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Research Article

Tourism Impact on Coastal Erosion: A Case of Alanya

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Abstract

Sandy coasts are constantly exposed to rapid coastal change. Sea level rise caused by climate conditions change; wave circumstances, and storm occurrences will increase erosion rates, exposing these areas to increasingly hazardous conditions. For coastal management purposes, monitoring and measuring these changes in erosion of sandy and pebbly beaches and their ecosystems is important. The loss of sand and gravel in coasts is not only due to the rise in sea level and the force of waves resulting from storms, which will intensify due to climate change. There is a new important factor of human intervention and impact on the beaches that must be mentioned and verified as to how the effect is in the long term with the increase in tourism in the coastal areas, especially in areas of a tourist nature. In the current study, the amount of sediment that each individual transports from the coastal beaches in the Alanya region is evaluated, and the effect of this sediment transportation is studied. There is not any sources available about the human-induced coastal erosion. From this point of view this study will be very useful for other researchers and shows the importance of human-induced coastal erosion. In this experimental study, samples of sand and gravel were collected from different locations on the Alanya coastline to be surveyed. The collected samples from the coastal beaches were classified by means of sieve analysis. The project was executed by going to the selected points of Alanya coast line, which were collected from the sediment attached to bodies (feet) of people. The study also responds to the identification of the eroded beach by correlating the average number of locals and foreigners who come to the study area and use the shore during a year (in tourism season) with the data collected during the project.

Keywords: Coastal Erosion, Shoreline, Erosion, Sea-level rise, Climate change

Introduction

Erosion is among the maximum urgent troubles in coastal regions as it impacts the elegance of the location in phrases of leisure and financial activities (including solar and seashore recreation, water sports, fisheries, tourism, etc.), in addition to its cap potential to conform to the weather—alternate associated climate events. The growing vulnerability of coastal regions is evident in public spaces policy plans and techniques. On the coasts of developed and developing countries, climate change interacts differently with human activities and other factors that cause change. Modifications in the environment and climate, and as a result of these changes the increasings in sea levels can further affect accommodation needs along the coasts of developed countries (Hadley, 2009). This makes a lot of damage to archaeological records, and it will probably keep doing so: If sea levels rise another unit meter in the next 100 years, many archaeological sites along all of the world's coasts will be destroyed, flooded, or drowned (Fitzpatrick et al., 2006). So, in some locations, erosion and rising sea levels pose immediate threats to archaeological sites.

Coastal areas are thought to have the most people living places, so they are significant and have a lot of economic value (Small and Nicholls, 2003). Average sea level change, high tides, and other wave events are a result of climate change that significantly impacts these places, making them vulnerable to fast coastal adjustments (Vos et al., 2019). Human actions and natural phenomena have huge effects on coastal erosion. It means that the waves and currents linked to sediment transport and beach shape are affected by human activity, which in turn impacts coastal dynamics (Pranzini and Williams, 2013a). It is a naturally occurring phenomenon that's been going on ever since the first land rose from the ocean, and it will continue to do so. Many diverse processes contribute to coastal erosion, but in the broadest sense, it is caused by a multitude of natural and human-made variables that can work singly or in concert (Burak et al., 2004; Rangel-Buitrago et al., 2020).

Natural Causes of Coastal Erosion

Sea level rise, wave height and frequency, storm tides, flood levels, and river flow are all a result of climate change (Wang et al., 2014). As a consequence of human involvement and climate impact, storm frequency, storm intensity, and sea levels are expected to increase, and wave height is expected to change (Stocker et al., 2013). River hazards such as high tides, tidal waves, and cyclone surges flows are all examples of short-term drivers that have significant impacts on both the short- storm and medium-term climate (Barnard et al., 2015; Vancoppenolle et al., 2010; Vos et al., 2019). Open beaches can see significant changes in the net transport of sediment along and across the coast (Robinet et al., 2018; Rueda et al., 2017).

Rising tides typically push sediment inland (Cooper et al., 2020). Coastal sediment loss is predicted to persist in the face of rising sea levels and more frequent and intense storms (Brown & McLachlan, 2002). Moreover, annual soil loss due to water erosion is estimated to be around 970 million tons (Panagos et al., 2016). Globally, at least 70 percent of sandy beaches have been affected by Erosion (Guo et al., 2020). Rising sea levels are an effect of global warming, and they present significant environmental and socioeconomic concerns, particularly in coastal areas. Several negative consequences on marine ecosystems and services are caused by sea level rising, including an increase in the severity of impacts from extreme sea level events and coastal hazards (Nevermann et al., 2022). Coastal Erosion has increased in recent years due to climate change and global environmental change-related increases in its severity and frequency (Zhang & Sheng, 2015). Twenty to ninety percent of the current world littoral wetland area is anticipated to be destroyed by the year 2100, depending on various global warming and associated factor scenarios (Masselink & Russell, 2013).

