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XXXII Cycle

Spectrophotometrical monitoring system for continuous heavy metal detection in water environment

Felice Catania
Supervisor: Prof. Sergio Ferrero

Research context and motivation

Water environmental monitoring is an important key to control and take care of human life and environment health. When water quality is poor, it affects not only aquatic life but the surrounding ecosystem as well. It is necessary that water monitoring instruments become within the reach of local authorities and control units, in order to increase the amount of data available on water pollution and facilitate shearing.
The pre-analytical phase, sample collection, transport and preservation, has a not inconsiderable impact on the total uncertainty of the result of the analysis.
It should also be considered that the set of procedures and operations that occur between the time the sample is taken, and the performance of an analysis is one of the most delicate phases of the entire analytical procedure. The analytical results, in fact, must make it possible to establish the characteristics of the analyzed matrix in the conditions in which it occurs at the moment in which the sample is taken.

Addressed research questions/problems

During the first year, the research activity was devoted to optical analysis of polymers and heavy metals dissolved in water. The most important results led the following studies during the second year, which were dedicated to the methodology for the detection of pollutants in water and the laboratory implementation.
Finally, during last year, the attention was paid towards the experimental phase, fabricating two different prototypes in order to check the reliability of the new instrument facing off-shore and industrial applications.

Figure 1. State of the art of water sampling and analysis.

Novel contributions

The answer will be an instrument, designed with lab-on-chip concept, with a modular structure. The device innovation relies on total automation of the analysis, from the sampling to production of results; Automatic filtration, dilution, concentration and preparation of the sample previous the measurement; Precision, reliability, fastness, robustness; Reduced volumes of sample and reagents; Low cost technology; High versatility, in terms of cost and technology.

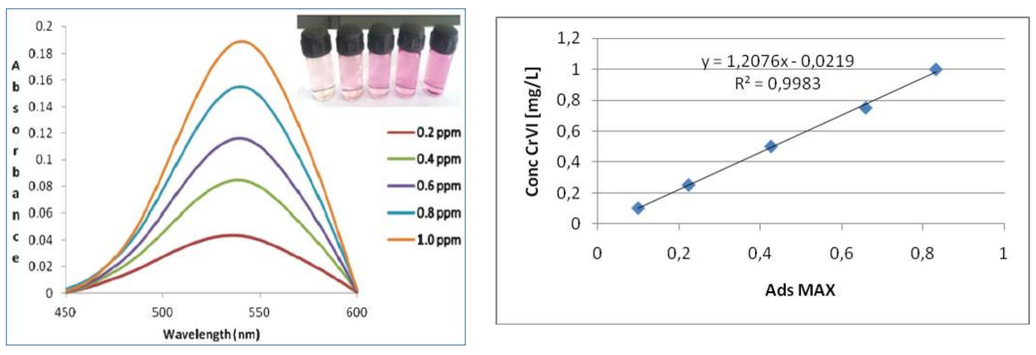

Figure 2. a. Spectrophotometrical analysis of Cu(VI) at several concentrations, **b.** Lab-on-chip measure at 520 nm of Cr(VI)

	Cr(VI)	Zn	Ni	Cu
Recipe	50mL of sample + 0.5mL H_2SO_4 (1:30) + 1mL of DFC dissolved in Methanol	20mL of sample + 3mL of Zincon dissolved in buffer at pH 8.5	20mL of sample + 10mL of a commercial buffer at pH4 + 3mL of Zincon solution	5ml of sample + 5ml of Zincon solution at pH 9.5
Linearity	10-0.1 ppm	10-0.1 ppm	10-0.1 ppm	10-0.1 ppm
Wavelength	520 nm	638 nm	600 nm	665 nm

Figure 3. Results of four different heavy metals measure with lab-on-chip device.

