Low-cost Field Methane Flux Measurement Device

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Introduction

We aim to design a low-cost (<$200), portable methane flux measurement device capable of monitoring methane (CH_4), carbon dioxide (CO_2), temperature, and humidity in lakes and ponds. This project is a collaboration between Cornell Atkinson Center for Sustainability, the Biological and Environmental Engineering (BEE) Department, and the Electrical and Computer Engineering (ECE) Department.

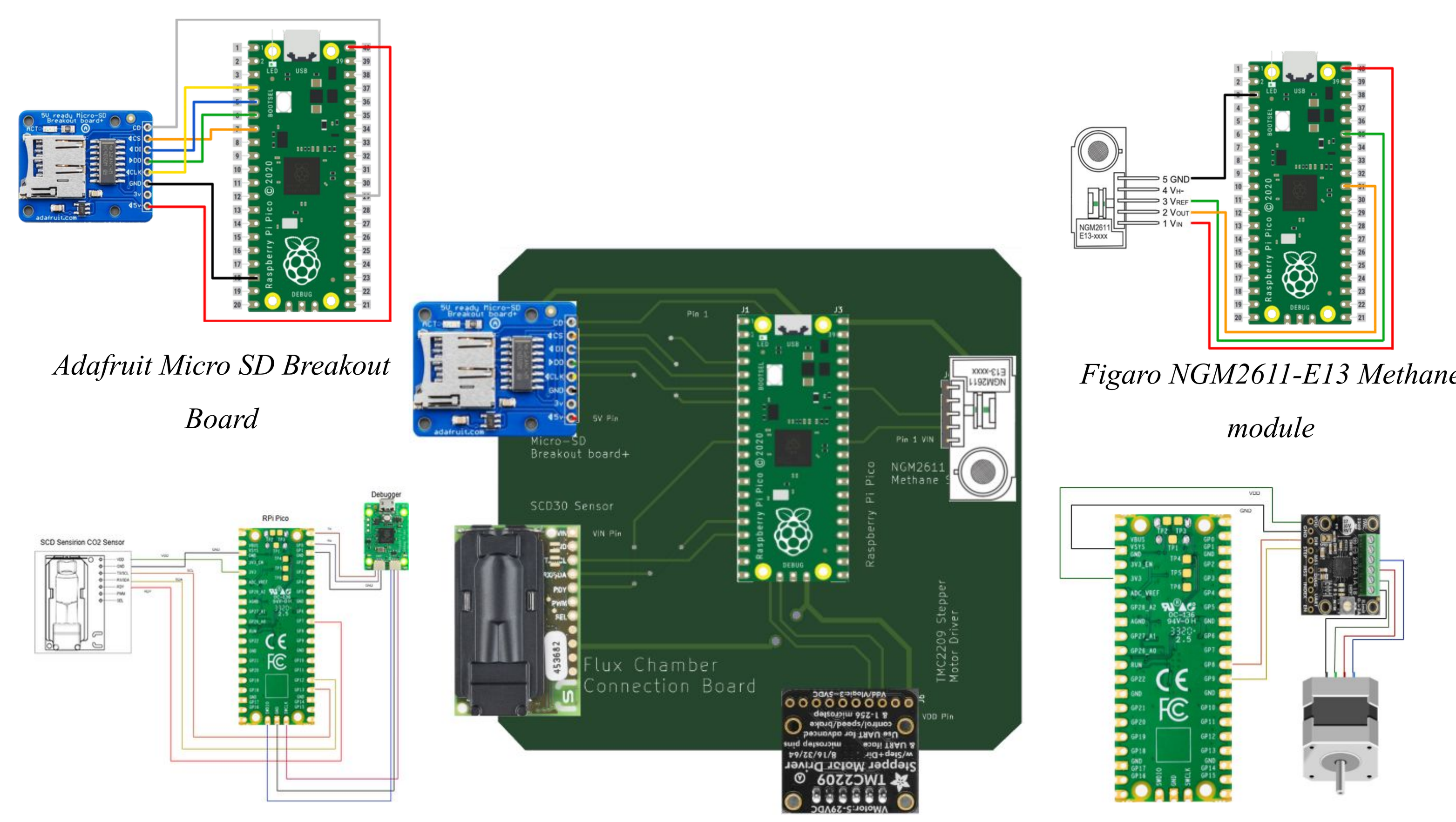
Motivation

Accurate measurement of methane and carbon dioxide fluxes from lakes and ponds is critical for understanding greenhouse gas emissions and their impact on climate change. However, existing flux monitoring devices are often expensive, heavy, bulky, and power-intensive, making them impractical for widespread field deployment, especially in remote or difficult-to-access locations. Transporting large, delicate equipment across rugged terrain or into isolated areas significantly limits the frequency and scope of environmental studies.