Human-Based Coastal Erosion

The human system includes artificial features such as harbor walls, buildings, roadways, groins, and breakwaters. When energy, sediment supply, and resistance are all altered, sandy beaches return to their pre-disturbance state as an equilibrium landform in the coastal system. The shape of beaches is affected by the force of storms, waves, and tides, the amount and location of deposited sediment, and the presence of things like coral reefs, bedrock, and artificial structures (Change, 2014). There is a relationship between human populations, human activities, and coastal environmental processes, which can lead to coastal hazards; the current tendency has been continuous migration toward the ocean and increased urbanization along the shoreline (Small and Nicholls, 2003).

Although tourism benefits coastal towns, the inflow of tourists in coastal areas harms their natural attractiveness. The use of complex structures is not always the best option, and the detrimental effects of these structures have been identified as a significant issue along a great number of beaches all over the world (Charlier et al., 2005; Griggs, 2005; Pilkey and Cooper, 2014; Pranzini and Williams, 2013b; Rangel-Buitrago et al., 2018). Human activity in coastal zones increases the coastal erosion as well as the effects on vulnerable ecosystems along the coastline such as the change of sediment transport due to the use of sea territory for anthropogenic functions. These functions have a significant role in non-climate change factors that impact coastal Erosion exposed to these functions and their effects. For instance, due to coastal erosion and rapid urbanization over the past half-century, the amount of damage to infrastructure along the Catalan Coast has increased by forty percent (Jiménez et al., 2012). However, these functions also cause a considerable variety in coastal erosion rates and processes. This diversity in coastal erosion rates influenced by different anthropogenic activities, in combination with climate change, is the reason for unpredictable changes in the coastal landscape. The unpredictability of the landscape is an argument for a need for protection measures or an adaptation strategy in the form of spatial planning. Although projects have been developed and measurements have been taken for the types of coastal erosion mentioned above, based on various researches, there is no literature on this subject for coastal erosion caused by sediment transport by the human body. In the current study, calculations will be made by authors for the first time, and coastal erosion was examined as a result of sediment transported by foot. It is tried to show the subject's importance by the researchers of this study.

Materials and Method

This study is being carried out in the Alanya District of Antalya province, Türkiye. The taken sand samples from the coasts in different locations were classified by sieve analysis in Alanya Alaaddin Keykubat University, Civil Engineering Laboratory. Sieve trays, digital scales, oven, sieve series, shaker, Basin, air temperature meter, and moisture meter were used in this study. The grain sizes of the analyzed sand samples were found by sieving and drawn granulometry curves. The locations of taken sand samples were determined and marked using the global mapper program. The purpose of this application was to classify the coastal beach according to grain diameters and show it on the map. Then, it could be able to show the importance of human-induced erosion on coasts.

Study Area

Alanya Coast was chosen for the study because it is a popular summer resort on the south coast of Türkiye, where many tourists travel there (Figure 1). It is located on 36°30'07"-36°36'31" Northern parallel and 31°38'40"-32°32'02" Eastern meridian. Alanya has a long coastline of approximately 70 kilometers. Because of the geographical situation and the weather conditions of Alanya, the summer starts from May to October, which is almost half the year. The area is also essential for Turkish tourism, because it has 662 hotels with at least 190,000 beds and about 3 million visitors annually, which include about 8% of the total number of visitors of Türkiye.

The total population (without tourists) was 257,671in 2020, while the population is about 364,180 in 2022 according to the address-based population registration system. It means that during t 22 years, the population of Alanya increased by approximately 41%. A significant proportion of this population also benefits from these beaches during the warm months. According to the data published by Turkish State General Directorate of Meteorology (DMİ), while rainfall events are common in the region between months November and March, the lowest rainfall is observed between June and September. In the current study the global mapper software and Google Map was used for marking the location of the samplings. Also, Microsoft Excel software was utilized for the statistical analysis of measured parameters in this study. This article has avoided describing and presenting all stages of the study process.

Fig. 1 location of Alanya, Antalya Province

The Guidelines of Grain Size Analysis for the Soil Grains

There are numerous soil classification systems in use, but this section will only discuss the most prevalent systems (Carrier III, 2003). Using soil classification systems allows for greater comprehension and illustration of soil particle characteristics. Particle size distribution and Atterberg limits are two of the criteria that are utilized by a number of different soil classification systems. These methods are typically complemented with a non-standardized classification of other soil qualities such as consistency and cementation, amongst others (Bowles, 1992). The size of particles or grains is a fundamental characteristic or physical property of particulate samples, sediments, and sedimentary minerals (Folk, 1980; Friedman & Sanders, 1982).

