Project Proposal Format

Project Title: Water Quality Monitoring System

Team ID: 1

Team Members:

Sarah Roomi

Janya Kaushal Bhatt

Priyanka Agarwal

**Introduction:**

a. Explain the problem the project aims to solve or the opportunity it seeks to capitalize on.

Access to clean and safe drinking water is a fundamental necessity. Contaminated water can lead to serious health hazards, including waterborne diseases such as cholera, dysentery, and typhoid. Many drinking water sources, such as water coolers in hostels or mess kitchens, do not have continuous monitoring systems, making it difficult to detect contamination before consumption.

b. Describe the project's objectives and deliverables.

This project aims to develop a portable water quality monitoring system that can be attached to a drinking water source to measure key water quality parameters in real time. The system will:

* Utilize sensors to measure pH level, turbidity, Total Dissolved Solids (TDS), temperature, and volatile organic compounds (VOC).
* Implement a centralized dashboard for authorities to monitor real-time data, receive alerts for abnormal conditions, and manage water treatment actions.
* The system uses ESP32 to collect water quality data from multiple sensors and transmits it via bluetooth / NRF to a ThingsBoard (not sure that we will use this particular platform for dashboard might use another one) dashboard for real-time monitoring and alerts.
* An OLED display provides local readings, and if unsafe levels are detected, notifications are sent, and corrective actions (e.g., chemical dosing) are triggered automatically.
* Store and visualize historical data to analyze trends and detect anomalies.
* Use peristaltic pumps to dispense corrective chemicals when water quality deviates from safe thresholds.
* Perform failure analysis and calibration to ensure accuracy and reliability.
* Display real-time sensor readings on an OLED display for instant local monitoring without relying on internet connectivity.

**Hardware Requirements:**

a. List the required hardware components such as sensors, actuators, controllers, and other Devices.

b. Specify the quantities and series of each component that is required.

* Controllers
  + ESP32 - (1)
* Sensors
  + VOC Sensor - (1)
  + pH level - (1)
  + Turbidity - (1)
  + TDS - (1)
  + Temperature - (1)
* Actuators
  + Peristaltic Pump (4)
* Other Devices
  + OLED Display (1)
  + Relay Module (1)
  + NRF module (2) (if we used NRF for communication)
* Miscellaneous
  + Jumper Wires
  + Resistors
  + PCB

c. Explain why each component is needed and how it will contribute to the project's goals.

ESP32 – Acts as the central controller for processing and transmitting sensor data.

Table 1.1

| Sensor | Purpose |
| --- | --- |
| VOC Sensor | Detects volatile organic compounds that may indicate contamination. |
| pH Sensor | Measures acidity/alkalinity of water to detect unsafe conditions. |
| Turbidity Sensor | Detects cloudiness/clarity of water, highlighting contamination. |
| TDS Sensor | Determines dissolved solids concentration, indicating purity. |
| Temperature Sensor | Ensures water temperature is within safe limits for consumption. |

Table 1.2

| Parameter | Pump | Chemical Used | Expected Effect |
| --- | --- | --- | --- |
| pH > 8.5 (Too Alkaline) | Peristaltic Pump 1 | Diluted HCl or Citric Acid | Reduces pH to normal |
| pH < 6.5 (Too Acidic) | Peristaltic Pump 2 | Sodium Bicarbonate or Calcium Carbonate | Raises pH to normal |
| TDS > 500 ppm (Too High) | Peristaltic Pump 3 | Distilled Water or Deionization Resin | Reduces excess minerals |
| TDS < 50 ppm (Too Low) | Peristaltic Pump 4 | Calcium & Magnesium Mineral Solution | Adds minerals |

Note: TDS less than 50 is safe only. Lacks minerals but it is technically safe to consume.

d. Mention the details of the hardware features that you intend to implement.

OLED Display – Displays real-time sensor readings for local monitoring.

Cloud Integration – Stores sensor data, historical analysis and generates real-time visualizations. (ThingSpeak/Firebase/ThingsBoard/Blynk) (We are not 100% sure which of these we will use in the final implementation of the project yet)

Battery / Power Bank– Provides portability and ensures uninterrupted operation.

Relay Module – Controls peristaltic pumps based on sensor readings.

Jumper Wires, Resistors, PCB – Necessary for circuit assembly and connections.

