# Democratizing Real-Time Water Quality Monitoring

## Low-Cost Software and Hardware Infrastructure for Water Quality Sensing in Indigenous Communities

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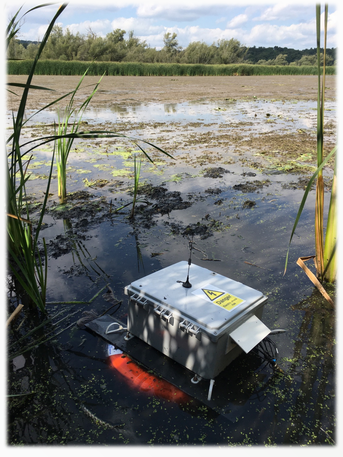
## Introduction

Our goal is to develop a low-cost, modular, and energy-efficient water quality monitoring system that utilizes self-hosted servers and can function effectively in remote areas with unreliable connectivity.

The system will support queries from both mobile devices and desktops, offer a user interface in multiple languages, and integrate with Terrastories (a geostorytelling application).

Designed for open source and educational use, the project ensures secure transmission and storage of sensitive data while maintaining configurability for various use cases.

- **Sensor nodes** to measure water quality parameters through connected sensors:
  - Dissolved oxygen sensor measures oxygen levels in the water, indicating the health of aquatic life.
  - Conductivity sensor reveals the amount of salts present, providing insight into water quality.
  - pH shows the acidity or alkalinity, helping detect imbalances.
  - Turbidity sensor indicates water clarity, with changes signalling potential disturbances.
  - Water Temperature sensor helps calibrate all sensor levels.
- **Gateway** to relay sensor-node's data to the server over the internet using a connection.
- **Server** programmed in Golang for fast and concurrent connections with custom APIs. A time-series database (Influx DB) for simple data storage and a smaller footprint.



Water Sensor Deployment at Cootes Paradise in 2022 Sep

## Low-Cost Water Quality Sensing

Our sensor node is using water pipe from the local store which has a much small form factor compared to other products, and it can be easily placed in a normal backpack.

**Low-Cost:**

- The sensor buoy is more affordable compared to commercial products with similar functionality.

| | Ours | Commercial |
|---|---|---|
| Sensor Node (Include probes and buoy) | ~ CA$1400 | ~ CA$5700 |
| Gateway (Include enclosure) | ~ CA$400 | ~ CA$300 |
| Server (Optional) | ~ CA$50 | / |

**Low-power:**

- Sensor node is using low-power Arduino-based board, the power during deep sleep is the lowest at 10uA, which makes the node run on 6 AA batteries for 2 months.
- Gateway will periodically wake up and listen for LoRa messages, so it can be running under the battery, while commercial gateway needs to be plugged in all the time.

| | Sleep Current (5V) | Working Current (5V) | Battery Life (12000mAh 5V) |
|---|---|---|---|
| Sensor Node | ~ 60 uA | ~ 300 mA | ~ 2 Month |
| Gateway | ~ 60 uA | ~ 500 mA | ~ 1 Month |

**Modular design:**

- Sensor: Customisable sensor, any sensors with UART/I2C connection would work.
- Motherboard: Arduino Mega for education (higher power), Moteino Mega for production (lower current).
- Network: LoRa mesh in rural areas (unreliable 3G signal), 3G for distant nodes (reliable 3G signal).
- Versioning and configuration are managed by a single config file.

**Security:**

- Security is a crucial aspect of the system, thus secure communication protocols is implemented between the sensor nodes, gateways, and servers.

## Web Application & Server

**Website:**

- A user-friendly progressive web application developed using React.
- Visualization for the indigenous community.
- Support multiple languages.
- Data can be exported for researchers.
- All sensors can be calibrated through web interface via web serial.

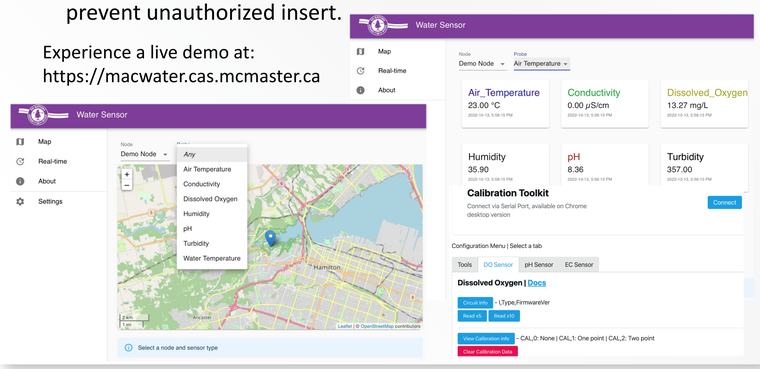
**Server:**

- Well-documented Server API for integration (e.g. Terrastories, Six Nations Water Quality Database, WATERRA [Capstone project] and other water quality projects).
- Docker containers for easy setup, cross-platform compatibility, and migration.

**Privacy and Security:**

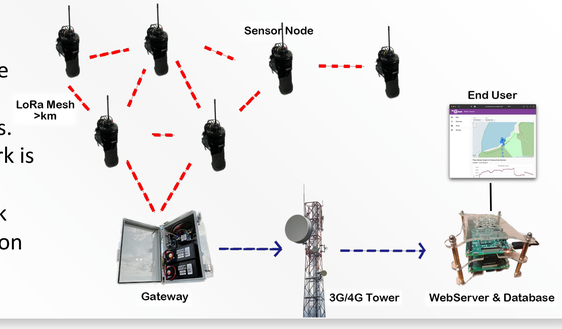
- Access to the data is limited to authorized users, and the data is encrypted by HTTPS during transmission and use authentication to prevent unauthorized insert.

Experience a live demo at:
https://macwater.cas.mcmaster.ca




## Unreliable Connectivity in Remote Areas

- Utilizes low-bandwidth, low-power, long-range networks for connecting motes.
- The mesh network is tolerant to faults, changing network topology, extension and contraction.

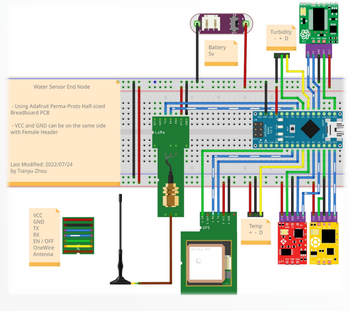



## Educational Use

All contribution is open-sourced in Gitlab, following standard practices for educational projects.

- Accessible for those interested in water quality sensing.
- Step-by-step documentation with pictures for easy replication.
- Global availability of hardware components.

Repo: https://gitlab.cas.mcmaster.ca/re-mote




## Acknowledgements

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## References

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