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The Effect of Soil Particle Size on the Soil Organic Matter and the Abundance of Sand Bubbler Crab *Scopimera globosa* at Tanjung Aru Beach, Kota Kinabalu, Sabah

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Abstract
Sandy beach area is an important ecosystem for most beach and intertidal animals especially for the crustaceans such as crabs and clams. The aim for this study is to identify the relationship of the soil particle size, soil organic matter and the abundance of sand bubbler crab, *Scopimera globosa*. This study was conducted at Tanjung Aru Beach 1, Tanjung Aru Beach 2 and Tanjung Aru Beach 3, Kota Kinabalu, Sabah. Three samplings were conducted from 11th August until 5th October 2015. The soil particle size was determined using sieving method while the soil organic matter was determined using the loss-on-ignition (LOI) method. The abundance of *S. globosa* was calculated based on the number of *S. globosa* obtained from the sampling. Results showed that positive correlation can be seen in the relationship of sand particle size on the soil organic matter ($n = 81$, $r = 0.447$, $p < 0.05$) and the abundance of *S. globosa* ($n = 81$, $r = 0.311$, $p < 0.05$). Besides, the relationship of soil organic matter and the abundance of *S. globosa* also showed positive correlation ($n = 81$, $r = 0.361$, $p < 0.05$). However, the relationship occur inversely for silt and clay whereby both showed negative correlation on soil organic matter ($n = 81$, $r = -0.447$ and -0.53, $p < 0.05$) and the abundance of *S. globosa* ($n = 81$, $r = -0.310$ and -0.431, $p < 0.05$). For recommendation, in order to study on the distribution of different types of soil particle size, soil organic matter and abundance of any crustaceans at the beach area, other factors such as tidal level, wave actions and vegetation in the area should be included because they also affect the distributions.

Introduction

Sandy beach area is a habitat for most beach and intertidal animals such as crabs, clams and beach fleas, sea pill bugs and polychaetes worms. For middle shore area, it is dominated by bivalves such as clams, amphipod and isopod crustaceans while for the upper shore area, it is dominated by decapod crustaceans such as crabs (Little, 2000).

Beach is considered as one of the Sabah Tourism Industry main focus and due to that, a highly rated hotel such as Shangri-La Tanjung Aru Resorts has been built at Tanjung Aru Beach area because of the nature and beautiful scenery of beach (Muda, 2013). Other than hotel, golf and yacht club such as Kinabalu Golf Club and Kinabalu Yacht Club are also built near the beach area (Sabah Tourism Board, 2015). Hence, better management is needed in order to develop more urban area in terms of constructions for building and facilities but at the same time natural environment of the beach area can be conserved and protected.

Identifying the soil particle size is important in construction because it determines the type of soil in the area (Lai *et al.*, 2015). At the same time, soil particle size also can be used to determine the soil organic content (Plaster, 2003). Indirectly, the abundance of crabs can also be determined because they feed on the organic matter (Saher & Qureshi, 2010). Thus, identifying the soil type from soil particle size can be used as an indicator to help in finding better management in term of geomorphic and geological features of the beach area. The information on classification of the soil can be used by engineers to identify the base of building for construction so that soil erosion can be avoided (Lai *et al.*, 2015). Meanwhile, soil organic matter and abundance of sand bubbler crab *S. globosa* also help to identify the changes that occur in the beach landscape. Once there are changes in the soil particle size, the organic content and the abundance of *S. globosa* might change as well (Beasy & Ellison, 2013).

Methodology

Study site

This study was done at Tanjung Aru Beach, Kota Kinabalu, Sabah. Three stations at Tanjung Aru Beach were selected, Beach 1 (05°56'56.4"N, 116°02'41.8"E), Beach 2 (05°56'33.9"N, 116°02'48.8"E) and Beach 3 (05°56'07.1"N, 116°02'48.0"E). Beach 1 is located near to residential and commercial building such as Kinabalu Golf Club and Kinabalu Yatch Club. Beach 2 is located in the middle of Beach 1 and Beach 2. It is also known as Prince Philip Beach. Beach 3 is located at the end of Tanjung Aru Beach where the area is lacked of accommodation such as food stalls and restaurants like Beach 1 and Beach 2.

