Feasibility Study of an Integrated Field Deployable Multi-Parameter Sensor Subsystem for Real-Time Water Quality Monitoring in Aquatic Environments

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Conventional water quality monitoring in Sri Lanka relies on resource-intensive manual sampling with laboratory testing like spectrophotometric determination and Winkler titrations or expensive static probes. These methods fail to capture dynamic spatiotemporal fluctuations, especially vertical variations within stratified water columns. To address this, this study evaluates the feasibility, calibration reliability, and transmission stability of an integrated multi-parameter sensor architecture designed as the core data-acquisition unit for a remote-controlled (RC) surface craft. The framework consists of three interdependent subsystems: data acquisition, telemetry/processing, and cloud storage. The data acquisition unit houses electronic pH, temperature, and conductivity sensors, with salinity and total dissolved solids (TDS) derived via calibrated algorithms. Managed by a NodeMCU microcontroller, the device captures raw metrics upon operator trigger and appends GPS coordinates. The dataset is instantly transmitted in structured JSON format over HTTPS to a Firebase Realtime Database for web dashboard display and automated Google Sheets synchronization. Crucially, these gathered datasets feed geospatial tools to develop 3D models, enabling the identification of hidden vertical pollution hotspots invisible to conventional horizontal monitoring. To validate performance and eliminate electrical crosstalk before full-vessel integration, field and controlled trials sequentially analyzed identical water samples using both the developed kit and a laboratory-grade YSI analyzer. In controlled testing (tap water), the subsystem achieved mean accuracies of 99.89% (temperature), 98.71% (pH), 98.54% (conductivity), 98.23% (TDS), and 97.76% (salinity). Under variable field conditions (pond water), accuracies were 99.82%, 96.45%, 93.12%, 91.08%, and 89.41%, respectively, establishing a dependable validation range of 89.41% to 99.89%. The results confirm that software calibration and hardware signal isolation effectively eliminated mutual probe electrical interference, while the telemetry subsystem achieved stable data streaming with zero packet loss. This validation confirms the feasibility of the integrated subsystems and establishes a deployment-ready data flow for imminent integration into an RC surface platform for high-resolution spatial water quality mapping.

Keywords: *Data acquisition subsystem, Firebase Realtime Database*, *Water quality monitoring, Telemetry subsystem*