CLEAN WATER AND SANITATION

Smart Bio-Sand Filtration System with Real-Time Water Quality Monitoring

GROUP MEMBERS :-

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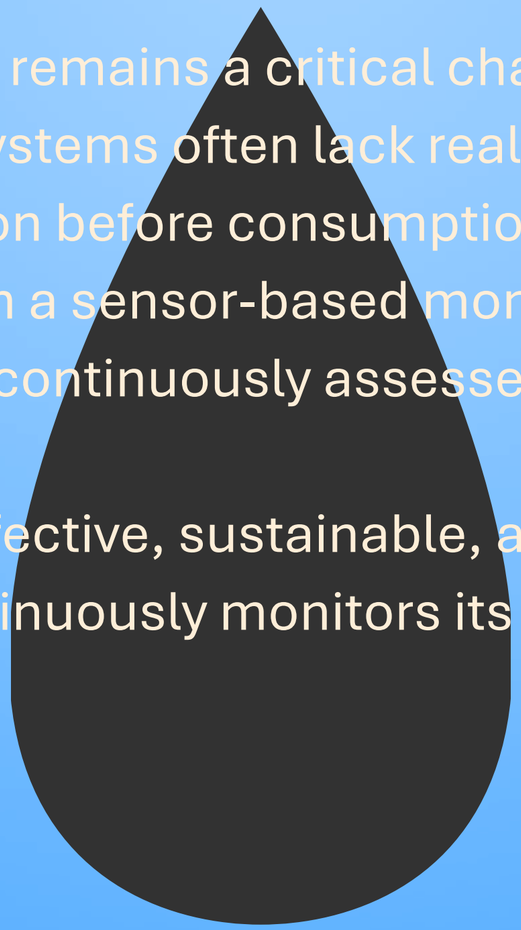
Introduction & Problem Statement

- Access to clean drinking water remains a critical challenge in rural and underdeveloped regions. Traditional filtration systems often lack real-time quality feedback, making it difficult to detect contamination before consumption. Our project addresses this gap by integrating a bio sand filter with a sensor-based monitoring system, ensuring water is not only naturally filtered but also continuously assessed for safety.

- How can we develop a cost-effective, sustainable, and smart water filtration system that filters water naturally and continuously monitors its quality in real time?



Objectives

To design and construct a bio-sand filtration system for physical purification of water.

To develop a real-time water quality monitoring kit using an Arduino Uno, sensors, and an LCD I2C module.

To implement an audible alert system (buzzer) for immediate feedback on water safety.

To reduce dependency on chemical purification methods and empower rural communities with a do-it-yourself water treatment model.

