INDIAN INSTITUTE OF INFORMATION TECHNOLOGY SRI CITY, CHITTOOR

AI/ML BASED IOT FRAMEWORK FOR WIDE AREA WATER QUALITY AND QUANTITY MANAGEMENT SYSTEMS

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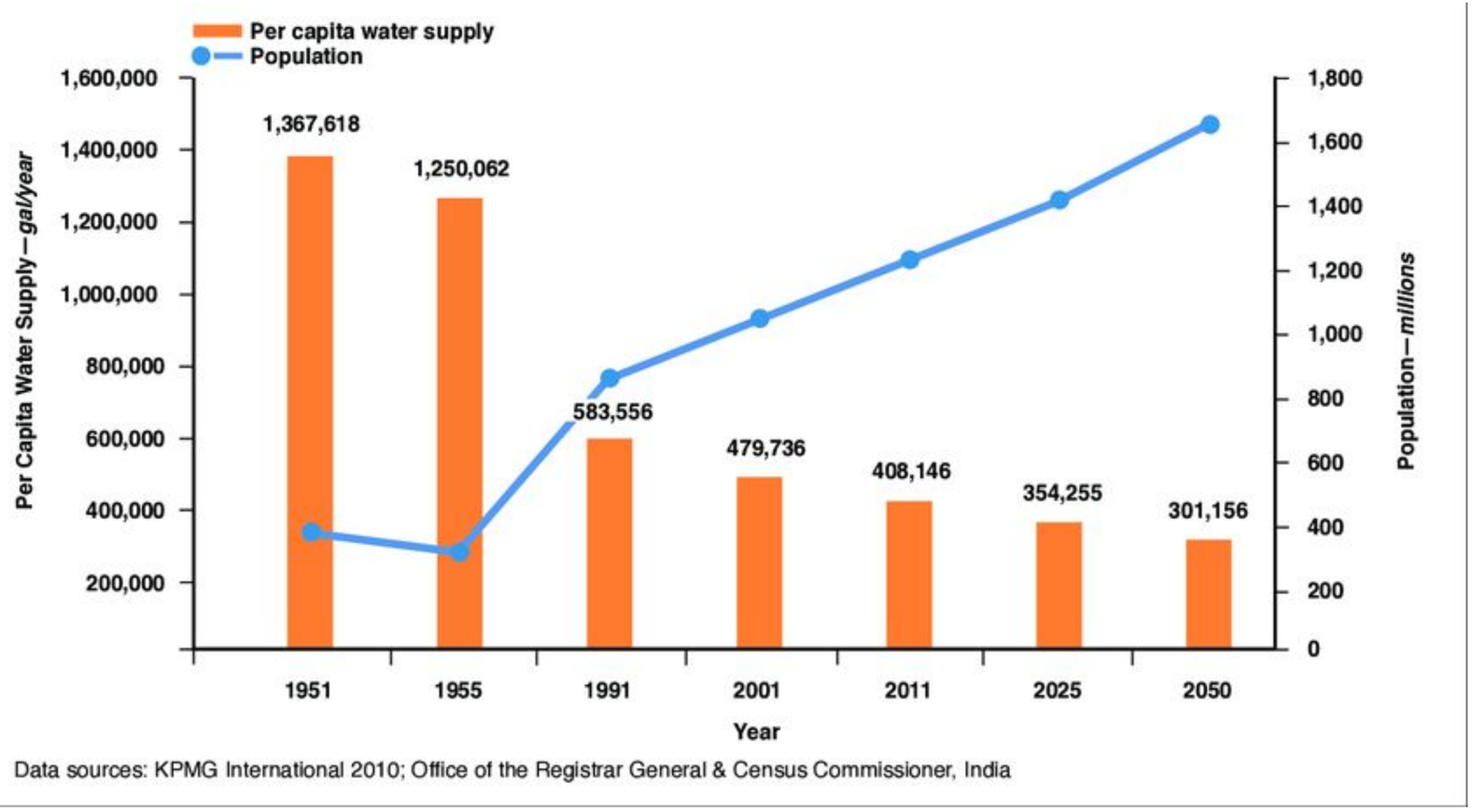
MOTIVATION



Data sources: KPMG International 2010; Office of the Registrar General & Census Commissioner, India

- **RISING DEMAND – POPULATION GROWTH INCREASES FRESHWATER NEEDS.**
- **Quality Decline – Pollution and overuse harm water sources.**
- **Sustainable Management – Essential for future water security.**

