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WATERNET AI

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Abstract: WaterNet AI is an intelligent water quality monitoring and analysis system designed to ensure the safety and suitability of water for drinking and irrigation purposes through real time data collection and machine learning–based classification. Water is essential for human, animal, and plant survival, yet increasing industrialization, mining activities, pollution, and natural factors often degrade water quality and make it unsafe for consumption or agricultural use. To address this challenge, WaterNet AI integrates a sensor- based monitoring network with low-power long-range communication (LoRa) technology to continuously collect critical water quality parameters such as pH, turbidity, dissolved oxygen, and conductivity from multiple water sources. The collected data is transmitted through a topology-aware partial mesh network designed using Radio Mobile simulations to ensure reliable communication across different land terrains. The system evaluates water samples using Water Quality Index (WQI) and Irrigation Water Quality Index (IWQI) standards recommended by the World Health Organization to determine their suitability. Since publicly available datasets for drinking and irrigation water quality are limited, custom datasets were created to train machine learning models. WaterNet AI applies and compares three machine learning algorithms—Random Forest, Logistic Regression, and Support Vector Machine—to automatically classify water quality. Experimental results show that Logistic Regression provides the best performance for drinking water classification, while Support Vector Machine performs better for irrigation suitability assessment. Additionally, Recursive Feature Elimination is used to identify the most influential water quality parameters that affect classification accuracy. By combining IoT-based sensing, wireless communication, and machine learning, WaterNet AI provides a scalable, automated, and efficient solution for real-time water quality monitoring and decision-making, helping communities, industries, and agricultural sectors manage water resources more effectively.

Keywords:Water Quality Monitoring, Machine Learning, WaterNet AI, Logistic Regression, Support Vector Machine (SVM), Random Forest, Water Quality Index (WQI), Irrigation Water Quality Index (IWQI), Data Preprocessing, Feature Selection, Recursive Feature Elimination (RFE), Predictive Analytics, Real-time Water Analysis, Environmental Monitoring Systems.

1. INTRODUCTION

Water is one of the most essential natural resources required for the survival of humans, animals, and plants. Access to clean and safe water plays a crucial role in maintaining public health, supporting agriculture, and sustaining ecosystems. However, due to rapid industrialization, urbanization, mining activities, and environmental pollution, the quality of water in many regions has been significantly affected. Contaminated water can lead to serious health problems and environmental damage, making it necessary to continuously monitor and assess water quality.

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Traditionally, water quality assessment involves collecting water samples from different sources and analyzing them in laboratories using physical, chemical, and biological tests. Although these methods provide accurate results, they are time-consuming, expensive, and require specialized equipment and trained personnel. In many cases, the results are not available in real time, which makes it difficult to quickly detect and respond to water contamination. Therefore, there is a need for an efficient system that can continuously monitor water quality and provide fast and reliable results.

With the advancement of technologies such as the Internet of Things (IoT), cloud computing, and machine learning, it has become possible to develop intelligent systems for monitoring environmental conditions. These technologies allow sensors to collect water quality parameters such as pH, turbidity, conductivity, hardness, and dissolved solids directly from water sources. The collected data can then be transmitted to a cloud platform where it can be analyzed using machine learning algorithms to determine whether the water is suitable for drinking or irrigation purposes.

WaterNet AI is a smart water monitoring and assessment system designed to address these challenges. The system integrates sensor-based data collection with machine learning models to automatically analyze water quality parameters and classify water samples based on their suitability for consumption or agricultural use. Machine learning algorithms such as Random Forest, Logistic Regression, and Support Vector Machine are used to evaluate the collected data and predict water quality more efficiently than traditional methods. 2 Furthermore, WaterNet AI provides a centralized platform where administrators can monitor datasets, train models, and analyze prediction results, while users can access the system to check water quality predictions.