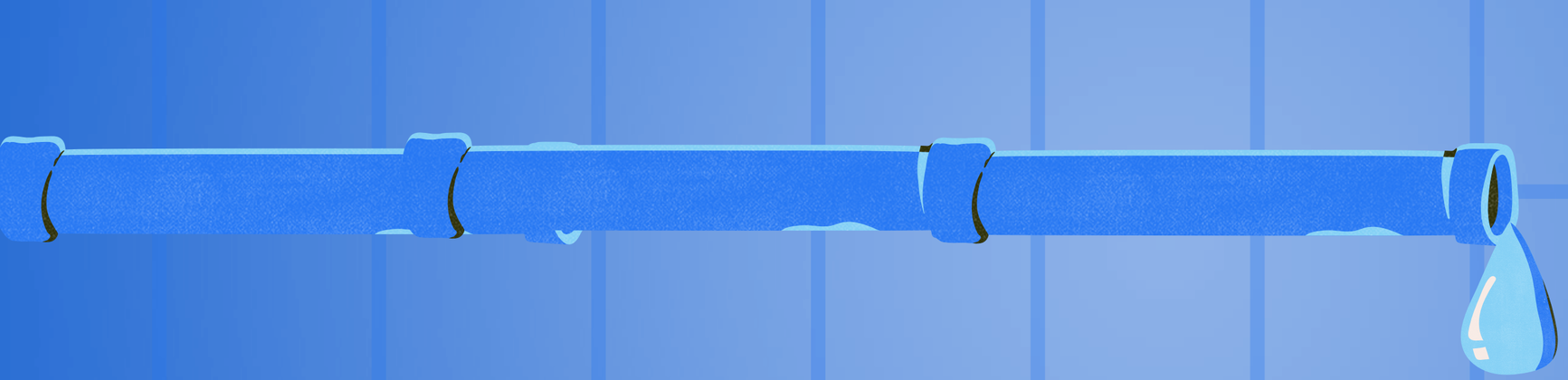
Future Scope

- **Remote Monitoring:** Integrate with mobile apps or IoT cloud dashboards for remote water quality monitoring.
- **Energy Independence:** Adapt the system to run on solar power.
- **Scalability:** Expand the system design for community-level water treatment and disaster relief operations.

LITERATURE SURVEY

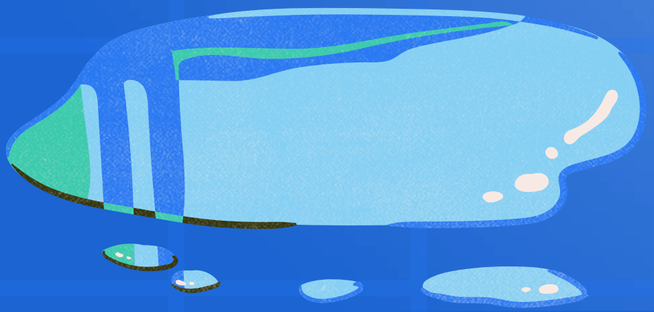
References:

- **YouTube – "CAWST Technology Talk: The Bio-sand Filter : https://www.youtube.com/watch?v=075sHlqtSRo "**
  A comprehensive guide about the functioning of bio-sand filter.
- **YouTube – "IOT Based Smart Water Quality Sensor Monitoring System Using ESP32 : https://www.youtube.com/watch?v=bTVjun1xg8I"**
- Demonstrates sensor integration with microcontrollers for real-time water quality monitoring.
- **Research Article – "Bio-sand Filters: Knowledge & Research Synthesis" (CAWST)**
  Provides insights into the efficiency and mechanisms of bio-sand filters in pathogen reduction.



