Design a System for Waste Water Recycling Using Arduino UNO and IoT Based on BUETK Hostels

Project Report (8th Semester)

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DEDICATION

Specially Dedicated

To our beloved Parents, Faculty Members, Friends and

Those people who have guided and inspired

Us throughout this project.

بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ

In the Name of Allāh, the Most Gracious, the Most Merciful

ABSTRACT

This project proposes the design and implementation of a wastewater recycling system for irrigation using Arduino UNO and IoT technology at Balochistan University of Engineering and Technology Khuzdar's Hostels. The system will collect wastewater from the hostels showers, sinks, and laundry facilities and treat it using physical, chemical, and biological processes. The treated wastewater will then be stored in a tank and used for irrigation of the hostel's gardens and landscaping. The system will use Arduino UNO microcontrollers and IoT sensors to monitor and control the wastewater treatment process. The project is expected to make a significant contribution to the sustainable management of water resources in Balochistan and provide a valuable learning experience for students at BUETK Khuzdar.

ACKNOWLEDGEMENT

Firstly, we are very grateful to the Almighty ALLAH for giving us the courage and opportunity to undertake our Final Year Project on an emerging Technology.

Secondly, we wish to thank lecturers, staff and technicians, for their cooperation, indirect or directly contribution in finishing our project. We are very much thankful to all our friends who helped use during the completion of this Project.

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We thank our parents who sacrificed their happiness and whose tireless efforts, love, help and encouragement enabled us to reach the platform where we are standing now.

ABBREVIATIONS

Abbreviation	Definition
BUETK	Balochistan University of Engineering and Technology, Khuzdar
CSE	Computer Systems Engineering
PREC	Project Review and Evaluation Committee
SDGs	Sustainable Development Goals
MCU	Microcontroller Unit
DC	Direct Current
LCD	Liquid Crystal Display
PEC	Pakistan Engineering Council
PLO	Program Learning Outcomes
WHO	World Health Organization
LED	Light Emitting Diode
USB	Universal Serial Bus
IDE	Integrated Development Environment
RO	Reverse Osmosis
IEEE	Institute of Electrical and Electronics Engineers

BALOCHISTAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY
KHUZDAR

Department of Computer Systems Engineering

Certificate

This is to declare that the effort submitted in this final project "**Design a system for waste water recycling using Arduino UNO and IoT base on BUETK Hostels**" is entirely written by the following students under the supervision of **Engr. Rozina Baloch**

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This project is submitted in the partial fulfillment of the requirement for the award of Degree of "**Bachelor of Engineering**" in Computer Systems

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CHAPTER 1

INTRODUCTION

CHAPTER 1: INTRODUCTION

Water scarcity and the responsible management of water resources have become critical challenges in today's world, driven by rapid urbanization, population growth, and environmental concerns. Educational institutions, being significant consumers of water, play a crucial role in addressing these challenges. One such institution is Balochistan University of Engineering and Technology Khuzdar (BUETK), which faces water supply issues due to the scarcity of freshwater resources in the region. The hostels within BUETK, catering to student accommodations, contribute to increased water consumption and wastewater generation, necessitating innovative approaches to wastewater management.

This project aims to design a cutting-edge system for wastewater recycling specifically tailored for irrigation purposes in BUETK. By utilizing the capabilities of Arduino UNO and Internet of Things (IoT) technology, the project endeavors to optimize water usage and contribute to sustainable water management practices. The proposed system not only addresses the issue of water scarcity within the BUETK but also aligns with global efforts to conserve water resources and reduce environmental impact.

The integration of Arduino UNO and IoT technology offers an innovative approach to wastewater recycling by enabling real-time data collection, remote monitoring, and automated control of the system. The system will encompass multiple stages of treatment, ensuring that the treated wastewater meets the necessary quality standards for safe irrigation.

Furthermore, this project not only showcases the potential of modern technology in addressing real-world challenges but also highlights the importance of collaboration between engineering, environmental science, and sustainability. The successful implementation of this system can serve as a model for other educational institutions and communities facing similar water scarcity issues.

1.1 Background

The global predicament of water scarcity, magnified by the rapid urbanization and population surge, has spurred urgent concerns. Among the prominent water consumers, educational institutions, particularly universities, stand out, with their hostels generating substantial volumes of wastewater. In this milieu, effective wastewater management becomes pivotal to safeguard water resources and avert environmental contamination. This scenario resonates profoundly within the context of Balochistan University of Engineering and Technology (BUETK) Khuzdar. Much like other educational institutions, BUETK Khuzdar grapples with water supply challenges due to the dearth of freshwater resources in the region. The hostels catering to student accommodation significantly amplify water consumption and wastewater production, underscoring the critical necessity for streamlined wastewater management strategies. Wastewater recycling surfaces as an environmentally sustainable solution to the water scarcity conundrum. By treating and repurposing wastewater for non-potable applications such as irrigation, flushing, and industrial processes, the strain on freshwater reserves can be substantially eased, concurrently mitigating the environmental consequences of unregulated wastewater discharge. This endeavor is fueled by the amalgamation of the Arduino UNO microcontroller and Internet of Things (IoT) technology. The Arduino UNO's capacity for data collection, device control, and remote communication paves the way for sophisticated systems that can adeptly monitor and manage intricate processes. The motivation behind this study finds its roots in addressing water scarcity within BUETK Khuzdar's hostels through pioneering technology.

1.1.1 Waste water (Greywater):

Greywater, often referred to as gray water or sullage, is the term used to describe gently used water that originates from various household activities and is relatively less contaminated than "blackwater" (water from toilets). Greywater is generated from sources within a residence or building other than toilets and kitchen sinks. It includes water from activities such as washing dishes, taking showers, using bathroom sinks, and doing laundry. Greywater typically contains fewer pathogens and contaminants compared to blackwater, making it suitable for certain non-potable (non-drinking) purposes after treatment. Common uses for treated greywater include:

- **Irrigation:** Treated greywater can be used to water plants, lawns, and gardens. However, it's important to ensure that the greywater is properly treated to remove any potential health risks.

- **Toilet Flushing:** In some systems, treated greywater can be used to flush toilets, reducing the demand for fresh water.
- **Industrial Processes:** In certain industries, treated greywater can be used for processes that don't require potable water quality.

It's important to note that untreated greywater should not be used for irrigation or other purposes due to potential health and environmental risks. Greywater can contain contaminants such as soap, detergents, oils, and microorganisms that can have negative impacts if not properly managed.

1.1.2 Greywater recycling:

Greywater recycling involves treating and reusing relatively less contaminated water from household sources like showers, sinks, and laundry machines. Instead of discarding this water, it undergoes treatment to remove impurities before being repurposed for tasks such as irrigation and toilet flushing. Greywater recycling is rooted in sustainability, conserving freshwater by using treated water for non-potable purposes. This practice eases strain on sewage systems, saves energy, reduces environmental impact, and offers economic benefits. Though greywater recycling systems encompass collection, treatment, and storage, converting greywater to drinking water quality is complex and not typically pursued. Before implementing such systems, it's vital to adhere to regulations, consult professionals, and ensure treated water meets safety standards.

