IRRIGATION POND WATER QUALITY MONITORING BY USING WIRELESS SENSOR NETWORK

ALI RAZA	**19-arid-2325**
MUHAMMAD ARHAM	**19-arid-2340**
SYED HASHIR ALI	**19-arid-2348**

DEPARTMENT OF STRUCTURAL AND ENVIRONMENTAL ENGINEERING
FACULTY OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
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by

ALI RAZA	**19-arid-2325**
MUHAMMAD ARHAM	**19-arid-2340**
SYED HASHIR ALI	**19-arid-2348**

A report submitted in partial fulfillment of
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in
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MUHAMMAD ARHAM 19-arid-2340	Signature:	______________
SYED HASHIR ALI 19-arid-2348	Signature:	______________
	Date:	______________

Certified that the contents and form of final year design project entitled **"Irrigation Pond Water Quality Monitoring by Using Wireless Sensor Network"** has been found satisfactory for requirements of the degree.

Supervisor: ____________________
(Dr Muhammad Azam)

Co-Supervisor: ____________________
(Engr Tariq Maqsood)

Chairman (Department): ___________________________

Incharge FAET: ___________________________

Evaluation made by the FYDP Supervisor for semester:…………

Ser. No	Student Name	ARID No.	I	II	III	Total
			Problem Identification & Objectives	Methodology	Work Plan and VIVA	
			(3)	(3)	(3)	(9)
1						
2						
3						
4						

Supervisor: ____________________

(Dr Muhammad Azam)

Evaluation made by the FYDP Evaluation Committee for semester:…………

Ser. No	Student Name	ARID No.	Grading of fields as per Rubric* (marks range from 0-4)								Total
			I	II	III	IV	V	VI	VII	VIII	15
			2	2	2	2	2	2	1	2	
1											
2											
3											
4											

FYDP Committee Member

FYDP Committee Member

FYDP Committee Member

I	II	III	IV	V	VI	VII	VIII
Literature Review	Methodology	Analysis & Conclusions	Technical Writing	Innovation	Practical Application	Formatting/ Organization	Originality

DEDICATION

We dedicate this project "irrigation pond water quality monitoring by using wireless sensor network" to Ateeq Afridi CEO of Act of kindness Pakistan for his best efforts to spread more kindness across the whole world. Their unwavering dedication, tireless efforts, and valuable contributions have been instrumental in the successful completion of this project.

We would also like to express our heartfelt gratitude to our parents, whose unwavering support and encouragement have been the driving force behind our pursuit of knowledge and excellence.

May this project serve as a testament to the collective commitment and collaborative spirit that has defined our journey. We are grateful for the guidance, wisdom, and inspiration provided by our mentors and the unending support from our loved ones.
With utmost respect and appreciation

(Muhammad Arham, Ali Raza, Syed Hashir Ali)

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ABBREVIATIONS

IOT	Internet of Things
WWTP	Wastewater Treatment Plant
SCADA	Supervisory control and data acquisition
PLC	Programmable logic controller
RTU	Remote terminal unit
AI	Artificial intelligence
ML	Machine learning
BOD	Biochemical oxygen demand
TDS	Total Dissolved Solids
COD	Chemical Oxygen Demand
DMAIC	Define, Measure, Analyze, Improve, Control
TSS	Total Suspended Solids
DO	Dissolved Oxygen
pH	Potential of Hydrogen

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Dr Muhammad Azam vast knowledge in the field of wastewater treatment and his deep understanding of the importance of water quality monitoring have been instrumental in guiding our research. His valuable suggestions and encouragement have constantly motivated us to explore innovative solutions and strive for excellence.

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ABSTRACT

This paper introduces a water quality monitoring system that aims to provide real-time data on water quality through a mobile application. The system incorporates advanced sensors capable of measuring contaminants at each stage of the water purification process, as well as evaluating the effectiveness of each purification step based on user-defined parameters. These sensors are designed to deliver precise and timely data, ensuring the optimal efficiency of the monitoring system. Traditional methods of water quality monitoring rely on manual sampling and laboratory analysis, which are time-consuming and do not offer real-time information. In contrast, the proposed system addresses these limitations by integrating cutting-edge sensors that can detect water contaminants in real-time. The design of the system focuses on efficiency and effectiveness in monitoring water quality. By setting specific parameters for water quality, users can receive notifications on the mobile application regarding the current state of the water and the efficiency of each purification step. This empowers users to have a comprehensive understanding of their water quality and make informed decisions, such as adjusting purification settings or seeking additional treatment if required. The sensors employed in the system are meticulously designed to provide reliable and accurate data. They utilize state-of-the-art technology to detect various types of contaminants present in water, thereby ensuring comprehensive monitoring capabilities. Additionally, the sensors real-time data collection abilities enable timely identification of any deviations from desired water quality parameters, facilitating prompt intervention and mitigation.

Keywords: Real time data; Sensors; Water quality monitoring system; Purification process; Contaminants detection

CHAPTER 1

INTRODUCTION

Wastewater treatment plays a vital role in protecting public health and the environment by removing contaminants from wastewater before its discharge or reuse.

1.1 IMPORTANCE OF WASTE WATER TREATMENT

Wastewater treatment plays a crucial role in ensuring the protection of public health and the environment by removing contaminants from domestic, industrial, and agricultural wastewater before it is discharged or reused. The design and implementation of efficient wastewater treatment processes are essential to minimize the impact of pollutants on water bodies and maintain ecological balance.

Traditionally, wastewater treatment has been a complex and resource-intensive process that requires careful monitoring and control. However, recent advancements in technology, particularly in the field of water quality monitoring systems, have significantly improved the efficiency and effectiveness of wastewater treatment.

