EDUCATUM JSMT Vol. 12 Number 1 (2026)
ISSN 2289-7070 / e-ISSN 2462-2451(76-87)
https://ejournal.upsi.edu.my/index.php/EJSMT/index

Comparative Analysis of Particle Grain Size Distribution and Moisture Content in Beach and Paddy Field Sediments

Nur Azlin Atikah Mohd Nasir[1], Nursuhaila Muhamad Fauzi[1], Sharir Aizat Kamaruddin[1*], Khairul Naim Abd. Aziz[1], Aimie Rifhan Hashim[1], Rohayu Ramli[1], Siti Hafsah Zulkarnain[2], Nurzaki Ikhsan[3], Abdol Samad Nawi[4], Rozita @Uji Mohammed[5], Hendry Joseph[6], Alahasin Rubama[7], Eliy Nazira Mat Nazir[8], Shukor Sanim Mohd Fauzi[9]

[1]Faculty of Applied- Sciences, Universiti Teknologi MARA (UiTM), Cawangan Negeri Perlis, Kampus Arau, 02600 Arau, Perlis, Malaysia
[2]Studies of Real Estate, School of Real Estate and Building Surveying, College of Built Environment, Universiti Teknologi MARA, 40450, Shah Alam, Selangor, Malaysia
[3]College of Engineering, Universiti Teknologi MARA, 40450, Shah Alam, Selangor, Malaysia
[4]Faculty of Business and Management, Universiti Teknologi MARA, Cawangan Kelantan, 18500 Machang, Kelantan, Malaysia
[5]Faculty of Business and Management, Universiti Teknologi MARA, Cawangan Sabah, 888997, Kota Kinabalu, Malaysia
[6]Faculty of Plantation and Agrotechnology Universiti Teknologi MARA, Cawangan Sabah, 888997, Kota Kinabalu, Malaysia
[7]ToCoDeS Legacy Sdn. Bhd., Team of Community Development Studies, Universiti Teknologi MARA, Cawangan Sabah, Beg Berkunci 71, 88997, Kota Kinabalu, Sabah, Malaysia
[8]Faculty of Business and Management, Universiti Teknologi MARA (UiTM), Cawangan Negeri Perlis, Kampus Arau, 02600 Arau, Perlis, Malaysia
[9]College of Computing, Informatics and Mathematics, Universiti Teknologi MARA (UiTM), Cawangan Negeri Perlis, Kampus Arau, 02600 Arau, Perlis, Malaysia

**Corresponding author:* shariraizat@uitm.edu.my

Received: 10 August 2025; **Accepted:** 15 November 2025; **Published:** 30 April 2026

To cite this article (APA): Nur Azlin Atikah Mohd Nasir et al., (2026) Comparative Analysis of Particle Grain Size Distribution and Moisture Content in Beach and Paddy Field Sediments. EDUCATUM Journal of Science, Mathematics and Technology, 13(1), 76–87

To link to this article:

Abstract

This study aims to compare particle grain size and moisture content in samples from beach sediment and paddy fields. Grain size variations were measured along different zones and stations in a line transect at each location. The grain sizes for both study areas were determined using dry-sieving and a Laser Diffraction Particle Size Analyzer. Results showed that beach sediment mostly consists of medium sand, is moderately sorted, very negatively skewed, and extremely leptokurtic. In contrast, paddy field sediment is mostly very fine silt, very poorly sorted, negatively skewed, and very leptokurtic. The mean of particle grain size recorded in beach and paddy field were 1.57 ± 0.23 and 7.63 ± 0.44 respectively. Moisture content was measured using oven-drying method. The mean of moisture content recorded in beach and paddy field were 6.72 ± 5.01% and 52.03 ± 3.35% respectively. Results revealed that paddy fields have significantly higher moisture content than beach sediment. Descriptive analysis from the data normality tests showed that the particle size and moisture content were not normally distributed however, there is significant difference in moisture content and particle size between both study areas that were due to continuous flooding in paddy fields, which retains fine particles and high moisture, while coastal areas experience tidal action that removes fine particles, leaving coarser sediments with lower moisture retention. The findings of this study can contribute to strategies for mitigating beach erosion and optimizing agricultural practices in paddy fields, ensuring sustainable environmental and land-use management.

Keywords Beach, Moisture, Paddy, Particle size, Sediment

INTRODUCTION

Grain size data offers important information for understanding deposition conditions, as sediment particles are arranged according to their grain size and hydrodynamic characteristics during the deposition process [1]. One of the basic physical characteristics of sediments is grain size, which is defined as the dimensions of a particle [2]. A statistical approach involving mean, kurtosis, sorting, and skewness is employed to analyze sediment grain size distribution [3]. Understanding the distribution of particle grain sizes and moisture content within sediments can provide valuable insights into the geochemistry, depositional processes, and sediment transport mechanisms of various ecosystem [4]. Beaches and paddy fields represent two distinct environments with unique sedimentary characteristics. Beach sediments are solid particles that are transported and accumulated in a particular area [5].

Beaches are dynamic systems that comprises loose particles such as sand, gravel, pebbles, and shells, influenced by tidal actions, wave energy, and wind, which affect the grain size distribution and moisture content of the sediments [6]. In contrast, paddy field sediments are primarily composed of fine particles such as clay and silt, which are retained due to the fields' continuous flooding [7]. Understanding moisture content and particle size of beach and paddy field sediments is crucial for effective erosion control and preventing land degradation. While much research has been conducted on sediment analysis in coastal or agricultural settings separately, this study is original in its direct comparison of these two contrasting environments. This research aims to fill a gap in knowledge by systematically comparing these parameters in beach and paddy field sediments, which can aid in better coastal zone management and agricultural planning. Mean size, sorting, skewness and kurtosis are the most useful parameters to compare between the sediments in both study areas [8].

