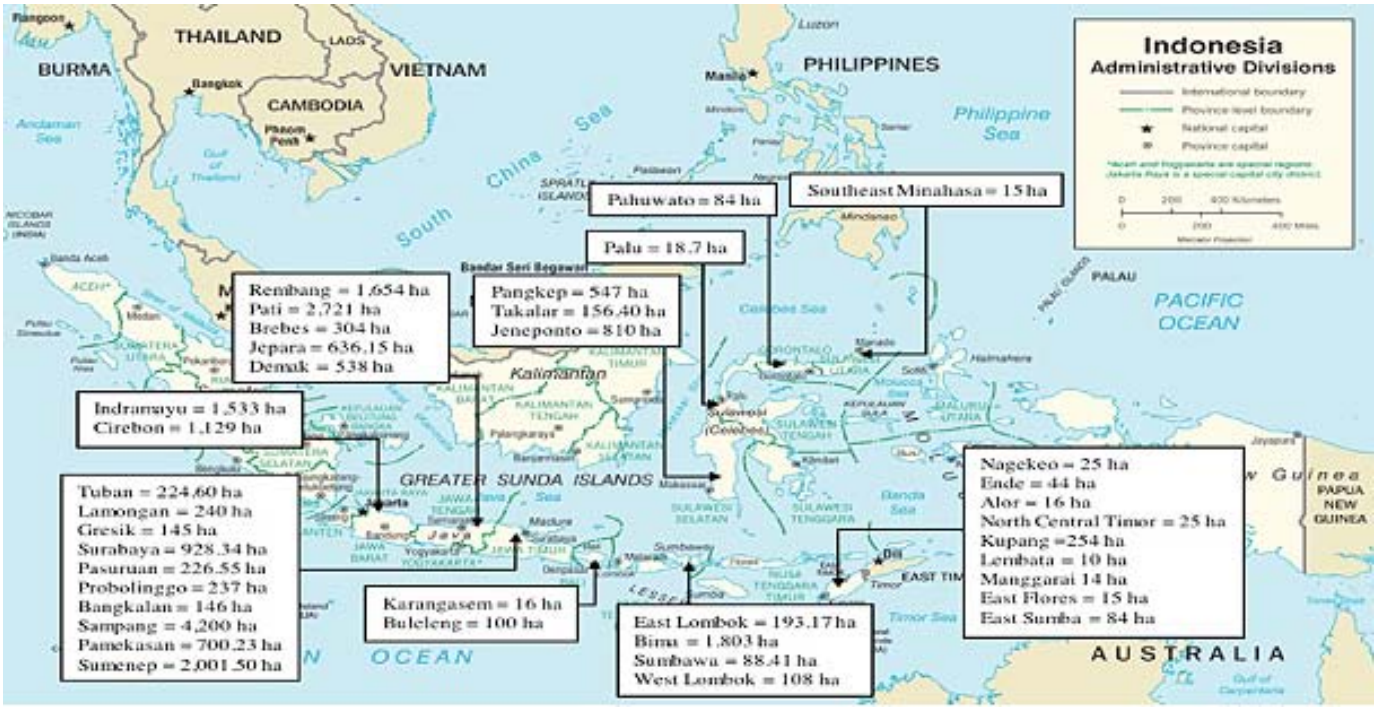

Figure 1 Salt land-based production in Indonesia

Source: KKP, 2015

Figure 2 The sample location in East Java and Bali

Source: Google Earth and Authors

(04) Gresik, (05) Surabaya, (06) Sidoarjo, (07) Sampang, (08) Pamekasan, and (09) Denpasar.

A general point location sampling was carried out in the coastal areas around Java, Madura, and Bali Islands. Furthermore, the patterns of ups and downs in the locations, include diurnal tide as well as mixed tide-prevailing diurnal and semi diurnal [7].

2.2 Crystallization and Purifying

The salt crystallization was carried out with three methods, namely Maduris, Portuguese, and Geomembrane, which used soil floor, salt floor, and Low-Density Polyethylene (LDPE)/High-Density Polyethylene (HDPE), respectively. Meanwhile, the purification technology was performed with the mechanical and re-crystallization processes.

