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Ethnomathematics: Exploration of Mathematical Concepts on the Process of Madurese Salt Production

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Abstract

The exploration of mathematical concepts as a human activity triggers the need to research ethnomathematics. This research is the analysis of fundamental activities of mathematics on the process of Madurese Salt Production in Pamekasan. This qualitative study was conducted using ethnography, and the data were obtained from conducting in-depth interviews and observations with some salt farmers. The analysis findings of fundamental activities of mathematics on the process of Madurese Salt Production are: 1) locating: choosing pond location based on the soil, water, and weather; 2) designing: designing the layout of brine pond and considering the plots based on the functions; 3) measuring: measuring the seawater concentration, the level of the water as raw materials, the thickness of salt crystals, the plots, and; 4) counting: calculating workers' wage and profit and loss; 5) playing, solving unpredictable weather to be able to be; and 6) explaining: the salt farmers shared hereditary knowledge about windmill. The results can be used as a source for the development of teaching materials in mathematics learning based on ethnomathematics on the process of Madurese salt production.

Keywords: Ethnomathematics, Madurese, Salt Production

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INTRODUCTION

Mathematics is used in science, the social science, medicine, and commerce (NCTM, 2000). The statement indicates that mathematics is fundamental for the development of other science. In daily life people calculate, find reasons, or solve problems (Ayd et al., 2014). For example, social arithmetic is used in commerce, geometry is used for the house shape, translation is used in displacement, and growth rate is used in the development concept. In short, mathematics is necessary due to most of our daily activities involve mathematics.

On the other hand, most students need a help in learning mathematics, in which it causes in low understanding of mathematical concepts, and it automatically causes student learning outcomes to be general. One of the factors is the incompatibility between what students learn at school and what they experience in daily life. The statement is supported by several studies which indicate that students frequently make mistakes in solving problems related to problems in daily life (Farida, 2015; Nuryatin & Zanthy, 2019; Utami & Effendi, 2019). Some believe that mathematics learning needs to be correlated with the contextual problems in society and what students have experienced. Then, a transformation of learning in class is a must. Furthermore, culture contributes to students' learning experience and knowledge assimilation process.

Culture is a unity and holistic from various manifestations as a result and implementation of a society. Through the reflection on sociocultural context, it is known by most students, culture enables

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them to gain the formal mathematics concept. For example, 1) students in Maluku can study geometry of several weaving patterns or other objects, such as the shape of the traditional cake, for the abstract concept (Laurens et al., 2019); 2) students in Bali can learn number pattern and modulo quickly from the tradition in their society (Darmayasa, 2016); 3) students in Semarang can learn transformation with Sam Po Kong building (Aisyah et al., 2022); 4) students in Java can learn number and geometry from farming (Pratama & Lestari, 2017).

In Madura, one of Indonesia's largest salt producer centers, salt production is distributed across four regions, i.e., Bangkalan, Sampang, Pamekasan, and Sumenep. As the area of salt producers from about mid of XIX century (after 1870) (Ricklefs, 2022), Madurese salt farmers are capable of producing salt from their antecedents (Madurese). In this case, it can be beneficial for education—specifically for mathematics learning—since the process of Madurese salt production involves mathematics-related activities. Thus, both the procedure and principles of mathematics can be used as learning sources, for example, determining the length, width, and area of the pond. Moreover, salt farmers choose the brine concentration using Hydrometer Baume; thus, they know when the brine can be streamed to the crystallized.

In other words, salt farmers incidentally used mathematical concepts in their salt production. Agriculture—one of which is salt farming—is the cultural element included in the livelihood system (Koentjaraningrat, 2011). Koentjaraningrat (2015) also asserts that social action with a humanitarian pattern is one of the elements of culture that is realized. It is in line with Bishop's Theory (1997) about the fundamental activity of mathematics is related. According to Bishop (1997), there are six fundamental mathematics activities: 1) locating—this activity is to help people decide on a suitable location for hunting, wind direction, and the location based on sky objects. Some activities found in locating are the location of a coordinate point, plotting, wind direction, and distance; 2) designing—this activity looks at shapes or patterns developing in some places. Some activities in designing are planning, abstraction, scale, similarity, congruence, shape properties, geometry shape, tiling, symmetry, and proportion; 3) measuring—this activity compares an object to another object to determine weight, volume, velocity, and time. Some of activities involved in the measurement are quantity comparison, ordering, time, volume, temperature, weight, conventional unit, standard unit, and currency; 4) counting—this activity is to help people represent an object owned by another object that has similar value. The tools used as the counter is a human body part (such as fingers), stone, and stick. Some activities found in counting are quantification, the name of numbers, using fingers and other body parts for counting, number, place value, base 10, and number operation; 5) playing—this activity shows the diversity of mathematical aspects in child's games. Some activities found in playing are puzzles, roles, paradoxes, procedures, strategies, probability, and group or individual games; and 6) explaining—this activity is to help people analyze graphic patterns, diagrams, and other activities giving direction to guide people in processing a representation manifested by the existing condition. Some activities found in explaining are classification, story explanation, symbol explanation, diagram, matrix, and mathematical modeling.