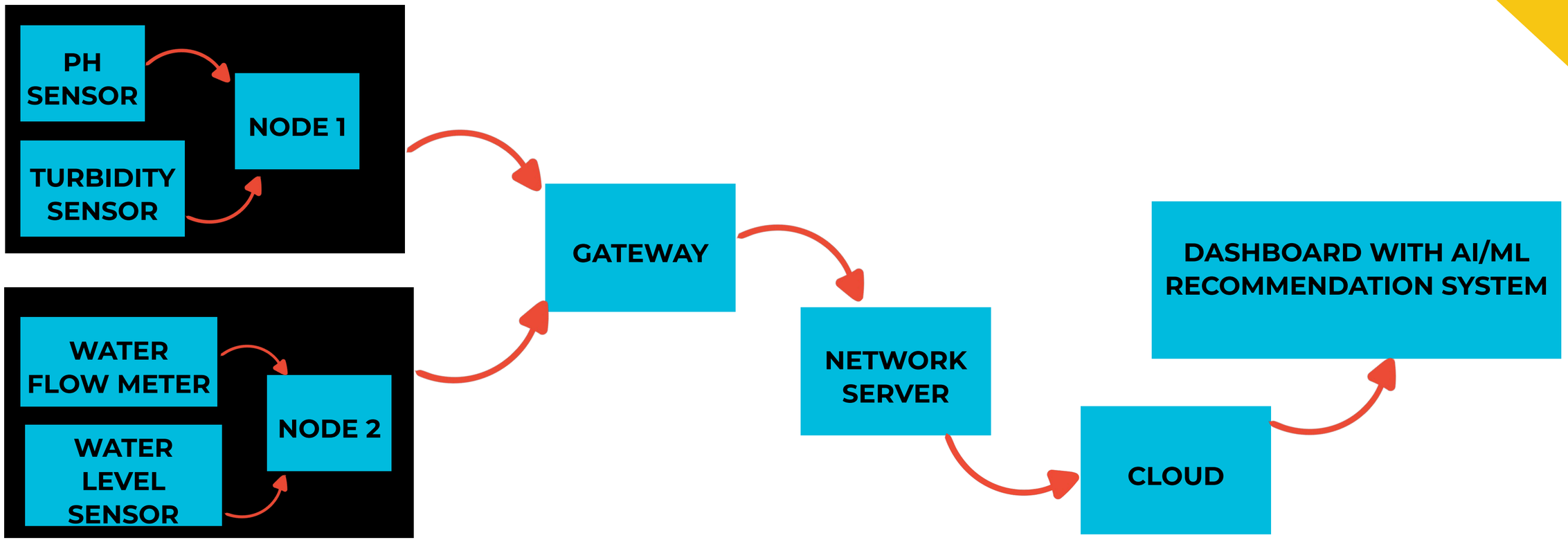
PROBLEM STATEMENT

IOT BASED END TO END FRAMEWORK FOR WATER MONITORING AND MANAGEMENT USING AI/ML RECOMMENDATION SYSTEM

LITERATURE SURVEY

YEAR	TITLE OF THE PAPER	AUTHOR NAME	CONTRIBUTION	OBSERVATION
2023	Design and Implementation of IoT-based Water Quality and Leakage Monitoring System for Urban Water Systems Using ML Algorithms	C. R. Natarajan, K. Ramya, G. S. S. Murthy	Applied LR, SVM, and RF to real-time water quality (pH, turbidity, temperature) and leakage detection using IoT sensors	The paper highlights model accuracy but lacks deployment details for long-term environmental adaptation
2023	Integrating IoT and AI for Holistic Water Quality Monitoring and Management	T. Shilpa, G. Keerthana, S. Vijayalakshmi	Proposed hybrid system using KNN, DT, RF, SVR, and XGBoost for multi-parameter prediction (DO, pH, turbidity, conductivity, temperature)	Offers a robust model comparison but faces potential latency and scalability issues in real-time large-scale deployment
2022	IoT-Based Water Consumption Monitoring System for Water Management	A. Iqbal, M. Khan, A. Qadir	IoT-based water meter data logging and visualization with proposed use of LR and RF for predictive analytics	Primarily focuses on monitoring and visualization; ML usage is discussed as a future enhancement, not yet implemented

PROPOSED METHODOLOGY



PREVIOUSLY COMPLETED

Hardware integration of Enthutech Sensors:

Water level sensor

Water Flow meter

Water Quality Sensors

PROGRESS

Dataset of the water quality parameters

Serial No.	Date	Time	Device Name	dissolved_oxygen	turbidity	ph
1	27/04/202	23:40:47	Water Quality	5.44	93.7	7.71
2	27/04/202	23:21:56	Water Quality	5.46	92.4	7.71
3	27/04/202	23:00:48	Water Quality	5.38	92.1	7.7
4	27/04/202	22:40:48	Water Quality	5.48	92.7	7.7
5	27/04/202	22:20:48	Water Quality	5.38	94.7	7.7
6	27/04/202	22:00:49	Water Quality	5.38	93.7	7.7
7	27/04/202	21:40:49	Water Quality	5.37	94.3	7.7
8	27/04/202	21:21:47	Water Quality	5.41	94	7.7
9	27/04/202	21:00:49	Water Quality	5.36	94.7	7.7
10	27/04/202	20:40:49	Water Quality	5.33	94.7	7.7
11	27/04/202	20:20:50	Water Quality	5.28	94.3	7.69
12	27/04/202	20:00:50	Water Quality	5.23	95.6	7.69
13	27/04/202	19:40:50	Water Quality	5.23	95.3	7.69
14	27/04/202	19:20:50	Water Quality	5.21	95	7.68

- This is the water quality dataset which consists of the Ph, turbidity and DO levels..
- It consists of 40 days of data and after data cleaning we are left with 3000 data points.

