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Article

Concentration and Emission of Carbon Dioxide (CO_2) Gas in Mangrove Ecosystem Sediments of Nania Village, Ambon City

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Abstract: Mangrove ecosystem is a type of coastal ecosystem that has many benefits from both ecological, social and economic aspects. The role of mangroves in absorbing carbon reaches 965 tons C/ha. The ability to store carbon is four times more than other ecosystems. Besides absorbing and storing carbon, mangroves also release carbon through litter production. The production of mangrove litter will then experience decomposition resulting in a flux of greenhouse gases. One of the greenhouse gases that triggers climate change is carbon dioxide (CO_2). The aim of this research was to determine the concentration and emission values of carbon dioxide (CO_2) in the sediments of the mangrove ecosystem of Nania Village, Ambon City. Gas sampling using a syringe through a syringe mounted on a hood. Analysis of gas concentrations used the gas chromatography method. Sediment sampling is carried out using a small shovel on the surface of the substrate under the mangrove canopy. Sediment samples will be analyzed using a sieving process. The results showed that the average concentration of CO_2 gas with the highest value in the sandy mud substrate with a value of 701.61 ppm and the lowest in the sand substrate with a value of 561.48 ppm. The largest CO_2 gas emission in the mangrove ecosystem sediments of Nania Village was found in the sand sediment type of 75.0535 mg/m^2/hour with an emission value, and the lowest was found in mud sediments, namely 30.1899 mg/m^2/hour.

Keywords: Ecosystem, Mangrove habitat, Carbon, Maluku

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1. Introduction

The mangrove ecosystem is a type of coastal ecosystem that has many benefits both in ecological, social and economic aspects (Rahman et al., 2020). Apart from that, one of the functions of mangroves that is now starting to be paid attention to is their ability to absorb carbon gas so that it can reduce carbon gas emissions in the atmosphere (Rahman et al., 2017). According to Alongi & Mukhopadhyay (2015), the role of mangroves in absorbing carbon reaches 965 tonnes C/ha. This carbon storage capacity is four times greater than other ecosystems. (Donato et al., 2012). Chen et al. (2014) explained that apart from absorbing and storing carbon, mangroves also release carbon through the production of litter in the form of fallen leaves and fruit, broken twigs, natural death and mangrove felling by humans. Mangrove litter production will then experience decomposition resulting in a flux of greenhouse gases such as CO_2, CH_4 and N_2O (Chen et al., 2012; Konnerup et al., 2014). CO_2 gas is formed through the decomposition process of organic material or litter by microbes but at a smaller concentration compared to CH_4 gas (Borges & Abril, 2011).

One of the greenhouse gases that triggers climate change is carbon dioxide gas (CO_2) which is produced from various human activities such as burning fossil fuels, motorized vehicles and industrial machines which causes carbon gas to accumulate (IPCC, 2001). Most of the carbon dioxide gas produced will be released into the atmosphere either by diffusion through the soil or fluxed by plants, thereby increasing the concentration of greenhouse gases which will have the effect of increasing the earth's surface temperature (Castillo et al., 2017). One of the areas that is a mangrove ecosystem habitat is the coast of Nania Village which is located in the Ambon Dalam Bay area. Information regarding the concentration and emissions of CO_2 gas in different types of sediment in the mangrove ecosystem in Nania Village is not yet known, so it is an interesting topic to research in order to produce scientific information regarding CO_2 gas emissions resulting from the degradation of organic material in mangrove sediments.

2. Materials and Methods

2.1. Location and Time of Observation

This research was conducted in November 2022 in the mangrove ecosystem area of Nania Village, Ambon City (Fig. 1).

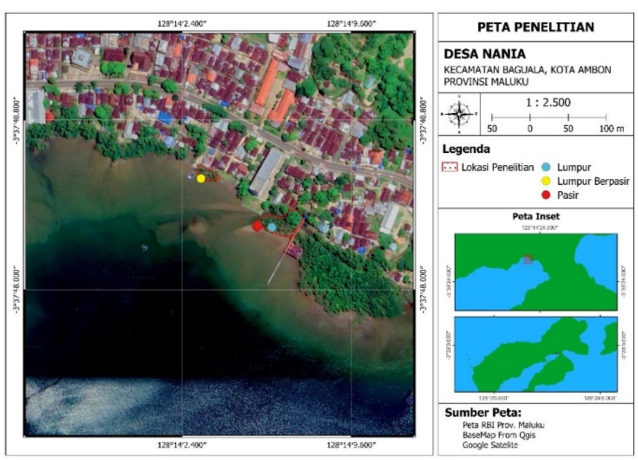

Figure 1. Locations of Observation

2.2. Tools and Materials

The tools and materials used in this research were a hood, syringe hose, 50 ml syringe, 10 ml vial, hose clamp, tool box, shovel, camera, scales, gas chromatography, shaker shield, glue, sample plastic and CO_2 analysis reagent.