The comparative analysis of particle grain size distribution and moisture content between beach and paddy field sediments can provide important data for understanding how different environmental factors influence sediment properties. The findings of this study can contribute to strategies for mitigating beach erosion and optimizing agricultural practices in paddy fields, ensuring sustainable environmental and land-use management. The research stands out due to its unique approach of comparing sediment characteristics across two distinct environments beaches and paddy fields. It uses methods like dry-sieving and laser diffraction, which contribute to environmental science and land management. By analyzing particle size and moisture content, the study offers new insights into how different factors affect sediments.

MATERIALS AND METHODS

Study Area

Field sampling was conducted in February 2024 during northeast monsoon. The northeast monsoon during November to March influences the coastal processes along both study areas which plays a major role in variation in textural characteristics. The locations of sampling sites were marked by using a handheld Global Positioning System (GPS). Beach sediments were collected at Pulau Tuba, Langkawi, Kedah (6.277˚N, 99.847˚E) whereas paddy sediments were collected at Gunung Keriang, Kedah (6.188˚N, 100.333˚E).

Samples were immediately brought to Marine and Physics laboratories at Universiti Teknologi MARA Perlis Branch for laboratory analyses.

Sampling Strategies

Data collection and information gathering were obtained from relevant agencies, including previous research reports, topographic maps, weather forecasts, wind data, and daily tidal water levels. Weather forecasts were used to ensure that field measurement activities were conducted under optimal weather and sea conditions. Nine sampling points at Pulau Tuba, Langkawi, Kedah, have been identified starting from the lowest water level up to 20 meters inland, over 400 m along the coast (Figure 1). The sampling point was divided into three zones, namely Zone A (dry area), Zone B (splash area), and Zone C (submerged area). Three replicates of sediment samples were collected randomly in a $0.3m^2$ quadrat at each zone by using a plastic scoop. All the sediment samples were collected during low tide for accessible purposes. Meanwhile, three paddy field stations at Gunung Keriang, Kedah were selected and marked from one box of paddy fields of different zones (lower, middle, and upper zone), and the distance between each zone is 5m, 20m, and 50m respectively, in a line transect, as illustrated in Figure 2. Three replicates of sediment samples were collected randomly in a $0.25m^2$ quadrat at each zone by using a plastic scoop. All the samples from both study areas were placed in plastic bags, labeled, and returned to the laboratory for further processing.

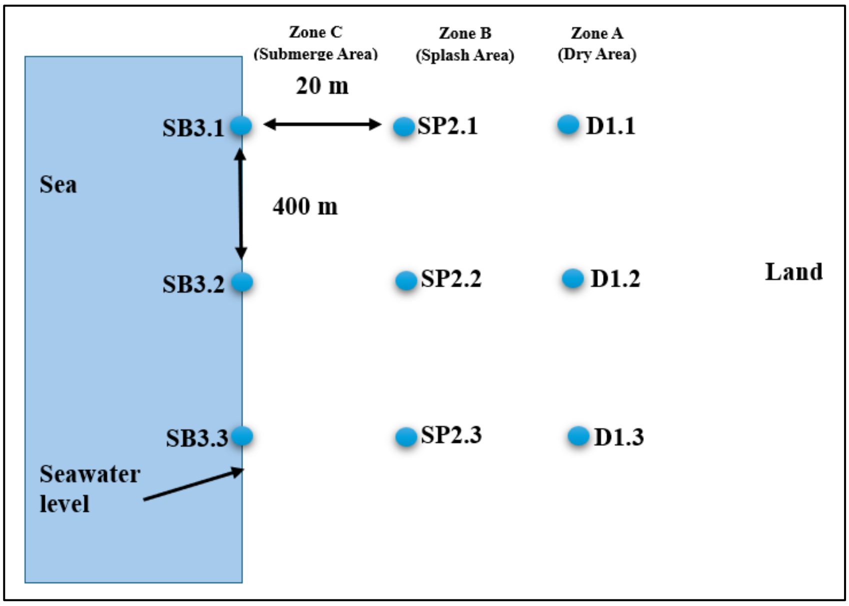

Figure 1 Schematic diagram of the sampling points location along the coastline of Pulau Tuba, Langkawi, Kedah.

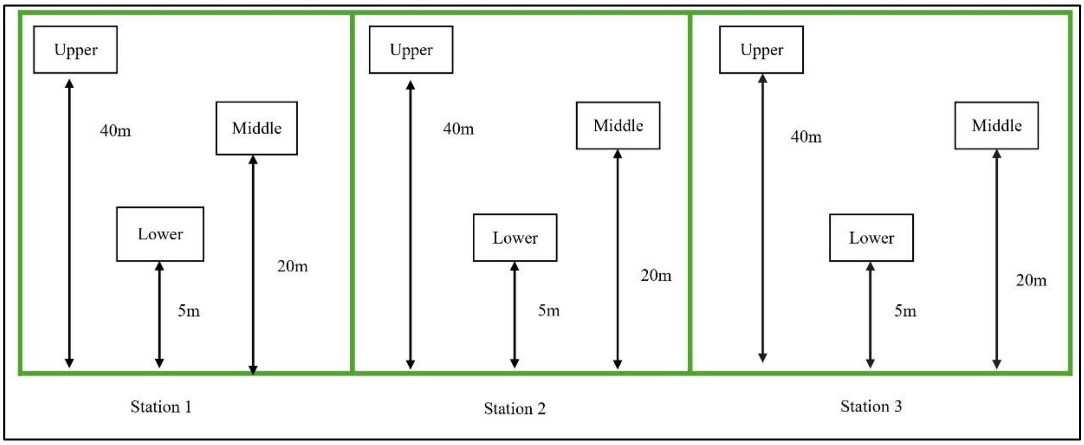

Figure 2 Schematic diagram of the location of sampling points at paddy field of Gunung Keriang.

