Production and Hydrochemical characteristics of brine and salt at salt production area in Pamekasan

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Abstract. The objectives of this study were to investigate the hydrochemical characteristics of local salts from three districts, namely Galis, Pademawu, Tlanakan district, and PT. Garam in Pamekasan regency. Two analyzed samples were seawater and salt. Hydrochemical parameters and chemical compositions of the main elements for seawater and its salt were investigated. The parameters for water samples were water temperature, Be, ammonia (mg/L), SO4 (mg/L). The parameter for the salt sample was NaCl purity. The sample of traditional pond brine was provided that the water temperature was in the range of 37-53°C, Be (19-27 °Be), ammonia (0.0953-0.4781 mg/L), and SO4 (22.071,0-52.360,0 mg/L). For PT Garam sample the value of temperature (41.0-43.0°C), Be (20-25 °Be), ammonia (0.1843-0.2143 mg/L), and SO4 (22.071-39.152 mg/L). The lowest NaCl score was traditional ponds (85.58), while the measuring of NaCl for PT Garam was 89.48 and 86.29%.

1. Introduction

Indonesia is an archipelago with a coastline of 81,000 km. Hence, Indonesia has potency as a salt producer. In contrast, few regions have been recognized as the leading producers of salt, namely East Java Province, especially on Madura Island. The salt production fields in Madura Island as a whole are 15,347 ha with a total production of 10,000 tons/year. While in terms of labor, which is absorbed in this work, salt farmers of Madura reach 12,567 people or 62% of the total East Java salt farmers [1]. The national salt demand increases every year. Unfortunately, the national supply can not cope with the demand [2].

In Indonesia, salt is produced mainly for consumption, and it has not touched the industrial sector [3]. Salt demand is not only for food but also non-food industry [4]. The gap between the need for salt and the capacity of national salt production has encouraged the government to import salt. The government has made a program to increase domestic salt production, especially in the national salt centers such as the district of Pamekasan, Sampang, Sumenep, Indramayu, Cirebon, Pati, Rembang, several districts in South Sulawesi, West Nusa Tenggara, and East Nusa Tenggara.

As the main production center and national salt pond land, Pamekasan District has a vital role in the success of the program. The area of the ponds in the Pamekasan Regency is 888.7 ha, which spread in three sub-districts, namely Galis, Pademawu, and Tlanakan. In the regular season, Pamekasan Regency's salt production reaches an average of 90-120 thousand tons. In 2007, 2010, and 2011 there was a weather disturbance during the production season. So that, salt production in Pamekasan Regency decreased from standard production capacity. As an illustration, in the 2010 season, due to extreme weather disturbances in the salt production season, from an area of 888.7 ha, it...
was only able to produce 225 tons of salt. Whereas, in the 2016 season, Pamekasan only managed 59,027 tons [4]. For supporting the programs, the study investigates the hydrochemical characteristics of brine and salt at PT Garam, and traditional ponds in Pamekasan was conducted.

2. Material and methods

2.1. Materials

Sampling was conducted at several locations of salt ponds in Pamekasan. Determination of sample points based on soil conditions and characteristics in each region [5]. The sample location coordinate was summarized in Table 1.

2.2. Method

Salt washing process aimed for removing impurities, and dissolve salt reducing agents. At each sample point, the measurements were taken. Temperature, Be, ammonia (mg/L), SO₄ (mg/L). In the salt samples, the measurements of NaCl (%), K (%), Ca (%), Mg (%), Al (%), Si (%), Cu (%), Cd (%), As ( %), Hg (%) were analyzed by following the standard method as explained by Desai et al. and Madaeni et al. [6,7]. The measurement results at each sample point can be seen in Table 1.

Table 1. Results of water measurement and salt content in each sample point.

| Code | Sub-District | Village   | Coordinate X | Coordinate Y | Temperature (°C) | Be (°Be) | Amoniak (mg/L) | SO₄ (mg/L) |
|------|--------------|-----------|--------------|--------------|-----------------|---------|----------------|------------|
| 1    | Tlanakan     | Branta Psr| 113.4542     | -7.2172      | 37              | 21      | 0.2037         | 38,649.5   |
| 2    | Pademawu     | Baddurih  | 113.4750     | -7.2208      | 38              | 19      | 0.1842         | 24,601.0   |
| 3    | Pademawu     | Baddurih  | 113.4924     | -7.2223      | 46              | 23      | 0.2009         | 30,588.0   |
| 4    | Pademawu     | Pagagan   | 113.4948     | -7.2258      | 42              | 24      | 0.1338         | 31,460.0   |
| 5    | Pademawu     | Pagagan   | 113.5087     | -7.2310      | 43              | 22      | 0.2247         | 28,953.5   |
| 6    | Pademawu     | Pagagan   | 113.5093     | -7.2339      | 44              | 23      | 0.2071         | 23,351.5   |
| 7    | Pademawu     | Majungan  | 113.5182     | -7.2312      | 48              | 25      | 0.1580         | 26,321.5   |
| 8    | Pademawu     | Padelengan| 113.5261     | -7.2256      | 52              | 23      | 0.2338         | 51,110.0   |
| 9    | Pademawu     | Tanjung   | 113.5364     | -7.2303      | 45              | 24      | 0.2130         | 35,656.0   |
| 10   | Pademawu     | Padelengan| 113.5236     | -7.2415      | 49              | 24      | 0.0953         | 33,204.5   |
| 11   | Pademawu     | Padelengan| 113.5262     | -7.2337      | 53              | 27      | 0.1842         | 41,238.0   |
| 12   | Galis        | Polagan   | 113.5663     | -7.1544      | 44              | 24      | 0.1872         | 33,023.5   |
| 13   | Galis        | Lembung   | 113.5610     | -7.1664      | 40              | 23      | 0.2337         | 48,290.5   |
| 14   | Galis        | Lembung   | 113.5669     | -7.1728      | 41              | 24      | 0.1964         | 50,170.0   |
| 15   | Galis        | Lembung   | 113.5697     | -7.1667      | 39              | 24      | 0.2284         | 33,739.0   |
| 16   | Galis        | Polagan   | 113.5780     | -7.1546      | 37              | 23      | 0.2119         | 35,106.0   |
| 17   | Galis        | Polagan   | 113.5755     | -7.1490      | 38              | 24      | 0.1832         | 33,723.0   |
| 18   | Galis        | Konang    | 113.5397     | -7.1683      | 40              | 25      | 0.1541         | 52,360.0   |
3. Results and discussion

