Real-Time Water Quality Monitoring System: An economical IoT Integration device for Assessing and Managing Rural Water Resources

Harshit K Sanghi

STEP BY STEP SCHOOL, DELHI

Problem

- Water quality in rural Gurugram is severely impacted by groundwater contamination and environmental degradation caused by sewage discharge, industrial effluents, over-extraction of groundwater, and poor infrastructure management.
- A government report revealed that **40 out of 75 water samples** from Gurgaon failed safety standards, exceeding acceptable drinking water limits (*Hindustan Times*).

Hypothesis

- An IoT-based water quality monitoring system enables real-time measurement of parameters like pH, turbidity, DO, etc. ensuring quick quality detection and timely responses.
- This proactive approach enhances water management and public health safety, particularly in underserved communities facing environmental and infrastructure challenges.

Materials

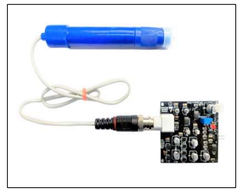
1. NodeMCU (ESP8266/ESP32)
2. pH Sensor
3. TDS Sensor
4. Dissolved Oxygen (DO) Sensor
5. Turbidity and Conductivity Sensor
6. ADS1115 ADC Module
7. Breadboard, Jumper Wires
8. Power Supply (5V)

Steps for the Device Assembly

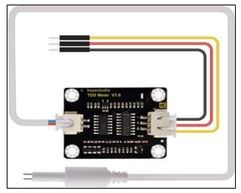
- Hardware Setup
- Software Setup
- Sensor Calibration
- Cloud Connection
- Cloud Dashboard Setup
- Power Considerations

Sensor Assembly

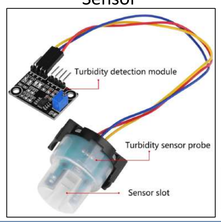
pH Sensor



Dissolved Oxygen Sensor



TDS Sensor



Turbidity & Conductivity Sensor

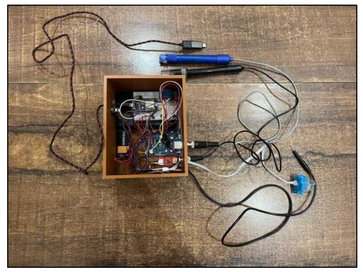


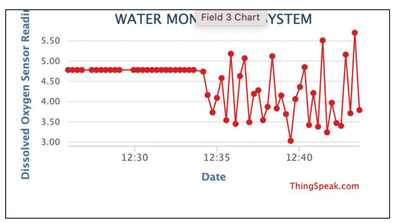
Fig 1: Image of the final assembled device

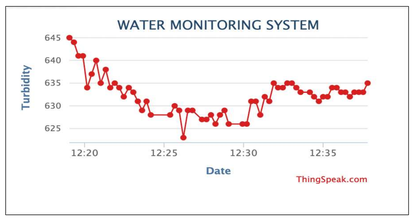
Results

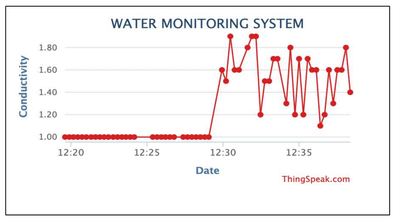
Parameters	Site 1	Site 2	Site 3	Permissible range
pH	6.8	5.6	6.7	6.5-8.5
Conductivity (mmho)	0.4	2.5	1.3	>1.0
Turbidity (NTU)	3	13	7	5-10
Dissolved Oxygen (mg/L)	8	5	6	4-6
TDS (mg/L)	672	2250	1500	< 200

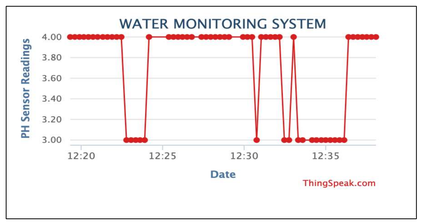
Table 1. Physico-chemical Analysis of water using the device

