Smart Water Quality Monitoring and Management with Smart Billing System

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Department of Electronics and Communication Engineering

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Vision of the Department

- **To build a strong teaching and research environment to cater to the manpower needs in Industrial and Academic domains of the rapidly growing Electronics and Communication Engineering.**

Mission of the Department

- **To produce certified industry-ready professional in Electronics and Communication Engineering, though innovative educational programs incorporating laboratory practices and project-based teaching-learning processes, in a modern environment.**
- **To create knowledge base of advanced technologies through research in the area of Electronics and Communication, for competitive and sustainable development of the country.**
- **To groom the department as a learning center to inculcate advancement of technology in Electronics and Communication Engineering with social values and environmental awareness.**

Program Specific Outcome (PSOs)

After completion of program graduate engineer would have:

- **PSO1. Professional skills: An ability to apply the knowledge in Electronics and Communication Engineering in various areas, like Communications, Signal processing, VLSI and Embedded Systems.**
- **PSO2. Competency: An ability to qualify at the State, National and International level competitive examinations for employment, higher studies and research**

Program Outcome

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and teamwork**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team,
    to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Course Outcomes for Final Year Project

After completion of the project, student will be able to:

Outcome No.	Outcome Statements	Bloom's Level
CO1	Apply technical knowledges in the solution of complex real-life problems related to public health and safety, culture, society, and environment	3
CO2	Review research literature and use the research-based knowledge to identify, formulate, and analyze the problem	5
CO3	Design innovative solutions for complex engineering problems, which will be published as research paper or developed as a marketable product	6
CO4	Apply modern tools to predict solution, design and develop the solution to problem	3
CO5	Assess societal, health, safety, legal and cultural issues, and the consequent responsibilities relevant to the professional engineering practice.	5
CO6	Evaluate the impact on the environment of working project	5
CO7	Apply ethical principles and commit to ethics and responsibilities related to engineering practice.	3
CO8	Function effectively as a member or leader of a team	3
CO9	Communicate effectively on professional activities with the team members, superiors and with society at large	3
C10	Plan, manage the project and control finance as a member and leader in a team.	3
C11	Apply the knowledge acquired during the project, in future higher studies or professional job.	4

Bloom's Level: Remember = 1, Understand = 2, Apply =3 Analyze = 4 Evaluate = 5, Create = 6

Program Outcomes -Competencies – Performance Indicators (PIs)

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization for the solution of complex engineering problems.

Competency	Indicators
1.1 Demonstrate competence in mathematical modelling	1.1.1 Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems 1.1.2 Apply advanced mathematical techniques to model and solve Electronics engineering problems
1.2 Demonstrate competence in basic sciences	1.2.1 Apply laws of natural science to an engineering problem
1.3 Demonstrate competence in engineering fundamentals	1.3.1 Apply fundamental engineering concepts to solve engineering problems
1.4 Demonstrate competence in specialized engineering knowledge to the program	1.4.1 Apply Electronics engineering concepts to solve engineering problems.

PO 2: Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Competency	Indicators
2.1 Demonstrate an ability to identify and formulate complex engineering problem	2.1.1 Articulate problem statements and identify objectives 2.1.2 Identify engineering systems, variables, and parameters to solve the problems 2.1.3 Identify the mathematical, engineering, and other relevant knowledge that applies to a given problem
2.2 Demonstrate an ability to formulate a solution plan and methodology for an engineering problem	2.2.1 Reframe complex problems into interconnected sub-problems 2.2.2 Identify, assemble, and evaluate information and resources. 2.2.3 Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions 2.2.4 Compare and contrast alternative solution processes to select the best process.
2.3 Demonstrate an ability to formulate and interpret a model	2.3.1 Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy. 2.3.2 Identify assumptions (mathematical and physical) necessary to allow modelling of a system at the level of accuracy required
2.4 Demonstrate an ability to execute a solution process and analyze results	2.4.1 Apply engineering mathematics and computations to solve mathematical models 2.4.2 Produce and validate results through skillful use of contemporary engineering tools and models 2.4.3 Identify sources of error in the solution process, and limitations of the solution. 2.4.4 Extract desired understanding and conclusions consistent with objectives and limitations of the analysis

PO 3: Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations. .	
Competency	**Indicators**
3.1 Demonstrate an ability to define a complex/ open-ended problem in engineering terms	3.1.1 Recognize that need analysis is key to good problem definition 3.1.2 Elicit and document, engineering requirements from stakeholders 3.1.3 Synthesize engineering requirements from a review of the state-of-the-art 3.1.4 Extract engineering requirements from relevant engineering Codes and Standards such as ASME, ASTM, BIS, ISO and ASHRAE. 3.1.5 Explore and synthesize engineering requirements considering health, safety risks, environmental, cultural, and societal issues 3.1.6 Determine design objectives, functional requirements and arrive at specifications
3.2 Demonstrate an ability to generate a diverse set of alternative design solutions	3.2.1 Apply formal idea generation tools to develop multiple engineering design solutions 3.2.2 Build models/prototypes to develop a diverse set of design solutions 3.2.3 Identify suitable criteria for the evaluation of alternate design solutions.
3.3 Demonstrate an ability to select an optimal design scheme for further development	3.3.1 Apply formal decision-making tools to select optimal engineeri solutions for further development 3.3.2 Consult with domain experts and stakeholders to select candidate engineering design solution for further development
3.4 Demonstrate an ability to advance an engineering design to defined end state	3.4.1 Refine a conceptual design into a detailed design within the existing constraints (of the resources) 3.4.2 Generate information through appropriate tests to improve or revise the design

PO 4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	
Competency	**Indicators**
4.1 Demonstrate an ability to conduct investigations of technical issues consistent with their level of knowledge and understanding	4.1.1 Define a problem, its scope and importance for purposes of investigation 4.1.2 Examine the relevant methods, tools and techniques of experiment design, system calibration, data acquisition, analysis, and presentation 4.1.3 Apply appropriate instrumentation and/or software tools to make measurements of physical quantities 4.1.4 Establish a relationship between measured data and underlying physical principles
4.2 Demonstrate an ability to design experiments to solve open-ended problems	4.2.1 Design and develop an experimental approach, specify appropriate equipment and procedures 4.2.2 Understand the importance of the statistical design of experiments and choose an appropriate experimental design plan based on the study objectives
4.3 Demonstrate an ability to analyze data and reach a valid conclusion	4.3.1 Use appropriate procedures, tools, and techniques to conduct experiments and collect data 4.3.2 Analyze data for trends and correlations, stating possible errors and limitations 4.3.3 Represent data (in tabular and/or graphical forms) so as to facilitate analysis and explanation of the data, and drawing of conclusions 4.3.4 Synthesize information and knowledge about the problem from the raw data to reach appropriate conclusions

PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.	
Competency	**Indicators**
5.1 Demonstrate an ability to identify / create modern engineering tools, techniques, and resources	5.1.1 Identify modern engineering tools such as computer-aided drafting, modeling, and analysis; techniques and resources for engineering activities 5.1.2 Create/adapt/modify/extend tools and techniques to solve engineering problems
5.2 Demonstrate an ability to select and apply discipline-specific tools, techniques, and resources	5.2.1 Identify the strengths and limitations of tools for (I) acquiring information, (ii) modeling and simulating, (iii) monitoring system performance, and (iv) creating engineering designs. 5.2.2 Demonstrate proficiency in using discipline-specific tools
5.3 Demonstrate an ability to evaluate the suitability and limitations of tools used to solve an engineering problem	5.3.1 Discuss limitations and validate tools, techniques, and resources 5.3.2 Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use.

PO 6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	
Competency	**Indicators**
6.1 Demonstrate an ability to describe engineering roles in a broader context, e.g. pertaining to the environment, health, safety, legal and public welfare	6.1.1 Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at the global, regional, and local level
6.2 Demonstrate an understanding of professional engineering regulations, legislation, and standards	6.2.1 Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public

PO 7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and the need for sustainable development.	
Competency	**Indicators**
7.1 Demonstrate an understanding of the impact of engineering and industrial practices on social, environmental and in economic contexts	7.1.1 Identify risks/impacts in the life-cycle of an engineering product or activity 7.1.2 Understand the relationship between the technical, socio-economic, and environmental dimensions of sustainability
7.2 Demonstrate an ability to apply principles of sustainable design and development	7.2.1 Describe management techniques for sustainable development 7.2.2 Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline

PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	
Competency	**Indicators**
8.1 Demonstrate an ability to recognize ethical dilemmas	8.1.1 Identify situations of unethical professional conduct and propose ethical alternatives
8.2 Demonstrate an ability to apply the Code of Ethics	8.2.1 Identify tenets of the ASME professional code of ethics 8.2.2 Examine and apply moral & ethical principles to known case studies

