

***Internet of Things (IoT) for Nutrient Monitoring and Control System in Hydroponic Lettuce***

*Supervised by Intan Sulistyaningrum Sakkinah, S.Pd., M.Eng.*

**Ari Abdul Aziz**  
**Departement Of Informatics Engineering**  
*Faculty Of Information Technology*

**ABSTRACT**

*This study aims to design and develop an automated Internet of Things (IoT)-based system for monitoring and controlling the balance of nutrient levels (TDS) and pH in hydroponic lettuce cultivated using the Nutrient Film Technique (NFT). The system is developed using an ESP32 microcontroller integrated with a pH-4502C sensor, a TDS Meter VI.0 sensor, and actuator modules. Automated decision-making is executed by implementing a forward chaining expert system algorithm that classifies data based on the growth phases of lettuce. Sensor data and pump statuses are transmitted in real-time to the Firebase cloud database and displayed through a mobile application. The Mean Absolute Error (MAE) testing results indicate an error value of 0.08 for the pH sensor and 14.72 PPM for the TDS sensor. Although computational logic testing achieved 100% accuracy across 24 rule bases, the 72-hour operational stress test revealed several physical limitations in the field. These limitations include overshoot effects requiring a 30-second diffusion tolerance delay, and an approximate 10-second sensor response delay due to nutrient residue accumulation, which forced the system to trigger a fail-safe actuator deactivation mechanism. Furthermore, the mobile application's performance proved highly dependent on local internet network stability, which can cause loading delays during data synchronization. This system serves as a functional prototype for automated nutrient management, although its operational continuity strictly requires periodic physical sensor maintenance and a stable network environment.*

**Keywords:** *Internet of Things, Hydroponics, Lettuce, Forward Chaining, Mobile Application.*