These fundamental activities of mathematics are tools to explore ethnomathematics by analyzing some mathematical activities of particular cultural groups, which then become the idea and concept of the groups. Ethnomathematics is a science that involves abstraction or mathematical concepts founded by Ubiratan D'Ambrosio (1985). Reflecting D'Ambrosio (2016) on the origin of human knowledge, he understands that every culture develops ways, styles, and techniques to do things in response to any search for explanation, understanding, and learning of a phenomenon occurs. It explains that ethnomathematics is a bridge between anthropologists and historians, and mathematic experts. Thus, it is crucial to accept mathematics in different forms (Hanik, 2017).

Basic mathematical activities have been used to analyze some activities of particular cultural groups, such as 1) traditional fishing tool making by Bintan people; 2) traditional house named Rumoh Aceh (Yudanti, 2022); 2) the process of fabric production of Shibori Tulungagungan (Puspasari, et al., 2021); 3) Srimpi Pandhèlori Dance (Pramestika & Apriani, 2021); 4) Weh-wehan tradition in Kendal (Fitriyah, 2021); and 5) Sam Poo Kong Building Heritage (Aisyah, et al., 2022). Considering the large number of articles available, no author has yet discussed the salt production process from an educational perspective, especially about mathematical concepts that can later be integrated into mathematics learning. Then, in this case, the aim of this research is the fundamental activities of mathematics of the process of Madurese salt production will be analyzed so that the exploration findings can be used as an alternative learning source and integrated into mathematic learning. As a result, mathematics learning can be more contextual since it is local wisdom-based.

METHODS

This study aims to explore the ethnomathematics of the process of Madurese salt production in terms of fundamental mathematical activities. This research is exploratory research with an ethnographic approach (Yusuf, 2017). The exploratory method is a method used to find, explore and discover a symptom or event by evaluating the symptom (Gulo, 2000; Prahmana, 2017). Meanwhile, the ethnographic approach is a research approach that seeks to describe the study of people in their cultural context (Awah, 2014; Spradley, 2016).

The cycle in this ethnographic research includes 6 (six) stages, namely: 1) selecting an ethnographic project—in this research, the project in question is exploring mathematical concepts within the scope of the Madurese salt production process; 2) posing ethnographic questions, namely how is the production process of Madurese salt; 3) ethnographic data collection—using 2 (two) methods, namely: in-depth interviews, to collect data on the process of salt production from land preparation to harvesting and the equipment used, and observation, to observe the behavior and habits of fish farmers salt when carrying out salt production activities (Denzin & Lincoln, 1994; Sugiono, 2017), 4) making ethnographic recordings, by making field notes, taking photographs, and making salt pond plans as a place to process Madura salt, 5) analysis of ethnographic data— using the Miles, Huberman, and Saldana interactive model which consists of three flow of activities components: a) data condensation, b) data presentation, and c) drawing conclusions (Miles, Huberman & Saldana, 2014). Observational data and interviews were analyzed by condensing data through grouping, focusing, processing, abstracting, and changing research data which were then presented according to the focus of the study of the problem and research objectives. Further, a conclusion was created by the form of an exploration of fundamental mathematical activities in the salt production process, then an interpretation of the mathematical concepts, procedures or principles that arise in the salt production processing the model of Miles and Huberman (1994), and 6) writing ethnographic results.

The informants in this study consisted of 6 (six) people who work as salt farmers from 3 sub-districts in Pamekasan Regency, namely Galis, Tlanakan, and Pademawu Districts. Each district was represented by two salt farmers. The three sub-districts are sub-districts that have salt ponds.

RESULTS AND DISCUSSION

Some salt production processes developed in society, such as the Madurese and Portuguese salt production. The difference between both salt production processes lies in the harvesting process. Madurese salt is processed in the soil during harvest time. Meanwhile, harvesting Portuguese salt is processed on the salt track. During its development as the impact of climate change, salt farmers tend to adopt the process of Madurese salt production by considering the possibility of producing salt in unpredictable weather since it requires a shorter time. Transcript 1 is the following interview excerpt describes the salt harvesting process.

