NSIEX+RS 2025
NEGERI SEMBILAN INTERNATIONAL EXPOSITION

HARMONY IN PROGRESS:

INTEGRATING SCIENCE, TECHNOLOGY, AND SOCIAL INNOVATION FOR SUSTAINABLE DEVELOPMENT GOALS

e-Book of Extended Abstract
Negeri Sembilan International (NSIEx) & Research Symposium
2025

YST005 - GRAVI-WICK: A PASSIVE, ELECTRICITY-FREE AND LOW-COST DRIP IRRIGATION SYSTEM FOR OPTIMAL SOIL HYDRATION

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ABSTRACT

Maintaining optimal soil conditions is crucial for increasing agricultural productivity, particularly in areas with limited water resources. This study presents the development and implementation of a real-time soil monitoring system utilizing multimeter devices deployed across multiple farm areas. Each device measures key soil parameters: moisture, pH, temperature, electrical conductivity, and flow rate. The collected data is transmitted via the internet to a cloud server where it is stored, processed, and analyzed. The system calculates a soil readiness score based on the sensor readings, which is visualized through a user-friendly web interface for farmers and administrators. The study data demonstrates the system's ability to track spatial and temporal variations in soil conditions, offering valuable insights into land suitability and irrigation efficiency. By integrating real-time environmental sensing with cloud-based analytics, the platform supports data-driven agricultural decision-making, contributing to smarter irrigation practices and improved land management strategies.

Keywords – Low-Cost Irrigation System, Precision Agriculture, Smart farming

INTRODUCTION

Indonesia is home to over 17 million smallholder farmers, many of whom work in remote rural areas with limited access, especially to modern irrigation infrastructure (Badan Pusat Statistik [BPS], 2022). Traditional irrigation methods, such as surface irrigation and manual watering are still widely used, which are not only inefficient but also labor-intensive and unsustainable in water-scarce areas. A major obstacle for these farmers is the lack of access to electricity or affordable irrigation pumps, particularly in outer islands and highland areas. According to the Indonesian Ministry of Energy and Mineral Resources, approximately 10,000 rural villages still experience limited or even unstable access to electricity (Kementerian ESDM, 2021). Therefore, there is an urgent need for a simple, low-cost, and energy-efficient solution that can support sustainable agricultural practices and ensure consistent soil moisture for plant growth. To address this issue, we introduced the GRAVI-WICK system. This concept utilizes gravity and capillary action to keep the soil well-watered. The system is very affordable and does not require complex electronic equipment. GRAVI-WICK can be used by smallholder farmers in areas with little attention.

The system works by slowly and consistently dripping water directly to the roots without the need for electronic components. This system helps reduce water waste and the amount of work required, even in challenging climates. Its design is perfectly matched with the right technology and agricultural intelligence, making it highly beneficial for addressing Indonesia's dry climate and water challenges.

OBJECTIVE

The objective of this invention is to create a low-cost passive drip irrigation system that can be used without the need for electricity or mechanical pumps. This system is suitable for agricultural land in rural and remote areas of Indonesia. Furthermore, this invention aims to create an irrigation device that is easy to use, scalable, and user-friendly. This device can be used by small farmers with simple equipment and is also easy to maintain.

DESCRIPTION OF THE PROJECT

This project successfully combines two complementary innovations: a gravity-based drip irrigation mechanism and an IoT-based soil monitoring system. This irrigation system operates passively, utilizing gravity and absorbent cotton fabric to regulate water flow without electronic automation (see Figure 1).

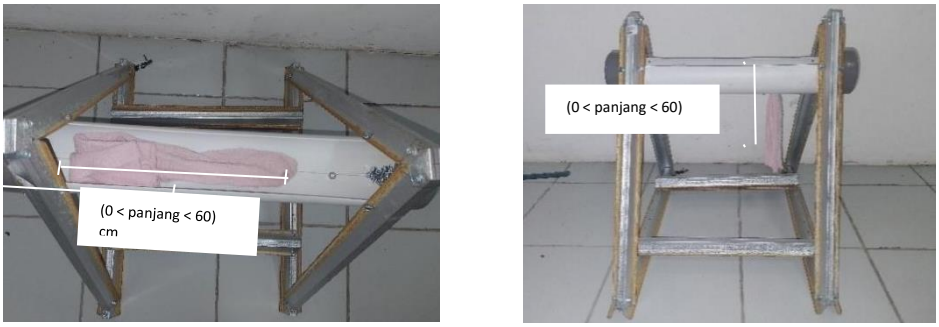

Figure 1. Concept of tools (instruments)

By adjusting the media ratio (MR) which is the proportion of fabric length hanging outside the pipe compared to inside, we observed that a lower MR (≤ 25%) with a 150 mm hanging segment resulted in a more stable flow rate.

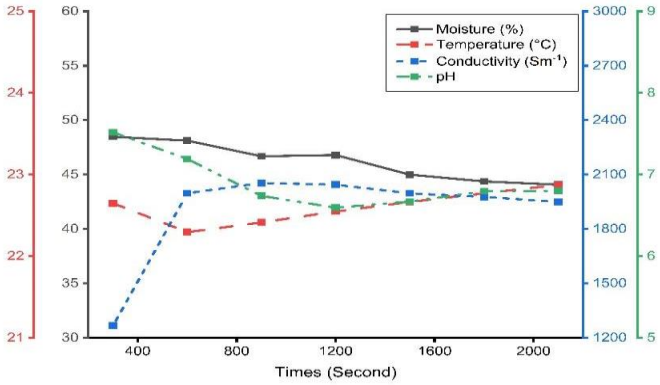

Figure 2. Data from an IoT-based multimeter

Complementing this, an IoT sensor network collects soil data every 10 seconds, including moisture, pH, temperature, conductivity, and water flow, and then processes this information in real time through a cloud-based platform.

Figure 3. IoT workflow

Together, these systems offer a sustainable and low-cost solution for efficient irrigation management, particularly in resource-constrained environments, supporting precision agriculture and environmental stewardship.

NOVELTY

The GRAVI-WICK system offers several key innovations and new contributions to sustainable irrigation:

a. It is electricity-free.
b. Its components are very affordable and readily available.
c. It can be installed on a variety of terrains and soil contours.
d. Its simple design means it requires no special skills and can be operated even by elderly farmers.

CONCLUSION

Ensuring optimal soil conditions is crucial for improving agricultural productivity, particularly in areas with limited water resources. This study presents the development and implementation of a real-time soil monitoring system that utilizes a network of multimeter devices distributed across multiple farm plots. Each device is designed to measure several soil parameters: moisture, pH, temperature, electrical conductivity, and drip rate per unit time (flow rate). The collected data is transmitted via the internet to a centralized cloud server, where it is stored, processed, and analyzed. The system calculates a dynamic soil readiness score based on sensor readings, which is visualized through a user-friendly web interface for farmers and administrators. By integrating real-

time environmental sensing with cloud-based analytics, the platform supports data-driven agricultural decision-making, contributing to smarter irrigation practices and improved land management strategies.

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