Table 1 Standard sieves of square mesh used in the Sieve Analysis (The Unified Soil Classification System)

Typical Sieve Stack		Alternative Sieve Stack	
Sieve No.	Opening, mm	**Sieve No**	Opening, mm
Lid		**Lid**	
4	4.75	**4**	4.75
10	2	**10**	2
20	0.85	**20**	0.6
40	0.425	**40**	0.3
60	0.25	**60**	0.15
140	0.106	**140**	0.07
200	0.075	**200**	
pan		**pan**	

The grain size analysis is widely used in classification of soils. The method is applicable to dry soil passing through 4.75 mm size sieve less than 10 % passing through 75-micron sieve. Several sieves with a rectangular (square) grain are the industry standard, complete with a cover plate and a bottom pan. It means that each sieve has squared shaped openings of a certain size. Two recommended sieve stacks (having successively smaller mesh sizes) are shown in Table 1.

The categorization system divides soils into two primary categories: coarse-grained soils, which have more than fifty percent by weight of their soil particles that remain on the No. 200 sieve, and fine-grained soils, which have fifty percent or more of their soil particles that pass through the No. 200 sieve. Sands and gravels are the two categories that make up the coarse-grained soils. Briefly, the sieve separates the larger particles from the smaller ones. The particles with a smaller diameter than the size of the square openings of the sieve pass the sieve. Conversely, the larger particles are retained by the related sieve. According to the information presented in Table.1, gravels and sands can each be further classified into one of four secondary classes. As mentioned before, the particle size distribution of granular material can be evaluated with a technique called sieve analysis. The size distribution of a material can have a significant impact on its performance. Sand, crushed rock, clay, granite, coal, soil, and various produced powders, grains, and seeds, down to a minimal size depending on the precise procedure, can all be analyzed using sieves. It is the most often used method for determining particle size because of its ease of use. Based on the USCS (The Unified Soil Classification System), particles with a size smaller than 0.002 mm are situated in the Clay soil type category, and the particle with a size between 0.002 mm and 0.075 mm are in Silt category. While, if the particle siz is between 0,075 mm and 4.75 mm, the soil is Sand type. This category of soils divided into three groups which are the Fine Sand, Medium Sand, and Coarse Sand. The particle size between 7.75 mm and 75 mm is related to the Gravel type of the soil. These states are presented in Table 2.

Determination of Weights of Existing Sample

Sand samples, previously taken from different locations, were first noted in the laboratory and then dried by drying at 100°C for 24 hours. After noting the dry weights after the firing process, the sand samples were subjected to sieve analysis, and it was noted how much sand and gravel remained in each sieve. After the sample weights noted following the firing process, the sand samples were subjected to sieve analysis and in this stage, the amount of sand and gravel remaining in each sieve was recorded.

Processing of the Existing Samples on the Map

The coordinates of the sand samples were determined by marking where they were taken from with Google Earth (The data that were previously sampled, subjected to sieve analysis, and classified were also marked on the map).

Fig. 2 Location map of the sampling points

Table 2 Unified Soil Classification System. (Robert, 2004).

Major Divisions	Subdivisions	USCS Symbol	Typical Names	Laboratory Classification Criteria	
Coarse-grained soils (More than 50% retained on No. 200 sieve)	Gravels (More than 50% of coarse fraction retained on sieve No. 4)	GW	Well-graded gravels or gravel-sand mixtures, little or no fines	Less than 5% fines	Cu ≥ 4 and 1 ≤ Cc ≤ 3 c
		GP	Poorly graded gravels or gravelly sands, little or no fines	Less than 5% fines	Does not meet Cu and/or Cc criteria listed above c
		GM	Silty gravels, gravel-sand silt mixtures	More than 12% of fines	Minus No. 40 soil plots below the Aline
		GC	Clayey gravels, gravel sand-clay mixtures	More than 12% of fines	Minus No. 40 soil plot on or above the A-line
	Sands (50% or more of coarse fraction passes sieve No. 4)	SW	Well-graded sands or gravelly sands, little or no fines	Less than 5% fines	Cu ≥ 6 and 1 ≤ Cc ≤ 3 c
		SP	Poorly graded sands or gravelly sands, little or no fines	Less than 5% fines	Does not meet Cu and/or Cc criteria listed above c
		SM	Silty sands, sand-silt mixtures	More than 12% of fines	Minus No. 40 soil plots below the Aline
		SC	Clayey sands, sand-clay mixtures	More than 12% of fines	Minus No. 40 soil plot on or above the A-line

The Calculations for Sample No 9

It is clear that the dimensions of the smallest remaining particle in the amount of soil contained in each sieve are smaller than the mesh holes of any of the sieves placed on it according to the sieving hierarchy. Additionally, the smaller pore openings of any of the sieves listed below are inadequate for their size (Bowles, 1992). The authors prepared Table 3 for the ninth sample, only to illustrate the calculation procedure for an experiment determination of average grain diameters of samples, as an alternative to the calculation tables for the remaining samples. The mass retained is calculated using Equation 1.

