AI-Powered Water Quality Detection and Purification Recommendation System Using Refactor Index

A PROJECT REPORT

submitted by

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to

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of

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in

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Department of Computer Science and Engineering

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Chittilappilly, Thrissur - 680 551

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DECLARATION

We undersigned hereby declare that the Project report (**”AI-Powered Water Quality Detection and Purification Recommendation System Using Refactor Index”**), submitted for partial fulfillment of the requirements for the award of degree of Bachelor of Technology of the APJ Abdul Kalam Technological University, Kerala is a bonafide work done by us under supervision of **Ms.Meethu M B**. This submission represents our ideas in our own words and where ideas or words of others have been included, we have adequately and accurately cited and referenced the original sources. We also declare that we have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in our submission. We understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title of any other University.

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This is to certify that the report entitled **"AI-Powered Water Quality Detection and Purification Recommendation System Using Refactor Index"** submitted by **ABIN SANTHOSH (IES22CS006), ADHITH SUNIL (IES22CS007) , ADHWAITH T T (IESS22CS008), ANITTA RAPHI E (IES22CS025)** to the **APJ Abdul Kalam Technological University** in partial fulfilment of the requirements for the award of the Degree of **Bachelor of Technology in Computer Science and Engineering** is a bonafide record of the seminar work carried out under my guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

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ABSTRACT

The proposed project introduces a smart water quality detection and purification recommendation system powered by artificial intelligence. The system uses sensors such as pH, turbidity, temperature, and dissolved oxygen to collect water data in real time. An ESP32 microcontroller with Wi-Fi and Bluetooth processes the readings and calculates a Refactor Index (RI), a single score that classifies water as “Good,” “Moderate,” “Poor,” or “Unsafe.” Results are displayed on an OLED screen and shared with users through a mobile application.Based on the RI score, the system also suggests suitable purification methods such as boiling, filtration, or UV treatment. This solution is low-cost, portable, and eco-friendly, making it useful for households, rural communities, aquaculture, and agricultural applications. By integrating AI and IoT technologies, the project ensures real-time monitoring, reduces health risks, and promotes sustainable water management.

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CHAPTER 1

INTRODUCTION

Water quality assessment has traditionally relied on laboratory-based chemical and biological tests, where samples are collected and analyzed to determine parameters such as pH, turbidity, and dissolved oxygen. While accurate, these methods are time-consuming, costly, and impractical for real-time monitoring, especially in rural or resource-constrained settings. Manual inspection or delayed testing often results in inconsistent evaluations and late detection of contamination, leading to health risks, waterborne diseases, and reduced trust in water sources. Such limitations also pose challenges for industries, agriculture, and aquaculture, where reliable water quality is critical for efficiency and safety. With the rising demand for clean water and growing environmental concerns, there is a pressing need for a low-cost, portable, and automated water quality monitoring system.

To address these challenges, the proposed project introduces an AI-powered water quality detection and purification recommendation system. The system integrates commonly available sensors, such as pH, turbidity, temperature, and dissolved oxygen, connected to an ESP32-WROOM-32 microcontroller. Data collected from the sensors is processed into a composite score known as the Refactor Index (RI), which simplifies water quality assessment by classifying results into categories: Good, Moderate, Poor, or Unsafe. The results are displayed on an OLED screen and shared via a mobile application, enabling users to easily monitor water quality in real time. Based on the RI score, the system also suggests appropriate purification techniques, including boiling, filtration, or UV treatment.

By leveraging artificial intelligence and Internet of Things (IoT) technologies, the system provides a reliable, efficient, and scalable solution for water quality management. It offers significant benefits for households, rural communities, and industries by enabling instant access to water safety information. Moreover, its solar-powered, eco-friendly design supports sustainable practices, reduces dependency on traditional testing methods, and minimizes health risks associated with contaminated water. In doing so, the proposed project demonstrates how smart technology can play a pivotal role in ensuring safe water access, environmental protection, and improved quality of life.

1.1 Overview

The proposed model introduces an AI-powered water quality detection and purification recommendation system that leverages the Refactor Index (RI) to provide real-time, accurate, and actionable insights for both communities and industries. The RI is a composite index (0–100) derived from parameters such as turbidity, pH, and dissolved oxygen, offering a simplified yet reliable measure of water quality. This model is powered by an ESP-32 SoC microprocessor, integrated with sensors (pH, temperature, turbidity, DO), and supported by a solar energy supply, making it a sustainable and low-maintenance solution.Once data is collected, the system calculates the RI, categorizing water into levels such as "Good," "Moderate," "Poor," or "Unsafe." Alongside detection, the AI-driven module suggests appropriate purification methods—for example, filtration, aeration, or chemical treatment based on the identified contamination profile. To ensure accessibility, results are displayed locally on an OLED screen and transmitted remotely via WiFi or Bluetooth to a user-friendly Android application, where individuals receive instant quality status updates and recommendations.For households and consumers, this system provides an easy, affordable tool to ensure safe drinking water and reduce health risks. For municipalities, aquaculture, and agricultural enterprises, it acts as a real-time monitoring and decision-support mechanism, improving efficiency, reducing testing delays, and enabling proactive water management. By combining IoT, AI, and renewable energy, the system represents a step toward sustainable and intelligent water governance, minimizing reliance on manual inspections and laboratory tests. With future expansions—such as integration of additional parameters (TDS, EC, heavy metals), cloud-based predictive analytics, and smart purification units—this approach showcases how artificial intelligence can transform environmental monitoring and contribute to global goals of health, sustainability, and resource conservation.