Source: Google Earth (2015)

Figure 1. Study site stations at Tanjung Aru Beach. Station 1: Beach 1, Station 2: Beach 2 and Station 3: Beach 3.

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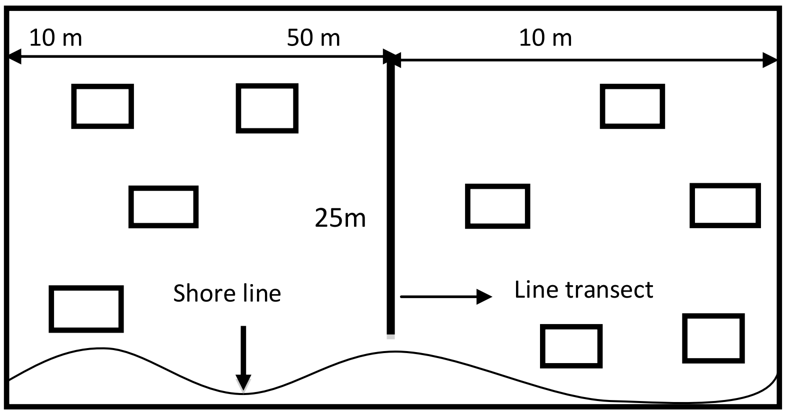
Crab and soil collection

Field work for this study was done for three months starting from August 2015 until October 2015. Each sampling was done once in a month with total three samplings during the whole period. Random sampling was done at the beach with nine quadrats per station and three replicates at each distance.



Represents replication of quadrats

Figure 2. Sampling layout by using quadrat size of 1m^2 (1m × 1m)

Crab sampling was done by using small spade to dig all open burrows contained inside each quadrat. The preservation was only done once for all sampling. Soil sampling was done at each distance with three replicates of 1.5 kg of sand were collected randomly. Total of sand collected was 4.5 kg per distance, 13.5 kg per station and 40.5 kg per sampling. According to Gengatharan (2007),

$$\text{Percentage of abundance of crab} = \frac{\text{Number of species in each quadrat}}{\text{Total number of species in the area}} \times 100.$$

Soil particle size

Samples were air-dried first before undergone the sieving method. The water in the sand must be removed by exposing as much surface of the sand to circulating air as possible for five days and the duration to air-dry the samples for this study also took five days to be fully dried (Benton Jones Jr., 1999).

Sieving method by using UTS sieve shaker was used in order to determine the particle size. Before the sample was poured into the sieve stack, the weight of each empty sieve was recorded. The sieve stack was placed on the sieve shaker and shook for 10 minutes. Each sieve weight was recorded after the sieve stack was then removed from the sieve shaker. Formula used was based on Coyne and Thompson (2006) in order to identify the percentage of sand, silt and clay particle size.

$$\text{Percentage of sand size particle} = \frac{\text{Weight of A (g)} + \text{Weight of B (g)} + \text{Weight of C (g)} + \text{Weight of D (g)}}{500\ \text{g}} \times 100$$

Percentage of clay size particle = $\frac{\text{Weight of E (g)}}{500\text{ g}} \times 100$

Percentage of silt size particle = $\frac{\text{Weight of F (g)}}{500\text{ g}} \times 100$

Where weight of A is the weight of sieve A which represents particles larger than 1mm, B is the weight of sieve B which represents particles between 250 micron and 1mm, C is the weight of sieve C which represents particles between 212 micron and 250 micron, D is the weight of sieve D which represents particles between 125 micron and 212 micron, E is the weight of sieve E which represents particles between 63 micron to 125 micron and F is the weight of particles less than 63 micron. Following is the table of diameter of sieve and type of soil based on sieve size.

Table 1. Sieve diameter and types of soil based on sieve set

Diameter of Sieve	Type of soil
1 mm	Sand
250 micron	
212 micron	
125 micron	Silt
63 micron	Clay

Source: (Coyne & Thompson, 2006)

Soil organic matter

The frozen sand must be defrosted first before drying them at 60 °C in the laboratory oven for 24 hours (Huzarska, 2013). For LOI method, 1 g of dried samples were placed in labelled pre-weighed crucibles. Then, the weight of the crucibles together with the sediment were weighed by using the analytical balance. This is considered as the initial weight. The samples were combusted at 550 °C for five hours in the muffle furnace (Mugai & Agong, 1997). After five hours, the crucibles were taken out from the furnace and cooled down in a desiccator. The final weight were taken after the crucibles were cooled down. Finally, the percentage organic content of the samples were calculated by using the following equation based on Benton Jones Jr. (1999).

