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ADVANCED WATER QUALITY MONITORING SYSTEM FOR POND MANAGEMENT AND ENVIRONMENTAL CONSERVATION

[1]D. Naresh Kumar, Assistant Prof., Dept. of ECE,
Guru Nanak institute of technology Hyderabad, India

[2]Dr. Santhosh Kumar Allemki, Associate Prof., Dept. of ECE,
Guru Nanak institute of technology Hyderabad, India

[3]M. Shravan Kumar Reddy, Assistant Prof.Dept. of ECE,
Guru Nanak institute of technology Hyderabad, India

ABSTRACT:

The quality of water in ponds is vital for maintaining aquatic ecosystems and ensuring access to clean water resources. Traditional monitoring methods, often labor- intensive and limited in scope, have driven the need for innovative solutions. This paper presents an IoT-based wireless system designed for real-time water quality monitoring in ponds. Powered by a microcontroller, the system employs multiple sensors to measure critical parameters, including pH, turbidity, and total dissolved solids (TDS). A novel integration with an aquatic boat enables comprehensive sampling from various pond locations, enhancing data accuracy. Collected data is transmitted to the cloud and accessible via the Aqua Specs mobile application for real-time analysis. Successfully tested in four ponds in Chhattisgarh, India, the system demonstrates high precision and scalability, offering a cost-effective solution for environmental monitoring and pond management.

Keywords: TDS, pH

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INTRODUCTON:

Water is an essential resource for life, yet its quality faces growing threats from pollution, climate change, and population expansion. Ponds, critical for rural ecosystems and groundwater recharge, require consistent monitoring to sustain ecological balance and public health. Conventional water quality assessment, reliant on manual sample collection and laboratory testing, is time-consuming and inefficient. The emergence of Internet of Things (IoT) technologies provides an opportunity to revolutionize monitoring through automation and real-time data collection. This project introduces an advanced IoT-based system tailored for monitoring pond water quality, focusing on parameters such as pH, turbidity, and TDS. Deployed in Chhattisgarh, a region abundant in natural water bodies, this system aims to enhance environmental conservation and promote sustainable water resource management.

LITERATURE REVIEW:

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PROBLEM IDENTIFIED:

Traditional water quality monitoring for ponds encounters several challenges:Time-Intensive Processes: Manual sampling and laboratory analysis cause delays, hindering timely responses

S.No	Author	Title, Journal & Year	Methods	Drawback
1.	J. Smith et al.	"Smart Water Monitoring Systems Using IoT", International Journal of Environmental Studies, 2020	Used IoT-based sensors (pH, TDS) with Wi-Fi module for remote data transmission	Limited to stationary setups; lacks mobile data collection
2.	K. Sharma	"Sensor-based Water Quality Analysis", Journal of Applied Environmental Science, 2019	Developed sensor module with Arduino for TDS and turbidity monitoring	No real-time alerts or cloud integration
3.	M. Rao and D. Patel	"Wireless Sensor Networks for Environmental Monitoring", IEEE, 2021	Applied WSN in remote monitoring of environmental data	High cost and complexity of sensor node deployment
4.	R. Kumar	"Real-Time Water Quality Monitoring System", IJRET, 2018	Real-time data collected using GSM module for alert systems	No GPS-based location tracking

to quality issues.Limited Spatial Coverage: Collecting samples from diverse pond sections is difficult, resulting in incomplete data.High Resource Demand: Conventional methods require significant labor and infrastructure, increasing operational costs.Lack of Real-Time Insights:

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Periodic monitoring fails to capture dynamic changes in water quality, limiting effective management.Regional Issues: In Chhattisgarh, overabstraction, pollution, and unplanned development exacerbate water management challenges, necessitating scalable solutions.These issues highlight the urgent need for an automated, real-time monitoring system to improve pond management and environmental conservation.

METHODOLOGY: The proposed IoT-based system facilitates wireless water quality monitoring in ponds through a robust framework:Hardware: The system is powered by a Raspberry Pi Pico W microcontroller, equipped with Wi-Fi and Bluetooth capabilities. Three sensors measure pH, turbidity, and TDS, interfaced via a three-pin connector. An OLED display provides on-site data visualization, while a GPS module ensures location-specific sampling.Aquatic Boat Integration: A remotely operated boat enables sampling from the pond's center and edges, ensuring comprehensive data collection.Software: MicroPython, programmed using Thonny IDE, manages sensor operations. Data is transmitted to the cloud via HTTP protocols and accessed through the AquaSpecs mobile application.Power Supply: A 5V DC supply, regulated by an LM7805 IC, powers the system, supported by a step-down transformer and bridge rectifier for stability.Implementation.This methodology ensures accurate, real-time data collection, adaptable to various pond sizes and environmental conditions.

ADVANTAGES:

The IoT-based water quality monitoring system offers numerous benefits:

- Real-Time Data Collection: Continuous monitoring enables rapid detection of water quality changes, supporting prompt interventions.
- Comprehensive Sampling: The aquatic boat facilitates data collection from diverse pond locations, enhancing analytical precision.Cost Efficiency: Automation reduces labor and infrastructure costs compared to traditional methods.
- Scalability: The system can be deployed across multiple ponds, making it ideal for regional water management.
- User-Friendly Interface: The AquaSpecs app provides remote data access, streamlining decision-making for stakeholders.
- High Precision: Sensors demonstrate low error rates (0.3% for pH, 0.06% for TDS, 0.9% for turbidity), ensuring reliable measurements.

DISADVANTAGES:

Despite its advantages, the system has limitations:

- Initial Investment: Hardware and software setup require upfront costs, which may challenge small-scale implementations.Power Requirements: Continuous operation depends on a stable power source, which may be limited in remote areas.
- Maintenance Demands: Sensors and the aquatic boat need regular calibration and maintenance to sustain accuracy.
- Cybersecurity Risks: IoT systems are susceptible to hacking, requiring robust encryption to protect data.

- Limited Parameter Scope: The system currently monitors pH, TDS, and turbidity, omitting other parameters like dissolved oxygen or biological contaminants.

APPLICATIONS:

The system has diverse applications:

- Pond Management: Supports aquaculture by monitoring water conditions to optimize aquatic life health.
- Environmental Conservation: Detects pollution early, enabling timely remediation to preserve ecosystems.Public Health: Ensures pond water safety for rural communities using it for drinking or irrigation.
- Agriculture: Enhances irrigation water quality monitoring, boosting crop productivity.
- Smart Cities: Integrates with urban water management systems to maintain water bodies.
- Research: Provides valuable data for environmental studies, informing policy and conservation strategies

RESULT:

This system successfully captured and transmitted real-time data on pH, turbidity, and TDS levels from various points in each pond. Analysis revealed fluctuating trends in water quality, prompting local stakeholders to initiate targeted interventions. The AquaSpecs mobile application provided an effective platform for monitoring, displaying data in user-friendly graphs and enabling timely alerts. These trials validated the reliability, scalability, and effectiveness of the proposed system in a real-world scenario.

CONCLUSION:

The proposed water quality monitoring system provides an efficient and scalable solution to overcome the limitations of traditional methods. By leveraging microcontrollers, cloud computing, and mobile technologies, the system ensures accurate and timely data collection, promoting informed decision-making. Its successful deployment in diverse environmental conditions demonstrates its adaptability and potential for widespread use in sustainable water resource management. Future work may involve integrating solar power, expanding sensor types, and incorporating AI-based analytics for predictive monitoring.

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