Low-Cost systems for water quality monitoring

Solutions innovantes à faible coût pour le suivi de la qualité de l'eau

Adam Adewolu[1,2], Benoit Anquez[3,4], Franck Perret[3], Abel Ranjel-Trejo[1], Navartil Oldrich[3], Frédéric Cherqui[5], José Bernado[1], Philippe Namour[4], Latifa Fakri-Bouchet[1,2].

1. Université de Lyon, Université Claude Bernard Lyon 1, Institut des Sciences Analytiques (ISA), UMR CNRS, 5280, 5 rue de la Doua, 69100, Villeurbanne, France.
2. Université de Lyon, INSA Lyon, Université Claude Bernard Lyon 1, 69621, Villeurbanne, France.
3. Université Lumière - Lyon 2 (Bâtiment Europe), 5, avenue Pierre Mendès-France, 69676 Bron cedex, France.
4. INRAE Lyon-Grenoble Auvergne-Rhône-Alpes, UR RiverLy 5, rue de la Doua, CS 20244, 69625 Villeurbanne Cedex, France
5. Université de Lyon, INSA-LYON, Université Claude Bernard Lyon 1, DEEP, F-69621, F-69622, Villeurbanne, France.

RÉSUMÉ

L'implication croissante des citoyens et des institutions dans le suivi, l'amélioration de la qualité de l'eau, stimule une forte demande de systèmes intelligents de surveillance des masses d'eau urbaines telles que les rivières, les eaux pluviales, les lacs et les eaux souterraines. La grande diversité de biocapteurs existants a apporté une multitude de solutions à cette demande. Cependant, les technologies de surveillance en continu, leur maintenance dans les installations déployées restent assez coûteuses, limitant ainsi leur nombre. De plus, avant d'obtenir un véritable outil de surveillance multi-physique performant et autonome, il reste, à l'heure actuelle, de nombreux verrous techniques et technologiques à lever. Dans ce travail, nous proposons deux solutions de plateformes multi-physiques de capteurs intelligents de surveillance à distance des masses d'eau. La première solution est constituée d'un assemblage de capteurs commerciaux bas coût (pH, conductivité électrique (EC) et turbidité). La seconde solution porte sur le développement d'une plateforme, basée sur des capteurs micro-ondes (Split Ring Resonator (CSRR) 0,2 GHz à 6,0 GHz). Cette plate-forme est dédiée non seulement à la mesure des mêmes grandeurs physiques précitées mais aussi à l'identification des substances détectées.

ABSTRACT

The current growing involvement of communities and institutions in the monitoring and improvement of water quality stimulates a strong and large demand for smart monitoring systems for urban water bodies such as rivers, storm water, lakes and groundwater. The great variety of existing biosensors has provided a multitude of solutions to this need. However, continuous monitoring technologies and their maintenance in deployed installations remain quite expensive, thus limiting their use. In addition, before obtaining a real powerful and autonomous multi-physical monitoring tool, there are currently many technical and technological obstacles to overcome. In this work, we propose two solutions of multi-physical platforms of smart sensors for remote monitoring of water bodies. The first solution consists of an assembly of low-cost commercial sensors (pH, electrical conductivity (EC) and turbidity). The second solution is to develop of a homemade platform, based on microwave sensors (Split Ring Resonator (CSRR) 0.2 GHz to 6.0 GHz). This platform not only is dedicated to the recording of same parametric values of the first solution, but also to identification of the detected substances by microwave spectroscopy.

MOTS CLES

Commercial sensors, Microwave sensing, Permittivity, Real-time, Water Quality Monitoring.