Dry-sieving method

The standard dry sieving procedures were used in beach sediment analyses to determine the grain size of the sediments. Particles larger than 63 µm in diameter were examined as coarse fraction. All unwanted materials, including shell fragments and leaves in the samples, were discarded and dried out for a whole night at 105ºC in the oven. A 100 g sample was then transferred to the coarsest sieve in the stacked series, with mesh diameters of 4 mm, 2.8 mm, 2 mm, 1.4 mm, 1 mm, 710 µm, 500 µm, 355 µm, 250 µm, 180 µm, 125 µm, 90 µm, and 63 µm. A mechanical shaker was used to agitate the sample for 10-15 minutes. The trapped materials in each sieve were weighed and recorded [9].

Particle size analysis

10g dried sediment samples were sieved through a 2 mm mesh and treated with 15 mL of 30% Hydrogen Peroxide (H_2O_2) to eliminate organic matter. The suspension was heated at 50°C for one hour, and the clear supernatant was removed with a pipette. This treatment was repeated two to three times until the samples were fully bleached, and all organic matter was removed [10]. Before introducing the samples into the laser particle analyzer (Laser Diffraction Particle Size Analyzer, Mastersizer 2000), 5 mL of Calgon solution was added. Statistical analyses were conducted using the laser particle sizer control program and MS Excel, with sediment grain size converted to phi (ϕ) units.

Moisture content determination

The oven-drying method was deployed to analyze moisture content. 30.0g from each sample was weighed into weighing tins. The wet soil samples were dried in the oven at 105 °C for 24 hours to remove any moisture in the soil sample. The samples were removed from the oven and set aside to cool before and were weighed for their dry weight in the weighing tin [11]. Moisture content for the soil samples from both beach and paddy field sites were calculated using the following equation:

$$\%\ \text{Moisture content} = \frac{\text{weight of wet soil} - \text{weight of the dry soil}}{\text{weight of the dry soil}} \times 100$$

Statistical analysis

Data analysis was conducted using the Statistical Package for Social Sciences (SPSS) version 29. Data distribution was determined by using the Kolmogorov-Smirnov and Shapiro-Wilk tests. If the data does not meet the assumptions for normality, the medians were used to compare groups by using nonparametric methods (Mann-Whitney U Test) [12].

RESULTS AND DISCUSSION

Particle grain size distribution of beach and paddy field sediment

The mean indicates the average grain size distribution at each sampling location, reflecting the condition of sediment availability and the level of transport energy [13]. Therefore, particle size and sorting information can be utilized to identify deposition environments [1]. In the present study of beach sediments, Zone A (dry area) were composed of medium sand with values ranging from 1.53 to 1.75 Ø. Zone B (splash area) were composed of fine sand (1.59 Ø) to medium sand (2.04 Ø). Zone C (submerge area) were composed of medium sand with values between 1.27 and 1.43 Ø. Therefore, most zones of the beach sediments were composed of medium sand and fine sand. Meanwhile, in this research of paddy field sediments, Station 1, Station 2 and Station 3 were composed of silt with values ranging from 6.99 to 8.19 Ø, 7.44 to 7.90 Ø, and 7.08 to 8.15 Ø respectively. Therefore, most paddy field sediments were categorized as very fine silt with the value of 77.80%. Sorting analysis was utilized to determine the variation in measured grain size that makes up most of the size distribution [6]. The current study of beach sediments, sediments at Zone A (dry area) were comprised of moderately well sorted (0.69 Ø) to moderately sorted (0.73-0.82 Ø). Zone B (splash area) were comprised of moderately sorted with values ranging from 0.74 to 0.93 Ø. Zone C (submerge area) were comprised of moderately sorted with values ranging from 0.89 to 0.94 Ø. Therefore, most zones had well moderately sorted, followed by moderately sorted with values 11.11% and 88.89% respectively. Meanwhile, Station 1 of paddy field sediments were comprised of poorly sorted (1.48 Ø) to very poorly sorting (2.02-2.08 Ø). Station 2 and Station 3 were mostly comprised of poorly sorted sediments with values ranging from 1.72 to 1.92 Ø and 1.82 to 1.94 Ø respectively. Therefore, most of the paddy field samples were comprised of very poor sorting, followed by poor sorting sediments with values 58.86% and 44.44% respectively.