PO 9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	
Competency	**Indicators**
9.1 Demonstrate an ability to form a team and define a role for each member	9.1.1 Recognize a variety of working and learning preferences; appreciate the value of diversity on a team 9.1.2 Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective team work, to accomplish a goal.
9.2 Demonstrate effective individual and team operations-- communication, problem-solving, conflict resolution and leadership skills	9.2.1 Demonstrate effective communication, problem-solving, conflict resolution and leadership skills 9.2.2 Treat other team members respectfully 9.2.3 Listen to other members 9.2.4 Maintain composure in difficult situations
9.3 Demonstrate success in a team-based project	9.3.1 Present results as a team, with smooth integration of contributions from all individual efforts

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	
Competency	**Indicators**
10.1 Demonstrate an ability to comprehend technical literature and document project work	10.1.1 Read, understand, and interpret technical and non-technical information 10.1.2 Produce clear, well-constructed, and well-supported written engineering documents 10.1.3 Create flow in a document or presentation - a logical progression of ideas so that the main point is clear
10.2 Demonstrate competence in listening, speaking, and presentation	10.2.1 Listen to and comprehend information, instructions, and viewpoints of others 10.2.2 Deliver effective oral presentations to technical and non-technical audiences
10.3 Demonstrate the ability to integrate different modes of communication	10.3.1 Create engineering-standard figures, reports, and drawings to complement writing and presentations 10.3.2 Use a variety of media effectively to convey a message in a document or a presentation

PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's work, as a member and leader in a team, to manage projects and in multidisciplinary environments. .	
Competency	**Indicators**
11.1 Demonstrate an ability to evaluate the economic and financial performance of an engineering activity	11.1.1 Describe various economic and financial costs/benefits of an engineering activity 11.1.2 Analyze different forms of financial statements to evaluate the financial status of an engineering project
11.2 Demonstrate an ability to compare the costs/benefits of alternate proposals for an engineering activity	11.2.1 Analyze and select the most appropriate proposal based on economic and financial considerations.
11.3 Demonstrate an ability to plan/manage an engineering activity within time and budget constraints	11.3.1 Identify the tasks required to complete an engineering activity, and the resources required to complete the tasks. 11.3.2 Use project management tools to schedule an engineering project, so it is completed on time and on budget.

PO 12: Life-long learning: Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	
Competency	**Indicators**
12.1 Demonstrate an ability to identify gaps in knowledge and a strategy to close these gaps	12.1.1 Describe the rationale for the requirement for continuing professional development 12.1.2 Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to close this gap
12.2 Demonstrate an ability to identify changing trends in engineering knowledge and practice	12.2.1 Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current 12.2.2 Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field
12.3 Demonstrate an ability to identify and access sources for new information	12.3.1 Source and comprehend technical literature and other credible sources of information 12.3.2 Analyze sourced technical and popular information for feasibility, viability, sustainability, etc.

PSO1. Professional skills: An ability to apply the knowledge in Electronics and Communication Engineering in various areas, like Communications, Signal processing, VLSI and Embedded Systems. ..	
Competency	**Indicators**
PSO1.1 Demonstrate an ability to apply knowledge in Communications, Signal Processing, VLSI and Embedded systems	PSO1.1.1 Design circuitry and systems related to Communications, Signal Processing, VLSI and Embedded systems PSO1.1.2 Provide solution to the problems related to the specified systems PSO1.1.3 Upgrade the systems with latest technology and incorporating more facilities

PSO2. Competency: An ability to qualify at the State, National and International level competitive examinations for employment, higher studies, and research	
Competency	**Indicators**
PSO2.1 Demonstrate an ability to qualify at the State, National and International level competitive examinations for employment, higher studies, and research	PSO2.1.1 Qualify top level competitive examinations for employment PSO2.1.2 Qualify top level competitive examinations for higher studies and research

Rubrics for Percentage of Performance Indicator and Mapping Grade in CO-PO matrix

Mapping ratio	Strength
>66%	3
<66% but >= 33%	2
<33% but >= 0%	1

CO-PO Matrix

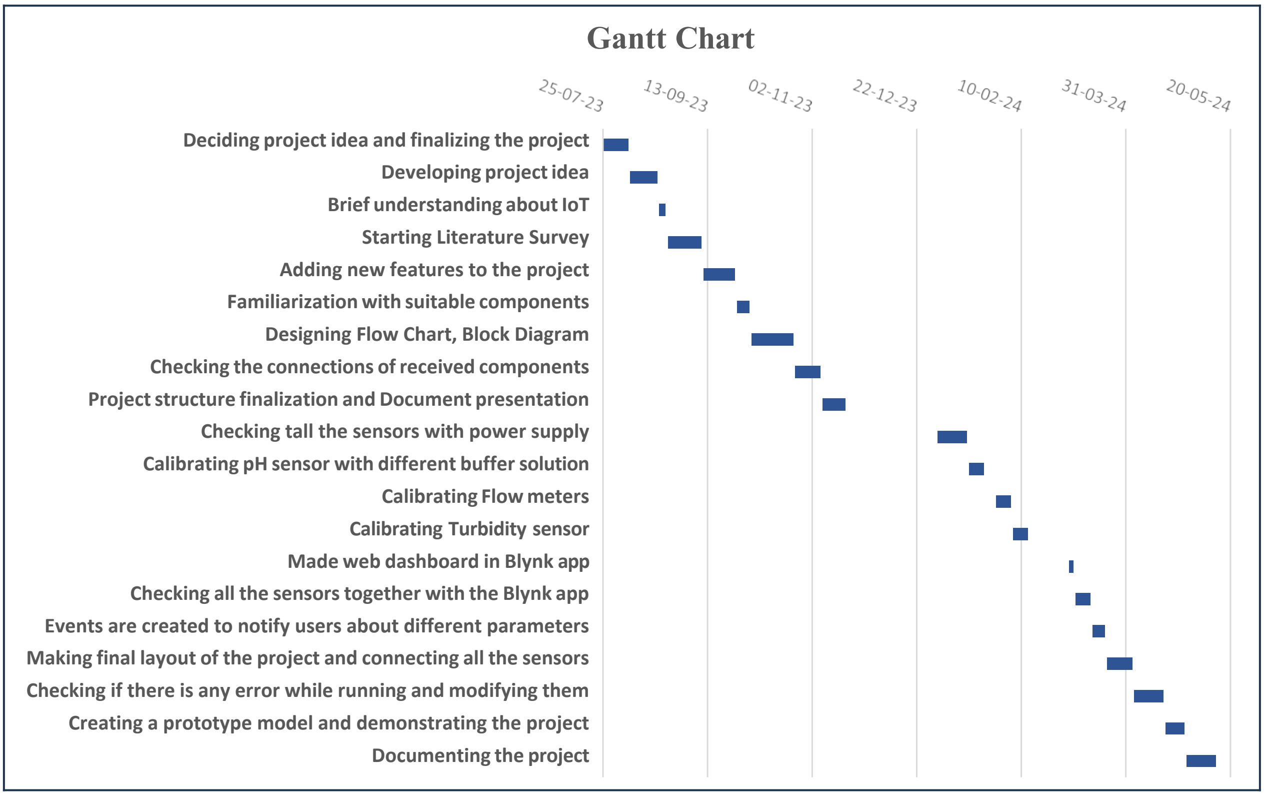
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	2	---	2	3	1	---	---	2	3	---	1	1
CO2	1	---	3	1	---	3	2	1	---	3	1	2	2	1
CO3	---	1	3	3	2	3	2	2	2	3	3	1	3	2
CO4	1	3	3	2	3	3	3	1	3	1	3	2	3	3
CO5	3	---	3	1	---	3	3	3	3	2	2	1	1	2
CO6	2	1	2	2	---	3	3	3	---	---	3	---	---	3
CO7	1	---	2	1	1	3	2	3	---	2	2	1	---	---
CO8	2	---	2	2	2	2	2	2	2	2	1	1	2	1
CO9	1	1	1	---	---	2	1	---	2	3	---	---	---	1
CO10	3	3	2	2	2	3	3	2	2	2	1	---	---	1

Program level Course-PO matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO	1.63	0.90	2.27	1.27	1.18	2.72	2	1.63	1.45	1.90	2	0.90	1.27	1.45

Project Planning:

TASK	Start Date	Duration	End Date
Deciding project idea and finalizing the project	25-07-23	12	06-08-23
Developing project idea	07-08-23	13	20-08-23
Brief understanding about IoT	21-08-23	3	24-08-23
Starting Literature Survey	25-08-23	16	10-09-23
Adding new features to the project	11-09-23	15	26-09-23
Familiarization with suitable components	27-09-23	6	03-10-23
Designing Flow Chart, Block Diagram	04-10-23	20	24-10-23
Checking the connections of received components	25-10-23	12	06-11-23
Project structure finalization and Document presentation	07-11-23	11	18-11-23
Checking tall the sensors with power supply	01-01-24	14	15-01-24
Calibrating pH sensor with different buffer solution	16-01-24	7	23-01-24
Calibrating Flow meters	29-01-24	7	05-02-24
Calibrating Turbidity sensor	06-02-24	7	13-02-24
Made web dashboard in Blynk app	04-03-24	2	06-03-24
Checking all the sensors together with the Blynk app	07-03-24	7	14-03-24
Events are created to notify users about different parameters	15-03-24	6	21-03-24
Making final layout of the project and connecting all the sensors	22-03-24	12	03-04-24
Checking if there is any error while running and modifying them	04-04-24	14	18-04-24
Creating a prototype model and demonstrating the project	19-04-24	9	28-04-24
Documenting the project	29-04-24	14	13-05-24



Total Budget:

Sl. No	Name of Component	Quantity	Cost/item
1	Arduino Mega 2560 with USB cable	1	1800
2	NodeMCU ESP8266	1	400
3	Electrode Probe for Liquid pH Value Detection Sensor Module	1	1900
4	YF-S401 water flow sensor	2	370
5	Water Turbidity Sensor with Analog Output Module	1	560
6	5V DC Water Pump	2	50
7	5V Relay Module	2	30
8	IONIX Activated Carbon Faucet Water Filters	1	200

Acknowledgement

We, the members of Group 4, acknowledge the inspiration rendered to us by our respected Director sir, Principal Ma’am, HOD sir, subject teachers, and our beloved Mentor Ma’am. Without their constant support and guidance, this project could not be successfully completed and demonstrated.