Transcript 1. Interview about the salt harvesting process

Researcher	:	*How long does it take to harvest salt?*
Salt Farmer from Pademawu District (F1, F2)	:	*We usually harvest salt within seven days.*
Researcher	:	*Is there a unique way so that the salt is harvested faster?*
Salt Farmer from Galis District (F3)	:	*Water residue from harvesting is not thrown away, but it is mixed with new water.*

The steps of Madurese salt production began with adding brine with a salinity of around 2^o - 3.5^o Be (stands for Baume—a scale notation used on a hydrometer to measure or determine the density of a liquid) to the reservoir pond/Bozeman. Then, the suspended solid was settled in the bottom of a pond, the water as raw material was streamed to the evaporator pond. The process of production on the pond involved vaporizing water to increase the concentration level of brine up to 22^o Be through draining and drying water under the sunlight (solar evaporation). The brine from the evaporator pond was then stored in the brine pond to obtain suitable water volume and level of brine concentration which could be settled. When the water volume and level of brine concentration could reach 25° Be, the brine was drained into the crystalized pond. The process of brine sediment into salt in the crystalized pond was considered perfect and ready to be harvested when the brine had decreased, and its concentration had reached 29° Be.

The fundamental activities of mathematics based on the analysis of interview and observation results are presented.

Locating

Salt production process with high productivity will be obtained when the location of the salt pond refers to the suitability of the soil, the availability of water as raw materials, and the weather. Relating to the factor of soil, Transcript 2 is an interview with one of the salt farmers in Galis regency was as follow.

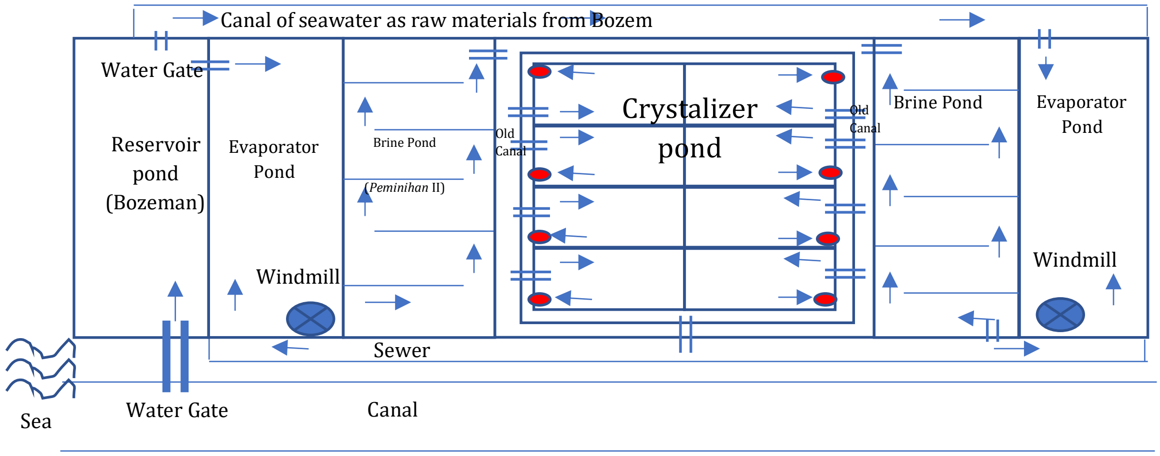
Transcript 2. Interview with salt farmer in Galis regency

Researcher	:	*Does every pond have similar level of productivity?*
Salt Farmer	:	*No, it does not. Every pond has a different level of productivity. some ponds have high productivity, and others have low productivity.*
Researcher	:	*Do you know some factors affecting the ponds so that they have different level of productivity?*
Salt Farmer	:	*Errr… yes, I do. I guess that the kind of soil, such as loose and alluvial soil. The alluvial soil has high level of productivity because the sea water as the main material can crystalize easily.*
Researcher	:	*Which Pond is suitable for accelerating sea water salinity or crystallization?*
Salt Farmer	:	*The one which is far from the sea.*
Researcher	:	*What about the pond or "bouzem"?*
Salt Farmer	:	*The one which is the nearest from the sea.*

Regarding the result of Transcript 2, it can be concluded that the farmer could define the suitable area for fulfilling some different needs, such as pond or "bouzem" located near the sea, while others are located afar from the sea. Moreover, for the results about the factors of soil, it was found that the open land, mud land, and sandy land type, could be the option for the salt pond location (Jayanthi, et al., 2021; Tambunan, et al., 2012). The sandy soil has macro pores (porous), dusty soil has meso pores (less porous), and the clay soil has micro pores (micro) and non-porous. In fact, the development of salt farm is based on the technical potency owned by each area of development. One of them is soil which has non-porous and it guarantees the availability of salt water and perfect sedimentation. Regarding the availability of water as raw materials, the salt pond location was suggested in an area where it could be reached by the tide sea and far from the estuary and residential waste. Then, regarding weather, a location with high sunlight intensity and wind gusts during the whole season with low humidity was suggested (Mahasin et al., 2020). In this case, the fundamental mathematics activities in locating were found in salt production.

