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Spatial Analysis of Organic Material, $CaCO_3$ and C-Organic in Coastal Area, Aceh Besar Regency

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Abstract – Most of the coastal zones of Aceh Besar are areas of accumulation of organic compounds such as C-Organic and $CaCO_3$. Therefore, studying the distribution of organic carbon and carbonates in sediments in coastal areas is necessary. This study aims to analyze the distribution of C-Organic and Calcium Carbonate ($CaCO_3$) coupled with pH and Salinity tests spatially on the surface at a depth of 40 - 60 cm in the coastal area of Aceh Besar District. The C-Organic content was analyzed using the Walkley and Black method, while Calcium Carbonate ($CaCO_3$) was analyzed using the Titrimetric method. Soil pH and salinity tests were carried out in situ using a pH meter, and soil salinity tests were tested using a salinometer. The study results show that the distribution of C-Organic and Carbonate content differs in each location in Aceh Besar Coastal area. The distribution of organic carbon and carbonates in the northern part of Aceh Besar, in the Ujong Batee Puteh area, has an average value of 0.86% and 10.28%. While the distribution of C-Organic in the Lamreh area is, on average, 0.44% and carbonate ($CaCO_3$) is 8.03%. On the other hand, in the western part of Aceh Besar, the distribution C-Organic in the Ujong Pancu area is, on average, 2.83%, and carbonate ($CaCO_3$) is 8.05%. The distribution of C-Organic in the Lhok Seudu area has an average value of 1.07% and carbonate ($CaCO_3$) of 9.65%. The results also reveal the fact that there are 3 (three) factors that influence the distribution of C-Organic and $CaCO_3$. These factors are the topographic location that allows the material to be eroded due to runoff, vegetation that enriches organic matter composition, and the depositional environment. The results of the pH distribution test in soil showed that the pH in the coastal area of Aceh Besar is relatively alkaline, and the salinity distribution is relatively low, indicating the absence of seawater intrusion and salt deposits. Further studies need to be carried out for other depth variations to obtain more comprehensive results of other distributions.

Keywords: C-Organic, $CaCO_3$, soil pH, salinity, coastal.

Introduction

Aceh Besar Regency is one of several districts in Aceh Province located around Banda Aceh City, the capital of Aceh Province. Geographically Aceh Besar Regency is located between 5°2' - 5°8' North Latitude and 95°0' - 95°8' East Longitude, with an area of 2,903.50 Km². (BPS Aceh Besar, 2018). Because of such a location, this coastal area is heavily influenced by processes on land and in the sea (Susiloningtyas *et al.,* 2017). The coastal of Aceh Besar is directly adjacent to the land and ocean, where this coastal is rich in organic matter contained in sediments.

Sedimentary organic carbon in coastal areas plays an important role in the biogeochemical cycle globally (Luo *et al.,* 2015). According to Scharlemann *et al.* (2014), the sedimentary organic carbon in coastal areas belongs to the largest terrestrial carbon storage medium. Organic carbon in sediments consists of a mixture of complex organic compounds whose sources come from marine and terrestrial origins (Gao *et al.,* 2015). This organic carbon content will increase or get higher along with biomass growth (Heriyanto and Amin, 2013).

Sediments have organic and inorganic content, either dissolved or suspended, with the texture of unconsolidated particles in coastal areas (Libes, 2009; Rifardi, 2012). Barus *et al.* (2020) state that sediment serves as a place to accumulate various materials on the coast, one of which is total organic carbon. Research on the distribution of C-Organic has been carried out in a case study on the south coast of the Natuna Islands by Daulat *et al.* (2014). The results showed that the distribution of C-Organic content in the waters ranged from 0.25-1.19 g/kg. Studies on C-Organic in several coastal areas other than Indonesia have also been carried out by Huo *et al.* (2019) on the coast of China, looking at carbonate source rocks with low total organic carbon content and high maturity as effective source rocks. The results showed that carbonate source rocks are effective with kerogens of type I-III (especially sapropelic groups).

Organic carbon studies on the coast of mangrove bay by Nofitasari (2018). The results showed that the C-Organic content was as large as the texture of muddy and sandy gravelly sediments. Jiang *et al.* (2021) conducted a study on East China's coast, reporting that sediment samples' carbonate and organic carbon content had no significant effect on mass organic carbon isotopes derived by ACR. Qu *et al.* (2020) researched organic carbon in Coastal China, Northeast of Shadong. The results show an increase in C-Organic storage in the coastal sediment.

Environmental changes caused by coastal influences can be directly recorded in sedimentary layers (Permanawati, 2016); an example is a carbonate ($CaCO_3$) sediment. $CaCO_3$ sediments on the coast generally come from fragments of coral reefs, where important massive calcium carbonate deposits are produced by Scleractinia corals (Romimohtarto and Juwana, 2005). Calcium carbonate is one of the essential materials that can exhibit distinctive properties and different states in sediments. Carbonate studies in Indonesia were conducted in the waters of Serang by Hartanto (2018); the results found that the highest carbonate content was found around 16% - 16.4% in coastal areas, while in watersheds, the carbonate content was 9.2 % - 9.6 % and in river flows carbonate was around 9.1 % - 9.8 %. A study of $CaCO_3$ has also been conducted by Orozco *et al.* (2020) on the coast of the Gulf of Mexico by using portable X-ray fluorescence instrumentation on sediment samples. The results indicate that the presence of carbonates that are not related to Ca (for example, $MgCO_3$, $SrCO_3$, $MnCO_3$, $FeCO_3$) was not detected by pXRF.

Aceh Besar's coastal characteristics have complex coastal dynamics, affecting the distribution of organic carbon content, salinity, soil pH, and $CaCO_3$. Indrayani and Hadisusanto (2009) state that the organic carbon content in sediments is closely related to the total organic carbon, $CaCO_3$, and nitrogen and phosphate content on the coast. Several coastal studies involving the three sedimentary elements have been carried out in Indonesia. A case study on the coast of Flores has been conducted on organic and total organic carbon by Permanawati and Hernawan (2018). The study's results showed that the percentage of total organic carbon was 0.999-4.453%.

In contrast, the distribution of organic carbon in the coastal sediments showed dynamic changes in the central water area compared to the western and eastern parts. Meanwhile, the chemical study of $CaCO_3$ has been studied by Aisha (2018) on the northern coastline of Java Island by looking at the distribution of carbonate rocks using the kriging method. The results showed that based on carbonate distribution models, the study environment had a reefal type of carbonate with a combination of limestone and dolomite rocks.

The study of organic carbon, salinity, soil pH, and CaCO3 on the coast focuses on spatially sediments to see changes and distributions in the coastal area. By knowing the spatial changes, we can use this information for the wiser use of coastal management, such as for coastal resource management and the development and planning of coastal areas in a sustainable manner (Setyowati, 2007). Therefore, the study aims to understand how the spatial distribution pattern and chemical elements of C-Organic sediments, salinity, soil pH, and CaCO3 are distributed in the Aceh Besar regency coastal sediment. We conducted the study by using spatial analysis together with GIS methods application. In addition, this study is very important to be carried out considering that this coastal zone has dynamic environmental characteristics that create heterogeneous conditions in order to monitor the condition of the coastal environment of Aceh Besar.

Materials and Methods

Time and site

This research was conducted on the coast of Aceh Besar. The study sampled 4 locations (Ujong Batee Puteh, Lamreh, Ujong Pancu, and Lhokseudu) with 20 sediment data taken in location and five data in each location

(Figure 1 and Figure 2). The distance between one sampling point and another is ± 100 meters at each location, starting from June to August 2021. Sample analysis was carried out at the Soil Laboratory of the Faculty of Agriculture, Syiah Kuala University, and Baristand Industri Banda Aceh Industrial Research and Development Agency. The data analysis used in this study is $CaCO_3$, soil pH, salinity, and C-Organic. The tools used in this study were Global Positioning System (GPS), Hand Auger, pH meter, Conductor, printer, and Arc GIS 10.8. The map of the research location can be seen in Figure 1, while the map of the distribution of the entire sampling point can be seen in Figure 2.

Soil Sampling

C-Organic soil, salinity, soil pH, and $CaCO_3$ sampling were carried out by the coring method (ASTM, 2008), with a depth of 40-60 cm meters perpendicularly using a Hand Auger tool. Soil samples were taken 5 samples at each study location. Sediment sampling is carried out at each sampling point. Soil samples were analyzed for identification at Aceh Industrial Research and Standardization Center (Baristand) Laboratory and the Soil Chemistry Laboratory.