Skewness describes the symmetry of the sediment sample distribution, indicating whether it is made up of finer or coarser particles [6]. In the study of beach sediments, the sediments at Zone A (dry area) exhibit positively skewed (0.17 Ø) to very negatively skewed distribution with values ranging from (-0.28 to -0.15 Ø). Sediments at Zone B (splash area) exhibit very negatively skewed distribution with values between -0.62 to -0.24 Ø. Sediments at Zone C (submerge area) exhibits negatively skewed (-0.28 Ø) to very negatively skewed distribution with values -0.55 Ø. Most zones of beach sediments in the current study were very negatively skewed, followed by positively skewed, and negatively skewed with values of 77.80%, 11.11%, and 11.11% respectively. Meanwhile, in this research of paddy field sediments, the sediments at Station 1 were positively skewed (-0.03 to 0.16 Ø) to negatively skewed distribution with values (-0.16 Ø). Sediments at Station 2 exhibits negatively skewed (-0.25 Ø) to very negatively skewed distribution (-0.04 to -0.02 Ø). Station 3 exhibits negatively skewed (-0.21 to -0.06 Ø) to very negatively skewed distribution with values -0.56 Ø. Therefore, most of the collected samples in paddy field in the present study exhibits negatively skewed, followed by positively skewed, very negatively skewed and symmetrical with values of 55.56%, 22.22%, 11.11%, and 11.11% respectively. Kurtosis analysis was used to determine if samples were peaked or flat [14]. In the current work of beach sediments, the sediments at Zone A (dry area) indicate an extremely leptokurtic with values ranging from 3.12 to 3.88 Ø. Sediments at Zone B (splash area) indicate very leptokurtic (2.99 Ø) to extremely leptokurtic (3.96 Ø). Sediment samples at Zone C (submerge area) exhibit an extremely leptokurtic distribution with values between 3.19 to 3.96 Ø. Therefore, most of the collected samples in beach sediments indicate an extremely leptokurtic distribution. Meanwhile, in this research of paddy field sediments, sediments at Stations 1 and 2 exhibited a very leptokurtic distribution with values ranging from 2.20 to 2.66 Ø, 2.40 to 2.44 Ø respectively. Sediments at Station 3 exhibited an extremely leptokurtic (3.02 Ø) to very leptokurtic (2.40-2.57 Ø). Therefore, most of the collected sediments in paddy fields along the study sites were dominated by very leptokurtic with ratio of 88.89%. One of them was extremely leptokurtic with 11.11% value. The sedimentological characteristics value of both study areas was tabulated as in Table 1 and Table 2 respectively.

Table 1 Sedimentological characteristics value of beach sediment for three zones.

Zone	Point	Mean (Ø)	Sorting (Ø)	Skewness (Ø)	Kurtosis (Ø)
A	D1.1	1.54 **MS**	0.82 **MdS**	-0.15 **VNS**	3.12 **EL**
	D1.2	1.75 **MS**	0.69 **MWS**	0.17 **PS**	3.12 **EL**
	D1.3	1.53 **MS**	0.73 **MdS**	-0.28 **VNS**	3.88 **EL**
B	SP2.1	2.04 **F**	0.74 **MdS**	-0.62 **VNS**	3.96 **EL**
	SP2.2	1.77 **MS**	0.88 **MdS**	-0.24 **VNS**	3.18 **EL**
	SP2.3	1.59 **MS**	0.93 **MdS**	-0.58 **VNS**	2.99 **VL**
C	SB3.1	1.30 **MS**	0.94 **MdS**	-0.55 **VNS**	3.52 **EL**
	SB3.2	1.27 **MS**	0.95 **MdS**	-0.28 **NS**	3.19 **EL**
	SB3.3	1.43 **MS**	0.89 **MdS**	-0.55 **VNS**	3.96 **EL**

MS = Medium Sand, **F** = Fine, **MdS** = Moderately Sorted, **MWS** = Moderately Well Sorted, **VNS** = Very Negatively Skewed, **PS** = Positively Skewed, **NS** = Negatively Skewed, **EL** = Extremely Leptokurtic, **VL** = Very Leptokurtic

Table 2 Sedimentological characteristics value of paddy field sediment for three stations.

Station	Point	Mean (Ø)	Sorting (Ø)	Skewness (Ø)	Kurtosis (Ø)
1	Lower	6.99 **S**	2.02 **VPS**	0.16 **PS**	2.31 **VL**
	Middle	7.38 **S**	2.08 **VPS**	-0.03 **PS**	2.20 **VL**
	Upper	8.19 **S**	1.48 **PS**	-0.16 **NS**	2.66 **VL**
2	Lower	7.44 **S**	1.79 **PS**	-0.02 **VNS**	2.43 **VL**
	Middle	7.89 **S**	1.72 **PS**	-0.04 **VNS**	2.40 **VL**
	Upper	7.90 **S**	1.92 **PS**	-0.25 **NS**	2.44 **VL**
3	Lower	8.15 **S**	1.92 **PS**	-0.05 **VNS**	3.02 **EL**
	Middle	7.08 **S**	1.94 **PS**	-0.26 **NS**	2.40 **VL**
	Upper	7.85 **S**	1.82 **PS**	-0.21 **NS**	2.57 **VL**

S = Silt, **VPS** = Very Poorly Sorted, **PS** = Poorly Sorted, **PS** = Positively skewed, **NS** = Negatively Skewed, **VNS** = Very Negatively Skewed, **VL** = Very Leptokurtic, **EL** = Extremely Leptokurtic

Moisture content of the beach and paddy field sediment

The moisture content of Zone A ranges from 0.15% to 0.62%, with an average of 0.45% (Table 3). The moisture content of Zone B ranges from 6.64% to 7.99%, with an average of 7.34%. However, the moisture content of Zone C varies from 12.18% to 12.91%, with an average of 12.36% with the highest moisture content among the three zones. The moisture content of Station 1 of paddy field ranges from 47.85% to 59.70%, with an average of 53.34%. The moisture content of Station 2 ranges from 49.49% to 52.28%, with an average of 51.09%. However, the moisture content of Station 3 varies from 48.96% to 54.18%, with an average of 51.71% with the highest moisture content among the three stations (Table 4). Water retention potential followed a similar trend, with paddy sediment showing greater retention capacity due to finer grain size and higher organic matter.

Table 3 Moisture content of beach sediments between zones.