Designing

The process of Madurese salt production needs some considerations for the layout and distribution based on the function. The design affects the quantity of salt production. Figure 1 shows that the salt pond is divided into some plots and canals (Guntur et al., 2018).



Source: Author's Document

Figure 1. The design of salt pond of Madurese

Figure 1 is the map of salt pond in Pamekasan, Madura. The picture describes the parts of pond based on their functions. The distribution and functions are 1) reservoir pond/Bozeman used to store brine as the raw materials; 2) evaporator pond used to evaporate water level to increase the salinity level of brine as the raw materials; 3) brine pond used to store brine; 4) crystalized pond used to settle the salt.

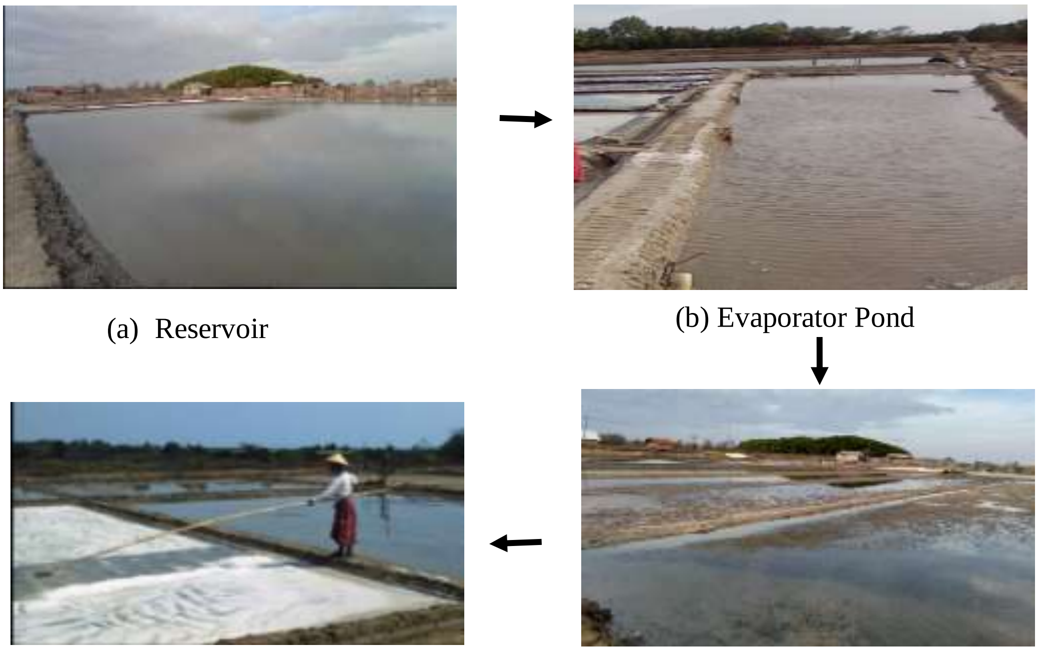
The reservoir pond was closest to the sea or the sea canal since it is used to store brine as the raw materials. The seawater from the sea/ the seawater canal streamed to the reservoir pond/Bozeman through a water gate. Then, next to the reservoir pond, an evaporator pond existed, and near the evaporator pond, a brine pond existed. A water gate was also used to stream the brine in the reservoir pond to the evaporator pond, while a windmill was used when the seawater flowed from the evaporator pond to the brine pond. The windmill was used due to the position of the brine pond, which was higher than the evaporator pond. The windmill worked by pumping the wind power. If the wind power was low, the windmill could not operate well; thereby, salt farmers had a pump machine. In this case, additional expenses were also spent on fuel. Figure 1 also shows that the evaporator pond and the brine pond were placed in two locations, i.e., on the left and right sides of the crystallizer pond. The description relates to the results of an interview with a salt farmer in Galis district (F5) and Tlanakan district as the Transcript 3.

