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Published in:
18th DWF Water Conference - 30th January 2024

Publication date:
2024

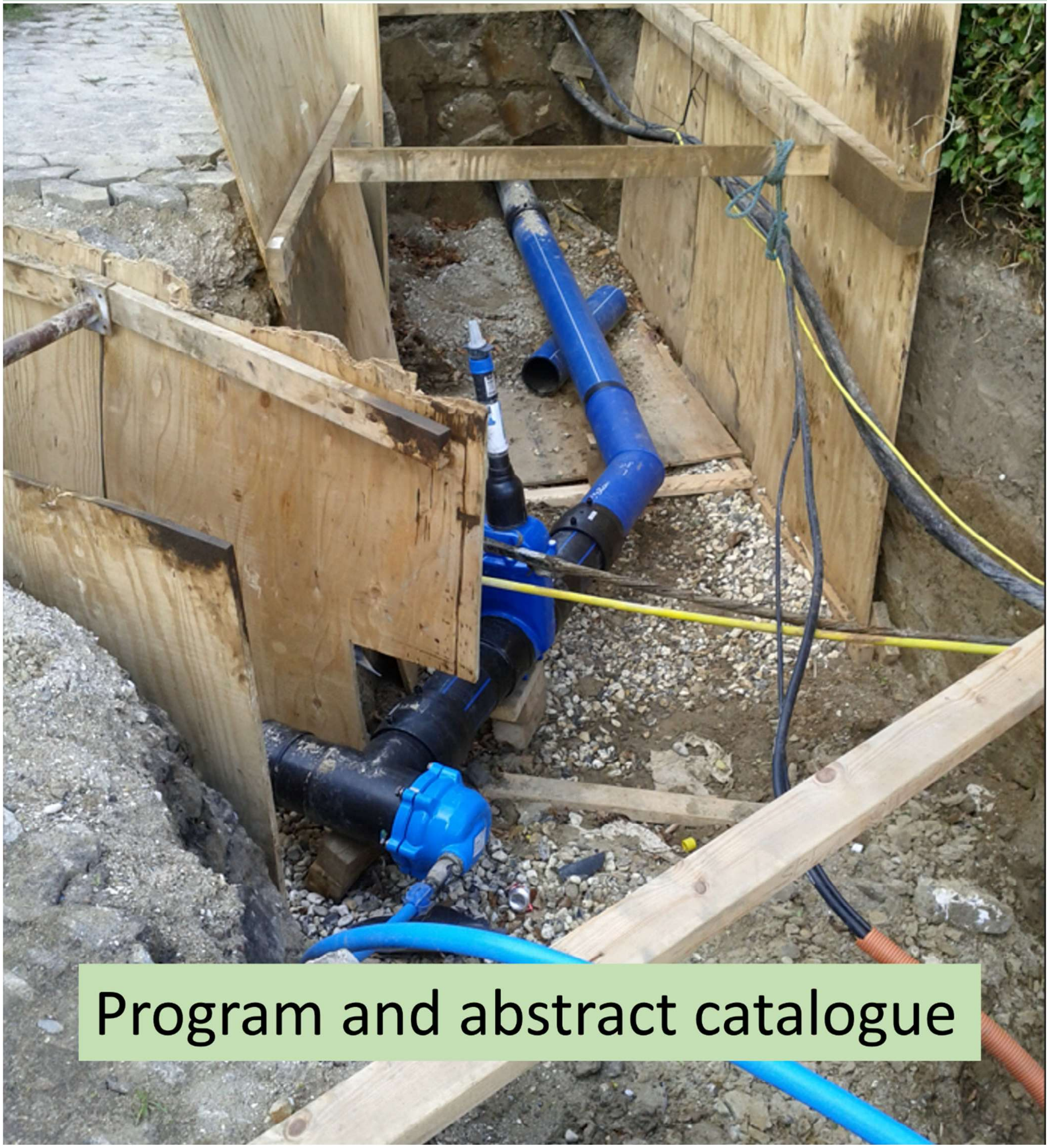
Document Version
Publisher's PDF, also known as Version of record

DWF
Danish Water Forum

WATER VALLEY
DENMARK

Venue:
Copenhagen University
Thorvaldsensvej 40
1871 Frederiksberg

18th DWF Water Research Conference – 30th January 2024



Program and abstract catalogue

Screening IoT sensing approaches to support real-time groundwater quality monitoring

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Introduction: Public authorities are currently looking for ways to acquire groundwater quality characterization to enable real-time data acquisition for more informative parameters beyond pH, conductivity and temperature. This monitoring network can provide a better understanding of the dynamics of pollution migration in highly polluted sites as well as enable faster identification and contingency actions in case of contamination incidents. So, the goal of this study is to provide a framework addressing the development of low-cost *in-situ* IoT-connected water monitoring stations. The main idea of the project is to combine optical and electrochemical processes with the Internet of Things approach to implement a low-cost remote real-time water monitoring system.

Methods and data: First of all, a literature review was carried out to select the potential methods for the detection of different groundwater parameters divided by groups. Scientific papers included in the review were obtained in the following scientific repositories: IEEE, ScienceDirect, Springer and Wiley. The target water quality parameters were divided in two groups: organic compounds (PAH, BTEX) and heavy metals. Based on the preliminary screening investigation of the methods, further studies were carried out to compare the different potential approaches and develop a framework for a IoT-connected system. For each one of the 2 aforementioned groups, a detection method or a combination was chosen. Then a framework defining the recommended measuring method for each group was defined. Based on that, the physical principles and the technical specifications of the sensors for each parameter were defined based on previous scientific studies. Finally, electronic systems were developed for each one of the measuring methods chosen in the previous steps. The proposed system was defined considering the following criteria: low-cost components, portability, cloud-based monitoring, off-grid power system and wireless communication.

Results: From the investigation 3 preliminary methods were selected: potentiometry, spectroscopy and voltammetry. The two latter approaches were preferred over the former. Spectroscopy based on fluorescence was preferred for organic compounds detection and differentiation and voltammetry was suggested for heavy metals quantification. Concerning voltammetry the study delves into the theory behind voltammetry, particularly cyclic voltammetry, square wave voltammetry, and stripping voltammetry in combination with new materials science technology to the development of screen printed electrodes to facilitate the portability and customization of specific detection of different heavy metals. The study outlines the importance of supporting electrolytes, and the modification of electrode surfaces for improved sensitivity as well as the critical role of the potentiostat in controlling potential and current measurements. For spectroscopy the combination of UV spectroscopy and fluorescence-based sensors could be an efficient way for the deployment of field portable testing of the aforementioned target compounds (BTEX, PAH) in groundwater wells.

Discussion and take-home message: The screening process provided insightful inputs that enabled the definition of the approaches to be followed for each target compound. Based on the framework and screening outcomes, the prototyping phase was initiated by designing and running preliminary testing to enable the implementation of spectroscopy and voltammetry-based probes for the detection of organic compounds and heavy metals, respectively. The research underscores the potential for these electrochemical and optical methods to revolutionize water quality monitoring due to their cost-effectiveness, speed, and ability to provide accurate measurements. It identifies the critical parameters affecting the analysis, such as scan rates and deposition times, and suggests the practical application of in environmental monitoring by local governmental bodies. Next steps will consist in establishing a portable system and testing it in real case studies by monitoring groundwater wells. In conclusion, the study advocates for the implementation of these methods in affordable and portable IoT-connected monitoring stations, enabling continuous, real-time monitoring of groundwater quality at various levels of government to ensure a sustainable and healthier ecosystem.

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