1.2 Significance of Study

The assessment of water quality has traditionally relied on manual testing and laboratory analysis, which are often time-consuming, costly, and inaccessible for real-time monitoring. These limitations can result in delayed interventions, unsafe consumption, and ineffective management of water resources. With increasing concerns about public health, sustainability, and the need for efficient water management, there is a pressing demand for reliable and automated solutions. This study addresses the problem by proposing an AI-powered system that uses the Refactor Index (RI) to evaluate water quality in real time and provide suitable purification recommendations. By integrating IoT-based sensors, solar-powered operation, and a user-friendly Android application, the model offers an objective and standardized method for monitoring water safety. The solution benefits households by ensuring access to clean drinking water, while supporting farmers, industries, and municipalities in making informed water management decisions. Thus, the significance of this study lies in presenting a practical, scalable, and sustainable approach that not only improves water quality assessment but also reduces health risks, promotes resource efficiency, and contributes to environmental sustainability.

CHAPTER 2

RELATED WORKS

2.1 IoT-Based Smart Water Quality Monitoring System

Prasad, Gokhale, and Patil (2022) propose an IoT-enabled water quality monitoring system using pH, turbidity, and temperature sensors connected to an Arduino microcontroller. The data is transmitted to a cloud server for visualization and remote monitoring. While the system demonstrates effective sensor integration and real-time data collection, it lacks an intelligent water quality index or purification recommendation, limiting its scope to raw data monitoring without actionable insights.

2.2 Water Quality Index (WQI) Calculation Using IoT Sensors

Kaur and Sharma (2023) introduce an IoT-based framework for calculating the Water Quality Index (WQI) using parameters such as pH, turbidity, and dissolved oxygen. The system computes a numerical score to categorize water quality, making it more user-friendly than raw sensor outputs. However, the WQI model remains static, without AI-driven adaptability or purification guidance, reducing its effectiveness for practical decision-making in households or industries.

2.3 AI-Based Water Quality Prediction Using Machine Learning

Singh et al. (2023) present a machine learning-based water quality prediction system that uses historical datasets of chemical and physical water parameters. Their work employs classifiers such as Random Forest and SVM to predict contamination levels. Although the system achieves high accuracy, it depends heavily on offline datasets and lacks real-time IoT integration, making it unsuitable for continuous field deployment and instant user feedback.

2.4 Low-Cost Portable Water Quality Testing Device

Rajalakshmi and Kumar (2021) design a portable device for water testing that measures turbidity, electrical conductivity, and total dissolved solids (TDS). The device emphasizes affordability and portability for rural areas. However, it does not utilize advanced AI models or provide purification recommendations, limiting its functionality to parameter measurement rather than decision support.

2.5 AI-Enabled Decision Support System for Water Treatment

Zhang, Li, and Huang (2024) propose an AI-enabled decision support system for recommending water treatment methods based on contamination levels. The approach integrates machine learning with water chemistry rules to guide users on filtration, aeration, or chemical treatment. While promising, the system is designed for industrial-scale applications and lacks IoT sensor integration or solar-powered portability, restricting its usability for household and small community contexts.

2.6 IoT-Based Real-Time Water Monitoring with Mobile Alerts

Reddy and Thomas (2022) develop an IoT water monitoring system that sends real-time SMS and mobile app alerts based on threshold values of pH and turbidity. This improves user awareness and accessibility. However, the model employs only simple thresholding techniques without a composite index or intelligent purification recommendations, making it less adaptive and scalable for diverse water quality conditions.

2.7 Smart Water Quality Monitoring Using Cloud and Big Data Analytics

Ahmed, Bose, and Rani (2023) propose a cloud-integrated water quality monitoring framework where IoT sensors collect parameters such as turbidity, pH, and dissolved oxygen, and the data is processed using big data analytics platforms. The system provides advanced visualization and trend analysis. However, it is heavily dependent on continuous internet access and high computational resources, making it less suitable for rural or off-grid communities where portability and cost-effectiveness are crucial.