Analysis of C-Organic

Analysis of C-Organic content was carried out using the Walkley and Black method. The working procedure for analyzing the C-Organic content is as follows: First, the sample was dried in the soil drying laboratory for 11 hours at a room temperature of 32 °C-33 °C. Second, weighing a soil sample of 0.500 g with a size of <0.5 mm, the sample was put into Erlenmeyer 250 ml. Third, the sample added a solution of 5 ml of $K_2C_{r2}O_7$ 1 N, then added it back using a solution of 10 ml of concentrated H_2SO_4, then stirred for 30 minutes. Next, after allowing it to stand, the aquadest 100 ml was added with a 5 ml phosphate solution (H_3PO_4). Finally, a blank solution of 1.5 ml was added and titrated using a $FeSO_4$ solution until the color changed.

Analysis of Calcium Carbonate ($CaCO_3$)

Analysis of $CaCO_3$ sediment was carried out using the Titrimetric method. The reagent materials used are HCL, PP Indicator, and NaOH. The work procedure in analyzing Calcium Carbonate ($CaCO_3$) is: first, the soil sample was weighed 1 gram using digital scales, and then the sample was placed on the watch glass (watch glass). Second, the sample was placed into the Erlenmeyer 250 ml. In the third step, aquadest 25 ml was inserted, and HCL 0.5 N 15 ml was added. The last, the previously mixed solution was warmed up after cooling; the HCL was tipped using a 0.1 N NaOH solution with a PP indicator until it turned pink.

Analysis of Soil pH

The working procedure for soil pH analysis is as follows: the first stage, weighing 10.00 g of soil samples using digital scales, is carried out. In the second stage, after weighing, the sample is put into a shaken bottle, and 25 ml of ion-free water is added. Next, a whisk is performed with a whisking machine for 60 minutes—the last stage measures the soil's pH content using a calibrated pH meter tool.

Analysis of Salinity Soil

The working procedure for soil salinity analysis is as follows: first, a sample weighing 10.00 g of soil samples is carried out using digital scales. Second, the sample is put into a shaken bottle and added to 25 ml of ion-free water after weighing. Next, a whisk is carried out with a whisking machine for 60 minutes. The third step is to measure the salinity content of the soil with a salinity conductometer that has been calibrated using the KCL standard solution. Finally, each will calibrate and measure the electrode for washing and drying with a tissue. Soil salinity values are reported in dS m^{-1} units using decimals.

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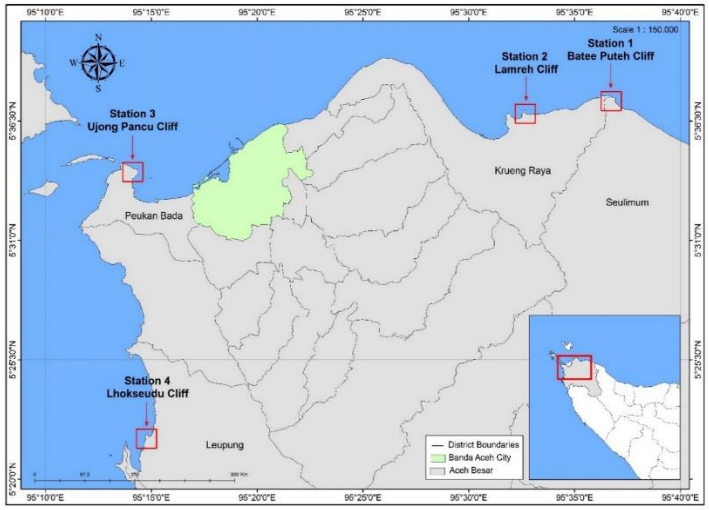

Figure 1. Research location in the coastal area of Aceh Besar Regency.

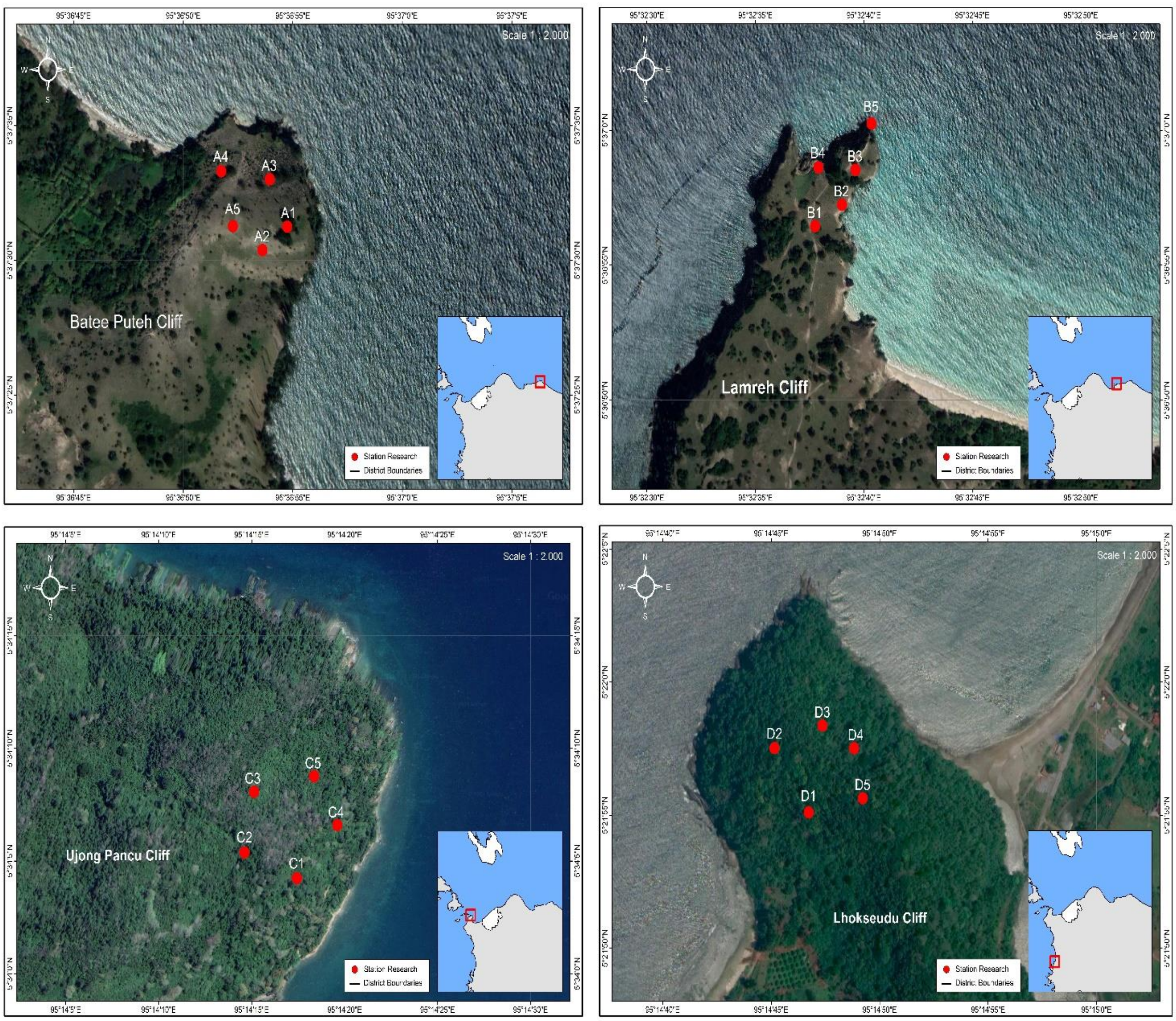

Figure 2. Station's Overall Sampling Point

Results

Laboratory test results for C-Organic, pH, salinity and carbonate parameters can be seen in Table 1 for station 1 Ujong Batee Puteh, Table 2 for station 2 Lamreh, Table 3 for station 3 Ujong Pancu, and Table 4 for station 4 Lhokseudu. The study results at Station 1 of the Ujong Batee Puteh cliff coastal area can be seen in Table 1. The results showed that the highest C-Organic value was 1.39%, while the lowest C-Organic value was worth 0.25%. The soil pH value > 8 indicates that the soil's pH in the area is alkaline. The salinity with the highest value is 0.30, while the lowest is 0.16. The highest $CaCO_3$ content is valued at 11.72%, and the lowest value is 8.10%. The average distribution value for C-Organik at station 1 Ujong Batee Puteh is 0.86%, while for carbonate ($CaCO_3$), it is 10.28%.