Transcript 3. Interview with salt farmer in Galis district

Researcher	:	*In your salt pond, why are evaporator pond and brine pond located in the next to the crystallizer pond? Are there any purposes?*
Salt Farmer (F5)	:	*Yes, the purpose is to make sea water as the material flow faster to the crystallizer pond.*
Researcher	:	*Does each area have similar amount?*
Salt Farmer (F5)	:	*No. The amount of evaporator and brine pond is greater than the crystallizer pond. The reason is to save water as the material reserves.*
Researcher	:	*How many evaporators and brine pond does a crystallizer pond need to always provide sea water as the material reserves?*
Salt Farmer (F5)	:	*About two evaporator ponds dan brine ponds.*

For the canals, there were two types of canals divided into 1) the canal of seawater as raw materials (2^o-3.5^o Be), used to flow the water as raw materials from the reservoir pond to the evaporator pond; 2) the brine canal (22^o-25^o Be), used to flow water from brine pond to crystallizer pond; and 3) the sewer canal, used to flow wastewater for salt production to the evaporator pond (see Figure 1). Thus, the location of canal making needs particular consideration to avoid mixing seawater as raw materials, brine, and wastewater for salt production. In this case, some fundamental mathematics activities were found in designing the salt production process, i.e., the plan of the salt pond layout.

Besides the layout design, fundamental mathematics activities in designing are mathematical concept of the comparison. The idea was used to decide the number of evaporator ponds and brine ponds adjusted to the number of crystalized ponds. Every crystallizer pond needed two ponds, i.e., an evaporator pond and a brine pond. Then, if there are two crystallizer ponds, four ponds are required, i.e., two evaporator ponds and two brine ponds. Next, if there is crystallizer pond, there will be 2n evaporator and brine ponds.



(a) Reservoir

(b) Evaporator Pond

(d) Crystalized Pond

(c) Brine Pond

Source: Author's Document

Figure 2. Salt production process based on land requirements

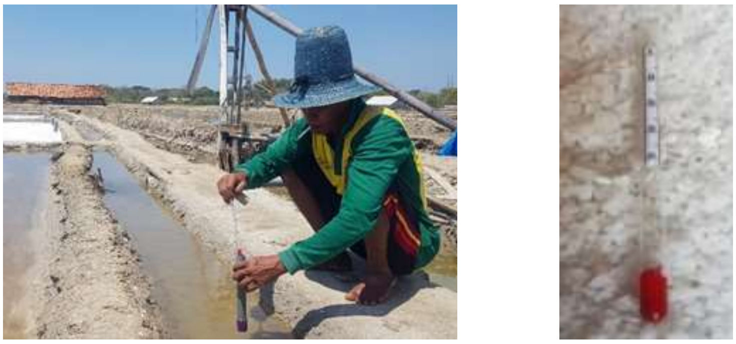
Figure 2 is the concrete picture of Figure 1 describing the layout and the functions. Moreover, it describes the process of salt production, starting from storing sear water in the reservoir pond, flowing it to the evaporator pond, brine pond, and then in the crystallizer pond.

Measuring

Measuring is comparing a quantity with a unit. Length, time, area, weight, volume, and angle can be measured using measuring tools. For instance, size can be measured using a ruler, caliper, micrometer screw, and altimeter. Based on the analysis of the interview and observation results, the fundamental activities of mathematics in measuring were found in the process of Madurese salt production, i.e., 1) measuring seawater concentration, 2) measuring the thickness of the salt crystal, and 3) measuring plot and tools.

Measuring the Sea Water Concentration

Why are the salt farms made in plots and made differently? The reason is that they depend on their functions and needs. The seawater that flowed to the crystalized pond was seawater with a particular concentration measured by Hydrometer Baume or Baumeter (Hudec & Jackson, 2012) (see Figure 3). Madurese salt farmers mostly called it "*timbangan*".



(a) (b)

Source: Author's Document

Figure 3. (a) Measuring the concentration of seawater, (b) Hydrometer Baume

The Figure 3 shows the activity of measuring sea water salinity using a tool called "timbangan" or hydrometer Baume. It is one of the daily activities in producing salt. The sooner the salinity of sea water, the faster the process of flowing sea water from a pond to another as its functions.

^{o}Be shows the level of seawater concentration–-the higher ^{o}Be of seawater, the more salt crystallization is produced (Gustiawati, 2016). The Hydrometer Baume applies the principles of Archimedes Law, stating that an object immersed in a fluid (non-solid object: fluid/ gas) will be pushed upward equal to the weight of the fluid displaced. Therefore, when Hydrometer Baume is immersed in the fluid, the fluid will return the upward force, which equals the weight of the Hydrometer Baume. Then, the Hydrometer Baume is to convert the force into the fluid's density unit.

