PROJECT MANAGEMENT

Workbook

2025

Student Name:
Jilla Kirthan
Professor Name:
NONE

This project, titled Smart Water Purification with Real-Time pH Monitoring is developed in alignment with the PMBOK Guide framework and serves as a case study for applying project management principles. It addresses the critical global issue of access to clean water by designing an innovative purification system that integrates real-time pH sensing technology. The project involves initiating, planning, executing, and controlling phases aimed at delivering a functional prototype capable of both purifying water and continuously monitoring its pH levels. This solution is intended to enhance public health outcomes, particularly in underserved or remote areas.

Project Description

This project aims to develop an advanced, automated water purification system that continuously monitors, analyses, and adjusts water pH levels in real-time to ensure safe and optimal water quality. The system integrates high-precision pH sensors for accurate detection, coupled with TDS Total Dissolved Solids and temperature sensors for comprehensive water quality assessment. A microcontroller such as Arduino or ESP32 processes the sensor data in real-time, triggering an automated purification mechanism such as chemical dosing (acid/base injectors), electrolysis, or activated carbon filtration to neutralize impurities and stabilize pH levels within the optimal range 6.5 and 8.5.

To enhance usability, the system features IoT connectivity Wi**-**Fi**/**Bluetooth enabling remote monitoring via a mobile app or web dashboard. Users receive instant alerts for critical pH deviations, along with historical data trends for long-term water quality analysis. The hardware **design** prioritizes durability and scalability, with options for modular expansion e.g., adding heavy metal or chlorine sensors. The user interface includes an LCD/OLED display for real-time readings and a voice-assisted alert system for accessibility.

Targeting households, laboratories, and industrial applications, the system ensures **cost-**effectiveness, energy efficiency, and compliance with global water safety standards WHO, EPA. Rigorous testing will validate **s**ensor accuracy ±0.1 pH resolution, system response time 10 seconds for pH correction, and reliability under varying water conditions hard water**,** high salinity, etc. Future enhancements may include AI-driven predictive maintenance, solar-powered operation, and integration with smart home systems.

By combining real-time monitoring, automated purification**,** and IoT-enabled accessibility, this project delivers a scalable, sustainable solution to global water quality challenges, promoting health, environmental conservation, and technological innovation

PART B

Initiating Process Group

Introduces you to two PMBOK Processes

a) Create Charter
b) Identify Stakeholders

2.1. PROJECT CHARTER

Project Title	**Smart Water Purification with Real-Time pH Monitoring**
Organization	Aqua purify
Start Date.	January 01th 2025
End Date.	May 31 th 2025
Project. Champion	Jilla Kirthan

Access to clean and safe drinking water is a fundamental necessity, yet many communities face challenges due to contamination, industrial discharge, and fluctuating water quality. Manual water testing methods are often delayed, inconsistent, or inaccessible, leading to health risks and ineffective water management.

This project aims to develop a smart water purification system integrated with real-time pH monitoring, using sensors, microcontrollers, and IoT technology. The system will continuously track the pH level of water, identify unsafe conditions, and automatically activate purification mechanisms when needed. All data will be logged and visualized through a real-time dashboard to enable analysis and prompt intervention.

By combining automation, sensor-based control, and data analytics, this system offers a proactive solution for maintaining water quality. The goal is to ensure timely purification, reduce manual effort, and promote sustainable, technology-driven water safety especially

in rural or resource-limited environments.	

Justification:
Water contamination is a growing concern due to environmental and industrial factors. Traditional purification methods often fail to adapt to sudden changes in water quality. A smart purification system that monitors pH in real-time ensures timely intervention and automation of the cleaning process. It not only improves the quality of water that is cleaned but also reduces unnecessary purification, saving energy and resources. This project enhances efficiency, safety, and sustainability in water management.

