Seawater quality parameters in the mangrove conservation area of Bukit Batu District, Bengkalis Regency, Riau Province

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Abstract. Seawater quality parameters is very important in supporting the growth of mangrove forest in Bukit Batu District. The purpose of this study was to analyse seawater quality parameters in the mangrove conservation area of Bukit Batu District. The research method is a survey method. Seawater samples measured in situ. Sediment samples were obtained from the coastal, namely ST I (Pangkalan Jambi Village), ST II (Pakning Asal Village) and ST III (Buruk Bakul Village). The study was conducted from May-July 2024. This study was conducted by purposive sampling, analysis of seawater quality parameters, total organic matter and C percentage of organic sediment based on Loss on Ignition. Seawater quality parameters showed that pH ranges between 6,68-6,92; temperature 27-31^{o}C; salinity 22-25 ppt; brightness 45-57 cm; and DO 5,4-6,8 mg/L. The results showed that highest average percentage of sediment organic matter was found in ST III at 16,32±6,83%, followed by ST II at 6,90±3,77% and ST I at 6,02±1,07%. The highest C percentage content of organic sediments was found in ST III at 9,47±3,96%. The quality of seawater in Bukit Batu District is still favorable for mangrove forest growth.

1 Introduction

Seawater quality parameters is very important in supporting the growth of mangrove forest conservation areas in Bukit Batu District. Characteristics of the mangrove forest is mangrove forest ecosystem with a variety of marine biota, and influenced by the tides of seawater. The functions of this area is to protect coastal area from the effects of abrasion, and act as blue carbon storage, especially, in mangrove sediments. The existence of mangrove forest conservation areas plays a very important role in coastal and marine areas, both ecological, economic and socio-cultural aspects. Mangrove forests can grow in rivers, river estuaries and beaches, the meeting of land and ocean areas (ecotone areas), influenced by tides. located in tropical and sub-tropical regions, has a variety of mangrove flora and fauna. Tidal influences supply nutrients to mangrove forest ecosystems, while mineralized river water provides

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nutrients to marine sediments. Mangrove forests absorb and store carbon, a potential alternative in addressing climate change mitigation.
The coastal island of Bengkalis, Riau Province, receives organic matter inputs from the mainland. The organic matter is accumulated in the estuaries and the sea by the movement of currents [1]. The organic matter (MO) was an explicit discrepancy between the large amounts of carbon transported from land to coasts, compared to the relatively small amounts of terrestrial carbon detectable in oceanic waters and sediments [2]. Organic matter content in mangrove ecosystems is influenced by mangrove vegetation characteristics such as density, canopy cover, dominant species and average mangrove age [3].

Mangrove forests act as carbon sequestration and have a potential carbon stock of 1,023 mg of carbon per hectare. Mangroves play a role in carbon binding through the process of photosynthesis and store it in the biomass of mangrove tree stands [4]. The greater the concentration of organic matter, the greater the total density of bacteria contained in seawaters [5]. The characteristic of mangrove sediment is important in the context of climate change mitigation, it allows the accumulation of organic matter and organic carbon in the sediments. Organic matter in seawaters will be broken down by decomposing bacteria into ammonia and ammonium compounds in the nitrification process to become nitrites and nitrates. The mangrove forest conservation area in Bukit Batu District, Bengkalis Regency is very suitable to be developed as a mangrove conservation area, mangroves grow well along the coast.

The mangrove plays an essential role in maintaining the sustainability of coastal ecosystems [6]; From a biological and ecological perspective, the mangrove ecosystem represents a vital habitat for marine biota, which utilize the area as a nursery ground for at least part of their life cycle [7], mangrove ecosystems play a significant role in social and economic contexts [8], The diminished extent of mangrove ecosystems can be attributed to two primary factors: a lack of public awareness concerning the functions and benefits of mangrove ecosystems and the absence of sustainable management and utilization practices [9].