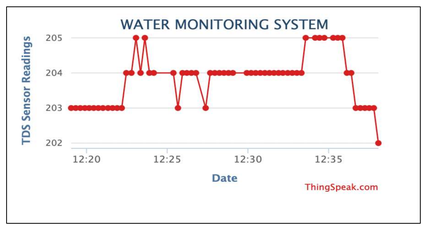
Fig 2. Real time data monitoring on the Thingspeak platform











Discussion

- **pH**: Sites 1 and 3 are safe for drinking with pH within the BIS range (6.5–8.5), but Site 2 (5.6) is too acidic and unsuitable.
- **Conductivity**: Sites 2 (2.5 mmho) and 3 (1.3 mmho) exceed the ideal limit (<1.0 mmho), indicating high ion concentrations that may pose risks.
- **Turbidity**: Site 1 (3 NTU) is within the BIS limit (≤5 NTU), but Sites 2 (13 NTU) and 3 (7 NTU) exceed it, making the water unsafe.
- **Dissolved Oxygen (DO)**: DO levels are adequate for all sites (Site 1: 8 mg/L; Sites 2 and 3: 5–6 mg/L), indicating good water health.
- **Total Dissolved Solids (TDS)**: Site 1 (672 mg/L) slightly exceeds the acceptable BIS limit, while Sites 2 (2250 mg/L) and 3 (1500 mg/L) are unsuitable due to high TDS.

Conclusions

- Sites 2 and 3 have multiple parameters (pH, conductivity, turbidity, TDS) outside permissible ranges, indicating possible pollution from runoff or waste discharge.
- Site 1 shows better water quality with minimal deviations, suggesting it is less impacted by contamination.
- Regular monitoring of water quality parameters is vital to ensure compliance with standards and safeguard public health and ecosystems.
- The IoT-based water quality monitoring system enables accurate, real-time data capture without human intervention.
- This system's precision in detecting deviations highlights its potential for reliable, ongoing water quality assessment.
- The scalable, technology-driven approach provides timely insights for proactive intervention, crucial for areas with rapid quality changes.

Future Directions

- **Predictive Analysis:** Integrate AI to forecast water quality trends and detect contamination risks early.
- **Real-Time Alerts:** Develop automated alert systems for immediate remediation actions in case of deviations.
- **Expanded Monitoring:** Add sensors for heavy metals and microbial contaminants to enhance the scope of water quality assessment.

References

1. U.N. Human Rights Council, "Annual Report 2019: Human Rights-Based Actions Bring Tangible Results," [Online]. Available: https://www.ohchr.org/en/stories/2020/06/annual-report-2019-human-rights-based-actions-bring-tangible-results.
2. [2] S. R. Sharma and A. K. Yadav, "Groundwater Quality Assessment for Drinking Purpose Using Traditional and Fuzzy GIS-Based Water Quality Index in Gurugram District of Haryana, India," [Online]. Available: https://discovery.researcher.life/article/groundwater-quality-assessment-for-drinking-purpose-using-traditional-and-fuzzy-gis-based-water-quality-index-in-gurugram-district-of-haryana-india/6f6a641f63223972b512acf9f635f86e.
3. [3] M. Kumar, A. K. Yadav, R. Hooda, and S. Singh, "Groundwater Quality Assessment in Gurugram District of Haryana, India," *Environmental Monitoring and Assessment*, vol. 192, no. 3, p. 749, 2020.
4. [4] A. Sharma, R. S. Rathi, and M. Kumar, "Water Quality Detection Using Cost-effective Sensors Based on IoT," [Online]. Available: Water Quality Detection Using Cost-effectiveSensorsBasedonIoTfinal.pdf. [Accessed: Oct. 29, 2024].
5. [5] R. Rawat and A. R. Siddiqui, "Assessment of Physiochemical Characteristics of Drinking Water Quality in Allahabad Metropolitan," [Online]. Available: rawat-siddiqui-2019-assessment-of-physiochemical-characteristics-of-drinking-water-quality-in-allahabad-metropolitan.pdf.

Acknowledgements

I sincerely express my heartfelt gratitude to my mentors Dr. Rohan Louis D'Souza , Mr. Suraj & Mr. Karan Khaswal, for their invaluable guidance and encouragement. A special thanks to my mom and dad for their unwavering support and belief in me throughout this journey. This project wouldn't have been possible without their motivation and constant inspiration.