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Aritra Adak

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Sujata Biswa

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Sreemoyee Ghosh

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Haniya Yeasmin

Dated:

Certificate

Department of Electronics and Communication Engineering
St.Thomas' College of Engineering and Technology

This is to certify that the project entitled **"The Smart Water Quality Monitoring and Management with Smart Billing System,"** has been carried out by

Aritra Adak (12200320022),

Sujata Biswas (12200320025),

Sreemoyee Ghosh (12200320045),

Haniya Yeasmin (12200321058)

under my guidance during the year **July,2023 to May,24** and accepted for partial fulfillment of the requirement of the Degree of Bachelor of Technology of Maulana Abul Kalam Azad University (formerly West Bengal University of Technology). Kolkata

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(Mrs.Sumani Mukherjee)

Signature of Project guide

Dated:

Content

Abstract

The Smart Water Quality Monitoring and Management System with Smart Billing System is a ground-breaking solution to integrate technology, environmental issues, and resource management to solve water problems and services. This project uses advanced sensors, real-time data analysis, aut omation, and smart billing system to im prove water quali conservation efforts, and financial sustainability. Through a network of sensors, predicti analytics, customer engagement, and data-driven decision-makin the system not on ensures a clean and safe water supply but also enables customers t actively participate water conservation. By combining environmental manag ment, technologi innovation and data-driv en efficiency, this project contributes to the sustainability a resilience of communitie and cities while reducing environmental in pact. Additionally, t future scope of the pro ject is promising, with opportunities to e xpand IoT, predicti analytics, water diversifi ation, blockchain integration, and particip tion in broader wa initiatives.

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Introduction

1.1. Project Overview

The Smart Water Quality Monitoring and Management with Smart Billing System represents a groundbreaking approach to modern water management. Leveraging advanced sensors strategically placed throughout the water distribution network, the system ensures real-time monitoring of crucial parameters, enabling proactive responses to water quality issues. Complemented by a Smart Billing System, the project promotes fair billing based on actual usage, with potential tiered pricing structures encouraging responsible consumption. Customer empowerment is at the forefront, providing a user-friendly portal for real-time access to water usage data and transparent billing information. Robust historical data maintenance, stringent security measures, and future-ready scalability further underscore the project's commitment to efficiency, transparency, and sustainability, making it a beacon in the evolution of water management practices [1].

Water shortage is a significant global challenge that many regions are already facing, and it is expected to become even more critical in the future due to factors such as population growth, climate change, and increased demand for water resources. Addressing this issue requires a combination of conservation, efficient use of water, technological innovations, and sustainable management practices [1][3].

As the world's population grows, water needs increase across agriculture, industry, and households. Climate change worsens this by altering rainfall, raising temperatures, and increasing extreme weather events. Some areas face long droughts, while others deal with more frequent floods, all affecting water availability and distribution significantly [2].

As more people move to cities, the demand for water increases. Urbanization often outpaces the development of water infrastructure, leading to over-extraction of groundwater and stress on existing water sources [1][2].

Agriculture and industry are major consumers of water. As economies grow, so does the demand for water in these sectors. Efficient water management practices are crucial to meet these needs sustainably [4].

Rapid population growth heightens the demand for water across agriculture, industry, and households, while climate change exacerbates water availability issues through altered precipitation patterns and extreme weather events. Pollution from industrial discharges, agricultural runoff, and improper waste disposal further contaminates water sources, jeopardizing both human consumption and agricultural use. Over-extraction of groundwater intensifies depletion concerns, amplifying long-term risks to water accessibility. Meanwhile, conflicts over water rights and access fuel geopolitical tensions between regions and countries. Addressing water scarcity demands a comprehensive approach, encompassing sustainable management practices, infrastructure investment, conservation initiatives, and international cooperation. Technologies such as desalination, rainwater harvesting, and efficient irrigation systems offer additional strategies to mitigate water scarcity challenges [2][4].

If we apply some amount to the water supply, we can have control over the misusing of water. People will be more sincere about how much water they need exactly and how to implement it. The system will keep the users updated about the amount of water used by them so that they can be careful. The users will be able to verify their bills in real time [1][2][3].

This billing system will give an update to the customer, if there is any leakage in the pipeline or if the tap is left open by mistake. We have added a purifying system in it so it will help us in decreasing the amount of health issues caused by the unpurified water. If for any purpose the customer is using more water than the allocated amount, then also they will get a notification of excess charging [3][4].

1.2. Objectives

This report introduces the Smart Water Quality Monitoring and Management System, intricately linked with a Smart Billing System. The objective of this integrated project is to provide a comprehensive solution that fuses advanced technology, environmental stewardship, and efficient resource management to revolutionize water quality monitoring and billing. The core principles of this innovative system encompass real-time data collection through a network of strategically placed sensors, data analysis through sophisticated algorithms, proactive alerting, and infrastructure automation. The Smart Billing System complements these features by calculating bills based on actual water usage and offering tiered pricing structures to encourage responsible consumption.

1.3. Applications

This multifunctional system serves as more than just a data collector and billing platform; it is a comprehensive solution that enhances water management and consumer awareness. Through advanced monitoring capabilities, it promptly identifies and notifies authorities about water quality issues, facilitating swift remedial action. Moreover, it proactively adjusts the water network to prevent the spread of contaminants, ensuring public health and safety.

Furthermore, its potential integration with the Internet of Things (IoT) expands its functionality, enabling real-time monitoring and control from remote locations. This feature provides homeowners with instant access to comprehensive water quality data and alerts about potential leaks, even when they are away from home.

In terms of billing, leveraging blockchain technology ensures transparent and tamper-proof transactions, enhancing trust and accountability in billing processes. Additionally, it aligns seamlessly with smart city initiatives, contributing to overall urban sustainability and efficiency.

Background of the Project

2.1. Literature Survey

This paper proposes a Smart Water Monitoring System that aims to tackle two major problems related to water distribution - water quality checking and water usage monitoring. The system consists of two parts: a smart water quantity meter and a smart water quality meter. The water quantity meter monitors the amount of water consumed by a household and notifies the consumer and authority. It implements a three-slab billing system based on the water usage. This leads to optimized water consumption.

The water quality meter checks the purity of drinking water by measuring parameters like pH, temperature, turbidity, and conductivity. It ensures the water is safe to drink and alerts the consumer and authority if any impurity is detected. An online monitoring system provides real-time access to the water quality and quantity data.

The system hardware consists of a Raspberry Pi microprocessor, Arduino board, sensors like pH, temperature, turbidity, and water flow sensors. The software includes a web portal for remote monitoring of the system.

The system aims to reduce unnecessary water usage and prevent health hazards from impure water by automating water quality checks and monitoring consumption. The paper discusses possible future works like using integrated sensors to reduce costs and machine learning algorithms to predict water usage.

In summary, the proposed Smart Water Monitoring System effectively tackles the problems of ensuring water quality and optimizing water usage through real-time monitoring and notifications [1].

The paper discusses a proposed system to continuously monitor the quality and quantity of drinking water supply. Clean drinking water is essential for good health. However, there are real-time challenges in ensuring the quality of supplied water.

The proposed system uses sensors like pH, turbidity, and conductivity sensors to determine the quality of the water. A solenoid valve is used to regulate the water supply based on the sensor readings. A water flow sensor measures the quantity of potable water supplied.

An Arduino Mega controller collects the sensor data and calculates the utilization charges. An ESP8266 Wi-Fi module sends the data to an IOT platform. A GSM module sends the water quantity and charges information to the users via SMS.

The system aims to ensure a successful supply of potable water and implement a smart water billing system. It can help prevent waterborne diseases by supplying clean drinking water and charging only for the potable water. In conclusion, the system can potentially monitor the water supply quality and quantity, calculate water bills accurately, and improve access to clean drinking water. The system can also be implemented for monitoring water usage in agriculture [2].

