Application of Threaded System, Rice Husk Ash Addition, Filtering, and Geomembrane to Increase Salt Production in Ambulu Village, Cirebon

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Abstract. Salt farmers in Indonesia generally carry out simple land processing to produce NaCl levels below 90\% and productivity below 80 tons/ha. Several separate efforts have been made to increase the quantity and quality of salt in traditional salt production systems. This work examines the threaded system, additive addition, and geomembrane to increase salt production in Ambulu Village, Cirebon, West Java, Indonesia. The result showed that the quality of salt increases compared to the traditional process. The quality of the salt can be improved. The traditional method of observation contains 91\% NaCl. Using a combination of Threaded applications and additives increases the NaCl content by up to 94\%. Adding Geomembrane technology from the two previous technologies resulted in salt with a NaCl content of 96\%. At the same time, the amount of salt production from Indonesia has also increased to 155 tons/ha, compared to the traditional method, which is 80-90 tons/ha.

1. Introduction
Salt produced by salt farmers in Indonesia generally uses a very simple technology and a very short harvest time. Salt of this group is priced very low, only between Rp. 150-400 per kilogram. Prices vary depending on location and season of salt. Generally, salt farmers produce KW 3 because the salt can be sold quickly to meet their daily needs. [1]. The fluctuation of people's salt production, which depends on the dry season, can be seen in the example in Cirebon Regency, one of Indonesia's main salt-producing areas [1]. In 2020 the amount of salt production only reached 2,186 tons, whereas, in the previous year, it reached 483,000 tons [1]. Monitoring to the salt farmer in Ambulu village, Losari, showed that the traditional salt industry in Cirebon still faces problems such as low NaCl content (<90\%), low selling price, and seasonal production process dependence.

Various technologies have been tried to be applied in Indonesia [1-4]. One of the technologies that has been developed is the Threaded System [5][6]. The principle of this threaded technology is threaded...
technology, which manipulates the flow to expand the evaporation surface. Flow manipulation is carried out on shallow channels to condense seawater into brine and natural filtering membranes to purify the water. These two studies found an increase in production, increasing production capacity by 30-40% compared to traditional production systems. This happens because a heat conductor exposes the embankment to solar radiation by 112% for large threads and 135% for small threads. Meanwhile, modifications to the reservoir pond resulted in land-use efficiency, from 28% of the total pond area to 75% of the total pond volume. Changes in structure and composition increase salt production to ± 200 tons/ha per harvest season [4]. Another technology is the addition of additives to increase precipitation. [7]. This technology adds a salt additive (ramsol) and proves its influence in forming salt crystals. The quality (smell, taste, color) of the salt produced is visually better. The technology tried is coating the crystallization pond with High-density Polyethylene (HDPE), or plastic Geomembrane, which may withhold the permeation of seawater into soil modifications of the traditional salt production process [8]. The modification of this geomembrane method has increased field productivity from 70,000 to 117,500 kg/year/ha.

This study aims to increase salt production by combining the three technologies above, namely Threaded System, Additive Addition, and Geomembrane in salt farming belonging to farmer groups, which have been proven to increase productivity and quality successfully. These three combination technologies were chosen due to the simplicity in application and relatively cost-efficient. Other technology, such as spray drying, is unproven and can only be applied in bigger production land. Appropriate technology for salt production with Threaded Systems, Additive Addition, and Geomembrane is carried out in an integrated manner.

2. Method
The study was done in Ambulu Village, Cirebon, West Java, with coordinate 6.8150° S, 108.8017° E as shown in Figure 1.

![Figure 1. The location of sampling of Ambulu Village, Cirebon, West Java, Indonesia.](image)

The threaded system followed the method used by Bramawanto et al. [5]. Modification of the water flow to make threads was done on the embankment using a hoe. For good results, the threaded area is hoed a little (usually because of cost problems, so it is not hoed), given husk ash, then compacted. The plot of land is designed according to the slope of the land so that the water should flow. However, if the water does not flow, it is usually done to equalize the soil before it is regulated/designed again with a sufficient slope to drain the water.
2.1 Rice Husk Ash Additive
The additive is in husk ash, which is made by burning rice husks to ashes. Husk ash is collected from several places such as tofu factories or brick-making places in Losari or Kuningan. Rice Husk ash is used as a cleaning additive. Husk ash is given to all elements (first holding pool, threaded pool, river, and crystal table). Production and application of rice husk ash follow the method mentioned by Yasin et al. [6]. Each pond/table consumes about 1/2 (half) sack of husk ash depending on the condition of the land, whether it has previously been used for salt production or not. In the threaded area, the husk ash is spread evenly, with a ratio of 2 (two) tables sprinkled with half a sack of ash. On the crystal table, the husk ash is given during the hardening process of the crystal table, namely by spreading the husk ash on the crystal table, then allowing it to dry, and hardening it with rollers.

2.2 Filtering
Filtering water was carried out by a perforated plastic bucket filled with palm fiber, coconut shells, and stones placed sequentially. The water filter is placed on each gate, that is, before the water enters the crystal table or the thread. This seawater filter aims to prevent dirt from river/estuary water from entering the crystal table or into the threaded flow. Figure 2 shows the seawater filtering in salt fields. The filtering method follows the one mentioned by Bramawanto et al. [5] and Yasin et al. [6].