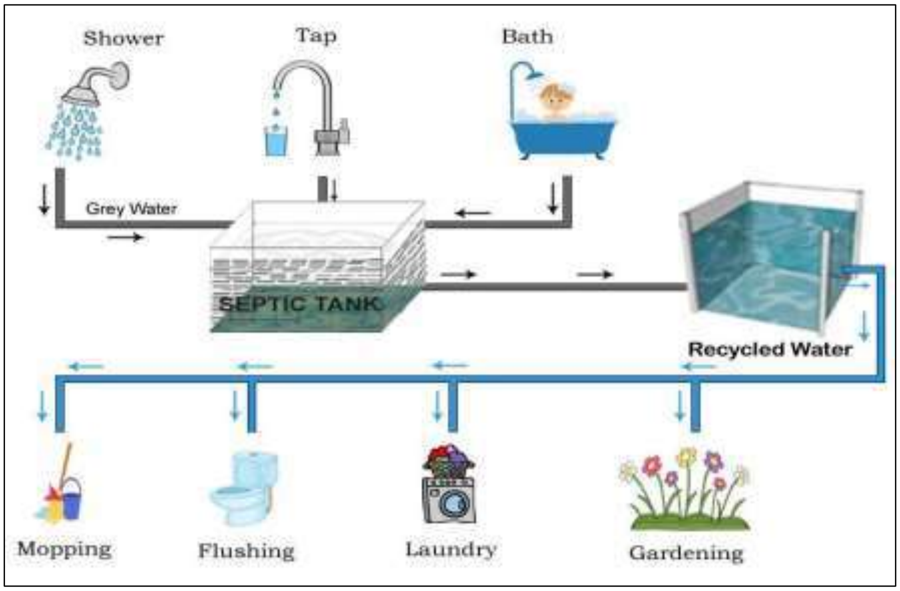

Figure 1-1.1 Greywater recycling

1.1.3 Greywater recycling methods:

Greywater recycling involves treating and reusing gently used water from household activities for non-potable purposes. There are several methods for recycling greywater. Here are some common greywater recycling methods:

1. **Bucket or Pail System:** This is a basic and low-tech method where greywater is manually collected in buckets or pails and then carried to plants for irrigation. While simple, it requires manual effort and may not be suitable for larger volumes of greywater.
2. **Greywater Diversion:** Greywater diversion systems collect greywater from sources like showers, sinks, and laundry and redirect it to outdoor plants or a subsurface irrigation system. These systems often use gravity to distribute greywater, and they can be relatively straightforward to install.
3. **Mulch Basins:** This method involves creating basins filled with mulch or gravel around plants. Greywater is distributed directly into the basins, where it percolates into the soil and provides moisture and nutrients to plants.
4. **Subsurface Drip Irrigation:** This is a more advanced method where greywater is distributed through a network of buried drip irrigation lines. It provides controlled and efficient distribution of greywater directly to plant roots, minimizing contact with humans and reducing surface runoff.
5. **Constructed Wetlands:** In this natural treatment method, greywater is channeled into a wetland area with aquatic plants that naturally filter and purify the water. The plants and soil microorganisms help remove contaminants before the water is released or used for irrigation.
6. **Biological Treatment Tanks:** These tanks use biological processes to break down and treat greywater before it's reused. The treated water can be suitable for irrigation. Different designs include reed beds, sand filters, and other configurations.
7. **Advanced Greywater Treatment Systems:** These are more complex and involve mechanical and chemical processes to treat greywater to higher standards. Some systems use membrane filtration, disinfection, and other technologies to produce treated greywater suitable for various non-potable uses.

8. **Automated Greywater Systems:** These systems incorporate sensors and automated controls to optimize greywater distribution, ensuring efficient use and preventing over-irrigation.

1.1.4 Methods used:

The specific greywater recycling method chosen for the project would depend on various factors, including available resources, space, local regulations, water quality, and project goals. However, considering the context of a university hostel and the integration of Arduino UNO and IoT technology, a suitable method could be a combination of "**Advanced Filtration**" and "**Automated Greywater Systems."** Here's why:

- **Advanced Filtration:**

Advanced filtration involves using various types of filters to remove finer suspended particles, bacteria, viruses, and dissolved contaminants from greywater. The advanced filtration steps could include processes like microfiltration, ultrafiltration, and potentially reverse osmosis (RO), depending on the specific water quality requirements.

- **Why Advanced Filtration:**

1. **Efficiency:** Advanced filtration is capable of removing a wide range of contaminants, ensuring that the treated greywater is suitable for irrigation without the risk of clogging irrigation systems or harming plants.
2. **Quality Control:** This method allows for precise control over water quality, ensuring that the irrigation water is consistent and meets established standards.
3. **Scale:** The hostel's environment might benefit from a more controlled and automated system, making advanced filtration suitable for handling the greywater generated within the facility.

- **Automated Greywater Systems (IoT Integration):**

Integrating Arduino UNO and IoT technology enhances the efficiency, monitoring, and control of the greywater recycling system. Automated systems can optimize water usage, detect malfunctions, and enable remote monitoring and adjustments.

- **Why Automated Greywater Systems:**

1. **Efficiency:** Automated systems can ensure that greywater is used efficiently, minimizing wastage and optimizing irrigation schedules based on real-time plant water needs.

2. **Real-time Monitoring:** IoT technology allows for continuous monitoring of water quality, system performance, and potential issues. This enhances system reliability and enables quick responses to any deviations.
3. **Remote Control:** With IoT integration, system parameters can be adjusted remotely, reducing the need for constant on-site management and maintenance.
4. **Data Insights:** The collected data can provide valuable insights into water consumption patterns, system efficiency, and potential improvements.

Combining advanced filtration with automated greywater systems leverages technology to provide a high-quality recycled water source for irrigation, while also optimizing system performance and water management.

1.2 Problem Statement

The proposed project aims to address this problem by designing and implementing a sustainable wastewater recycling system using Arduino Uno and IoT technology. The system will be developed specifically for BUETK Hostels in Khuzdar, but the knowledge gained from the project can be extended to other regions facing similar challenges. The system will effectively filter and recycle wastewater to provide a reliable source of clean and safe drinking water, thus improving the health and well-being of the population in the area.

1.3 Significance of Project

The significance of designing a wastewater recycling system using Arduino UNO and IoT technology for Balochistan University of Engineering and Technology (BUETK) Khuzdar's hostels is multi-faceted and carries substantial importance. Firstly, this project addresses the pressing issue of water scarcity, which is particularly acute in the region, by introducing an innovative solution that optimizes water resource utilization. The integration of Arduino UNO and IoT technology enables real-time monitoring and control of the wastewater recycling process, resulting in efficient water management and reduced water wastage.

Secondly, the system's ability to treat and reuse wastewater for non-potable purposes reduces the strain on existing freshwater sources. This has a positive impact on the environment by minimizing the discharge of untreated wastewater into natural water bodies, thereby mitigating pollution and safeguarding aquatic ecosystems. The project's success can inspire local communities to adopt similar approaches to water management, fostering long-term sustainable practices.