OUR UNIQUE CONTRIBUTION

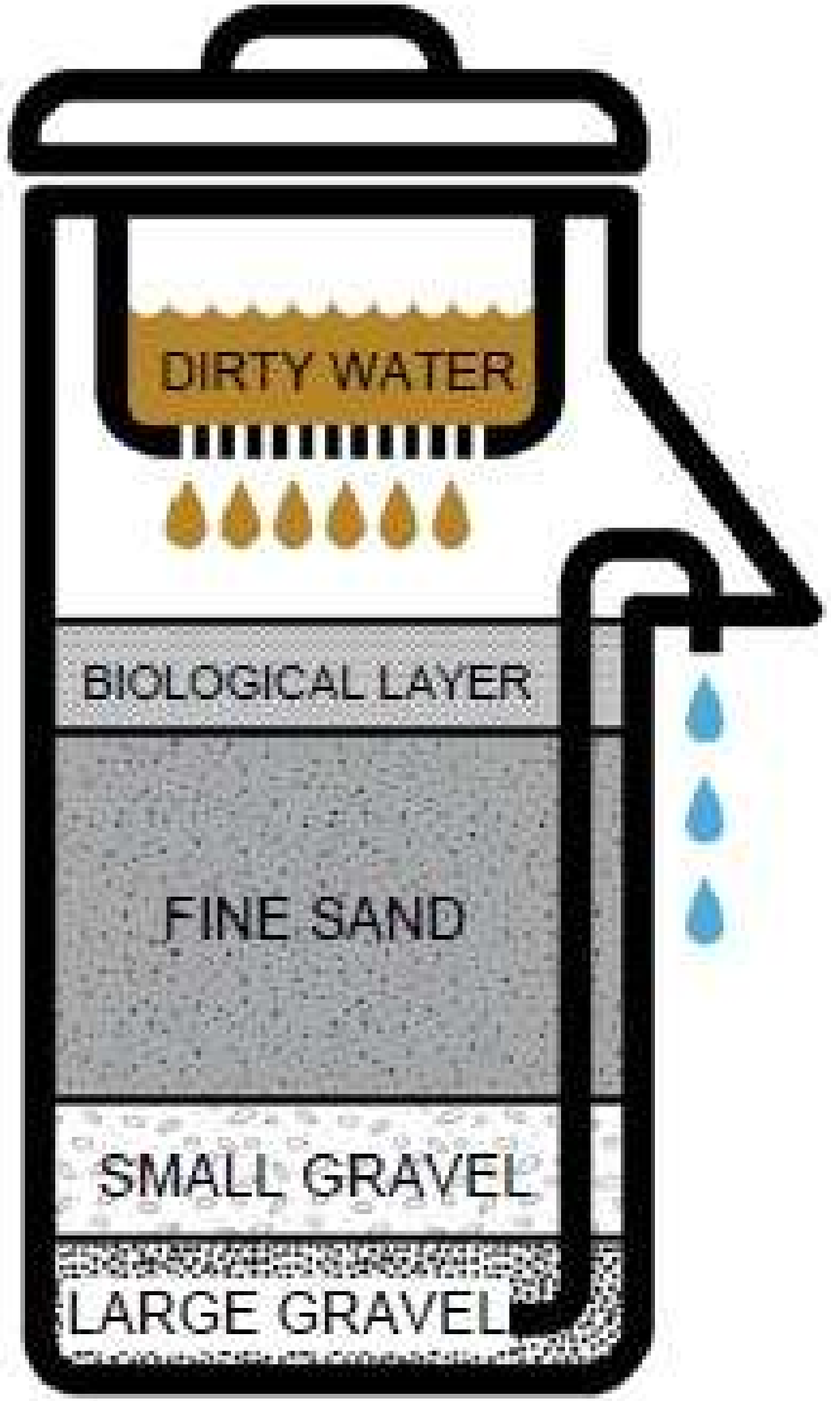
While many existing systems focus either on water filtration or quality monitoring, our project uniquely integrates both. It combines natural biosand filtration with real-time sensor feedback (displayed on an LCD I2C module) and an alert system to offer a robust, sustainable, and user-friendly water purification solution.



METHODOLOGY

Biosand Filtration Unit

- **Inlet Reservoir:** Stores raw water.
- **Diffuser Plate:** Distributes water evenly, protecting the biological layer.
- **Biological Layer (Schmutzdecke):** Contains beneficial microorganisms that help break down pathogens.
- **Fine Sand Layer:** Traps suspended particles and additional pathogens.
- **Coarse Sand & Gravel Layers:** Provide further physical filtration and structural support.
- **Outlet Pipe:** Delivers filtered water for consumption and monitoring.



Bio-Sand Filter Layers

- **Dirty Water Inlet**: Where untreated water is poured in.
- **Biological Layer**: Kills pathogens using beneficial microbes.
- **Fine Sand**: Filters out small particles and contaminants.
- **Small Gravel**: Supports sand and aids in water flow.
- **Large Gravel**: Base layer for drainage and structure.
- **Outlet Pipe**: Releases clean, filtered water.