List of attended classes

- 02RHPRV – Intellectual Property Rights, Tech Transfer and Hi-tech Entrep (23/03/2017, 6 CFU)
- 04NPEPE – Materials for MEMS and charact of tech processes (30/01/2017, 10 CFU)
- 01NPOPE – Micro and nanotech applied to biomedicine, enviro (08/02/2017,12 CFU)
- 01QFDRV – Photonics: a key enabling tech for engineering appli (24/07/2017, 5 CFU)
- 01NYCPE – Physics of tech processes for Micro & Nano syst (28/06/2017, 12 CFU)
- 01QORRV – Writing Scientific Papers in English (08/06/2017, 3 CFU)
- Basic Vacuum Course - AIV XXIII Conference -Firenze, April 4-7, 2017 (04/04/2017,1 CFU)

Adopted methodologies

The system that is the object of my project will be able to completely automate the sample preparation phase and, using the lab-on-chip technology, greatly minimize the time and cost of sample preparation.
A microfluid system, consist of glass syringes, micro pumps, and degassing system, allows to acquire the necessary quantity of water sample, filtering the sample through cascade of filters up to nanoporosity, possibly dilute or concentrate the sample, mix with any reagents.

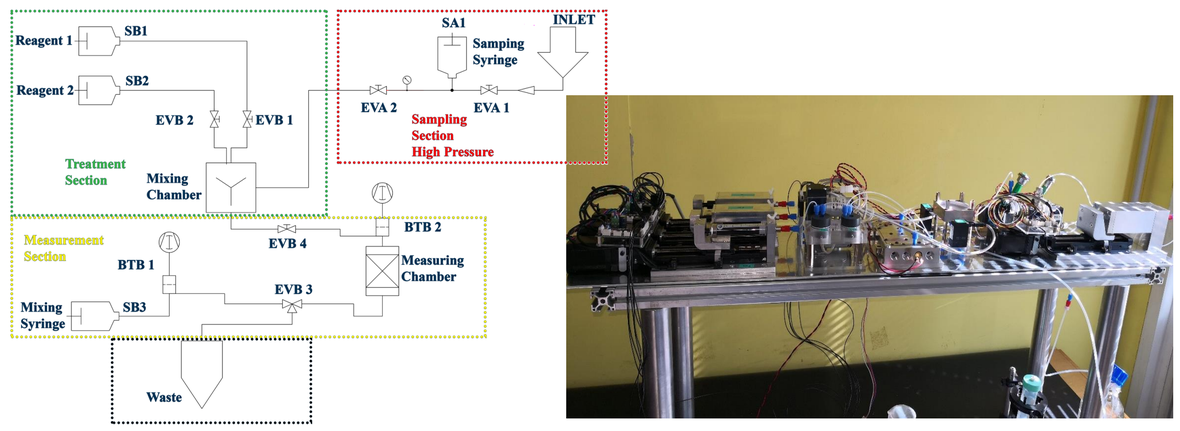

Figure 4. Microfluidic design, including optical design and develop of measure chamber, and bench prototype realization.

Sensing platform for real-time mapping of water quality in proximity of offshore hydrocarbon production sites mounted on an AUV (Autonomous Underwater Vehicle) equipped with wireless control and data transfer.

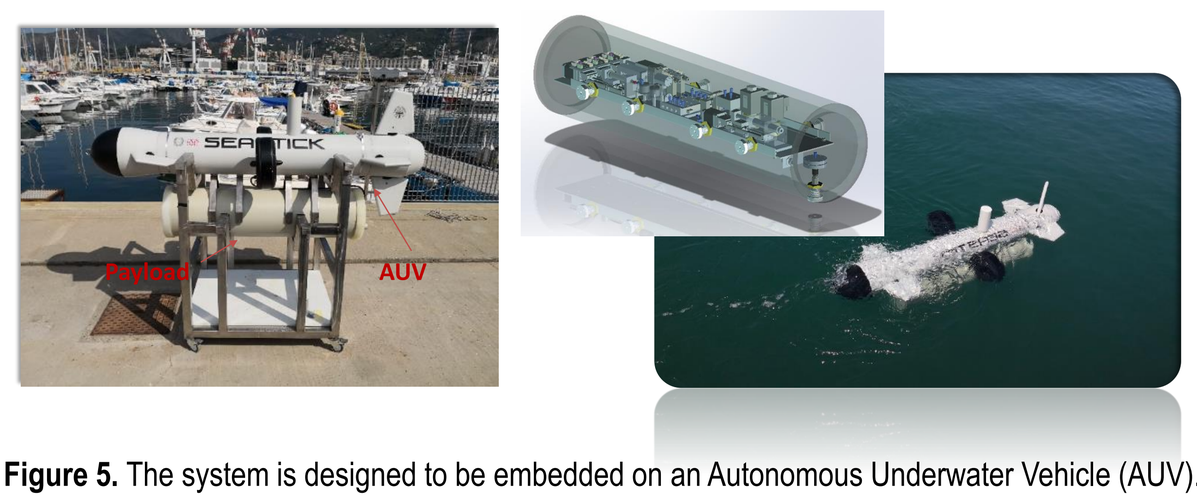

Figure 5. The system is designed to be embedded on an Autonomous Underwater Vehicle (AUV).