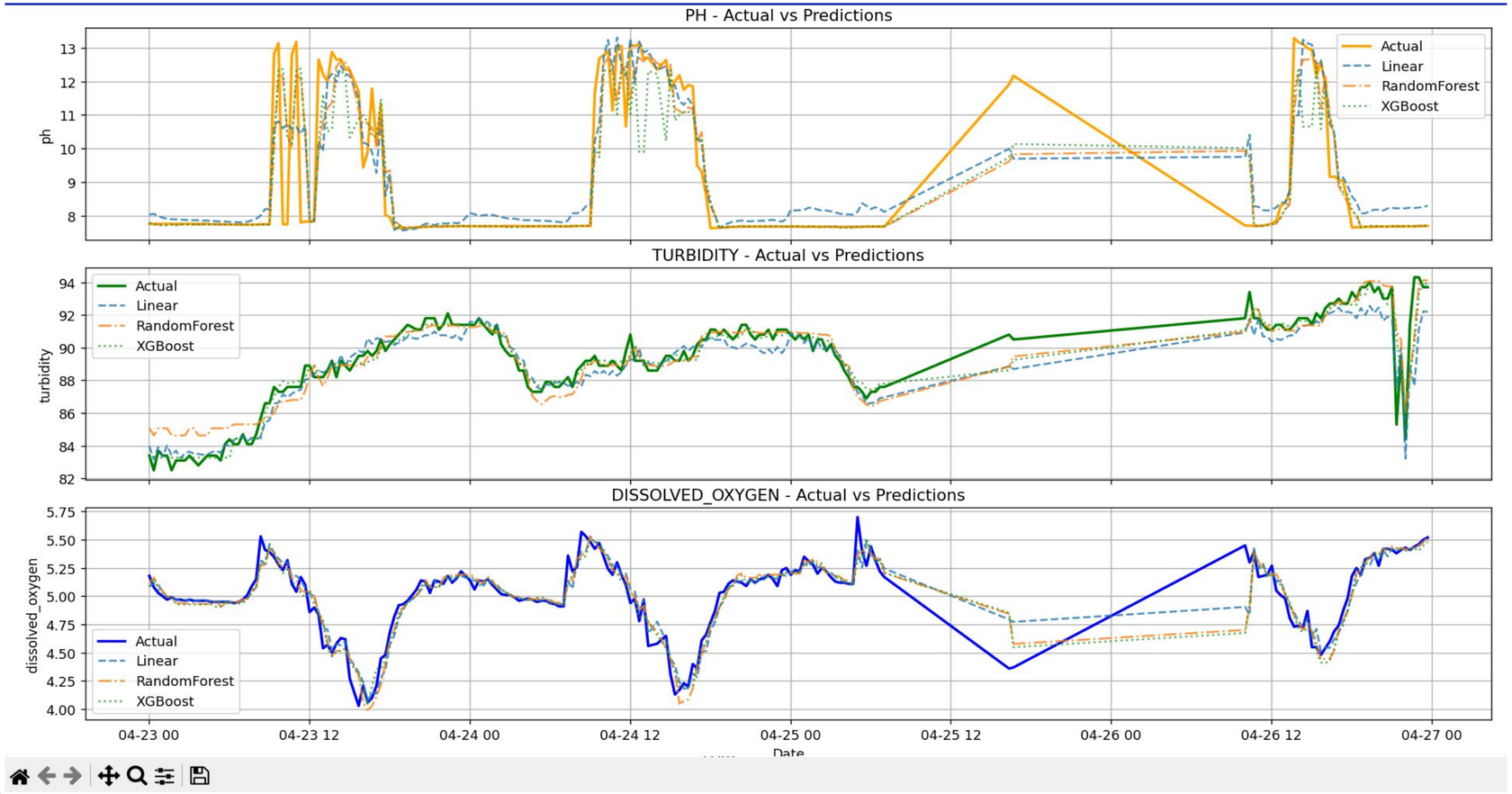
PROGRESS

ML Models used for predicting:

Model	Special Features	Strengths	Limitations
Linear Regression (LR)	Simple model that establishes a linear relationship between input variables and output	• Easy to implement and interpret • Low computational cost • Good for baseline comparisons	• Assumes linearity • Sensitive to outliers • Limited performance on complex data
Random Forest (RF)	Ensemble of decision trees using bagging and feature randomness	• Handles non-linear relationships well • Robust to overfitting • Works well with missing or unscaled data	• Less interpretable than single models • Slower prediction for large forests
XGBoost (Extreme Gradient Boosting)	Boosting-based ensemble method optimized for speed and performance	• High accuracy • Built-in regularization to reduce overfitting Efficient memory usage and parallel processing	• Complex tuning required • Longer training time • May overfit if not tuned properly

PROGRESS

ML MODELS AND PREDICTIONS OF WATER QUALITY AND FLOW RATE



- Water Quality parameter Predictions.
- Used Linear Regression, Random Forest and XGBoost for clear comparison and understanding.

PROGRESS

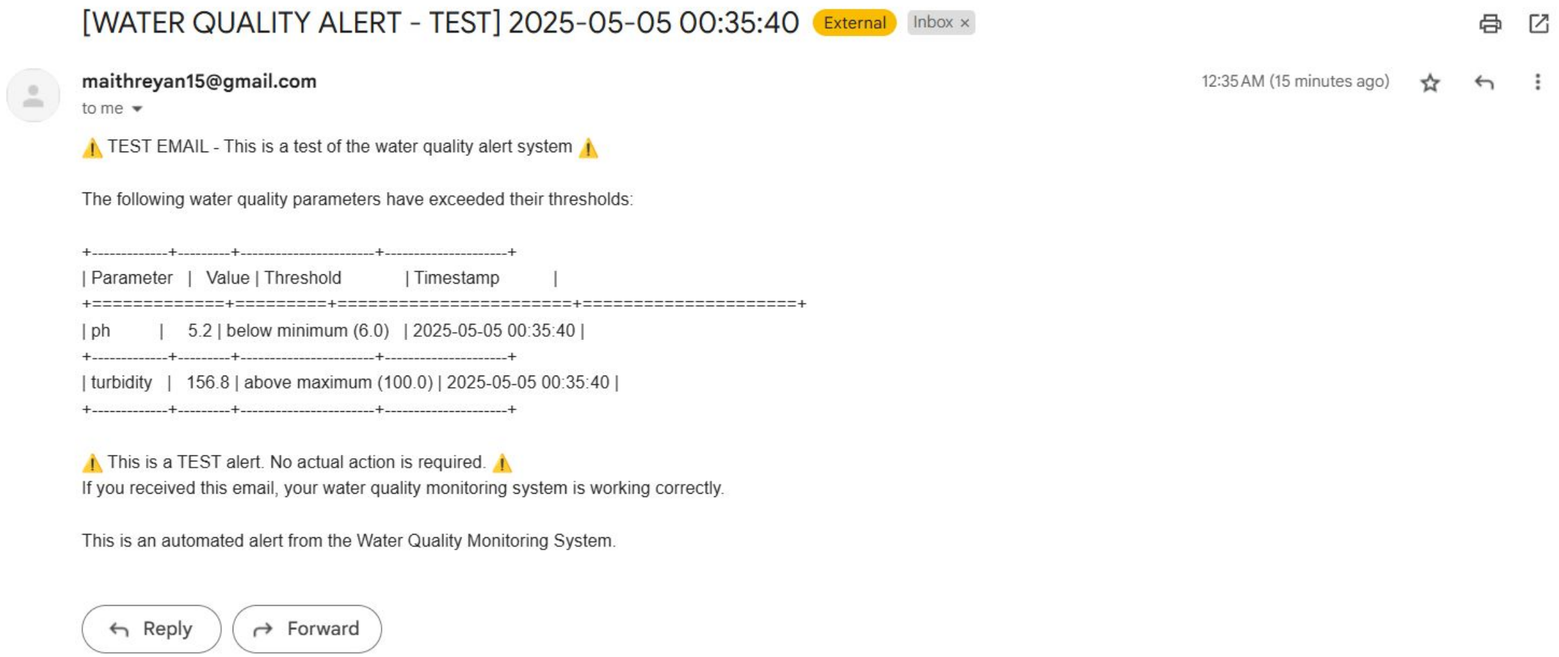
Prediction Parameters:

Parameter	Model	RMSE	MAE	R^2 Score
ph	Linear	0.826	0.513	0.825
ph	RandomForest	0.862	0.385	0.81
ph	XGBoost	0.994	0.474	0.747
turbidity	Linear	0.907	0.64	0.896
turbidity	RandomForest	0.918	0.626	0.893
turbidity	XGBoost	0.706	0.421	0.937
dissolved_oxygen	Linear	0.103	0.063	0.902
dissolved_oxygen	RandomForest	0.11	0.071	0.887
dissolved_oxygen	XGBoost	0.108	0.067	0.891

- The linear regression model works the best compared to the rest, but we need more data in order to accurately predict the parameters.

PROGRESS

Email Notification system based on water quality parameters:



[WATER QUALITY ALERT - TEST] 2025-05-05 00:35:40 External Inbox ×

maithreyan15@gmail.com 12:35 AM (15 minutes ago)

to me

⚠️ TEST EMAIL - This is a test of the water quality alert system ⚠️

The following water quality parameters have exceeded their thresholds:

Parameter	Value	Threshold	Timestamp
ph	5.2	below minimum (6.0)	2025-05-05 00:35:40
turbidity	156.8	above maximum (100.0)	2025-05-05 00:35:40

⚠️ This is a TEST alert. No actual action is required. ⚠️
If you received this email, your water quality monitoring system is working correctly.

This is an automated alert from the Water Quality Monitoring System.

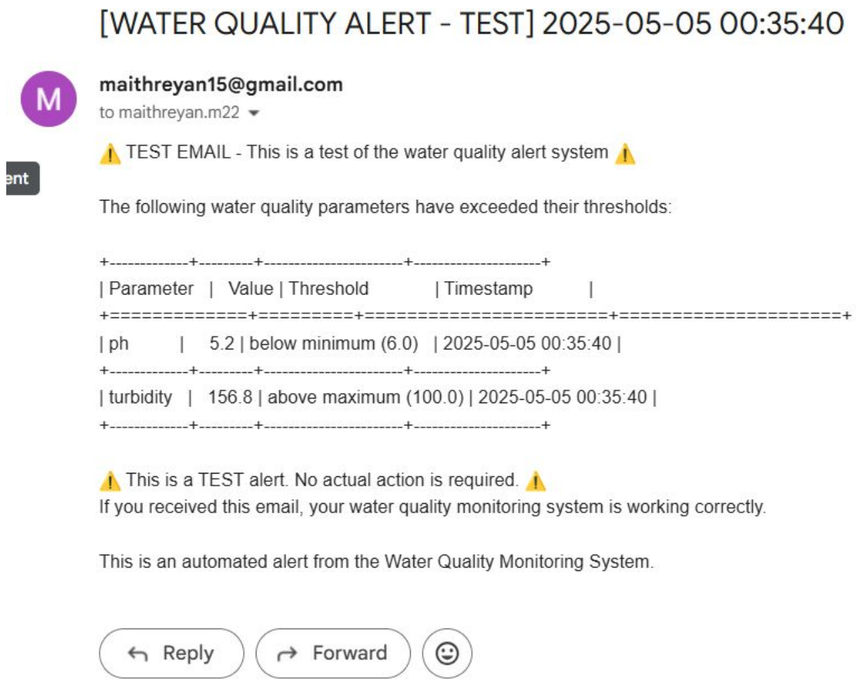
Reply Forward

Received email

- The system automatically sends an email notification if the quality parameters reach dangerous levels.
- Used SMTP for easy access control