The structure of a water quality monitoring system specifically tailored for wastewater treatment. The system's primary objective is to provide real-time data on the quality of wastewater, allowing operators to make informed decisions and optimize treatment processes.

The utilization of a mobile application enhances the accessibility and convenience of monitoring wastewater quality. By leveraging mobile technology, operators can receive instant updates and notifications regarding the performance of the treatment plant, allowing for timely adjustments and interventions when necessary.

One of the critical aspects of wastewater treatment is the measurement of various parameters that indicate the presence and concentration of contaminants. The proposed water quality monitoring system incorporates advanced sensors capable of detecting and quantifying these parameters accurately. This enables the system to provide comprehensive data on the effectiveness of each treatment step and identify any deficiencies that may arise during the process.

Efficiency is a key consideration in wastewater treatment, as it directly impacts resource consumption and overall plant performance. By continuously monitoring the quality of wastewater, operators can optimize the treatment process, minimizing energy and chemical usage while ensuring compliance with regulatory standards.

1.2 DESIGN AND STRUCTURE OF THE WATER QUALITY MONITORING SYSTEM

The design and structure of a water quality monitoring system are crucial for ensuring accurate and reliable data collection, efficient data processing, and effective communication of information. A well-designed system enables comprehensive monitoring of water quality parameters, timely detection of anomalies, and informed decision-making for water resource management. Here, we outline the key elements and considerations involved in the design and structure of a water quality monitoring system.

1.2.1 Sensor Selection and Placement

The system begins with the careful selection of appropriate sensors capable of measuring the desired water quality parameters. Sensors should be chosen based on their accuracy, reliability, and compatibility with the specific monitoring objectives. Once selected, the sensors are strategically placed at relevant locations in the water bodies or within the water treatment infrastructure to capture representative data.

1.2.2 Data Acquisition and Transmission:

The system incorporates mechanisms for data acquisition from the sensors, either through wired or wireless connections. The collected data is then transmitted to a central database or a cloud-based platform. The choice of data transmission technology, such as cellular networks, satellite communications, or Internet of Things (IOT) protocols, depends on factors like data volume, transmission range, and cost-effectiveness.

1.2.3 Real-time Monitoring and Visualization:

To provide timely information to stakeholders, the system includes real-time monitoring capabilities. This allows users to access up-to-date water quality data and visualize it through user-friendly interfaces, such as dashboards or mobile applications. Visualization tools enable easy interpretation of complex data, aiding in decision-making processes.

1.2.4 Alert and Notification System:

An effective water quality monitoring system includes an alert and notification system to promptly inform stakeholders about critical events or deviations from desired water quality standards. These alerts can be sent via email, SMS, or push notifications on mobile applications, enabling timely response and intervention.

1.2.5 Integration with Decision Support Systems

The design and structure of the system should facilitate seamless integration with decision support systems. This enables water managers, policymakers, and other stakeholders to utilize the collected data and analysis results for informed decision-making regarding water resource management, pollution control measures, and emergency response.

1.2.6 Scalability and Adaptability

The system should be scalable and adaptable to accommodate future expansion or changes in monitoring requirements. It should be designed with modular components, allowing for easy integration of new sensors, technologies, or functionalities as needed. This ensures the system can keep pace with evolving water quality monitoring needs.

1.3 REAL TIME DATA ACQUISITION AND PROCESS OPTIMIZATION

Real-time data acquisition and process optimization are integral components of an effective water quality monitoring system. The ability to collect and analyze data in real-time provides valuable insights into the current state of water quality, enabling timely decision-making and proactive intervention to ensure optimal process performance. Here, we delve into the significance of real-time data acquisition and its role in process optimization.

1.3.1 Continuous Monitoring

This data collection makes possible continuous monitoring of water quality parameters. Unlike traditional periodic sampling and laboratory analysis, which provide only snapshots of water quality at specific time intervals, real-time monitoring offers a continuous stream of data. This allows for the detection of short-term fluctuations, rapid changes, or pollution events that might otherwise go unnoticed. Continuous monitoring ensures a comprehensive understanding of the dynamic nature of water quality and enables swift responses to any emerging issues.

1.3.2 Early Detection of Anomalies

The quick identification of anomalies is made easier by real-time data capture or deviations from desired water quality standards. By continuously monitoring water quality parameters such as pH, dissolved oxygen, turbidity, conductivity, and specific contaminants, operators can identify sudden changes or trends that indicate potential problems. Early detection enables timely investigation and intervention, helping to prevent further deterioration of water quality and mitigate any adverse impacts on the environment or public health.

1.3.3 Process Optimization

In order to optimize the water treatment process, real-time data collecting is essential systems. By monitoring key parameters at different stages of the treatment process, operators can gain valuable insights into the efficiency of each step and make necessary adjustments in real-time. For example, by closely monitoring parameters such as coagulant dosage, flow rates, or disinfection levels, operators can optimize chemical dosing, adjust treatment processes, or implement control strategies to enhance treatment performance. Real-time data allows for the identification of process inefficiencies, enabling operators to fine-tune operations and maximize the effectiveness of water treatment processes.

1.3.4 Timely Decision-Making

Actual data collection equips decision-makers with up-to-date information, with up-to-date data readily available, operators, managers, and policymakers can make informed decisions based on the current status of water quality. This includes adjusting treatment strategies, implementing appropriate control measures, or initiating emergency response actions when necessary. Timely decision-making is crucial for ensuring the protection of water resources, safeguarding public health, and optimizing the overall efficiency of water treatment processes.

