DETERMINING THE WATER QUALITY OF NILE FISH POND USING THE IOT-BASED FUZZY LOGIC METHOD

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ABSTRACT

Water quality in fish ponds is a critical factor in the cultivation of Nile tilapia (Oreochromis niloticus), as parameters outside the optimal range—such as unsuitable pH, high turbidity, or non-ideal temperatures—can cause stress, reduce growth rates, increase susceptibility to diseases, and even result in mass mortality. In practice, many fish farmers still rely on manual monitoring or visual observation, which is prone to errors, inefficient, and less accurate in detecting rapid changes in water quality. This study aims to design and develop an Internet of Things (IoT)-based water quality monitoring system for Nile tilapia ponds using the Mamdani fuzzy logic method to classify water conditions in real time. The system employs an ESP32 microcontroller connected to three main sensors: a pH sensor, a turbidity sensor, and a temperature sensor. The collected data are transmitted to a Firebase database and displayed through a web-based interface. pH is categorized into acidic, neutral, and alkaline; turbidity into clear, slightly turbid, and turbid; while temperature is classified into cold, normal, and hot. The measurements are processed using a fuzzy rule base to generate linguistic outputs of "Excellent," "Moderate," or "Poor" according to the water quality standards for Nile tilapia. The testing phase consisted of two stages: sensor calibration using standard solutions and reference measuring instruments, and field testing in five fish ponds owned by a single farmer, consisting of both earthen and tarpaulin ponds with flowing water systems. Calibration results showed average measurement errors of ±1.0% for pH, ±0.3% for turbidity, and ±1.5% for temperature, all within acceptable tolerance limits. Field tests demonstrated that the system could consistently classify water quality in accordance with actual conditions, with very low data transmission delay. The farmer's feedback indicated that the system significantly facilitates fast and accurate water quality monitoring, showing strong potential for wider implementation to enhance the productivity and efficiency of Nile tilapia farming.

Keywords: *Pond Water Quality, Nile Tilapia (*Oreochromis niloticus*), Internet of Things, Mamdani Fuzzy Logic, ESP32, pH Sensor, Turbidity Sensor, Temperature Sensor*.