While current commercial systems offer highly reliable and accurate measurements, they typically cost over $500 per unit, consume significant amounts of power, and are cumbersome to transport and operate in the field. Their lack of portability and high energy requirements present substantial barriers to long-term and large-scale monitoring efforts.

Requirements

- The device must accurately measure methane and carbon dioxide flux as it is emitted from the body of water upon which the device is deployed.
- The overall cost to construct one unit should be no more than $200.
- It must be possible to build the product using easily attainable devices and materials that anyone (even a hobbyist) can purchase and utilize.
- The device should be able to perform for at least a week without any external support.
- Data collected by the device should be organized, easy to collect from the device, and easy to understand.
- The power consumption of the device should be minimal. (It currently uses a car battery and does last long.)
- It must be simple and relatively quick to construct and deploy the final design.



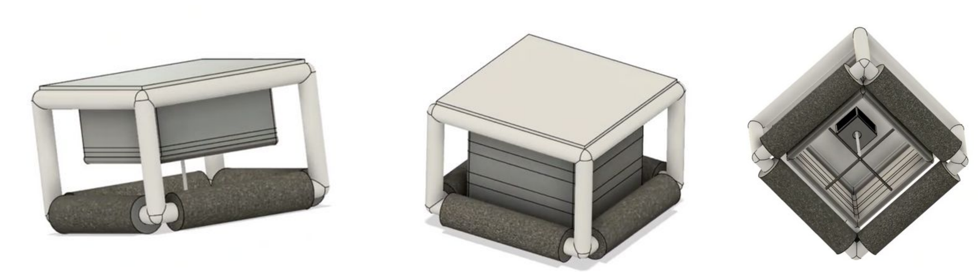
Adafruit Micro SD Breakout Board

Figaro NGM2611-E13 Methane module

Sensirion SCD30 CO2, Temperature and Humidity

Adafruit TMC2209 Stepper Motor Driver

For the electronic part, a Figaro NGM 2611-E13 Methane module will read the methane data, and SCD-30 sensor will acquire CO2, temperature, and humidity data. After the pico got those data, the pico will send and storage them into SD card through an Adafruit Micro-SD breakout board.



All components will be mounted into a floating chamber. There is a telescopic structure inside the chamber. When the telescopic structure drop down, it will touch the water surface and generate a sealed space in order to let sensor collect accuracy and unchanged data. After each measurement, the structure will go up and refresh the air inside the chamber, and be prepared for the next round of measurements.

Sensor Measurements

Reading	CO2(ppm)	Temperature(°C)	Humidity(%)	CH4(ppm)
1 - Closed Space	1056.3	25	47.53	41
2	1054	24.99	47.78	38
3	1044.93	24.99	46.58	42
4 - Exposure to exhaled air	2534.34	25.2	50.1	41
5	3450.12	25.12	49.59	41

The results shown were limited to measuring in lab with limited ventilation owing to the high CO2 levels.

Implementation

Our approach to this project was modular. In three subteams, we independently worked on the following three subsystems

- Interfacing the SD card breakout board with the Raspberry Pi PIco and the methane sensor
- Interfacing the carbon dioxide, temperature, and humidity sensor with the Raspberry Pi Pico
- Interfacing the stepper motor to the Raspberry Pi Pico via a motor driver as well as mechanical system design

These three systems are then integrated with each other to create one large system. In order to accomplish this, we designed a PCB consisting of sets of header pins. This allows for a plug-and-play style design, making it easy to attach and detach components for the purposes of troubleshooting or replacement.

The mechanical design consists of a chamber that is framed with PVC. The chamber seals itself against the water surface and is lifted / lowered using a stepper motor. The PCB with all electronic components is affixed to the roof of the chamber.

Future Work

- Conduct field testing at multiple sites to validate long-term performance.
- Integrate real-time wireless data transmission.
- Extend sensor calibration for diverse environmental conditions.
- Optimize chamber materials for enhanced durability and reliability.

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