PROGRESS

Email Notification system based on water quality parameters:



[WATER QUALITY ALERT - TEST] 2025-05-05 00:35:40

maithreyan15@gmail.com 00:35 (16 hours ago)
to maithreyan.m22

⚠️ TEST EMAIL - This is a test of the water quality alert system ⚠️

The following water quality parameters have exceeded their thresholds:

Parameter	Value	Threshold	Timestamp
ph	5.2	below minimum (6.0)	2025-05-05 00:35:40
turbidity	156.8	above maximum (100.0)	2025-05-05 00:35:40

⚠️ This is a TEST alert. No actual action is required. ⚠️
If you received this email, your water quality monitoring system is working correctly.

This is an automated alert from the Water Quality Monitoring System.

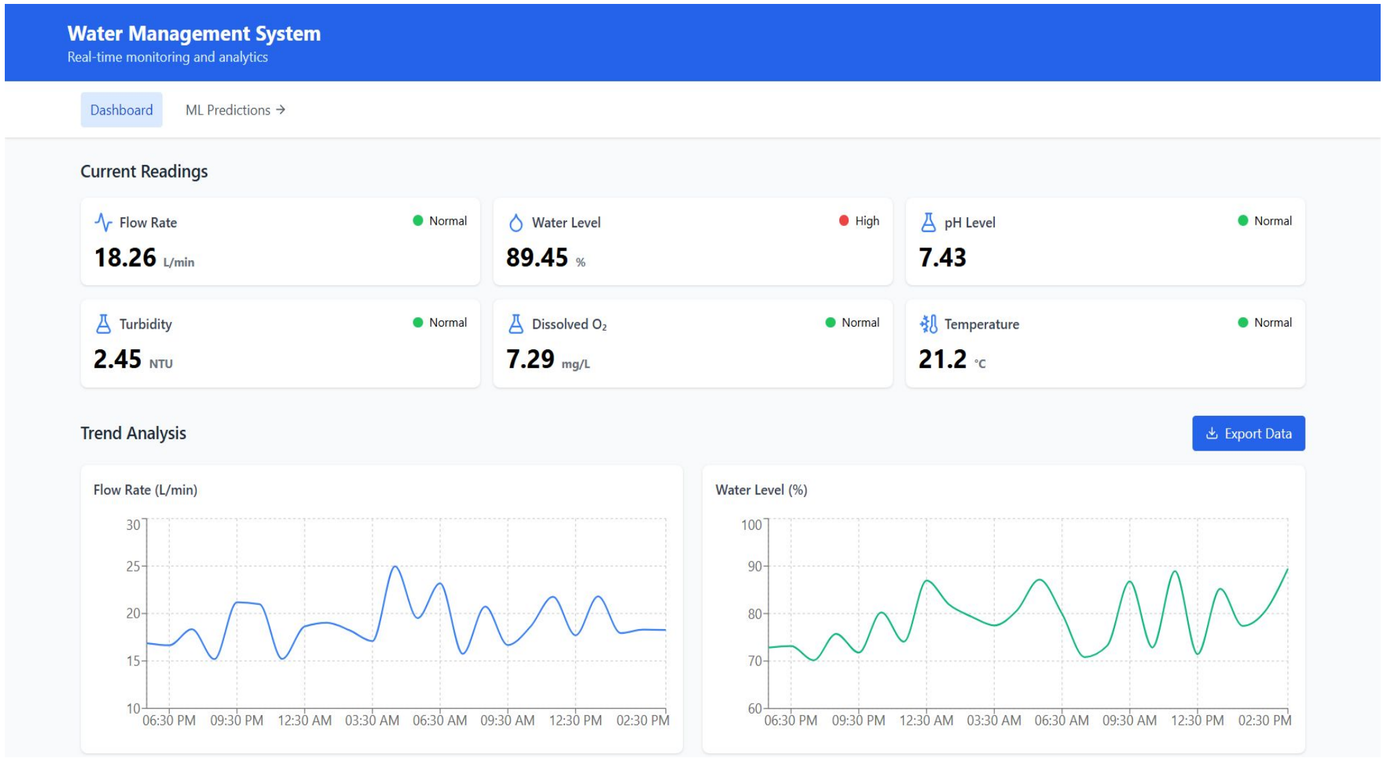
Reply Forward

Sent email

- This is the sender email id through which the device notifications are being sent.
- Parallely dashboard notifications are also being developed.