1.3.5 Proactive Intervention:

Immediate information gathering enables proactive intervention to solve water quality problems as they arise. By continuously monitoring water quality parameters, potential problems can be detected at an early stage, enabling proactive measures to be taken. This may include adjusting treatment processes, increasing monitoring frequency, conducting targeted investigations, or implementing specific mitigation strategies. Proactive intervention minimizes the potential risks associated with compromised water quality, helping to maintain the integrity of water resources and ensuring the provision of safe and clean water to consumers.

1.4 SIGNIFICANCE OF MOBILE APPLICATION INTEGRATION

The integration of a mobile application in a water quality monitoring system offers significant advantages and enhances the overall functionality and accessibility of the system. Here, we discuss the significance of mobile application integration and its benefits.

1.4.1 Real-time Data Access

A mobile application provides real-time access to water quality data anytime and anywhere. Users, such as water utility operators, environmental agencies, or even the general public, can conveniently access up-to-date information on water quality parameters through their smartphones or tablets. This immediate access to real-time data enables prompt decision-making and quick responses to any water quality issues or emergencies.

1.4.2 Enhanced User Engagement

Mobile applications facilitate user engagement by providing an interactive and user-friendly interface. The intuitive design and features of the application make it easier for users to explore and understand the collected data. Users can view graphical representations, charts, and maps, making complex data more accessible and easier to interpret. Engaging users through mobile applications encourages active participation in environmental monitoring efforts, fostering a sense of ownership and responsibility towards water quality management.

1.4.3 Alerts and Notifications

Mobile applications enable the delivery of alerts and notifications regarding critical water quality events or deviations. Users can receive timely alerts about potential contamination incidents, changes in water quality parameters, or any actions required. Push notifications, SMS messages, or email alerts can be sent directly to users' mobile devices, ensuring that they stay informed and can take appropriate actions promptly.

1.4.4 Data Submission and Citizen Science

Applications for portable devices may have capabilities that let users report their observations or measurements of water quality. This promotes citizen science initiatives, where individuals can contribute data collected from their local water bodies, augmenting the monitoring efforts of environmental agencies. User-submitted data can be validated and incorporated into the larger monitoring system, creating a collaborative network of a data collection.

1.4.5 Historical Data Analysis

The applications for mobile devices can offer access to historical water quality data, allowing users to analyze trends and patterns over time. By visualizing historical data through the application, users can gain insights into long-term changes, identify recurring issues, or evaluate the effectiveness of past interventions. This historical analysis supports evidence-based decision-making and facilitates the implementation of long-term water quality management strategies.

1.4.6 Remote Monitoring and Management

Smart applications enable remote monitoring and management of water quality systems. Operators and managers can remotely access and control monitoring devices, adjust parameters, or troubleshoot issues without the need for physical presence at the monitoring site.

Chapter 2

LITERATURE REVIEW

Gerevini et al., (2023) presented an end-to-end approach for real-time recognition of pollutants spilling in wastewater using the IoT-ready SENSIPLUS platform. The research focused on leveraging the Internet of Things (IoT) technology to monitor and detect the presence of pollutants in wastewater in real-time. The authors proposed a comprehensive system that combined sensor networks, data acquisition, and machine learning algorithms for effective pollution recognition and early detection. The study demonstrated the effectiveness of the SENSIPLUS platform in continuously monitoring the wastewater quality, detecting pollution events, and providing timely alerts for intervention and remediation. This research contributed to the development of intelligent and proactive wastewater management systems, enhancing the capability to prevent and mitigate the negative impacts of pollutant spills in real-time.

Chen (2004) conducted research and he provided an overview of electrochemical technologies and their applications in wastewater treatment. The author discusses various electrochemical processes, such as electrocoagulation, electrooxidation, electro flotation, and electrodialysis, highlighting their principles, advantages, and limitations. The study explores the efficiency of these technologies in removing different types of contaminants, including organic compounds, heavy metals, and nutrients, from wastewater. Additionally, the paper discusses the factors influencing the performance of electrochemical systems and provides insights into process optimization and scale-up considerations. Overall, this review serves as a valuable resource for understanding the potential and challenges of electrochemical technologies in wastewater treatment and their role in achieving efficient and sustainable waste water management.

Chemosphere et al., (2008). investigated the removal of carbamazepine and diclofenac in wastewater treatment plants and their subsequent occurrence in water bodies. The paper presents an in-depth analysis of the fate and behavior of these pharmaceutical compounds during the treatment process and their potential presence in receiving water bodies. The authors discuss the challenges associated with the removal of these emerging contaminants and highlight the importance of developing effective treatment strategies to minimize their impact on the environment. The findings contribute to our understanding of the occurrence and persistence of carbamazepine and diclofenac in aquatic systems, emphasizing the need for continuous monitoring and improved wastewater treatment practices to mitigate their environmental risks.4s

Zhang et al., (2021). explored the application of Internet of Things (IoT) technology in the municipal industrial wastewater treatment process based on the membrane bioreactor (MBR) technology. The paper focuses on the integration of IoT technology for real-time monitoring and control of various parameters in the MBR system. The authors discuss the benefits of IoT in enhancing the efficiency and performance of wastewater treatment by enabling remote monitoring, data collection, and decision-making support. The findings emphasize the potential of IoT-based systems to improve the operation and management of municipal industrial wastewater treatment plants, leading to more effective and sustainable water treatment processes.

Wang et al., (2020) investigated the application of deep learning techniques for energy and materials-saving management in wastewater treatment plants. The paper focuses on leveraging the capabilities of deep learning algorithms to optimize the operation and resource utilization of these plants. The authors highlight the potential benefits of using deep learning models for real-time data analysis, prediction, and decision-making in wastewater treatment processes. The findings emphasize the importance of integrating advanced technologies like deep learning to improve energy efficiency, reduce material consumption, and enhance overall performance in wastewater treatment plants. This research contributes to the development of smarter and more sustainable approaches to managing wastewater treatment processes.

