FP-OCEAN-2013 / IP Project n° 614168

SEA-on-a-Chip (Real time monitoring of SEA contaminants
by an autonomous Lab-on-a-Chip biosensor)

FINAL REPORT by Scientific Advisory Committee

The SEA-on-a-CHIP (SOAC) EU funded project gathered together 17 institutions (10 universities and research institutes, 6 SMEs and 1 industry) to develop a prototype for an autonomous analytical and early warning system capable to identify in the sea water a range of chemical contaminants, determine their concentrations and send real-time the information to land based receiving stations. The practical application for the technology is the monitoring of water quality in aquaculture systems in real-time, and it therefore shows support for both food safety as well as environmental protection.

SOAC project partners worked together during three years to develop technical solutions for each component of the device and combine them in a sea going autonomous platform. Such project was a challenge for many scientific and technological fields in order to perform operations ranging from programmed water sampling, preconcentration of targeted contaminants from water samples, specific and quantitative reactions to determine concentrations of eight analytes, keep chemical reagents preserved at low temperatures for long time, enable specific reactions in miniaturized chambers, eliminate the spent samples and chemicals into a suitable storage, collect the signal from chemical reactions, amplify, transduce signal, store it, and transmit it to land based receivers, treat signal in suitable software, and all this operated with an autonomous and reliable power supply placed on board the platform.

During the SOAC project life time, three prototypes were built and tested until reaching with the third one, a satisfactory solution on grounds of conceptual design of the autonomous sampler-analyser-transmitting device, installed in a buoy capable to stand alone in the sea for more than one month.

From the initial concept several approaches were used and tested, allowing for significant progress to be made. This included selection of contaminants to analyse, which once agreed included irgarol 1051, sulfapyridine, chloramphenicol, domoic acid, PBDE 47, deltamethrin and estradiol. It must be noted that some of these analytes are not easy to determine even in the laboratory and, therefore, miniaturize the analytical process in a programmed and autonomous protocol to perform the determination of concentrations of eight very different analytes and provide results on real time was a major challenge. Furthermore, the best signal to be transduced into a result was also to be identified and indeed, the first prototype based the analysis on the impedance of signal from chemical reactions but this proved to be not reliable. A shift to amperametric analysis proved later to be a better solution. Maintain the chemical reagents chilled at right temperature was another challenge, and the stabilization of specific anti body reagents for contaminants analysis was another challenge. Transmission device and software protocols were also to be designed and built for this purpose.

At each significant step achieved, a milestone was reached and a prototype was built and tested in the field with successful results. The final one was tested in Olhão, Portugal, for a month of continuous analyses in an autonomous manner. It demonstrated that the project objectives had been attained.

Along the way, the coordination of this complex project had been effective in work planning, exchange of information, and allowing partners to understand the difficulties of each other and cooperate to find the best technical solutions for building the autonomous module.

Along this pathway, significant developments were achieved sometimes with innovative solutions in the intervening disciplines from immunosensors to microfluidics and reaction chambers, signal transducing, data logging, data transmission and power supply management to the autonomous device. Furthermore, an outstanding reporting of progress made and dissemination of scientific information from the project was made through articles and communications to scientific conferences during the lifetime of project. At the end, a very informative video was made describing the concept and functioning of the autonomous module, and released already in youtube (https://goo.gl/129a5R). Actually in itself this video is a visual summary of the project achievements. Patents for some technical developments were requested to protect innovative ideas.

It is worth mentioning that during the project life time, the coordination of Sea-o-a-chip successfully encouraged the exchange with sister projects (and others) inviting them to participate in the open technical workshops. Projects such as BRAAVOO, ENVIGUARD, CERES, AQUASPACE, ECsafeSEAFOOD, GLOBAQUA, CFIS-Ecopharma and IMTA-EFFECT have therefore interacted with each other and Sea-on-a-Chip, in a stimulating process of exchange of scientific information and discussion of progress.

Also the SEA-on-a-CHIP Scientific Advisory Board, that from the beginning to the end of the project participated actively in discussions, brainstorming and conceptual developments to overcome difficulties arisen, is proud of the SEA-on-a-CHIP achievements. The SAB congratulates all project partners and SOAC coordination for the success of this EU funded project. The project was particularly challenging from the perspective of coordinating the activities of multiple partners, and the project team has done an excellent job in delivering the work that was proposed.

A prototype was built and successfully tested, the analytical results were validated against laboratory based analytical determinations and data transmission and accessibility was demonstrated. Now it is time to promote the prototype and to adapt and embed this tool in the world of daily applications for an autonomous and real time analyser of contaminants and biotoxins at sea. A follow up project to adapt and improve the current prototype to user´s needs would be desirable. Such a project could build a more robust and commercial version of the current Sea on a Chip prototype.

Many potential field of application for such an autonomous analyser can be envisaged. For example, the analyses of biotoxins in sea water and results available in real time from an autonomous device may anticipate in about one week the time for warning shell fish producers and consumers about biotoxins, and thus save human lives; surveillance of pesticide residues in sea water may prevent consumption of contaminated sea food and even warn about residue discharges into aquatic bodies; analyses of sterols in real time may inform on treated sewage discharges and effectiveness of urban sewage treatment; hydrocarbons in coastal regions with oil rigs may allow for continuous survey of process water discharges and water quality; real time analysis of antifouling agents may inform about water quality in marinas and harbours, and analysis of water quality in bathing areas may prevent public health hazards and outbreak of infectious diseases in case of occurrence of toxic chemical and biological compounds in sea water.

Testing, validation, adaptation of the Sea on a Chip prototype to different environments from polar seas to tropical environments, and from regulators to users' needs, is the next step. This is a necessary step to adapt this autonomous device and make a contribution to sea based economy.

Advisory Committee

(P.-D. Hansen, Fernando P. Carvalho, Neil Auchterlonie, Fernando Rubio)

After the Final Annual Meeting, 18-19 May 2017, in Olhão, Portugal.