Moreover, the implementation of this system has the potential to generate valuable data on water consumption patterns, treatment efficiency, and overall system performance. This data-driven approach not only aids in fine-tuning the system for optimal results but also contributes to research efforts in water conservation, technology integration, and sustainable development. The outcomes of this project can be shared with academic and professional circles, contributing to the wider body of knowledge in the field of wastewater management.

In conclusion, the significance of designing a wastewater recycling system using Arduino UNO and IoT technology for BUETK Khuzdar's hostels extends beyond immediate water conservation. It encompasses environmental preservation, technological advancement, and the promotion of sustainable practices. This project represents a proactive step towards addressing water scarcity and fostering a culture of responsible resource management, serving as a beacon for institutions striving to balance their operational needs with environmental stewardship.

1.4 Aim of Project

The aim of this project is to design, develop, and implement an innovative wastewater recycling system utilizing Arduino UNO and IoT technology within the hostels of Balochistan University of Engineering and Technology (BUETK) Khuzdar. The primary objective is to create a comprehensive and efficient solution that addresses water scarcity challenges by optimizing the collection, treatment, and reuse of wastewater. By integrating cutting-edge technologies, the project aims to achieve enhanced monitoring, control, and resource utilization, ultimately contributing to sustainable water management practices within the university's hostel premises.

1.5 Objectives

I. To provide an efficient and cost-effective solution for wastewater treatment that can be implemented in semi-arid regions like Khuzdar.

II. To utilize IoT technology for real-time monitoring of the system performance and optimize its operation.

1.6 Timeline

Proposed Time line of project for 7th semester is presented in Table-1.1 whereas Time line for 8th Semester is presented in Table-1.2

Table 1.1 TimeLine (7th Semester)

Time Line (7th Semester)			
Step No	**Work to be done**	**Status**	**Tentative Deadline**
1.	Literature Review (Knowledge about waste water filtration and other tasks)	Partially completed related to background	April 2023
2.	Final Planning of the project	Completed	May 2023
3.	Requirements Gathering and data collection	Completed	June 2023
4.	System Design	Completed	July 2023-August 2023
5.	7th Semester report	Completed	August 2023

Table 1.2 TimeLine (8th Semester)

Time Line (8th Semester)			
Step No	**Work to be done**	**Status**	**Tentative Deadline**
6.	Hardware implementation	Completed	September 2023
7.	Software implementation	Completed	October 2023
8.	Integration and testing	Completed	November 2023
9.	Project report finalization	Completed	December 2023

1.7 PLOs of the Project

As per Pakistan Engineering Council (PEC) requirement, each project is required to be associated with Program Learning Outcomes (PLOs) of the program. In line with PEC, this capstone project deals with 12 PLOs as mentioned in Table-1.3 It can be seen from the Table that this project comprehensively deals with all requirements of PEC.

Table 1.3 PLOs of Project

S. No.	PLOs of Project	Link with Project
1.	Engineering Knowledge	Demonstrate a profound understanding of engineering principles, including water resource management, sustainable technologies, and control systems.
2.	Problem Analysis	Apply analytical and critical thinking to identify challenges related to water scarcity, wastewater management, and the integration of Arduino UNO and IoT technology.
3.	Design/Development of Solutions	Design a comprehensive and efficient wastewater recycling system tailored to the specific requirements of BUETK Khuzdar's hostels.
4.	Investigation	We will conduct experiments to test the feasibility of using Arduino UNO and IoT technology to recycle wastewater in BUETK Khuzdar's hostels.
5.	Modern Tool Usage	Gain hands-on experience in using Arduino UNO, sensors, and IoT technology to collect data, control devices, and remotely monitor the wastewater recycling system's operation. We are using the modern tools i.e., MIT App inventor, ThingSpeak, IoT, Arduino Software etc.).
6.	Engineer and the Society	Water scarcity and pollution are serious problems that have a big impact on society. Educational institutions can play a role in addressing these problems by implementing efficient wastewater management systems.
7.	Environment and Sustainability	Recognize the importance of sustainable practices by designing a wastewater recycling system that minimizes environmental impact, conserves resources, and reduces water wastage.
8.	Ethics	Our project is survey based the data was taken from the student is confidential and in polite way.

9.	Individual and Team Work	Our project is based on individual and team work. We work individual and team work.
10.	Communication	Our project is based on communication in the present scenario we arrange meetings through MS-Teams.
11.	Project Management	Our project is also based on management we are working according to timeline which we have planned
12.	Lifelong Learning	Engage in continuous learning and professional development to stay updated with emerging technologies, advancements in wastewater management, and the evolving field of IoT-based systems.

1.8 Link with BUETK Vision

The Vision of BUETK is:

"To become a world class higher education Institute leading to socio economic development of the region and beyond".

Our project is related to a real-world challenge faced by world and an effort towards solving it with technology so it relates with BUET Vision.

1.9 Link with CSE&S Department Vision

The Vision of the CSE & S Department is:

"To become a leader in the field of Computer Systems Engineering and Sciences by producing Research Oriented Skilled Professionals to combat the challenges of 4th Industrial Revolution and beyond"

Our project is based on hands-on experience in using Arduino UNO, sensors, and IoT technology to collect data, control devices, and remotely monitor the wastewater recycling system's operation. Which will lead to seeking new skills for professionals.

1.10 Link With Sustainable Development Goals (SDGs)

In line with UN Vision 2030 and HEC vision 2025, this project is related with SDG-6 which is **Clean Water and Sanitation**. The SDGs are shown in Figure 1.1.

Figure 1.1-2 Sustainable Development Goals (SDGs)

1.11 Complex Engineering Problem Traits

Following CEP traits are part of this project.

1. WP1: Depth of Knowledge Required
2. WP2: Range of conflicting requirements
3. WP3: Depth of analysis required

CHAPTER 2

LITERATURE REVIEW

CHAPTER 2: LITERATURE REVIEW

In this Chapter, literature review regarding Greywater recycling, Arduino UNO and IoT with a focus on BUETK's hostels and other cities of Balochistan, water recycling and its applications based with Arduino UNO and IoT have been discussed.

2.1 Introduction

Water is a precious and finite resource that is essential for life and many other aspects of human society. It is important that we use it wisely and take steps to protect and conserve it for future generations. As per the United Nations, more than 80% of wastewater generated by society, flows back into the environment without being treated or reused. The World Health Organization (WHO) reports that 2.2 billion people lack access to safely managed drinking water services globally, leading to waterborne diseases such as cholera, typhoid, and dysentery. Access to clean and safe drinking water is essential for preventing waterborne diseases in Pakistan, with 44% of the population lacking access. Khuzdar, a semi-arid region in Balochistan, is facing water scarcity and lack of access to clean and safe drinking water, which can have significant impacts on the health and wellbeing of the population. This study aims to propose an innovative system for wastewater filtration using Arduino Uno and IoT.