Wang et al., (2022). proposed that a full-view management method based on Artificial neural networks (ANNs) to achieve energy and material-savings in wastewater treatment plants. The research focuses on leveraging ANNs for comprehensive monitoring, modelling, and optimization of various processes in these plants. The authors emphasize the potential of ANNs in capturing complex relationships, predicting system behavior, and optimizing resource utilization for improved energy and material efficiency. The findings highlight the significance of adopting a holistic approach using ANNs to achieve sustainable and cost-effective operations in wastewater treatment plants. This research contributes to the advancement of management strategies that promote energy and material savings in the wastewater treatment industry.

Sun et al., (2019). investigated the presence, detection, occurrence, and removal of microplastics in wastewater treatment plants (WWTPs). The paper provides a comprehensive analysis of the sources, fate, and behavior of microplastics throughout the wastewater treatment process. The authors discuss various methods for the detection and quantification of microplastics in WWTPs, highlighting the challenges and limitations associated with these techniques. Furthermore, they examine the efficiency and effectiveness of different treatment processes in removing microplastics from wastewater, including physical, chemical, and biological methods. The findings emphasize the need for comprehensive strategies to mitigate the release of microplastics into the environment and enhance their removal during wastewater treatment processes. This research contributes to our understanding of microplastic pollution and provides insights into potential solutions for reducing its impact on water resources.

Stottmeister et al., (2003). explored the effects of plants and microorganisms in constructed wetlands for wastewater treatment. The paper provides a comprehensive analysis of the interactions and synergies between plants and microorganisms in these wetland systems. The authors discuss the role of plants in providing physical support, oxygenation, and nutrient uptake, while microorganisms contribute to the degradation and transformation of pollutants. The study also examines the various design configurations and operational parameters that influence the treatment efficiency of constructed wetlands. The findings highlight the potential of constructed wetlands as a sustainable and cost-effective approach for wastewater treatment, emphasizing the importance of understanding the complex interactions between plants and microorganisms. This research contributes to the advancement of knowledge in the field of constructed wetlands and provides valuable insights for optimizing their performance in wastewater treatment applications.

Singh et al., (2022). proposed an IOT-based smart wastewater treatment model for Industry 4.0, integrating artificial intelligence (AI) techniques. The paper focuses on leveraging IoT technology to enable real-time monitoring and control of wastewater treatment processes in the context of Industry 4.0. The authors emphasize the application of AI algorithms for data analysis, optimization, and decision-making to enhance the efficiency, effectiveness, and sustainability of wastewater treatment operations. The study highlights the potential of IoT and AI in improving process automation, resource management, and environmental performance in the field of wastewater treatment. The findings contribute to the development of innovative approaches for smart wastewater treatment in the era of Industry 4.0, emphasizing the importance of harnessing advanced technologies for more efficient and intelligent wastewater management.

Rishitha and Ullas (2019). proposed an IOT-based automation system for domestic sewage treatment plants with the aim of optimizing water quality and power consumption. The study focuses on leveraging IoT technology to monitor and control various parameters in real-time, enabling efficient water treatment processes and minimizing power consumption. The authors highlight the benefits of automation in improving the overall performance and sustainability of domestic sewage treatment plants. Although this paper is presented in conference proceedings, it provides insights into the application of IoT in optimizing water quality and energy efficiency in domestic sewage treatment systems.

Pisa et al., (2019). Presented a artificial neural network (ANN)-based soft sensor for predicting effluent violations in wastewater treatment plants. The research focuses on developing a model that can effectively identify potential non-compliance events and predict effluent quality parameters based on real-time process data. The authors emphasize the use of ANNs as a reliable tool for data-driven modeling and prediction in wastewater treatment processes. The findings highlight the potential of the proposed soft sensor to aid in proactive decision-making and optimize plant operations to prevent effluent violations. This research contributes to the advancement of intelligent monitoring and control systems in wastewater treatment, facilitating better compliance with regulatory standards and enhancing overall plant performance.

Chapter 3

PROBLEM STATEMENT & OBJECTIVE

3.1 PROBLEM STATEMENT

- The untreated wastewater often contains microbes and pathogens, chemical pollution, antibiotic residues, and other threats to the health of farmers, food chain workers, and other Consumers.
- Wastewater transports pathogens, nutrients, contaminants, and solids into the ocean lakes ponds rivers that can cause coral bleaching and disease and mortality for coral, fish, and shellfish.
- Rapid population growth and urbanization lead to increased wastewater generation. Existing treatment facilities may not be able to handle the volume of wastewater produced, resulting in overloading and reduced treatment efficiency.
- Industrial activities produce a significant amount of wastewater containing various toxic substances, heavy metals, and chemicals. Treating industrial wastewater requires specialized techniques and technologies to remove these pollutants effectively.
- The presence of emerging contaminants, such as pharmaceuticals, personal care products, and microplastics, poses a challenge in wastewater treatment. These substances are not effectively removed by conventional treatment processes.
- Climate change can affect wastewater treatment systems through altered rainfall patterns, sea-level rise, and increased frequency of extreme weather events. These changes can impact the capacity, efficiency, and resilience of treatment plants and infrastructure.

3.2 OBJECTIVE

Following are the objectives of the project:

1. Design and development of waste water treatment plant using IOT technology.
2. Clean the different part of raw water in treatment plant.
3. Showing the real time data how much each step cleaning the water.