Table 1. Station 1 of Ujong Batee Puteh.

No	Location		C-Organic (%)	Soil pH	Salinity (mS cm-1)	$CaCO_3$ (%)
	Latitude (N)	Longitude (E)				
1	5°37'34.80"	95°36'52.90"	0,25	8,37	0,16	8,10
2	5°37'29.50"	95°36'55.11"	1,39	8,22	0,30	9,36
3	5°37'32.62"	95°36'55.33"	1,07	8,18	0,25	11,44
4	5°37'30.85"	95°36'52.62"	0,85	8,33	0,19	10,81
5	5°37'33.10"	95°36'50.40"	0,78	8,22	0,25	11,72

Table 2. Station 2 of Lamreh.

No	Location		C-Organic (%)	Soil pH	Salinity (mS cm-1)	$CaCO_3$ (%)
	Latitude (N)	Longitude (E)				
1	5°36'57.50"	95°32'37.70"	0,40	8,58	0,20	12,56
2	5°36'59.62"	95°32'40.09"	0,63	8,14	0,40	6,93
3	5°36'57.98"	95°32'35.19"	0,53	8,51	0,20	7,38
4	5°36'54.88"	95°32'38.47"	0,30	8,47	0,25	6,43
5	5°36'54.82"	95°32'35.37"	0,34	8,60	0,25	6,87

Table 3. Station 3 of Ujong Pancu

No	Location		C-Organic (%)	Soil pH	Salinity (mS cm-1)	$CaCO_3$ (%)
	Latitude (N)	Longitude (E)				
1	5°34'00.9"	95°14'16.9"	0,76	7,12	0,13	6,11
2	5°33'59.03"	95°14'14.48"	0,76	8,11	0,20	8,89
3	5°34'3.56"	95°14'19.21"	0,43	6,13	0,10	9,68
4	5°34'2.07"	95°14'14.67"	0,53	5,71	0,07	7,76
5	5°34'5.21"	95°14'17.39"	0,35	5,50	0,10	7,83

The study results at Station 2 of the Lamreh coastal area can be seen in Table 2. The results showed that the highest C-Organic value was valued at 0.63%, while the lowest C-Organic was worth 0.30%. The soil pH value > 8 indicates that the soil's pH in the area is alkaline. The salinity with the highest value is 0.40, while the lowest is worth 0.20. The highest $CaCO_3$ content is valued at 12.56%, and the lowest value is 6.43%. The average distribution value for C-Organic at station 2 Lamreh is worth 0.44%, while for carbonate ($CaCO_3$), it is worth 8.03%.

The study results at Station 3 of the Ujong Pancu coastal area can be seen in Table 3. The results showed that the highest C-Organic value was valued at 0.76%, while the lowest C-Organic value was worth 0.35%. The highest soil pH value is 8.11, and the lowest soil pH value is 5.50. The highest value is 0.20, while the lowest is 0.07. The highest CaCO3 content is valued at 9.68%, and the lowest value is 6.11%. The average distribution value for C-Organik at station 3 Ujong Pancu is 2.83%, while for carbonate (CaCO3), it is 8.05%.

The study results at Station 4 of the Lhokseudu coastal area can be seen in Table 4.4. The results showed that the highest C-Organic value was valued at 1.55%, while the lowest C-Organic value was worth 0.82%. The highest soil pH value is 8.05, and the lowest is 6.74. The salinity with the highest value is 0.30, while the lowest is 0.10. For temperature values in all distributions of research points, the value is the same at 25 °C. The highest $CaCO_3$ content is valued at 10.95%, and the lowest value is 8.11%. The average value of the distribution for C-Organic at station 4 Lamreh is worth 1.07%, while for carbonate ($CaCO_3$), it is worth 9.65%.

Table 4. Station 4 of Lhokseudu

No	Location		C-Organic (%)	Soil pH	Salinity (mS cm-1)	$CaCO_3$ (%)
	Latitude (N)	Longitude (E)				
1	5°21'54.3"	95°14'44.10"	0,85	6,74	0,10	10,95
2	5°21'57.74"	95°14'48.23"	0,98	8,05	0,30	9,04
3	5°21'52.07"	95°14'47.07"	1,16	7,62	0,18	8,11
4	5°21'54.39"	95°14'47.72"	0,82	6,92	0,12	10,76
5	5°21'57.38"	95°14'45.70"	1,55	7,13	0,20	9,41

Discussion

Distribution of C-Organic

The distribution of C-Organic includes where organic materials accumulate either decomposed or those that have not been decomposed in a particular distribution. The distribution of C-Organic in this study is caused by the distribution of organic carbon in the difference in sediment origin sources, the alternation of the strength of coastal dynamics, and differences in the productivity of coastal areas when organic carbon material is deposited (Permanawati and Hernawan, 2018). The results of the analysis for the distribution of C-Organic at a depth of 40-60 cm at each station in the study area can be seen in Figure 3. Figure 3 shows the distribution at point 1 C-Organic is slightly valued compared to other points with a value of 0.25% due to soil erosion at the site. Soil erosion that occurs in these layers plays a role in reducing the soil's organic carbon (Victorious, 2012). The presence of soil erosion at point 1 is green on the contour map, where C-Organic is of low value. This follows the study of Diara (2017), which stated that the decrease in soil C-Organic through the erosion process would cause soil fertility to be low.

The largest C-Organic is found at point 2 by 1.39%, marked in orange on the contour map. C-Organic at that point is due to the presence of litter in the form of fallen twigs and leaves so that the decomposition process occurs and the process of litter deposition in the area is added. Sabaruddin *et al.* (2009) posit the same thing, that litter accumulates both in the surface layer of the soil and below the soil surface. This accumulation process makes an increase in the content of C-Organic.

The distribution at point 3 C-Organic is worth 1.07%. This is due to the presence of vegetation in the area. The more vegetation C-Organic will increase, and vice versa. The distribution at point 4 and Point 5, marked in yellow, has C-Organic values of 0.85 and 0.78; this value is influenced by the small amount of vegetation in the distribution of the location, causing a decrease in nutrients which results in poor or less fertile soil. This is in accordance with the study of Subarno and Sartohadi (2015), which explained that in areas that are small in vegetation, C-Organic in the soil would decrease. In addition, soil C-Organic will decrease as the soil depth increases (Subarno and Sartohadi, 2015).

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The results of the analysis for the distribution of C-Organic at a depth of 40-60 cm at each station in the study area can be seen in Figure 4. Figure 4 shows that the most considerable C-Organic distribution value is at point 7 with a range of 0.63, while the smallest C-Organic is at point 9 with a range of 0.30. Jackson *et al.* (2017) the dynamic accumulation and distribution of C-Organic at the site is the result of stabilization and destabilization of processes influenced by factors both biotic (quantity, chemistry, composition, and relative allocation of plant inputs) and abiotic (climate, soil surface aspects, slope, soil temperature, and humidity, texture). A decrease in the content of C-Organic at point 9 can lead to a decrease in terms of soil fertility. This is in accordance with Lal (2004), which states that a decrease in C-Organic leads to a decrease in soil fertility and the onset of degradative processes such as erosion, compaction, and nutrient deficiencies.

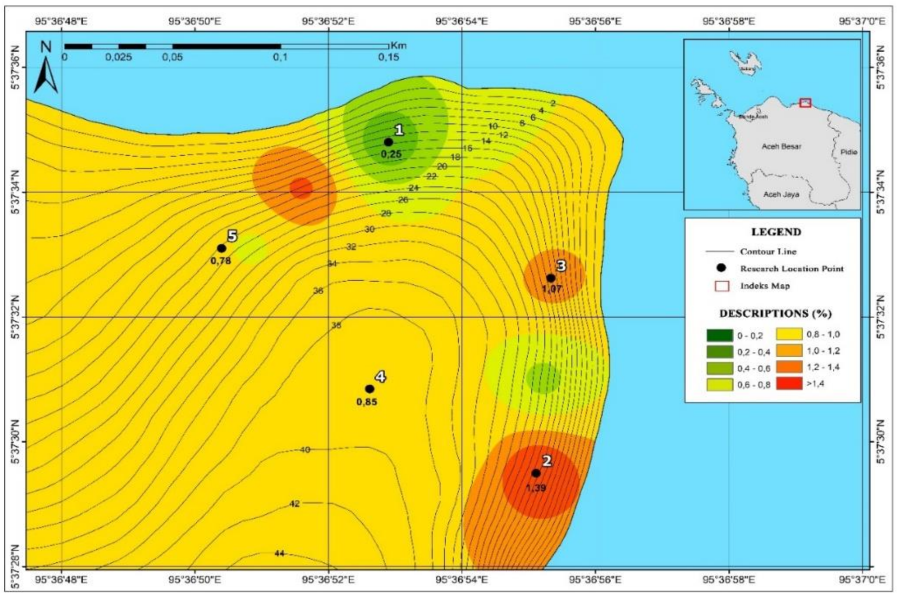

Figure 3. GIS Analysis of C-Organic contours at station 1 of Ujong Batee Puteh Cliff.