The evaporator pond is the reservoir of seawater as the raw materials. From the evaporator pond, seawater flowed to the brine pond, i.e., the brine reservoir. The identification of seawater as raw materials and brine was based on the level of seawater concentration. Some ponds were made to distinguish the seawater concentration in the brine pond, starting from 8^{o} Be to 22^{o}-25^{o} Be. The following Transcript 4 is one of the result of data interview with a salt farmer in Galis district (F3) explaining about sea water salinity.

Transcript 4. Interview about sea water salinity

Researcher	:	*What makes evaporator pond and brine pond different? Both of them look alike.*
Salt Farmer (F3)	:	*The salinity of the sea water is different.*
Researcher	:	*How do you know the salinity of the sea water?*
Salt Farmer (F3)	:	*Using the "timbangan" (showing a tool called "timbangan", and demonstrating how to measure the salinity).*
Researcher	:	*How is the salinity of seawater for the evaporator pond?*
Salt Farmer (F3)	:	*8^{o}-21^{o} Baume.*
Researcher	:	*What about brine pond?*

Salt Farmer (F3) : *Around 22°-25° Baume. If the salinity is around 22°-25° Baume, the sea water is ready to be flowed to the crystallizer pond.*

In this case, measuring the seawater concentration was essential. If the brine concentration of the last pond in the brine pond—which was going to flow to the crystallizer could not reach 22°-25° Be, the salt crystal would be damaged (Guntur et al., 2018).

Measuring the Thickness of Salt Crystal

The Madurese salt is processed by crystalizing the seawater. The technology used is water evaporation on a wide area using sunlight (solar evaporation) (Efendy et al., 2020). Since productivity and salt quality depends on sunlight, salt farmers are worried about unpredictable rain, and the salt crystal would be damaged when it rained, causing failed harvest.

Typically, they could harvest the salt crystal on the tenth to the fifteenth day. The older the salt crystal, the thicker it is; however, brine had to be gradually added (Guntur et al., 2018). Adding no brine made the thickness of the salt crystal remains the same as measuring the last time brine was added. The following Transcript 5 is one of the results of interviewing a salt farmer Tlanakan district (F5) talking about measuring the thickness of salt before it is harvested.

Transcript 5. Interview about measuring the thickness of salt

Researcher : *"How do you know whether the crystals of salt are ready to be harvested?"*

Salt Farmer (F5) : *"By the number of days. We usually harvest it within 7 to 10 days. When it is cloudy, we will harvest it soon even though it is not 7 days."*

Researcher : *"Is there another thing that you use besides the number of days?"*

Salt Farmer (F5) : *"Yes, from the thickness of the salt. I use to measuring it using my finger. If it is sunny and the thickness of the salt is ¾ of my finger, I will harvest it."*

Therefore, they could gather the salt by considering the age of the salt and the thickness of the salt crystal.

Measuring the Land Plots and Tools

The first step of the salt production process was preparing land with accurate calculations. There were some considerations needed, i.e., 1) the area of the land provided and 2) the need for the volume of seawater as raw materials for the process of salt production. In this case, the measurement uses the standard measure, i.e., meter (m). Another preparation for the process of salt production is tools. The tools help salt farmers in the land preparation until the salt harvest. They can be seen in Figure 4.

(a) (b) (c)

(d) (e) (f)

Source: Author's Document

Figure 4. The tools of measuring the land plots (a) *Sorkot*, (b) *Glidik*, (c) *Pengais*, (d) *Geluy*, (e) *Penyatca*, (f) *Pengempo'*

Figure 4 shows the tools in producing salt based on its size and use. They are: 1) *sorkot*, a mop used to clean the membrane surface after harvesting (see Figure 4a), 2) *glidik*, a leveling and land compactor tool used to harvest the bottom of the salt crystallization pond and *lok colok gen* (the water reservoir) (see Figure 4b), 3) *pengais*, a tool to gather the sediment of salt production waste (Figure 4c), 4) *geluy*, a water leveler and salt mixer (Figure 4d), 5) *penyatca*, a salt breaker tool (Figure 4e), and (6) *pengempo' garam*, a tool to collect salt (see Figure 4f). In this case, each tool has a different length depending on its function. For instance, the size of *sorkot* is 2 m, the weight of *glidik* is 70 kg, the length of *geluy* is 6 m, the length of *pengais* is 2 m, and the size of *penyatca* is 1.5 m.

Counting

Most Madurese people do not use or mention the number using Indonesian, but Madurese. Most also tend to neglect 0 as thousands, ten thousand, and hundred thousand. Transcript 6 is the following an excerpt from an interview with salt farmers from Tlanakan District (F5) regarding the pronunciation of currency values.