Chapter 4

METHODOLOGY

4.1 COMPONENTS USED IN OUR PROJECT

The project for the online monitoring design of a waste water treatment plant using IoT technology incorporates various essential components. IoT sensors are strategically placed to capture and monitor critical parameters such as water quality, flow rates, and pH levels. QR codes are assigned to each monitoring point, facilitating quick and easy access to real-time data by scanning them with a smartphone or QR code scanner. The central control system processes the data received from the sensors and provides a user-friendly interface for operators to monitor the plant's performance. Additionally, a cloud-based platform may be utilized for data storage, analysis, and remote access. This integrated system allows for efficient monitoring, proactive maintenance, and data-driven decision-making, ensuring optimal operation of the waste water treatment plant.

4.2 FILTERS

In filtration systems, various sensors are used to monitor and control the filtration process. Here are four filter which is used in our filtration systems.

4.2.1 Sediments Removal Cartridge

A sediment removal cartridge is a type of water filter designed specifically to remove sediment, particles, and debris from water. Sediment cartridges are commonly used as a pre-filter in water filtration systems to protect downstream filters and appliances from clogging and damage caused by large particles (as shown in figure 4.1)

- Uses

i. Sediment cartridges typically utilize a physical filtration mechanism to trap and remove sediment and particles.

ii. These are available in various micron ratings, which indicate the size of particles they can effectively capture.

iii. Sediment cartridges can effectively remove a wide range of sediment types, including sand, silt, rust, dirt, and other suspended solids.

Figure 4.1 Sediments Removal Cartridge

4.2.2 Polypropylene Yarn Filter (PPY)

A Polypropylene Yarn Filter, also known as a PPY filter or polypropylene string-wound filter, is a type of water filter commonly used for sediment filtration. It utilizes a string-wound design made of polypropylene yarn to remove sediment, particles, and other impurities from water (as shown in figure 4.2)

- Uses:
  1. Polypropylene Yarn Filters are commonly used in various water treatment applications, including point-of-entry systems, point-of-use systems, industrial processes, and commercial settings.
  2. The string-wound design of the filter allows for effective depth filtration. As water flows through the filter, larger particles are trapped in the outer layers of the yarn, while smaller particles are captured deeper within the winding structure.

Figure 4.2 Polypropylene Yarn Filter

4.2.3 Carbon Filter Cartridge

A Carbon Filter Cartridge, also known as an activated carbon filter cartridge, is a type of water filter that utilizes activated carbon to remove impurities, chemicals, and odors from water. It is commonly used for improving the taste, odor, and overall quality of drinking water (as shown in figure 4.3)

Figure 4.3 Carbon Filter Cartridge

4.2.4 Activated carbon cartridge

It is also known as a carbon filter cartridge, is a filtration device used to remove impurities and contaminants from water, air, or other fluids. It contains activated carbon, a highly porous material that has been treated to have an increased surface area, making it effective at adsorbing (not absorbing) a wide range of substances.

Activated carbon is made from various carbon-rich materials, such as coconut shells, wood, or coal, which are processed to create a large number of tiny pores. These pores provide a vast surface area for the adsorption of contaminants. When fluid passes through the cartridge, the activated carbon captures and retains impurities, chemicals, odors, and other organic compounds, thereby improving the quality and taste of the fluid.

4.2.5 Chemical Filtration

Chemical filtration is an essential process used in microfiltration water treatment plants to enhance the efficiency and effectiveness of the treatment process. It involves the use of specific chemicals to improve the removal of contaminants and impurities from water.

Microfiltration is a type of membrane filtration that uses membranes with pore sizes typically ranging from 0.1 to 10 micrometers. These membranes are designed to remove suspended solids, bacteria, viruses, and other particulate matter from water, providing a high level of filtration.

4.2.6 Beverage and Food Processing

Carbon cartridges are used in the food and beverage industry for the removal of unwanted tastes, odors, and chemicals from liquids, including water, juices, wines, and spirits. In the microfiltration process for wastewater treatment, the performance of the system and the associated operational parameters play a crucial role in achieving efficient and effective filtration. The following table provides an overview of the key performance parameters of a typical microfiltration system. These values are indicative of the expected performance, including the filtration rate, membrane pore size, and removal efficiencies for solids, bacteria, protozoa, and turbidity reduction. It is important to note that these values may vary based on factors such as membrane type, operating conditions, and the specific characteristics of the wastewater. Their Performance parameter and their value is given below in the table 4.1

Table 4.1 Performance Measures Parameters

Performance Parameter	**Value**
Filtration Rate	50-100 L/m2/h
Membrane Pore Size	0.1 - 0.5 µm
Solids Removal Efficiency	> 99%
Bacteria Removal Efficiency	> 99.9%
Turbidity Reduction	> 90%

In a wastewater treatment plant utilizing IoT technology, various components play crucial roles in monitoring, controlling, and optimizing the treatment processes (as shown in Table 4.2)

Table 4.2 Component and their Functions

Component	**Functionality**
Sensors	Measures parameters such as pH, temperature, dissolved oxygen, etc.
IoT Gateway	Collects and transfers data between sensors, actuators, and the cloud
Cloud Platform	Stores and analyses the collected data for monitoring and optimization.
Remote Monitoring	Enables real-time monitoring and control of the plant from anywhere via mobile or web applications.
Alarms and Alerts	Notifies operators of any abnormal conditions or system failures.
Data Visualization	Presents the data in a graphical format for easy understanding and analysis

4.3 SENSORS USED IN THIS PROJECT

The following sensors are used in our project:

- **a.** Ph sensor
- **b.** Turbidity Sensor
- **c.** Flow Sensor
- **d.** LM35 Digital Temperature Sensor

4.3.1 pH Sensor:

pH is an important parameter that indicates the acidity or alkalinity of a solution. In filtration systems, pH sensors are used to monitor the pH level of the water being filtered. Maintaining the proper pH level is crucial for the efficiency of the filtration process and the quality of the filtered water (as shown in figure 4.4).