Zone	Point	Moisture Content (%)
A	D1.1	0.15
	D1.2	0.59
	D1.3	0.62
B	SP2.1	6.64
	SP2.2	7.40
	SP2.3	7.99
C	SB3.1	12.18
	SB3.2	12.10
	SB3.3	12.91

Table 4 Moisture content of paddy field between each station

Station	Zone	Moisture Content (%)
1	Lower	52.46
	Middle	47.85
	Upper	59.70
2	Lower	51.49
	Middle	49.49
	Upper	52.28
3	Lower	48.96
	Middle	54.18
	Upper	51.98

The normality assumption was checked before proceeding with variance analysis. A data normality test is conducted to assess whether the distribution of collected research data is normal or symmetrical. The Smirnov and Shapiro-Wilk Kolmogorov tests were used to evaluate data normality, providing a goodness of fit assessment for the observed variables [15]. The results of the normality test of particle grain size and moisture content for beach and paddy field sediments showed that the significant values in the Kolmogorov-Smirnov test and Shapiro-Wilk test ($p<0.001$) were smaller than 0.05, indicates that the data of particle grain size and moisture content readings for both study areas are not normally distributed. The data normality test results of particle size and moisture content for both study areas using Kolmogorov-Smirnov and Shapiro-Wilk test were tabulated respectively as shown in Table 5.

Table 5 Data normality test results of particle size and moisture content for both study areas using the Kolmogorov-Smirnov and Shapiro-Wilk test respectively

	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Particle_Size	0.298	54	<.001	0.725	54	<.001
Moisture_Content	0.286	54	<.001	0.781	54	<.001

a. Lilliefors Significance Correction

As the continuous data does not meet the normal distribution, a nonparametric test (Independent Samples Mann-Whitney U Test) was carried out to investigate the distribution of the particle grain size and moisture content across the categories of Group respectively. As a result, since the p-value (< 0.001) is less than the significance level (typically 0.05) from the Mann-Whitney U Test, the null hypothesis was rejected. This means there was sufficient evidence to conclude that the particle size distributions and moisture content were different across the categories of Group (1=beach, 2=paddy) (Table 6).

Table 6 Results from non-parametric tests of distribution of particle size and moisture content across the group

	Null Hypothesis	Test	Sig.[a,b]	Decision
1.	The distribution of Particle_Size is the same across categories of Group.	Independent-Samples Mann-Whitney U Test	<.001	Reject the null hypothesis
2.	The distribution of Moisture_Content is the same across categories of Group.	Independent-Samples Mann-Whitney U Test	<.001	Reject the null hypothesis

a. The significance level is .050.
b. Asymptotic significance is displayed.

Discussion

Grain Size and Deposition Environment

Sediment properties can vary significantly across landscapes, even over short distances [16]. In general, soil particle size distribution includes varying proportions of clay, sand, and silt. Clay, with its colloidal nature, significantly promotes soil aggregate formation, enhances soil structure stability, and improves resistance to soil erosion [17]. The present research of paddy field, the sediment particle size distribution varied slightly from clay to very fine silt category and was characterized as silty clay and silty clay loam type of sediment. Paddy fields, which are low energy environments contain finer sediments that settle more readily. Finer sediments have smaller pores, resulting in lower permeability and higher water content because water is held more tightly within the pore network [18]. Understanding soil texture is crucial for soil management and is one of the most important physical properties [19]. The fine size of silt particles makes them prone to erosion by both wind and water [19]. Sediments containing high levels of silt and clay retain more water compared to sandy sediments, which makes them particularly suitable for the leaching process [20]. The distribution of soil particle sizes influences not only soil permeability and organic matter content but also soil fertility, erodibility, conservation efforts, moisture and nutrient movement, vegetation productivity, ecological restoration, and land degradation [21].

In theoretical description, beaches are formed as depositional units that are well developed between the low water line (low tide) and the high-water line (high tide) [6]. In the present study most zones of the beach sediment were revealed to be medium sand and fine sand. These similar predominantly trends of medium and fine sand were also observed in [22]. In their work, beach sediment along Pahang coastline from Cherating to Nenasi consist of medium to fine sediment size. However, [14] found coarser grain size of sediment which consisted mainly of medium sand at beach areas of Tanjung Lumpur to Cherok Paloh. This is likely due to variations in sea level, wave energy, and the nearby sources of alongshore sand between the two monsoon seasons. The interaction between beach slope and grain size reflects the influence of physical processes such as waves, tides, currents, and sediment transport, which govern the equilibrium state of the beach face and shoreline evolution [6]. Sediment size is crucial for the interaction of sand particles with oscillatory flow in the wave bottom boundary layer, where most morphological changes occur. Mean grain size represents the average particle size within a sediment sample. Beach is a high-energy environment which exhibits coarser sediments due to the deposition of larger particles by strong wave action. Coarser sediments have larger pore spaces, which impact higher permeability and quicker drainage that will lower water retention [23].

Sorting analysis, through standard deviation, was used to assess the variation in grain size distribution, with lower values indicating well-sorted samples typically found in low-energy environments [6]. In this study, most paddy field samples were very poorly or poorly sorted. A mix of particle sizes can fill the space between coarser grains, thus reducing the overall permeability effectively and the water-holding capacity increases. Meanwhile, beach sediments were mostly moderately sorted. Uniform grain sizes will produce consistent, connected pore spaces. Therefore, the regular arrangement can allow water flow rapidly, which reduces water retention [17]. Skewness was used to evaluate the symmetry of sediment distribution, where most paddy field samples were negatively skewed, and beach sediments were predominantly very negatively skewed. Kurtosis analysis showed that paddy field sediments were largely very leptokurtic, while beach sediments were extremely leptokurtic. These results align with previous studies of [22] along the Pahang coastline, reflecting the influence of depositional environmental characteristics such as wave and current actions on sediment sorting and distribution. Variations in kurtosis values reflect changes in the flow characteristics of the depositional environment [24]. For instance, extremely high or low kurtosis values suggest that part of the sediment has been sorted in a high-energy environment. Soil moisture is an essential factor in crop development, drought prediction, irrigation control, flood forecasting, and water management in agriculture [25] [26] [27].