2.8 AI-Powered River Water Quality Assessment Using Deep Learning

Chen, Wang, and Zhou (2024) introduce a deep learning-based system for predicting river water quality using satellite imagery and sensor data. The approach applies convolutional neural networks (CNNs) to detect patterns in pollution spread and forecast contamination risks. While effective for large-scale environmental monitoring, the model lacks direct sensor-to-user interaction and real-time purification recommendations, limiting its applicability for household or small-scale water safety solutions.

CHAPTER 3

SYSTEM DEVELOPMENT

3.1 Proposed System

The proposed system is an AI-powered water quality monitoring and purification recommendation system that analyzes water parameters in real time. It uses sensors such as pH, turbidity, temperature, and dissolved oxygen to collect data, which is processed by an ESP32-WROOM-32 microcontroller. The system calculates a Refactor Index (RI) — a single, easy-to-understand score that classifies water as Good, Moderate, Poor, or Unsafe. Results are displayed instantly on an OLED screen and shared via a mobile application using Wi-Fi or Bluetooth connectivity. Based on the RI score, the system provides intelligent purification recommendations, such as boiling, filtration, or UV treatment. Designed to be low-cost, portable, and solar-powered, it ensures accessibility in both urban and rural areas. By integrating AI and IoT technologies, the system delivers accurate, automated, and eco-friendly water assessment—reducing dependence on manual testing. It promotes real-time monitoring, public health, and sustainable water management, offering a smarter approach to safe water access.

3.2 System Architecture and Methodology

Input: The system primarily takes real-time data from multiple water quality sensors, including pH, turbidity, temperature, and dissolved oxygen sensors. These sensors are connected to the ESP32-WROOM-32 microcontroller, which collects and transmits readings wirelessly. The data represents the physical and chemical characteristics of the water, forming the input base for analysis.

Output: The output of the system is a Refactor Index (RI) score that classifies the water quality into four categories—Good, Moderate, Poor, or Unsafe. In addition, the system provides purification recommendations such as boiling, filtration, or UV treatment, helping users take immediate corrective actions. The results are displayed on an OLED screen and shared with users through a mobile application for easy access.

Data Processing and AI Integration: At the core of the system lies an AI-based analytical module that processes sensor data to compute the Refactor Index (RI). The module normalizes readings, removes noise, and applies a trained model or threshold-based algorithm to generate reliable water quality predictions. By integrating artificial intelligence, the system ensures accurate and consistent assessment, even under varying environmental conditions.

Refactor Index Calculation: The RI is computed using a composite equation that combines sensor values such as turbidity, pH deviation, and dissolved oxygen ratio. Each parameter contributes to the overall water quality score, ensuring a multidimensional and precise representation. The RI ranges from 0–100, where higher values indicate better water quality. This numerical approach simplifies complex data into an easy-to-understand metric for users.

System Pipeline: The operational pipeline of the proposed system is designed to ensure seamless, real-time monitoring and intelligent decision-making for water quality management. The process starts at the sensor layer, where multiple water quality parameters such as turbidity, pH level, and dissolved oxygen are continuously measured from the water source. These sensors act as the foundation of the system, providing raw, real-time environmental data. Once the data is collected, it is transmitted to the ESP32 microcontroller, which serves as the processing unit. The ESP32 plays a crucial role in cleaning and organizing the sensor data by applying preprocessing techniques such as noise filtering, normalization, and feature extraction. After the data is refined, the microcontroller calculates the Refactor Index (RI), a numerical value that reflects the overall quality of the water. This RI score is then used to classify the water quality into categories like Good, Moderate, Poor, or Unsafe.Once the classification is complete, the system transitions to the output and communication layer. The processed data and the corresponding RI category are displayed on an OLED screen, allowing users to view results on-site instantly. Simultaneously, the same data is transmitted wirelessly through Wi-Fi or Bluetooth to a connected mobile application, making the results easily accessible even from remote locations.

User Interface (UI): A user-friendly mobile application serves as the front-end interface, allowing users to view real-time water quality results and suggested purification methods. The interface is designed for simplicity, ensuring that users with minimal technical knowledge can operate it effortlessly. Notifications and visual indicators (such as color codes) enhance clarity and usability.

Backend and Deployment: The backend consists of the ESP32-WROOM-32 microcontroller integrated with sensors and powered by a solar module for sustainable operation. The communication between hardware and software occurs via IoT protocols, ensuring seamless real-time data transfer. The system is scalable and adaptable for integration into community water systems, industrial monitoring, or smart home applications, making it versatile and cost-effective.