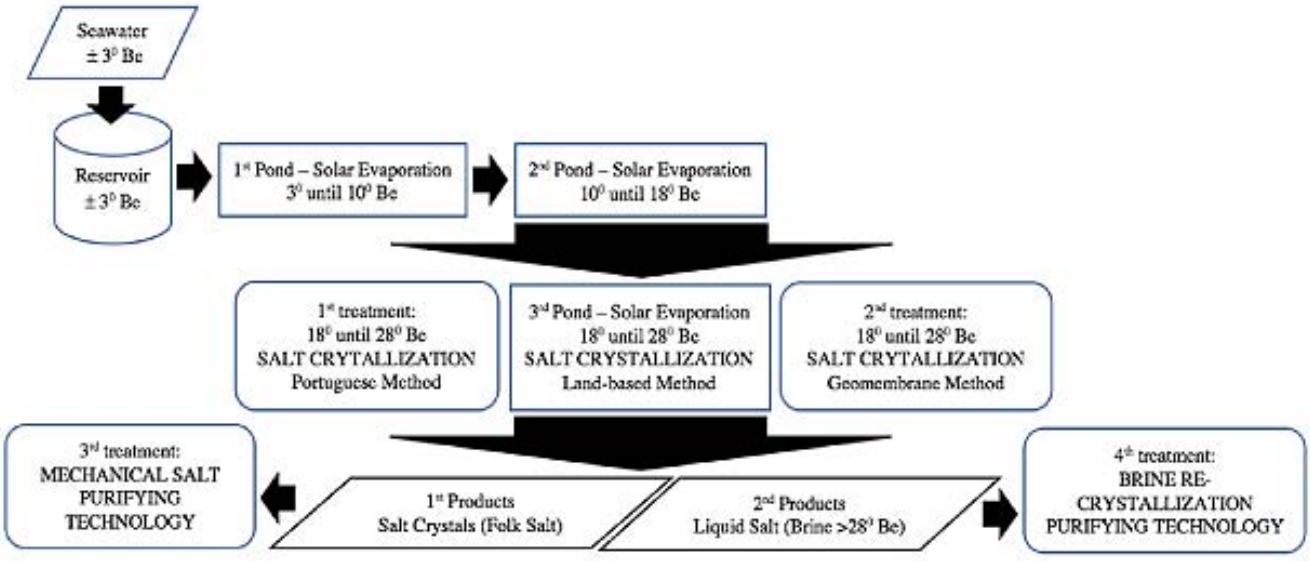

Figure 3 The concept of crystallization and purifying

Source: Authors

2.3 Statistical Analysis

Data on the NaCl content of the salt fields and purification process was analyzed using the descriptive and inferential statistical approaches [8].

$$Mean: \bar{y} = \frac{\sum_{i=1}^{n} y}{n} \quad (1)$$

$$Standard\ Deviation: s = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n-1}} \quad (2)$$

$$Estimation\ \propto = 10\%\ and\ one\ tail: \bar{y}\ \pm t_{n-1/\propto}\left(\frac{s}{\sqrt{n}}\right) \quad (3)$$

Where:

$\bar{y}$ = sample mean
Σy = sum of all data values
n = number of items in the sample
s = sample standard deviation
t = t-distribution table

3 Result and Discussion

3.1 Salt Land Based: Existing Condition

The NaCl percentage for the coastal areas of North Java and South Madura was within the standard quality range [9]. These criteria are often met in salt production using the total crystallization technology or the Maduris method, as shown in Table 1.

Table 1 showed that the average percentage of NaCl in Java and Madura was 85.94% and 85.65% with a standard deviation of 2.22 and 5.60, respectively. The average interval estimation of NaCl percentage in Java ranged from 85.08% to 86.79% with a confidence level of 90% (α = 10%), while 80.31% to 90.99% was recorded in Madura. The content found in the imported salt was more than 90%.

Table 1 Sample of maduris salt quality

No	Indonesia	Natrium Chloride (NaCl – %)	Import	Natrium Chloride (NaCl – %)
1	Pati	83.74; 79.90; 85.56	India	91.34
2	Tuban	86.71; 86.13	Australia	96.71
3	Lamongan	87.55		
4	Gresik	84.22; 82.31; 86.17; 87.0; 87.39; 86.48		
5	Surabaya	87.90; 85.54; 88.86; 88.95; 88.05; 85.12; 84.59		
6	Sidaorjo	86.51		
7	Pamekasan	76.90; 89.36; 89.54		
8	Sumenep	83.11; 89.35		

Source: Authors

3.2 Salt Land Based: The Portuguese Method

An improvement of the evaporation model was carried out on land owned by H. Amiril in Pademawu Pamekasan, Madura.

Figure 4 shows the model of multilevel seawater evaporation using the Portuguese method. The process started with the pumping of seawater into some swaths of purification to raise the density level from 3^0Be to 20^0Be. Subsequently, the water was channeled into the old swath to obtain deposits of white salt crystals and brine of 31^0Be. The Energy evaporating heat was generated from solar and wind with an open system. The average level of NaCl on the model was 92.16% with a standard deviation of 0.89. Meanwhile, the average interval estimation of NaCl percentage ranged from 91.11% to 93.21% with a confidence level of 90% (α = 10%).