1 INTRODUCTION

The growing involvement of institutions interest in water monitoring and natural hazard management is stimulating for a large demand for smart water monitoring systems. However, the high cost of continuous water quantity and quality monitoring is still restricting. This also leads to low-quality data to study water bodies (WB) (such as rivers, urban storm water, lakes and groundwater). In addition, available monitoring stations are not close to the WB, therefore water samples are grabbed and analyzed in a nearby laboratory. Unfortunately, these results are not real-time based processing. For real-time processing, the use of expensive techniques is necessary. An alternative solution is the use of low-cost monitoring systems. However, they have some limitations too. The first technical constraint identified deals with the performance (high accuracy and reliability). Next, the ruggedness and durability in harsh environments is challenging (e.g. urban context, small streams/torrents, sediment transport and flooding monitoring). A simple, low-cost but effectively encapsulated probe design is needed to ensure their proper functioning in these harsh conditions. Thirdly, the power supply become also an extremely important issue. An optimized battery power system equipped with solar technology is highly desirable. Finally, most current systems are not real-time and/or Internet of Things (IoT) compatible, using wireless sensors and Internet systems are a step toward smarter cities. For this project, our goal is to design and assess an operational monitoring technology dedicated to water quality and natural hazard detection system based on open-source electronic prototyping platforms (Arduino, Raspberry) and low-cost sensors. The contribution of this project entails twofold. The first part deals with the approach of remote monitoring using a low cost sensor network. The second part consists in the use of a microwave/radiofrequency sensor solution for water multi-parametric monitoring (pH, turbidity, contamination, metal contamination and other parameters).

2 SYSTEM ARCHITECTURES AND METHODOLOGIES

The first proposed solution consist of a monitoring system composed of in sensor nodes; data loggers, wireless transmission devices and an acquisition system/ cloud as seen in Figure 1. Turbidity sensors have been evaluated on their ability to correctly measure the optical density of water in the presence or absence of sunlight. Data recording is done autonomously and remotely, with an optimal quality of service, thanks to a microcontroller-based development board (Arduino), homemade programs and low-power wide-area network (LPWAN) for communication (LoRaWAN). LoRaWan and the cloud services create the virtual link between sensor nodes and end-users. Thus a user via the cloud can remotely access the data from a sensor.

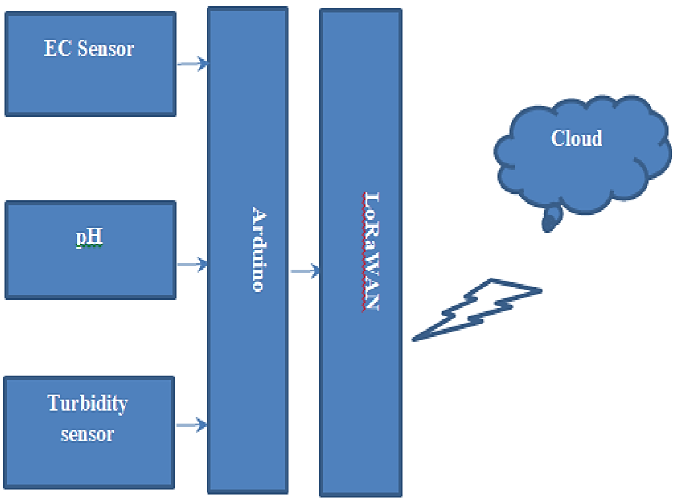

Fig 1. The block diagram of a water monitoring station

Figure 2 presents the description of the first system: the GPS shield provides the real-time location of the unit and the power supply connected to the solar panel allow the unit to be more autonomous. Figure 3 presents the experimental setup for the second system with the RF sensor (i.e. CSRR configuration).

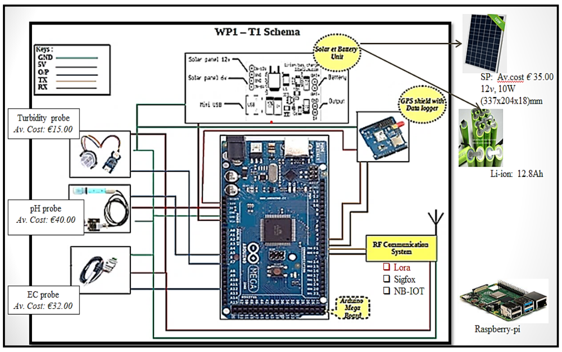

Fig 2. An example of the Water Monitoring Station showing different probing devices and components.