Based on this, research on the seawater quality parameters in the mangrove forest conservation area of Bukit Batu District Bengkalis Regency, Riau Province needs to be studied. This is for the conservation and sustainability of mangrove forests ecosystems on Bukit Batu district. The purpose of this study was to analyse seawater quality parameters in the mangrove forest conservation area of Bukit Batu District. The benefit of the research is to obtain information and data on the seawater quality parameters in the mangrove forest ecosystems of Bukit Batu District, Bengkalis Regency, Riau Province.

2 Materials and Methods

The research method was a survey method. The research was conducted from May to July 2024, in the mangrove forest ecosystem of Bukit Batu District Bengkalis Regency, Riau Province. Data obtained directly (in situ) from the field consists of parameters of seawater quality such as temperature, acidity (pH), salinity, water brightness and dissolved oxygen (DO). Sediment samples were collected from the mangrove forest, namely ST I (Pangkalan Jambi village), ST II (Pakning Asal village) and ST III (Buruk Bakul village). Each research station consists of three sampling points.

Analysis of samples in Chemical Oceanography Laboratory, FPK UNRI. For more details can be seen in Figure 1. This study was conducted by purposive sampling. The data that has been obtained, the analysed using the formula:

a. Mangrove Area Transect

Plots were made measuring 10 x 10 m^2 in each transect and the distance between plots was 10 m [10]. The substrate was taken by purposive sampling in each plot using PVC with depth ± 10-30 cm.

b. Seawater Quality Parameters

Analysis of seawater quality parameters referring to [11]. Measurement of seawater quality was carried out in situ at each research station, the parameters tested were temperature, pH, salinity, brightness and DO. Water quality measurements are descriptive and refer to the Minister of Environment Decree No. 51 of 2004 on Seawater Quality Standards.

c. Total Organic Matter

The total organic matter content of the sediment was analysed using the titrimetric method SNI 06-6989.22.2004, with reference to [12; 13]. In the first step, 5 ml of sulphuric acid was added to 100 ml of distilled water at a temperature of 70ºC. Then 10 ml (V1) of 0.01 N oxalic acid (N1) was added. The solution was then titrated with potassium permanganate 0.01 N until the solution turned pink. The volume was recorded (V2) and the true normality of potassium permanganate (b) was calculated as follows:

$$B = \frac{V_1 \times N_1}{V_2}$$

In the next step, 100 ml of water sample (d) was added to three boiling stones and potassium permanganate was gradually added until it showed a pink colour. Then 5 ml of 8 N sulphuric acid (c) was added and heated to boiling on a hotplate at 105°C ± 2°C. After that, 10 ml of 0.01 N potassium permanganate was added and reheated for 10 minutes, and titrated with 0.01 N potassium permanganate until pink in colour. The volume used for titration (a) was duly recorded. If the volume used for the titration exceeded 7 ml, the sample was diluted (f) and the titration was repeated. The total organic matter was calculated using the following formula:

$$\text{Total organic matter (mg/L)} = \frac{[(10+a)b-(10xc)]\ 1 \times 31.6 \times 1000}{d} \times f$$

d. Carbon Percentage of Organic Sediment

The C percentage of organic sediment based on Loss on Ignition (LOI), water content and ash content [14]. The LOI method is a measure of the mass of the sample lost (e.g., oxidized and lost as a gas, or vaporized), the sediment sample is heated to a high temperature. According to [15], carbon storage in mangrove forests is greater than carbon storage in other forest types. In mangrove forests is greater than carbon storage in other types of forests, where the most carbon storage is in mangrove sediments.

e. Sediment Fraction

The percentage sediment fractions were analyzed using Shepard triangle [16]. The sediment samples obtained from the research site were subjected to a sediment type analysis. The sediment analysis employed two distinct methods: the stratified sieving technique for fractions 1-4 and the pipette method for fractions 5-7. The classification of sediment fractions is based on the proportion of gravel, sand, and mud content, which is then plotted on Sheppard's triangle as a percentage value.