This paper discusses a system to continuously monitor the quality and quantity of supplied drinking water. Clean and healthy drinking water is essential for good health. However, there are challenges in ensuring the quality of supplied water. The proposed system uses sensors to measure various water quality parameters like pH, turbidity, conductivity, and temperature. An Arduino Mega controller is used to collect data from the sensors and control the system. An ESP8266 Wi Fi module transmits the sensor data to an IoT platform. A solenoid valve regulates the water supply based on the sensor measurements. If the water quality is not within the required parameters, the valve redirects the water to a different outlet. A water flow sensor measures the quantity of water supplied. The system calculates the charges for the supplied potable water based on the quantity. This information is sent to the users via SMS using a GSM module. An LCD display shows the sensor readings and water supply information. The IoT platform allows the organization managing the water supply to monitor the system online. The proposed system aims to ensure a continuous supply of clean drinking water and implement a smart water billing system. This can help overcome challenges in real-time water supply management. The authors suggest that the same system could be implemented on a larger scale to monitor water supply for agricultural use as well [3].

This paper proposes a real time water quality monitoring and management system that will allow water quality monitoring at household levels as well as help limit the use of this natural resource. The system will monitor parameters like pH content and total dissolved solids (TDS) content of tap water and provide a user interface with meters to illustrate the quality factors. For this system, they plan to use an Arduino Uno board along with sensors to measure the pH value, TDS content and flow rate of tap water. A GSM module will also be used for message alerts. Monitoring pH and TDS are considered important parameters for water quality along with acceptable limits as per WHO guidelines and Indian standards. The system will consist of a pH sensor to measure acidity or alkalinity, an in-house fabricated circuit for reading TDS, a flow rate sensor, and a solenoid valve to regulate water flow. A cloud platform called Thing Speak will be used to store and retrieve data from the sensors for visualization and analysis. The system works by first initializing the Wi-Fi connection.

Then, the flow rate sensor measures water flow while the pH and TDS circuits analyze the pH value and TDS content of the tap water. Based on the readings, the system determines water quality using LED indicators. If the water quality is unsatisfactory, purification can be implemented in future versions along with machine learning to forecast quality. The proposed system aims to advance conventional water testing and help manage water resources efficiently. Though limited in scope currently, it indicates the potential of such systems as part of smart buildings and smart cities in future [4].

The paper discusses a proposed real time water quality monitoring system using Internet of Things technology. The system aims to address the issues of traditional manual water quality testing which is time consuming and less accurate. The proposed IOT based system uses sensors to continuously monitor various water quality parameters like temperature, pH, turbidity, and salinity. The data from the sensors is processed using an Arduino microcontroller which then separates the water into two chambers for either drinking or livestock purposes. The data is also sent to the cloud where consumers can view it on their mobile phones. The system also generates water bills based on the amount of water consumed. The paper discusses three major subsystems of the proposed system: the data collection subsystem using various sensors, data transmission subsystem using an IOT module and network, and data management subsystem for analyzing and reporting the water quality data. Some of the key water quality parameters that can be monitored include temperature, pH, turbidity, salinity, nitrates, and phosphates. Monitoring the aquatic macro invertebrates can also assess water quality. The proposed low-cost system aims to provide real time monitoring of water quality parameters using sensors connected to a Raspberry Pi module. The sensor data is then sent to the cloud where it can be accessed. The system also detects water flow and generates water bills for consumers. LED displays show the water level to alert consumers.

In summary, the proposed IOT based water quality monitoring system aims to provide a low cost and real time solution to assess water quality more efficiently compared to traditional manual testing methods. The system uses sensors and cloud connectivity to continuously monitor and report on various water quality parameters [5].

Details of the Project

3.1. Project Description

Smart water monitoring and management and smart billing system, represent the innovative design to ensure efficient use of water usage, maintain the quality of drinking water, purification, and generate a bill on daily water consumption.

Firstly, we divide the source water in two ways, i.e. drinking water and non-drinking water. This water distribution is done with the help of a DC motor along with the relay module. Here relay module acts as a switch to operate the DC motor. Whenever we press “On” in the Blynk app, the relay module gets activated and the DC pump starts water distribution. As soon as we press “Off,” the relay module gets disconnected and the DC pump stops. This distribution system is used for both sides.

In the case of drinking water, our first focus is on water purification, here we use a Carbon Faucet water filter for filtering purposes as we represent the prototype of the project, else here for further application we can use any reliable filter for purification. After the purification process our next step is to check the quality of the water, does it meet the drinking standards or not? To monitor this, we will regularly check the pH and turbidity value of the water with the help of advanced sensor technology. pH sensor measures the level of alkalinity or acidity of the purified water and with the help of a turbidity sensor, we can check the cloudiness or haziness of the water, caused by suspended particles. By continuously assessing these parameters, we guarantee the safety and purity of the supplied drinking water. This purified water will be allocated for drinking purposes, on the other hand, non-purified water will be directly distributed for household work.

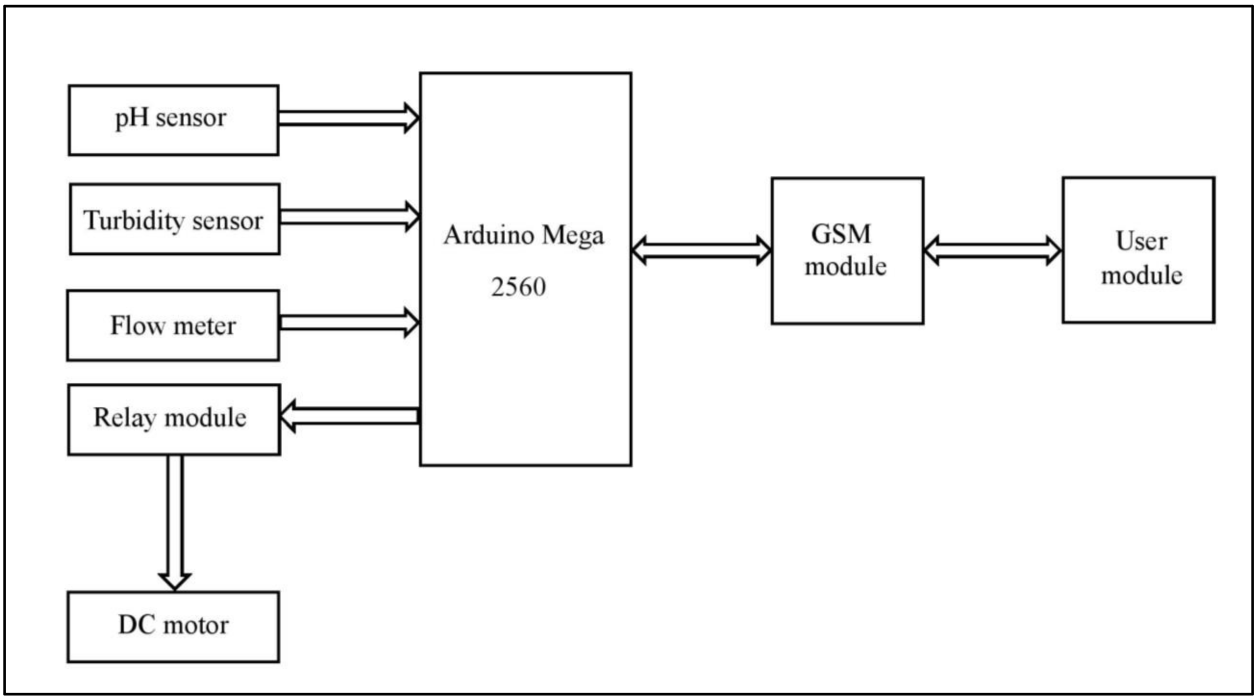
Now comes the billing part of the project. Here for measuring the total uses of daily water both drinking and non-drinking water; we use two separate flow meters. This flow meter helps to detect the total flow of water in a house. By tracking total water usage, we can generate bills for the consumers. Here we set a limit for daily water usage, for drinking water this is 6 liters and for non-drinking water, the limit is set to 10 liters. For drinking water, there is a standard charge of Rs 5/liter, if the usage exceeds the daily limit the charge will be increased to Rs 7/liter. On the other hand, for non-drinking water the standard charge will be Rs 1/liter and if the consumption exceeds the daily limit the charge will be increased to Rs 3/liter.

By integrating all the sensors with the Blynk app, our system not only ensures the provision of safe drinking water but also promotes efficient water usage through a transparent billing process.

3.2. Specifications

- **Water quality monitoring:** Quality monitoring incorporates pH sensors to measure the acidity or alkalinity of water and uses turbidity sensor to assess the clarity and purity of water.
- **Water purification system:** Here we utilize an advanced purification system to ensure safe drinking water. Purified water is segregated for drinking purposes and non-purified water is for household use.
- **Smart Billing System:** The system helps to track total water usage accurately for each consumer and generates bills based on actual consumption, promoting transparency and fairness.
- **Real-Time Monitoring**: In addition to control capabilities, the Blynk app provides real-time monitoring of water usage and tap status. Users can view live data on water flow rates, consumption metrics, and tap statuses to track usage and identify potential issues. This real-time monitoring enables users to make informed decisions and optimize water usage efficiency.
- **Scalability and Compatibility:** This is designed to scale according to varying water demand and infrastructure needs. It is also compatible with existing water distribution networks and infrastructure.