Percentage of organic matter = $\frac{\text{Initial weight (g)} - \text{Final weight (g)}}{\text{Initial weight (g)}} \times 100$

Statistical Analysis

All variables were tested for normality by Shapiro-Wilk's test ($p > 0.05$). All variables were not normally distributed. Spearman's rank order was used to determine the relationship between the variables since the variables were not normally distributed (Coakes, 2005).

Result and discussion

Relationship of soil particle size and soil organic matter

From Figure 3, the sand particle is positively correlated with the amount of organic matter with n = 81, r = 0.447, $p < 0.05$. Meanwhile, for silt and clay particle size in Figure 4 and Figure 5, both showed negative correlation with the amount of organic matter with n = 81, r = -0.447 and -0.53, p < 0.05. The higher the percentage of sand, the higher the amount of organic matter and the lower the percentage of silt and clay, the lower the amount of organic matter. Beach area is mainly composed of sand and this had caused the relationship of sand particle and organic matter to be positive. Besides, the percentage of silt and clay at the beach area was equal or very near to 0 %.

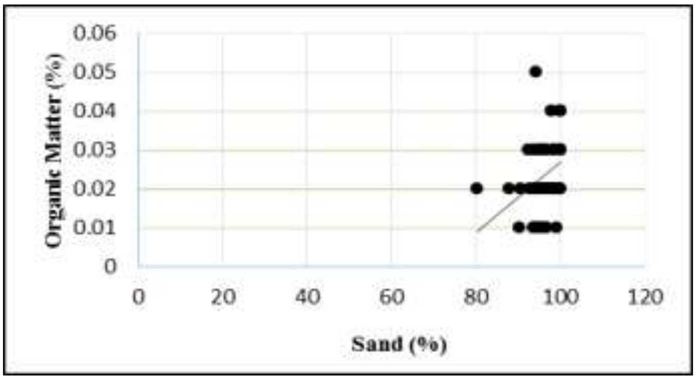


Figure 3. Correlation of sand particle size and organic matter.

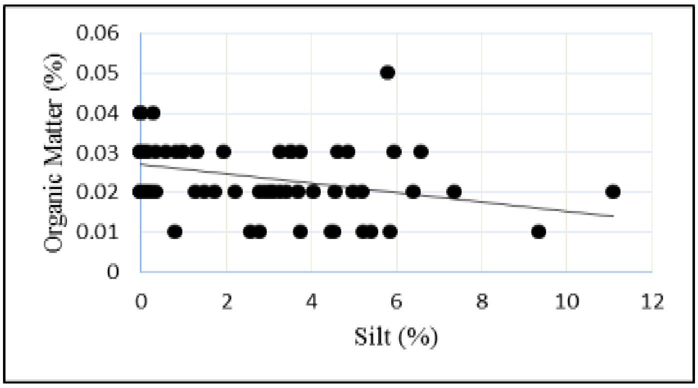


Figure 4. Correlation of silt particle size and organic matter.

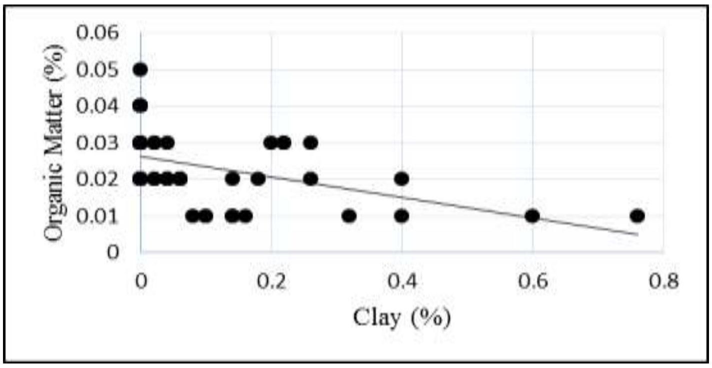


Figure 5. Correlation of clay particle size and organic.