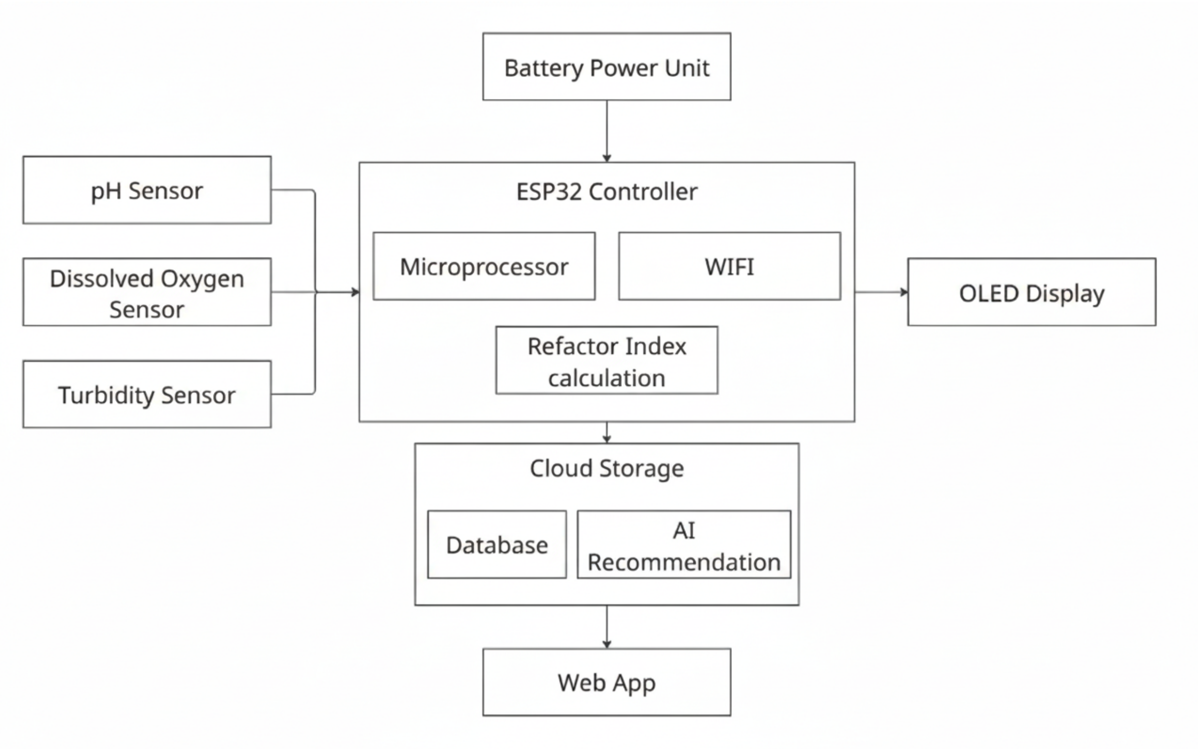

Figure 3.1: Proposed system methodology

3.3 Advantages

- **High Accuracy in Water Quality Detection:** The system employs an AI-powered model based on the Refactor Index (RI), integrating parameters such as pH, turbidity, dissolved oxygen, and refractive index to deliver precise and reliable assessments of water quality.
- **Real-Time Monitoring:** Using ESP32 microcontroller and IoT-enabled sensors, the system provides instant readings and continuously updates water quality data, ensuring immediate awareness of contamination levels.
- **Smart Purification Recommendations:** The integrated AI module analyzes water parameters and suggests the most effective purification methods such as filtration, UV treatment, or chemical disinfection based on detected impurities.
- **User-Friendly and Accessible:** The system features a mobile application and OLED display interface, allowing users with minimal technical knowledge to easily monitor

water quality and receive purification advice.

- **Eco-Friendly and Sustainable:** Powered by solar energy, the system promotes environmental sustainability and can operate in off-grid or remote locations without dependence on external power sources.
- **Low-Cost and Portable:** Built using affordable components like ESP32, laser diode, and photodetector modules, the system provides a cost-effective solution suitable for homes, farms, and small industries.
- **Cloud Connectivity and Data Logging:** Through Firebase integration, all sensor data and computed RI values are stored and visualized in real time, enabling remote monitoring and long-term analysis.
- **Scalability and Flexibility:** The model can be expanded to include additional parameters such as TDS, conductivity, and temperature, and scaled for use in smart cities, rural communities, or industrial water management.
- **Health and Safety Assurance:** By enabling early detection of poor-quality or unsafe water, the system helps reduce waterborne diseases and supports safe water consumption for households and communities.

3.4 Existing System

The current methods of water quality assessment are largely manual and laboratory-based, relying on chemical, biological, or physical analysis of collected samples. Although these methods provide accurate results, they are time-consuming, expensive, and unsuitable for real-time monitoring. In many regions, especially rural and developing areas, water testing is performed infrequently, which delays contamination detection and increases health risks. This dependency on manual testing and human interpretation often leads to inconsistent evaluations and limited access to safe water information.

