Underwater apparatus and in situ seawater sampling method

Abstract

The present invention relates to an underwater system with a peristaltic pump for targeted and precise water sampling without contamination. It includes a specific protocol for the study of marine filter-feeding organisms, allowing comparison between inhaled and exhaled water. Applicable to the study of nutrients, plankton, microorganisms, and metabolic processes in marine ecosystems.

State of the Art

Early techniques for sampling marine filter feeders were indirect and rather rudimentary, with limitations in terms of accuracy, sample volume and the ability to prevent contamination. The introduction of In/Ex methods enabled the simultaneous collection of water inhaled and exhaled by the organisms, thereby improving the accuracy of the data. Subsequent techniques, such as VacuSIP or In/Ex systems using ROVs, have increased control and reproducibility, but still suffer from limitations regarding constant flow and volume, lengthy handling times and the risk of contamination. The new patented system overcomes these limitations, enabling targeted, continuous and contamination-free underwater sampling, suitable for larger volumes and useful for advanced metabolomic studies.

Description of the Invention

The present invention overcomes the limitations highlighted in the state of the art, enabling targeted, continuous, and contamination-free underwater sampling, suitable also for larger volumes and advanced metabolomic studies. The patented system consists of correctly positioning a sampling tube of approximately 1–2 mm within a target outlet point (sponge osculum). This sampling tube is then incorporated inside MS/CA cassettes above the peristaltic pump rotor and directs the sampled seawater into collection bags as the pump rotor rotates. The water flow is monitored via a hot-bead flow sensor (Hot-Bead Flow Sensor) based on semiconductor NTCs, in which a heated NTC measures local flow and a reference NTC measures ambient temperature. The temperature difference is converted into a current signal proportional to the flow rate. An adjustable level switch and a PWM controller manage the pump's on/off operation and speed adjustment, ensuring sampling occurs only when the flow reaches a target threshold. This allows precise, non-invasive seawater collection, suitable for the study of filter-feeding organisms and aquatic microenvironments.

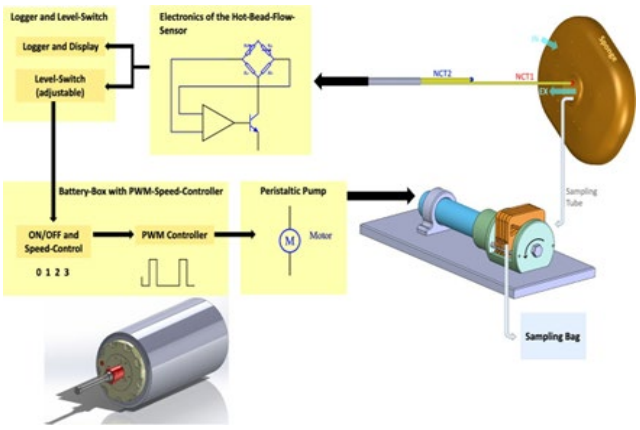

FIGURE 1: Schematic diagram of the operating principle and electronics of the PeriSIP.

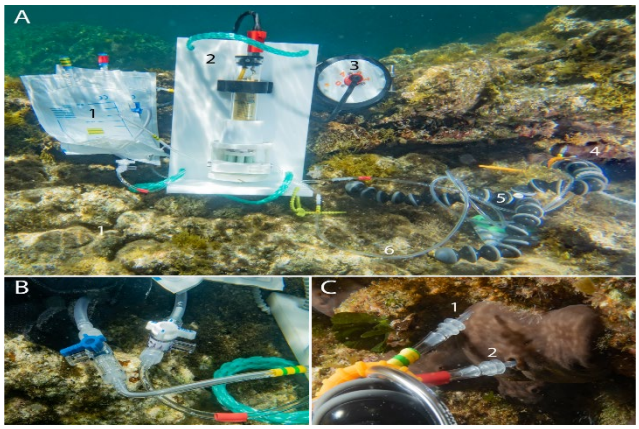

FIGURE 2: Underwater peristaltic pump system

Industrial Propriety:

PCT application under validation n.PCT/IB2024/060966 filed on 6 November 2024
Italian patent application n.102023000023784 filed on 10 November 2023

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Advantages

The advantages of the invention are as follows:

- Simultaneous sampling of multipli water flows, increasing efficiency and the amount of data collected.
- Controlled and constant sampling flow, essential for accurate quantitative analyses.
- Sampling of water from very specific and defined points, including from thin or localised flows.
- Reduced risk of contamination from other areas of the aquatic environment.
- The electronics and precise regulation minimise unintended variations in sampling, resulting in more reliable results.

Applications

The patented invention can be applied to:

- In ecological and biological studies to analyse water quality, microflora, plankton or specific contaminants.
- In sampling within waterworks, sewage treatment plants or water treatment systems where precise data from specific points is required.
- In the monitoring of fragile or sensitive ecosystems, for the detection of chemical or biological substances in highly localised flows, and for targeted sampling in industrial or port areas to assess discharges and contamination.

Development stage

CURRENT TRL: 6/7 -The prototype has been successfully tested in a relevant environment.

PROSPECTIVE TRL: 9 - System fully operational and validated under real-world conditions.