Transcript 6. Interview regarding the pronunciation of currency values

Researcher : *If I come to a market in Madura, sellers use to mentioning money without using "ebu" (ebu = thousand). For instance, "due ebu" is called "due". Is it similar?*

Salt Farmer (F5) : *Yes, it is. They say "setong", "due", "telo" for thousand. "Sapolo" and "sebeles" for ten thousand. Then, "satos", "satos tong" for hundred thousand.*

In this case, the salt farmers also used the way to say the number in Madurese. In other words, they indirectly knew the value of a number by only mentioning tens, hundreds, or thousands. Table 1 shows the place value of the number used by salt farmers.

Table 1. Salt Farmers' Way to Say the Place of Value of Number

Real Number	Sounding		Place of Value
	Symbol	Verbal	
1.000	1	*Sèttong*	Thousands
10.000	10	*Sapolo*	Ten of thousands
100.000	100	*Satos*	Hundred thousand
1.000.000	1.000	*Saebuh*	Millions

Table 1 explains the actual value of money and how to pronounce it. In its pronunciation, what is interpreted as the place value of thousands is ignored. For instance, Rp 2,000 (two thousand rupiah) is pronounced 2 (*dua* or *due'*); Rp 13,000 is pronounced 13 (*tiga belas* or *telo' beles*); Rp 120,000 is pronounced 120 (*seratus dua puluh* or *satos due' polo*).

In this case, the fundamental mathematics activities in counting on the salt production process are found in the following activities.

Wage Payment

Salt farmers needed additional farmers to 1) construct canal galleys and fix the crystalized pond and evaporator and brine pond, 2) transport salt from the crystalized pond to the reservoir, 3) transport salt from the salt reservoir to the freight car when the salt was going to be sold. The description about wage payment is explained by a salt farmer from Tlanakan district (F5) in the following Transcript 7.

Transcript 7. Interview about wage payment

Researcher	:	*What kind of activities do the worker usually do?*
Salt Farmer (F5)	:	*There are some activities, such as making a canal and an embankment; repairing the evaporator, brine, and crystallizer pond to the reserves; transporting salt when it is sold. In this case, the salt is transported from salt reserves to the transportations for loading the salt.*
Researcher	:	*What about the wage payment?*
Salt Farmer (F5)	:	*It depends on the work. If the work is to make a canal and an embankment, and repairing the pond, the wage will be Rp120,000 per day. If they transport the salt, the wage depends on the agreement between the land owner and the worker. The wage can be in the form of salt, money, or both.*

1. *The reconstruction or establishment of canals, galleys, crystalized ponds, and evaporator and brine ponds.*

   The construction of canals, galleys, crystalized ponds, and evaporator and brine ponds was undertaken at the beginning of the dry season—usually in March. The number of workers depended on the land area and the finishing time, and it finished faster when more workers were hired. In this case, the worker's wage was calculated by multiplying the wage in a day by the number of employed workers and the days when they finished the work.

2. *Transporting salt from the crystalized pond to the reservoir.*

   The payment of the wage system for transporting the salt from the crystalized pond to the various reservoirs among the salt farmers depended on the deal between the workers and the salt farmers. In this study, it is found that there were two systems of wage payment systems: 1) the combination of money and salt. Stated by salt farmer from Galis Distric (F3) dan salt farmer from Tlanakan Distric (F5), the salt carriers' wage was *lema' belles* (Rp 15,000) and salt loaded in a one-wheel barrow cart (*arco*, see Figure 5) which was equal to 70 kg; 2) payment with salt loaded by two one-wheel barrow carts. The wage used the first or second payment system to transport salt for every 20 one-wheel barrow carts.

Source: www.alisson.id

Figure 5. Transportation of Salt using *Arco*

Figure 5 shows the way to transport salt traditionally using a cart called “arco”. In some cases, the cart was used as the unit of wage payment. The wage was used to be paid in 20-times-load salt. The *arco* cart was 70 kg. The agreement applies for the first or second payment system—the combination of money and salt or salt only.

3. *Transporting salt from the salt reservoir to the freight car when the salt is sold*

The expenses spent for transporting the salt were calculated per ton, and the expenses per ton depended on the distance, and the terrain traversed. Then, both workers and salt farmers made a deal. In this study, the wage per ton was *empa lema'* (Rp 45000). Concerning the fundamental activities of mathematics, some concepts were found: 1) direct proportion, found when they decided to expenses wage for the workers; 2) inverse proportion, found when the time to finish the work was faster than usual; and 3) the concept of greater than and less than, found when comparing workers' wage using the combination of money and salt system and money system. Number operation (i.e., addition and multiplication) was also included.