3.3. Block Diagram



➢ Explanation of Block Diagram

Arduino Mega 2560: It acts as a central processing unit of this IoT system. All the sensors like pH sensor, turbidity sensor, flow meter and DC water motor are connected with the Arduino mega. It acts as a power supply and also collects data from the sensors and sends the data to the GSM module.

pH sensor: The pH sensor measures the acidity or alkalinity of the water by detecting the concentration of hydrogen ions (H+) in the solution. It provides real-time data on water quality which helps to monitor and maintain the desired pH level of drinking water.

Turbidity sensor: The turbidity sensor measures the turbidity of the water caused by suspended particles. The sensor consists of a light source and a detector. The detector is positioned at an angle to detect light scattered by particles floating in the water. The amount of this scattered light is directly proportional to water turbidity.

Flow sensor: Flow sensor measures the rate of water flow through a pipe. It gives the data of total water consumption and this data helps to generate the bill for every consumer. It consists of a turbine or a paddle wheel that rotates as the water passes through it. This rotation produces electric pulses, which are proportional with the flow rate of water. These pulses are counted and converted into volume for measurements.

Relay Module: This module is used as a switch in the water distribution system. When the relay is activated, the contact closes and the DC motor starts operating. When the relay gets disconnected then the contacts open and the DC motor stops operating.

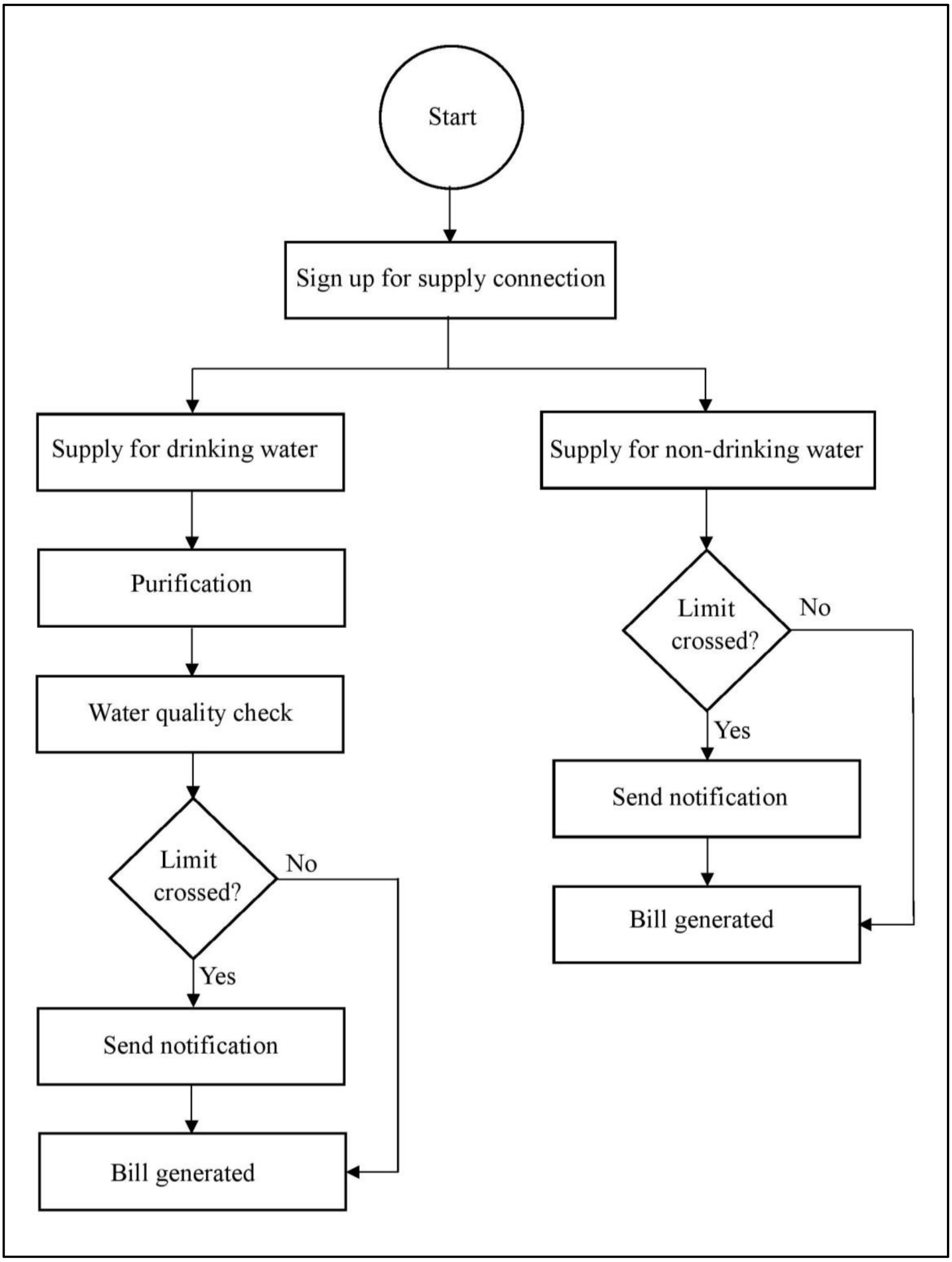
DC motor: The DC motor along with the relay module works as an opening and closing water valve. It acts as a water distribution unit and supplies the water to every house.

GSM Module: The GSM module acts as a communication interface between the water monitoring devices (sensors, flow meters, etc.) and the central server. GSM module provides wireless communication with the system for remote monitoring and control. It allows the user to control the functionalities of the system though a user interface module. It provides the real-time alert and notifications to the users and enhancing the reliability of the system.

User Module (Blynk App): Blynk is a software platform that allows you to build IoT applications for project purposes. It provides a mobile app through which users can control the hardware remotely through the internet. This Blynk application provides customized user interfaces called “widgets”. These widgets consist of buttons, sliders, gauges, displays, and more.

The water-related data collected from various sensors, including turbidity sensor, pH sensor and flow sensors, are transmitted to the user module or cloud-based server through a communication network. This allows users to monitor the water quality and the total water consumption and also they can view the billing information from their smartphones.

3.4. Flow Chart



➢ Explanation of Flow Chart

Sign-In: Users initiate the process by signing into the water supply system. This involves providing authentication credentials such as a username and password.

Start Water Supply: Once signed in, the system authorizes water supply for the users. This could involve opening valves or activating water pumps to begin the distribution of water.

Water Distribution: From the source, water will be distributed to each house through two different connections, one is for drinking water and another is for non-drinking water.

Water Purification: With the help of any water filter firstly we will purify the water which is distributed for drinking purposes.

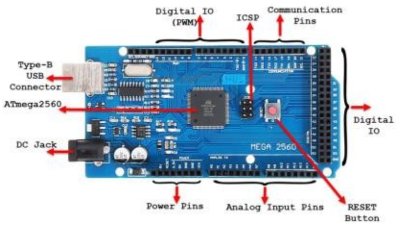
Water Quality Check: Various sensors, including turbidity and pH sensors, are employed to assess the quality of the drinking water.

Daily water consumption limit: For measuring the daily water consumption, both for drinking and non-drinking water two separate flow sensors are used. These sensors are implemented to monitor daily water consumption.

If the daily consumption exceeds the predetermined limit, the system sends notifications to both the user about it. Despite the notification, the water flow continues to meet the user's needs.

Monthly Bill Generation: By collecting the data from the flow sensors a daily bill is generated for each user. This bill is generated separately for both drinking and non-drinking water and if the consumption exceeds the daily limit the cost will increase per litre of water.