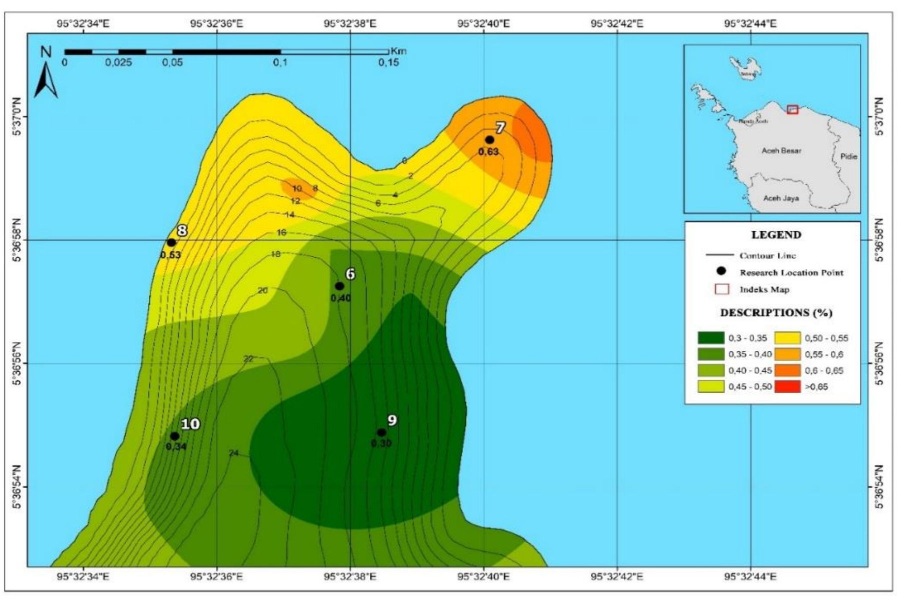

Figure 4. GIS Analysis of C-Organic contours at station 2 of Lamreh Cliff.

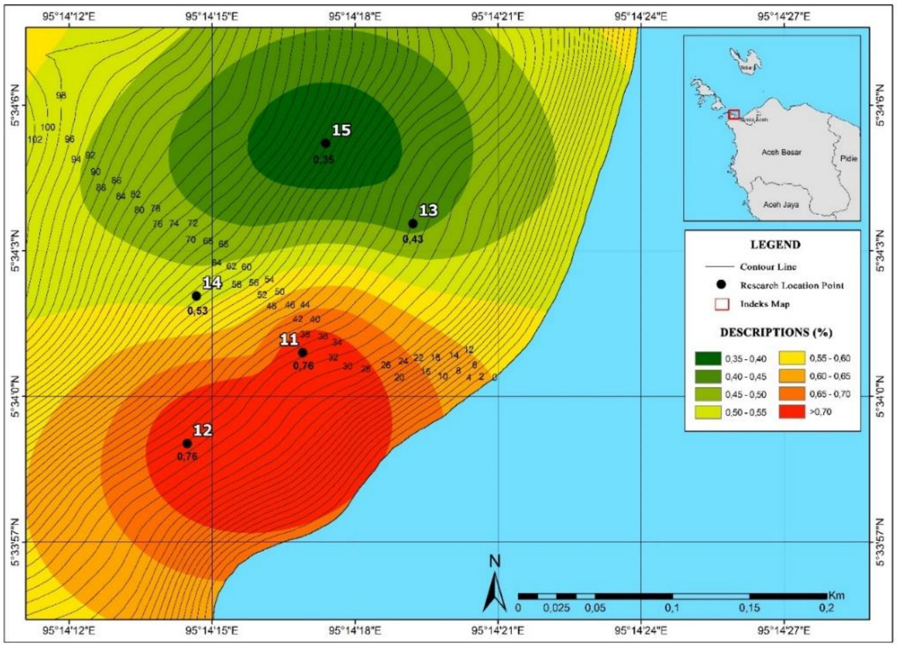

Figure 5. GIS Analysis of C-Organic contours at station 3 of Ujong Pancu Cliff

The results of the analysis for the distribution of C-Organic at a depth of 40-60 cm at each station in the study area can be seen in Figure 5. Figure 5 shows the most significant C-Organic values at points 11 and 12 with > 0.70, while the smallest C-Organic is located at point 15 with a value of 0.35. The difference in C-Organic in each distribution is due to the topography, soil conditions, and vegetation. Topography, soil conditions, and vegetation are essential factors controlling C-Organic content in different ecosystems and vegetation types (Manning *et al.,* 2015; Huang *et al.,* 2021). Several influencing factors (topography, soil, and vegetation conditions) on C-Organic content have been extensively investigated (Bai and Zhou, 2020; Jimenez-Gonzalez *et al.,* 2020; Mirchooli e*t al.,* 2020). C-Organic has a low content at point 15 due to topographic factors. C-Organic has a low content at point 15 due to topographic factors. This is because the topography is an essential factor that causes C-Organic differences. C-organic loss increases with an increase in the slope gradient due to soil erosion can eliminate most of the C-Organic (Li *et al.,* 2016).

The results of the analysis for the distribution of C-Organic at a depth of 40-60 cm at each station in the study area can be seen in Figure 6. Figure 6 shows that an immense C-Organic value is at point 20 with a content of 1.55%, while the smallest C-Organic content is found at points 16 and 19 with a range of 0.85% and 0.82%. The distribution at points 16 and 19 indicates erosion and reduced nutrition at that point by looking at a decrease in C-Organic. This is to the opinion (Lal, 2004) that the decline in C-Organic causes a decrease in soil fertility and the emergence of degradative processes such as erosion. In addition, the variation in values in the distribution of C-Organic at station 4 is due to the complexity of environmental conditions. Ward *et al.* (2014) and Yu *et al.* (2019) state that the main factors affecting the spatial distribution of C-Organic content can vary across regions due to the complexity of environmental conditions.

Distribution of $CaCO_3$

The distribution of $CaCO_3$, in general, shows how the environmental conditions of soil carbonates affect deposition and soil quality. It is spatially known that calcium carbonate plays a vital role in soil formation and its chemical and physical properties (Najafian *et al.,* 2012). The distribution of $CaCO_3$ at station 1 can be seen in Figure 7. Figure 7 shows that the distribution of $CaCO_3$ at station 1 has a pattern of magnitude content at points 3 and 5, namely 11.44% and 11.72%. The content of $CaCO_3$ at that point is affected by a large amount of carbonate deposition. Points 1 and 2 have almost the same pattern as elevations worth 15 m; this corresponds to Moulin *et al.* (1994), the content of soil $CaCO_3$ is strongly influenced by elevation. Meanwhile, at point 4, the content of $CaCO_3$ is caused by erosion at that point.