Moisture Content and Retention Potential

Herein, the moisture content of paddy field sediments varies significantly, ranging from 51% to 53%. Monitoring soil moisture in paddy fields is necessary for managing, planning, and allocating water resources within irrigation systems [28]. Paddy field sediments showed significantly greater moisture content and retention capacity. These soils are rich in silt which have a greater capacity to hold water due to their finer pore spaces and larger surface area [29]. Additionally, paddy fields' repeated flooding and anaerobic conditions promote the buildup of organic matter, which improves the soil's capacity to hold onto water [30]. Over time, finer-textured soils' strong capillarity and slow permeability promote moisture stability and minimize water loss [31]. As a result, the availability of soil moisture data is a prerequisite for better agricultural planning and management, particularly regarding agricultural productivity [32]. In beach sediment study, the moisture content varies significantly, ranging from 0.15% to 12.91% [33]. Beach sediments showed significantly lower moisture content and retention capacity due to their coarser texture, primarily medium sand composition and high permeability. These physical attributes promote decreased water-holding capacity and quick drainage [34]. Due to their wider pores, sandy soils have less capillary retention because water can flow freely under gravity [35]. The fluctuation in moisture content, ranging from 6% to 41%, indicates a transitional zone where moisture content decreases toward the land [36]. The cohesive-adhesive forces on the surface of sand grains, induced by surface moisture, help retain and resist the erosion of the uppermost sediment layer into the ocean [37].

The localized sampling approach used in this study is one of its limitations which it might not accurately represent the seasonal variations or long-term changes in particle grain size distribution and moisture content across different environmental locations. Since the sediment samples were collected from a specific site, they might not accurately reflect more general environmental conditions or changes over time, such variations in precipitation patterns or shifts in land use. Future studies with longer-term sampling and seasonal monitoring would provide a more comprehensive understanding of how moisture content and grain size distribution evolve over time in both beach and paddy field sediments and their impact on ecosystem health and agricultural productivity. The use of Geographic Information System (GIS) technology can also be used to observe the relationship between each of these variables and the ecosystem in an effort to ensure that humans live in a safe environment [38], [39], [40].

CONCLUSION

The grain size distribution analysis revealed significant differences between beach and paddy field sediments. Beach sediments were dominated by coarse particles, particularly medium sand, indicating high-energy depositional settings driven by wave action and tidal currents. In contrast, paddy field sediments had a finer particle composition, with greater proportions of silt and clay fractions such as very fine silt, which was most likely impacted by agricultural activities like irrigation and soil management. Moisture content analysis reinforced these environmental distinctions. Beach sediments often had lower moisture content levels due to frequent exposure to sunlight and breeze, which promoted evaporation. In contrast, paddy field sediments had higher moisture content levels, which were linked to irrigation techniques and the presence of standing water during rice cultivation seasons. The surrounding environment played an important role in generating these sediment properties. The dynamic nature of coastal processes, such as erosion and sediment movement, had a substantial influence on grain size distribution in beach sediments. Conversely, agricultural methods and hydrological regimes have a major impact on moisture content changes in paddy field sediments.

ACKNOWLEDGEMENTS

We want to thank Universiti Teknologi MARA and the University of Ryukyus for Sakura Science Exchange Program support (600-TNCPI/PBT 5/3 INT (074/2023)).

AUTHOR CONTRIBUTION

Experimental design; Sharir Aizat Kamaruddin, Khairul Naim Abd. Aziz; Collection the data and Analyses; Nur Azlin Atikah Mohd Nasir, Nursuhaila Muhamad Fauzi; Interpretation of data: Aimie Rifhan Hashim, Rohayu Ramli; Fundings: Siti Hafsah Zulkarnain, Nurzaki Ikhsan, Abdol Samad Nawi, Rozita @Uji Mohammed, Hendry Joseph, Alahasin Rubama; Protocol: Eliy Nazira Mat Nazir, Shukor Sanim Mohd Fauzi

CONFLICT OF INTEREST

Authors declare no conflict of interest.

REFERENCES

[1] Mutaqin, B. W., Isnain, M. N., Ningsih, R. L., Darmawan, H., & Suratman, N. (2024). Grain size and sedimentation process in the Anak Krakatau coastal area of Indonesia. *Results in Earth Sciences*, 100018. https://doi.org/10.1016/j.rines.2024.100018

[2] Zeng, L., Yi, S., Zhang, W., Feng, H., Lv, A., Zhao, W., Luo, Y., Wang, Q., & Lu, H. (2019). Provenance of loess deposits and stepwise expansion of the desert environment in NE China since ~1.2 Ma: Evidence from Nd-Sr isotopic composition and grain-size record. *Global and Planetary Change*, *185*, 103087. https://doi.org/10.1016/j.gloplacha.2019.103087

[3] Setiawan, I., Ilhamsyah, Y., Gunarya, M. W., Ihsan, M. R., & Yuni, S. M. (2024). Bottom sediment analysis at Lhok Seudu Beach, Aceh Besar. *Journal of Maritime Research, 21*(1), 333–337. https://www.jmr.unican.es/index.php/jmr/article/view/833/835