2.2 Wastewater Recycling and its Importance

Wastewater recycling is the process of treating wastewater so that it can be reused for other purposes, such as irrigation, industrial processes, and groundwater recharge. It is an important way to conserve water and protect the environment.

2.2.1 Benefits of wastewater recycling

- **Conserves water:**

Wastewater recycling can help to conserve freshwater resources. In many parts of the world, freshwater is becoming increasingly scarce. Wastewater recycling can help to reduce the demand for freshwater by providing an alternative source of water for irrigation, industrial processes, and other uses.

- **Protects the environment:**

Wastewater recycling can help to protect the environment by reducing the amount of pollution that is released into rivers, lakes, and oceans. When wastewater is not recycled, it is often treated and then released back into the environment. This can pollute the water and harm aquatic ecosystems. Wastewater recycling can help to reduce this pollution by treating the wastewater to a higher standard so that it can be reused safely.

- **Saves energy:**

Wastewater recycling can help to save energy. The treatment of wastewater requires a lot of energy. Wastewater recycling can help to reduce this energy demand by reducing the amount of wastewater that needs to be treated.

- **Reduces greenhouse gas emissions:**

Wastewater recycling can help to reduce greenhouse gas emissions. The treatment of wastewater produces greenhouse gases. Wastewater recycling can help to reduce these emissions by reducing the amount of wastewater that needs to be treated.

- **Creates jobs:**

Wastewater recycling can create jobs in the water treatment and wastewater recycling industries. These industries are growing rapidly as more and more countries are looking to recycle wastewater.

The importance of wastewater recycling is growing as the world faces increasing water scarcity and environmental challenges. Wastewater recycling is a sustainable way to conserve water, protect the environment, and save energy.

2.2.2 Examples:

Here are some examples of how wastewater recycling is being used today:

1. **In California**, wastewater is recycled to irrigate crops in the Central Valley. This helps to conserve freshwater and reduce the state's reliance on imported water.
2. **In Singapore,** wastewater is recycled to supply up to 40% of the city's water needs. This has helped Singapore to become a global leader in water conservation.
3. **In Israel,** wastewater is recycled to irrigate crops, recharge groundwater, and supply industrial processes. This has helped Israel to become one of the most water-efficient countries in the world.

These are just a few examples of how wastewater recycling is being used around the world. As the world's water resources become increasingly scarce, wastewater recycling is becoming an increasingly important way to conserve water and protect the environment.

2.3 Arduino UNO

The Arduino Uno is a popular microcontroller board that is commonly used for prototyping and creating various electronic projects. It is based on the ATmega328P microcontroller and comes with a set of digital and analog input/output pins, as well as built-in components like LEDs and a USB interface for programming and communication. Arduino boards, including the Uno, are widely used in the maker and electronics community due to their ease of use and versatility.

Features and components of the Arduino Uno:

1. **Microcontroller:** The Arduino Uno is powered by an ATmega328P microcontroller. This microcontroller runs the code that you upload to the board, controlling the behavior of the various connected components.
2. **Digital Input/Output Pins:** The Uno has 14 digital input/output pins (labeled as D0 to D13). These pins can be used for tasks like reading sensors, controlling LEDs, and interfacing with other digital devices.
3. **Analog Input Pins:** There are 6 analog input pins (labeled as A0 to A5) on the Uno. These pins allow you to read analog signals from sensors and other devices.
4. **PWM Outputs:** Some of the digital pins (D3, D5, D6, D9, D10, D11) can also function as Pulse Width Modulation (PWM) outputs. PWM is used for controlling devices that require variable power levels, like dimming an LED or controlling the speed of a motor.
5. **Built-in LEDs:** The Uno has built-in LEDs on pins D13, D12, D11, and D10. The LED on pin D13 is often used as a basic indicator in example projects.
6. **USB Interface:** The Uno features a USB interface that allows you to connect it to your computer for programming and communication. This interface is used for uploading your code to the board and for serial communication between the board and your computer.
7. **Power Connector:** The board can be powered either via USB or an external power source (7-12V DC) connected to the power jack.
8. **Reset Button:** The reset button restarts the microcontroller, allowing you to upload new code or reset the board's state.

9. **Voltage Regulator:** The onboard voltage regulator ensures that the microcontroller and other components receive a stable voltage.

The Arduino Uno is particularly well-suited for beginners and hobbyists who want to learn about electronics and programming. Its user-friendly interface, extensive online community, and vast library of code examples make it a great platform for prototyping and experimentation. You can program the Arduino Uno using the Arduino Integrated Development Environment (IDE), which provides a simple interface for writing and uploading code to the board.

2.4 Arduino UNO Applications in greywater recycling

Arduino Uno can be used in various ways to enhance and monitor greywater recycling systems, making them more efficient and responsive. Here are some potential applications of Arduino Uno in greywater recycling:

1. **Water Flow Monitoring:** Use Arduino Uno along with flow sensors to monitor the flow rates of greywater entering and leaving different stages of the recycling system. This information can help optimize the treatment processes and ensure efficient water utilization.
2. **pH and Water Quality Monitoring:** Arduino Uno can interface with pH sensors and water quality sensors to monitor the pH level and chemical composition of the greywater. This data is crucial for maintaining effective treatment processes and ensuring the treated water meets reuse standards.
3. **Automated Pump Control:** Connect Arduino Uno to pumps and valves to automate the flow of greywater through different treatment stages. Arduino can control the pumps based on input from sensors or predetermined schedules, ensuring proper movement through the recycling system.
4. **Tank Level Monitoring:** Implement ultrasonic distance sensors with Arduino Uno to monitor the levels of greywater in storage tanks. This helps prevent overflow or underutilization of treated water.
5. **Filter and Treatment System Monitoring:** Use Arduino Uno to monitor the status of filters, membranes, and treatment equipment. Arduino can trigger alerts or maintenance notifications when filters need cleaning or replacement, ensuring consistent treatment performance.

6. **Data Logging:** Arduino Uno can log sensor data, including flow rates, pH levels, and water quality measurements, over time. This historical data can be useful for analysis, optimization, and identifying trends.
7. **Smart Irrigation:** Integrate Arduino Uno with irrigation systems to automate the use of treated greywater for landscape irrigation. Arduino can control valves and sprinklers based on soil moisture levels, weather forecasts, and water availability.
8. **Remote Monitoring and Control:** Use Arduino Uno's communication capabilities (such as Wi-Fi or Ethernet shields) to enable remote monitoring and control of the greywater recycling system. This is especially valuable for managing systems in larger facilities or from a central location.
9. **Alerts and Notifications:** Set up Arduino Uno to send alerts and notifications via email or text messages in case of system failures, deviations from set parameters, or maintenance requirements.
10. **Energy Efficiency:** Arduino Uno can optimize the operation of pumps, valves, and other components to minimize energy consumption while maintaining effective greywater treatment and reuse.
11. **Human Interface:** Create a user-friendly interface using Arduino Uno, such as an LCD display or LED indicators, to provide real-time information about system status, water quality, and reuse metrics.

