SAND SIZE ANALYSIS OF POTENTIAL SALTBEDS IN BORONGAN CITY, PHILIPPINES USING MICROSCOPIC AND SEDIMENTATION TECHNIQUE

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Abstract: Sand samples from four (4) identified areas of Borongan City were analyzed to create baseline data on the sand profile for the proposed production of salt in Eastern Samar. Physical profile of the sand was determined following different standard procedures for sand analysis. Results show that the sands are fairly different in terms of their color, but all has similar structure, consistence, density and texture. Grain size and uniformity coefficient (fineness) were also determined and computed which indicated no significant difference in terms of fineness of the grains in the four (4) different areas of Borongan City. Since all are fine sands, then it can be utilized for salt production.

Keywords: grain size analysis, fineness modulus, physical profile, sand beds, uniformity coefficient

1 Background of the Study

Where does beach sand come from, anyway? The sand found on a specific beach is created by its surroundings. It's unique to that beach—like a fingerprint. Most beaches get their sand from rocks on land. Over time, rain, ice, wind, heat, cold and even plants and animals break rock into smaller pieces. This weathering may begin with large boulders that break into smaller rocks. Water running through cracks erodes the rock. In areas where it's cold enough to freeze, water expands as it turns to ice. This forces the cracks open wider. The freeze-thaw cycle happens over and over again. Each time, gaps widen. Pieces break off. Over thousands of years they break down into smaller and smaller rocks, pebbles, and grains of sand (Castro, J., 2013).
Sand is a granular material composed of finely divided mineral particles. Sand has various compositions but is defined by its grain size. Sand grains are smaller than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type; i.e., a soil containing more than 85 percent sand-sized particles by mass (Ottawa Agriculture Canada, 2019).

The nature of Sea salt production is a reaction that separates NaCl and other impurities in seawater. Sand is used as an intermediate substance for salt crystallization. The process of making clean salt on sand includes 3 main stages: sea water supply, production of salty sand and lastly, filtration and crystallization of salt. Several experts and studies reported that this process has considerably improved salt's quality to have higher purity. Furthermore, it is also environment-friendly because no unnecessary wastes are emitted in the whole process (Thuan, N., n.d.).

A recent report by the CNN (2023) articulated that the Philippines relies heavily on the importation of salt as local production has "deteriorated" despite having one of the longest shorelines in the world, senators said Wednesday. During a hearing on the industry, Sen. Joel Villanueva said that the country's imports reached 93% of total salt requirements, while exports only amounted to more than $200,000 in 2021. Senator Cynthia Villar also pointed out that salt production in the Philippines has dropped to about 40,000 metric tons from 240,000 metric tons recorded in the 1960s and 1970s. Moreover, Villar slammed agriculture authorities present during the hearing, saying they should have provided training to farmers to learn iodization.

In Eastern Samar alone there is are no salt producers wherein there are numerous numbers of good sand bed sites wherein one can produce salt via sand intermediate, hence, this research was conducted to assess the physical profile of the sand beds around Borongan city which can be utilized for salt production and help in increasing the amount of salt produced in the country and as well as provide an iodized salt to Estehanons which follow RA 8172 or the ASIN Law of the Philippine Republic.

1.1 Objectives of the Study

1. Identify and quantify the physical properties of the sands in sand beds around Borongan City, in terms of:
   a. Color
   b. Density
   c. Texture
   d. Sand structure
   e. Sand consistence
2. Analyze the washed Grain Size and Uniformity Coefficient;
3. Determine if there is a significant difference in terms of the washed grain size analyzed from different sand beds in Borongan City.

2 Methodology

2.1 Research Design

This study utilizes the Experimental Research Design utilizing quantitative analyses in determining the physical properties of the sands collected from sand bars and beds in Borongan City as well as the sieve analysis and fineness modulus.

2.2 Locale of the Study

This study was conducted at the Chemistry Laboratory of the College of Nursing and Allied Sciences. Sand samples were collected from identified sand bars, sand beds as well as beaches in the area of Borongan City. In this study, 4 sampling locations were identified namely, Baybay, Cabong, Lalawigan and Punta Maria.