[4] Woodruff, J. D., Venti, N. L., Mabee, S. B., DiTroia, A. L., & Beach, D. (2021). Grain size and beach face slope on paraglacial beaches of New England, USA. *Marine Geology*, *438*, 106527. https://doi.org/10.1016/j.margeo.2021.106527

[5] Dadson, I. Y., Panou, P. S., & Adu-Boahen, K. (2024). Sediments Composition and Morphology of the Fosu Lagoon Barrier Beach, Bakaano, Cape Coast, Ghana. *Ghana Journal of Geography*, *16*(1), 91–127. https://doi.org/10.4314/gjg.v16i1.4

[6] Hamsan, M. a. S., Mustapa, M. Z., & Ramli, M. Z. (2019). Morphology and sand characteristics at five recreational beaches in Pahang. *Journal of Sustainability Science and Management, 14(6),* 22–38. http://irep.iium.edu.my/77106/

[7] Chen, T., Shi, Z., Wen, A., Li, L., & Wang, W. (2023a). The role of paddy fields in the sediment of a small agricultural catchment in the Three Gorges Reservoir region by the sediment fingerprinting method. *Land*, *12*(4), 875. https://doi.org/10.3390/land12040875

[8] Shi, Y., E, C., Zhang, Z., Peng, Q., Zhang, J., Yan, W., & Xu, C. (2023). Comparison and significance of grain size parameters of the Menyuan loess calculated using different methods. *Open Geosciences*, *15*(1). https://doi.org/10.1515/geo-2022-0474

[9] Abuodha, J. (2003, January). Grain size distribution and composition of modern dune and beach sediments, Malindi Bay coast, Kenya. *Journal of African Earth Sciences, 36(1–2),* 41–54. https://doi.org/10.1016/s0899-5362(03)00016-2

[10] Abdulkarim, M., Grema, H. M., Adamu, I. H., Mueller, D., Schulz, M., Ulbrich, M., Miocic, J. M., & Preusser, F. (2021). Effect of using different chemical dispersing agents in grain size analyses of fluvial sediments via laser diffraction spectrometry. *Methods and Protocols, 4*(3), 44. https://doi.org/10.3390/mps4030044

[11] American Society for Testing and Materials. (2005). Standard test methods for laboratory determination of water (moisture) content of soil and rock by mass (ASTM D2216-05). *ASTM International*

[12] Mishra, P., Singh, U., Pandey, C., Mishra, P., & Pandey, G. (2019). Application of student's t-test, analysis of variance, and covariance. *Annals of Cardiac Anaesthesia,* 22(4), 407. https://doi.org/10.4103/aca.aca_94_19

[13] Suriani, P. D., Fajar, M. H. M., Ariyanti, N., Ramadhani, A. P., Ulumuddin, F., Rahayu, H. K., Wirayudhatama, M., Alfany, M. K., Rafi, M. E. D., & Zukhrufah, S. Z. (2024). Sediment Deposits Texture Analysis of Besuk Kobokan River in the Northern Slope Semeru Volcano Lumajang. *IOP Conference Series Earth and Environmental Science*, *1307*(1), 012025. https://doi.org/10.1088/1755-1315/1307/1/012025

[14] Azid, A., Hasnam, C. N. C., Juahir, H., Amran, M. A., Toriman, M. E., Kamarudin, M. K. A., Saudi, A. S. M., Gasim, M. B., & Mustafa, A. D. (2015). Coastal erosion measurement along Tanjung Lumpur to Cherok Paloh, Pahang during the northeast monsoon season. *Jurnal Teknologi, 74*(1). https://doi.org/10.11113/jt.v74.3009

[15] Zakaria, Z., Setyosari, P., Sulton, S., & Kuswandi, D. (2019). The Effect of Art-Based Learning to Improve Teaching Effectiveness in Pre-Service Teachers. *Journal for the Education of Gifted Young Scientists*, *7*(3), 531–545. https://doi.org/10.17478/jegys.606963

[16] Addise, T., Bedadi, B., Regassa, A., Wogi, L., & Feyissa, S. (2022). Spatial variability of soil organic carbon stock in Gurje Subwatershed, Hadiya Zone, Southern Ethiopia. *Applied and Environmental Soil Science, 2022,* 1–12. https://doi.org/10.1155/2022/5274482

[17] Wang, N., Eziz, M., Mao, D., & Sidekjan, N. (2023). Fractal Characteristics of the Particle Size Distribution of Soil along an Urban–Suburban–Rural–Desert Gradient. *Land, 12*(12), 2120. https://doi.org/10.3390/land12122120

[18] Kairytė, M., & Stevens, R. L. (2014). Composite methodology for interpreting sediment transport pathways from spatial trends in grain size: A case study of the Lithuanian coast. *Sedimentology*, *62*(3), 681–696. https://doi.org/10.1111/sed.12156

[19] Kalev, S. D., & Toor, G. S. (2018). The Composition of Soils and Sediments. In *Elsevier eBooks* (pp. 339–357). https://doi.org/10.1016/b978-0-12-809270-5.00014-5

[20] Ramli, R., Pardi, F., Singh, H. R., Roslani, M. A., Aziz, K. N. A., & Kamaruddin, S. A. (2024). Spatial variability of organic matter in two mangrove ecosystems in Langkawi, Kedah, Malaysia. *Biodiversitas*, 25(1). https://doi.org/10.13057/biodiv/d250138

[21] Wang, Y., Ma, R., & Zhu, G. (2023). Representation of the influence of soil structure on hydraulic conductivity prediction. *Journal of Hydrology*, *619*, 129330. https://doi.org/10.1016/j.jhydrol.2023.129330

[22] Rosnan, Y., Zaini, M. M., Noraisyah, S., Lokman, H. M. & Nor Antonina, A. 2010. Beach Cycle and Sediment Characteristics Along Pahang Coastline. Proceedings of 9th International Annual Symposium on Sustainability Science and Management, Universiti Malaysia Terengganu, May 8th–11th 2010. *UMT Press*. 2: 764–767.