High level Requirements	• pH sensors, microcontroller (e.g., Arduino/ESP32), solenoid valves • Real-time data display via LCD or web dashboard • Tools: Arduino IDE, Python (for backend), ThingSpeak/IoT cloud • Safe, potable water output
Success Criteria& Who Measures it.	Success is measured by improved water quality, system efficiency, and reliability, assessed by project stakeholders and quality assurance teams. More number of buyers leads to success.
Stakeholder List	Project Sponsor, Government Agencies, Technical Team,End-Users, NGOs & Environmental Groups, Investors, Maintenance & Support or Team, Suppliers & Vendors, Municipal Workers, Household Drainage Cleaners, Project Team Engineers/Developers, Local Government and Authorities, Residents/End Users
Project Budget	1,24,300/-RS
Assigned Project Manager, Responsibility and Authority Level	Jilla Kirthan (Team Lead) **Reports to:** CEO, Clean Environment Organisation **Responsibility & Authority:** Jilla Kirthan is designated as the Team Lead for the *Smart Water Purification with Real-Time pH Monitoring* project. He is responsible for coordinating team activities, monitoring project milestones, and ensuring timely progress.
Signatures	CEO – Clean Environment Organisation Head of Operations – Jilla Kirthan

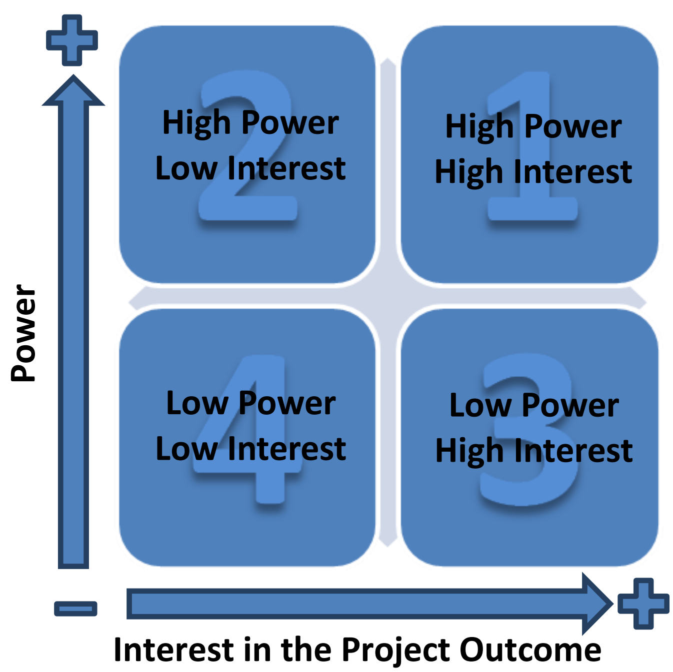
2.2. STAKEHOLDERS

Stakeholder	Role
Company Leadership	Key decision-makers; provide strategic direction and funding
Technical Project Team	Design and develop the system (hardware + software)
Municipal Workers	Operate and maintain the system in real environments
Household Drainage Cleaners	Use the system for small-scale residential cleaning
Local Residents	Indirect beneficiaries of improved water quality
Environmental Authorities	Ensure compliance with water quality and safety standards

How to Rank the Stakeholders?

In determining the rank of the stakeholders, use the following approach. Identify stakeholders that have substantial interest in the outcome of the project and have substantial power to help achieve the project goals.

a. High Power and High Interest in Project Outcome: CEO – Clean Environment Organisation
b. High Power but Low Interest in Project Outcome: Environmental Authorities
c. Low Power but High Interest in Project Outcome: Municipal Workers / Household Drainage Cleaners
d. Low Power and Low Interest in Project Outcome: Local Residents
e. Medium Power and High Interest in Project Outcome: Technical Project Team



2.3. STAKEHOLDERS REGISTER & MANAGEMENT STRATEGY

Stakeholder	Stakeholder Rank (High/Med/Low)	Role	Goal (Interest or outcome for the Stakeholder)
D. Rakesh Kumar	**High interest and High power**	Project Manager	Oversees project planning, budget, execution, and delivery of the system.
CEO – Clean Environment Org.	**High power and High interest**	Project Sponsor	Provides funding, strategic guidance, and approves key milestones and deliverables.
Environmental Authorities	**Low power and High interest**	Compliance & Regulation	Ensure the system meets safety, health, and environmental standards; keep informed to monitor environmental impact.
Municipal Workers	**Low power and High interest**	End Users (Public Purification)	Operate the system for cleaning rivers/lakes; rely on ease of use, reliability, and system effectiveness.
Household Drainage Cleaners	**Low Power but High Interest**	End Users (Local Drainage Use)	Use the system in domestic or small-scale cleaning; need functional, easy-to-operate features.
Local Residents	**Low Power and Low Interest**	Indirect Beneficiaries	Benefit from improved water quality and hygiene in their communities; no direct involvement in the project.