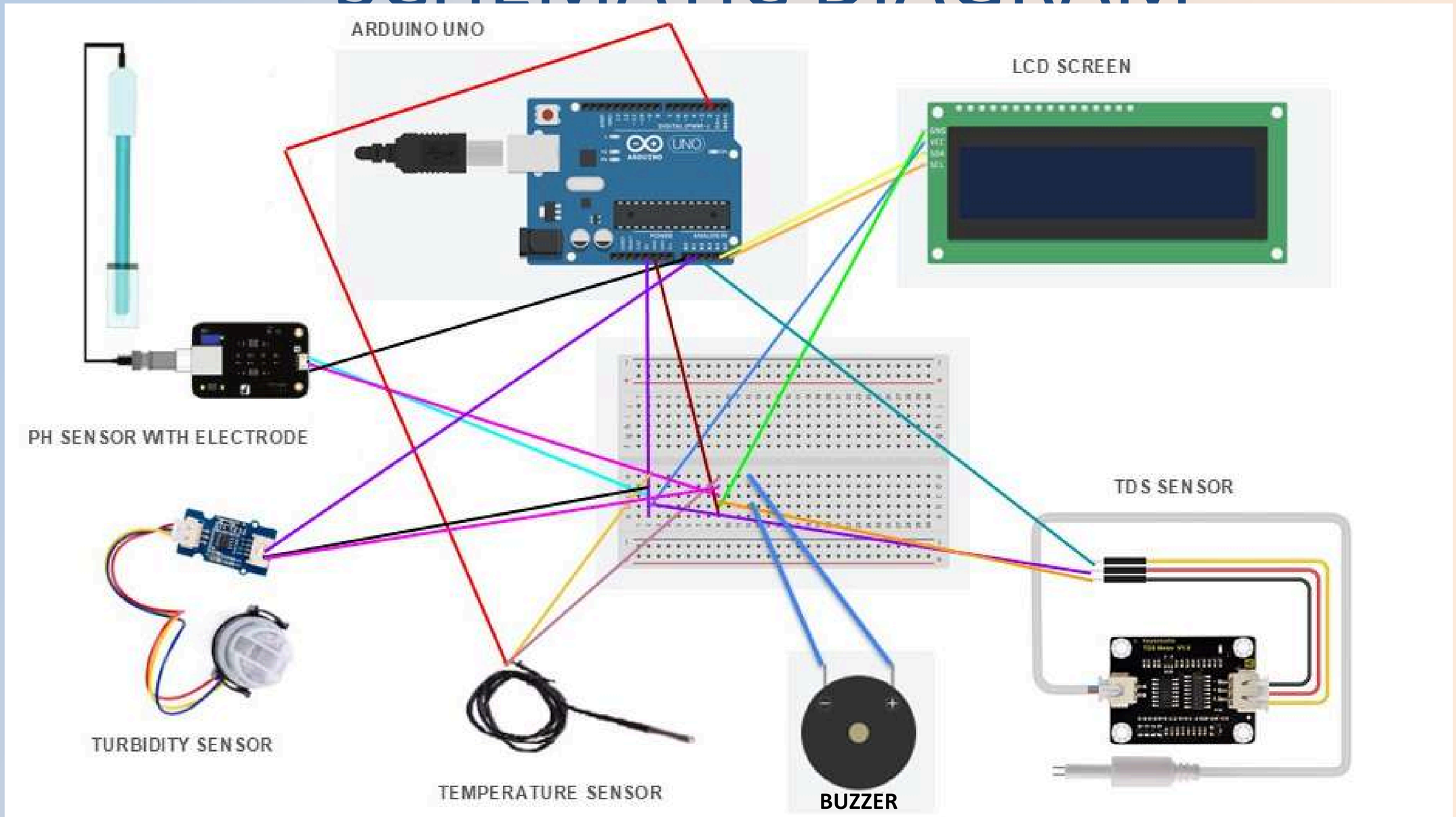
Water Quality Monitoring System:

The filtered water is continuously tested with the following components, all managed by an *Arduino Uno*:

- **pH Sensor:** Checks water acidity/alkalinity to ensure it stays within safe drinking limits.
- **TDS Sensor:** Measures total dissolved solids to assess mineral and salt content.
- **Turbidity Sensor:** Monitors water clarity, indicating potential impurities.
- **Temperature Sensor:** Measures temperature to assess conditions that could affect sensor accuracy or microbial growth.
- **LCD I2C Module:** Displays real-time sensor readings for immediate visual feedback.
- **Buzzer:** Provides audible alerts if any sensor readings exceed safe thresholds.