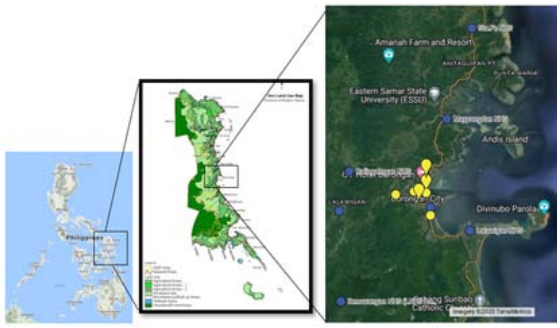

Figure 1. Location Map of Borongan City

Identified sandy beach areas as well as sand bars and beds located within the city proper of the City of Borongan served as sampling sites, all other similar areas outside the city did not form part of this study.

2.3 Data Gathering Procedures

The following step-by-step processes were utilized by this study to come up with homogenous results of data:

2.3.1 Gathering of Sand Samples

Sand samples were gathered from identified sampling sites around the city of Borongan. These samples were kept in a dry plastic container, labeled and was brought into the laboratory for sieve analysis, fineness modulus.
Representative sample from each site were gathered using Quartering Method.

2.3.1.1 Sample Inclusion

Samples included are clean sand beds around Borongan City only.

2.3.1.2 Sample Exclusion

Sand beds outside of Borongan City was not considered part of this research. Also, sand beds with high number of different types of organic and inorganic debris from the sea were not considered as sampling site.

2.3.2 Physical Properties

2.3.2.1 Color

Sand color was determined by determining the color name, utilizing the Munsell Notation, the water state and the physical state. To determine the color, the following procedure was done: Place a dry sample in the palm of your hand (this may be a finely ground sample, or a soil aggregate). With your light source behind you (light shining over your shoulder), choose a page from the Munsell color book that is close to the color of your sample. Holding the color page over the sample, move the page around to view your sample through the holes in the page. Find the closest match. When you have found a close match, determine if your sample may be redder or yellower than the color chip you have chosen; if you think it may be, go one page to the front of the book (for red) or to the back of the book (for yellow) and look at the chip with the same value and chroma. The better match color was recorded as the sands color.

2.3.2.2 Density

Density was determined by weighing 1 g of sand sample and recording its weight for density determination. Volume was determined by using the displacement of 1 g of sand. Test was conducted three (3) times using the following equation (Eq. 2). Average density was calculated.

$$density = \frac{mass}{volume}$$

Equation 1. Density Equation

2.3.2.3 Texture

To determine the texture of the sand, the analysis was done using the Flow diagram for teaching texture by feel analysis. Journal of Agronomic Education. 8:54-55 modified from S.J. Thien. (1979). Also, Texture class was determined fairly well in the field by feeling the sand particles and estimating silt and clay content by flexibility and stickiness.

2.3.2.4 Sand Structure

Sand structure is the shape that the soil takes based on its physical and chemical properties. Each individual unit of sand structure is called a ped. Take a sample of undisturbed sand in your hand (either from the pit or from the shovel or auger). Look closely at the soil in your hand and examine its structure. Possible choices of soil structure are: granular, blocky, prismatic, columnar, platy, massive and single grained.

2.3.2.5 Sand Consistence

Take a ped from the top sand horizon. If the soil is very dry, moisten the face of the profile using a water bottle with a squirt top and then remove a ped to determine consistence. (Repeat this procedure for each horizon in your profile.) Holding it between your thumb and forefinger, gently squeeze the ped until it pops or falls apart. Record one of the following categories of soil consistence on the data sheet. Sand consistence was recorded either as loose, friable, firm and extremely firm.

2.3.3 Sieve Analysis

Dry sieve analysis and washed sieve analysis are two methods of determining proportions of various particle sizes in a mineral aggregate. Standard procedures for running the sieve analysis are given in AASHTO T 27 and AASHTO T 11.

Regardless of the size of the aggregate, the procedure for running a sieve analysis is basically the same. The steps for this procedure are outlined as follows.

