

Biosensing Network for Real-time Water Monitoring

Elise Saoutieff¹, Célia Boko¹, Arthur Ohl¹, Clément Garaffa¹, Guillaume Nonglaton¹, Luana Cuvillier¹, Richard Murray², Alan O'Riordan², Sana Muzaffar², Arjan GJ Tibbe³, Jinane Elias³, Gabriela Dudnik⁴, Abdessamad Falhi⁴, André Fivaz⁴, Cecilia Jimenez-Jorquera⁵, Josep Maria Margarit-Taulé⁵, Enrique Asin Garcia⁶, Cécile van der Vlugt⁷, Petra Hogervorst⁷

¹ Univ. Grenoble Alpes, CEA, Leti, Grenoble, France

² Nanotechnology Group, Tyndall National Institute, Cork, Ireland

³ OnePlanet Research Center, IMEC, Eindhoven, Netherlands

⁴ CSEM, Neuchâtel, Switzerland

⁵ IMB-CNM, CSIC, Barcelona, Spain

⁶ Wageningen University, Wageningen, Netherlands

⁷ RIVM, Bilthoven, Netherlands

elise.saoutieff@cea.fr

Summary:

A biosensor-based monitoring system for water monitoring is growing of interest especially to detect in real-time typical pollutants such as nutrients (nitrates and phosphates), Estrogenic endocrine-disrupters, PFAS (Perfluoroalkyl, and polyfluoroalkyl substances) and Microcystines.

The paper presents a biosensing network developed in the BIOSENSEI project along with the first laboratory results focus on the electronic system architecture. This will enable the first continuous, reliable and robust real-time monitoring and detection of these pollutants in watercourses using cellular-based biosensors.

Keywords: Water monitoring, biosensor, real-time, Nb-IoT, Integrated systems

Background, Motivation and Objective

Water pollution, the leading environmental cause of physical and mental illness, accounted for 1.4 million premature deaths worldwide in 2022 (16% of total deaths) and 12.5% of deaths each year in the EU. Together with the EU Drinking Water Directive from January 2023 [1], there is an urgent need to provide high-quality water, prevent pollution and develop methods to improve the protection of human health.

Better monitor, report and prevent water pollution by providing real-time digital tools directly to users is thus a priority.

In the Horizon Europe project BioSensei (Biosensor-based diagnostic platform enabling real-time monitoring of existing and emerging pollutants), we are addressing these challenges by tackling pollutants of concern, such as PFAS, endocrine disruptors (EDs) and microcystins [2,3].

Based on previous work [4] [5] [6], novel mixed-signal front-ends is developed for the combinatorial sensing approach (electrochemical and fluorescence transducers) and sampling conditions. These systems will transfer sensor data to the project cloud to facilitate long-term autonomous sensing with Nb-IoT communication.

System Architecture

The BioSensei Node (Fig.1) is a subsystem composed by (a) the BioSensei Sensor Head, (b) the BioSensei electronic front-end and (c) the BioSensei IoT.

(a) Cellular biosensors are encapsulated and immobilized at bimodal transducers (nanoelectrochemical and optical) for detection of the target pollutants: Nitrate, Nitrite, Phosphate, Estrogens E1, E2, E3, E12 and PFAS.

(b) the electronic front-end is separated into electrochemical and optical front-end subunits.

(c) the IoT controls the electronic front-end, to which it will request to start a measurement and from which it will collect the values measured by the sensor. The IoT will then store, process and transmit these values to the BioSensei Cloud platform. Up to 10 bio-sensors will be integrated on the BioSensei platform associated to up to 10 sensor front-ends.

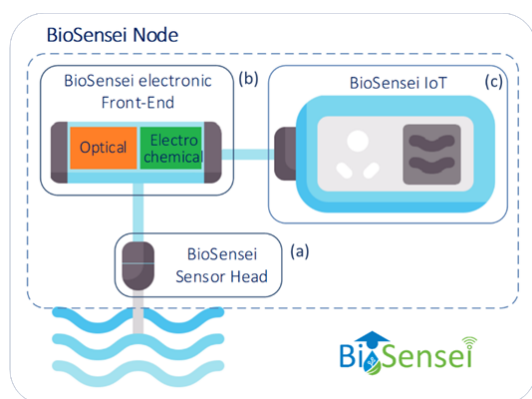


Fig. 1. BioSensei simplified design

IoT node

The IoT node embeds a wireless communication module to link to the BioSensei Cloud platform via the Internet by means of either a Gateway and a mid-range communication infrastructure like on Fig.2.

Nb-IoT communication was chosen as the most appropriate for the BioSensei use cases, using LTE "Long Term Evolution" coverage network.

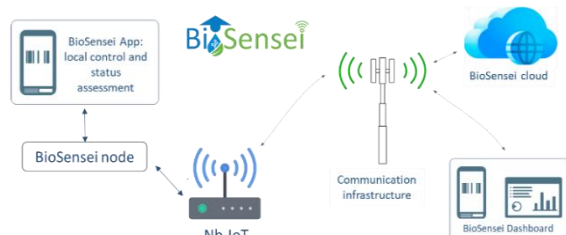


Fig. 2. BioSensei IoT

Laboratory results

The IoT board was connected with the 6 terminals optical sensors AFE (Analog Front-End), the 2 terminals electrochemical AFE and the edge-computing board like shown in Fig. 3.

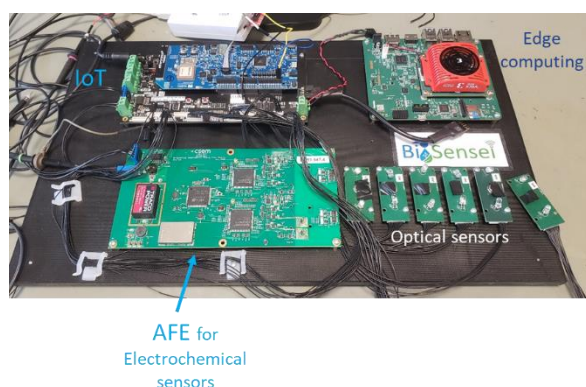


Fig. 3. Set-up for the communication IoT test

Good communication between the different boards were highlighted. The robustness of the electronics and Nb-IoT communication were

demonstrated through successful laboratory tests.

The next actions will be the integration of the overall system with 10 cells in laboratory and subsequent trials with different pollutants and finally the deployment in Ireland and Netherlands tests site.

BioSensei will make a significantly contribution to enhancing water understanding to improve management practices.

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