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PRECISION FARMING THROUGH IOT: MONITORING HEAVY METALS IN WATER

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Abstract—**IoT to monitor heavy metal concentrations in irrigation water, crucial for precision agriculture. Low-cost sensors detect heavy metals concentration, connecting to an IoT network for real-time data collection and transmission to the Blynk application. The system provides immediate insights into heavy metal levels, serving as an early warning to prevent crop and soil damage. The proposed model, developed using the NodeMcu8266 and screen-printed electrode strip, includes an LCD display, buzzer for alerts, and Blynk application for sending alert messages and displaying current, voltage, slope, and concentration data on the dashboard.**

Index Terms—**IoT, Heavy metal concentrations, Precision agriculture, Low-cost sensors.**

I. INTRODUCTION

In order to meet the growing need for food, modern agriculture needs to be efficient and precise. For the safety and health of crops, This study proposes a real-time monitoring system for heavy metal levels in irrigation water using the Internet of Things. Unbalanced pesticide mixes, excessive fertiliser use, and manufacturing waste are some few ways that agricultural areas may become contaminated with heavy metals. While old methods are tedious and manual, IoT technology offers quick responses and continuous monitoring. This innovation quality agricultural products while also enhancing water management and minimising environmental effect.

A. Objectives

Three main goals are the focus of the planned effort. Establishing monitoring apparatus that is capable of identifying and quantify the levels of heavy metals in water is the first step. Secondly, to make it possible for farmers to get instant alerts when heavy metal levels go above a set threshold via email, Blynk notifications, and buzzer alarms. This will make it possible to take quick corrective action and guarantee the protection of the crop and lands. The use of IOT technology to guarantee automatic and ongoing data collecting. Timely analysis will be facilitated by this ongoing monitoring.

II. RELATED WORKS

The related works aims to identify trends and challenges in project. It explores methodologies and theories to ensure informed decision-making, establishing the foundation for a successful system.

Zhenqing Li,Debao Xu et al. focuses on a portable, affordably priced device that provides on-site monitoring for the poisoning of heavy metals through differential pulse voltage technology. Using a disposable plastic pipette chip, the six-electrode sensor showed low detection and quantification limits for Pb, Hg, and Cu, along with high sensitivity and specificity. the construction of an instrument, which was verified by examining industrial effluent and sources of rainfall [1].

Madhu Biyani, adhika Biyani et al. created a low-cost DEP sensor platform with a MiniStat100 potentiostat that is managed by KME (Korea Meditec) software for on-site trace detection of heavy metals (copper, mercury, lead, and cadmium) [2].

Dhal, Sambandh Bhusan et al. proposed a low-cost, real-time smart sensing and actuation system to control heavy metal concentrations in aquaponic solutions. The system senses nutrient concentrations (calcium, sulfate, phosphate) and

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provides information to an Android app's built-in machine learning model. Algorithm 1 in the app performs spectrophotometer analysis to ascertain the calibration probe data to determine the concentration of unknown test samples. The hydroponic system maintains optimal nutrient levels through a feedback loop, enhancing productivity [3].

A.A. Dalvi and S. A. Bhalerao et al.outlined one global environmental problem that affects civilization.The economy, and agriculture is heavy metal contamination. Plants use defence systems such as metal detoxification pathways, mycorrhizal connections, and root exudates to counteract toxicity [4].

G. Wang, D. Sun et al. Dopamine hydrochloride, maleic acid, and In the investigation, optical devices were employed to create sensors. Commercial fibre was heated and stretched to produce a microfiber sensor that is tapered using a specially designed 3D-printed mould. When coated with nPDA MA, which is predicated on the ideas of a Mach-Zehnder interferometer, the sensor is extremely sensitive to changes in refractive index and possesses enhanced heavy metal ion detection selectivity [5].

J. R. Crespo, S. R. Elliott et al. was to develop and evaluate an inexpensive, basic Arduino potentiostat for conducting electrochemical measurements such as potential step voltammetry and cyclic voltammetry. The system utilizes a serial

USB interface to enable real-time gathering and modifying data which is then displayed and saved using open-source processing software [6].

Ruiyu Ding, Yi Heng Cheong et al. focus on voltammetry and potentiometry using microfluidic sampling systems. Pre treating paper with primary ions helps alleviate issues such as higher detection limits and super-nernstian responses en countered with ion-selective and reference electrodes on paper substrates in potentiometry. Voltammetry examines paper's interaction with sample ions and methods to enhance stripping currents using paper electrodes and capillary forces for sample transport [7]

III. PROPOSED SYSTEM

The sculpture is divided into several interconnected sections designed for precise control and observation. An electrode strip sensor with screen printing in its centre is in charge of signal detection. The microcontroller NodeMCU8266 then receives these signals. Wi-Fi connectivity makes it possible for the NodeMCU8266 to send the information acquired to the Blynk programme. This programme is used to transmit warning notifications as well as represent data.