2.3. Gas Sampling

Gas sampling was carried out by placing a hood under the mangrove canopy based on the characteristics of the substrate, namely sand, mud and sandy mud (Fig. 2). A hood with a volume of 17 liters and a base area of 0.0615 m^2 is placed on each sediment to collect gas which is the result of the decomposition of litter or organic material that has taken place in each mangrove sediment.

Figure 2. Sungkup (gas trap)

Gas is taken through a syringe using a syringe to be collected in a vial with a volume of 10 ml. Gas sampling was carried out at intervals of 30 seconds each with 5 repetitions, namely 0 s, 30 s, 60 s, 90 s, and 120 s (s = seconds). For each type of substrate, 15 samples of gas were taken so that the total samples obtained for the three types of sediment observed were 45 samples.

2.4. Sediment Sampling

Sediment sampling was carried out using a small shovel on the surface of the substrate under the mangrove canopy based on the results of (visual) observations at locations with different substrate characteristics. Then the sediment sample will be analyzed using a sieving process in order to identify the grains of the sediment and determine the type of substrate taken.

2.5. Gas Concentration Analysis

The concentration of CO2 carbon gas was analyzed using the gas chromatography method. In the CO2 gas concentration analysis, 2 ml of gas was passed through the thermal conductivity detector (TCD) for 5 minutes with 3 repetitions. Carbon gas concentration measurements were carried out at the Laboratory of the Agricultural Environmental Research Institute, Pati Regency - Central Java.

2.6. Carbon Gas Emissions

After the carbon gas concentration value is obtained, the carbon emission value is then analyzed using the equation from Rahman et al., (2020).

$$F = \left| \frac{S * V * t * mW}{(RT * A)} \right| \tag{1}$$

Description:

F : Flux of carbon gas (mg.m-2.h-1),

S : slope of regression of carbon gas concentration measured every 30 seconds,

V : volume of sungkup (L),

A : area covered by sungkup (m^2),

R : ratio of ideal gas = 0,082 L.atm/K/mol,

T : air temperature in sungkup (K),

T : time transformation = (1 hour/gas sampling time interval)

mW : relative atomic mass of C (CO_2 = 44 g/mol).

2.7. Sediment Granule Analysis

Sediment grain measurements were carried out using a sieving process using a sieve shaker which was carried out in the Aquatic Resources Management laboratory, Faculty of Fisheries and Marine Sciences, Pattimura University. Sifting of each sediment sample lasts for 5 minutes in order to filter grains from each level of the sieve. The method for analyzing grain size and sediment type uses a dry sieving strategy on a multilevel sieve (sieve analysis) and granulometric analysis. Grain size dispersion is determined using the granulometric method (Hubbard and Pocock, 1972; Hsieh, 1995; Nugroho & Basit, 2014). Determining the type of sediment using the Shepard Triangle Diagram classification.

3. Results

3.1. Sediment Characteristics

The results of the analysis of grain characteristics show that in the grain distribution there are three categories of grain dominance which can be seen in (

*Table **1***), namely sand, mud and sandy mud. At the first point the grain size results were 98.5% sand and 1.5% mud. For the second sampling point the grain size results were 8.1% sand and 91.9% mud and the grain size results for the third sampling point were 34.6% sand and mud 65.4%.

Table 1. Results of grain size analysis

No	Sampling Point	Granule size (%)		Domination category
		Sand	Mud	
1	Point 1	98,5	1,5	Sand
2	Point 2	8,1	91,9	Mud
3	Point 3	34,6	65,4	Sandy Mud

3.2. CO2 Gas Concentration

Based on the results of CO_2 gas concentration analysis on three types of substrates, namely sandy mud, mud, and sand, it was found that the CO_2 gas concentration value for sandy mud substrates was 701.61 ppm, mud was 628.44 ppm, and sand was 561.48 ppm (Figure 3). The sandy mud substrate has the highest CO_2 gas concentration while the sand substrate has the lowest CO2 gas concentration.

