ANALYSIS OF CHEMICAL CONTENTS IN RAW MATERIAL OF RICH MINERALS SEA SALT

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Abstract

The mineral content of seawater is a natural raw material to produce rich mineral sea salt. Rich mineral sea salt is a consumption salt with a NaCl content of <50% used to live a low sodium diet for a healthy lifestyle. In general, traditional sea salt was produced with the multistage evaporation method to obtain a NaCl content of ≥ 94.7%, whereas the production of rich mineral sea salt uses a total evaporation method and then removes the salt flower at a certain concentration to get low sodium chlorine and contain other natural minerals. This study aims to analyze the chemical content of the raw material of rich mineral sea salt. The location of seawater used as raw material for rich mineral sea salt is Camplong District, Sampang Regency. Samples were obtained from sea level with a distance of ± 400 m from the coastline and carried out during high tide conditions. The chemical analysis of seawater samples consists of Na, Mg, Ca, K, Fe, Cl^- dan SO_4^{2-}. The analysis method is based on the Indonesian National Standard of environmental quality test. The results of the major mineral analysis showed that the largest mineral content of seawater was calcium (Ca^{2+}) at 492.350±10.395 mg/L and Sodium (Na^+) at 482,000±1.979 mg/L. In contrast, the smallest mineral content is iron mineral (Fe^{2+}) of < 0.08 mg/L. These results will be used for preliminary data before producing naturally rich mineral sea salt.

Keywords: *mineral, seawater, low sodium*

Introduction

Indonesia, especially Madura Island, has the greatest maritime potential in various minerals content in seawater. Minerals such as water, carbohydrates, proteins, fats, and vitamins are found in fluids and body tissues. Minerals are inorganic substances that are important for maintaining certain physicochemical and biochemical activities such as membrane activity, enzymes, and hormone secretion (Gupta and Pedosphere, 2014). Naturally, the fulfillment of macro minerals sodium, potassium, calcium, and chlorine is more than 100 mg/day. Sodium in the body is the main cation in intracellular fluid. Simultaneously chlorine, sodium, and potassium help the movement of nerve impulses and maintain the balance of body fluids and the pH value. In addition, potassium also helps muscles contract and support normal blood pressure. The mineral calcium is often associated with healthy bones and teeth, where 99% of calcium is stored in the bones. The adult body requires 1000–1200 grams of calcium, although its absorption rate tends to decrease with age (Quintaes and Diez-Garcia, 2015).

Salt is one of the mineral sources needed by the body with the largest content of sodium chloride (NaCl > 94%) and also contains magnesium chloride ($MgCl_2$), calcium carbonate ($CaCO_3$), magnesium sulfate ($MgSO_4$), potassium chloride (KCl) and other minor compounds (Kartika *et al*., 2019). Based on the regulation of the Minister of the health of the Republic of Indonesia Number 30/2013, the limit for salt consumption per person/day is 2000 mg sodium or the equivalent of 5 grams of table salt. However, too much sodium in the blood can increase blood pressure and cause hypertension. Hypertension is a condition of blood pressure in the blood vessels increasing chronically because the heart works harder to pump blood to supply oxygen and nutrient to the body. The hypertension criteria are when the systolic blood pressure is more than 140 mmHg, and the diastolic blood pressure is more than 90 mmHg. If this condition is not controlled, it can cause heart attacks, strokes, kidney disorders, and blindness (Budijanto and Pangribowo, 2019).

Salt raw materials can be obtained from various sources to produce rich mineral sea salt. Generally, salt production is extracted from seawater (salt lakes), salt mines (mineral deposits), and saltwater in the ground (Stan-Lotter et al., 2011). The differences in the salt quality from several sources are based on the mineral contents such as cations (Na^+, Mg^{2+}, Ca^{2+}, K^+) and anions (Cl^-, SO_4^{2-}). These ions are the main constituents that arrange 99.9% of the salt (Millero *et al*., 2008). Hence, the main content of salt is not lost and is free from contaminants. Efforts are needed to obtain a source of raw salt materials that are far from the people's activities, industry, estuary, shipyards, and harbors (Naser, 2013; Baeyens *et al*., 2019; Harmesa and Cordova, 2021). The location of salt production along the coast causes heavy metal contaminants when seawater sources accept domestic and industrial waste such as organotin, mercury, arsenic, cadmium, and lead, whereby the highest concentrations are located near those locations (Delly *et al*., 2021). In addition, the consumption of contaminated salt can accumulate health problems (Bai *et al*., 2015; Manzoor *et al*., 2018; Baeyens *et al*., 2019). Hence, seawater sources used to obtain natural rich minerals sea salt should be free from contaminants and also collected during high tide condition due to the largest ion contents (Droste *et al*., 2022). The seawater source used for raw material of rich mineral sea salt production is located in Camplong District, Sampang Regency, Madura (7°13'08.8" South Latitude and 113°21'05.8" East Longitude). Camplong's climate is tropical wet and dry with temperatures ranging from 21-33^{o}C in the dry season and 22-33^{o}C in the rainy season. The seawater sample analysis consisted of the mineral content of Na^+, Mg^{2+}, Ca^{2+}, K^+, Cl^-, and SO_4^{2-}. Understanding preliminary data of minerals sea water used to produce natural rich minerals sea salt is the best knowledge to study further.