According to Jiao *et al.* (2014), the silt and clay were supposed to be positively correlated with the amount of soil organic matter but not the sand. However, the compositional variability cannot be the only factor that is used to determine the amount of organic matter in the soil (Bergamaschi *et al.*, 1997). The amount of soil organic matter can also be affected by the tidal and wave actions including the vegetation that exist in the area since all stations for this study were done at the beach. Forces that are caused by the tidal level and wave actions affect the particle transport and deposition. As a result, it leads to the variability of concentration of suspended material in the soil (Ward *et al.*, 2015). Other than that, vegetation species that exist and populate the area also plays an important role in the amount of organic matter in the soil. The vegetation helps to capture the sediment particles and indirectly increase the decomposition of organic matter due to the presence of root growth and litter deposition (Roner *et al.*, 2015).

Although previous study by Jiao *et al.*, (2014) showed that sand had negative correlation with organic matter while silt and clay showed positive correlation with the organic matter, the present study by Priyalakshmi & Menon (2014) showed that the size of the particle size alone did not affect the organic matter. The angularity of the sand particle size also affects the organic matter by increasing the attachment of the organic matter to its surface. Angularity means the shape of the particle is not round and has more angle or sharp corner, the higher the chances for the organic matter to attach at its surface.

Relationship of soil particle size and abundance of S. globosa

Figure 6 showed positive correlation between the sand particle size and the abundance of *S. globosa* with n = 81, r = 0.311, p = 0.05. Meanwhile, Figure 7 and 8 showed negative correlation between the silt and clay particle size with the abundance of *S. globosa* with n = 81, r = -0.310, p =0.05 and -0.431, $p < 0.05$. Though, the distribution of *S. globosa* was mainly affected by its behaviour whereby it was able to burrow the sand for its protection. In addition, *S. globosa* only dug burrows in the area that was well-drained and contain firm sand including the exposure to low tide (Takeda *et al.*, 1996).

