Methods Article

Rh-Chamber: A Novel Chamber Design for Gas Sampling in the Coastal Sediment and Water Surface

ABSTRACT

This research aims to develop and test Rh-Chamber, an innovative gas sampling tool designed for coastal environments. The coastal environment is a dynamic ecosystem that plays an important role in the global biogeochemical cycle, especially in the production and release of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Until now, existing gas sampling methods have limitations, especially in maintaining representative field conditions and capturing temporal dynamics of gas release. The Rh-Chamber comes as a highly flexible solution, allowing sampling both on coastal sediments and on the water surface. The design consists of a gas incubator, a float and a ballast, which allows the appliance to function optimally in various current and sediment conditions. Gas sampling is done manually using syiringe, with varying time intervals. The results show that Rh-Chamber provides better accuracy in measuring gas flux in coastal ecosystems than conventional methods. These innovations also have the potential to be used in climate change research, especially to evaluate the contribution of coastal ecosystems to greenhouse gas emissions. Although there are some limitations, such as the need for additional manpower in its operation in deeper waters, the Rh-Chamber makes a significant contribution to coastal environmental research.

1. INTRODUCTION

The study of gas flux in the coastal environment plays an important role in understanding the interaction between sediment, water, and the atmosphere. Gases such as carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) play a significant role in the biogeochemical cycle and global climate change [1, 2]. The coast is a dynamic ecosystem with large fluctuations in the production and release of these gases, mainly due to the complex interaction between biological, physical, and chemical processes [3]. Therefore, an accurate and efficient method for measuring gas flux from sediment and water surface is of great importance.

So far, various gas sampling methods have been developed to capture gases released from coastal sediments [4] or water surfaces [5]. However, conventional methods often have limitations, such as the inability to maintain representative field conditions or limitations in capturing the temporal dynamics of gas release. Some existing sampling chamber designs also tend to be difficult to use in environments with strong currents or soft sediments. This leads to the need for innovations that can address these problems.

Rh-Chamber comes as a new solution specifically designed to address these challenges. In contrast to traditional methods, Rh-Chamber offers flexibility in its use, both on coastal sediments and on water surfaces. Its innovative design allows for more accurate sampling of gases by taking into account variations in environmental conditions, such as water currents, sediment movement, and pressure changes. In addition, the Rh-Chamber is equipped with an improved sealing mechanism, which ensures that no gas leaks during the sampling process.

The main goal of the development of the Rh-Chamber is to improve the accuracy and efficiency of gas sampling in coastal environments. With its easy-to-adapt modular design, the Rh-Chamber is expected to be used in a variety of field conditions, especially in areas with strong currents.
The importance of this innovation also lies in its application in climate change research. Greenhouse gases released from coastal environments have an important role in global climate models. Using the Rh-Chamber, researchers are expected to collect more accurate data on the release of these gases, which can ultimately be used to improve estimates of the contribution of coastal ecosystems to climate change.

This article will explain in detail the design concept of Rh-Chamber and its operational methods in the field both in sediment and water surface in coastal ecosystem areas such as seagrass and mangroves. Through this study, we hope that Rh-Chamber can become a standard method in gas flux research in coastal ecosystems, helping scientists collect more representative data and provide new insights into the dynamics of gas release in coastal environments.

2. CHAMBER DESIGN CONCEPT

The Rh-Chamber consists of 4 main components, namely the gas incubator, syiringe, buoy, and ballast anchor (Figure 1). The gas incubator is made of PVC-based gallons with a diameter of 26 cm, a height of 45 cm, and a volume of 17 L. Gas incubators are equipped with an airtight cover connected to the syiringe. The syiringe is made of an infusion hose with a diameter of 2 mm and a length of 30 cm (15 cm outside the gas incubator and 15 cm inside the incubator).

The syiringe is equipped with a threaded valve that can be loosened and tightened so that it can regulate air circulation inside and outside the gas incubator. The syiringe serves as a place to take and release gas from the incubator.

Floating square shape (100 x 100 cm) made of fiber-coated plywood with a thickness of 5mm. In the center of the floating there is a hole of 26 cm to place the gas incubator. The floating position is right at 5 cm below the incubator gas.

Ballast anchors are made of cast cement molds, consisting of 2 pieces with a weight of 1 kg each. Ballast anchors are equipped with ropes (4 mm in diameter) whose length can be adjusted according to the depth from the surface to the bottom of the water. The ballast anchor functions to stabilize the position of the gas incubator when sampling on the water surface.

