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AUTOMATED CATFISH FEEDING AND WATER QUALITY MONITORING SYSTEM USING THE ARDUINO

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ABSTRACT

The Arduino-based aquaponics automation control system for catfish farming is designed to optimize catfish rearing in urban environments by using various sensors and automation components. This system utilizes a pH sensor, temperature sensor, and TDS sensor to monitor water quality in real-time, as well as an ultrasonic sensor to measure the water level in the pool. Data from these sensors is used to regulate and control the water pump system, which functions as a means of recirculating water to keep it clean and maintain its quality. With the results, the TDS sensor value has a range of 327.75 – 325.22 ppm. The pH sensor value has a range of 7.09 – 7.05. The temperature sensor value has a range of 29.94 – 30.00 °C. The value of the ultrasonic sensor by measuring the water level of the fish pond with a value obtained is 28 cm. Apart from that, this system is equipped with a servo motor which is used to feed the fish automatically, ensuring that the fish get food on time, feeding once a day at 17:00 WIB with a total feed output of 188 gr for 5 seconds with the servo angle being 90°. All data generated from these sensors is stored in a structured manner in memory for long-term analysis and monitoring purposes. Implementation of this control system shows effective results in raising catfish in urban settlements. With automation and continuous monitoring, this system not only simplifies aquaponics management but also increases efficiency and sustainability in dense urban environments. This system offers a practical and innovative solution to the problem of maintaining aquaponics in limited areas, as well as contributing to the development of sustainable urban farming technology

Keywords: Aquaponics, TDS Sensor, pH Sensor, Temperature Sensor.

INTRODUCTION

Driven by rapid population growth and pervasive urbanization, the challenge of securing food supplies in metropolitan areas has become increasingly critical. Severe spatial constraints in urban sectors preclude the effective implementation of traditional agricultural practices. To mitigate this issue, advanced urban farming technologies, most notably aquaponics, have emerged as viable solutions. Aquaponics represents an integrated cultivation framework that combines aquaculture (fish farming) with hydroponics (soilless plant cultivation), thereby establishing a symbiotic ecosystem where both biological components mutually sustain one another.

Aquaponics integrates two primary subsystems: aquaculture and hydroponics. Within this framework, metabolic waste produced by the fish is biochemically decomposed by nitrifying bacteria into essential nutrients required for plant growth (Sastro, 2015). This mechanism establishes a highly efficient nutrient cycle, thereby minimizing environmental discharge and optimizing water conservation. The fundamental operation of aquaponics relies on a closed-loop water recirculation system, wherein water from the aquaculture tank is continuously driven into the hydroponic growth medium for biofiltration before being routed back to the fish environment (Sari, 2014). Consequently, this continuous cycle significantly mitigates water consumption and prevents the effluent pollution typically associated with conventional aquaculture systems.

Water quality constitutes a critical determinant of success in aquaponic systems. Physico-chemical parameters—including water temperature, pH, salinity, dissolved oxygen (DO), and the concentrations of ammonia, nitrite, and nitrate—must be continuously monitored and maintained within optimal thresholds to ensure the mutual vitality of both fish and plants (Boyd & Pillai, 1984). Fluctuations or imbalances in these water quality parameters can adversely affect aquatic health and crop yield, ultimately leading to systemic failure of the aquaponic ecosystem.

To mitigate these challenges, a real-time monitoring and control system capable of regulating critical water quality parameters is highly imperative. Automation technology driven by sensors and microcontrollers plays a pivotal role in enhancing the operational efficiency and efficacy of aquaponic frameworks. Therefore, this study aims to design and develop an automated closed-loop recirculation control system utilizing an Arduino Uno R3 as the central processing unit. The proposed system integrates a pH sensor for acidity monitoring, a Total Dissolved Solids (TDS) sensor to evaluate nutrient concentrations, a temperature sensor to track thermal fluctuations, and an ultrasonic sensor to quantify water and feed levels.

This research is anticipated to yield a significant contribution to the advancement of highly efficient and sustainable aquaponic systems, particularly within the framework of urban agriculture constrained by limited spatial resources.

RESEARCH METHOD

Research Desaign

This study aims to design and evaluate an automated closed-loop recirculation system for aquaponics, utilizing an Arduino Uno as the central microcontroller. The architecture integrates a multi-sensor array to facilitate real-time monitoring of critical water quality parameters. The research methodology encompasses hardware and software co-design, empirical measurements utilizing pH, temperature, and ultrasonic sensors, and subsequent statistical or quantitative analysis of the acquired datasets.

System Components

The Arduino Uno serves as the central microcontroller unit (MCU) to process incoming sensor telemetry and regulate the automated control loops. To monitor chemical stability, a pH sensor is integrated into the architecture to measure water acidity; the acquired data are subsequently processed by the MCU to actuate corrections and maintain the potential of hydrogen within a stable, optimal range. Concurrently, a temperature sensor is deployed to monitor thermal fluctuations within the aquaponic ecosystem. This continuous thermal tracking ensures that the water temperature is maintained within thresholds conducive to the physiological requirements of both the aquaculture and hydroponic components.