Fig 1. Research location map in the mangrove forest

3 Results and Discussion

3.1 Mangrove Forest Characteristics in Bukit Batu District

Mangrove forests exhibit distinctive characteristics, growing on substrates that are simultaneously flooded with freshwater and seawater. These forests are found in a variety of coastal habitats, including river estuaries and peat swamps. The nutrient content of seawater can be affected by tides, then mineral materials from the river can become nutrients contained in sediments [17]. Mangrove forests in the Bukit Batu district grow well and are used as conservation areas. Some of the research stations on mangrove forest conservation area in Bukit Batu Distric can be seen in Table 1 dan Figure 2.

Table 1. Mangrove forest conservation area

Research Station	Mangrove Forest Area	Coordinates
I	Pangkalan Jambi Village	E 102.150176º N 1.289785º
II	Pakning Asal Village	E 102.1555049º N 1.337063º
III	Buruk Bakul Village	E 102.060688º N 1.421415º

Pangkalan Jambi Village

Pakning Asal Village

Buruk Bakul Village

Fig 2. Mangrove forests in Bukit Batu District

Mangrove conditions in mangrove forest conservation areas are mostly natural mangroves so they need to be preserved. The types of mangroves found at the location of the research station can be seen in Table 2.

Table 2. Types of mangrove plants in the mangrove forest conservation area.

No.	Local Name	Species Name	Family Name
Pangkalan Jambi Village			
1	Bakau minyak	*Rhizophora apiculata*	Rhizophoraceae
2	Nyirih	*Xylocarpus granatum*	Meliaceae
3	Nipah	*Nypa fruticans*	Arecaceae
4	Tumu merah	*Bruguiera gymnorrhiza*	Rhizophoraceae
5	Api-api putih	*Avicennia marina*	Avicenniaceae
6	Perepat	*Sonneratia alba*	Sonneratiaceae
Pakning Asal Village			
1	Bakau minyak	*Rhizophora apiculata*	Rhizophoraceae
2	Nyirih	*Xylocarpus granatum*	Meliaceae
3	Bebetak	*Excoecaria agallocha*	Euphorbiaceae
4	Nipah	*Nypa fruticans*	Arecaceae
5	Tumu merah	*Bruguiera gymnorrhiza*	Rhizophoraceae
6	Api-api putih	*Avicennia marina*	Avicenniaceae
7	Api-api boak	*Avicennia alba*	Avicenniaceae
8	Perepat	*Sonneratia alba*	Sonneratiaceae
Buruk Bakul Village			
1	Bakau minyak	*Rhizophora apiculata*	Rhizophoraceae
2	Nyirih	*Xylocarpus granatum*	Meliaceae
3	Bebetak	*Excoecaria agallocha*	Euphorbiaceae
4	Nipah	*Nypa fruticans*	Arecaceae
5	Tumu merah	*Bruguiera gymnorrhiza*	Rhizophoraceae
6	Api-api putih	*Avicennia marina*	Avicenniaceae
7	Api-api boak	*Avicennia alba*	Avicenniaceae
8	Perepat	*Sonneratia alba*	Sonneratiaceae
9	Pedada/berembang	*Sonneratia caseolaris*	Sonneratiaceae
No.	**Local Name**	**Species Name**	**Family Name**

10	Bakau kurap/blukap	*Rhizophora mucronata*	Rhizophoraceae
11	Tangar/palun/purun	*Ceriops tagal*	Rhizophoraceae
12	Jeruju/simeulue	*Acanthus illicifolius*	Acanthaceae

3.2 Seawater Quality Parameters

The objective of the analysis of the quality of the coastal waters of Bukit Batu District is to describe the condition of the seawater at the time of the research, including the concentration of organic matter in the sediment. It can be seen in the Table 3. Based on Table 3., it can be seen that the average measurement results of water temperature ranged from 27-31 ^{o}C; pH ranged from 6.68 – 6.92; water salinity range from 22 - 25 ppt; water brightness ranged fom 45-57 cm; and DO ranged from 5.4 – 6.8 mg/L. The quality parameters of seawaters in Bukit Batu District are still favourable for mangrove growth. According to [1], decreasing environmental quality can be identified from changes in the physical, chemical and biological components of seawaters