**Data Collection Plan:**

a. Explain how you are planning to collect the data.

// Our system will use a cloud-based dashboard for real-time monitoring, with ThingsBoard as the primary option; however, the final platform may vary based on project requirements and feasibility, including alternatives like ThingSpeak or Firebase.

// The system will utilize wireless communication methods such as Bluetooth or NRF, though the final choice may vary based on project requirements and potential exploration of alternative technologies.

1. Data Collection from Sensors :

The system will use multiple sensors to measure water quality parameters in real-time. The ESP32 microcontroller will interface with these sensors to acquire data periodically.

1.) Sensors will be connected to ESP32 through analog/digital/GPIO/I2C interfaces depending on their type.  
2.) The ESP32 will read sensor values every 10 minutes (adjustable interval).  
3.) Error Checking: If a sensor reading is out of range or inconsistent, it will be flagged and re-measured.  
4.) Calibration: Each sensor will be pre-calibrated, and offset values will be stored in memory.

| Sensor | Parameters Required | Data Format |
| --- | --- | --- |
| Ph Sensor | Acidity / Alkalinity(0-14) | float |
| Turbidity sensor | Cloudiness (NTU) | integer |
| TDS sensor | Total dissolved solids (ppm) | integer |
| Temperature sensor | Temperature (degree c) | float |
| VOC sensor | Volatile organic compound | float |

## 2. Data Transmission for Cloud Integration & OLED Display :

### Cloud Integration (ThingsBoard via bluetooth / NRF)

* The ESP32 will transmit sensor data wirelessly via bluetooth / NRF to a cloud-based dashboard (ThingsBoard).
* Example of Data Packet Structure (Sent to ThingsBoard):

{

"timestamp": 1710215472,

"pH": 7.2,

"TDS": 350,

"Turbidity": 3.1,

"Temperature": 22.5,

"VOC": 0.02

}

* Advantage of using bluetooth / NRF:
  + Works in remote areas with no Wi-Fi.
  + Low power consumption for long-term monitoring.
  + Supports long-range communication (up to several kilometers).
  + If bluetooth / NRF is not available, the ESP32 will store data locally and send it later when the network is restored.

### OLED Display for Local Monitoring

* An OLED display will show real-time sensor readings locally.
* If water is unsafe, the display will flash warnings (e.g., “HIGH TDS – Unsafe Water”).
* Example of Displayed Information:

pH: 7.2 | TDS: 350ppm

Turbidity: 3.1 NTU

Temp: 22.5°C | VOC: 0.02

Status: SAFE

* Purpose of OLED?
  + Low power consumption.
  + Compact and easy to integrate.
  + Provides instant feedback without requiring cloud access.

## 3. Data Visualization & Insights on Dashboard :

### What the Dashboard Will Show?

The ThingsBoard dashboard will provide real-time monitoring, historical analysis, and alerts.

1) Real-time sensor values in a tabular and graphical format.  
2) Graphical Trends:

* Line graphs for pH, TDS, Turbidity, Temperature, and VOC levels over time.
* Comparison charts to detect long-term changes in water quality.

3) Alerts & Notifications:

* If a parameter crosses a threshold, an SMS or Email alert will be sent.

Example: “ALERT: High Turbidity detected (7.8 NTU) at Water Cooler #5!”

* If a parameter is unsafe, a peristaltic pump will dispense corrective chemicals.

Example: If pH is too low (<6.5), the system will add a neutralizing agent.

b. What are the possible outcomes you would like to infer from them?

Possible outcomes that can be inferred from the data collections are:

1. PH sensor data:

a)High PH: High PH level(>8.5) indicates that the water is alkaline.Very alkaline water can have an unpleasant smell or taste, and it can also damage pipes and water-carrying appliances.

b)Low PH: Low PH(<6.5) indicates that the water is acidic. It indicates that the water is most likely contaminated with pollutants and is unsafe to drink.

2. TDS sensor data:

a)High TDS level(>500 ppm) indicates contamination or the presence of harmful substances, alerting you to potential health risks associated with consumption.

b)Low TDS level(<50ppm) indicates lack of essential minerals in drinking water.

3. Turbidity sensor data:

High turbidity in water indicates the presence of a large amount of suspended particles, like silt, sediment, algae, or other debris, causing the water to appear cloudy or murky, which can be a sign of poor water quality.

