

# Low-Cost Environmental Monitoring System for Water Parameters Measurement in Mining

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## Extended Abstract

Mining activities pose various environmental risks that necessitate effective monitoring and mitigation strategies. This work presents a novel low-cost environmental monitoring system designed to support risk assessment and enable real-time control actions for mining and quarrying (M&Q) sites. The system is designed to offer an accessible and easily adaptable solution for monitoring water parameters, as part of a broader environmental framework that may include other receiving matrices such as air and soil. Telemetry allows for the remote, continuous monitoring of key water quality indicators, facilitating prompt control actions.

This study delineates the requisite components for implementing an online monitoring system for environmental parameters, such as pH, Turbidity, and Total Dissolved Solids (TDS), utilizing low-cost and commercially available hardware (e.g., Arduino and ESP32 boards). This affordable system enables measurements which, while lacking high precision, effectively allow for the observation of trend shifts, as well as the acquisition of real-time, semi-quantitative data to aid in undertaking the necessary actions to mitigate adverse environmental effects as soon as possible, reducing the need for high-cost instrumentation. The sensor network communication is established via the LoRa protocol, facilitating the wide-area deployment of sensor nodes around the mining operation.

The pH sensors were calibrated using standard buffer solutions (pH 4, 7, and 10). Due to the complexity of the measured variable, turbidity sensor calibration required a more intensive process; a HANNA HI93703 turbidimeter, calibrated with 0, 10, and 500 NTU standards, served as the reference. Final calibration was performed by comparison with the HI93703 using water samples from 'El Tomillar' gravel pit (Hormisoria). This work was conducted within the framework of the EU-funded project ROTATE [Grant Agreement ID: 101058651].

A prototype was engineered to acquire readings of pH, Turbidity, and Total Dissolved Solids (TDS) in waters near mining operations, utilizing a network based on Arduino MKR 1310 microcontrollers and LoRa communication. To mitigate data loss, measurements are also stored on microSD cards, given that many locations may lack a Wi-Fi network for cloud data upload. The estimated cost per sensing node is approximately €300 ( $\approx$  \$350). The study demonstrates the viability of developing and implementing a data acquisition and measurement system at a reasonable cost. Leveraging open-source code available in the cloud, as well as the code generation capabilities of AI tools, the prototype development does not require deep electronic knowledge. The derived measurements facilitate the real-time monitoring of water quality adjacent to the quarry and streamline decision-making for environmental variable control.

The prototype can be scaled to multipoint measurements, as well as to monitoring other environmental variables, such as Suspended Particulate Matter (SPM), using low-cost components. Furthermore, this can be implemented by the mining or industrial operation's own personnel, obviating the need for high-cost instrumentation.

**Keywords:** Mining-Influenced water, testing, acid mine drainage measure, data acquisition systems