Planning Process Group

Collect Requirements Process

Requirement Document

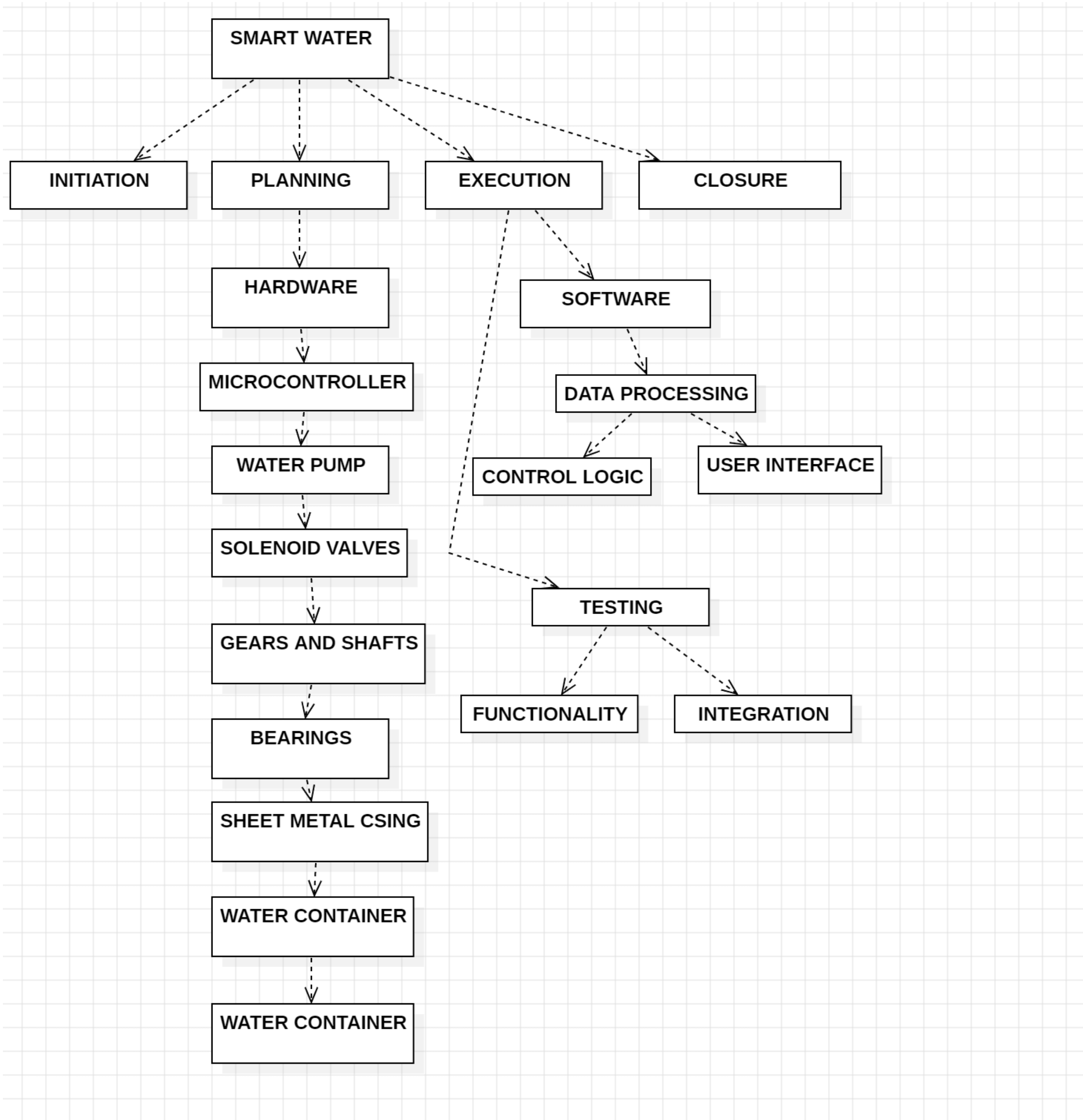
Category	Requirement	Stakeholder	Acceptance Criteria
Funding	Budget allocation and timely disbursal for equipment, sensor components, and operations	CEO – Clean Environment Org.	100%
Technical Data	Real-time access to pH sensor readings and integration with data logging system	Technical Project Team	90%
Location Finalization	Where ever cleaning of solid waste is required	Municipal Workers & Supervisors	85%
Execution of Project	On-field support and training for handling purification system and pH monitoring tools	Municipal Workers	100%
Commissioning	Approval of system performance, water quality improvement, and safety compliance	Environmental Authorities	90%