Figure 4.4 pH Sensor

4.3.2 Turbidity

Turbidity refers to the cloudiness or haziness of a liquid caused by suspended particles. Turbidity sensors are used to measure the turbidity level of the water before and after filtration. By monitoring turbidity, filtration system operators can assess the effectiveness of the filtration process and detect any potential issues such as clogged filters or excessive particle levels (as shown in figure 4.5 and 4.6 respectively).

Figure 4.5 Turbidity Sensor

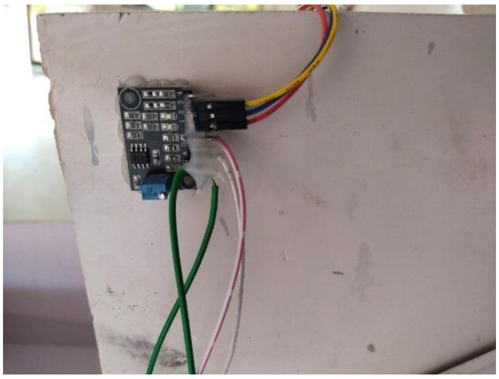

Figure 4.6 Turbidity Transducer Module

4.3.3 Flow Sensor

Flow sensors are used to measure the rate of water flow through the filtration system. They provide real-time information on the flow rate, which is essential for ensuring proper filtration. Flow sensors help in detecting any abnormalities in flow, such as low flow rates or blockages, which may indicate a problem with the system and allow for timely intervention. Flow sensors also contribute to the optimization of the filtration process. By closely monitoring the flow rates, operators can assess the overall performance of the system and make necessary adjustments to maintain optimal filtration efficiency. They can identify areas that require attention, such as clogged filters or inadequate flow distribution, and take appropriate actions to restore optimal conditions.

The continuous monitoring of flow rates helps operators to identify any abnormalities or deviations in the flow patterns. For instance, a low flow rate could indicate a potential blockage or malfunction in the system, while a sudden increase in flow rate might suggest a surge or a burst in the pipeline. Detecting these anomalies promptly allows for timely intervention and troubleshooting, minimizing potential damages and ensuring uninterrupted operation of the treatment plant (as shown in figure 4.7).

Figure 4.7 Flow Sensor

4.3.4 Temperature Sensor

Temperature sensors are used to monitor the temperature of the water during the filtration process. Water temperature can affect the performance and efficiency of filtration systems. For example, some filtration methods may be more effective at certain temperatures, and excessive temperature changes can also impact the quality of the filtered water.

Temperature sensors enable operators to maintain optimal filtration conditions and prevent any adverse effects on the filtration process.

These sensors, in combination with appropriate control systems, allow filtration systems to operate efficiently, maintain water quality standards, and provide reliable and safe filtered water (as shown in figure 4.8).

Figure 4.8 LM35 Temperature Sensor

4.4 METHODS OF TREATMENT

The following steps are included in our project which implement on our prototype project, these are given below.

4.4.1 Primary Treatment

Solids such as stones, grit, and sand may be removed from wastewater by gravity when density differences are sufficient to overcome dispersion by turbulence. This is typically achieved using a grit channel designed to produce an optimum flow rate that allows grit to settle and other less dense solids to be carried forward to the next treatment stage. Gravity separation of solids is the primary treatment of sewage, where the unit process is called "primary settling tanks" or "primary sedimentation tanks." It is also widely used for the treatment of other types of waste water. Solids that are denser than water will accumulate at the bottom of quiescent settling basins. More complex clarifiers also have skimmers to simultaneously remove floating grease such as soap scum and solids such as feathers, wood chips, or condoms. Containers like the API oil water separator are specifically designed to separate non-polar liquids.

4.4.2 Coarse Filtration

This step involves using a coarse filter, such as a screen or gravel, to remove larger particles from the water. Coarse filters are used to remove suspended large solids from wastewater in order to prevent blockage, physical damage and abrasion of downstream wastewater systems, such as membrane filtration, or before discharge into the sewer systems.

4.4.3 Fine Filtration

These are filters used for filtering fine particles after pre-filters and as secondary and final filters before absolute filters. It is generally preferred for filtration of particles with particle size in the range of 1-10 µm. For the purpose of this article the term 'fine particle filter' is used to describe any filter which removes all or the majority of particles larger than 20 microns. Fine particle filters employ various mechanisms to achieve efficient particle removal. They may incorporate a variety of filtration media, such as synthetic fibers, glass fibers, or specialized materials with electrostatic or mechanical properties. These media are designed to create a dense network of microscopic passages that efficiently trap particles as they pass through the filter. Fine particle filters are essential components in industrial applications where airborne particles can have adverse effects on equipment performance. They are used in automotive painting booths, aerospace manufacturing, electronics assembly, and many other sectors where particle control is critical. Their role as secondary and final filters before absolute filters makes them an essential component in comprehensive filtration systems.

4.4.4 Microfiltration/Ultrafiltration

Microfiltration (MF) is a pressure-driven separation process, which is widely used in concentrating, purifying or separating macromolecules, colloids and suspended particles from solution. MF membranes typically have nominal pore sizes on the order of 0.1–1.0 µm. MF processing is widely used in the food industry for applications such as wine, juice and beer clarification, for wastewater treatment, and plasma separation from blood for therapeutic and commercial uses. In biotechnology industries, MF concerns applications such as cell recycle and harvesting, separation of recombinant proteins from cell debris, and purification of process streams.

In highly fouled membranes, the loss of effective pore area or pore numbers can result in filtrate fluxes that are less than those observed in UF. To minimize the negative effects of membrane fouling, optimization of the module device is required.