Research Methods

This research was conducted in September 2021. The sampling location point is shown in Figure 1. Seawater sampling using a water pump and carried out during high tide conditions. It aims to obtain seawater samples with the largest ion contents.

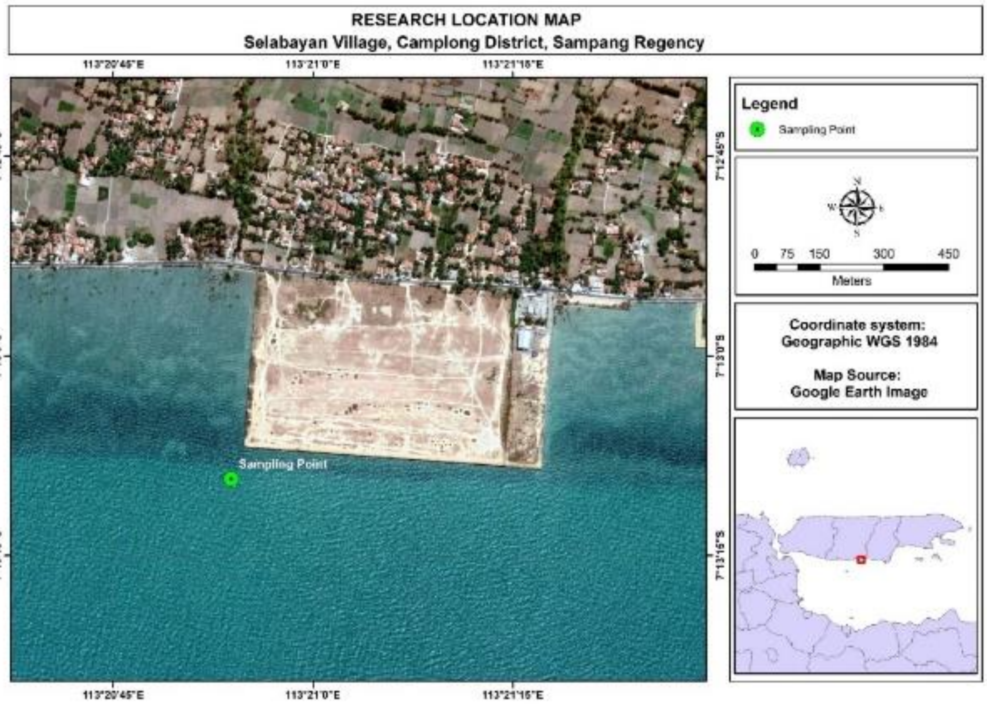

Figure 1. Map of sampling locations

Materials

The materials used were seawater samples, Whatman 42 paper, analytical grade chemicals with the Merck brand such as HCl, C_2H_2, HNO_3, NaCl, K_2CrO_4, $AgNO_3$, phenolphthalein indicator, NaOH, H_2SO_4, H_2O_2, $BaCl_2.2H_2O$, dan Na_2SO_4.

Instrumentation

The instrumentations used in this study were a water pump Honda WB30XT GX 200, Atomic Absorption Spectroscopy (Shumadzu Corp., AA-7000) with acetylene air flame complete with cathode lamps Na, Mg, Ca, K, and Fe, glassware sets (Pyrex and Iwaki), mohr method of argentometric titration and UV-Vis Spectrophotometer (Shimadzu UV-VIS 2700).

Procedure

The mineral contents analysis method is based on the SNI Catalog of Environmental Quality Testing Methods, Center for Environmental and Forestry Standardization 2020 conducted at the Research and Industrial Standardization Center – Surabaya. Metals were analyzed using Atomic Absorption Spectroscopy, namely the sodium metal (Na^+) test was carried out at SNI code 06.2428.1991; magnesium metal (Mg^{2+}) in SNI code 06-6989.55-2005; calcium metal (Ca^{2+}) in SNI code 06-6989.56-2005; potassium metal (K^+) in SNI code 6989.69:2009; and ferrous metal (Fe^{2+}) at the SNI code 6989.4:2009, while the non -metal chlorine (Cl^-) content test using argentometric method (Mohr) at the SNI code 06-6989.19-2004 and sulfate test (SO_4^{2-}) with turbidimetric method on SNI code 06-6989.20-2004.