By leveraging Arduino Uno's capabilities, you can create a smart and responsive greywater recycling system that conserves water, reduces costs, and contributes to sustainable water management. Keep in mind that depending on the complexity of your project, you might need additional components like sensors, actuators, and communication modules to achieve your desired functionality.

2.5 Internet of Things (IoT)

The Internet of Things (IoT) refers to the network of interconnected physical devices, objects, and systems that communicate and exchange data with each other over the internet. These devices, often embedded with sensors, actuators, and communication technologies, can collect, transmit, and receive data without direct human intervention. The goal of IoT is to enable smart, efficient, and autonomous interactions between the physical world and the digital realm. Here are some key aspects and applications of IoT:

Key Aspects of IoT:

1. **Connectivity:** IoT devices are connected to the internet or other networks, allowing them to communicate with each other and with centralized systems.
2. **Sensors and Data Collection:** IoT devices are equipped with various sensors that can collect data about the environment, such as temperature, humidity, motion, light, and more.
3. **Actuators:** In addition to sensors, IoT devices often include actuators that allow them to perform actions based on the data they receive. For example, turning on a smart thermostat to adjust room temperature.
4. **Data Processing and Analysis:** IoT devices can process data locally or send it to centralized systems for analysis. Data analysis can provide valuable insights and enable informed decision-making.
5. **Remote Monitoring and Control:** IoT enables remote monitoring and control of devices and systems, allowing users to interact with and manage devices from anywhere with an internet connection.
6. **Automation and Autonomy:** IoT devices can operate autonomously based on predefined rules or data analysis, reducing the need for constant human intervention.

Applications of IoT:

1. **Smart Homes:** IoT devices are widely used in smart homes for tasks like home security, energy management, lighting control, and appliance automation.
2. **Industrial IoT (IIoT): In** industries, IoT is used for predictive maintenance, real-time monitoring of equipment, supply chain optimization, and process automation.
3. **Healthcare:** IoT-enabled medical devices and wearables can monitor patients' health remotely and transmit data to healthcare providers for diagnosis and treatment.
4. **Smart Cities:** IoT is employed for city infrastructure management, traffic management, waste management, and environmental monitoring.
5. **Agriculture:** IoT devices in agriculture aid in precision farming, monitoring crop conditions, soil moisture, and automating irrigation systems.

6. **Environmental Monitoring:** IoT devices can monitor air and water quality, weather conditions, and wildlife behavior for environmental conservation efforts.
7. **Transportation:** IoT plays a role in intelligent transportation systems, vehicle tracking, fleet management, and smart traffic control.
8. **Retail:** IoT is used for inventory management, personalized marketing, and improving customer experience in retail settings.
9. **Energy Management:** IoT enables energy consumption monitoring, demand response, and optimization of energy usage in buildings and industries.
10. **Wearable Technology:** Smartwatches, fitness trackers, and other wearables collect and transmit data about users' activities, health, and well-being.
11. **Supply Chain Management:** IoT can track the movement and conditions of goods throughout the supply chain, improving logistics and reducing losses.
12. **Remote Sensing:** IoT devices can be deployed in remote locations to collect data from harsh environments, enabling scientific research and monitoring.

IoT has the potential to revolutionize various industries by making processes more efficient, enhancing decision-making, and enabling new levels of automation and connectivity. However, it also brings challenges related to data security, privacy, and the management of vast amounts of data generated by interconnected devices.

2.6 IoT Applications in greywater recycling

Internet of Things (IoT) technology has the potential to greatly enhance and optimize greywater recycling systems by providing real-time monitoring, control, and data analysis capabilities. Here are some IoT applications in greywater recycling:

1. **Smart Sensors and Monitoring:** IoT-enabled sensors can be installed in various parts of the greywater system to monitor parameters such as water flow rates, water quality (chemical composition, pH, contaminants), and storage tank levels. These sensors can provide real-time data, allowing operators to detect any anomalies or issues promptly.
2. **Remote Monitoring and Control:** IoT platforms can enable remote monitoring and control of greywater systems. This is particularly useful for system operators who can access data and make adjustments from their smartphones or computers. They can remotely start, stop, or adjust system components based on real-time data.

3. **Predictive Maintenance:** IoT devices can collect data on the performance of pumps, filters, and other components in the greywater recycling system. By analyzing this data, predictive maintenance algorithms can be used to identify potential equipment failures before they occur, reducing downtime and maintenance costs.
4. **Data Analytics and Optimization:** IoT-generated data can be analyzed to identify trends and patterns in greywater usage and system performance. This data can help operators optimize the system's efficiency, adjust treatment processes, and improve overall water quality.
5. **Automated Water Treatment:** IoT-connected systems can automatically adjust treatment processes based on the quality of the incoming greywater and the intended reuse application. For example, if the greywater is destined for landscape irrigation, the system could adjust the treatment to meet the required water quality standards for irrigation.
6. **Integration with Building Management Systems (BMS):** In commercial and residential buildings, greywater recycling systems can be integrated with building management systems through IoT interfaces. This integration allows for coordinated water management, such as adjusting greywater usage based on building occupancy or water demand.
7. **Real-time Alerts and Notifications:** IoT systems can send alerts and notifications to operators or users in case of emergencies, system malfunctions, or when specific thresholds are exceeded. This ensures quick response and minimizes potential disruptions.
8. **Water Quality Assurance:** IoT sensors can continuously monitor the water quality in the greywater system and provide assurance that the treated greywater meets the required standards for safe reuse. This is particularly important for applications like toilet flushing or irrigation.
9. **User Engagement and Education:** For residential greywater systems, IoT technology can engage users by providing insights into water usage patterns, savings, and the environmental impact of their choices. This can lead to more responsible water usage and greater awareness of water conservation.

10. **Regulatory Compliance:** IoT systems can assist in collecting and storing data necessary for regulatory reporting and compliance with water quality standards for greywater reuse.

Implementing IoT applications in greywater recycling enhances the efficiency, reliability, and overall performance of these systems.

2.7 Previous Arduino-based Projects in Water Management

The study focuses on monitoring an Effluent Treatment Plant (ETP) in real-time using a wireless sensor network. The proposed system offers an automated and cost-effective approach to monitor water quality, leveraging wireless sensors for continuous data collection. This real-time, server-based solution has been demonstrated in the field with successful results, showing that it can monitor water quality parameters consistently and transmit the data to a cloud server. This method contrasts with existing approaches that are expensive, not real-time, and time-intensive. However, potential limitations include delays in data transmission if internet speed is slow. The study plans to enhance the system's simulation capabilities by adopting more advanced software for simulation purposes[1]

In the context of monitoring a Sewage Treatment Plant (STP), an Internet of Things (IoT) approach involves utilizing a compact set of crucial sensors, such as turbidity and pH sensors, connected to Arduino microcontroller boards. These sensors gather real-time data on key water quality parameters, enabling a comprehensive analysis of their interrelationships. The data collected by these critical sensors is then transmitted to a cloud-based local server via the Arduino microcontroller boards. This setup provides continuous monitoring of the STP's status, offering insights into the treatment process efficiency and water quality conditions. Through this IoT-enabled system, operators and stakeholders can gain a better understanding of the plant's performance and make informed decisions for effective sewage treatment management [2].

