Non-invasive measurement of O_2 and CO_2 in experiments with dredged sediments

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Introduction:
One way of determining the rate of organic matter degradation in small scale experiments with dredged sediments is to make a mass balance between O_2 and CO_2, both dissolved and gaseous. In this type of determinations it is important to acquire precise data that can be later extrapolated to field conditions. Traditional methods to measure O_2 and CO_2 are invasive and can interfere with the results. For instance, taking a gas sample will decrease the volume of gas in the bottle, increasing the pressure and changing the equilibrium conditions; and using needles to sample the bottom of the sample would carry atmospheric gas and material from the upper layers.
Non-invasive optical O_2 and CO_2 sensors allow the acquaintance of information without making physical contact with the samples. It has been widely demonstrated that O_2 sensors are reliable for measuring the partial pressure of both dissolved and gaseous oxygen. However, the CO_2 sensors have been tested for dissolved but not for gaseous measurements
Our aim is to demonstrate that we can use these sensors to determine the evolution with time of the balance between O_2 to CO_2 in lab scale experiments with dredged sediments without interfering with the system. For that, the partial pressure given by O_2 and CO_2 sensors under different gas compositions and humidity was compared with Gas-Chromatograph measurements.
The preliminary results confirm that remote sensing can be used in these type of lab experiments with dredged sediments.

Methods: Values given by the O_2 and CO_2 sensor probes were compared with Gas-Chromatograph (GC) measurements in order to validate the method.
For that, different concentrations of O_2, CO_2 and Helium (He) were set inside closed bottles (Figure 1) using a gas mixer. O_2 and CO_2 concentrations ranged from 0 to 22%, being the sum of both always 22%. In case of O_2 this range covers from the atmospheric concentration until total depletion. In case of CO_2, this range covers from atmospheric concentration until total conversion of atmospheric O_2 to CO_2, considering that no extra CO_2 will be formed from dredged sediment. He has been chosen to make up 100% of gas in the headspace because it allows the detection of leakages or incorrect mix of the gases inside the bottles.
In addition, the relative humidity was set at 4 different values using water (R.H.=100%) and 3 salt solutions:

1. Magnesium nitrate – R.H. = 54.38 %
2. Ammonium sulphate – R.H. = 81.43%
3. Potassium nitrate – R.H. = 94.62%

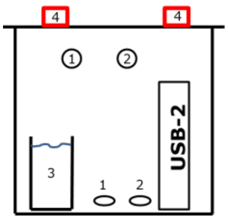

Figure 1: Experimental Setup. Legend: 1 – O_2 sensor; 2 – CO_2 sensor; 3 – salt solution; 4 – sampling port

Furthermore, USB-2 loggers of temperature and humidity were placed on each bottle to determine when equilibrium was reached between atmosphere relative humidity and salt solution.
O_2 and CO_2 sensors and fiber optic transmitters provided by *PreSens – Precision sensing*® were used and the method provided by the company for handling and placing the sensors was followed.

Results: The preliminary results show that the O_2 and CO_2 sensor probes can be used as an reliable tool to evaluate the conversion of O_2 to CO_2, meaning that this technique can be applied in future experiments with dredged sediments.

Conclusion: Determination of the O_2 and CO_2 evolution in small scale lab experiments with dredged material should be done with non-invasive techniques to avoid disturbance and increase reproducibility of the results.

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