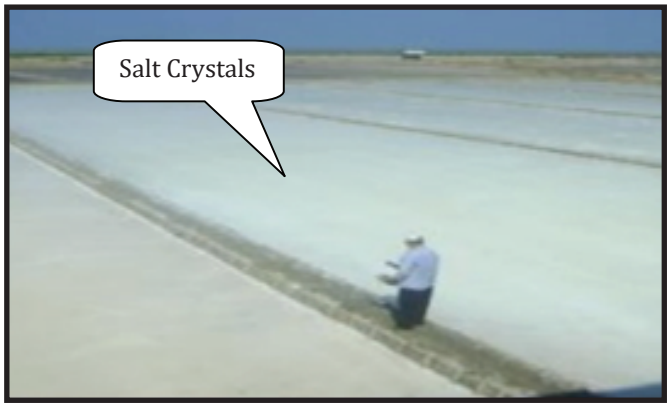

Figure 4 The salt crystallization

Source: Authors

Table 2 Salt Quality with LDPE

No	Salt Land Owner's	NaCl %
1	Hasan Suludi	91.21
2	H. Hamiah	91.78
3	H. Fathor	93.65
4	Mansur	92.02
5	H. Tohari	91.09
6	H. Andik	91.28
7	Marsial/Sujojo	92.73
8	H. Munajib	92.15
9	Supri	91.53
10	Naim	90.50
11	H. Kholik	92.14

Source: Authors

3.3 Salt Land Based: The Geomembrane Method

The condition of the land management in Surabaya showed that 86% of the areas with deposits is on lease to investors, while 14% is privately owned. Furthermore, the farmers do not have ownership of the salt produced, but it is shared in a ratio of 2:1 with the tenants. The Observations showed that 51% of the product are in quality III level, while 48% belongs to the quality II. Romokalisari has a salt production capacity of ±75 tons/hectare/season. The mineral produced has a clean white color, and it was crystallized using Low Density Polyethylene (LDPE).

Figure 5 and Table 2 showed that the average percentage of NaCl in the geomembranes technology was 91.89% with a standard deviation of 0.88. Furthermore, the average interval estimation of NaCl percentage ranged from 91.40% to 92.37% with a confidence level of 90% (α = 10%).

Figure 5 The salt crystallization in Surabaya town

Source: Authors

3.4 Salt Purifying: The Traditional Method

Figure 6 shows the raw materials obtained from circulation seawater and sand beach for the manufacture of Salt in Kusamba Bali. The chemical laboratory test conducted at Airlangga University on the product showed that it contains 96.60% NaCl and 5.18% KIO_3 with a clear white and clean appearance. This finding indicates that the salt in the area has a high quality.

Figure 6 The brine circulation sand beach and coconut tree as crystallization in Bali

Source: Authors

3.5 Salt Purifying: Mechanical Process

The first step in salt purification is known as 'brine for leaching,' which involves preparing the washing water in the brine pond with a minimum viscosity of 18 degrees Baume meter. The samples were then crushed, washed, and flushed through the Disc Mill [10] and Wash Tank [11], as shown in Figure 7.

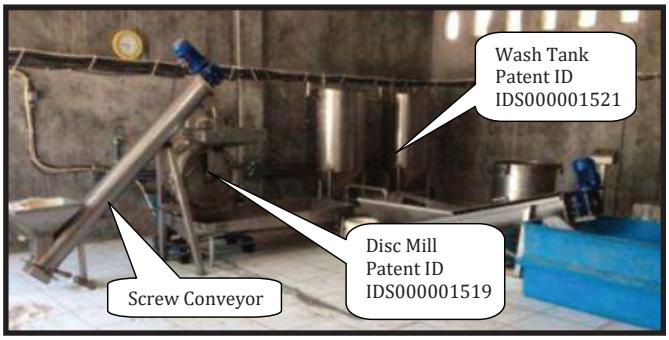

Figure 7 Disc mill and wash tank in Drajat washing plant

Source: Authors

Subsequently, the salt crystals obtained were dried using a Spinner and Rotary Drier [12], as shown in Figure 8.