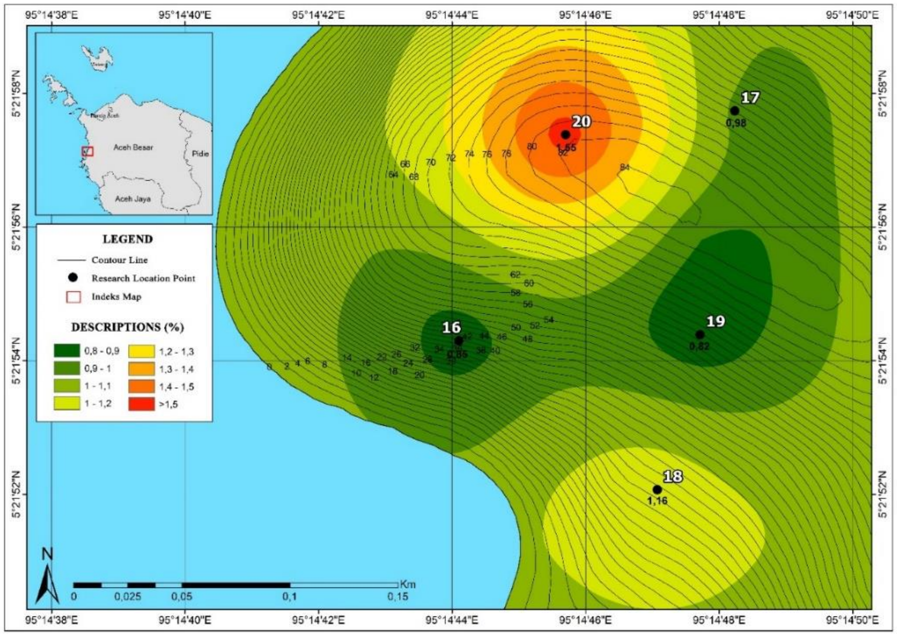

Figure 6. GIS Analysis of C-Organic contours at station 4 of Lhokseudu Cliff.

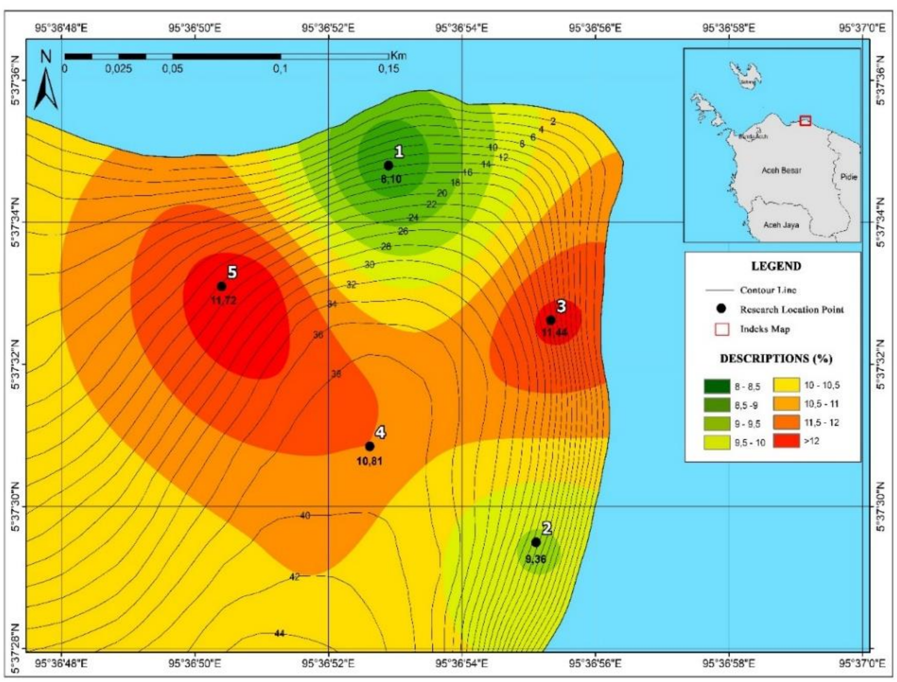

Figure 7. GIS Analysis of $CaCO_3$ contours at station 1 of Ujong Batee Puteh Cliff.

The distribution of $CaCO_3$ at station 2 can be seen in Figure 8. Figure 8 shows that the figure shows that the distribution of $CaCO_3$ varies. Point 6 has the most considerable calcium carbonate content, around 12.56%. Another case at point 9 has the lowest value of around 6.43%. Various soil properties influence the abundance of carbonates at the entire point of station 2. Following Peverill *et al.* (2001), that carbonate abundance is influenced by various soil properties, including texture, porosity, permeability, structure, and cation exchange

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capacity. The ground $CaCO_3$ at station 2 is derived from the calcareous parent material. This follows the statement of Monger *et al.* (2015), Calcium Carbonate can be derived from calcareous parent material (primary carbonate) or formed during pedogenesis (secondary carbonate).

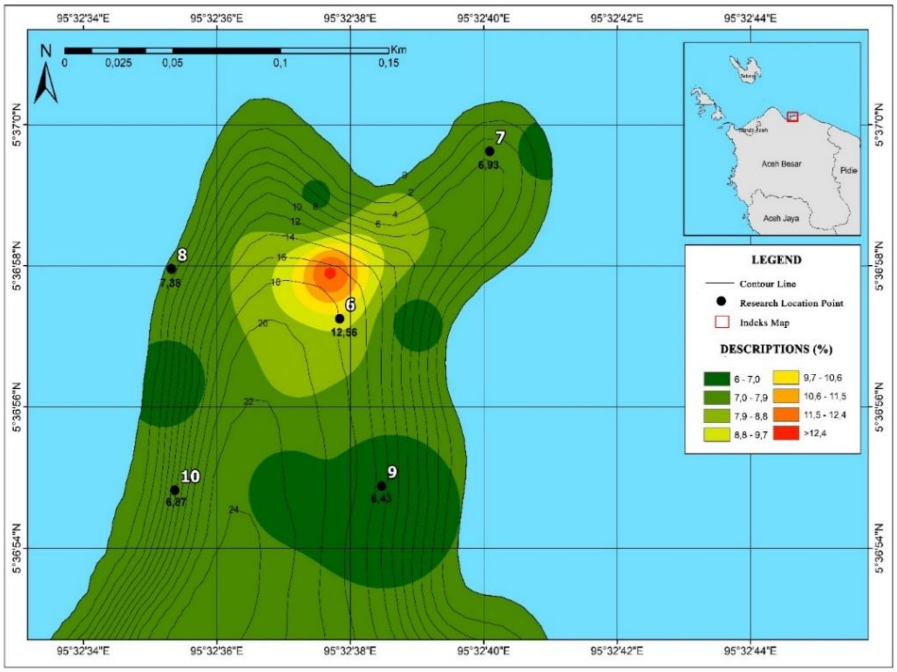

Figure 8. GIS Analysis of $CaCO_3$ contours at station 2 of Lamreh Cliff

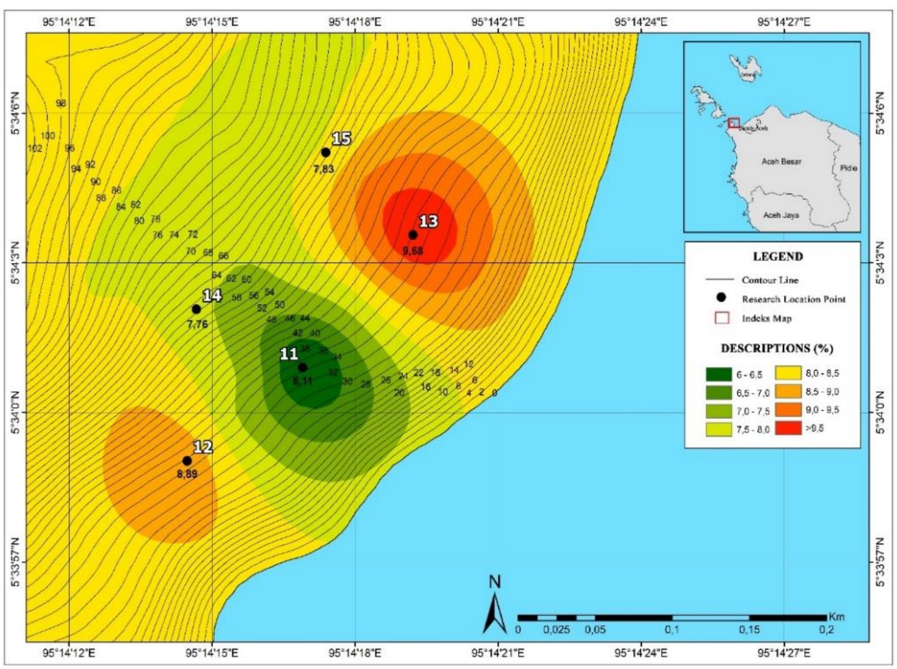

Figure 9. GIS Analysis of $CaCO_3$ contours at station 3 of Ujong Pancu Cliff.

The distribution of $CaCO_3$ at station 3 can be seen in Figure 9. The picture shows that the distribution of $CaCO_3$ is different. The distribution at point 13 has the largest content among other distributions. This is influenced by a large amount of accumulated carbonate deposition at the site. The distribution of the $CaCO_3$

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accumulation area is not necessarily the material source of the site since carbonate particles can move from the source because they are affected by the movement of water.