3.5. Components Specifications

Component	Specifications	Photograph
1. Arduino Mega 2560 [6]	• Microcontroller: ATmega2560 • Total 54 digital input/output pins of which 15 can be used as PWM outputs • 16 analog input pins • 4 UARTs (hardware serial ports) • 16 MHz crystal oscillator • Operating Voltage 5V	 **Fig-1**
2. NodeMCU ESP8266 [7]	• PROCESSOR : Tensilica 32-bit RISC CPU Xtensa LX106 • Operating Voltage: 3.3V. • Digital I/O Pins : 16. • Analog Input Pins : 1. • Frequency range:2.4GHz-2.5GHz • Supports protection mode: WPA / WPA2	 **Fig-2**
3. Electrode Probe for Liquid pH Value Detection Sensor Module [8]	• PH range: 0-14 PH • Response Time: ≦1min • Alkali Error 0.2 pH • Temperature range: 0-60°C	 **Fig-3**
4. YF-S401 water flow sensor [9]	• Flow Rate Range:0.3~6L/min • Accuracy: ±5% (0.3-3L/min) • Working Voltage: DC 5V~24V	 **Fig-4**

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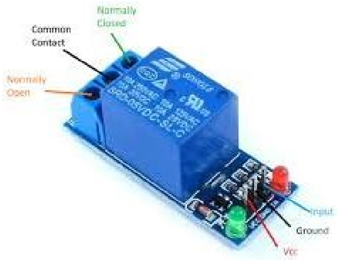
Component	Specifications	Photograph
5. Water Turbidity Sensor with Analog Output Module [10]	• Operating Voltage: DC 5V • Output Method: Analog output: 0-4.5V; Digital Output: High/Low level signal (you can adjust the threshold value by adjusting the potentiometer)	 **Fig-5**
6. 5V DC Water Pump [11]	• Operating Voltage: 3V-5V • Flow Rate: 1.2 – 1.6 L/min.	 **Fig-6**
7. 5V Relay Module [12]	• Operating Voltage: 5V • Digital output controllable • Control signal: TTL level	 **Fig-7**
8. IONIX Activated Carbon Faucet Water Filters [13]	• Filtration Technology: Activated carbon filtration • Filtration Efficiency: Removes impurities, chlorine, odor, and sediment from tap water	 **Fig-8**

3.6. Algorithm

- **Arduino Mega 2560**

Step 1: Initialization: Include necessary libraries.

Step 2: Initialize global variables:

2.1 Set pulse counts and flow rates for both drinking (DW) and non-drinking (NDW) water to zero.

2.2 Initialize variables to track total water flow and old time.

Step 3: Setup Function:

3.1 Initialize serial communication for debugging.

3.2 Configure SoftwareSerial for communication with sensors.

3.3 Set pin modes for sensor inputs.

3.4 Attach interrupts to sensor input pins for pulse counting.

Step 4: Loop Function:

4.1 Read current time.

4.2 If a specified time interval has elapsed:

4.2.1 Calculate flow rates for both DW and NDW sensors using pulse counts.

4.2.2 Send flow rate values over the chosen communication interface

4.2.3 Reset pulse counts for flow sensors.

4.2.4 Update old time.

4.2.5 Read and send mapped values of turbidity and pH sensors.

4.3 Check for incoming commands/data on the serial port:

4.3.1 Parse incoming commands/data.

4.3.2 Execute corresponding actions based on the received commands/data.

Step 5: Interrupt Service Routines: Define functions to increment pulse counts for DW and NDW sensors when interrupts are triggered.

➢ NodeMCU ESP8266

Step 1: Initialization: Include necessary libraries.

Step 2: Define Blynk configuration constants: Blynk template ID, name, and authentication token.

Step 3: Initialize global variables:

3.1 Define variables for flow rates, total flow, turbidity, pH, and total cost for DW and NDW.

3.2 Define pins for software serial communication.

Step 4: Define Blynk virtual pin handlers: Define Blynk virtual write functions for handling incoming data from Blynk app widgets

Step 4: Setup function:

4.1 Begin serial communication for debugging.

4.2 Initialize software serial communication with specified pins and baud rate.

4.3 Connect to the Wi-Fi network with provided credentials.

4.4 Set pin for any output if required.

Step 5: Loop function:

5.1 Run Blynk tasks.

5.2 Check for incoming data on the serial port:

5.2.1 Process data accordingly:

5.2.1.a : Read flow rates and update total flow and cost variables for DW and NDW.

5.2.1.b : Check if total flow exceeds a threshold and in that case send notifications about the increase of cost for DW and NDW.

5.2.1.c : Read sensor data for turbidity and pH.

5.3 Update Blynk virtual pins with updated sensor data and total costs.

Result

4.1. Photographs

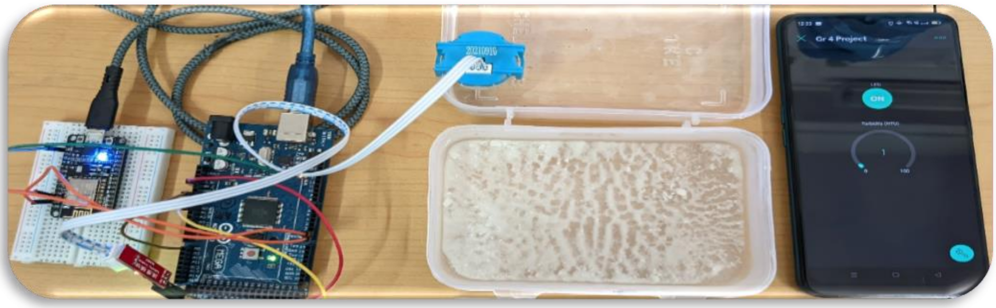


Fig-9: Turbidity of drinking water (0-5 NTU)

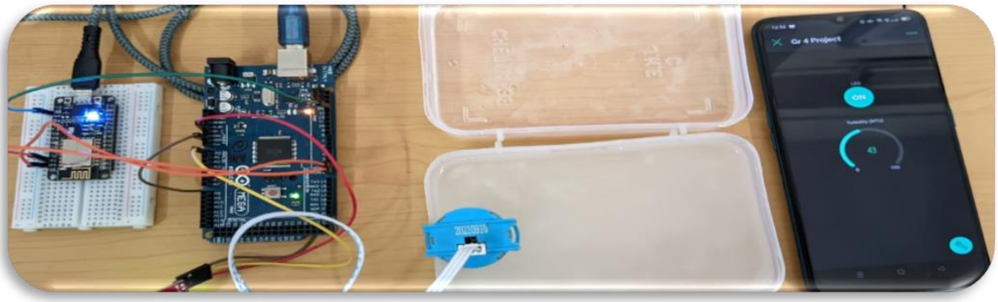


Fig-10: Turbidity of Murky water (more than 5 NTU)

Fig-11: Turbidity when particles resist dissolving in water (more than 15NTU)