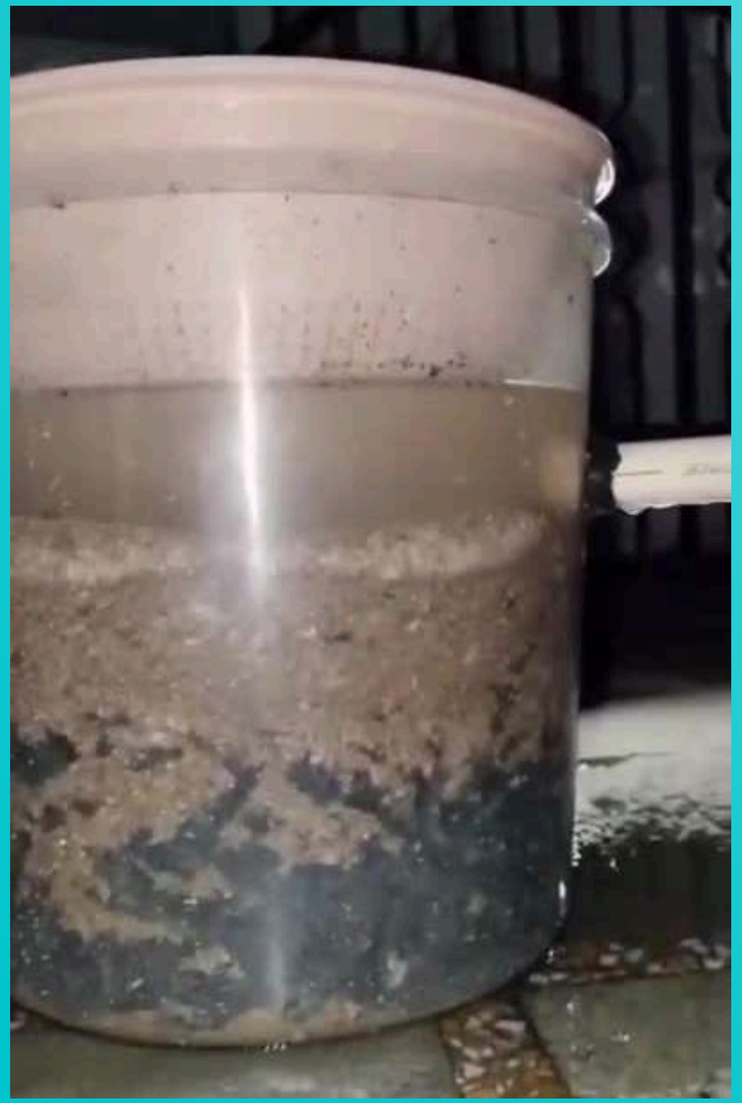
Logic: The Arduino continuously reads sensor data. If any parameter falls outside its safe range (for example, pH below 6.5 or above 8.5), the system triggers the buzzer. Simultaneously, current sensor readings are updated on the LCD I2C module, providing an instant overview of water quality.