2.4. PROJECT SCOPE STATEMENT

PROJECT OBJECTIVE
To design and implement a Smart Water Purification System with Real-Time pH Monitoring that enhances water quality for domestic and municipal applications by providing automated purification and continuous water quality feedback through sensors. The goal is to reduce manual intervention, increase water safety, and provide an eco-friendly solution for clean water access.
DELIVERABLES
• Fully functional smart purification unit with integrated real-time pH sensors • Real-time pH monitoring system with display/alert mechanism • Deployment-ready system for rivers, lakes, and household drains • User manual for operation and maintenance • Training module for municipal workers and local users • Project documentation and performance report
TECHNICAL REQUIREMENTS
• pH sensor modules with digital interface • Microcontroller or IoT board (e.g., Arduino, Raspberry Pi) • Water purification components (e.g., filters, UV unit, pumps) • Real-time data display unit (LCD/LED or mobile/web interface) • Power source (solar panel or AC power) • Data logging capability for monitoring pH trends over time • Enclosure for environmental protection (IP-rated casing) • Coding tools like Arduino IDE or Python-based interface for data handling • Optional: Cloud integration for centralized monitoring (Phase 2)

LIMITS AND EXCLUSIONS (Constraints)
• The system will focus on pH-based monitoring and purification only in Phase 1 additional water quality parameters like TDS or turbidity will be considered in future phases. • Limited field deployment to select test locations (e.g., local drains or lakes) during the initial project cycle. • Real-time cloud integration is optional and may be implemented based on available funding. • Maintenance will require basic training and regular inspection of sensors and filters.
RISKS
• Sensor calibration errors affecting pH readings • Electrical or mechanical component failure in harsh environments • Resistance from end-users in adapting to new technology • Budget constraints delaying procurement of components • Data inaccuracy or transmission issues during real-time monitoring • Environmental challenges (e.g., weather, debris affecting functionality)
ACCEPTANCE CRITERIA
• System must maintain stable pH monitoring with less than ±0.2 variance • Water output must meet predefined safety standards (based on local municipal criteria) • Stakeholders (municipal workers, supervisors) approve system usability and effectiveness after testing • Training provided to users must result in at least 80% operational proficiency • Final sign-off from project sponsor and environmental authorities
Signatures **Jilla Kirthan** Project Manager - Smart Water Purification Project Clean Environment Organization **K Ravi Krishna** Project Sponsor – Head of Operations Clean Environment Organization

2.5. WORK BREAKDOWN STRUCTURE (WBS)



2.6 MILESTONE

The project begins with the Project Initiation phase, where the charter is approved and key stakeholders are identified, targeted for completion by 5th January 2025. Following this, the team will move into the Requirements Collection phase, gathering all technical and functional needs, to be completed by 12th January 2025. The next milestone is Design Finalization, which involves completing the blueprint for both the purification system and real-time pH sensor integration, scheduled for 25th January 2025.

Once the design is finalized, the Prototype Development phase will begin, during which a working model will be built and tested for basic functionality, with a target date of 10th February 2025. This will be followed by System Testing and Adjustments, where the integrated system is tested end-to-end and refined based on test results, expected to be completed by 25th February 2025. After successful testing, the Deployment Preparation phase will commence, which includes final hardware tuning, preparing documentation, and user training materials, set to conclude by 10th March 2025.

2.6. Define and Estimate Activities and Resources

Activity List

Activities	Effort	Resource
Requirement Analysis	Medium	Team Lead, Technical Team
Sensor Selection & Procurement	High	Hardware Engineers
System Design & Integration	Medium	Embedded Systems Engineer
Software Development	Medium	IoT Programmers
pH Monitoring Calibration	Medium	Lab Technicians
Testing and Validation	Medium	QA Team
User Training & Deployment	Medium	Trainers, Field Technicians

2.7. Activity Durations

Activity Durations

Activity	Duration (days)
Requirement Gathering	4
Sensor Selection & Procurement	8
System Design & Integration	12
Software Development	10
pH Monitoring Calibration	5
Testing and Validation	7
User Training & Deployment	5