Obtain a representative sample of the material from the original sample by either a sample splitter or the quartering method (in this research, quartering method was used to obtain representative sample). Reduce to a size that can be handled on the balance and sieves, also, according to maximum stone size. Reference AASHTO T 27.

Quartering Method - The following method for size reduction by quartering is outlined for use when a conventional sample splitter is not available.

1. Distribute a shovel full of the aggregate as uniformly as possible over a wide, " at area on a tight weave canvas or other smooth surface. Continue to distribute shovels full of material in layers until all the sample is used to make a wide, " at pile that is reasonably uniform in thickness and diameter. Do not permit coning of the aggregate.
2. Divide the pile cleanly into equal quarters with a square-ended shovel or straight piece of sheet metal. When a canvas is used, the division may be conveniently made by inserting a thin stick (or rod) under the canvas and raising it to divide the sample equally, first into halves, then into quarters.
3. Remove two opposite quarters, including all fine materials, and set aside.
4. Repeat the foregoing procedure with the remaining portion of the aggregate until a test sample of desired size is obtained.
5. If desired, store the portion that has been set aside for possible check testing.

Dry aggregate sample thoroughly. The samples are dried to constant weight on a hot plate or in an oven at a temperature of 230°F (110ºC).

Accurately weigh the dried sample. When weighing and handling the sample, extreme care must be taken to avoid any loss of the material, as this will affect the accuracy of the results. Also, do not adjust the weight of the split sample to an even figure, such as 500 grams, 1000 grams, etc. Use the entire reduced and dried sample.

Record the total dry weight on the worksheet. For example, assume the total dry weight of the sample is 506.4 grams.

Wash the sample over a nest of two sieves, the upper or top sieve being the No.16 (1.18 mm) mesh sieve and the lower or the bottom sieve being the No. 200 (75 µm) mesh sieve. Doing this, you would take your sample, add water, to cover the material completely, add a drop of soap and wash it thoroughly being careful not to lose any of the material. Pour the water and material over the nest of sieves, the No. 16 (1.18 mm) and No. 200 (75 µm), being careful not to lose any of the material, then repeat the procedure until the water is clear.

2.3.4 Fineness Modulus

To determine the uniformity coefficient, the Fineness Modulus was calculated. Fineness Modulus is defined as an index to the particle size not to the gradation. Fineness Modulus is calculated from the sieve analysis. It is defined mathematically as the sum of the cumulative percentages retained on the standard sieves divided by 100. The standard size sieves are 6 (150 mm), 3 (75 mm), 1 1/2 (37.5 mm), 3/4 (19.0 mm), 3/8 (9.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 16 (1.18 mm), No. 30 (600 µm), No. 50 (300µm), and No. 100 (150 µm). Always report the fineness modulus to the nearest 0.01. In fineness modulus, the finer the material the more the water demand is. The F.M. of fine aggregates should not be less than 2.3 or more than 3.1, or vary by more than 0.20 from batch to batch. In terms of intermediate salt crystallization, the resulting uniformity coefficient (UC) value provides an indication of the uniformity of the sand particle sizes. A lower UC value indicates a more uniform particle size distribution, while a higher UC value indicates a wider range of particle sizes.

Fineness Modulus tells us what type of sand can be utilized for salt production, the choice between coarse or fine sand depends on the specific requirements of the process since, both coarse and fine sand can be used in different stages of salt production, and their suitability depends on factors such as filtration efficiency, water flow rate, and salt quality.

Coarse sand typically consists of larger particles and has a higher porosity. It is commonly used in the initial stages of salt production, such as in pre-filtration or as a support layer for finer sands. Coarse sand allows for faster water flow rates and efficient removal of larger impurities. It can help prevent clogging of filtration systems by providing adequate space for water movement.

On the other hand, fine sand consists of smaller particles and has a higher surface area per unit volume. It is often used in the later stages of salt production, such as in fine filtration or as a final layer to achieve higher purification levels. Fine sand can effectively capture smaller impurities and fine particles, resulting in a higher quality of salt.