Figure 8 Spinner and rotary drying in Drajat washing plant

Source: Authors

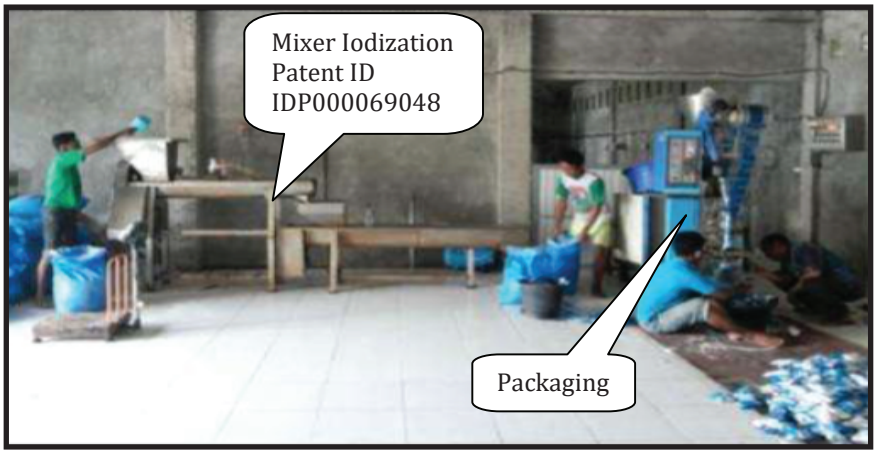

Figure 9 Iodization and packaging in Drajat washing plant

Source: Authors

Table 3 Product quality of consumption salt

No	Production	NaCl %	KIO_3 ppm
1	Batch-1	97.53	56.46
2	Batch-2	97.41	53.10
3	Batch-3	97.98	56.96
4	Batch-4	97.70	50.55
5	Batch-5	98.99	53.41
6	Batch-6	96.55	52.14
7	Batch-7	95.35	51.67
8	Batch-8	94.92	51.54
9	Batch-9	94.18	50.34
10	Batch-10	94.39	51.16
11	Batch-11	94.44	50.10

Source: Authors

The crystals were then fortified with iodine [13] followed by the packing of "Samudra" salt in a 200 grams pack, as shown in Figure 9.

Figures 7 to 9 and Table 3 showed that the average percentage of NaCl in the salt processing technology was 96.32% with a standard deviation of 1.71. Furthermore, the average interval estimation of NaCl percentage ranged from 95.38% to 97.25% with a confidence level of 90% (α = 10%). The average percentage of KIO_3 in the salt was 52.22 ppm with a standard deviation of 1.28. The average interval estimation of KIO_3 percentage ranged from 51.22 ppm to 53.77 ppm with a confidence level of 90% (α = 10%). These findings showed that all the salt products met the standards of quality criteria [14].

Table 3 shows the test result of chemistry laboratory analysis from Airlangga University for salt consumption.

3.6 Salt Purifying: Re-crystallization Process

The raw material for re-crystallization with a density of ± 28 degrees Baume meter was obtained from brine in crystallization ponds owned by H. Amiril on Jumiang beach, Sub Pademawu Pamekasan, Madura. Figure 10 shows the proc-

Figure 10 Brine re-crystallization

Source: Authors

ess, which was carried out through evaporation by solar energy using the greenhouse treatment method.

The chemistry laboratory test result from Airlangga University revealed that the salt crystals contain 92.96% NaCl, while results from Japan showed a range of 93.63% to 95.76%.

4 Conclusion

The interval estimation of NaCl percentage for Folk Salt in the North Coastal area of East Java ranged from 85.08% to 86.79% with a 90% confidence level. Meanwhile, a range of 80.31% to 90.99% was obtained in the South Coastal area of Madura. The NaCl content of salt produced with the Portuguese method in Pamekasan Madura ranged from 91.11% to 93.21%, while a range of 91.40% to 92.37% was obtained from Geomembranes Technology in Romokalisari Surabaya.

The Mechanically Salt Purifying Technology, which was used to produce 200g/sachet of Samudra product, has a production capacity of 2 tons per day. This salt has a pure white color with NaCl and KIO3 content range of 95.39% to 97.25% and 51.22 ppm to 53.77 ppm, respectively, which indicates that it can be used to start a business venture. The product obtained also met the quality criteria for purification, namely NaCl > 94% and KIO_3 > 30 ppm. This result showed that the salts produced from all re-crystallization treatments had good quality and the NaCl content ranged from 90% to 97%.

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Author Contributions: Location determination and study conceptualization was carried out by Bagiyo Suwasono, while the salt quality was assessed by Nuhman Usman. The salt land parameter were obtained by Ahmad Najid and Bagiyo Suwasono, while the mechanical Process was performed by Edi Jadmiko and Bagiyo Suwasono. Recrystallization was carried out by Ahmad Najid and Bagiyo Suwasono.

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