4.4.5 Disinfection

This step involves using a disinfection method, such as UV light or chlorine, to kill any remaining microorganisms in the water and make it safe to drink. Chlorination is the process of adding chloramine to drinking water to disinfect it and kill germs. It is sometimes used as an alternative to chlorination. Chloramines are a group of chemical compounds that contain chlorine and ammonia. The particular type of chloramine used in drinking water disinfection is called monochloramine which is mixed into water at levels that kill germs but are still safe to drink.

Figure 4.9 Total 5 steps working of project

The online monitoring design of a waste water treatment plant using IoT technology incorporates several important steps. The process begins with pre-treatment, followed by coarse filtration, fine filtration, microfiltration, and disinfection. These steps ensure the removal of debris, solid particles, and microorganisms from the wastewater.

The collected data, including water quality parameters, filtration efficiency, and disinfection levels, is transmitted through the ESP32 Wi-Fi module. This enables real-time monitoring and analysis of the plant's performance. The data can be accessed remotely via a website and mobile application.

By integrating IoT technology, operators can efficiently manage the waste water treatment plant, make informed decisions, and optimize resource utilization. The system promotes proactive maintenance, adherence to water quality standards, and environmentally conscious practices.

The implementation of IOT technology in waste water treatment plants enhances operational efficiency, facilitates remote monitoring, and ensures the production of high-quality treated water. A flow chart diagram Illustrate the working methodology of raw water treatment plant (as shown in figure 4.5)

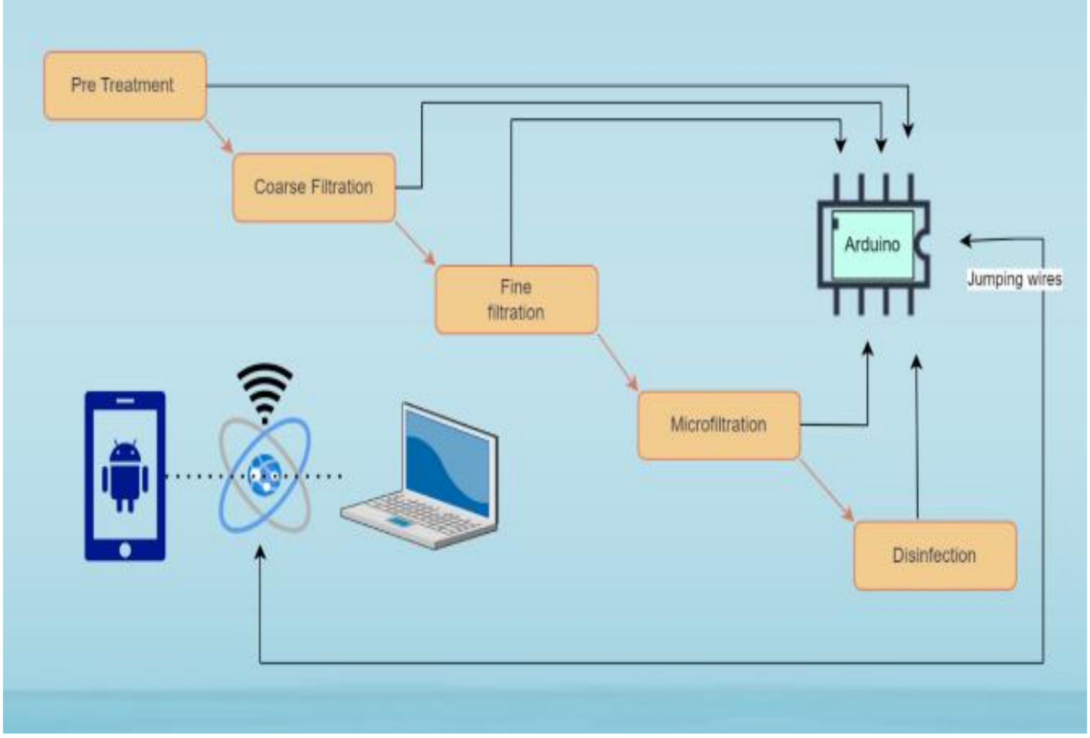

Figure 4.10 Flow Chart Diagram Illustrate the working methodology of raw water treatment plant

Chapter 5

RESULTS & DISCUSSION

Here's the table showing the measurements before and after treatment of water in a microfilter water treatment plant using sensors for turbidity, temperature, pH, oxygen level, and mineral concentration (as shown in table 5.1)

Table 5.1 Showing the Measurements Before and After Treatment

Sample	Turbidity (NTU)	Temperature (°C)	pH	Oxygen Level (mg/L)	Mineral Concentration (ppm)
Before	1.78	27	7.5	3.8	96
After	1.02	24	6.5	6.7	75

5.1 IMPROVED WATER QUALITY

By implementing a microfiltration system with filters and sensors, you can effectively remove suspended particles and impurities from the water. This can lead to improved water clarity, reduced turbidity levels, and enhanced overall water quality (as shown in figure 5.1).

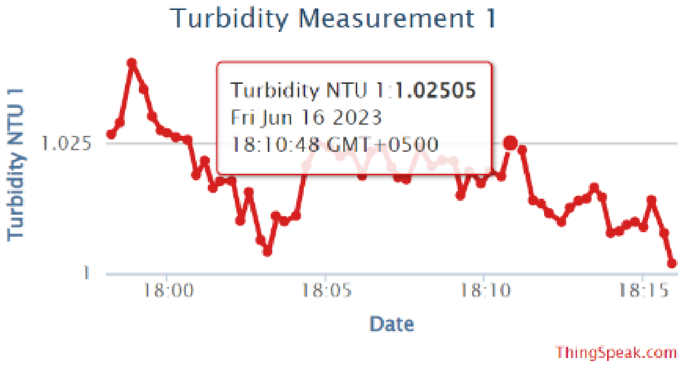

Figure 5.1 Graphical Presentation of Turbidity Measurement

5.2 EFFICIENT MONITORING

The sensors for turbidity, pH, and temperature provide real-time data about the water parameters. This enables continuous monitoring of the water quality and allows for prompt actions to maintain optimal conditions. Any deviations from desired turbidity, pH, or temperature levels can be quickly identified and addressed (as shown in figure 5.2)