A. System Setup

This model setup consists of NodeMcu8266,screen printed electrode connector,screen printed electrode strip,LCD display , buzzer and test sample show in the Figure 1

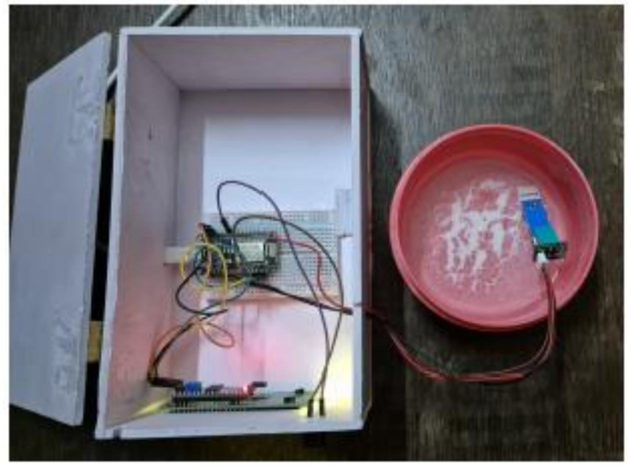

Fig. 1. NodeMCU8266 and SPE connector (Screen Printed Electrode connector) make up the model setup

- NodeMCU ESP8266 Microcontroller: synchronises the gathering and processing of data.
- Screen Printed Electrode connector: linked to the strip, sending conduction data to the NodeMcu8266
- Screen Printed Electrode strip: conduction while using the electrode on the test sample.
- LCD display: show the voltage and concentration • Buzzer: triggered when concentration surpasses the threshold.

B. Circuit Diagram

The circuit schematic shows how a buzzer, an LCD display, and a screen printed electrode connector are connected to a microcontroller NodeMcu8266. The NodeMcu8266 is linked to the screen printed via A0 to the working electrode (WE), GND to the conducting electrode (CE), and 3.3 volts to the reference electrode (RE).with information shown on the LCD, and the SDA and SCL connections, as well as the Vcc and ground connections to NodeMcu8266, indicate that the microcontroller is communicating with the LCD via I2C.Buzzer connected ground and D3 of the NodeMcu8266.As seen in Figure 2

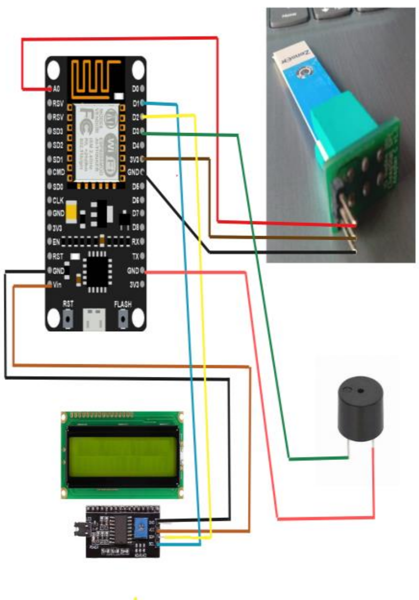

Fig. 2. Circuit Diagram of the Model

C. Limitations

Sensor can be cross-sensitive to several heavy metals, with variable ranges and susceptibility to environmental interference, posing calibration challenges. Sensor drift and limited dynamic range further affect accuracy, alongside potential issues with internet connectivity.

IV. METHODOLOGY

Several crucial processes are Participating in the IoT-based system's methodology for real-time heavy metal monitoring in irrigation water. Screen-printed electrode strips with the ability to identify the concentration of heavy metals are installed and linked to microcontrollers, like the NodeMCU8266, which process and send data to a cloud platform application called Blynk over WiFi show in the Figure 3. The system gathers and analyses data continually. When dangerous amounts are found, predefined thresholds cause alerts to be sent via email, the Blynk web application, and a buzzer. Farmers may easily monitor their data by using the Blynk programme, which processes and visualises data. To guarantee dependability, precision, and scalability for wider applications and improve water quality management in precision agriculture, the model is put through a rigorous testing process in a variety of agricultural situations.