Table 3. The measurements of the seawater quality parameters

Research Station	Average Seawater Quality Parameters				
	Temperature (^{o}C)	pH	Salinity (ppt)	Water Brightness (cm)	DO (mg/L)
I (Pangkalan Jambi Village)	30	6.73	23	45	5.4
II (Pakning Asal Village)	27	6.68	22	52	5.2
III (Buruk Bakul Village)	31	6.92	25	57	6.8

3.3 Percentage of Sediment Organic Matter Content

Organic matter in mangrove forest ecosystems determines the quality of the environment in the coastal district of Bukit Batu, Bengkalis Regency. If the organic matter content in the sediment increases, it can cause changes in the quality of the coastal waters. The total organic matter content in the coastal waters of the Bukit Batu sub-district ranges from 1.0-4.6 mg/L. The results of the analysis of the percentage of sediment organic matter content can be seen in Table 4.

Table 4. Percentage of organic matter content

Research Station	Sampling Point	Weight of Organic Matter (g)	Sediment Organic Matter (%)
I (Pangkalan Jambi Village)	1.1	2.1	7.22
	1.2	1.4	5.15
	1.3	1.8	5.70
Average			**6.02 ± 1.07**
II (Pakning Asal Village)	2.1	1.0	5.08
	2.2	1.1	4.38
	2.3	2.1	11.23
Average			**6.90 ± 3.77**

Research Station	Sampling Point	Weight of Organic Matter (g)	Sediment Organic Matter (%)
III (Buruk Bakul Village)	3.1	4.6	23.59
	3.2	2.3	10.04
	3.3	2.5	15.34
Average			**16.32 ± 6.83**

Based on Table 4, the results showed that highest average percentage of sediment organic matter was found in ST III at 16.32 ± 6.83%, followed by ST II at 6.90 ± 3.77% and ST I at 6.02 ± 1.07%.

It can be seen that the highest percentage of sediment organic matter content of seawater was at station III (23.59%). The percentage of organic matter content in Bukit Batu District Bengkalis Regency is still favourable for mangrove forest growth. In accordance with the stipulations set forth In the Ministry of Population and Environment's Decree No. 2 of 1988 on waste water quality standards, the permissible limit for the content of organic matter in water is 80 mg/L [18].

3.4 Mangrove Sediment Fraction

Sediment is the result of the mineral accumulation process caused by the deposition of materials and other particles through chemical processes that occur in the sea. The results of the analysis of sediment types in Bukit Batu District can be seen in Table 5.

Table 5. Types of mangrove sediment fraction in seawaters

Research Station	Sampling Point	Sediment Fraction (%)			Sediment Type
		Gravel	Sand	Mud	
I (Pangkalan Jambi Village)	1.1	2.33	55.96	41.70	Muddy sand
	1.2	1.72	43.33	54.96	Sandy mud
	1.3	1.26	19.35	79.38	Mud
Average		**0.78 ± 0.54**	**39.55 ± 18.60**	**13.90 ± 19.11**	
II (Pakning Asal Village)	2.1	2.69	20.22	77.10	Mud
	2.2	0.48	9.90	89.62	Mud
	2.3	2.45	10.77	86.79	Mud
Average		**0.90 ± 1.21**	**6.74 ± 5.72**	**25.70 ± 6.57**	
III (Buruk Bakul Village)	3.1	1.31	16.27	82.42	Mud
	3.2	2.43	26.84	70.73	Mud
	3.3	2.62	17.46	79.92	Mud
Average		**0.44 ± 0.71**	**20.19 ± 5.80**	**27.47 ± 6.16**	

Based on Table 5, it can be seen that the mangrove sediment type at Station I, II and III has a sediment type dominates by mud. The highest percentage of mud sediment fraction was found in ST II, the average of mangrove sediment fraction was 25.70 ± 6.57%. The sediment type is thought to be due to the influence by the flow of river flanking the research station. The organic matter content of sandy sediments is typically low. The sediments facilitate effective oxidation due to the presence of larger pore water, which enables the rapid expulsion of organic matter. The finer texture of mud sediments allows for a relatively high organic matter content.