3.4.1 Limitations of the Existing System:

Manual and Time-Consuming Process: Traditional water testing requires collecting samples and transporting them to laboratories for detailed analysis, which may take several hours or even days, delaying timely action.

High Cost and Resource Dependency: Laboratory testing involves specialized equipment, chemical reagents, and trained personnel, making frequent testing impractical and expensive for small communities or households.

Lack of Real-Time Monitoring: Conventional systems do not provide continuous tracking of water quality parameters, meaning sudden contamination events often go undetected until significant harm has occurred.

Limited Accessibility: In many rural or remote areas, access to testing facilities is minimal, forcing communities to rely on assumptions or outdated data regarding water safety.

No Automated Analysis or Recommendations: Current systems only generate numerical data without offering automatic evaluation or purification guidance. Users must interpret technical readings manually, which is challenging for non-specialists.

Error-Prone and Inconsistent: Manual sampling, handling, and record-keeping introduce human error, leading to inconsistent results or incorrect assessments of water safety levels.

Environmental Concerns: Frequent chemical-based testing produces waste materials and consumes significant resources, making it less sustainable for continuous monitoring.While some IoT-based and digital monitoring systems have been developed, most are limited to single-parameter detection or require complex configurations. None provide a comprehensive, AI-driven, and real-time solution that can both assess water quality accurately and recommend purification methods for immediate corrective action

3.5 Requirement Specification

3.5.1 Hardware Requirements

Processor: ESP32-WROOM-32 Microcontroller A dual-core processor with integrated Wi-Fi and Bluetooth is used for real-time data acquisition, computation of the Refactor Index (RI), and wireless communication with the mobile application.

Sensors: pH Sensor, Turbidity Sensor, Temperature Sensor, Dissolved Oxygen (DO) Sensor These sensors collect water parameters such as acidity, clarity, temperature, and oxygen concentration to evaluate overall water quality.

Display: 0.96-inch OLED Display Module Used for showing real-time Refactor Index values, water status (Good, Moderate, Poor, Unsafe), and purification suggestions.

Power Supply: Solar Panel with Rechargeable Battery A renewable power source ensures portability, sustainability, and continuous operation even in remote locations.

Connectivity: Built-in Wi-Fi / Bluetooth Module Enables wireless data transmission from the ESP32 microcontroller to the mobile application for remote monitoring and updates.

Additional Components: Breadboard, Jumper Wires, Voltage Regulator Used for prototyping, power stability, and interconnecting various hardware components.

3.5.2 Software Requirements

Front-end: Android Studio (Java/Kotlin) The mobile application is developed using Android Studio to provide users with real-time water quality results and purification recommendations through an intuitive interface.

Back-end / AI Integration: Python with TensorFlow / Scikit-learn AI algorithms are implemented to process sensor data and calculate the Refactor Index (RI). The backend logic interprets readings and triggers suitable purification suggestions.

Languages: Python, C/C++, Java, Kotlin Python is used for AI model development, C/C++ for programming the ESP32, and Java/Kotlin for mobile app development and integration.

Tools Frameworks: – Arduino IDE: For coding and flashing the ESP32 microcontroller. – Android Studio: For mobile app development and debugging. – TensorFlow / Scikit-learn: For machine learning model training and integration. – ThingSpeak or Firebase: For optional cloud data storage and visualization.

Operating Environment: Compatible with Android OS (version 8.0 and above) and supports IoT connectivity via Wi-Fi and Bluetooth.

3.5.3 Functional Requirements

Sensor Data Collection: The system must accurately collect real-time readings from pH, turbidity, temperature, and DO sensors to assess water quality.

Refactor Index (RI) Calculation: The ESP32 should process sensor inputs to compute the Refactor Index (RI) that classifies water as Good, Moderate, Poor, or Unsafe.

Purification Recommendation: Based on the RI score, the system must suggest appropriate purification methods such as boiling, filtration, or UV treatment.

Data Transmission: The system should transmit computed results wirelessly to the mobile application using Wi-Fi or Bluetooth.

User Interface (UI): The app should clearly display RI values, water condition, and recommended purification steps in a simple and easy-to-understand format.

Real-Time Monitoring: Users should receive instant water quality updates, ensuring quick action against unsafe or contaminated water.

Data Logging: The system should optionally record previous readings for trend analysis and long-term monitoring.

3.5.4 Non-Functional Requirements

Performance: The system must deliver water quality results within 2–3 seconds of data acquisition and ensure continuous monitoring with minimal delay.

Scalability: The system should support additional sensors (e.g., TDS, conductivity) and be easily upgradable for future AI model improvements or cloud integration.

Security: Data transmission between the ESP32 and mobile app must be secure, ensuring that sensor data and user information are protected from unauthorized access.

Usability: The mobile app should be intuitive and accessible for non-technical users, with clear visual indicators (e.g., color codes) for different water quality levels.