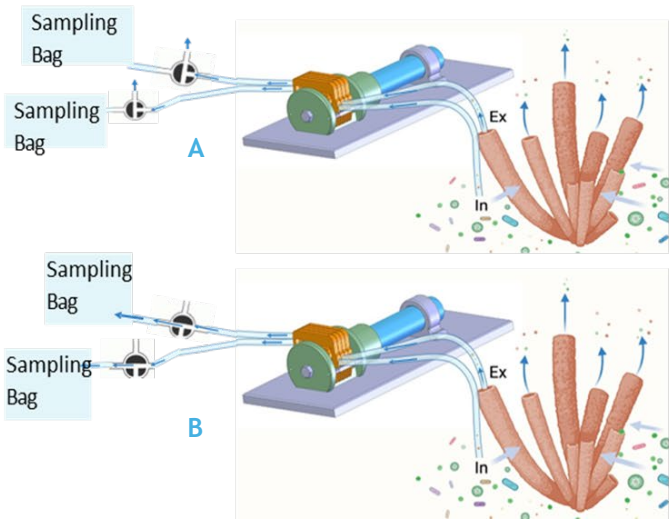

FIGURE 3: Circuit system and adapter between the tube and the bags: position A drains the residual water, while position B directs the sample into the bag after the system has been flushed.

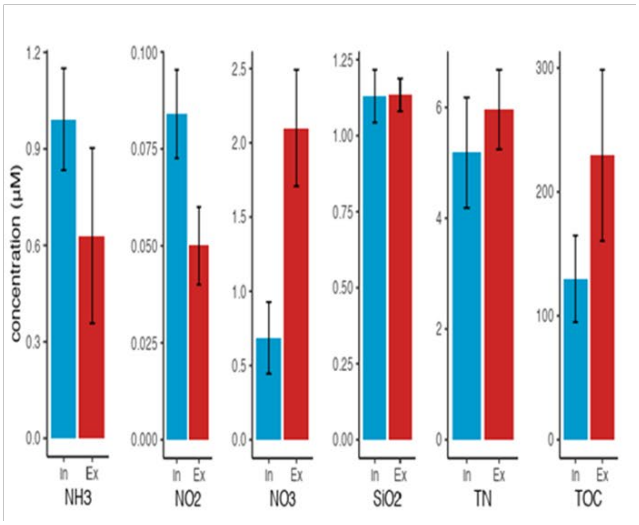

FIGURE 4: Analysis of inorganic and organic nutrients in the In/Ex water sampled from the C. reniformis sponge. Blue: inhaled water; Red: exhaled water.

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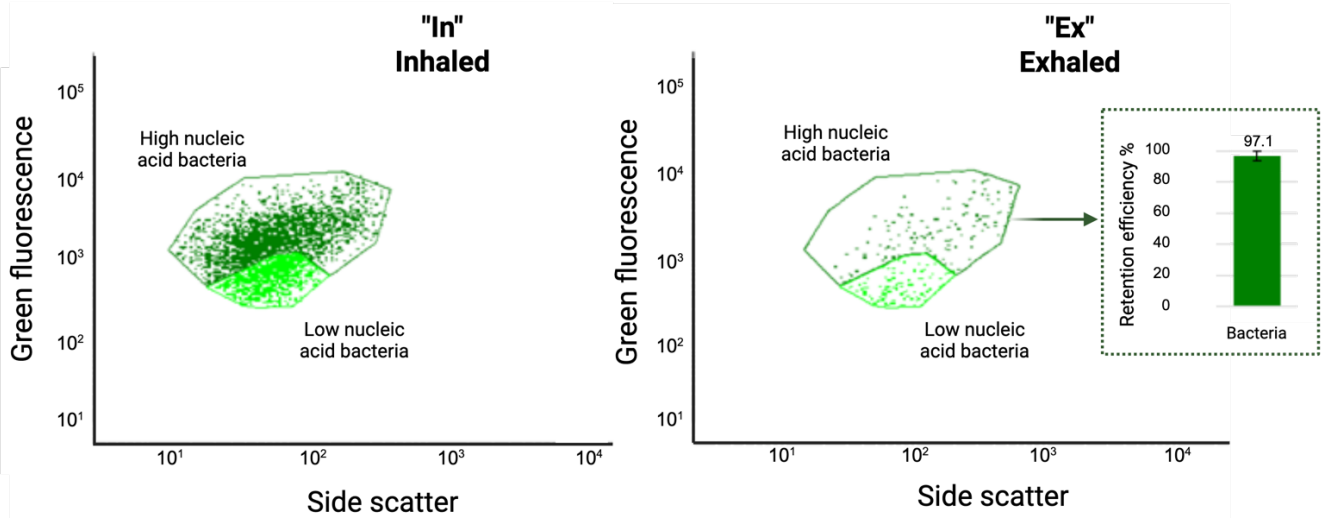

FIGURE 5: Flow cytometric analysis of heterotrophic bacteria in samples of inhaled and exhaled water collected from *Chondrosia reniformis* specimens. The visibly lower cell counts in the exhaled samples reflect the sponge's efficient retention of cells (97.1%).