SCHEMATIC DIAGRAM



DEMONSTRATION VIDEO

Bio-Sand Filtration System



Water Quality Monitoring

READINGS MEASURED

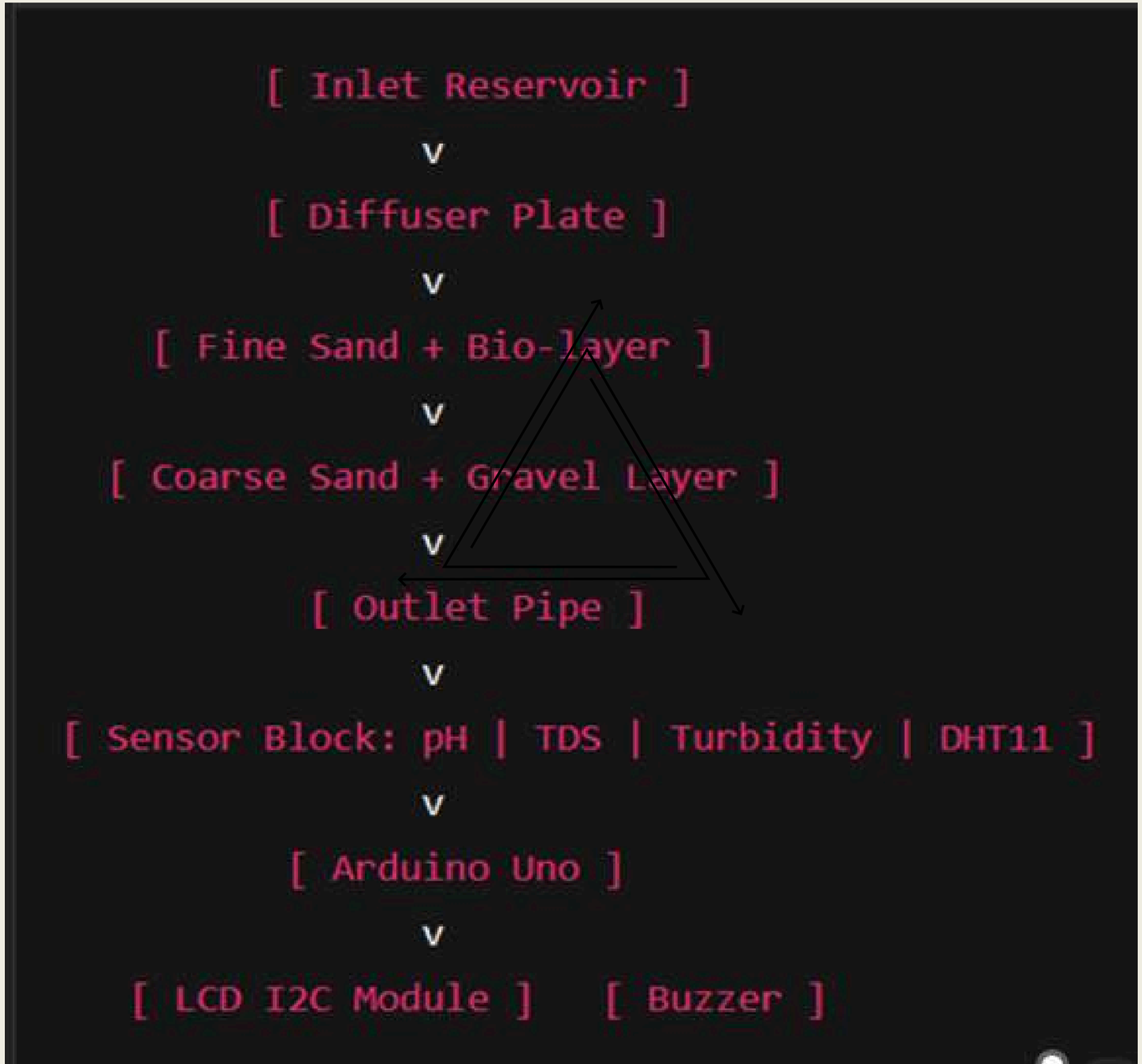
BEFORE FILTRATION

Temperature - 27.5 C
pH - 5.7
Turbidity - 255 NTU
TDS - 2200 PPM

AFTER FILTRATION

Temperature - 28.3 C
pH - 6.8
Turbidity - 8 NTU
TDS - 208 PPM

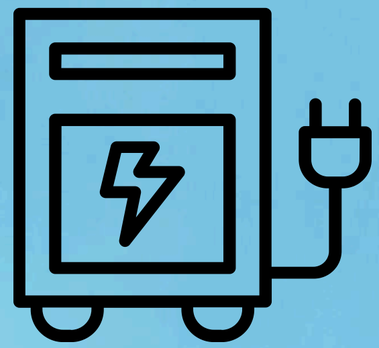
Schematic Diagram



Component	Function/Description
Inlet Reservoir	Stores raw water before filtration begins.
Diffuser Plate	Evenly distributes water to prevent disturbance of filtration media.
Fine Sand + Bio-layer	Filters small particles and removes pathogens through microbial activity.
Coarse Sand + Gravel Layer	Removes larger suspended particles and supports upper layers.
Outlet Pipe	Collects and channels the filtered water out of the filtration system.
Sensor Block	Monitors water quality with sensors:
	- **pH** (acidity/alkalinity)
	- **TDS** (Total Dissolved Solids)
	- **Turbidity** (clarity of water)
	- **DHT11** (temperature and humidity)
Arduino Uno	Microcontroller to collect and process sensor data.
LCD I2C Module	Displays water quality parameters in real time.
Buzzer	Provides an alert if any parameter exceeds safe thresholds.