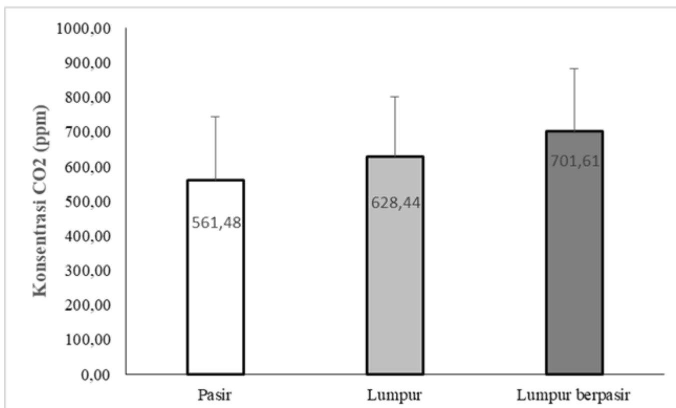

Figure 3. Concentration of Carbon Dioxide Gas (CO_2) in Various Substrate Types

3.3. CO_2 Gas Emissions

Based on the results of CO_2 gas emission analysis on the three types of substrate, namely sandy mud, mud, and sand, it was found that the CO_2 gas emission value for sand substrate was 75.0535 mg/m^2/hour, mud was 42.2486 mg/m^2/hour, and sandy mud was amounting to 30.1899 mg/m^2/hour (Figure 4). Sand substrates have the highest CO_2 gas emissions while sandy mud substrates have the lowest CO_2 gas emissions.

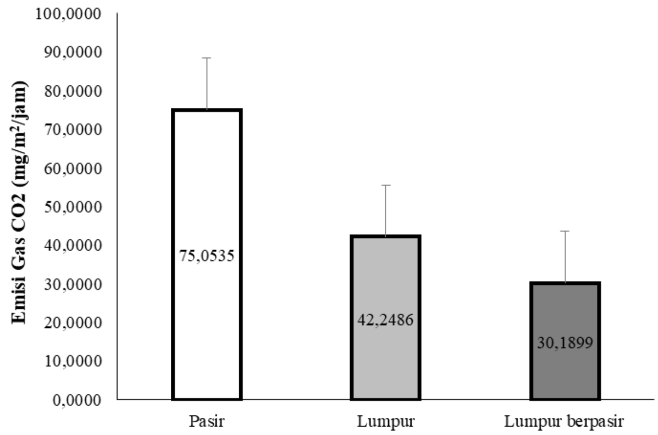

Figure 4. Carbon dioxide (CO_2) gas emissions on various types of substrates

4. Discussion

Authors should discuss the results and how they can be interpreted from the perspective of previous studies and of the working hypotheses. The findings and their implications should be discussed in the broadest context possible. Discussion should discuss limitation of methodology, either in data and analyses. In principle, it should be discussed about the weakness of the research and should be in the range of scientific acception. Future research directions may also be highlighted.

The substrate type in Nania Village, based on observations at the location, tends to have sand and mud substrate types (

Table ***1***). The type of substrate greatly influences the level of organic material deposition and the rate of litter production which causes carbon gas to concentrate in it. According to Supriantini et al. (2017), the source of sediment in mangrove areas comes from land and from the mangrove itself in the form of piles of fallen leaves, twigs and dead organisms deposited in mangrove areas which contain lots of organic and mineral materials.

The sandy mud substrate shows a higher value than the sand and mud substrate (Figure 3), because the sandy mud substrate has a denser substrate texture so that carbon will be retained and concentrated to a greater extent in it. According to Huang et al. (2018), substrate characteristics play an important role in the availability of organic material. Mud sediments have a finer particle size which tends to provide abundant organic material so that the decomposition process by microorganisms becomes very high. This is supported by research from Hakim et al. (2016), sediments with a mud structure contain more organic carbon than sand sediments.

The results of CO_2 emissions are different for each type of substrate (Figure 4). The highest CO_2 emission value is found on the sand substrate with a value of 75.0535 mg/m^2/hour and the lowest emission value is found on the sandy mud substrate with a value of 30.1899 mg/m^2/hour. The results of the analysis are inversely proportional to the CO_2 concentration value, where the highest CO_2 concentration value is found in the sandy mud substrate and the lowest concentration value is found in the sand substrate. The sand substrate shows a higher value than the mud and sandy mud substrate because the sand substrate has a more hollow texture so the carbon released will be greater than on other types of substrate.

According to Hartoko (2010), sandy sediments have low organic material content, this is because these sediments allow good oxidation to occur due to the presence of larger pore water, so that the organic material will run out quickly. On the other hand, in clay sediments which have a finer texture, the organic material content is relatively high. High CO_2 emissions in an ecosystem are caused by differences in vegetation, litter production rates and the number of individual mangroves growing in the area.

5. Conclusions

Based on the research results, it can be concluded that the highest concentration of carbon dioxide gas (CO_2) is found in the sandy mud substrate, namely 701.61 ppm and the lowest in the sand substrate, namely 561.48 ppm. For carbon dioxide (CO_2) gas emissions, the highest value is found on the sand substrate, namely 75.0535 mg/m^2/hour and the lowest value on the sandy mud substrate, namely 30.1899 mg/m^2/hour.

Conflicts of Interest: The authors declare no conflict of interest.

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