[23] Xie, Y., Dang, X., Zhou, Y., Hou, Z., Li, X., Jiang, H., Zhou, D., Wang, J., Hai, C., & Zhou, R. (2020). Using sediment grain size characteristics to assess effectiveness of mechanical sand barriers in reducing erosion. *Scientific Reports*, *10*(1). https://doi.org/10.1038/s41598-020-71053-3

[24] Baiyegunhi, C., Liu, K., & Gwavava, O. (2017). Grain size statistics and depositional pattern of the Ecca Group sandstones, Karoo Supergroup in the Eastern Cape Province, South Africa. *Open Geosciences, 9(1).* https://doi.org/10.1515/geo-2017-0042

[25] Ghulam, A., Qin, Q., Teyip, T., & Li, Z. (2007). Modified perpendicular drought index (MPDI): a real-time drought monitoring method. *ISPRS Journal of Photogrammetry and Remote Sensing, 62*(2), 150–164. https://doi.org/10.1016/j.isprsjprs.2007.03.002

[26] Yao, N., Li, Y., Liu, Q., Zhang, S., Chen, X., Ji, Y., Liu, F., Pulatov, A., & Feng, P. (2022, May). Response of wheat and maize growth yields to meteorological and agricultural droughts based on standardized precipitation evapotranspiration indexes and soil moisture deficit indexes. *Agricultural Water Management, 266,* https://doi.org/10.1016/j.agwat.2022.107566 107566.

[27] Anderson, M. C., Allen, R. G., Morse, A., & Kustas, W. P. (2012). Use of Landsat thermal imagery in monitoring evapotranspiration and managing water resources. *Remote Sensing of Environment, 122,* 50–65. https://doi.org/10.1016/j.rse.2011.08.025

[28] Arif, C., Mizoguchi, M., Mizoguchi, M., & Doi, R. (2012). Estimation of soil moisture in paddy field using Artificial Neural Networks. *International Journal of Advanced Research In Artificial Intelligence, 1*(1). https://doi.org/10.14569/ijarai.2012.010104

[29] Lal, R., & Shukla, M. K. (2004). Principles of soil physics. In *CRC Press eBooks*. https://doi.org/10.4324/9780203021231

[30] Bouman, B., & Tuong, T. (2001). Field water management to save water and increase its productivity in irrigated lowland rice. *Agricultural Water Management, 49*(1), 11–30. https://doi.org/10.1016/s0378-3774(00)00128-1

[31] Lal, R. (2015). Restoring soil quality to mitigate soil degradation. *Sustainability, 7*(5), 5875–5895. https://doi.org/10.3390/su7055875

[32] Kang, Y., Khan, S., & Ma, X. (2009, December). Climate change impacts on crop yield, crop water productivity and food security – A review. *Progress in Natural Science, 19*(12), https://doi.org/10.1016/j.pnsc.2009.08.001 1665–1674.

[33] Mohd Nasir, N. a. A. (2024). Comparative analysis of particle grain size distribution and moisture content in beach and paddy field sediments [Unpublished bachelor's thesis]. Universiti Teknologi Mara, UiTM.

[34] Hillel, D. J. (2003). Introduction to environmental soil Physics. *In Elsevier eBooks*. https://doi.org/10.1016/b978-0-12-348655-4.x5000-x

[35] Rawls, N. W. J., Gimenez, N. D., & Grossman, N. R. (1998). Use Of Soil Texture, Bulk Density, And Slope Of The Water Retention Curve to Predict Saturated Hydraulic Conductivity. *Transactions of the ASAE, 41*(4), 983–988. https://doi.org/10.13031/2013.17270

[36] Schmutz, P. P., & Namikas, S. L. (2018). Measurement and modeling of the spatiotemporal dynamics of beach surface moisture content. *Aeolian Research*, *34*, 35–48. https://doi.org/10.1016/j.aeolia.2018.08.001

[37] Hoonhout, B. M., & De Vries, S. (2016). A process-based model for aeolian sediment transport and spatiotemporal varying sediment availability. *Journal of Geophysical Research Earth Surface*, *121*(8), 1555–1575. https://doi.org/10.1002/2015jf003692

[38] Kamaruddin, S. A., Abd. Aziz, K. N., Roslani, M. A., & Zainol, Z. E. (2021). Sustainable management of the coastal water pH of pulau tuba using the inverse distance weighted (IDW) method. *Jurnal Intelek, 16*(2), 162-174. https://doi.org/10.24191/ji.v16i2.428

[39] Kamaruddin, S. A., Hashim, A. R., Zainol, Z. E., Ahmad, A., Abd.Aziz, K. A., Roslani, M. A., Shuhaime, N., Tajam, J., Hamid, H. A., & Mat Nazir, E. N. (2022). Evaluation of the performance of spline interpolation method in mapping and estimating the total suspended solids over the coastal water of pulau tuba, Kedah. *IOP Conference Series: Earth and Environmental Science, 1051*(1), 012018. https://doi.org/10.1088/1755-1315/1051/1/012018

[40] Mohd Rizal, N. I., Kamaruddin, S. A., & Nazri, R. (2022). Microplastic pollution in marine waters: A Malaysian perspective. *Journal of Tourism, Hospitality and Environment Management, 7*(28), 76-88. https://doi.org/10.35631/jthem.728006