Reliability: The hardware and software must maintain consistent operation in varied environments, including temperature or pH fluctuations, ensuring accurate and stable results.

Maintainability: The system should allow easy sensor calibration, firmware updates, and AI model retraining for long-term usability.

Portability: Designed to be compact and lightweight, the system must function efficiently in field conditions, powered by solar energy or battery backup.

CHAPTER 4

SYSTEM LEVEL DESIGN

4.1 Level 0

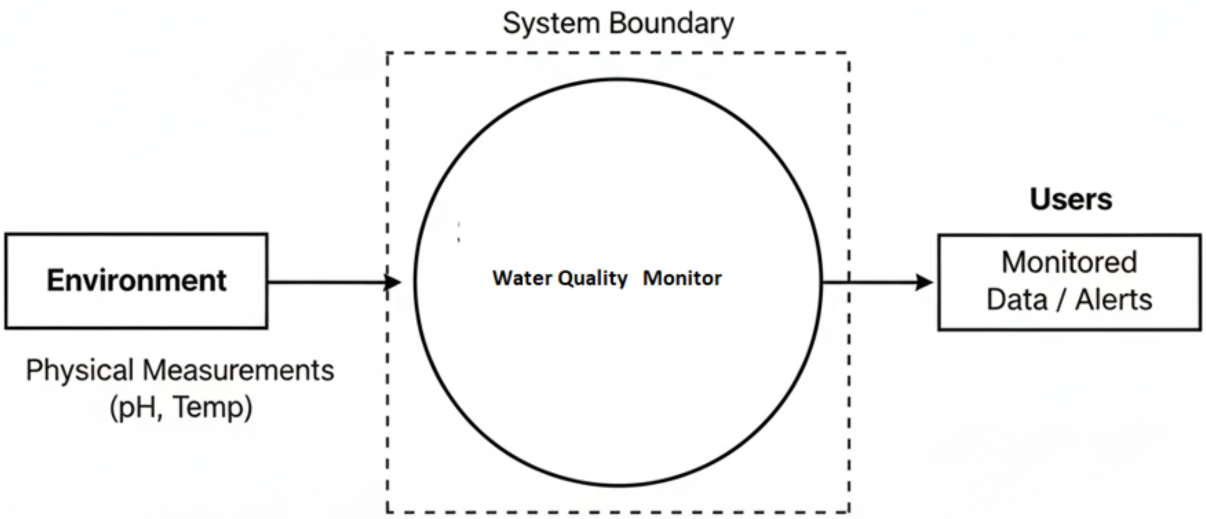

Figure 4.2: Level 0

- **Environmental Input:** This is the initial stage of the system where physical measurements such as *pH level* and *temperature* are collected directly from the surrounding water environment. These measurements serve as the primary input to the water quality monitoring system. The data may vary due to environmental factors such as time of day, location, and seasonal changes.
- **Water Quality Monitor:** This represents the core processing unit within the system boundary. The collected measurements are analyzed to determine water quality levels.

The system processes sensor data, filters noise, and applies predefined thresholds or AI-based algorithms to detect anomalies. It continuously monitors parameters and evaluates whether they fall within acceptable environmental standards. If any deviation or contamination is detected, the system generates alerts in real-time.

- **Output to Users:** The final output provides *monitored data* and *alert notifications* to the end users. These results are displayed through a user interface such as a mobile app or dashboard. Users can view current water conditions, track historical trends, and receive instant alerts about unsafe water quality levels, enabling timely actions for safety and maintenance.