2.8. DELIVERABLES LIST BY TEAM

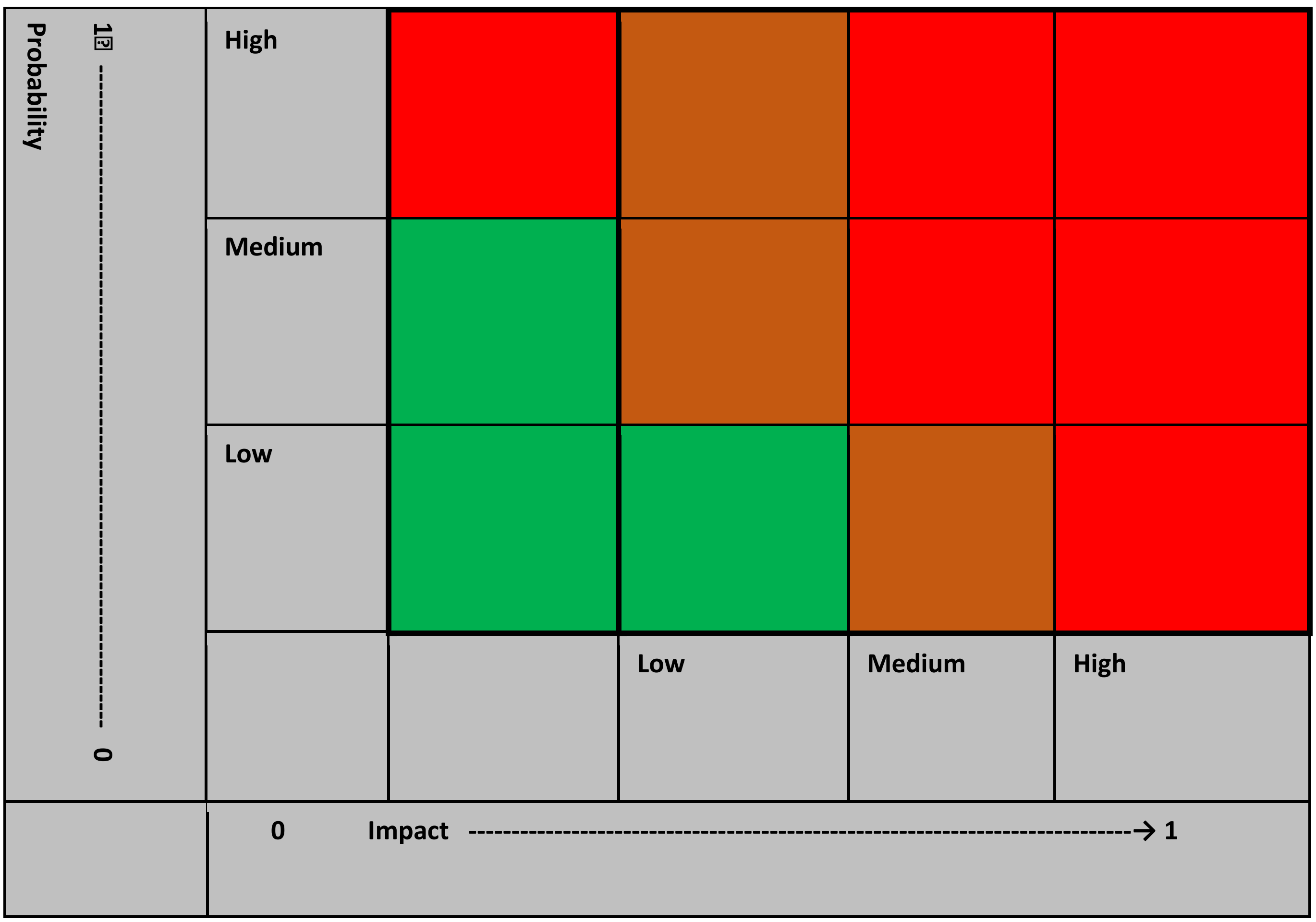
An alternate Way to view the activity list is to view it by resource

Team (Work Resource)	Activities (List Key deliverables only)
Team 1	1. Requirement Gathering and Sensor Procurement 2. Hardware Setup and System Integration
Team 2	3. Real-Time pH Monitoring Software Development 4. Calibration and Testing
Team 3	5. Final Deployment and Field Installation 6. User Training and Maintenance Documentation