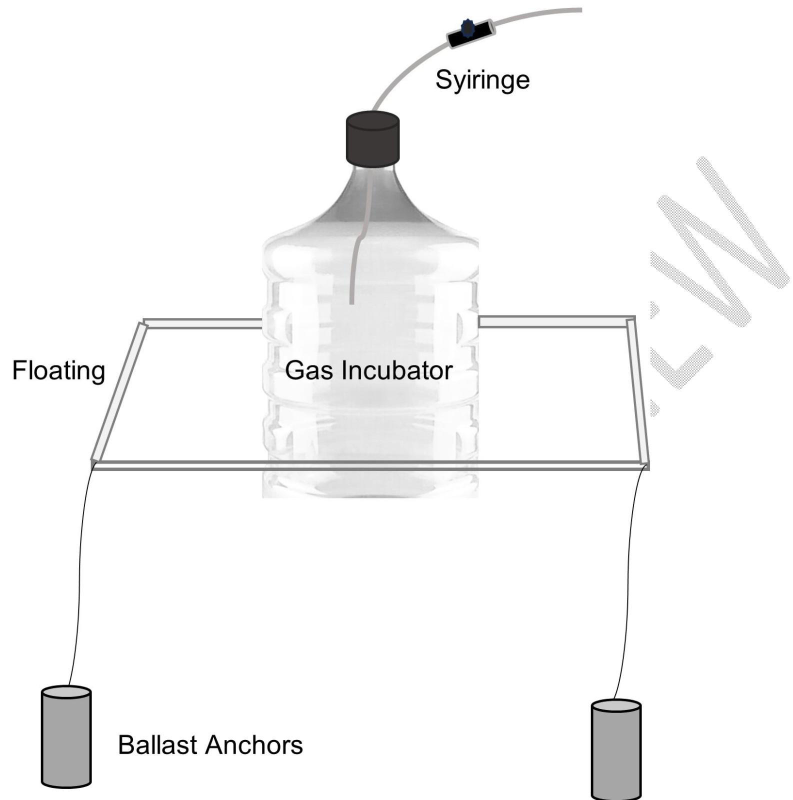

Figure 1. Illustration of Rh-Chamber Design

3. OPERATIONAL METHODOLOGY

3.1. Operational Methodology in the Sediment

The application of Rh-Chamber in sedimentary areas of coastal ecosystems is carried out by placing and inserting it into the sediment to a depth of 5 cm. This method is relatively similar to that of other chambers as applied by Nazareth and Gonsalves [4], Kesaulya et al. [6], Rahman et al. [7], and Tubalawony et al. [8]

A simple difference can be made in the placement of 2 ballasts to apply pressure to the gas incubator so that there is no gas circulation from the incubator to the outside or vice versa (Figure 2). With the presence of ballasts, gas sampling in sediment can be carried out even if it is flooded to a depth of < 10 cm.

Gas intake can be done at specific time intervals, for example intervals of 30s to five times, i.e. 0s; 30s; 60; 90s; and 120s [4] or two-hour intervals seven times, namely

2h; 4h; 6; 8 a.m.; 10 a.m.; and 12 [9]. Gas extraction is carried out through syiringe to be subsequently put into an airtight vial (10 ml) bottle that has been sterilized (Figure 3).

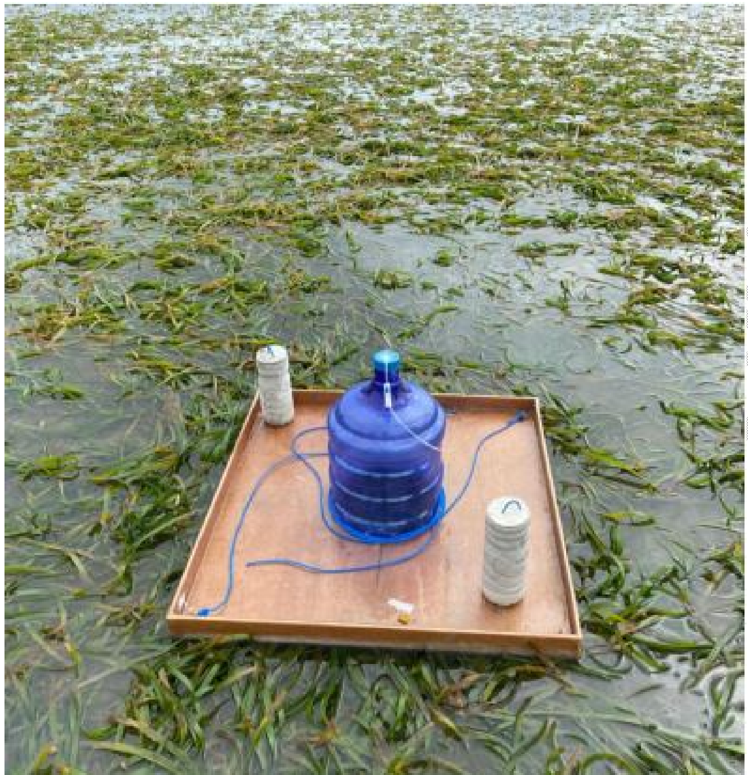

Figure 2. Operational Placement of Rh-Chamber on Gas Sampling in the Seagrass Sediment Area