It provides a larger surface area for adsorption and filtration processes, improving the overall purification efficiency. Ultimately, the selection of coarse or fine sand depends on the desired level of filtration, the specific impurities present, and the required salt quality. It is important to consider the specific requirements of the salt production process and consult industry guidelines or experts to determine the most suitable sand size for optimal performance.

Therefore, it is important that a salt bed be finer so as to yield ha high purification of the salt product.

2.4 Statistical Analysis of Data

1 – Way Analysis of Variance (ANOVA) was used to determine significant difference in terms of the washed grain size analyzed from different sand beds in Borongan City. Also, mean/average computation was used.

3 Results and Discussion

Four (4) sand samples were taken from four (4) sampling location around Borongan City which were considered for its sand beds, namely, Baybay, Lalawigan, Punta Maria and in Cabong area. The sands collected from these locations were subjected to physical characterization in terms of its color, density ,texture, sand structure, the following results were obtained.

3.1 Physical Properties

Table 1. Physical Properties of Sand Samples

Sand Samples	Color	Density (g/cc)	Texture
Baybay	Dark Gray	1.52	Sandy
Cabong	Dark Gray	1.50	Sandy
Lalawigan	Very Dark Gray	1.52	Sandy
Punta Maria	Reddish Yellow	1.53	Sandy

It can be observed based on the table above that only the sand coming from Punta Maria has a lighter coloration than those sands coming from Cabong, Lalawigan and Baybay areas. This is because the three previously observed areas are the once stretching the coastlines of Borongan City, whereas Punta Maria is situated outside the urban proper and that, it is separated from the coast due to its rocky location. This implies that the sand in Punta Maria area is lighter in color than those other 3 locales.

In terms of the samples' density, it can be seen that all the sand samples have almost identical density, only separated by a ±.01 differential. However, this data is similar to what a density of sand would be like, because the density of sand is around 1.52 g/cm^3 (Vitz, et al., n.d.). Therefore, this data coincides with the data given by Vitz et al. (n.d.).

Based on the standard identification of soil texture, all soil samples were identified as SAND. As the description, supports, when the balls of soil sample were squeezed when added with dropwise of water, it was neither too wet nor too dry indicating sandiness of the samples.

3.2 Sand structure

In terms of structure, it was generally observed that the samples coming from all the sites were SINGLE GRAINED, indicating its sandiness. This observation was further evidenced by the observation of dry samples where the individual particles that do not stick together and always have a loose consistence.

Table 2. Sand Structure and Consistence

Sand Samples	Structure	Consistence
Baybay	Single-grained	Loose
Cabong	Single-grained	Loose
Lalawigan	Single-grained	Loose
Punta Maria	Single-grained	Loose

3.3 Sand consistence

When the soil samples were observed for tis consistency, the sand samples coming from all the areas were considered to be LOOSE, in terms of sand consistence. Loose consistence is generally observed for samples with single grained structure including sand.

3.4 Washed Grain Size and Fineness

Using a set of sieves of various pore size, the grain size of the sand coming from all sampling areas were determined via sieve analysis and calculations, the result of the computation which was taken from https://www.geoengineer.org/education/laboratory-testing/step-by-step-guide-for-grain-size-analysis#selected-topics (n.d.) was then interpreted to determine what type of sand is present for every area sampled.

Table 3. Average Grain Size of the Sand Samples

Sand Samples	Average Particle Size	Sand Type	Fineness Grade	Interpretation
Baybay	0.293	Fine	3	Poor/ Uniformly Grade
Cabong	0.283	Fine	3	Poor/ Uniformly Grade
Lalawigan	0.320	Fine	3	Poor/ Uniformly Grade
Punta Maria	0.440	Medium	4	Poor/ Uniformly Grade

Looking into the table above, it can be observed that the sand sample coming from Punta Maria does not only have a distinguishable color to the other but also in terms of particle size, the Punta Maria sand has a larger particle size than those coming from the other three (3) locations. With this, it can be seen that the three locations, Cabong, Lalawigan and Baybay are good areas for producing salt, although it me have a disagreeable color due to its sand color.