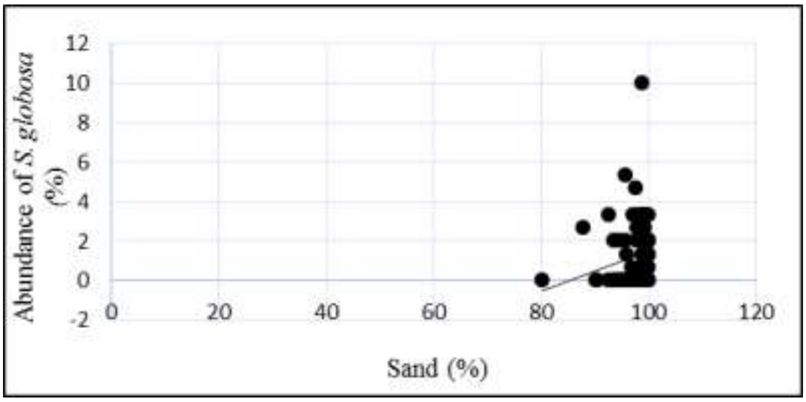


Figure 6. Correlation of sand particle size and the abundance of *S. globosa*

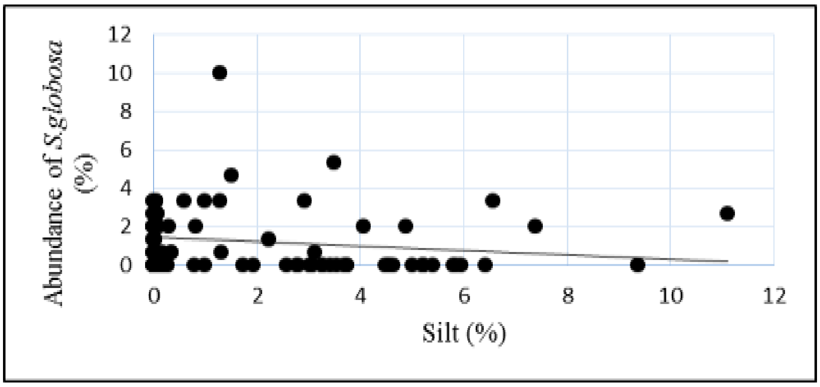


Figure 7. Correlation of silt particle size and the abundance of *S. globosa*

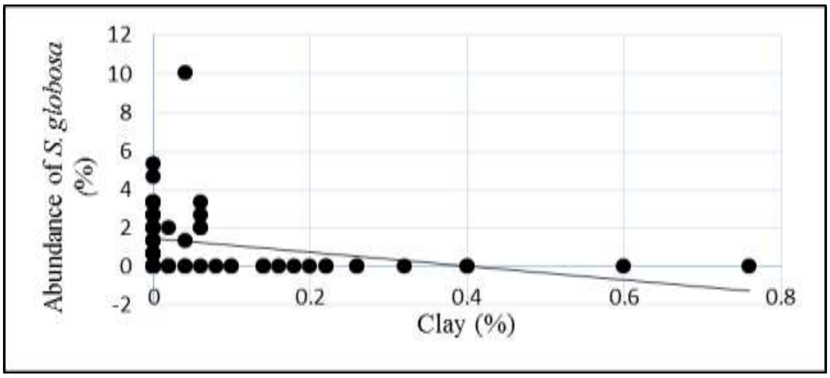


Figure 8. Correlation of clay particle size and the abundance of *S. globosa*

Previously, the distance from the seawards and landwards also affected the abundance of *S. globosa* whereby its abundance was highest at the middle area which was not too near towards the sea and not too near towards the landwards. The landwards area was not a well-drained area because it was not exposed to the tidal and wave actions. Although during the high tides, the landward area had low chances of exposing to waves and this causes the soil in the area to be dried. Meanwhile, the shoreline area was not suitable for the *S. globosa* because the area was too exposed to the waves which can caused the *S. globosa* to be washed away to the sea. As *S. globosa* is a very small organism, exposing itself to the waves was not preferable (Takeda, 2010). In addition, beach surface was said to be unstable due to the various ocean activities such as continuous movement of sand during high tide, upwelling and storm surges accompanied by the monsoon (Priyalakshmi & Menon, 2014).

Relationship of soil organic matter and abundance of S. globosa

The relationship between the soil organic matter and abundance of *S. globosa* was determined by using Spearman's rank order. The P value for the relationship of the organic matter with abundance of *S. globosa* was less than 0.05 and it showed that the correlation did not caused by random sampling. From Figure 4.12, the abundance of *S. globosa* showed positive correlation with the amount of soil organic matter, $r(81) = 0.361$, $p < 0.05$ as shown in Spearman's rank order. The higher the amount of organic matter, the higher the abundance of *S. globosa*. However, the correlation was not that strong because *S. globosa* is a species that can withstand in the area that has low food source or organic matter as observed by Koga (1998).

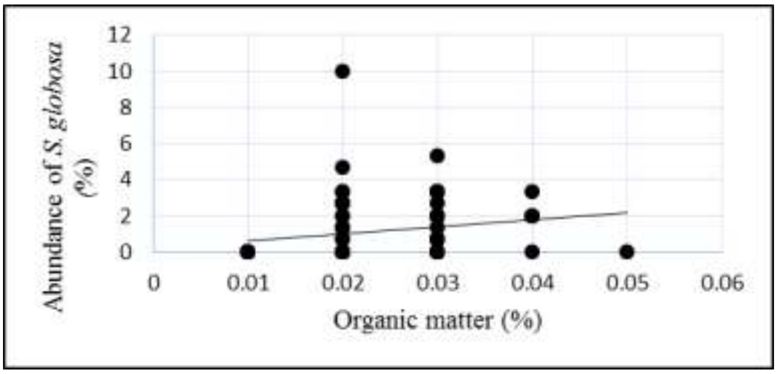


Figure 9. Correlation of soil organic matter and the abundance of *S. globosa*.

Conclusion

Positive correlation can be seen in the relationship of sand particle size on the soil organic matter and the abundance of *S. globosa* including the relationship of soil organic matter and the abundance of *S. globosa*. Meanwhile, the relationship occur inversely for silt and clay. The higher the amount of sand at the beach area, the higher the amount of organic matter. Other than that, the higher the amount of organic matter in the area, the higher the abundance of *S. globosa*.

For recommendation, in order to study on the distribution of different types of soil particle size, soil organic matter and abundance of any crustaceans at the beach area, other factors such as tidal level, wave actions and vegetation in the area should be included because they also affect the distributions of the soil particle size, the soil organic matter and the abundance of the crustaceans.

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