4.2 Level 1

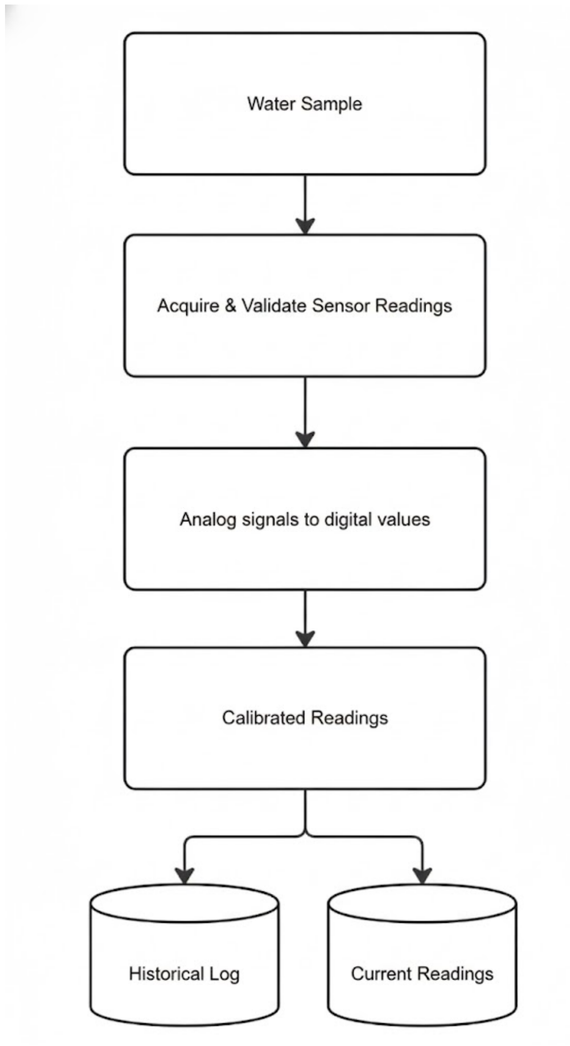

Figure 4.3: Level 1

- **Water Sample:** The process begins with collecting a water sample from a designated source such as a river, reservoir, or treatment plant. This sample represents the input to the monitoring system and contains physical and chemical parameters that need to be analyzed.
- **Acquire & Validate Sensor Readings:** Sensors are deployed to measure key water quality parameters such as pH, turbidity, temperature, and conductivity. This module is responsible for acquiring data from multiple sensors and validating them to remove noise, handle missing values, and ensure accuracy. Validation checks are essential to confirm that the readings are within acceptable operational limits.
- **Analog Signals to Digital Values:** Most sensors output analog signals corresponding to the measured parameter. These signals are converted into digital values using an Analog-to-Digital Converter (ADC), enabling the system to process, store, and transmit the data in a digital form. This conversion forms the bridge between the physical and computational domains.
- **Calibrated Readings:** The raw digital values are then calibrated to ensure accuracy and consistency. Calibration involves applying correction factors or mathematical models to account for sensor drift, environmental effects, or manufacturing variations. The output from this stage represents precise and reliable water quality readings.
- **Historical Log:** This component stores all previously collected and calibrated readings in a database for long-term analysis. The historical log allows trend tracking, statistical evaluation, and comparison over different time periods. It plays an essential role in detecting gradual changes or anomalies in water quality.
- **Current Readings:** This module maintains the latest real-time calibrated readings obtained from the sensors. These readings are typically used for monitoring dashboards, alerts, or control decisions in water management systems. They reflect the most up-to-date state of water quality and can be visualized or transmitted to remote monitoring units.

4.3 Level 2

- **View Request:** The process begins when the user initiates a request to view the water quality status. This triggers the system to collect and display the latest information from the sensors.
- **Display Current Status:** The system fetches the most recent sensor data and presents an overview of current conditions such as pH, temperature, turbidity, and conductivity.

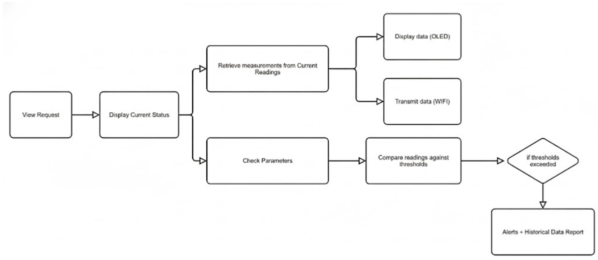

Figure 4.4: Level 2

- **Retrieve Measurements from Current Readings:** This module collects real-time data from sensors and prepares it for visualization and wireless transmission.
- **Display Data (OLED):** The acquired sensor readings are shown on the **OLED display** for local monitoring and quick reference by operators.
- **Transmit Data (Wi-Fi):** The same data is transmitted wirelessly to a central database or cloud server for remote access and analytics.
- **Check Parameters:** The system verifies that all required parameters are being received correctly and performs consistency checks to avoid data errors.
- **Compare Readings Against Thresholds:** Each parameter is compared with predefined **threshold values** to ensure water quality remains within safe limits.
- **If Thresholds Exceeded:** A conditional decision point that checks whether any parameter surpasses the permissible limits.
- **Alerts + Historical Data Report:** If limits are exceeded, the system generates **alerts** and stores the incident in the historical database for reporting and future analysis.

4.4 Level 3

- **Environment:** Provides Physical Measurements and the Refractive Index Model (D3), which are external inputs to the system.
- **D1: Current Readings (pH, Temp):** Stores the latest calibrated physical measurements.
- **D2: Historical Log:** Stores past data used as an input to derive thresholds.
- **D3: Thresholds:** Stores the acceptable limits for water quality parameters, often derived from historical data or regulatory standards.
- **Users:** Receives **D2: Historical / Alerts** and the overall **Monitored Data / Alerts** generated by the system.