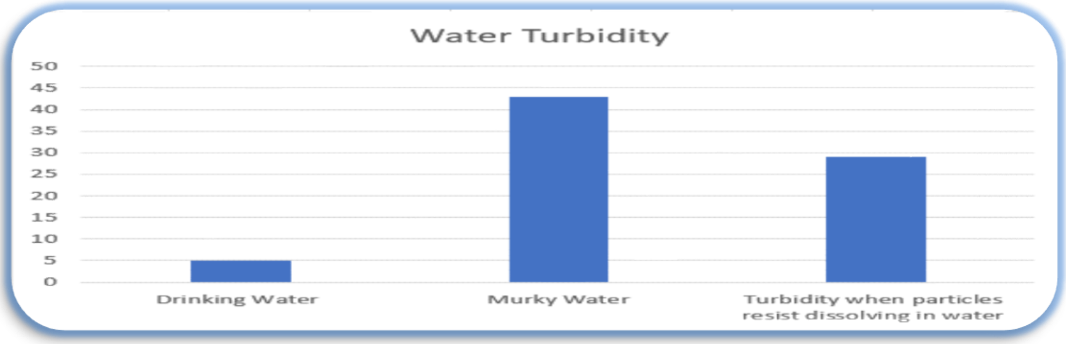


Fig-12: Turbidity of different samples of water

Fig-13: PH value of Distilled water is near 7

Fig-14: PH value of Baking soda is near 9

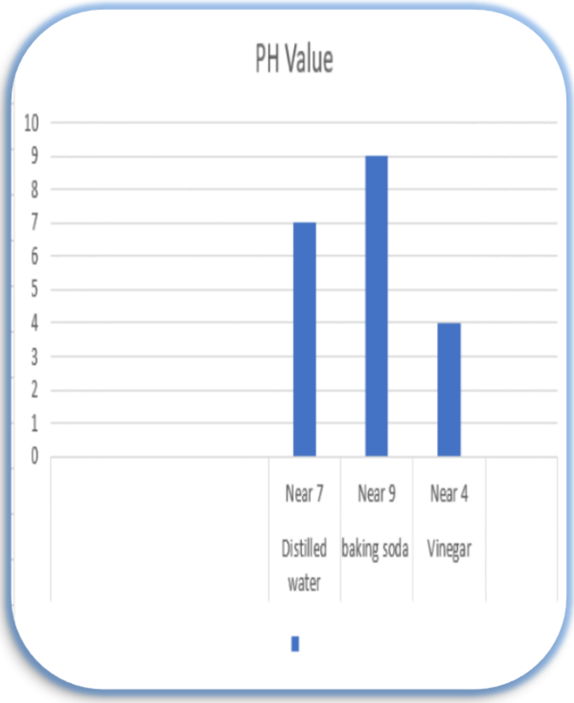


Fig-15: PH value of Vinegar is near 4

Fig-16: PH value of different water samples

Fig-17: Working of Flow Meter

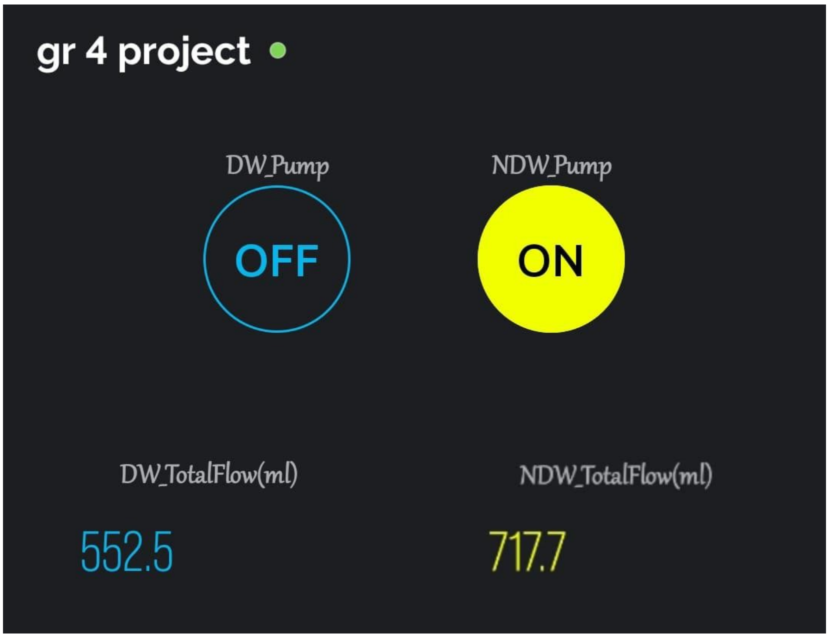


Fig-18: Through Blynk App Total water flow measurements

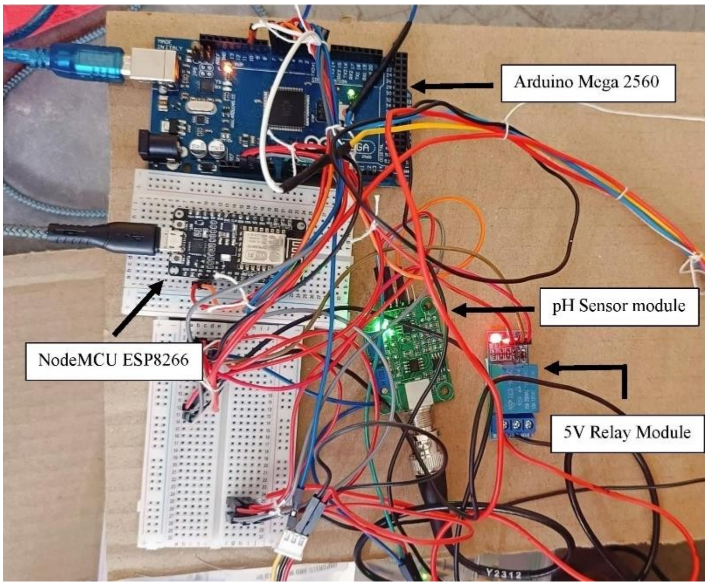


Fig-19

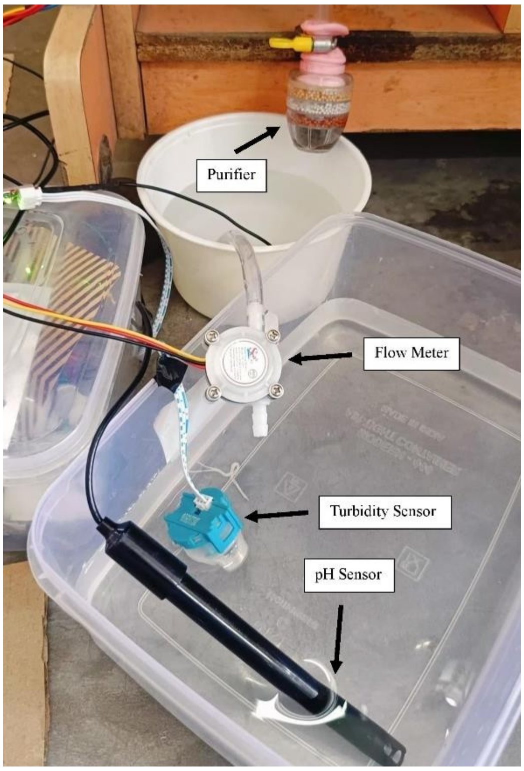


Fig-20

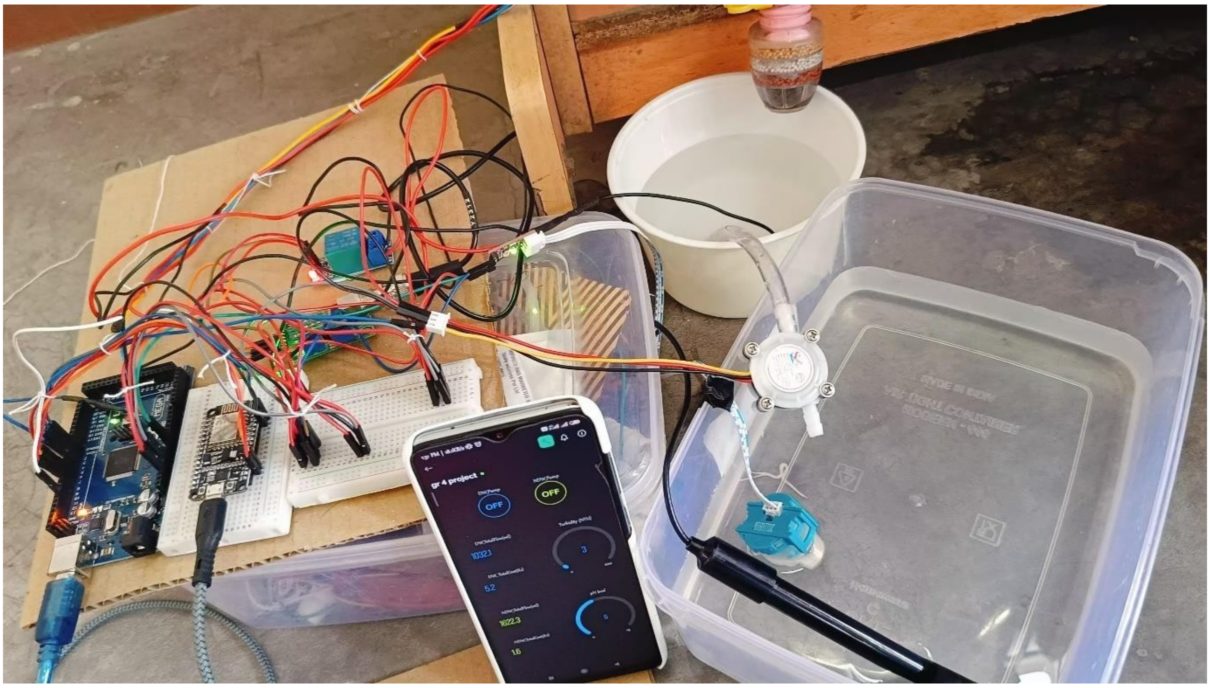


Fig-21

Fig-19,20,21: All components are connected

Fig-22: Final result with all connections

Fig-23: Final Reading

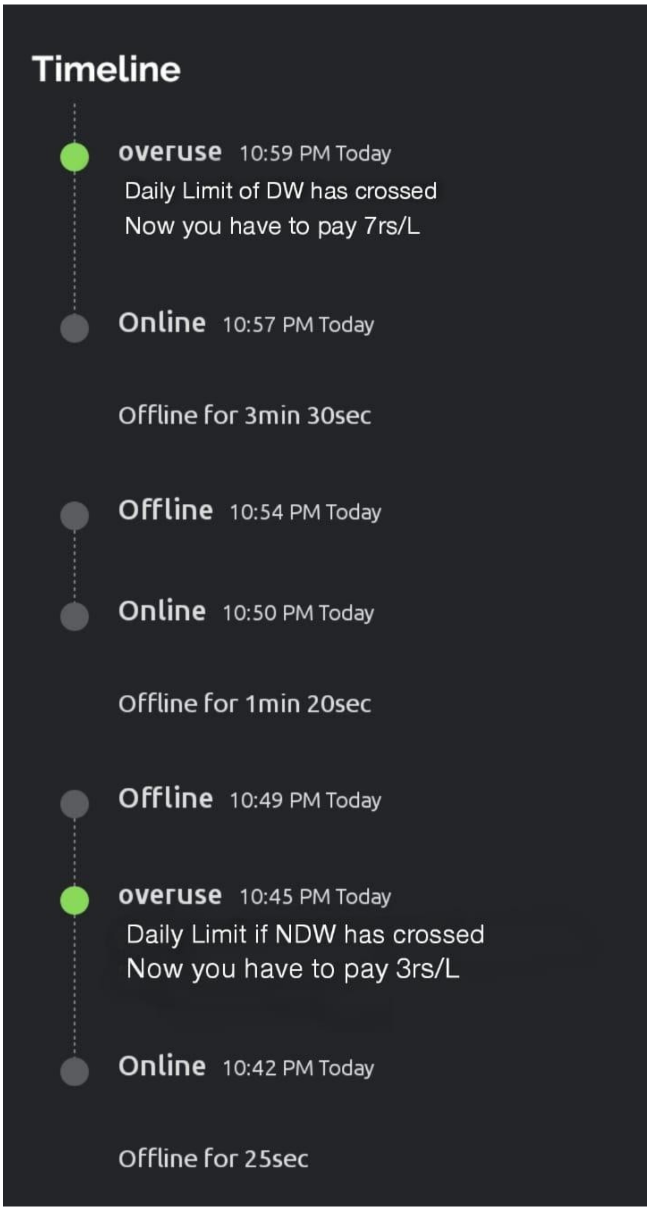


Fig-24

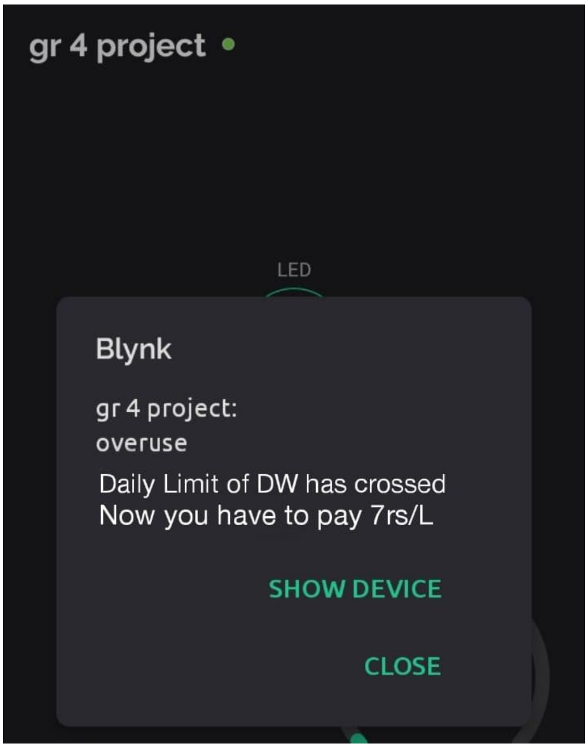


Fig-25

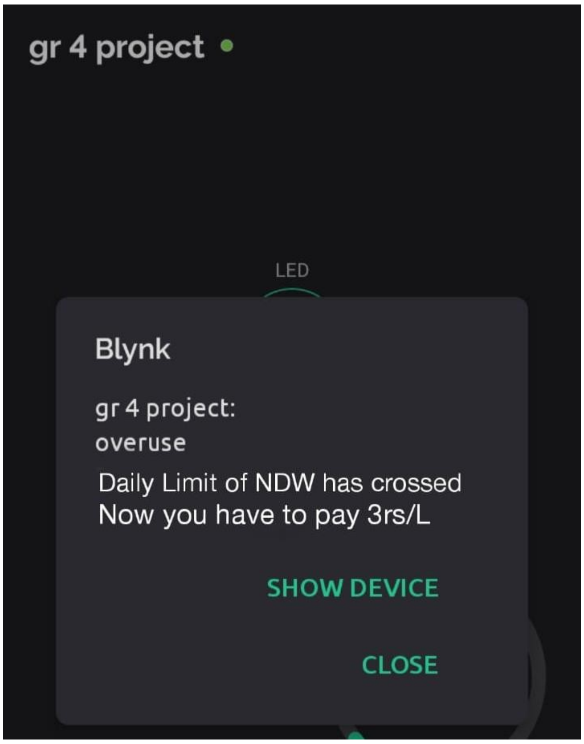


Fig-26

Fig-24,25,26: Notifications generation of Total daily limit of Drinking and Non-drinking water exceeds

Comments on Result

The results indicate the turbidity levels across various water samples, each with its significance:

For checking the turbidity of the water, we used 3 containers, Distilled water in one container and another container, we mixed chalk power. In Fig.9 we dipped the turbidity sensor in Distilled water and checked the value of the Blynk application. By doing this experiment we noticed that, for distilled water the value of the turbidity sensor is 1 NTU (Nephelometric Turbidity Units)., this falls within the acceptable range for drinking water turbidity, indicating clarity and minimal particulate matter. It's crucial to ensure the water is safe for consumption and meets regulatory standards.

Next in Fig.10, we can see the turbidity sensor was dipped in murky water. By doing this experiment we noticed for murky water we got the value of turbidity which is more than 5 NTU. Elevated turbidity suggests increased levels of suspended particles or sediment in the water.

In Fig.11 the turbidity sensor again dipped in the second container but this time water with Particles resists dissolving in water, and we noticed the value is now more than 15 NTU. In Fig.11 we can observe that chalk powder resists dissolving in water, they remain suspended, causing cloudiness and reduced clarity, resulting in a turbidity measurement of more than 15 NTU.

In all cases, monitoring turbidity levels is essential for ensuring water quality and safety, as it can serve as an indicator of potential issues that may require corrective actions or treatment to maintain or improve water quality standards.

The results of testing the pH values of different substances provide valuable insights into their acidity or alkalinity:

For testing the pH we take 3 glasses of bikar, In the 1st bikar we have Distilled water, in the 2nd bikar we have Baking Soda Solution and, in the 3rd, bikar there is Vinegar.

After testing the pH values, we noticed that in Fig.13, The pH of Distilled water is 7, which indicates a balanced level of acidity and alkalinity. Any deviation from this may indicate impurities or atmospheric contamination.

There is Baking Soda Solution in Fig.14, where we can perceive that when Baking Soda is dissolved in water, typically produces a basic solution with a pH greater than 7. In our experiment, we got pH 9 for the Baking Soda Solution.

In Fig.15 Vinegar is present. We know Vinegar is acidic due to the presence of acetic acid, so its pH value is typically below 7. In our experiment, we get pH 4 for Vinegar.

Fig 16 shows the overall analysis of pH for different water solutions.

The result of testing the flow meter using the Blynk interface:

In Fig 17 we have used a flow meter to check the flow of water. This flow meter helps to measure the total flow of the water which gives a clear measurement of the amount of daily water consumption.