The distribution of $CaCO_3$ at station 4 can be seen in Figure 10. The picture shows that the distribution of $CaCO_3$ is different. Point 16 has the most considerable calcium carbonate content at 10.95%, while the lowest is found in point 18, with a value of 8.11%. The varying value of Calcium Carbonate ($CaCO_3$) in the distribution of these stations can indicate various processes that lead to its formation (Durand *et al.,* 2007).

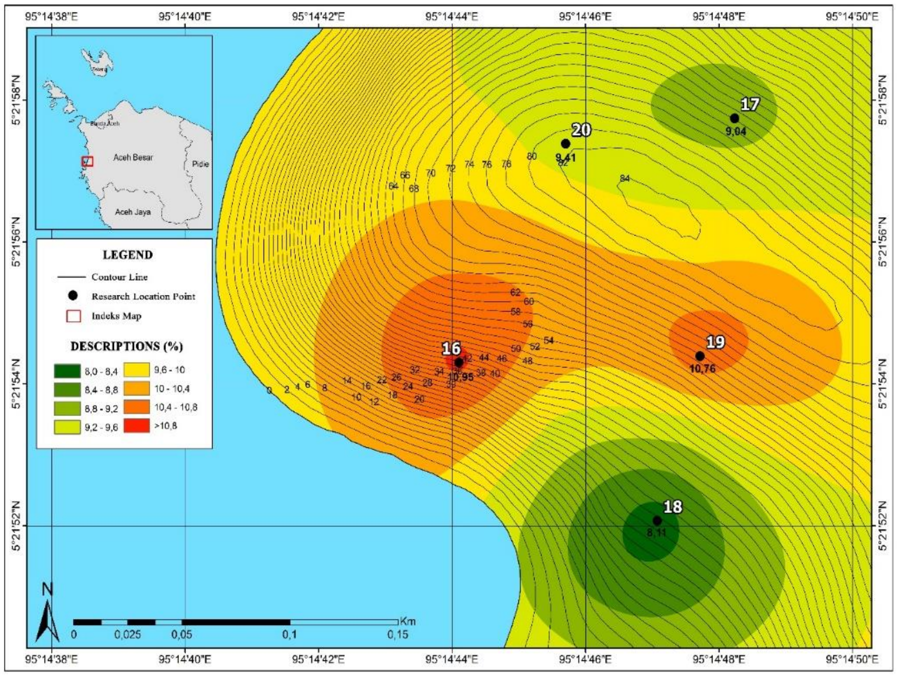

Figure 10. GIS Analysis of $CaCO_3$ contours at station 4 of Lhokseudu Cliff.

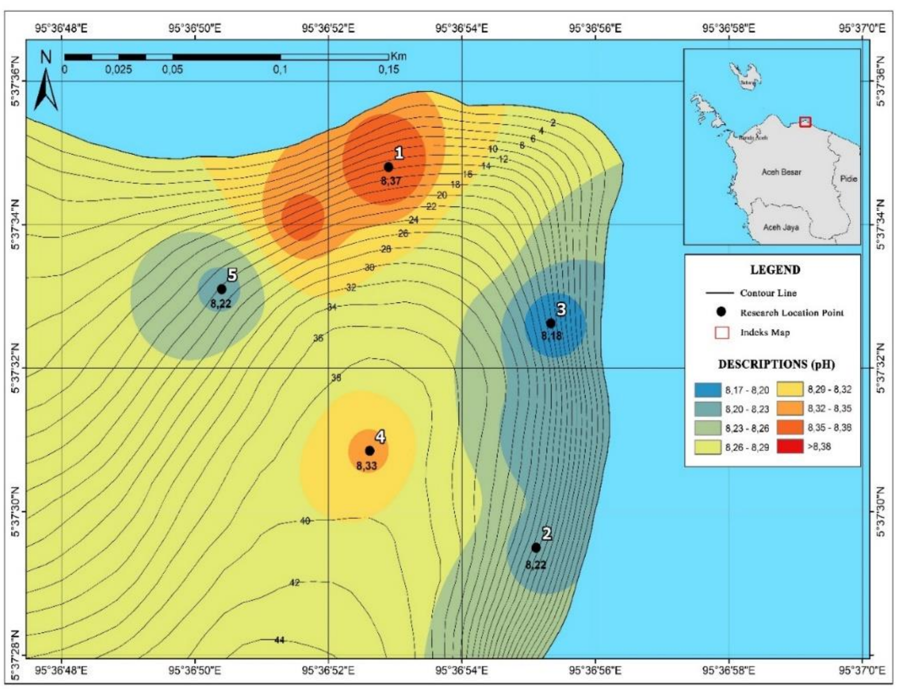

Figure 11. GIS Analysis of soil pH contours at station 1 of Ujong Batee Puteh Cliff.

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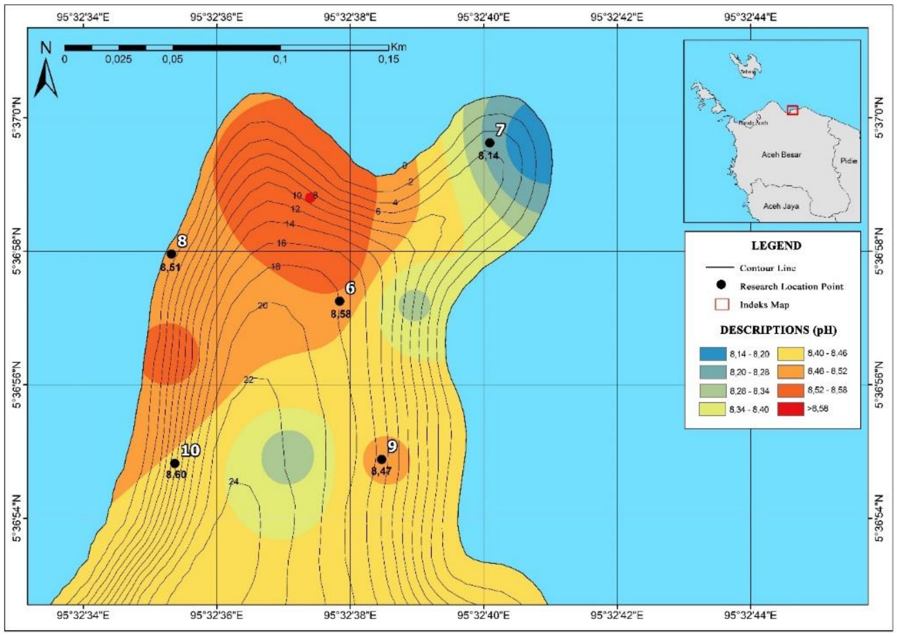

Figure 12. GIS Analysis of soil pH contours at station 2 of Lamreh Cliff.

Distribution of soil pH

Soil pH distribution can have a significant (fundamental) influence on soil chemical processes because it is considered the primary soil variable. The soil pH distribution has a value that indicates the soil's acidity and alkalinity properties range from 0 to 14. The general pH distribution of the soil shows how the environmental conditions are to the acidity and alkalinity of the soil. The analysis showed that the soil pH distribution pattern varied at each station in the study area. The pH distribution of the soil at station 1 can be seen in Figure 11. The figure shows that the soil pH has a variable value, where the soil pH in the entire distribution at station 1 is >8, which indicates that the soil pH at the station is relatively alkaline; this is because, at the station, it is found that carbonate rocks have undergone weathering. The distribution at point 1 can be seen on the orange map, the distribution at point 4 is yellow, and the distribution at points 2, 3, and 5 has the same color: blue. The difference in soil pH values at each point of distribution is due to the presence of soil pH content that binds to the settling environment in the area.

The pH distribution of the soil at station 2 can be seen in Figure 12. Figure 12 shows that the pH distribution of the soil at the whole point is relatively the same, i.e., alkaline. Soil pH with alkaline conditions at this station makes the nutrients contained in the soil will be very difficult to absorb by plants. Alkaline soils generally have very little nutrient content and microorganisms, so vegetation growth is disturbed in the distribution. In addition, the difference in distribution at one point with another is due to the influence of calcium carbonate ($CaCO_3$) deposition at the site. It can be seen that the sediment types in the area include biogenous sediments. Biogenous sediments (soils) are sediments derived from the overhaul of dead corals and the remains of marine organisms (living things). In addition, a small amount of rainfall can make the soil pH content at the study site alkaline.