![Figure 2. The making of simple seawater filter in salt fields at the preparation stage.](image)

2.3 Geomembrane
The geomembrane is used based on Susanto et al. [8] so that salt crystals are quickly formed from the seawater and do not come into contact with the soil dirt. The prepared geomembrane was spread in such a way so that it covers the soil. Land preparation is described as the following illustration:

![Figure 3. Schematic and dimensions of the crystal table with geomembrane (upper view and cross-section view).](image)
2.4 Analysis
Physical and chemical analysis were carried out on seawater, the raw materials for making salt, and salt production from several table crystals. During the salt production process, temperature and humidity were measured using a thermohygrometer. Laboratory tests were carried out at the Department of Chemical Technology Laboratory, Faculty of Engineering, University of Indonesia. Determination of NaCl (sodium chloride) levels in solid salt and seawater was carried out using modified Argentometry methods of SNI 01-3556-2010 and SNI 6989.19:2000.

3. Results and Discussion
Appropriate Technology in the Salt Production Process in Ambulu Village is modifying the conventional salt production process, which is usually done by salt farmers in Ambulu. Modification of this process This process modification was carried out on a salt pond area of + 5 Ha.

The process of land preparation, namely dividing the land for the following functions: (1) Main Reservoir Pond, (2) Drainage Pool with Large Threads, (3) Water Reservoir Pond that has passed the Large Thread, (4) Subsequent drainage pond with a small threaded, (5) Old Water Reservoir Pond, (6) Bitten Water Reservoir, (7) Crystalline Table.

The modifications made to the land preparation process are located in the sluice gate position to flow water to the crystal table. Conventionally, the sluice gate from the pond is located on one side. In that case, the water flows in a straight line. In the 'threaded' flow, the position of the sluice gate from pond to pond alternates left and right so that the direction of the water flow forms a thread, which prolongs the evaporation time.

| Sampling Point       | Control [°Be] | Threaded [°Be] | Threaded and Filter [°Be] | Threaded, Filter & Geomembrane [°Be] |
|----------------------|---------------|---------------|---------------------------|--------------------------------------|
| Intake water         | 3.27          | 3.27          | 3.27                      | 3.27                                 |
| First Pond           | 3.50          | 4.07          | 4.07                      | 4.07                                 |
| The second Pond      | --            | 7.74          | 26.09                     | 30.4                                 |
| Crystallization Pond | 30.3          | 30.4          | 30.4                      | 30.4                                 |

Table 1 shows an increase in salt content from the intake water to the first pond and second pond until salt crystals are formed in the crystallization pond. The salinity from the intake water to the first pond is relatively increased even though it is only 1 degree Baume. The increase due to the presence of Threaded is visible compared between the salt content in the control (second pond) and Threaded column. Similarly, there is a clear increase in the use of combinations. From this, it can be concluded that the use of a combination of technologies produces a very clear change in salinity/

Another modification made in improving the quantity and quality of salt production lies in the use of filters and additives as supporting components that improve the quality of the salt produced. Table 2 shows the land quality and productivity using different salt production methods.

| Samples                                      | NaCl [% w/w] | Productivity [Tons/ha] |
|----------------------------------------------|--------------|------------------------|
| Threaded Salt                                | 94.2 ± 1.2   | N/A*                   |
| Thread, Filter Rice Husk ash & Geomembrane Salt | 96.7 ± 0.8   | 155                    |
| Control (traditional method)                  | 91.3-92.4    | 90                     |

*a data not available
Salt measurements from locations around the study (table 2) showed a significant increase in yield. Laboratory test results show 91% NaCl content in conventional salt, 94% with Threaded technology and additives, 96% with threaded technology, additives, and Geomembrane. Thus, the quality of traditional salt can be increased. In the conventional process, farmers generally do not filter the water that enters the reservoir. This is one of the causes of salt production to be dirty. The filtration minimizes impurities that may be carried away by the water flow. Likewise, the use of additives has the main function of removing impurities in the salt produced.

Total salt production of 155 tons/ha also increased compared to last year (80 tons/ha) or with conventional land systems simultaneously (90 tons/ha). An increase in productivity is also in line with what was done by Yasin et al. [6]. The productivity increases to 180 tons/ha compared to the traditional method with 120 tons/ha. The basis of the traditional method has already been high, i.e., 120 tons/ha. This high productivity was due to the long production season at the time of observation [6]. However, the quality of the salt only increased to 94% NaCl.

Meanwhile, Susanto et al. [8] can produce salt of up to 98% NaCl using geomembrane. The results are almost the same as those obtained by this study, which is 97%. An increase was followed by an improvement in productivity quality up to 120 tons/ha.

4. Conclusion
The results of this test indicate an increase in the quality and quantity of salt production using a combination of technology. An almost two-fold increase in productivity occurred from 80 to 155 tons/ha. The use of rice husk ash as an additive has increased the NaCl content from 91% in conventional salt to 96% with a combination of threaded technology, additives, and geomembranes.

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