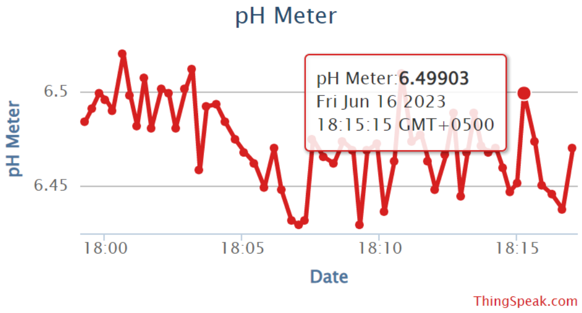

Figure 5.2 Real time Monitoring of pH of water

5.3 MAINTENANCE AND TROUBLESHOOTING

The sensor data can assist in predictive maintenance and troubleshooting. By monitoring turbidity levels, you can determine when the filters need to be cleaned or replaced. Abnormal pH or temperature readings can indicate potential issues with equipment or process efficiency, enabling timely maintenance or adjustments.

5.4 DATA ANALYSIS AND REPORTING

Collecting and analyzing the sensor data over time can provide valuable insights into water quality trends and system performance. This information can be used for generating reports, identifying long-term patterns, evaluating the effectiveness of the microfiltration system, and making informed decisions for process improvements (as shown in figure 5.3).

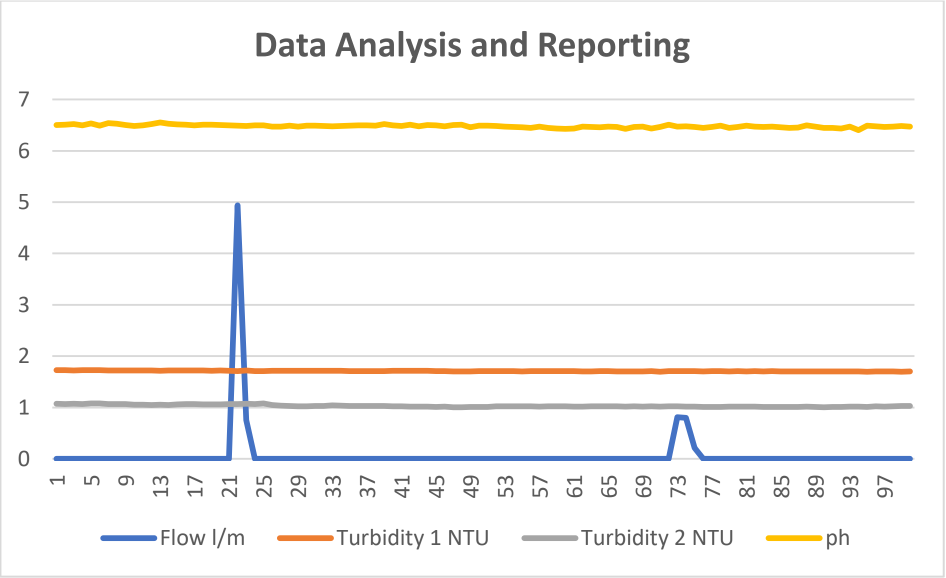

Figure 5.3 Data Analysis and their graphical representation

The integration of IoT technology in waste water treatment plants has led to the development of online monitoring systems. These systems utilize QR codes to provide real-time data access and analysis. By scanning QR codes placed at different monitoring points, operators can retrieve information about water quality, flow rates, and other critical parameters. This allows for remote monitoring, proactive maintenance, and data-driven decision-making. The combination of IoT and QR codes enhances operational efficiency, compliance, and overall management of waste water treatment plants. You can get real time data monitoring of our project just scan this QR code (as shown in figure 5.4) with your mobile.

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SCAN ME

Figure 5.4 QR code for Monitoring of the Project

Chapter 6

CONCLUSIONS & RECOMMENDATION

6.1 CONCLUSION

In conclusion, the implementation of a microfiltration water plant project utilizing filters and sensors for turbidity, pH, and temperature monitoring has proven to be a successful approach for improving water quality, optimizing processes, and ensuring compliance with regulatory standards.

Through the integration of microfiltration technology, suspended particles and impurities were effectively removed from the water, leading to enhanced water clarity and overall quality. The continuous monitoring of turbidity, pH, and temperature levels provided real-time data, allowing for efficient management and prompt actions to maintain optimal conditions. The ability to adjust filtration rates, backwashing frequencies, and other operational parameters based on sensor readings resulted in improved process efficiency and reduced maintenance requirements.

The availability of sensor data facilitated predictive maintenance, enabling timely cleaning or replacement of filters based on turbidity measurements. Monitoring pH levels helped ensure effective disinfection and prevent corrosion or scaling issues, while temperature monitoring aided in optimizing various processes within the plant. Furthermore, the collected sensor data offered valuable insights into water quality trends and system performance, contributing to informed decision-making and long-term process improvements.

6.2 RECOMMENDATION

Overall, this project showcased the effectiveness and benefits of integrating filters and sensors into a microfiltration water plant. The successful outcomes in terms of improved water quality, optimized processes, and regulatory compliance underscore the significance of utilizing advanced technologies in water treatment systems. Moving forward, further research and development efforts can focus on exploring additional sensor technologies and optimizing the integration of IoT solutions to further enhance water treatment processes and ensure sustainable water management.

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