3.1. Productivity and production of salt
The result of the salt productivity survey at farmers’ pond locations shows the distribution of salt productivity in each salt-center villages, as shown in Table 2. The chemical component of brine and salt on each station was summarized in Table 3.

| Code | Sub-District | Village  | Productivity (ton/Ha) | Wide (Ha) |
|------|--------------|----------|-----------------------|-----------|
| 1    | Galis        | Konang   | 94                    | 77.1      |
| 2    | Galis        | Lembung   | 95                    | 269.9     |
| 3    | Galis        | Pandan   | 94                    | 10.4      |
| 4    | Galis        | Pandan   | 95                    | 834.6     |
| 5    | Galis        | Polagan  | 95                    | 93.8      |
| 6    | Pademawu     | Baddurih | 87                    | 23.4      |
| 7    | Pademawu     | Bunder   | 94                    | 104.4     |
| 8    | Pademawu     | Bunder   | 95                    | 5.1       |
| 9    | Pademawu     | Dasok    | 94                    | 14.0      |
| 10   | Pademawu     | Majungan | 87                    | 65.1      |
| 11   | Pademawu     | Majungan | 88                    | 5.0       |
| 12   | Pademawu     | Padelegan| 88                    | 81.2      |
| 13   | Pademawu     | Pademawu Timur | 95 | 275.6 |
| 14   | Pademawu     | Pagagan  | 87                    | 6.7       |
| 15   | Pademawu     | Pagagan  | 92                    | 39.0      |
| 16   | Pademawu     | Tanjung  | 95                    | 31.4      |
| 17   | Pademawu     | Tanjung  | 101                   | 13.5      |
| 18   | Tlanakan     | Branta Pesisir | 87 | 4.9  |
| 19   | Tlanakan     | Branta Tinggi | 87 | 5.8  |
| 20   | Tlanakan     | Tlesah   | 87                    | 3.1       |

| Code | NaCl | K | Ca | Mg | Al | Si | Cu | Cd | As | Hg |
|------|------|---|----|----|----|----|----|----|----|----|
|      |      |   |    |    |    |    |    |    |    |    |

Table 2. Productivity (ton/Ha) on salt farms in each village in Pamekasan District.
Table 2 shows that salt productivity in Kecamatan Galis is high, with productivity of 94-95 tons/Ha. The highest productivity is found in Lembung, East Pandan, and Polagan Village. Salt productivity in the village can be in Konang Village, Heavy Pandan area of 94 tons/ha/year. The highest salt productivity was found in some southern capitals with a productivity of 101 tons/Ha/year. While the eastern Pmekasan regency, East Pademawu, Bunder, and Dasok have an average productivity of 94-95 tons/Ha/year. Lower salinity productivity is found in the south coastal area of Pademawu, namely Majungan, Padelegan, Pegagan, and Baddurih villages, with productivity ranging from 87 up to 88 tons/Ha/year. The distribution of salt productivity in Pamekas Regency is shown in Table 2.

Production is the result of multiplication between productivity with a land area of salt farmers. The projected salt production in each village is a multiplication of the average productivity at the village level (Table 2) with the area of land in the village.

In Kecamatan Galis the largest salt production is found in Pandan village, which reaches 80,257 tons or 65.75 percent of total salt production of Galis Subdistrict. Other large quantities of salt production are found in Lembung village, which reaches 25,644.5 tons (21.01%). Lower salt production is found in Konang village 7,246.5 (5.94%) and Polagan 8,910.2 tons (7.3%).

The largest salt production in Pademawu District is located in Pademawu Timur village 26,179.7 tons or 42.51 percent of Pademawu salt production total. Other production areas of Bunder were 10,301.1 tons (16.73%), 1,134.5 tons (2.13%), 6,097.9 tons (9.9%) padelegan 7,142.8 tons (11.60%),
Pegagan 4,173.6 tons (6.78%) and Tanjung 4,347.1 tons (7.06%). The largest salt production in Tlanakan District is located in Branta Pesisir and Branta Tinggi villages, with each village producing 425.1 tons and 507.3 tons.

Salt productivity is expressed in tons/ha/year. Productivity is an output indicator of the various factors or resources used in the production of salt [8]. Theoretically, factors affecting salt production are technical and non-technical factors. Technical factors include land carrying capacity. While the non-technical factors associated with the ability or skill of farmers in processing seawater into salt. If both factors support each other, then the number of salt farmers can increase [9]. Conversely, if one of the factors experiencing barriers, then the yield obtained by farmers is not optimal.

4. Conclusions
The best quality salt production is in the Polagan village of Galis District, with a value of NaCl salt concentration 95.35%. The highest production capacity is in Pandan village (80.257 tons), which accounted for 65.75% of the total salt production of Galis District. The chemical characteristics of salt from all areas relatively meet with the Indonesian National Standard (SNI) of salt.

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