2.9. PLAN RISK MANAGEMENT

Risk	Type of Risk (Good or Bad (threat)	Consequence or Impact
Sensor malfunction or inaccuracy	Bad	Leads to incorrect pH readings, affecting water quality and system reliability
Power or connectivity failure	Bad	Disrupts real-time monitoring and automated purification
Calibration drift over time	Bad	Reduces accuracy of monitoring; requires manual intervention
Improper use by untrained personne	Bad	May cause damage to system or ineffective purification
Delays in component procuremen	Bad	Slows down project timelines and affects deployment

Environmental exposure (heat/rain)	Bad	Potential damage to sensors or electronic components installed in outdoor conditions
Data loss or no data backup	Bad	Inability to analyze historical performance or troubleshoot
Low community acceptance	Bad	May hinder proper usage or adoption of system in local areas



2.10. PLAN QUALITY MANAGEMENT

Plan Quality

The quality management plan ensures that the system purifies water efficiently while providing real-time and accurate pH monitoring. All components hardware, software, and sensors must meet environmental, usability, and technical standards. This plan involves continuous testing, calibration, and verification of system output against quality benchmarks.

Quality Roles and Responsibilities

Role	Responsibility
Project Manager	To oversee project execution, timelines, compliance with quality standards, and documentation.
Embedded Systems Engineer	To ensure that sensors and control circuits function accurately for water monitoring.
Software Developer	To develop and test the real-time pH display and monitoring interface
Deployment Technician	To ensure proper setup, calibration, and testing of the device in real environments.
Environmental Expert	To validate water purification effectiveness and compliance with safety regulations.

2.11. QUALITY MANAGEMENT PLAN

Summarizes the previous Section

Quality Management Plan

Project Title:	Smart Water Purification with Real-Time pH Monitoring	**Version: 1.0**	**Date:**	10-04-2025

Overview:

Quality is a key focus in this project. The efficiency of the water purification system, accuracy of real-time pH monitoring, and the overall reliability of the device are critical success factors. The project manager and technical team will ensure all deliverables comply with environmental standards and stakeholder expectations.

Quality Responsibilities and Quality Roles:

Quality is monitored by the Project Manager (Vishnu Vardhan) and the Technical Lead. Their responsibilities include supervising system performance, component integration, and maintaining stakeholder satisfaction through continuous inspection, calibration, and user feedback.

Quality Assurance Approach:

We assure quality in the purification and monitoring solution through regular sensor calibration, testing water output quality e.g., turbidity, pH and verifying compliance with environmental norms.Feedback from field testing and expert reviews ensures iterative improvements throughout the project lifecycle.

Quality Control Approach:

Each development phase component assembly, circuit integration, and real-time pH display is subjected to inspection and functional testing. Sensor outputs are verified against standard solutions, and purification levels are validated through lab testing before final deployment.

Quality Reporting Plan:

Weekly quality reports are generated detailing sensor accuracy purification effectiveness and system performance. Any faults or performance drops trigger immediate inspection and recalibration. Updates are regularly presented to stakeholders including municipal partners and environmental experts.

2.12. DEVELOP HUMAN RESOURCES PLAN

Human Resources Plan

Project Title:	Smart Water Purification with Real-Time pH Monitoring	Version: 1.0	Date:	10-04-2025

Roles and Responsibilities:

1. **Project Manager (Vishnu Vardhan)** – Oversees project execution, manages scheduling, budgeting, coordination, and final deliverables.
2. **Electronics Engineers** – Responsible for designing and assembling the purification system and sensor circuitry.
3. **Sensor Calibration Technicians** – Ensure accurate real-time pH readings and calibrate the system periodically.
4. **Embedded System Developers** – Develop and program the microcontroller to display and manage pH data in real time.
5. **Field Test Team** – Conducts real-world testing in water sources and reports system effectiveness.
6. **Quality Analysts** – Inspect the final output water quality and system performance for compliance.

Staff Acquisition:

Team members will be selected based on their expertise in water treatment, embedded systems, and environmental monitoring. Internal students and lab staff will be primarily used, with technical mentors or external consultants involved as required.

Staff Release:

Personnel will be released after their specific contributions are completed e.g.sensor technicians after system calibration, developers post-software integration, ensuring knowledge transfer and documentation are handed over to maintenance teams.