Mangroves can grow on a variety of substrates (gravel, sand and mud). Mangroves grow in the mud clay mixed with organic matter. The organic matter also varies according to the composition of the substrate. The content of organic matter on the muddy substrates is generally higher than on a substrate of gravel and sand. According to [19], tidal processes and grain size can influence the process of deposition and release. Tides affect the movement of mangrove litter, grain size distribution and the amount of sediment transport that becomes a source of carbon in the ecosystem.

3.4 Carbon Organic Sediments

Mangroves can sequester carbon and deposit it in sediments and store it for longer periods of time. Mangroves absorb CO_2 and turn it into energy, which is stored in the form of organic carbon. Carbon in sediments can accumulate for long periods of time, up to thousands of years. It can be seen in Table 6.

Table 6. Percentage of carbon organic sediment

Research Station	Sampling Point	% Carbon Organic	% Ash Content
I (Pangkalan Jambi Village)	1.1	4.19	92.78
	1.2	2.99	94.85
	1.3	3.30	94.30
	Average	**3.50 ± 0.62**	**93.98 ± 1.07**
II (Pakning Asal Village)	2.1	2.94	94.92
	2.2	2.54	95.62
	2.3	6.51	88.77
	Average	**4.00 ± 2.19**	**93.10 ± 3.77**
III (Buruk Bakul Village)	3.1	13.68	76.41
	3.2	5.83	89.96
	3.3	8.90	84.66
	Average	**9.47 ± 3.96**	**83.68 ± 6.83**

Based on Table 6, it can be seen that the highest C percentage of organic sediments was found in ST III at 9.47 ± 3.96%, classified into moderate. The highest ash percentage of organic sediment was found in ST I at 93.98 ± 1.07%. The highest water percentage of organic sediment was found in ST III at 60.87 ± 6.60%. The percentage of water content can be seen in Figure 3.

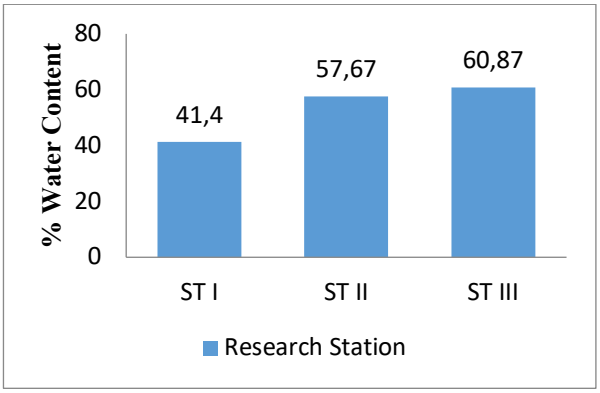

Fig 3. The percentage of water content

Organic carbon content in sediments is the amount of carbon that can be absorbed and stored by sediments in the form of organic matter which becomes input for soil structure and is utilized as energy for soil organisms [20]. Mangrove management generally involves various aspects, including the monitoring and maintenance of the ecosystem, protection against physical damage, pollution, and local community participation [21].

4 Conclusion

a. This research that has been conducted in the mangrove forest conservation area in Bukit Batu District, Bengkalis Regency. The highest average percentage of sediment organic matter content and C percentage content of organic sediments was found in ST III, classified into moderate.
b. The type of substrate at ST I, ST II and ST III are muddy that makes mangroves grow optimal.

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