In Fig 18 with the help of the Blynk application, we can observe the total water consumption of both drinking and non-drinking water. With the help of this data, the user will get the daily bill for water consumption.

Final Result analysis:

In Fig 19,20 and 21, we have seen that all the sensors are connected to the system.

Fig 22 shows the total setup of this project with all the components and in Fig 23 its corresponding data is visible in the Blynk application.

In Fig 24,25 and 26 the Blynk application shows "Daily limit of NDW has crossed Now you have to pay 3rs/L” and “Daily limit of DW has crossed Now you have to pay 7rs/L” It indicates that the user has surpassed the daily water usage limit. In such cases, users are prompted to pay 7 rupees per liter for drinking water and 3 rupees per liter for non-drinking water for the excess water consumed, incentivizing them to be more mindful of their water usage and avoid unnecessary wastage.

Conclusion

6.1. Discussions

The implementation of the Smart Water Quality Monitoring and Management and Smart Billing System represents a significant advancement in the field of water management. This initiative merges cutting-edge technologies, environmental stewardship, and resource optimization to tackle the persistent challenges related to water quality monitoring and billing mechanisms. The fundamental principles underpinning this endeavor, such as the utilization of sophisticated sensors, real-time data analysis, proactive alert systems, and intelligent billing procedures, demonstrate a comprehensive and forward-looking strategy.

The integration with the Smart Billing System further enhances the efficacy of the project by ensuring that consumers receive accurate bills reflecting their actual water usage, potentially motivating them to adopt water conservation practices through a tiered pricing structure. This combination of technological innovation, transparency, and accountability in billing sets a new benchmark for the industry.

This project's application extends to environmental analysis, data sharing and increased emergency response planning. By adjusting different features of water management process in real time-based applications, it offers more efficient and cost-effective water management in future.

In summary, the project on Smart water Quality monitoring and management and Smart billing system embraces technology to enhance water quality, resource conservation, and financial efficiency while reducing its environmental footprint.

6.2. Future works

- Improved notification system: We can enhance the notification system to send alerts to the users when their water usage reaches certain thresholds. These alerts will be generated at 50%, 80%, and 90% of their designated water allowance. Users receive notifications via a mobile app, encouraging them to monitor their usage and take proactive measures to reduce consumption.
- Database management: If we create a monthly database, we can store daily data about pH, turbidity, and other water quality parameters. It will enable users to monitor the consistency of water quality. If the quality deteriorates, the user will notified, and steps will taken to address it when poor water quality persists for consecutive days.
- Advanced Monitoring system: If we can use more number of sensors then the system can

distinguish between normal and purified water usage. It will help us to know the difference between water quality before and after purification. From this data, we can easily analyze the power of purification and take action accordingly.

- Remote controlling: By using a controller circuit we can provide the remote controlling mechanism to the user. It will help users to control the flow rate from anywhere.

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Arduno Mega code

Node Mcu (ESP 8266) code