Training:

Training sessions will be organized to cover:

- pH sensor usage and calibration
- Embedded programming tools (e.g., Arduino IDE)
- Safe handling of purification components
- Environmental compliance standards

Performance Reviews:

Performance will be periodically reviewed by **Vishnu Vardhan** Project Manager to ensure that the team is aligned with the projects goals and timeline. Progress will be evaluated against predefined milestones, task completion rates, and quality of deliverables. Regular team meetings will be held to assess individual contributions, identify roadblocks, and provide constructive feedback.
Corrective measures such as additional support, reassignments, or schedule adjustments. Outstanding performers may be recognized to boost morale and encourage excellence. All reviews will be documented to track improvements and lessons learned for future projects.

Regulation and Policy Compliance:

All team members must adhere to environmental safety guidelines, institutional project protocols, and ethical practices related to data usage and equipment safety. Compliance with pollution control board standards will be strictly enforced.

Item description

1	**Hardware and Software Resources:** • pH Sensors and Microcontrollers (e.g., Arduino, Raspberry Pi) for real-time data collection • Water pumps and purification modules (e.g., UV filters, activated carbon units) • Development laptops or embedded systems for programming and interfacing • Simulation and development environments (e.g., Arduino IDE, Python IDEs)
2	**Software Libraries and Tools:** • Python (with libraries like Pandas, NumPy for data handling) • Real-time data monitoring and plotting tools (e.g., Matplotlib, Plotly) • Communication protocols (e.g., serial communication libraries, MQTT) • Cloud dashboard or IoT platforms (e.g., Thing Speak, Blynk, or custom web dashboards) for remote pH monitoring

Note:

2.13. Communication Management Plan

Communication Management Plan

Message	Description (What is it about?)	Report to	Method (How are you communicating?)	Frequency (When and how Frequently?)	Sender (Who is sending it?)
System Progress Report	Updates on development stages, sensor integration, and testing phases	Project Guide / Professor	Email, Team Meetings	Weekly	Jilla Kirthan (Project Manager)
Water Quality Test Results	pH readings and purification system effectiveness	Environmental Authorities	Email Report and Dashboard	Bi-weekly	Technical Team
Technical Issues & Fixes	Log of bugs or issues in hardware/software and actions taken	Project Team	Shared Document and Slack	As issues occur	Embedded Systems Developer
Budget & Resource Updates	Allocation, usage, and requirements of project resources	Department Head and Sponsoring Org.	Email or Report Submission	Monthly	Project Manager
Stakeholder Review Feedback	Summary of stakeholder inputs, suggestions, and actions	All Team Members	Team Review Meeting	After milestone completions	Jilla Kirthan (Project Manager)
Deployment & Maintenance Log	Status updates post-deployment and upkeep of the purification system	Maintenance Team and Supervisor	Shared Log Sheet	Weekly post-deployment	Deployment Technician

2.14. COST ESTIMATION

Total Estimated Cost: ₹ 124,300

Item	Description	Estimated Cost (INR)
Sensors and Hardware	pH sensors, microcontrollers (e.g., Arduino/Raspberry Pi), pumps, and filtration units	₹40,000
Software Development Tools	Python libraries, firmware development tools	₹5,000
Cloud Services & Hosting	Data storage, dashboard hosting, real-time data access (AWS, Azure, etc.)	₹15,000
Labor and Technical Team	Compensation for team members, field testers, and developers	₹30,000
Testing & Calibration	Lab tests for pH levels, calibration kits, field trials	₹10,000
Packaging & Assembly	Structural casing, water-safe housing, wires, PCB fabrication	₹8,000
Training & Documentation	Manuals, team training sessions, and user guide printing	₹5,000
Contingency Reserve (10%)	To handle unexpected costs or changes	₹11,000

2.15. PROJECT SUMMARY

Now that we have completed the project plan you can summarize the details such as:

Performance Indicator	**Planned**
Total Effort	960Hr
Total Duration	45 Days
Start Date	10 April 2025
End Date	25 May 2025
Cost	1,24,300/- Rs