Figure 3. Gas Sampling via Syiringe in the Rh-Chamber in the Seagrass Sedimentary Area

3.2. Operational Methodology in the Water Surface

Gas sampling on the surface of the waters in the seagrass meadow area can be carried out at a certain depth interval. Rh-Chamber can be placed on the surface of waters with a depth of 10 – 100 cm. However, for the effectiveness of research that can be accessed without additional equipment such as canoes or boats, sampling is recommended at depth intervals of 0-25 cm, 26-50 cm, 51-75 cm, and 76-100 cm.

When laying the Rh-Chamber, the weights should be placed on the base with a rope length that adjusts to the depth of the water, so that the chamber remains stable even if there is a slight disturbance by currents or waves (Figure 4). Water depth measurements can be made using scale pegs or portable meters that can be operated vertically. Gas extraction can be done when the water moves at high tide (0 cm to 100 cm) or moves low tide (100 cm to 0 cm). The gas intake interval can be adjusted according to the purpose of the study, but it is recommended to use the usual interval such as previous studies exemplified by Nazareth and Gonsalves [4] and Tubalawony et al. [8].

Figure 4. Operational Placement of Rh-Chamber for Gas Sampling on the Surface of Seagrass Waters

4. DISCUSSION

4.1. Advantages of Rh-Chamber

The unique Rh-Chamber design with floating and ballast anchors provides a significant advantage in gas sampling in coastal environments, especially on the surface of waters. This is not only applied to seagrass areas, but can also be applied to estuary areas, mangrove ecosystems, and freshwater areas. With the use of Rh-Chamber, the measurement of greenhouse gas flux can be analyzed comprehensively especially in relation to the influence of aquatic parameters such as depth, temperature, salinity, pH, DO, and vegetation abundance. This is very important to know, considering that the estimation of greenhouse gas flux so far has only focused on sedimentary areas of coastal ecosystems so that it cannot produce comprehensive flux data.

4.2. Challenges and Limitations

Although Rh-Chamber has an advantage in gas sampling on the surface of waters. However, challenges arise when the current and wave conditions are very strong which results in the instability of the Rh-Chamber, so sampling cannot be carried out. Another challenge arises when sampling is carried out at a depth of > 2m, sampling must be done on a canoe and of course requires more labor and cost so that the research becomes inefficient and effective.

On the other hand, gas collection is still done manually through syiringe so that in the application, sampling must be done by 2-3 people. Another limitation is the absence of water paremeter sensors in the gas incubator such as temperature, salinity, pH, and DO, so all of these parameters must be measured separately around the sampling area or right at the sampling point before or after gas sampling is carried out.

4.3. Potential Applications

Rh-Chamber has significant application potential not only to sediments or water levels of coastal ecosystems. However, Rh-Chamber can also be implemented in aquaculture pond waters and floating net cages. The application of Rh-Chamber in aquaculture waters can contribute significantly to the evaluation of aquaculture practices that support climate change mitigation efforts. By knowing the amount of flux and global warming potential of greenhouse gases contributed by aquaculture activities, aquaculture practices can evaluate aquaculture water management methods, feeding, and aeration systems so that the aquaculture practices carried out really carry out the principles of sustainable cultivation based on climate change mitigation [10].

5. CONCLUSION

Rh-Chamber is an important innovation in gas sampling in coastal environments, providing a solution to the limitations of conventional methods. With its flexible design and ability to operate over sediment as well as water surfaces, the Rh-Chamber enables more accurate and representative measurements of greenhouse gas fluxes such as CO_2, CH_4, and N_2O. The versatility of this tool makes it suitable for use in various coastal ecosystems, including seagrass beds, mangroves, and aquaculture waters.

Although Rh-Chamber offers advantages in terms of accuracy and efficiency, some challenges are still found, such as the difficulty of stabilizing the tool in strong currents and the limitations in its use in deeper waters. In addition, manual gas sampling still requires more effort and time. Nevertheless, the great potential of this tool in environmental research, especially in the context of climate change, makes it a significant innovation.

Overall, the Rh-Chamber could become a new standard method in the study of greenhouse gases in coastal ecosystems, providing more comprehensive data on gas emissions and helping scientists improve estimates of the contribution of coastal ecosystems to global climate change.

DISCLAIMER (ARTIFICIAL INTELLIGENCY)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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