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Long-term flow monitoring of submarine gas emanations

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One of the Carbon Capture and Storage (CCS) strategies currently under study is the sequestration of CO2 in sub-seabed geological formations. Even after a thorough review of the geological setting, there is the possibility of leaks from the reservoirs. As part of the EU-financed project CO2ReMoVe (Research, Monitoring, Verification), which aims to develop innovative research and technologies for monitoring and verification of carbon dioxide geological storage, we are working on the development of submarine long-term gas flow monitoring systems. Technically, however, these systems are not limited to CO2 but can be used for monitoring of any free gas emission (bubbles) on the seafloor.

The basic design of the gas flow sensor system was derived from former prototypes developed for monitoring CO2 and CH4 on mud volcanoes in Azerbaijan. This design was composed of a raft floating on the surface above the gas vent to collect the bubbles. Sensors for CO2 flux and concentration and electronics for data storage and transmission were mounted on the raft, together with battery-buffered solar panels for power supply. The system was modified for installation in open sea by using a buoy instead of a raft and a funnel on the seafloor to collect the gas, which is then guided above water level through a flexible tube.

Besides some technical problems (condensed water in the tube, movement of the buoys due to waves leading to biased measurement of flow rates), this setup provides a cost-effective solution for shallow waters. However, a buoy interferes with ship traffic, and it is also difficult to adapt this design to greater water depths. These requirements can best be complied by a completely submersed system.

To allow unattended long-term monitoring in a submarine environment, such a system has to be extremely durable. Therefore, we focussed on developing a mechanically and electrically as simple setup as possible, which has the additional advantage of low cost. The system consists of gas collector, sensor head and pressure housing for electronics and power supply. The collector is a plastic funnel, enclosed in a stainless-steel frame to add weight and stability. The whole unit is fixed to the sediment by nails or sediment screws. The sensor head is equipped with an “inverted tipping-bucket” sensor, which basically works like a turned upside-down rain gauge. It fills with the collected gas until full, then empties completely and starts again, which allows the calculation of the flow rate by container volume and frequency of the cycle. This sensor type is very robust due to a design nearly without moving parts and suitable for very low to medium flow rates. For higher flow rates different sensor heads using turbine wheels or pressure differences can be used. The pressure housing for this prototype is made of aluminium and contains a Hobo Pendant data logger with integrated battery supply.

Since this setup is inexpensive, it can be deployed in numbers to cover larger areas. By addition of multi-channel data loggers, data transmission by acoustic modem or cable, relay stations on the seafloor or buoys etc. the infrastructure can be adapted to the environmental setting and financial budget.

Prototype tests under laboratory conditions as well as field tests on natural submarine gas vents as an analogue to leaking storage sites have demonstrated the capabilities and robustness of the systems.