2.16. RISK MONITORING AND CONTROL

Updated Risk Register

Risk ID	Risk	Risk Response	Resource Responsible for Mitigation	Current Risk Status
1	Equipment Malfunction	Schedule routine maintenance and have backup units ready	Jilla Kirthan (Project Manager)	Under control
2	Water Quality Sensor Failure	Use high-quality sensors and perform regular calibration	Technical Team	Monitored and stable
3	Timeline Delay	Ensure timely task tracking and resource allocation	Project Manager & Team Leads	All phases on schedule
4	Budget Overrun	Optimize procurement and monitor spend frequently	Project Manager	Costs within limits
5	Regulatory Compliance Issues	Review standards and ensure compliance from start	Compliance Coordinator	No issues reported

2.17. PROJECT CHANGE CONTROL

During the implementation phase of the project, there were unexpected requirements that led to necessary changes in scope and operations:

Issue:
The original sensor integration method and water filtration layout were approved and development had started. However, during a stakeholder demo, the municipal department and environmental experts suggested improvements in the design for better compatibility with water bodies of varying sizes and for more accurate pH readings.

a. Change in System Design Layout
We revised the mechanical layout and operational flow of the purification unit to support or modular deployment. This change ensures compatibility with both large-scale and household water sources.

b. Change in Sensor Vendor
Based on feedback from the project guide and environmental stakeholders, we collaborated with a different sensor vendor to integrate more accurate and durable pH sensors into the system and aligning with real-time data accuracy needs.

Impact:
The cost and timeline impacts were minimal. The flexibility in the project plan allowed quick adaptation, and the updated design was approved without significant delay or budget increase.

2.18. LESSONS LEARNED

Phase	**What Worked?**	**What Did not Work?**	**Lessons for Next Project.**
Initiation Phase	Problem identification and stakeholder engagement	Delayed communication with field staff	Ensure early direct interaction with field-level stakeholders
Planning Phase	Clear scope definition and resource allocation	Timeline estimations were not precise	Build a detailed activity-wise schedule with buffer time
Execution Phase	Sensor integration and data logging worked smoothly	Initial filtration design had compatibility issues	Conduct prototype testing in multiple environments before final deployment

2.19 COMMUNICATION PLAN

Sound communication is a key factor to the successful implementation of the Smart Water Purification with Real-Time pH Monitoring project. Consistent updating and open lines will make sure that all stakeholders are informed and aligned in every stage. The project manager, Vishnu Vardhan, will head the communication process, giving weekly progress reports and milestone reports to the company management through email and review meetings. Technical progress, such as sensor performance and system integration status, will be communicated with the IT and engineering teams via project dashboards and collaborative software like Slack or Microsoft Teams. Environmental authorities will be reviewed monthly to confirm compliance with regulations, while training and feedback sessions with end-users will be organized after deployment to obtain community feedback and confirm system usability. This organized approach to communication will facilitate transparency, prompt decision-making, and seamless coordination among all stakeholders of the project.

2.20 PROCUREMENT PLAN

The procurement of hardware and software components for the Smart Water Purification with Real-Time pH Monitoring project must be done timely and at an affordable cost to promote smooth implementation. Procurement will be handled by the Project Manager together with the Finance and Technical teams. Main hardware consists of water quality sensors, microcontrollers Arduino or Raspberry Pi, and purification modules, to be obtained from qualified suppliers with a history of proven environmental solutions. Software needs, such as pH data processing libraries, cloud storage services, and mobile interface development tools, will be procured through in-place organizational licenses or negotiated procurement agreements. All purchases will be done in accordance with the company procurement policy, in terms of quality, cost, and timely delivery. Vendor quotations, evaluations, and approvals will be systematically documented, and a buffer period will be incorporated in the schedule for any unexpected delay in supply. After procurement, the components will be quality checked and functionally verified prior to integration into the system.

New Execution:

The execution phase of the AI Smart Water Purification with Real-Time pH Monitoring project involved translating the project plan into actionable steps to develop and deploy the purification system. During this stage, sensor modules were installed and configured to capture real-time pH levels from water sources. The AI algorithms were trained using sample datasets to accurately detect deviations in water quality and trigger automated purification processes. Hardware components such as pumps, filters, and microcontrollers were integrated into the system to enable dynamic control based on sensor feedback. The team collaborated to ensure smooth integration between software and hardware elements, while dashboards were developed to visualize pH levels and system performance. Thorough testing was conducted to validate the responsiveness and accuracy of the AI-driven control logic. All activities were carefully monitored by the project manager to ensure they aligned with the project schedule and quality expectations. This phase ensured the successful implementation of a reliable, intelligent water purification solution with minimal manual intervention.