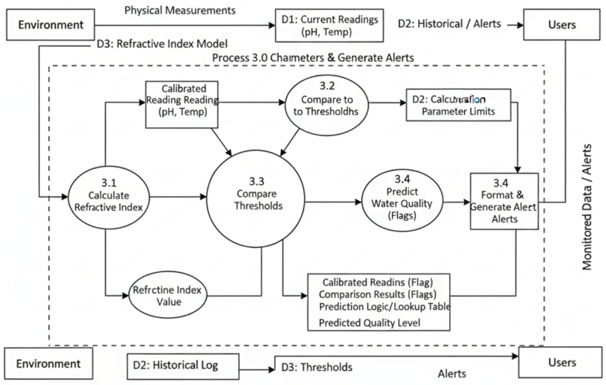

Figure 4.5: Level 3

- **Calculate Refractive Index:**
  - Takes the Calibrated Reading (pH, Temp) and the Refractive Index Model (D3) as input.
  - Calculates the Refractive Index Value.
- **Compare to Thresholds:**
  - Takes the Calibrated Reading (pH, Temp) and the derived (D3) as input.
  - Its output, D2, is used to feed into the Calculation Parameter Limits step.
- **Compare Thresholds:**
  - This is the central logic process. It receives data from Calculate Refractive Index and Compare to Thresholds.
  - Its primary role is to combine the physical measurements, the calculated refractive index, and the comparison results to determine if any violation has occurred.
  - Outputs include fCalibrated Readings (Flag), Comparison Results (Flags), Prediction Logic/Lookup Table, and the Predicted Quality Level.
- **Predict Water Quality (Flags):**
  - Uses the output from Compare Thresholds to assign a qualitative assessment (e.g., Good, Moderate, Poor) or a flag indicating the predicted water quality level.
- **Format & Generate Alert Alerts:**
  - Takes inputs from D2: Calculation Parameter Limits Predict Water Quality (Flags), and the outputs of Compare Thresholds.

- This final step compiles all necessary information to Format & Generate Alert Alerts, which are then delivered to the Users as Monitored Data / Alerts.

CHAPTER 5

CONCLUSION

The AI-Powered Water Quality Detection and Purification Recommendation System Using Refactor Index (RI) aims to overcome the limitations and inefficiencies of traditional water testing methods. Manual and laboratory-based techniques are often time-consuming, costly, and inaccessible for real-time use, especially in rural and resource-limited areas. By integrating artificial intelligence and IoT technology, the proposed system provides an automated, accurate, and real-time solution for monitoring water quality and ensuring safe consumption.The system leverages sensors such as pH, turbidity, temperature, and dissolved oxygen, connected to an ESP32-WROOM-32 microcontroller, to calculate a composite Refactor Index (RI) that classifies water as Good, Moderate, Poor, or Unsafe. Based on the RI score, the system provides suitable purification recommendations, including boiling, filtration, and UV treatment. This intelligent framework enables instant decision-making, empowering users to act quickly and effectively against water contamination.In addition to improving accuracy and accessibility, the project emphasizes sustainability, portability, and cost-effectiveness. Its solar-powered design and real-time IoT integration make it suitable for households, industries, and agricultural applications. With a user-friendly mobile interface and scalable architecture, the system demonstrates how AI can transform environmental monitoring and public health protection.The project contributes to the creation of a smart, reliable, and eco-friendly water quality management system. Future enhancements may include cloud data storage, predictive analysis, multi-sensor calibration, and voice-enabled notifications. With these improvements, the system can evolve into a comprehensive platform for continuous water quality assessment and management, promoting global access to clean and safe water while supporting the goals of sustainability and public well-being.

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5.1 Future Scope

The system demonstrates a strong foundation in real-time monitoring and recommendation. Future enhancements can focus on broadening its analytical depth, operational scale, and integration capabilities to serve industrial and governmental applications.

- **Integration of Advanced Sensor Types:**
  - Incorporate **biological and chemical sensors** (e.g., heavy metal, microbial, and dissolved organic carbon sensors) to detect contaminants beyond basic physical parameters, providing a more comprehensive water safety profile.
- **Implementation of Predictive Maintenance:**
  - Develop machine learning models to **forecast sensor drift, calibration needs, and component failure** within the monitoring unit, enabling proactive maintenance and ensuring continuous accuracy.
- **Real-Time Remediation Control:**
  - Integrate the system with **Automated Purification Units** (APUs). The AI-driven recommendations can be used to directly control purification processes (e.g., adjusting chemical dosing or filtration rates) in real-time without human intervention.
- **Edge Computing Deployment:**
  - Optimize the AI prediction model for **edge computing devices**. This would allow the system to perform complex water quality assessments and issue immediate local alerts without relying on constant cloud connectivity, significantly reducing latency.
- **Blockchain Integration for Data Integrity:**
  - Use **Blockchain technology** to securely log all sensor readings and AI-generated purity certifications. This ensures tamper-proof data traceability, crucial for regulatory compliance and public trust.

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