PROGRESS

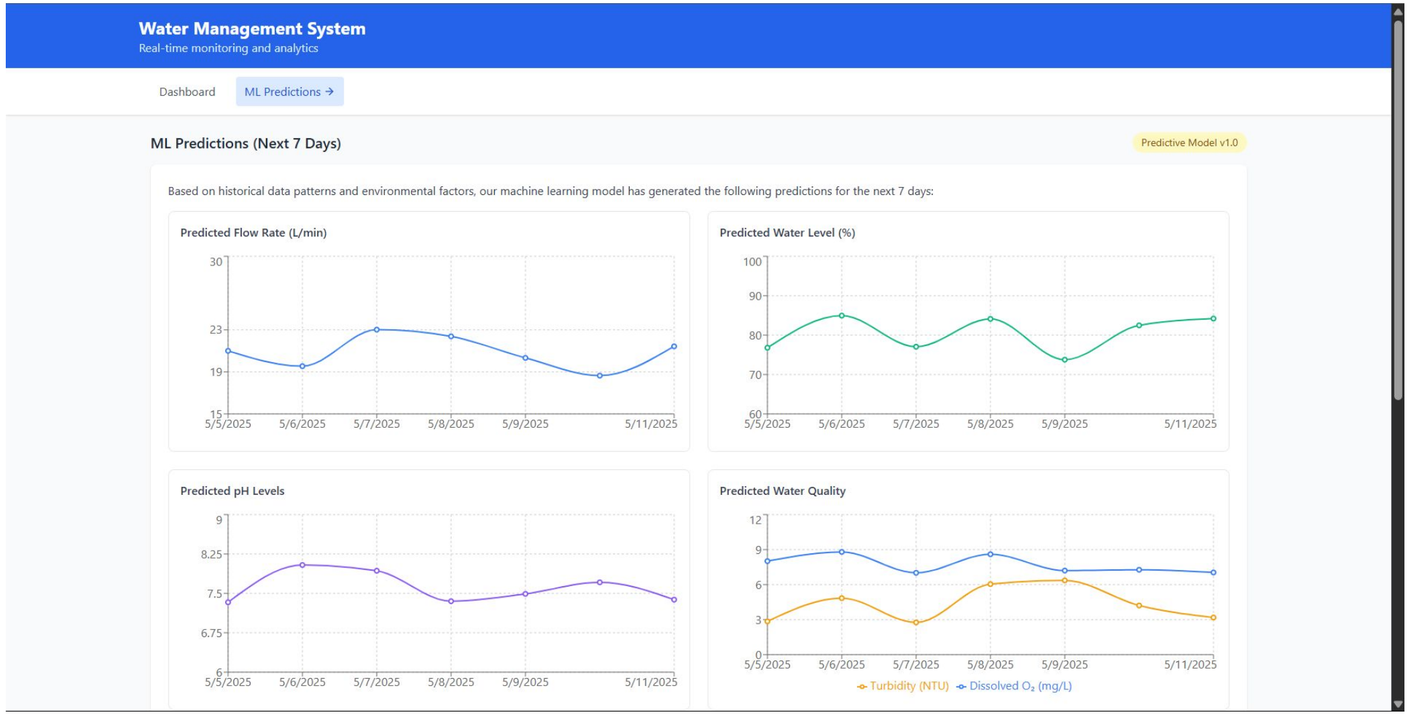
Initial drafts of dashboard for the proposed statement:



- This is the initial draft of the dashboard which will display all the different parameters.
- It will also show the all the graphical data along with a way to download the previous data in a csv file format.
- It is made using React

PROGRESS

Initial drafts of dashboard for the proposed statement:

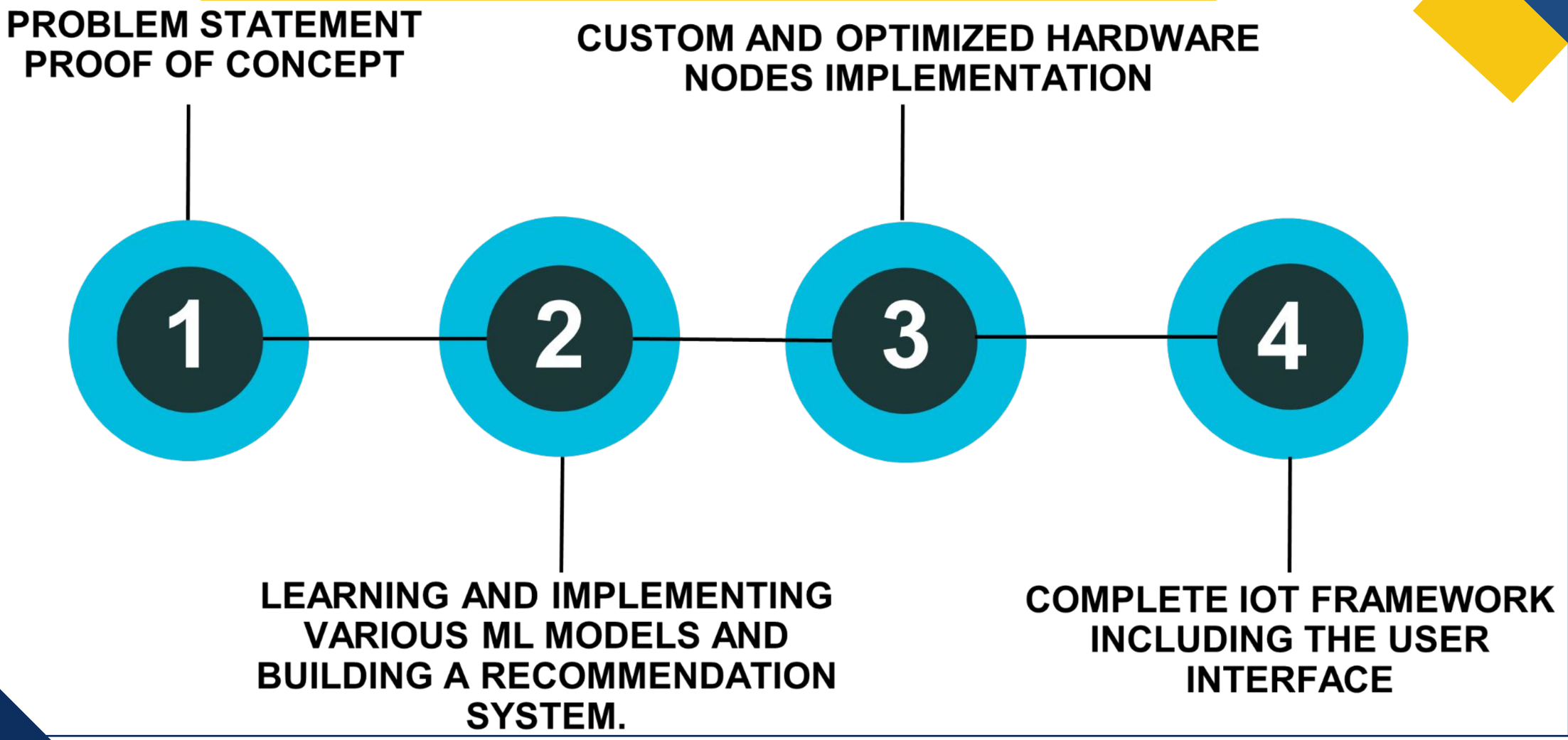


- Here it will display the future ML predicted trends if the same environmental conditions continues.
- Along with this we are developing a mobile app to display all these data.

PLAN FOR NEXT EVALUATION

- Implement approx. 5 nodes along with their communication modules in our campus.(including the sensor, communication modules and gateway etc.)
- Gather their realtime data and store it in a cloud database.
- Further improvements in mobile app/dashboard.

TIMELINE


PROBLEM STATEMENT
PROOF OF CONCEPT
CUSTOM AND OPTIMIZED HARDWARE
NODES IMPLEMENTATION
1
2
3
4
LEARNING AND IMPLEMENTING
VARIOUS ML MODELS AND
BUILDING A RECOMMENDATION
SYSTEM.
COMPLETE IOT FRAMEWORK
INCLUDING THE USER
INTERFACE

REFERENCES

- Zhang, Y., et al. (2023). "Emerging contaminants in water resources: Detection methods and removal technologies." Water Research, 215, 118262.

- Chen, X., et al. (2024). "Machine learning applications for predicting and managing water scarcity in urban environments." Journal of Hydrology, 612, 128964.

- Patel, S., & Johnson, M. (2023). "Community-based watershed management for sustainable water quality improvement: A systematic review."

- Lopez-Maldonado, E., & Berger, T. (2023). "Integrated water resources management under climate change: Case studies from arid regions."

THANK YOU