Mass retained (g) = MR = MF – M (Eq.1)

The percentage of mass retained is then computed using Equation 2.

$$P_R = \frac{M_R}{M_S} * 100\% \qquad \text{(Eq.2)}$$

P_R is the Percentage of mass retained (%) in this equation. Using the numbers of the percentage of mass retained, the percentage of passing will be determined.

$$P_P = 100 - P_{PR} \qquad \text{(Eq.3)}$$

Where, P_P is Percentage of Passing (%) = MF presents the mass of fines (gr), MI is the mass of bowl (gr), and MS shows the mass of sand (gr).

Table 3 An example of Calculations (Sample No. 9)

Sieve No.	Sieve opening (mm)	Mass retained (gr)	Percent of mass retained	Mass passing	Percent Passing
4	4.75	17.3	16.31%	49.5	89.39%
10	2.36	32.2	71.14%	215.9	28.86%
20	1	183.7	83.49%	253.4	16.51%
40	0.425	69.7	23.16%	70.3	76.84%
60	0.30	0.6	0.20%	0.6	23.16%
120	0.15	0	0.00%	0	0.00%
200	0.075	0	0.00%	0	0.00%
PAN	PAN	0	100.00%	303.5	0.00%

Sieve Analysis of Existing Samples, and Determination of Average Grain Diameters of Samples

By using the obtained data, the percentages of how much passed through which sieve and how much remained were determined. As a result of sieve analysis calculations, the Granulometry curves were drawn for each sample with the help of Microsoft Excel program. Each sample has a distinct color, which appears in Figure (3) and varies from sample to sample. The dimensions of the samples are computed, and the total result of the lines indicates the quality of the soil. The analysis results from taking soil samples are presented in detail. According to the sieve study, the soil samples range from moderately sandy to very sandy (Figure 3). Mixed grain, silt, and sand (mostly sand, some coarse) Sand, coarse grain, loose silt, fine silt, and sand make up the bulk of samples 1–30. In the soil test and from the obtained results, it is obvious that the Alanya coastal soil of the study area is mainly sandy (coarse sands). After the Granulometry curves were drawn for samples, the coordinate of locations of all samples were noted in the text document together in three columns (x and y coordinates in the first two columns, and sample d50 diameters in the third column according to Table 4). For this purpose, Global Mapper application was used. However, since the Global Mapper application gave an error in the coordinate order in degrees, minutes seconds (and as a result of this error, it shows the different locations), the coordinates were first required to convert to decimal, which is presented as Table 4

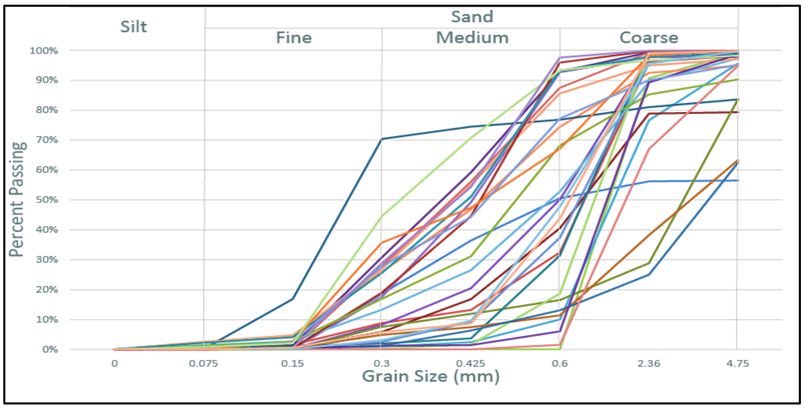

Fig. 3 Granulometry curves of all sample (Figure 3 Sieve Analysis Test)

Table 4 Coordinate data encoded for Global Mapper

X	*Y*	*d_{50} (mm)*	*X*	*Y*	*d_{50} (mm)*
31.840306	36.592306	0.6	32.053694	36.522089	0.5
31.863933	36.585647	1.0	32.043924	36.528979	0.8
31.790889	36.604694	1.5	32.043772	36.528774	1.8
31.935794	36.560515	0.5	32.030003	36.537436	0.4
31.910268	36.568595	1.5	32.029614	36.536801	0.5
31.881730	36.579113	0.4	32.014562	36.543026	0.5
31.811444	36.595444	0.3	32.014410	36.542903	2.0
31.811444	36.595556	1.1	31.968812	36.556070	0.3
31.881408	36.578712	**6.8**	31.982265	36.547266	1.1
31.910525	36.568878	0.8	31.981953	36.546763	1.1
31.790972	36.604833	1.0	31.968350	36.555512	0.4
31.935670	36.560454	3.4	32.002917	36.541665	**0.1**
32.054019	36.522325	4.0	32.007165	36.543082	0.9

Then, by importing this text file into the Global Mapper, coordinates were opened in the program. Since the sample diameter was entered in the Z column, a color scale and average height curve distribution of the samples were obtained. Thanks to this distribution, the grain diameter analysis of the sampled coastline length was performed. With this analysis, it was determined where there was sand and gravel of which grain diameter.