HARDWARE REQUIREMENTS

- **Arduino Uno:** Central microcontroller.
- **pH Sensor Module:** Measures water acidity/alkalinity.
- **TDS Sensor:** Assesses total dissolved solids.
- **Turbidity Sensor:** Monitors water clarity.
- **Temperature Sensor:** Measures water temperature .
- **LCD I2C Module:** Displays real-time sensor readings.
- **Buzzer:** Provides audible alerts.
- **Connecting Wires & Breadboard:** For sensor interconnections.
- **Power Supply:** Battery or USB power for the Arduino.
- **Bio-sand Filter Components:** Sand, gravel, diffuser plate, inlet/outlet setup, container.

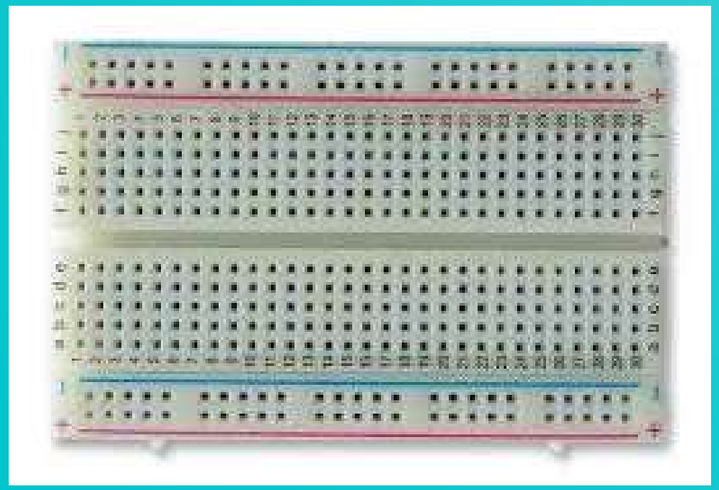


HARDWARE COMPONENTS

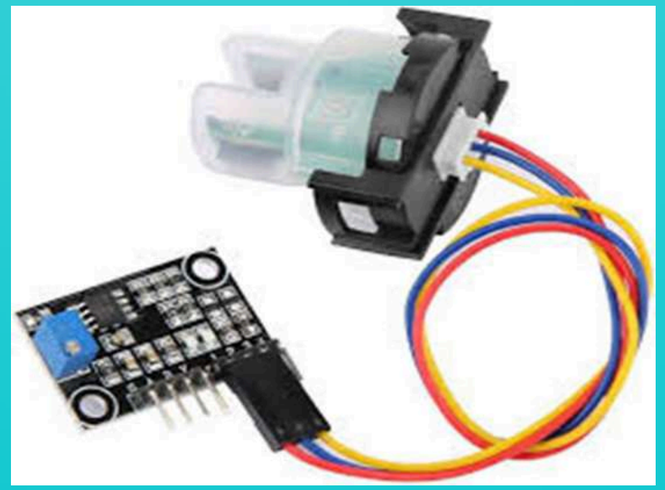
LCD I2C Display Module

Arduino Uno

Temperature Sensor



Breadboard



Turbidity Sensor

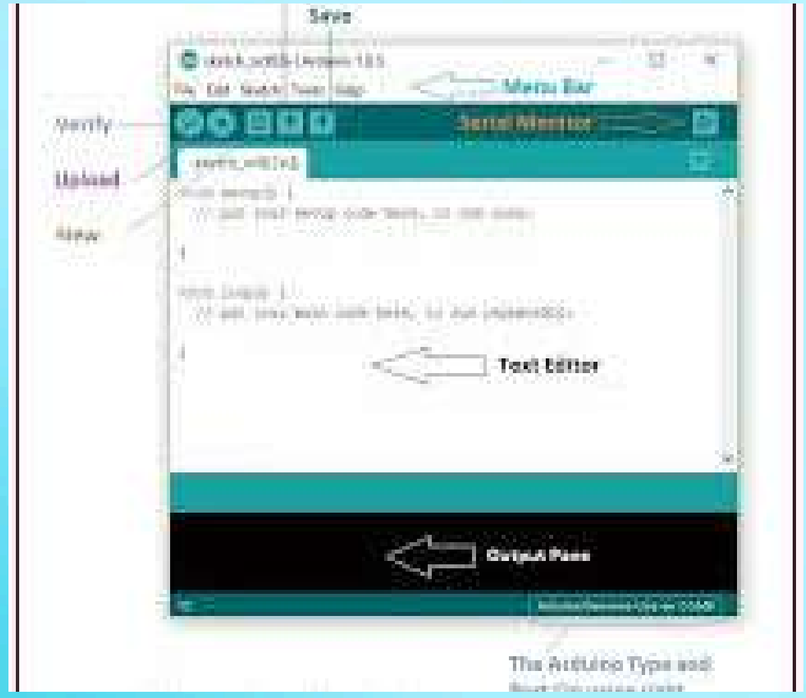
Buzzer

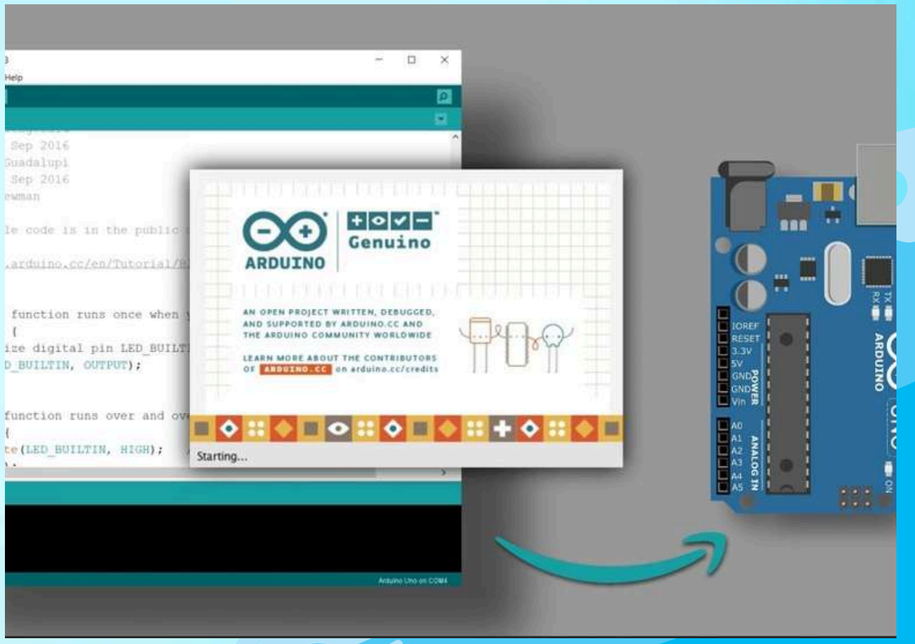
pH Sensor Kit

TDS Sensor

SOFTWARE REQUIREMENTS

- **Arduino IDE:** For coding and uploading the program.
- **Embedded C/C++:** Programming language for Arduino.
- **Serial Monitor:** For debugging and real-time sensor data observation.





Conclusion

The **Smart Bio-Sand Filtration System** with **Real-Time Water Quality Monitoring** presents a practical, sustainable, and affordable solution for ensuring access to safe drinking water, particularly in rural and disaster-affected regions. By combining natural filtration with sensor-based monitoring, the system not only purifies water effectively but also empowers users with real-time insights into water quality. Its **low maintenance**, **eco-friendly design**, and **potential for future integration with mobile alerts and automated responses** make it a scalable solution for addressing clean water challenges in vulnerable communities.


Thank You