Results and Discussion

The mineral contents (Na^+, Mg^{2+}, Ca^{2+}, K^+, Fe^{2+}, Cl^- and SO_4^{2-}) in seawater samples have been analyzed and used as raw material for rich minerals salt (Anthoni, 2006; Millero et al., 2008). The availability of these mineral content is the main content of cations and anions in seawater. Seawater used as a source of rich minerals sea salt was obtained from the sea surface at a distance of about ± 400 m from the shoreline and stored in a water sampler. Figure 2 shows the concentration of the main minerals contained in seawater in the Camplong-Sampang District. The largest mineral content of seawater is calcium (Ca^{2+}) at 492,350±10,395 mg/L and sodium (Na^{+}) at 482,000±1,979 mg/L; while the smallest mineral content is iron metal (Fe^{2+}) of < 0.08 mg/L. The abundance of calcium in seawater occurs naturally in the earth's crust and coral constituents, forming the $CaCO_3$ compound in the sea. In addition, calcium minerals source from rocks that dissolve into water, such as limestone, marble, calcite, dolomite, gypsum, fluorite, and apatite.

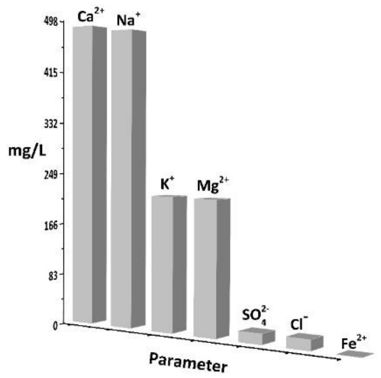

Figure 2. Mineral content analysis results

The major minerals contents in several areas are shown in table 1. The difference in mineral content in each region is influenced by the salinity of seawater. Salinity is the total amount of dissolved salt expressed in units of ppt or $^{0}/_{00}$. The greater the salt solubility, the density value or salt content in seawater is higher than in freshwater. The salinity level in the sample was tested using a refractometer and resulted in a concentration of 30 ppt. The ocean salinity level is influenced by water's physical properties, the water cycle, the ocean cycle, climate, environmental salinity, sea and land distance, and also its geomorphology (Yohannes, 2017). Water can dissolve rocks and sediments and then react with volcanoes and hydrothermal cycles in the ocean, these reactions produce complex solutions in the ocean. In addition, the ice formation through the process of condensation and evaporation increases the ocean salinity. Sodium and chloride levels in the Arabian Gulf are 1719 mg/L and 2276 mg/L, which are higher than the three regions according to table 1. Arid air conditions and most of Earth's deserts located in the Arabian Gulf Sea make a very significant evaporation rate leading to hypersaline. Salinity level in Arabian Gulf reaches 37.5 ppt (Smith *et al.*, 2007).

Table 1. Mineral content in seawater

Mineral	**Concentration (mg/L)**			
	Camplong*	**Mediterranean****	**Arabian Gulf*****	**Seoul******
Ca^{2+}	492.350±10.395	467	28	470
Na^{+}	482.000±1.979	12.282	1719	1228
K^{+}	215.850±2.899	501	51.1	500
Mg^{2+}	214.300±0.00	1423	90	1420
Fe^{2+}	<0.08	-	-	-
Cl^{-}	16.895 ± 0.021	22.011	2276	2201
SO_4^{2-}	16.900 ± 0.00	3202	368	3200

* This Research
** (Nir et al., 2014)
*** (Mustafa et al., 2013)
**** (Na and Park, 2016)

The production of rich minerals sea salt depends on the mineral content of the raw materials because the process uses the multistage evaporation method. The multistage evaporation method is the separation of minerals contained in seawater based on the seawater density which can be measured by Baume meter degree. This research is the basis for determining the process of multistage precipitation in low sodium salt production by separating the salt flower that appears at a specific concentration. Abdel, Aal (2013) investigated composition-density changes during the evaporation of seawater in Black Seawater at 25^o C. That result revealed during evaporation, salt dissolved in seawater crystallize at different concentration levels. Hussein *et al*., (2017) also explained when seawater evaporates, soluble salts are formed at various stages of the evaporation process. Crystallization of salts dissolved in seawater is determined by their solubility product and occurs at different concentration levels. As the seawater gradually concentrates, the brine concentration increases leading to the multistage precipitation of the least soluble salts first.

Conclusions

The results of the major mineral analysis showed that the largest mineral content of seawater was calcium (Ca^{2+}) of 492.350 ± 10.395 mg/L and Sodium (Na^{+}) of 482,000 ± 1.979 mg/L; while the smallest mineral content is iron mineral (Fe^{2+}) of < 0.08 mg/L. Furthermore, production of rich minerals sea salt with NaCl contents < 50% used total evaporation methods and removed salt flower at a specific concentration.

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