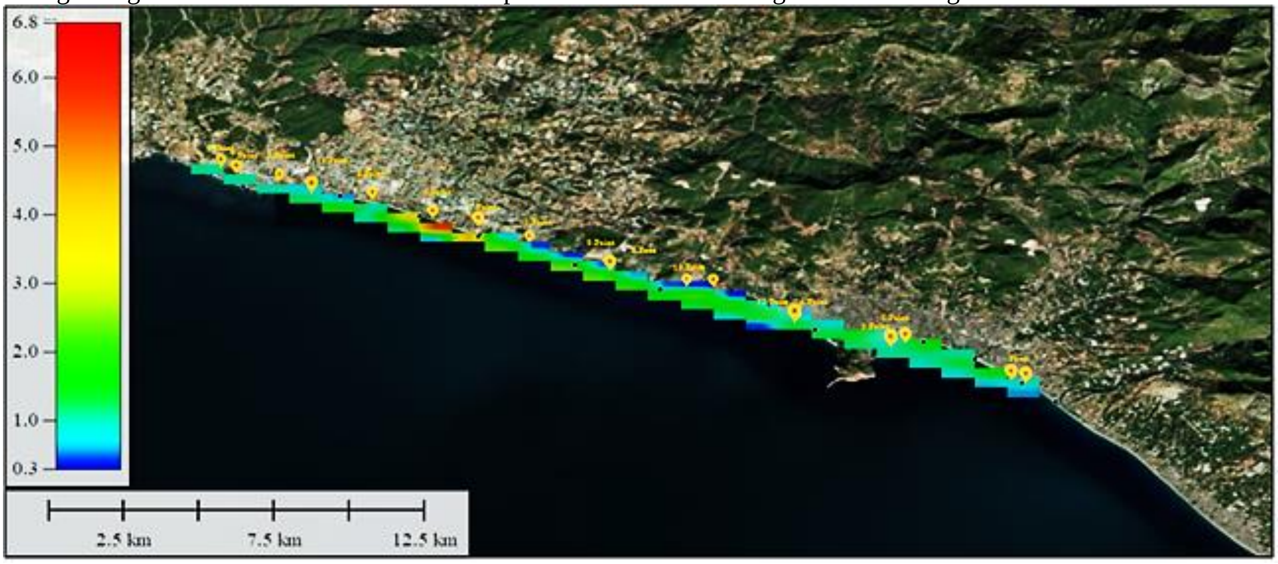

Fig. 4 Coordinates engraved on the map according to d50.

Table 5 the data for experiments in the three different positions

EXPERIMENT	1. POINT	2. POINT	3. POINT
		Point A	
Coordinate	36.535747 32.0325	36.555669 31.968887	36.592376 31.840750
In (At the beginning of the experiment)	26.9°C	33.8°C	35.7°C
Out (At the end of the experiment)	29.6°C	31,7°C	38.2°C
wetness	36%	19%	14%
		Point B	
Coordinate	36.5354113 32.032197	36.555560 31.968740	36.592188 31.840785
In (At the beginning of the experiment)	25.5°C	30.50°C	37.5°C
Out (At the end of the experiment)	26.1°C	25.4°C	24.2°C
wetness	44%	39%	12%

Experimental work at Three Selected Points

The experiment was done in three different positions in terms of grain diameter. This experiment was carried out by two people with foot numbers of 36-37 and 41-42, which were representing female and male persons, respectively. The steps of the experimental were as follows:

- Firstly, three locations were predetermined.
- The locations of the selected points, the current air temperature, and humidity parameters were noted.
- On the beach, the feet were put into the sea and got wet. Then the sand was accumulated by walking vertically along the beach. The routes of walking are also given in the Figure 5.
- Sand samples attached to feet of two person with the mentioned foot size were taken by washing with the help of water on a piece of cloth to remove the sand and collected in the pan.
- This process had been completed three times and applied to both people (Figure 5).
- The same process was performed on the feet that were washed irregularly (to wash the feet irregularly, 3-4 holes were drilled in the cap of a pet bottle and thus, irregular washing was performed.
- The same procedure was applied to the unevenly washed foot three times and for two people.
- The operations were performed in the same way in all three selected locations

Fig.5 Discharging the sand collected from the feet into the tray

Fig.6 The routes of the 1st , 2nd, and 3rd test locations.

Table 6 Sand masses accumulating by feet at the sampling location.

