Cyprus Research and innovation Center Ltd, Cyprus www.cyric.eu

Consiglio Nazionale delle Ricerche, Italy www.cnr.it

Alpes Lasers SA, Switzerland www.alpeslasers.ch

National Technical University of Athens, Greece www.ntua.gr

Technische Universität Wien, Austria www.tuwien.ac.at

Friedrich-Alexander-Universitaet Erlangen-Nuernberg, Germany www.fau.eu

AUG Signals Hellas, Greece www.augsignals.gr

VIGO System S.A., Poland www.vigo.com.pl

IREN S.p.A., Italy www.gruppoiren.it

Geographical Information Systems International Group, Italy www.gisig.eu

PHOTONICS PUBLIC PRIVATE PARTNERSHIP

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Dr. Panayiotis Philimis,Coordinator
www.cyric.eu
info@cyric.eu

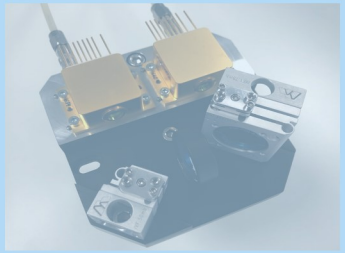
WATERSPY

High sensitivity, portable photonic device for thorough water quality analysis

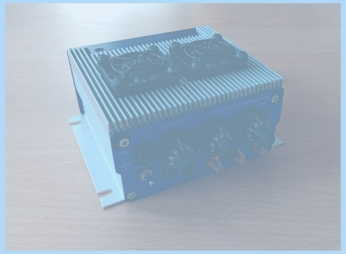
www.WaterSpy.eu

What is WaterSpy?

WaterSpy is a device for pervasive and on-line monitoring of tap water.
For many contaminants, which will lead to human health hazards, good measurement devices are available. For bacterial contamination the situation is worse. Water utilities, public authorities and regulators rely heavily on trustable and fast water analysis. Especially *E. coli*, *Salmonella* and *P. aeruginosa* are of interest for human health. Currently time-consuming and expensive laboratory analysis have to be performed. WaterSpy focuses on these three strains of bacteria and develops an add on device for currently available quality monitoring platforms. The device will be able to perform automated and fast quality analysis for bacterial contaminants in water.
Challenges of the project are to meet the legal requirements for the concentration of contaminants, given in the EU directives on water quality. Due to the very low acceptable concentration of contaminants, the sensitivity of the device has to be very high to catch up with current laboratory analysis.



beam combiner



balanced detection module

▪ Alpes Lasers developed QCLs emitting at the amide region for direct monitoring of bacteria (at 1540-1585 1/cm) and around 1261-1292 1/cm for monitoring the enzyme-product. These two lasers were put together using a beam combiner in order to have only a single beam from both devices.

▪ VIGO developed the HgCdTe photodetectors for WaterSpy, the former module was upgraded by the implementation of improvements in the balanced detection module design and the integration of the thermoelectric cooler controllers into the module itself.

Approach and Objectives

- Key Strategic Objectives:
  ▪ Develop compact photonics technology, capable of identifying selected heterotrophic bacterial cells in the water. Specificity and sensitivity levels will respect regulatory requirements.
  ▪ Validate the technology's cost-effectiveness and suitability for large area coverage.

- WaterSpy develops water quality analysis photonics technology suitable for inline field measurements operating in the mid-infrared region (6-10 μm).

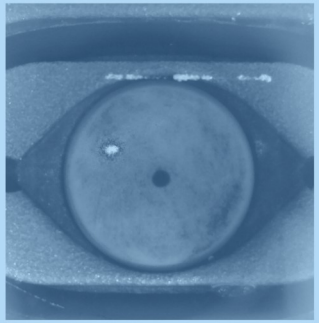
- The solution is based on the combined use of advanced Quantum Cascade Lasers employing the Vernier effect and fast and sensitive Higher Operation Temperature (HOT) photodetectors.

- Targeted analytes are specific heterotrophic bacterial cells. Several novel techniques are employed for increasing Signal-to-Noise Ratio.

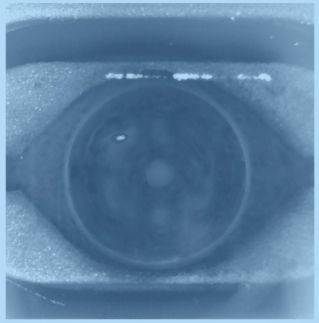
- The device will require about 6 hours for a complete sample analysis. With currently used systems, the same analysis could take up to 3 days.

- The WaterSpy technology will be integrated, for validation purposes, to a water quality monitoring platform, in the form of a portable device add-on.

- Towards the end of the project, the WaterSpy device will be tested at two locations within a single pilot site:
  The Prato water treatment plant, which serves the city of Genova (approx. 580000 inhabitants).



Beads



E. coli

Project updates

▪ The pre-concentration module consists of the ultrafitration part, where water undergoes filtration of the bacteria and ends in a concentrated sample of 100 ml and the filtration through the MAF column where the bacteria are trapped in the MAF filter and later are extracted with opposite-flow of a buffer. This procedure delivers at the end a further concentrated sample of 1 ml that will be used by the next incubation stage.

▪ Infrared spectroscopy by itself wouldn't be sufficient to meet the requirements of measuring 1 bacterium in 100 ml of water. That's the reason for an additional amplification step, implemented as an incubation. The sample is incubated in a heated syringe-based incubator combined with a broth to enable their growth. This incubated sample is handed over to the acoustofluidic cell for the final analysis.

▪ The final measurement is done in the acoustofluidic cell, where bacteria from the sample are trapped using ultrasonic radiation forces. The product of an enzymatic reaction is measured via laser-based ATR spectroscopy.

▪ In order to achieve the necessary selectivity and distinguish among three target bacteria (E.coli, S. enterica, P. aeruginosa) and omnipresent harmless bacteria in water, we are using antibodies in the WaterSpy device. A few different solutions need to be injected into the acoustofluidic cell to apply antibodies in this procedure. This is done by the solution injection module.

▪ The optical setup was, by integrating the new QCLs and detectors, redesigned in a compactly way and upgraded by a heat-resisting housing and an additional water cooling system for getting a firmer signal.

▪ The main processing unit of the WaterSpy device is realized by a CompactRIO Controller from National Instruments, which controls all subsystems and communicates with TRITON for commands and result exchanges.