The widespread usage of Reverse Osmosis (RO) in water purifiers has led to a significant problem of excessive water wastage, with 75% of water being discarded and only 25% being made drinkable. This wastage, equivalent to 4 glasses of water for every 1 glass of drinkable water, contributes to water scarcity and pollution, as the discarded water enters sewage systems. To address this issue, a comprehensive solution has been devised - an automated system using Internet of Things (IoT) technology, integrated with a user-friendly Blynk app for real-time monitoring and control. This system is managed by an ESP32 microcontroller, allowing users to track water purification processes and make informed decisions about water usage, thereby minimizing waste and promoting efficient water management [3].

A novel approach to wastewater treatment is suggested for application in wastewater reuse scenarios. Unlike conventional setups that treat water to meet specific regulatory standards, this innovative scheme offers flexibility by rapidly adjusting water quality and quantity according to its intended use. This means the system can tailor its treatment process based on the purpose of the water. Through modeling and simulations, the study demonstrates the adaptability of this approach, especially when handling varying water flows and different forms of nitrogen content in the treated water. The paper introduces a new and adaptable wastewater treatment configuration with potential implications for more efficient water reuse practices [4].

China is facing a major water crisis due to rapid urbanization and industrialization. The government has invested very little in wastewater treatment facilities, and the country's natural resources are scarce. This has led to the deterioration of the water environment and a growing need for water management practices. Decentralized treatment of domestic wastewater is an attractive option for China because it is more cost-effective and sustainable than centralized treatment. Decentralized treatment facilities are typically smaller and located closer to the source of the wastewater, which reduces the need for long-distance transportation and treatment. The common characteristic of all decentralized treatment options is the "zero-discharge" and "closing-the-loop" approach. This means that the treated effluent is recycled for agricultural or municipal reuse, rather than being discharged into the environment. This helps to protect the water environment and conserve water resources. Decentralized treatment of domestic wastewater is gaining increasing importance in China as a way to address the country's water crisis. The government is providing financial incentives for the development of decentralized treatment facilities, and there is a growing awareness of the benefits of these systems among the public [5].

Water is a vital resource crucial for all life forms, yet its scarcity is becoming a global concern due to growing demands and population expansion. Water scarcity is pervasive, prompting the need for effective solutions. As the world's population continues to rise, so does the demand for water, particularly during the arid summer months. To address this challenge, wastewater management is vital, with interoperability being a central aspect. Treating and purifying wastewater for reuse is a significant strategy to prevent water-related issues, especially in times of increased demand, ensuring a sustainable water supply for various purposes [6].

The escalating need to recycle and recover substantial water quantities wasted across diverse industries is growing increasingly urgent. This urgency is particularly evident in the UAE, where the proliferation of registered vehicles has surged dramatically over the past decade. With a staggering 3.4 million registered cars in the UAE, the efficient management of wastewater generated by car washes assumes paramount importance. The wastewater from car washes is categorized as non-domestic greywater and is laden with contaminants like oil, grease, suspended solids, sand, dust, and trace chemicals resulting from engine washing and brake lining. To address this, determining the removal efficiency of soaps, especially at pH 3, where the interaction between basic soaps and acidic conditions occurs, is essential. Further research avenues encompass exploring various electrode types, time intervals, voltage settings, and pH levels to enhance the efficacy of soap removal processes [7].

Water serves as a critical resource for agricultural endeavors, yet its management in India has encountered challenges. In addressing these concerns, innovative methods have been employed for monitoring urban wastewater. This involves the utilization of a smart solution that integrates an array of sensors to assess water quality. The gathered data is then displayed on an LCD screen. The primary objective of this project is to ascertain crucial water quality parameters such as pH, turbidity, temperature, biological oxygen demand

(BOD), and total dissolved solids (TDS). By doing so, the system is capable of detecting deviations in these parameters, triggering an alert message whenever levels deviate from the standard or predefined thresholds. This system is executed through an Arduino Uno Controller, fostering effective management of water quality and aiding in the prevention of abnormalities that could adversely impact agricultural processes and water resources. Water pollution has become a pervasive issue, largely attributed to industrial activities. The analysis of such polluted water is a significant global challenge. It is imperative to establish continuous monitoring mechanisms for such polluted water to address this issue effectively. The deterioration of surface water bodies is primarily due to the presence of organic nutrients. A considerable portion of observed plant life demonstrated that agriculture, a major concern within this context, contributes to both diffuse and specific sources of pollution, encompassing organic matter, nutrients, pesticides, and hydro-morphological influences. Employing an array of sensors for parameter monitoring, such as hydrogen ion concentration (pH), is pivotal. This facilitates the determination of the acidity or alkalinity of a solution, thereby aiding in the assessment and management of water quality [8].

The project focuses on an IoT-based Smart Water Quality Monitoring System using three sensors: pH, soil moisture, and temperature. These sensors play critical roles in measuring pH within the range of 0 to 14, assessing soil moisture as a percentage (0-100%), and determining water temperature for plants and safe consumption. The proposed system detects pH, temperature (in centigrade), and soil moisture (in percentage), displaying this data on a web page in tabular format. Physical parameters like temperature, pH, and conductivity are measured using separate sensors connected to Arduino Uno and NodeMCU. The IoT's role in monitoring water quality is emphasized, promoting technology use and awareness to enhance water quality. The IoT is a network connecting physical devices through electronics, sensors, and software to exchange data. Imbalanced water pH disrupts aquatic organisms' biochemical reactions. Despite inventions, pollution and global warming challenge safe drinking water availability. The project's main objective is to design an IoT-based system for real-time monitoring of physical parameters like temperature, pH, and soil moisture. The system's potential scope includes monitoring environmental conditions, water quality, treatment, and disinfection. IoT's role in Industry 4.0 is highlighted, with sensors and actuators collecting data from the physical environment. The temperature sensor's accuracy and the importance of real-time water quality monitoring are emphasized. The system can detect water quality anomalies, and it can be adapted to user needs [9].

The traditional sewage treatment plant operates manually, requiring skilled operators to oversee each reactor's processes. The goal is to purify sewage water by removing contaminants for safe discharge. In a college sewage treatment plant, three tanks, BBR, FAICR, and AICR, are used for primary, secondary, and tertiary treatment respectively. The current manual operation lacks reliability and efficiency, as it depends on operator intervention.

To address this, the proposal suggests automating the college sewage treatment plant using IoT technology. Various sensors, Arduino UNO, and a Wi-Fi module are employed. An Ultrasonic sensor monitors tank levels, activating the motor and valve automatically when levels reach a certain point. A pH sensor gauges reactor pH levels. To manage toxic compounds, MQ-4 and MQ-135 sensors detect methane and hazardous gases, respectively, ensuring safe air quality for plant staff.

Traditional sewage often contains harmful substances and pathogens. The automation system aims to enhance the plant's robustness and efficiency by addressing these parameters, thereby improving the sewage treatment process [10].