Profit and Loss Calculation

The salt production process is highly susceptible to failure because it depends on sunlight. If the sunlight is good, the process will be less than 10 days (normally 10 to 15 days). In that situation, salt farmers can earn more income. On the other hand, if the rainfall is high, it cannot produce salt. Rain aggravates the salt production process while it is just started; as a result, the salt production failed. The failure of harvesting caused loss for salt farmers due to the cost incurred for preparing production ponds.

In this case, social arithmetic was used as it was used to calculate profit and loss. Social arithmetic includes 1) number operation, i.e., addition, subtraction, multiplication, and division, and 2) the concept of greater than and less than, used to know profit and loss, was done by comparing the expenses and income (Abualigah et al., 2021). If the expenses are greater, loss occurs; on the other hand, profit is obtained if it is lower.

Playing

One of the fundamental activities of mathematics in playing is probability. Probability is the way to show knowledge or belief in a particular event that will or has occurred. The concept has been rigorously formulated into mathematics and is widely used in finance, science, and philosophy. In this case, the probability of an event is the number showing the likelihood of the event occurrence, which is between 0 and 1. The event has one as the probability value must be an event that will occur or has occurred (Ross, 2010; Jaynes, 2003). For instance, the sun remains rising in the east. On the other hand, the evidence has 0 as its probability value is an impossible event or will not occur. For instance, a goat bears an elephant.

As stated, salt production depends on the weather. When the weather is favorable, the harvest may succeed. On the other hand, when it is not good, the yield tends to fail. In this case, salt farmers always r elate to those probabilities. If there are no other factors except the weather, the likelihood of being successful in harvesting is 1.

Meanwhile, when the weather is unfavorable, the salt farmers' possibility of succeeding and get failed in harvesting is 1/2 for each. It is possible since rain comes unpredictably, even in the dry season. To overcome it, salt farmers began harvesting the salt crystal even though it had not been 10-15 days. As a result, besides probability, there is another fundamental activity of mathematics called strategy.

Explaining

The founder of the windmill has yet to be found. Based on Wikipedia, the oldest document about a windmill was written in Arabic in the ninth Century showing that the windmill operated on the border between Iran and Afghanistan was established some centuries ago (Bitay et al., 2021; Mishmastnehi et al., 2021). Similar to the windmill used in China, the windmill with a similar type is used to evaporate seawater to produce salt. It was used in Crimea, Europe, and the United States.

During the process of Madurese salt production, the windmill was used to flow the seawater from the lower to the higher place. The windmill used by the salt farmers was a small-scale windmill made from a wooden board with four blades with 1 m of length for each edge, and the shape of the angles is similar to a rectangle. In this case, the main components of a windmill are the rotor and blade. A rotor is a collection of edges connected to a hub and nacelle, and a rotor is the one that collects the power of energy. Although theoretically making a windmill requires mathematical modeling (Bird, 2007), that is, wind with mass "m" moving at speed "v" will produce a kinetic energy of:

$$E = \frac{1}{2} mv^2 \quad (1)$$

The fundamental activity of mathematics use refers to the tendency of explaining problems using mathematical modelling, and then it is solved using the existing rules (Pasaribu, et al, 2020). In mathematics, the modelling theory is a theory presenting mathematic concepts through the concept of sets or a theory about models which support mathematical systems. The theory of modelling begins with the assumption of the existing mathematical objects (e.g. the existence of all numbers), and then it searches and analyzes the existence of operations, relations, and axioms owned by each object or by the objects.

CONCLUSION

This study is limited to the salt production process in Pamekasan, specifically in Pademawu, Tlanakan, and Galis district. There are several fundamental mathematical activities found in the process of salt production: 1) the locating activities were found in selecting an appropriate location for the salt pond by considering the soil, water, and its fundamental mathematical activity is the Cartesian coordinate system, 2) the designing activities were found in creating a design of salt ponds and deciding the plots of ponds based on their functions weather and its fundamental mathematical activity is the concept of comparison, 3) the measuring activities were found in measuring brine concentration, water level as raw materials, the thickness of the salt crystal, and plots of pond and tools utilized and its fundamental mathematical activity is measurement and unit conversion, 4) the counting activities were found in deciding workers' wages and calculating profit and loss and its fundamental mathematical activity is social arithmetic such as profit and loss, 5) the actions of playing were found in using strategies in applying particular methods to solve unpredictable weather to harvest the salt and its fundamental mathematical activity is the concept of probability, and 6) the explaining activities were found in sharing knowledge about windmill making from generation to generation and its fundamental mathematical activity is mathematical modelling. The results can be used as a source for developing teaching materials in mathematics learning based on ethnomathematics on the process of Madurese salt production.

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