By combining real-time data collection, wireless communication networks, and intelligent data analysis, the proposed system provides an efficient and scalable solution for water quality monitoring.The primary objective of the WaterNet AI system is to improve water resource management by enabling continuous monitoring, accurate prediction, and early detection of water quality issues. This helps governments, industries, farmers, and communities make better decisions regarding water usage, ensuring safe drinking water and sustainable agricultural practices.

2. Literature Survey

The evolution of water quality monitoring systems has progressed significantly over the years, driven by advancements in environmental science, wireless communication, and machine learning technologies. In earlier studies, traditional monitoring approaches focused on collecting water samples from different locations and analyzing physico-chemical parameters such as pH, dissolved solids, turbidity, and heavy metals using laboratory-based methods. Around the early 2000s, researchers implemented monitoring networks in regions like Brazil and Mozambique, where multiple stations were used to collect water quality data, which was then analyzed using statistical techniques such as Principal Component Analysis (PCA). However, these methods were time-consuming and lacked real-time monitoring capabilities.

During the mid-2010s, research shifted towards optimizing monitoring systems using computational techniques. Approaches such as Genetic Algorithms were used to determine the optimal placement of monitoring stations and improve sampling efficiency. Although these methods enhanced system performance and reduced operational costs, they were mostly limited to simulation environments and did not support intelligent decision-making for water quality classification.

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With the advancement of wireless communication technologies, particularly between 2015 and 2020, Low Power Wide Area Network (LPWAN) technologies such as LoRa, SigFox, and Ingenu were introduced for environmental monitoring applications. These technologies enabled long-range, low-power data transmission, making them suitable for water quality monitoring in remote areas. Among these, LoRa gained popularity due to its balance of range, energy efficiency, and scalability. Researchers also validated simulation tools like Radio Mobile and NS3 by comparing simulation results with real-world implementations, proving their effectiveness.
Between 2020 and 2023, the use of Water Quality Index (WQI) and Irrigation Water Quality Index (IWQI) became more prominent for evaluating water suitability. These indices simplified the assessment process by combining multiple parameters into a single value. However, they relied heavily on manual calculations and were not efficient for handling large datasets or providing automated predictions.

In recent years (2022–2025), machine learning techniques such as Random Forest, Support Vector Machine (SVM), Artificial Neural Networks (ANN), and Logistic Regression have been widely applied to water quality prediction. These models improved accuracy and enabled automated classification of water suitability. However, many systems still lacked proper data preprocessing, feature selection, and integration with real-time monitoring technologies.Overall, existing approaches either focus on traditional monitoring, communication efficiency, or machine learning-based prediction individually, but fail to provide a fully integrated solution. This creates a need for a unified system like WaterNet AI, which combines data preprocessing, machine learning models, IoT-based monitoring, and intelligent analysis to provide an automated, scalable, and real-time water quality assessment system.

3. Proposed System

The proposed system, WaterNet AI, is a smart water quality monitoring and prediction system designed to determine whether water is suitable for drinking or irrigation. The system collects important water parameters such as pH, hardness, dissolved solids, chloramines, sulfate, conductivity, organic carbon, trihalomethanes, and turbidity from datasets or monitoring sources. These parameters are processed using data preprocessing and labeling techniques to prepare the data for analysis. Machine learning algorithms such as Random Forest, Logistic Regression, and Support Vector Machine are then used to train models and classify water quality. The system automatically predicts whether the water is safe or unsafe based on the analyzed parameters and displays the results to users through a user-friendly interface. This approach provides a more efficient and intelligent solution for water quality monitoring and assessment.

These parameters are preprocessed and used to train machine learning models. The system provides automated predictions through a web-based interface.

Advantages

- Automated water quality prediction
- Reduced manual effort
- Faster and accurate analysis
- Scalable for large datasets
- Cost-effective solution

4. Methodology

1. Data Collection

The system follows a modular architecture consisting of key components such as the User Interface Module, Machine Learning Module, and Database Module. Water quality datasets are collected from multiple

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sources and stored in CSV format. These datasets include important parameters such as pH, hardness, solids, chloramines, sulfate, conductivity, organic carbon, trihalomethanes, and turbidity, which are essential for analyzing water quality.