CHAPTER 3
METHODOLOGY & IMPLEMENTATION

CHAPTER 3: METHODOLOGY & IMPLEMENTATION

3.1 System Design:

System design is a critical phase in developing a wastewater recycling system using Arduino UNO and IoT. During this phase, you will create a comprehensive plan for how all the selected components will work together to achieve the system's objectives. Here's a detailed breakdown of this step:

3.1.1 Architecture and Schematic Diagram:

- Create a system architecture diagram that illustrates the overall structure of the wastewater recycling system. Clearly define the relationships between components, including sensors, actuators, the Arduino UNO, IoT module, and treatment units.
- Develop a schematic diagram that outlines the movement of wastewater through different treatment stages and the data flow within the system.

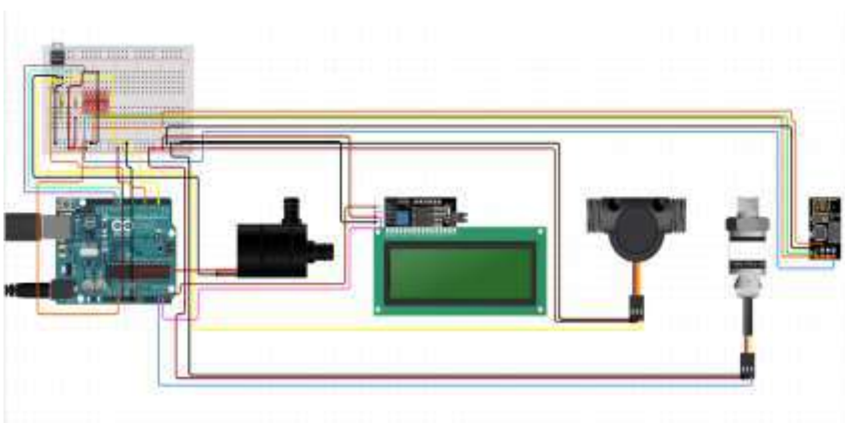

Figure 3-1 Architecture and Schematic Diagram

3.1.2 Control Logic:

The control logic that will govern the system's operation. Specify how the Arduino UNO will process data from sensors and make decisions based on predefined rules.

- Detail the logic for activating pumps, valves, and heaters to control water flow and quality.

3.1.3 Treatment Process Design:

The treatment process in detail, including the order of treatment stages (e.g., filtration, chemical treatment, biological treatment) and the specific components used.

- Specify the parameters and conditions under which each treatment stage operates effectively.

3.1.4 IoT Integration:

The IoT module will be integrated into the system. Define the data transmission protocols and methods for sending data to the chosen IoT platform.

- Determine how remote monitoring and control will be implemented through the IoT module.

3.1.5 Scalability and Future Expansion:

The system's scalability to accommodate increased wastewater volumes or additional treatment units in the future. Plan for expansion if BUETK hostel requirements change.

3.2 Component Selection:

Selecting the right components is crucial for building an effective wastewater recycling system using Arduino UNO and IoT. This step involves choosing sensors, actuators, controllers, and other hardware elements that best suit the project's requirements. Here's a detailed breakdown of this step:

1. **Arduino UNO:** The main controller that collects data from sensors and controls various devices.

Figure 3-2 Arduino UNO

2. **IoT Module (Node MCU ESP32):** To enable communication with the internet and cloud services.

Figure 3-3 IoT Module (Node MCU ESP32)

3. **Sensors:**

   i. pH Sensor: To measure the pH level of the water.

Figure 3-4 pH Sensor

ii. Flow Sensor: To measure the rate of water flow.

Figure 3-5 Flow Sensor

4. **Relays:** To control pumps, valves, and other devices.

Figure 3-6 4-channel Arduino Relay

5. **Pumps:** To manage the flow of water for recycling and purification.

Figure 3-7 Pump

6. **Water Tanks:** Storage tanks for collecting and storing wastewater.

Figure 3-8 Water Tank

7. **Purification System:** Filters, UV sterilizers, or other purification methods.

Figure 3-9 Purification System

8. **Power Supply:** Arduino and sensors need a stable power source.

Figure 3-10 12v DC Adapter

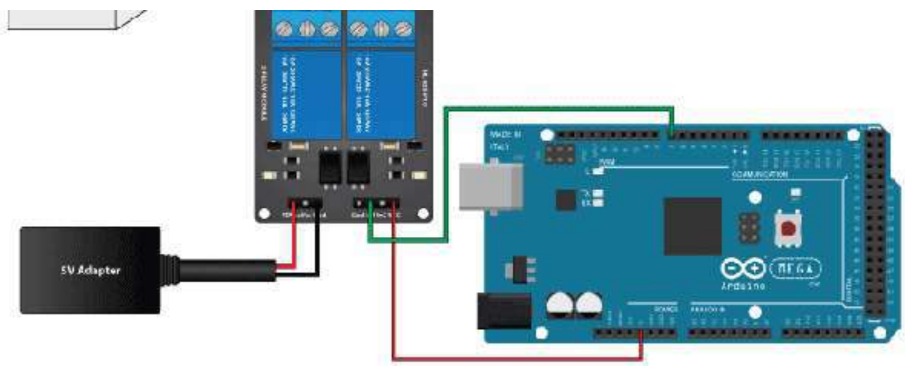

Figure 3-11 5v DC Arduino Power supply

9. **Voltage regulator modules:** DC modules are needed for Arduino and water pumps.

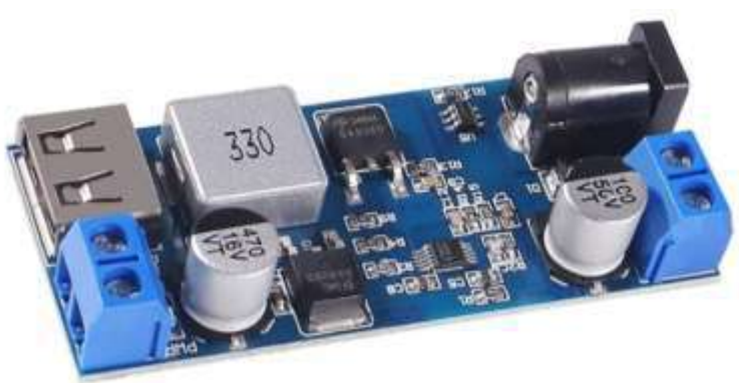

Figure 3-12 Voltage Regulator

10. **Internet Connection:** Wi-Fi module or Ethernet shield for IoT connectivity.

Figure 3-13 Internet Connection

11. **Cloud Service:** An IoT platforms like Blynk for data storage and remote monitoring.

Figure 3-14 Cloud Service

3.3 Hardware Implementation:

The hardware implementation phase involves bringing the design of the wastewater recycling system to life. During this phase, you'll physically assemble and configure all the selected components, ensuring they work together as planned.

3.3.1 Assembly and Installation:

- Assemble the hardware components according to the wiring diagrams and plans developed during the system design phase.
- Install sensors, actuators, treatment units, the Arduino UNO, IoT module, and other hardware in their designated locations within the BUETK hostel premises.