1st EXPERIMENT POINT	
Shoe size (41-42)	**Shoe size (36-37)**
Samples for unwashed feet	
1) 15,8 gr	1) 8,6 gr
2) 19,3 gr	2) 13,6 gr
3) 31,5 gr	3) 17,5 gr
Samples for slightly washed feet	
1) 1,2 gr	1) 0,5 gr
2) 0,6 gr	2) 0,6 gr
3) 0,6 gr	3) 0,9 gr

2nd EXPERIMENT POINT	
Shoe size (41-42)	**Shoe size (36-37)**
Samples for unwashed feet	
1) 41,8 gr	1) 49,1 gr
2) 42,1 gr	2) 41,4 gr
3) 62,3 gr	3) 45,6 gr
Samples for slightly washed feet	
1) 2,7 gr	1) 2,8 gr
2) 2,9 gr	2) 3,2 gr
3) 9,7 gr	3) 5,5 gr
3rd EXPERIMENT POINT	
Shoe size (41-42)	**Shoe size (36-37)**
Samples for unwashed feet	
1) 40,3 gr	1) 17,6 gr
2) 15,7 gr	2) 23,3 gr
3) 20,7 gr	3) 13,8 gr
Samples for slightly washed feet	
1) 4,0 gr	1) 2,3 gr
2) 1,8 gr	2) 3,3 gr
3) 2,4 gr	3) 1,6 gr

Measuring Masses of Dried Collected Sediments

In order to be able to measure the sediment samples of human origin collected from the marked locations during the experiment, it was important to leave them in the oven and dry it at 100 ° C for 24 hours. After 24 hours the moisture of the samples was completely dried. After drying step, the mass of each dried sample was measured and recorded on a precision scale. Detailed Table 6 of sand masses accumulating on feet.

Fig. 7 Samples collected standing during field.

The measured Mass Graphs according to Dimensionless Unit Feet Number for both the unwashed feet and slightly-washed feet conditions are provided by using Table 6 for the three experiment points, and presented as Figure 8.

Total Number of Persons Entering the Beach by Month

The number of tourists coming to Alanya during the year for the year 2015 was determined and noted by distinguishing the months of the holiday season. The reason for using of year 2015 data was that these data was the only available latest official data, which was given by the official site of the Alanya District Governorate. It was required to have some assumptions for this study in this stage. It was assuming that each person (tourist) takes a holiday for five days and goes to the sea or the beach five times in total. Since some of them take a holiday for a month, some for a week or a few, and some for a day. Among the local people of Alanya, half of Alanya's population goes to the sea and the beach every weekend, and as a result, the data in the Table 7 was obtained by assuming that a total of two hundred thousand local people set foot on the beach every month. Based on the values calculated in Table 7, the Amount of erosion (transported) sediment is shown in Table 8, in which the best and worst situations were estimated. The two cases (best and worst situations) were calculated together for the three samples in the washed and unwashed situations.

Discussion and Conclusion

Within the scope of the study, the coastline and what the coast is, and how it was formed were tried to be expressed. The causes of natural and artificial erosion of the coast, i.e. man-made, were briefly expressed and explained. Apart from known natural and artificial erosions, the subject of "Tourism Induced Erosion with Standing Sediment" was discussed under the sub-title of human-induced coastal erosion as an erosion type, which can be put into artificial erosions category. This type of erosion is not encountered in any source that has been tested and measured before. From this point of view this study will be very useful for other researchers and shows the importance of human-induced coastal erosion.

Within the scope of this subject, samples were taken from the locations specified in the report, and the d50 radii of these samples were determined by sieve analysis. The aim here is to determine where and what type of sand is available by taking a look at the average radius scale of the coastline.