2. Data Preprocessing and Labeling

Before applying machine learning algorithms, the collected data is preprocessed to improve its quality and consistency. This includes handling missing values, normalization, and feature scaling. The data is then labeled using Water Quality Index (WQI) and Irrigation Water Quality Index (IWQI) standards to classify water as suitable or unsuitable for drinking and irrigation purposes.

3. Machine Learning Model Implementation

The system implements multiple machine learning algorithms such as Random Forest, Logistic Regression, and Support Vector Machine (SVM) to classify water quality. These models are trained using preprocessed datasets and evaluated based on accuracy and performance. Logistic Regression performs best for drinking water prediction, while SVM shows better results for irrigation suitability

4. Feature Selection (RFE)

To improve model efficiency and reduce complexity, Recursive Feature Elimination (RFE) is applied. This technique identifies the most significant water quality parameters that influence prediction accuracy by removing less important features iteratively.

5. System Implementation (Web-Based Application)

The system is developed as a web-based application using Python and the Django framework. The User Interface allows users to register, log in, input water parameters, and view prediction results. The backend processes user inputs and communicates with the machine learning module to generate predictions.

6. Prediction and Result Visualization

The system processes input parameters and predicts water quality using trained machine learning models. The results are displayed to users in a clear and interactive format, including prediction outputs, accuracy results, and visualization graphs such as bar charts and ratio analysis.

5. Proposed System Hardware Results

5.1. Interface and Working System

The system provides a user-friendly web-based interface designed for efficient interaction with the WaterNet AI platform. The interface allows users to securely log in using their credentials and access the system functionalities. It integrates features such as dataset processing, machine learning-based prediction, and result visualization within a single platform. The system processes user inputs and performs water quality prediction using trained machine learning models, ensuring accurate and fast results.

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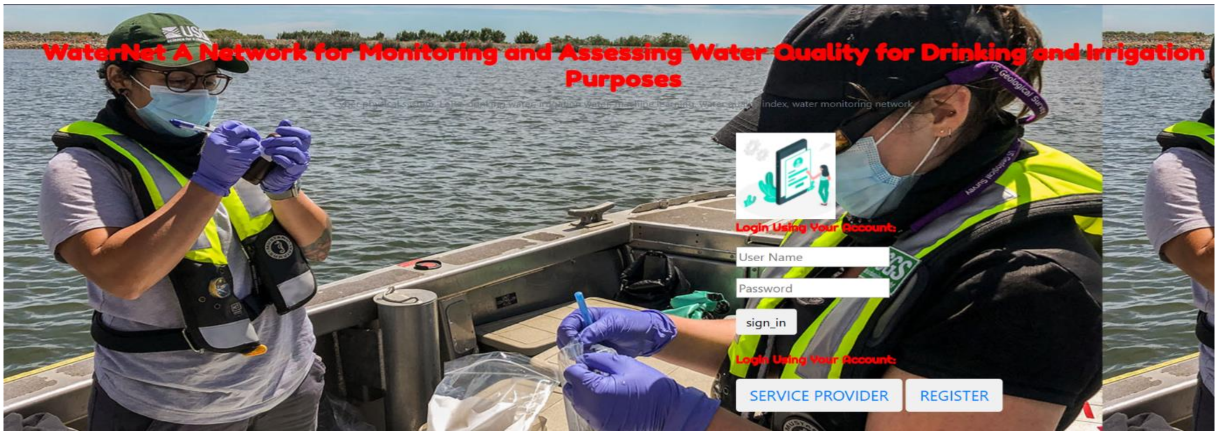

Fig:5.1 Interface of this project

5.2 Interface of the Project

The home interface of the system presents a modern and interactive dashboard titled "WaterNet: A Network for Monitoring and Assessing Water Quality for Drinking and Irrigation Purposes." It provides users with a clean and intuitive login interface to access system functionalities.