The pH distribution of the soil at station 3 can be seen in Figure 13. The picture shows that the soil pH distribution differs in acidic, neutral, and alkaline pH. The soil pH distribution at point 11, marked in yellow, is classified as neutral pH. Point 12 belongs to the alkaline pH, marked in orange on the map. The distribution at points 13.14 and 15 are classified into acidic pH characterized by deep blue and blue colors. The acidic pH at the 3 points of distribution is associated with a combination of natural processes. Xu *et al.* (2002), soil acidification can be widely associated with a combination of natural and anthropogenic processes that lower soil pH. In addition, the distribution of acidic soil pH at points 13.14 and 15 leads to reduced nutrient availability. This is in accordance with Liu *et al.* (2013), who explains that acidification of the soil can reduce the availability of some nutrients. This is in accordance with Liu *et al.* (2013), who explains that acidification of the soil can reduce the availability of some nutrients. Under natural conditions, acidification soils include slow processes that occur over hundreds to millions of years (Guo *et al.,* 2010). In addition, the pH of soils with acid content generally has high rainfall.

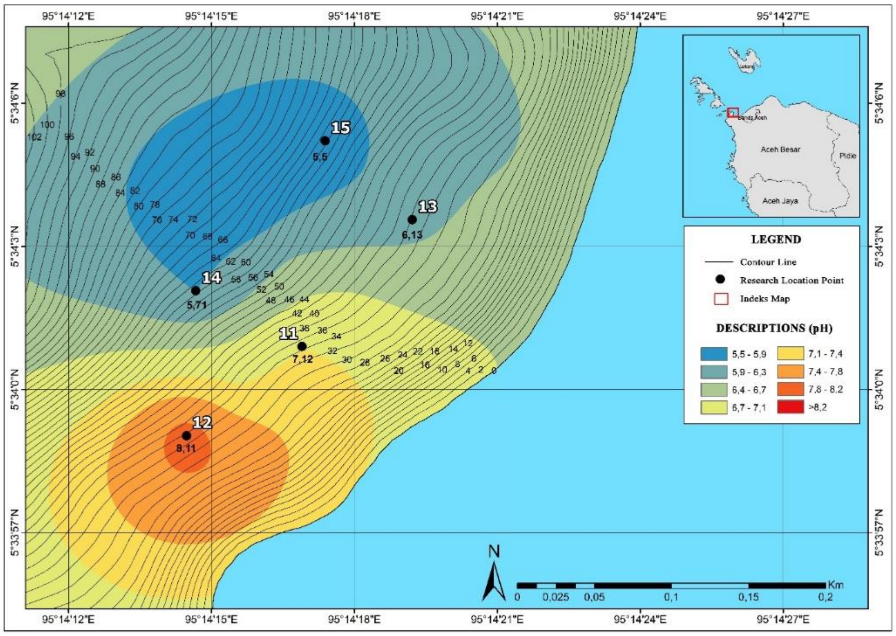

Figure 13. GIS Analysis of soil pH contours at station 3 of Ujong Pancu Cliff.

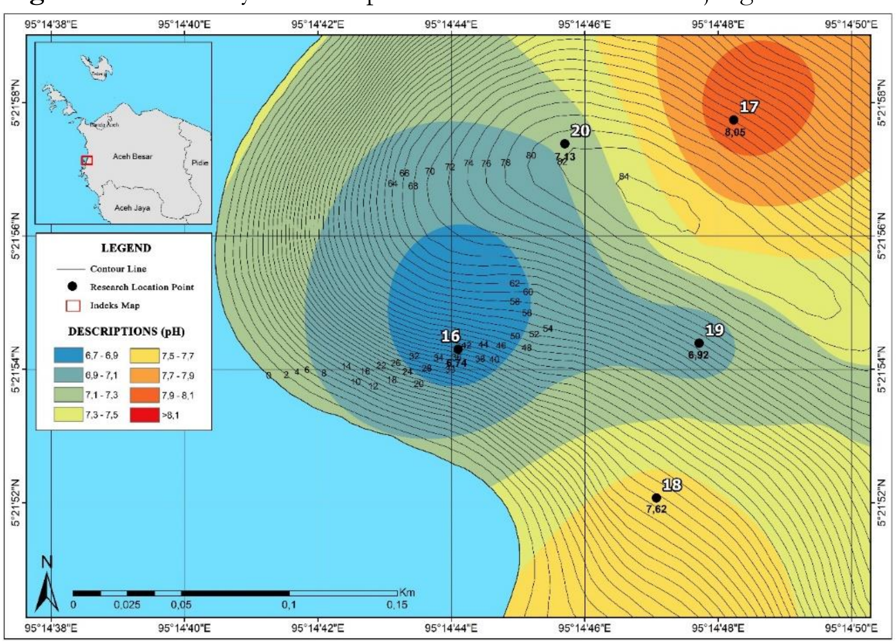

Figure 14. GIS Analysis of soil pH contours at station 4 of Lhokseudu Cliff.

The pH distribution of the soil at station 4 can be seen in Figure 14. The figure shows that the overall pH distribution of the soil varies. The pH distribution of the soil at points 16 and 19 are included in the acidic pH, while the distribution at points 17 and 18 includes bases. The acidic pH at points 16 and 19 is caused by the lack of Calcium (Ca) elements at those points. In addition, it is suspected that there is nutrient washing at the distribution of points 16 and 19. This is in accordance with Rengel *et al.* (2000), which state that the distribution at a point with an acidic pH content at a depth of 40-60 cm is caused by a large number of alkaline cations, such as calcium and magnesium in soil nutrients are lost through the process of leaching and uptake of trees

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(vegetation). Acidic soil pH in this study showed a correlation or relationship between C-Organic and soil pH. The higher the C-Organic, the acidic soil pH, and vice versa. Xu *et al.* (2021) explained the same thing in a case study in Europe: the higher the C-Organic, the pH of the soil becomes acidic, the lower the soil's pH becomes alkaline.

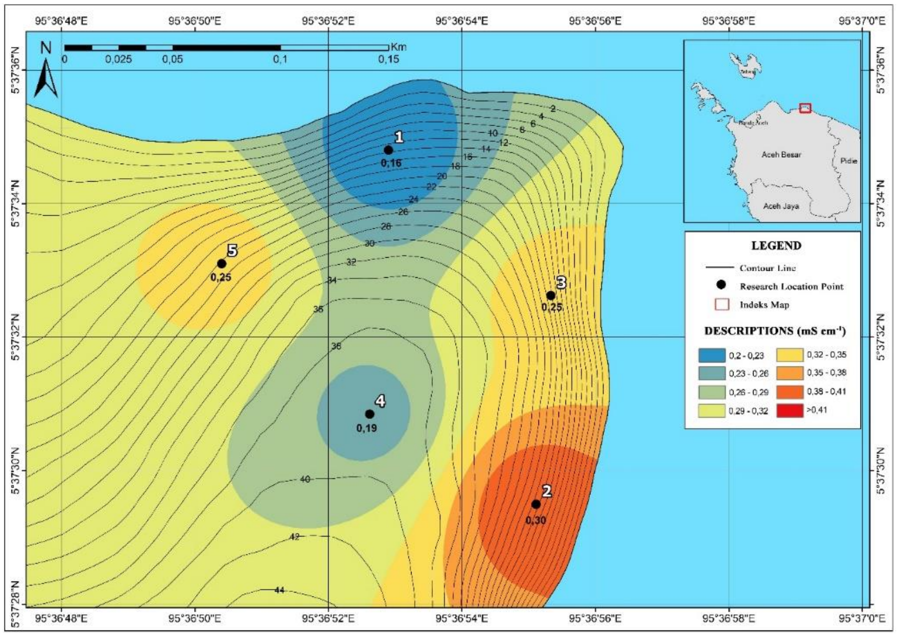

Figure 15. GIS Analysis of soil salinity contours at station 1 of Ujong Batee Puteh Cliff.