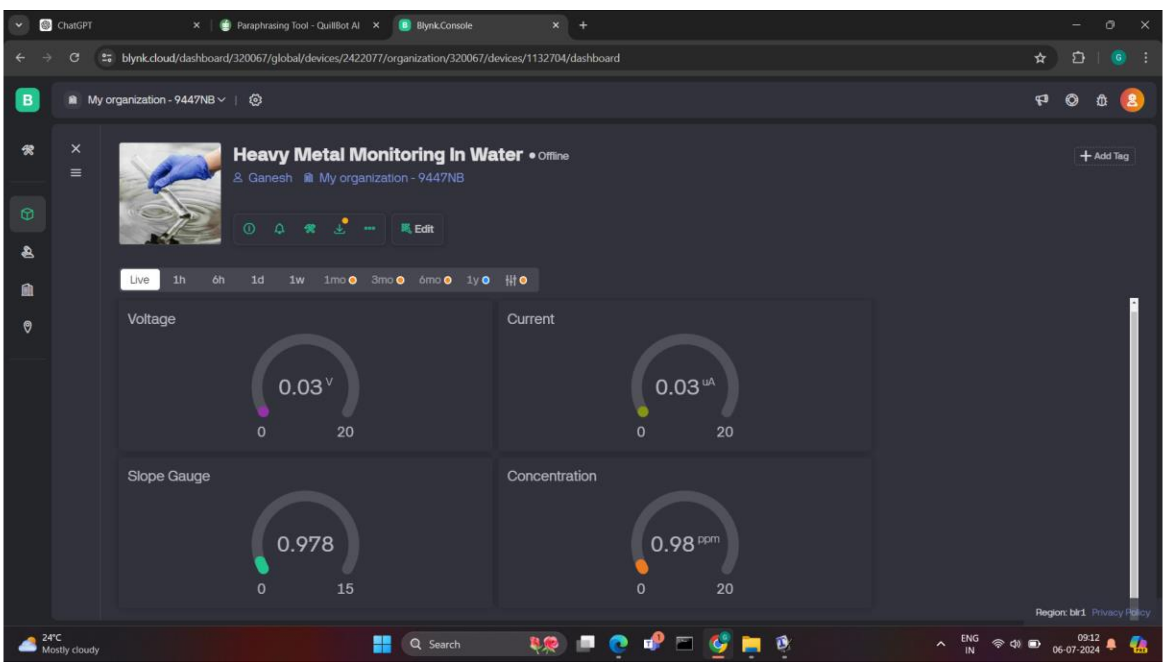

Fig. 3. Blynk Web Application

V. RESULTS AND CONCLUSION

TABLE I
MODEL TEST RESULTS

Important Parameters	Results		
	Criteria	Expected Result	Outcome
Blynk Appli cation	Wi-Fi connected	Display and monitor the voltage, current, slope, and concentration in online	Display and monitor the voltage, current, slope, and concentration in online
	Wi-Fi not connected	display the offline	display the offline
Normal water test	screen printed electrode strip in water	Display the focus on the LCD screen; it's roughly less than 3 ppm.	Display the focus on the LCD screen; it's roughly less than 3 ppm.
	screen printed electrode strip not in water	Display the fo cus on the LCD screen; it's zero	Display the fo cus on the LCD screen; it's zero
Sample water test	screen printed electrode strip in known concentration water	Display the focus on the LCD screen; it's roughly greater than 3 ppm to 9.50 ppm.	Display the focus on the LCD screen; it's roughly greater than 3 ppm to 9.50 ppm.
	screen printed electrode strip not in water	Display the fo cus on the LCD screen; it's zero	Display the fo cus on the LCD screen; it's zero

This implemented model for monitoring heavy metal concentrations in irrigation water demonstrated reliable performance. It successfully displayed real-time data through the Blynk application when connected to Wi-Fi and continued local monitoring offline. Email alerts effectively informed users of threshold breaches without false positives. Normal water tests showed approximatly low-level readings (below 3ppm) and zero concentration without the strip in water. Sample water tests confirmed readings between 3 ppm and 9.50 ppm, with consistent zero readings when the strip was not in water. Show in the Table I. These results validate the system's efficacy in detecting and reporting heavy metal concentrations, ensuring the safety and health of crops.

This project concluded that the developed IoT-based system offers a robust solution for real-time heavy metal monitoring in irrigation water. By integrating low-cost sensors, NodeMCU8266 microcontroller, and the Blynk application, it provides efficient data collection, real-time analysis, and timely alerts. The system enhances water quality management in precision farming, enabling early detection and prevention of soil and crop contamination. Its reliable performance and accurate sensor readings ensure timely corrective actions, minimizing environmental impact. This scalable system represents a significant advancement in precision agriculture, promoting sustainable practices and ensuring the production of quality agricultural products.

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