The homepage includes essential options such as:
- **User Login** (Username and Password authentication)
- **Service Provider Access** (Admin functionalities)
- **User Registration** (New user account creation)

he interface also includes an expandable overlay design, where users can switch between different modules without leaving their workspace. Additional components such as the Code Snippet Library and customizable settings enhance usability. This interface ensures easy accessibility, interaction, and improved productivity for developers.

5.3 User Registration Interface

The User Registration Interface allows new users to create an account in the WaterNet AI system. This module is designed to collect essential user details required for authentication and access to system functionalities. The interface provides a structured form where users can enter their personal and login information.

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Fig:5.3: User Registration Page

This interface enhances code reusability, improves organization, and provides flexibility by allowing users to personalize the system according to their preferences, thereby increasing overall productivity.

5.4 User Profile Interface

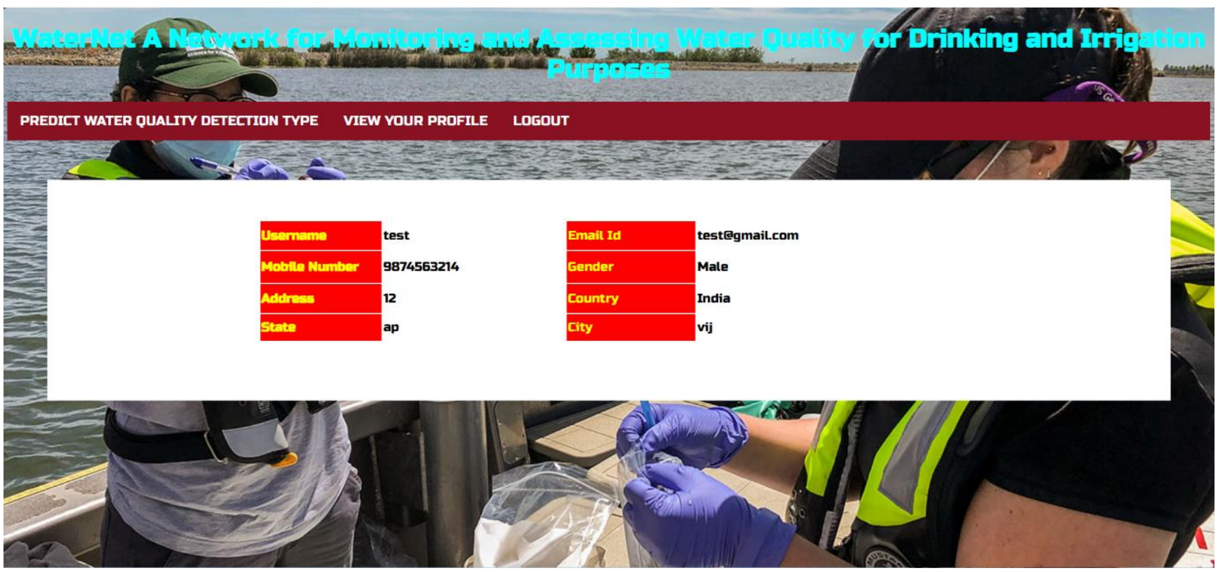

Fig:5.4 User Profile Page

The User Profile Interface allows registered users to view their personal information stored in the WaterNet AI system. This module provides a clear and organized display of user details after successful login. It ensures that users can verify their registered information and access system features efficiently.