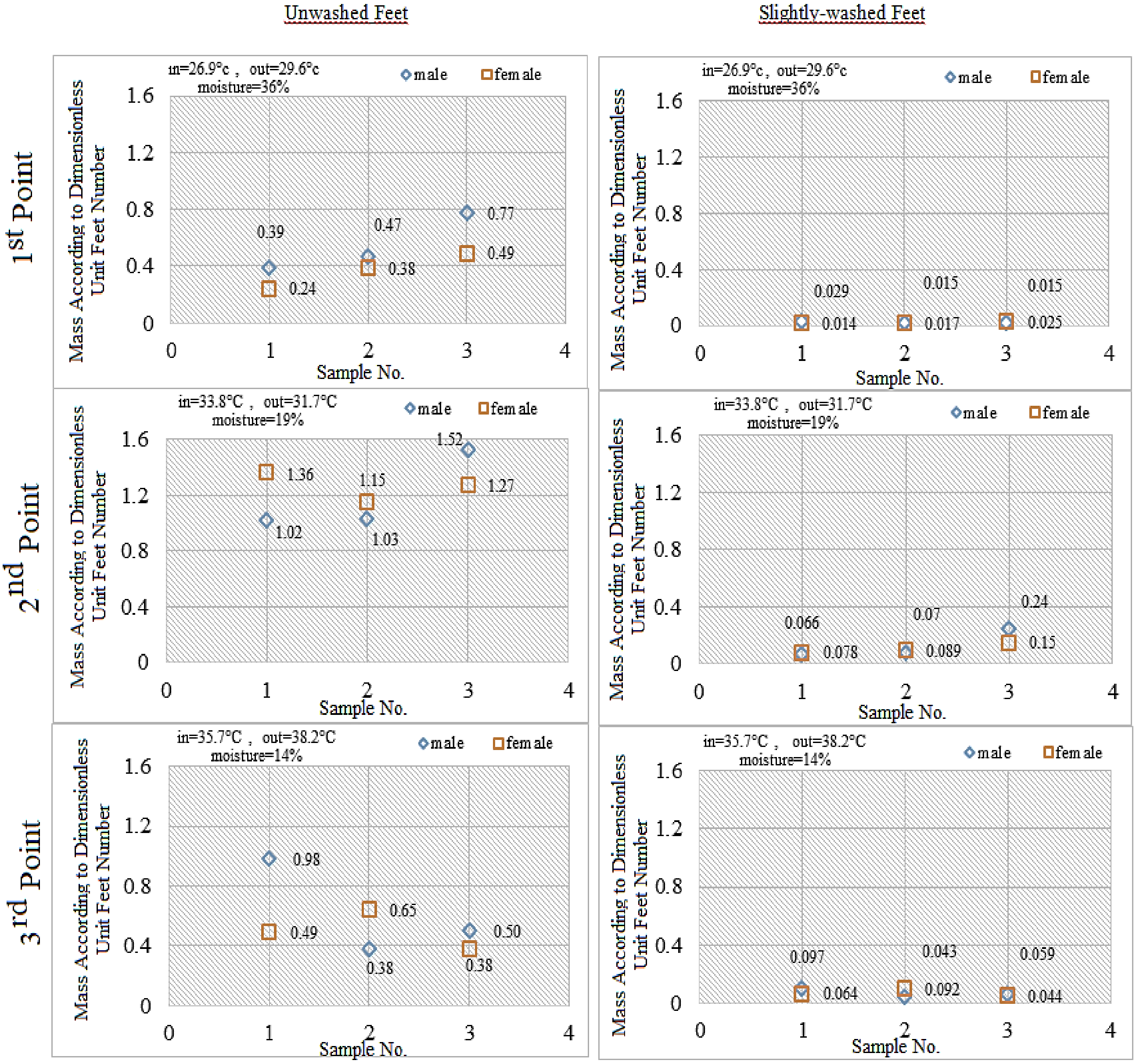

Fig 8 Samples for Test Point for Unwashed Foot and Slightly Washed Foot

Table 7 Total number of people entering the beach by month

Months	Number of Tourists	Average Number of Days people Take Vacation	Number of Indigenous People Entering the Sea	Average Number of Days pepople Entered the Sea	Total Number of People Entering the Beach
April	652,000	5	200,000	4	4,060,000
May	1,388,037	5	200,000	4	7,740,185
June	1,642,032	5	200,000	4	9,010,160
July	2,036,137	5	200,000	4	10,980,685
August	1,952,730	5	200,000	4	10,563,650
September	1,585,690	5	200,000	4	8,728,450
October	1,087,683	5	200,000	4	6,238,415

Table 8 Amounts of sand exposed to erosion

	1. Spot Unwashed	2. Spot Unwashed	3. Spot Unwashed
The Worst Possibility	44.14 ton	77.96 ton	56.18 ton
The Best Possibility	13.78 ton	58.47 ton	21.78 ton
	1. Spot Washed Slightly	**2. Spot Washed Slightly**	**3. Spot Washed Slightly**
The Worst Possibility	1.66 ton	13.76 ton	5.62 ton
The Best Possibility	0.80 ton	3.78 ton	2.46 ton

For Unwashed Foot		**For Slightly Washed Feet**	
Worst Case	77.96 tons*40(average leg size) =3118.4 tons	**Worst Case**	13.76 tons*40 (average leg size) = 550.4 tons
Best Case	13.78 tons * 40 (average leg size) = 551 tons	**Best Case**	0.80 tons*40 (average leg size) = 32 tons