Future work

Future activities will focus on development of new optimized method to detect dissolved heavy metals, such as Arsenic, and engineering of the device. Critical aspects of the device, which need to be investigated, are:

- Validation of the results, compared to laboratory analysis;
- Reproducibility and standardization of the methods.

Submitted and published works

- M. Periolatto, F. Catania, C.F. Pirri, L. Scaltrito, S. Ferrero, "Spectrophotometric monitoring system, integrated in an autonomous underwater vehicle, for continuous heavy metal detection near offshore sites" Offshore Mediterranean Conference and Exhibition 2019, March 27-29, 2019 (Published on international Conference Proceeding);
- G. Scordo, V. Bertana, L. Scaltrito, S. Ferrero, M. Cocuzza, S.L. Marasso, S. Romano, R. Sesana, F. Catania, C.F. Pirri, "A novel highly electrically conductive composite resin for stereolithography" ,DOI:10.1016/j.mtcomm.2018.12.017. pp.12-17. In MATERIALS TODAY COMMUNICATIONS - ISSN:2352-4928 vol. 19, 2019;
- V. Bertana, G. De Pasquale, S. Ferrero, L. Scaltrito, F. Catania, S.L. Marasso, M. Cocuzza, F. Perrucci, "3D Printing with the Commercial UV-Curable Standard Blend Resin: Optimized Process Parameters towards the Fabrication of Tiny Functional Parts" DOI:10.3390/polym11020292. pp.292. In POLYMERS - ISSN:2073-4360 vol. 11 (2), 2019;
- F. Catania, M. Periolatto, L. Scaltrito, Matteo Cocuzza, C.F. Pirri, S. Ferrero, "Spectrophotometric monitoring system, integrated in an autonomous underwater vehicle, for continuous heavy metal detection near offshore sites", AIV XXIV CONFERENCE, Conference Center Hilton/RG Hotel Giardini Naxos, Sicily (IT), May 7 - 10, 2019 (Poster)
- F. Catania, S. Ferrero, M. Cocuzza, C.F. Pirri, L. Scaltrito, M. Periolatto, "Cr(VI) in Water: Continuous, on Site Spectrophotometric Determination Laboratory test preliminary to microfluidic device prototyping", pp.265-270. In International Journal of Applied Science and Environmental Engineering vol. 1 (1), 2018
- F. Catania, "Sensing Platform For The Offshore Sites Sea Water Environmental Monitoring", NanoInnovation Conference and Meating, Rome September 26-29, 2017,
- F. Catania, L. Scaltrito, P. Sirianni, M. Messere, M. Cocuzza, S. Marasso, F. Perrucci, C.F. Pirri, S. Ferrero, "Hollow core waveguide for simultaneous laser plastic welding", LiM - Lasers in Manufacturing, Munik (DE) June 26-29, 2017 (Published on international Conference Proceeding);
- F. Catania, A. Piscitelli, S. Ferrero, M. Cocuzza, C. F. Pirri, L. Scaltrito, M. Periolatto, "Cr(VI) in water: continuous, on site spectrophotometric determination", Sixth Intl. Conf. Advances in Bio-Informatics, Bio-Technology and Environmental Engineering- ABBE 2018 (Published on international Conference Proceeding);
- Ravenna 28/03/2019 Workshop "SMART & INTELLIGENT MONITORING, MAINTENANCE AND SUSTAINABLE REPURPOSING SYSTEM FOR SEALINES"
- F. Catania et al. "Elettrodi ottenuti mediante scrittura laser di fibre polimeriche per applicazioni e-Textile" (patent pending)

POLITECNICO DI TORINO

PhD program in
Electrical, Electronics and Communications Engineering