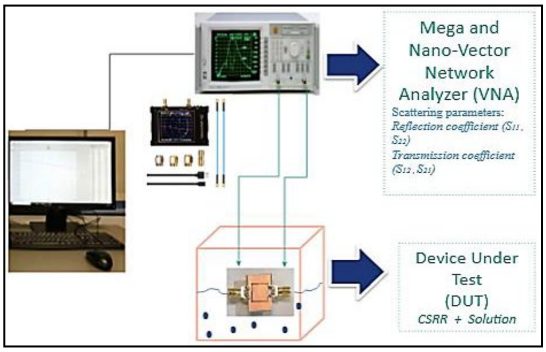

Fig 3. The experimental setup with a proposed RF sensor.

3 RESULTS

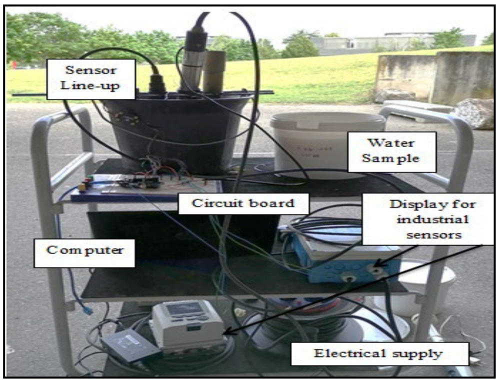

Fig 4. Mobile Lab Ambient light test and correction with SEN0189

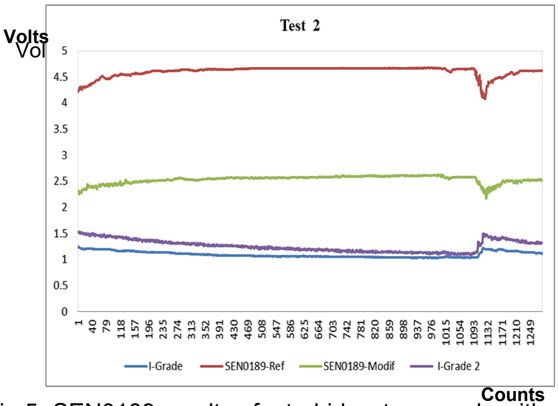

Fig 5. SEN0189 results of a turbid water sample with corrections code of the influence of ambient interferences.

The first tests were carried out at OMAEE Lyon 2. The Mobile Lab, Figure 4, was made up of four turbidity probes, two industrial grades and two SEN0189 (one modified while the other serves as a reference). These sensors were tested in turbid water samples mimicking river under the influence of sunlight. The response is as shown in Figure 5 with voltage plotted against the number of counts. The noise reported in our previous observation appears to have been rectified and the modified SEN0189 is now working in the detection window of turbidity-voltage calibration. This marks a starting point of success towards the conventional SEN0189 probe.

4 CONCLUSIONS AND PERSPECTIVES

The remote monitoring system designed to monitor the aquatic environment, by assembling commercial real-time sensors based on Arduino and data transfer via the LoRaWAN communication, costs less than 200 € HT in total with promising performances. However, there are some striking limitations poised on this system such as biofouling, interference by ambient light, longevity and their sensitivity does not yet equal the commercial sensor ones. We have proposed a solution which employs the use of a corrected SEN0189 probe to measure turbidity values of a water bodies however this might still bring into question its durability and portability. To improve these performances, we propose a novel technique via low-cost microwave detection without light interference. This solution also offers real-time detection, Arduino compatibility and multi-parametric observations. One of the points of limitation is the miniaturization of the required Vector Network Analyzer (VNA) device, which could hamper its deployment to a remote location on which we are continuing our research.

BIBLIOGRAPHY

1. Dai, Q., Shin, E. and Smith, C. (2018). Open and inclusive collaboration in science. OCDE, Paris, France, 29.
2. Yue, R. and Ying, T. (2011). A water quality monitoring system based on wireless sensor network & solar power supply. IEEE International Conference, 126-129.
3. Zhang, K., Amineh, R.K., Dong, Z. and Nadler, D. (2019). Microwave Sensing of Water Quality. IEEE Access, vol. 7, 69481-69493.