RESULT AND DISCUSSION

TDS Sensor Testing

The purpose of testing the Total Dissolved Solids (TDS) sensor is to assess the sensor’s performance and accuracy in measuring the concentration of dissolved solids or particles in fish pond water, as well as to evaluate the sensor's response to various concentration levels of dissolved substances. This testing is important to ensure that the sensor can provide accurate and consistent data, which is essential for monitoring fish pond water quality. Additionally, evaluating the sensor's response to various levels of dissolved substance concentration helps identify its ability to handle varying water conditions and provides insight into the sensor's reliability and sensitivity in practical applications.

Table 1. TDS Sensor Test Results

Number	TDS Sensor Reading (ppm)	Standard Unit (ppm)	Error Value
1.	327,75	326	0,53
2.	326,86	326	0,26
3.	326,14	326	0,04
4.	325,14	326	0,26
5.	325,22	326	0,23

Laboratory calibration of the TDS sensor was performed by benchmarking its performance against a certified standard reference TDS meter. The reference device consistently yielded a value of 326 ppm, whereas the sensor under evaluation recorded readings ranging from 325.22 to 327.75 ppm. Although minor deviations from the standard reference value were observed, the discrepancies were minimal. These findings suggest that the sensor maintains sufficient precision and operates within acceptable accuracy tolerance limits for the intended application.

Temperature Sensor Testing

The results of the temperature sensor calibration tests conducted at various sensor voltages are shown in the table below

Table 2. Temperature Sensor Test Results

Number	Nilai Sensor (℃)	Sensor Value (℃)	Error
1.	29,94	30,1	0,33
2.	30,00	30,1	0,33
3.	30,00	30,00	0
4.	30,00	30,00	0
5.	30,00	30,00	0,2

Temperature sensor calibration testing was conducted in the laboratory. The test results showed an increase in sensor readings, as shown in Table 2. The sensor voltage readings ranged from 29.94 to 30.00, while the standard device's readings ranged from 30.1 to 30.00. The test results for the voltage values produced by the sensor indicate that the voltage of the temperature sensor is relatively low and close to the cold end of the scale.

The calculated % deviation, with a temperature sensor value of 30.00 and a standard device value of 30.1, is 0.33% according to the % deviation formula.

pH Sensor Testing

The results of the calibration test for the 4502C pH sensor using a pH meter, conducted at the sensor's operating voltage, are shown in Table 3 below.

Table 3. Results of Water pH Sensor Testing

Number	pH meter	Standard Tools	Error
1.	7,09	7,3	2,96
2.	7,09	7,3	2,96
3.	7,08	7,2	1,69
4.	7,03	7,2	2,41
5.	7,05	7,2	2,12

Calibration testing of the water pH sensor using a pH meter was conducted in the laboratory. The test results showed a decrease in the sensor's reading as the sensor value dropped, as shown in Table 4.2. The output voltage measured ranged from 7.09 to 7.05, compared to the standard instrument's range of 7.3 to 7.2. The test results for the output voltage produced by the sensor indicate that the voltage is at the neutral pH level.

The percentage deviation between the sensor value of 7.09 and the standard instrument value of 7.3 is 2.96%.

Ultrasonic Sensor Testing

Calibration results of the ultrasonic sensor using a measuring tape to test the ultrasonic sensors located in fish ponds, biopores, and infiltration wells. The results show that the fish pond has a depth of 50 cm, the infiltration well has a depth of 100 cm, and the biopore has a depth of 50 cm. Table 4 shows that the reference instrument reading remained at 29 cm, while the sensor reading was 28 cm. This can be seen in Table 4 below.

Table 4. Results of ultrasonic sensor testing in a fish pond.

Number.	Sensor Value (cm)	Standard Measurements (cm)	Error Value
1.	28	29	3,57
2.	28	29	3,57
3.	28	29	3,57
4.	28	29	3,57
5.	28	29	3,57

The results of the ultrasonic sensor measurements in the pool, with a sensor reading of 28 and a standard instrument reading of 29, show a percentage deviation of 3.57%.

Discussion

The research results show that the TDS sensor readings varied but remained consistent, with an average value of approximately 326, indicating that the pond water conditions were stable and safe for the fish. The pH sensor recorded an average value of approximately 7.07, which falls within the normal range and is safe for the aquatic environment. The temperature sensor showed high consistency with an average value of 30.00°C, in line with the reference value and safe for fish metabolism. Testing of the ultrasonic sensor in the fish pond showed stable results, with a small deviation between the sensor value and the reference value. The automatic fish feeding system functioned properly, dispensing 188 grams of feed over 5 seconds. Sensor data is read by the LCD and stored in memory.

CONCLUSION AND SUGGESTION

According to research, a system designed for fish farming in urban settlements has demonstrated high effectiveness in automating and monitoring aquaponics. This system integrates various electronic components and sensors, such as servo motors for automatic feeding, pH, temperature, and TDS sensors, and ultrasonic sensors to monitor water conditions, as well as pumps for water circulation. Powered by solar panels, this system ensures sustainable operation, with sensor data displayed on an LCD screen and stored on a microSD card. As a result, this system simplifies aquaponics management without requiring direct supervision, while also making optimal use of limited land.

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