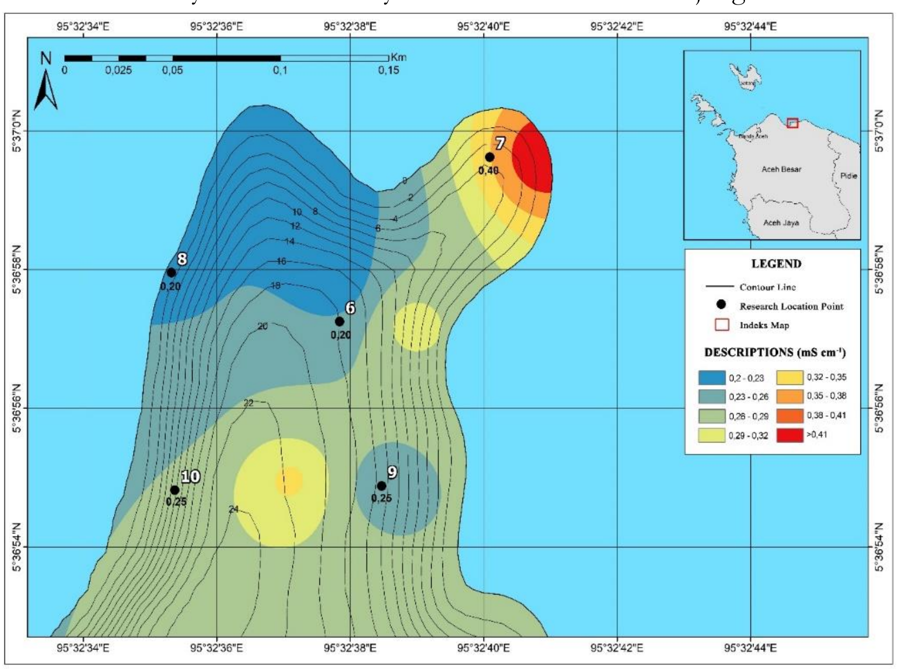

Figure 16. GIS Analysis of soil salinity contours at station 2 of Lamreh Cliff.

Distribution of Soil Salinity

The distribution of salinity at station 1 in the case study can be seen in figure 15. The figure shows that the overall salinity at that point of station 1 shows a value that does not vary significantly. The salinity at points 1 and 4 is marked in blue with values 0.16 and 0.19. The salinity content of the soil at points 3 and 5 is marked in yellow with the same value of 0.25. The salinity at point 2 is 0.30, marked in deep orange color. The salinity

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content of the soil at point 2 has the highest content compared to other distributions; this is due to the salinity level, which is influenced by the evaporation rate on the coast, following the statement of Matatula *et al.* (2019) that in high coastal evaporation conditions, soil salinity levels are also high.

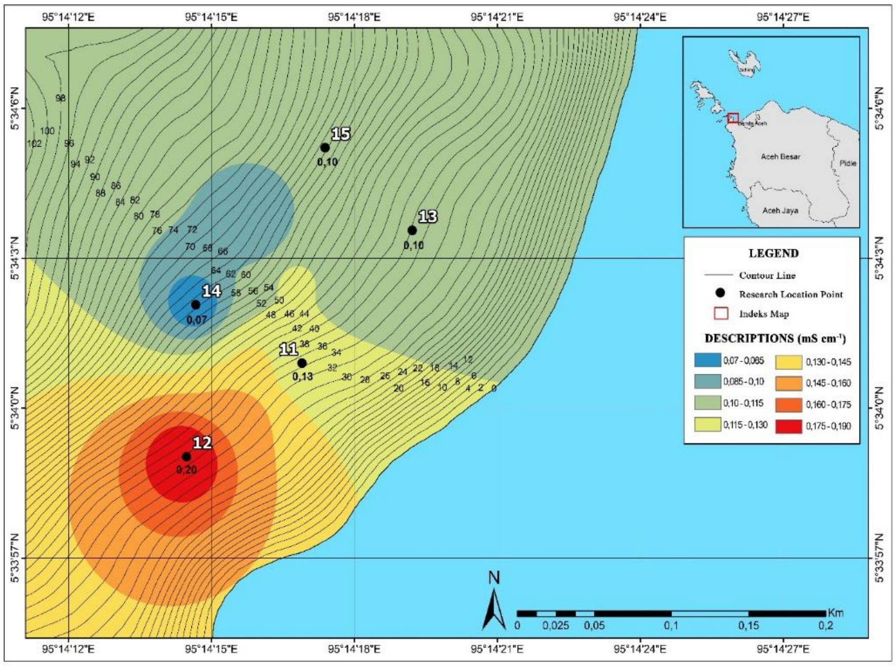

Figure 17. GIS Analysis of soil salinity contours at station 3 of Ujong Pancu Cliff.

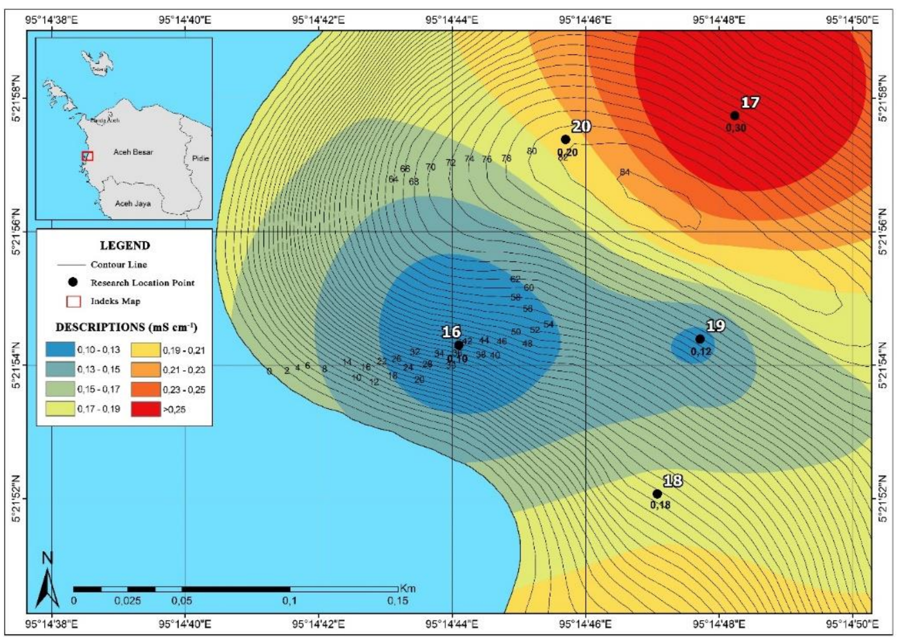

Figure 18. GIS Analysis of soil salinity contours at station 4 of Lhokseudu Cliff.

The distribution of salinity at station 2 can be seen in figure 16. The figure shows that salinity at this station is relatively neutral. The salinity distribution for points 6 and 8 is low-value with a content of 0.20. The same is found in points 9 and 10 with a value of 0.25, which belongs to the low salinity. The increase in salinity occurs at point 7 with a value of 0.40 marked in orange on the map. The increase in salinity in the soil disrupts growth, especially plant and vegetation productivity (Sipayung, 2006).

The distribution of salinity at station 3 can be seen in figure 17. Figure 17 explains that the salinity of point 11, which is worth 0.13, is marked in yellow. The salinity content of the soil at points 13 and 15 is marked with a green, while the salinity content at points 12 and 14 is marked with deep orange and deep blue. The salinity distribution at this station is low due to the sampling time; the field conditions are wet or have finished raining. This follows Nontji (2002), where variations influence the distribution of salinity levels on the coast in factors including rainfall, evaporation, and river flow.

The distribution of salinity at station 4 can be seen in figure 18. The image shows that the figure explains that points 16 and 19 have the same color, blue, indicating the lowest salinity value among other points. This is caused by the factor of slight evaporation on the coast, where the smaller the evaporation that occurs in coastal areas, the less (low) soil salinity will decrease. In addition, the distribution of salinity in this coastal cliff is still relatively low due to seawater intrusion. Patty (2013) explained that salinity on the coast is lower than on the high seas. This happens because seawater near land still has an influence from terrestrial water, which makes salinity at the location low.

Conclusion

The study results concluded that the distribution of C-Organic and carbonate content is different in each coastal station of Aceh Besar. C-Organic in Coastal Aceh Besar is relatively low, while calcium carbonate ($CaCO_3$) is relatively high. The difference in C-Organic in each distribution is due to vegetation factors, decomposition, and erosion. The difference in the distribution of Calcium Carbonate ($CaCO_3$) is influenced by sedimentary deposition in calcareous parent rocks. The higher the C-Organic, the acidic soil pH, and vice versa. The pH distribution of the soil is relative to the alkaline state, and the salinity is relatively low.

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