

Development of an IoT-Based Water Quality Monitoring and Automatic Water Replacement System for Betta Fish Aquariums

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ABSTRACT

Maintaining stable water quality in small Betta splendens aquaria is challenging, due to pH, temperature, dissolved solids, and turbidity can gradually change and often go unnoticed until fish exhibit stress. To address this, BETTANK was developed automatic IoT-based water quality monitoring and partial water replacement system. The prototype integrates an ESP32 microcontroller, sensors for pH, temperature, TDS, turbidity, and water level, relay-controlled pumps, a Firebase Realtime Database, and a Flutter mobile application. When monitored parameters exceed predefined thresholds, BETTANK performs a systematic partial water replacement cycle while logging the events to the cloud.

The system underwent through variety of evaluation, through sensor calibration, functional testing, live demonstrations, fish observation, as well as a usability survey and comparative analysis. All 15 functional test cases and 7 live demonstration scenarios passed successfully, and the cloud logs confirmed correct operation of the automatic water replacement feature. The usability survey yielded an overall mean score of 4.05/5 from 24 participants. BETTANK demonstrates an effective and accessible approach for real-time monitoring and pH-informed automatic water replacement, that integrate IoT hardware, cloud integration, and mobile application support to enhance the maintenance of Betta aquariums.

Keywords: *IoT, Betta splendens, water quality monitoring, automatic water replacement, ESP32, Firebase, Flutter*