4.Temperature sensor:

Water temperature indicates the potential for microbial growth, and the solubility of certain chemicals in the water, which all contribute to the overall quality of drinking water.

Higher temperatures can promote the growth of bacteria and other microorganisms, potentially impacting water quality and safety.

5. VOC sensor data:

High amount of VOCs in water indicates that the water might be toxic and unsafe to consume. Monitoring VOCs in drinking water is critical because even small concentrations can pose health risks, ranging from short-term symptoms like nausea to long-term effects like cancer depending on the specific VOC.

**Conclusion:**

a. Summarize the key points of the proposal and reiterate the project's objectives.

Ensuring access to clean and safe drinking water is crucial for public health. Many water sources, such as hostel water coolers and mess kitchens, lack continuous monitoring, making it difficult to detect contamination before consumption. This project aims to develop a smart water quality monitoring and correction system that can automatically detect and rectify water quality issues in real time. It is explained in detail below.

1 - The system continuously monitors water quality using five sensors:

* pH Sensor – Measures acidity or alkalinity.
* TDS Sensor – Measures total dissolved solids to ensure proper mineral balance.
* Turbidity Sensor – Checks water clarity (detects dirt or contamination).
* VOC Sensor – Detects harmful organic compounds.
* Temperature Sensor – Ensures water is within a safe temperature range.
* The ESP32 microcontroller reads data from these sensors and processes it in real time.

2 - The system performs automatic correction & sends user alerts if it detects any unsafe conditions

* If any parameter exceeds or drops below safe levels, the system takes corrective action using Peristaltic Pumps (actuators) which automatically dispense appropriate chemical solutions to restore safe drinking conditions, (Explained in detail in table 1.2)
* Example: If pH > 8.5, a pump dispenses diluted HCl or citric acid to lower it.
* Simultaneously, alerts are sent to the user via the Blynk app on their smartphone.

3 - Data Sent to Cloud for Remote Monitoring

* The ESP32 transmits water quality data to a cloud-based IoT platform such as:
  + ThingSpeak – Stores and analyzes sensor readings.
  + Firebase – Enables real-time database storage.
  + ThingsBoard – Provides remote monitoring dashboards.
* Users can view real-time and historical trends of water quality via graphs and reports.

### 4 - Data Displayed on OLED Screen

* The OLED display provides real-time readings on-site, allowing users to monitor water quality without needing Wi-Fi or cloud access.
* Key information displayed includes:
  + pH Level: Current acidity/alkalinity status.
  + TDS Level: Mineral concentration.
  + Turbidity, VOC & Temperature: Current water condition.

5 - Handling Low or No Wi-Fi Conditions

* If Wi-Fi is unavailable, the system will still function without internet:
* Bluetooth / NRF (Short-Range Communication) → Data is sent via Blynk app to a smartphone, which can upload it to the cloud when Wi-Fi is restored.
* A microcontroller (ESP32) processes the sensor data and displays real-time readings on an OLED screen for local monitoring.

Key Objectives

* Real-time water quality monitoring using IoT-enabled sensors.
* Automated correction mechanisms to ensure water remains safe.
* Data visualization and historical tracking via cloud integration.
* Mobile alerts for immediate action in case of unsafe conditions.
* Versatile communication options to function even without Wi-Fi

**Extra (Proposed Future Enhancements):**

In addition to the core features of the project, we are exploring several potential enhancements that may improve system performance and functionality. While these are not confirmed for the final implementation, they are mentioned as part of our project proposal for future development:

* GPS Mapping for Water Source Tracking:
  + Each water source (e.g., water cooler, tank, well) could be mapped with its safety status on a ThingsBoard dashboard.
  + Visual indicators will mark the status of each source:
  + ✅ Safe – Green marker
  + ⚠️ Unsafe – Yellow marker
  + ❌ Contaminated – Red marker
* Automated Chemical Dosing System:
  + We aim to develop a system that optimizes the dosage of corrective chemicals based on sensor readings, ensuring precise treatment without manual intervention.
* Predictive Analysis Using AI/ML:
  + We are exploring the use of machine learning models (e.g., linear regression) to predict potential water quality issues.
  + By analyzing patterns in historical data, the system may identify correlations (e.g., a rise in temperature linked to pH changes) to predict unsafe conditions before they occur.
* These features are ambitious additions that may be incorporated depending on time, resources, and project feasibility.