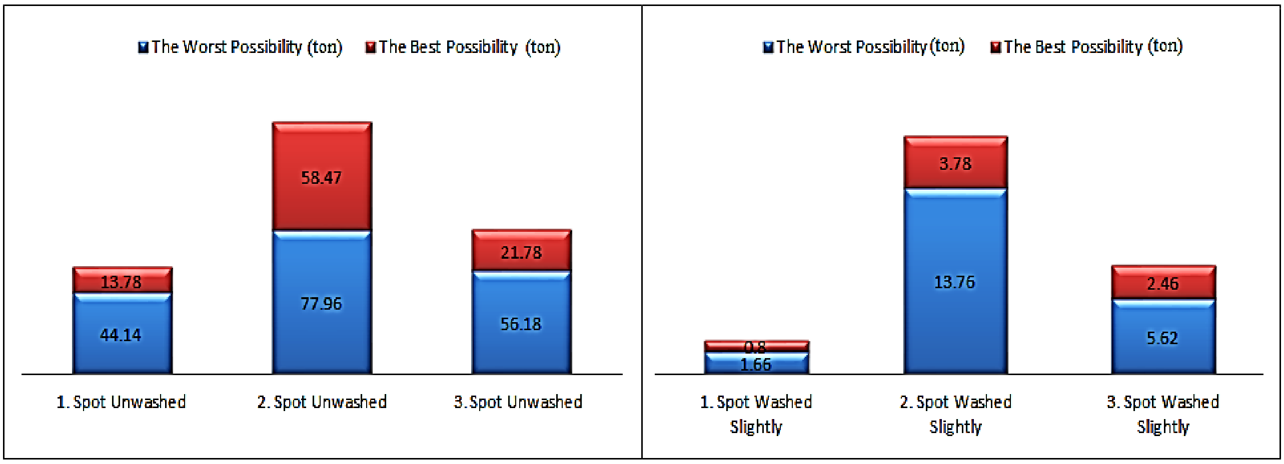

Fig.9 Amounts of sand exposed to erosion at Alanya coastline in worst and best situations

This process was completed by passing the collected sand samples through sieve analysis and determining the d50. The taken samples coordinates were entered on the map, as described in the report, indicating the d50 radii. Then three different locations with a different type of sand were determined along the beaches located on Alanya coastline. By going to these designated places, walking from the seaside to the upper part of the beach (this route is shown as point A and point B in the photographic report), sand, gravel and other sediments that stick to wet feet while standing are washed in the tray and taken into sample containers. Another remarkable thing here is that the amount of sand adhering to the body is higher on the coasts with smaller grain diameters. The same procedure was performed three times in all three positions. The same application was made by washing the feet carelessly. The reason for this is that it does not carry sediment by leaving the sea, the coast, like everyone else.

The samples collected from this experiment after the measurements were dried in the oven at 100°C for 24 hours to remove their wetness (moistıre). Thus, the sands were dried to be able to measure accurately. At the end of 24 hours, each sample was measured separately and noted how many grams they were. The mass values from the measured dried samples are presented in the report. A dimensionless distribution was obtained by dividing all the results obtained after these measurements by the foot number of the person concerned (foot sizes of 36 and 41for female and male representers, respectively).

The number of tourists coming to Alanya in the last months of the tourism season, which is official via the internet (the data for the year 2015 was available), is multiplied by 5, assuming that they have an average of 5 days of vacation, and assuming that half of the number of local people swim an average of 4 days a month (only weekends), during each month (the months when tourism sector is active and swimming is possible). The average number of people entering the sea was calculated. By adding up the months calculated during the tourism season, how many tourists came in a year was also calculated and noted. By multiplying this result by the dimensionless results obtained by dividing the samples by the foot number, the amount of sand eroded per month was calculated. The calculations are also given in detail in the report. For each point, the samples of both people for the unwashed and carelessly washed (slightly washed) feet were shown in a common graph, and the best and worst possibilities were determined and calculations were made according to these.

Considering the worst and best possibilities of each location and evaluating the best and worst possibilities of them, 77.950 tons to 80 tons of sand at the worst, 13.750 tons to 14 tons of sand at the best case, 13.750 tons to 14 tons of sand with unwashed feet cause coastal erosion is happening. This situation was calculated at very low levels on slightly washed feet. Namely, at worst, 13.760 tons of sand is eroded by transporting 800 kg of sand at best. As it can be understood from here, there is a big difference between the feet that are washed, even if it is slightly, and those who leave the shore without being washed. These are the results calculated according to the dimensionless foot number.

It is known that the average foot size is 38 for women and 42 for men. From this, it can be said that the average foot number of both genders is 40. If the results found are multiplied by 40, it can be said that there is unwashed sediment from 550 tons to 3200 tons. This situation ranges from 32 tons to 550 tons on slightly-washed feet. Thanks to the studies carried out within the scope of this project, it has been determined how much tourism-based sediment transport is.

As it can be understood from the obtained results, the difference between the amount of sediment carried by the unwashed foot and the amount of sediment carried by the slightly (carelessly) washed foot is obvious.

However, even with slightly washed feet, there is an annual risk of coastal erosion of up to 200 tons. The reason that affects coastal erosion so much should not be ignored. Human-induced sediment transport should be prevented by placing fountains at the coastal endpoints as close as possible.

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