The user profile page presents a structured dashboard where all registered user details are displayed in a readable format. The interface includes a navigation menu with options such as:

- Predict Water Quality Detection Type

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- View Your Profile
- Logout

5.5 Water Quality Prediction Interface

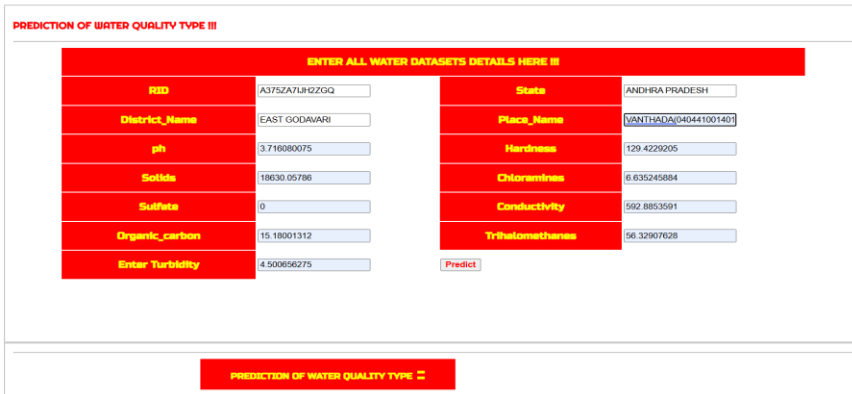

Fig:5.5 Water Quality Prediction page

The Water Quality Prediction Interface enables users to input water parameter values and predict the quality of water using machine learning algorithms. This module is one of the core components of the WaterNet AI system, where users can analyze whether water is suitable for drinking or irrigation purposes.

5.6 Water Quality Prediction Result Interface

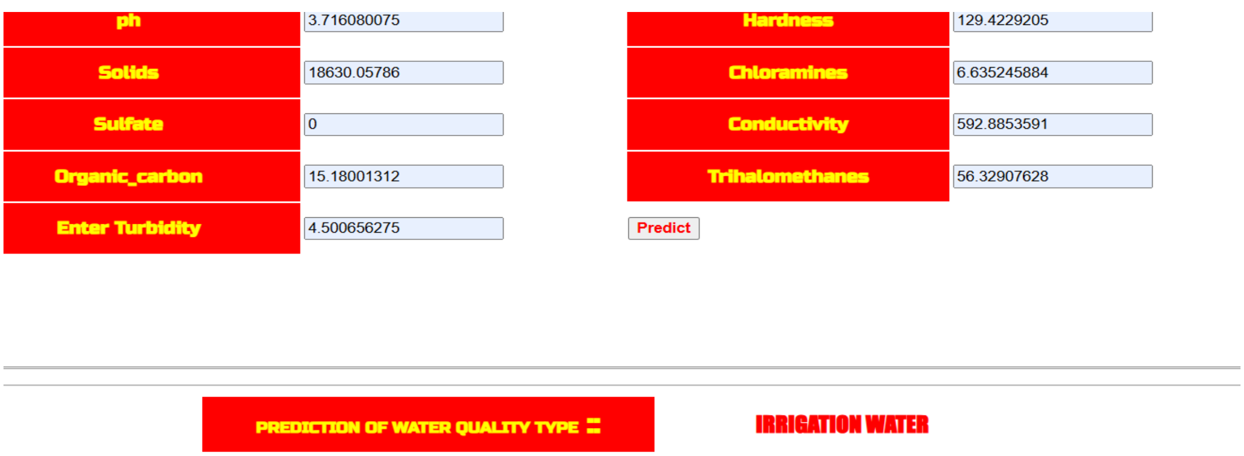

Fig:5.6 Prediction Result Interface

The result page presents the output in a clear and highlighted format under the section titled "Prediction of Water Quality Type". After entering the required water parameters and clicking on the "Predict" button, the system analyzes the data using trained machine learning models and generates the prediction.

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6. CONCLUSION

WaterNet AI provides an intelligent and automated solution for water quality monitoring by integrating machine learning techniques with water parameter analysis. The system improves prediction accuracy, reduces manual effort, and enables faster decision-making for water suitability assessment. By combining data preprocessing, machine learning models, and user-friendly web interfaces, the system offers a scalable and efficient approach for managing water resources. This solution can significantly benefit communities, industries, and agricultural sectors by ensuring safe water usage and sustainable development.

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