This data can be used as further evidence with the addition of the statements that fine sand consists of smaller particles and has a higher surface area per unit volume. It is often used in the later stages of salt production, such as in fine filtration or as a final layer to achieve higher purification levels. Fine sand can effectively capture smaller impurities and fine particles, resulting in a higher quality of salt.

It provides a larger surface area for adsorption and filtration processes, improving the overall purification efficiency. Ultimately, the selection of coarse or fine sand depends on the desired level of filtration, the specific impurities present, and the required salt quality.

Therefore, it is important that a salt bed be finer so as to yield ha high purification of the salt product.

From the data on Sieved Grain Size Analysis, uniformity coefficient or fineness modulus was calculated; additional information from https://www.geoengineer.org/education/laboratory-testing/step-by-step-guide-for-grain-size-analysis#selected-topics (n.d.) was used to effectively measure uniformity of sand from various locations in Borongan City. It was calculated that the fineness modulus or uniformity coefficient from all the san samples were 4 which is interpreted as uniformly graded or consist of uniform grain diameter. In the uniformity assessment, it is stated that a when the fineness number or uniformity coefficient is greater than 4, the soil is classified as well graded, whereas when fineness number or uniformity coefficient is less than 4, the soil is classified as poorly graded or uniformly graded.

With the given data, it can then be advised that having a uniform sand bed is crucial for salt production. As stipulated, it is important that a salt bed be finer so as to yield ha high purification of the salt product. Therefore, all sand beds sampled can be a good area for salt production, but if we recur to the color, which may affect the salt products, it is suggested that salt production be conducted on all the sand area regardless of their color because of the uniformity in other sand properties of all the sand beds sampled.

3.5 Significant Difference Testing

Significant difference testing was also calculated to determine if there is a significant difference on the sieve size analysis of the sands taken from the four (4) different sand beds in Borongan City. 1 – way ANOVA was used, the ANOVA table can be seen below.

Table 4. ANOVA Table

Sources of Variation	*df*	Sum of Squares	Mean Squares	F – value	
				Computed	Tabular
Between groups (K-1)	3	0.0457	0.0152	0.217	4.07
Within groups (N-1) – (K-1)	8	0.5613	0.0701		
Total (N-1)	11	0.607			

$\alpha = .05$

Since the F-computed value of 0.217 is lower than the F-tabular value of 4.07 with 3 and 8 degrees of freedom (df) at .05 level of significance, we accept the null hypothesis, indicating that there is no significant difference in the grain size of the sands coming from the four (4) different sand areas in Borongan City, namely, Baybay, Cabong, Lalawigan and Punta Maria. This means that all 4 sites have similar grain size which is also graded as uniformly in relation to the fineness modulus which indicates that the sands in these areas are fine to medium.

4 Conclusions

Based on the results of the sand analysis of the four (4) representative sand samples, the following are concluded:

1. The sands coming from Baybay, Cabong and Lalawigan are grayish in color, while the sand from Punta Maria is yellowish. All sand samples are sandy in terms of structure, single-grained and are loosely consistent.
2. In terms of sand type, Baybay, Cabong and Lalawigan are fine sand, while the sand from Punta Maria is medium sand. Fineness modulus indicates that all sand samples are uniformly graded. This means that they have uniform consistency all throughout.
3. There is no significant difference in the grain size of the sands coming from the four (4) different sand areas in Borongan City, namely, Baybay, Cabong, Lalawigan and Punta Maria. This means that all 4 sites have similar grain size which is also graded as uniformly.

5 Recommendations

In relation to the data generated and analyzed, as well as the conclusions, the following are recommended by the researchers:

1. Assess other sandy areas on Borongan City with potential of having fine grain consistency which is needed to have a high-grade salt product.
2. Conduct similar study to further support or compete the current results.
3. Conduct additional study on other sandy areas in Eastern Samar which can be possible for salt production using sand beds.
4. All sand beds sampled are ideal for salt production regardless of their color, but because of their uniform grain consistency and structure as well as its fine-medium particle size which are ideal properties to produce high quality salt.

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Primary Paper Section: C

Secondary Paper Section: DD, DA