3.3.2 Safety Checks:

- Perform safety checks to ensure that the hardware installation complies with safety regulations and poses no hazards to residents, the environment, or maintenance personnel.

3.3.3 Training:

- Train BUETK hostel staff or operators on how to operate and maintain the hardware components of the system.
- Ensure that personnel understand safety procedures and emergency protocols.

3.4 Software Development:

The software development phase of the wastewater recycling system involves creating the code and programs needed to control the hardware components, process sensor data, and enable communication with the IoT platform. Here's a detailed breakdown of this step:

3.4.1 Programming Languages and Tools:

- The appropriate programming languages and development tools for the software development. Common choices for Arduino UNO programming include Arduino IDE, C/C++, and Python for IoT module.

3.4.2 Arduino UNO Code:

- Write the code for the Arduino UNO to control the hardware components and implement the control logic developed during the system design phase.
- Program the Arduino to read data from sensors, activate actuators (e.g., pumps, valves), and maintain the desired treatment process.

3.4.3 IoT Platform Integration:

- Integrate the software with the selected IoT platform, allowing data to be transmitted securely to the cloud.
- Implement code to handle data transmission, storage, and retrieval from the IoT platform.

CHAPTER 4
RESULTS AND DISCUSSION

CHAPTER 4: RESULTS AND DISCUSSION

This chapter presents the experimental results and subsequent discussion of the waste water recycling system implemented using Arduino UNO and a LOT (Low-cost Optical Turbidity) sensor based on BUETK (Balochistan University of Engineering and Technology, Khuzdar) specifications.

4.1 Experimental results

4.1.1 pH scale:

The pH scale measures pH level of water whether it is acidic or neutral. As you can see from the pH scale above, pure water has a pH value of 7.

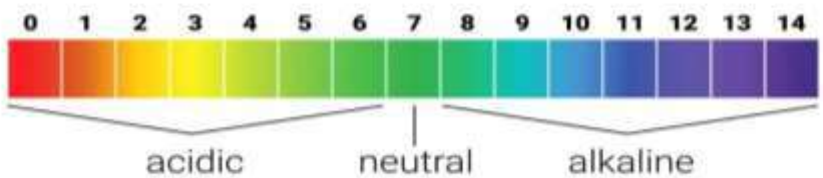

Figure 4-1 pH scale

4.1.2 System Calibration and pH Monitoring:

The initial phase involved calibrating the IoT sensor to establish a reliable relationship between sensor readings and pH levels in the water. The calibration curve formed the basis for accurate pH measurements.

Figure 4-2 System Calibration

Figure 4-3 Waste water pH value (Blynk App)

Figure 4-4 Waste water pH value (LCD)

4.1.3 Control System Performance:

The Arduino UNO-based control system's ability to turn on or off the water pump in Blynk software. The system displayed strong performance, maintaining water quality within desired limits. This highlights its potential for automated and adaptive water treatment processes.

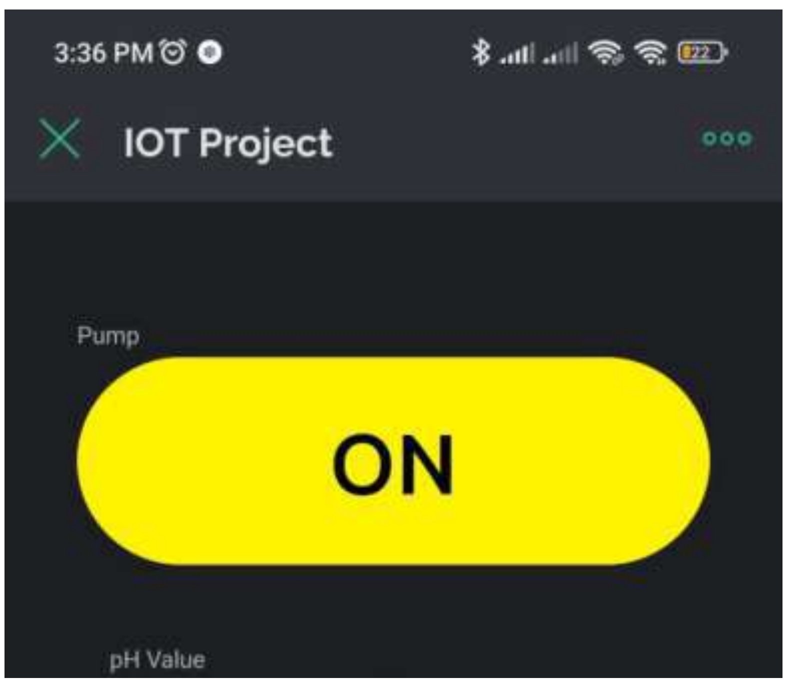

Figure 4-5 Water Pump switch (Blynk App)

4.1.4 Water Recycling Efficiency:

Treated water samples were analyzed for pH. Comparative analyses demonstrated the system's efficacy in significantly improving water quality through the recycling process. The results specify its potential for modifying environmental impact and resource protection.

4.1.5 Statistical Analysis:

Statistical methods, including regression analysis and t-tests, were applied to validate the significance of the experimental results. The analysis provided statistical confidence in the reliability and effectiveness of the waste water recycling system. This quantitative validation enhances the credibility of the system's performance.

4.2 Discussion of results

4.2.1 Implications of Results:

The positive outcomes of the experiments indicate the potential for widespread application of the Arduino UNO-based waste water recycling system. Its effectiveness in real-time monitoring, control, and improving water quality suggests a valuable contribution to sustainable water management practices.

Figure 4-6 Filtered water (LCD)

4.2.2 Limitations:

Despite its success, the system has limitations, including potential sensitivity to extreme environmental conditions. Acknowledging these limitations is crucial for refining the system's design and operation.

4.2.3 Future Recommendations:

To enhance the system, future research could focus on increasing the size and capacity of water filter unit and its stages of water filtration unit for comprehensive water quality attaining. Moreover, exploring IoT connectivity for remote monitoring and control would further advance the system's practicality and adaptability.

1. **Implement a multi-stage treatment process:**

Consider incorporating additional treatment stages, such as membrane filtration or activated sludge, to further improve the quality of the recycled wastewater and ensure it meets stringent reuse standards.

2. **Expand the system's functionality:**

Explore the integration of sensors for other water quality parameters, such as dissolved oxygen, nitrates, and phosphates, to provide a more comprehensive assessment of the recycled wastewater's quality.

3. **Develop a real-time monitoring and control dashboard:**

Design a user-friendly dashboard that visualizes real-time sensor data, system performance metrics, and alerts for potential issues, enabling proactive maintenance and optimization.

4. **Conduct cost-benefit analysis:**

Perform a comprehensive cost-benefit analysis to assess the economic viability of the wastewater recycling system, considering factors such as capital investment, operational costs, and water savings.

CHAPTER 5

CONCLUSION AND FUTURE WORK

CHAPTER 5: CONCLUSION AND FUTURE WORK

5.1 Conclusion:

This study demonstrates the feasibility of implementing a wastewater recycling system using Arduino UNO and IoT for BUETK Hostels. The system effectively reduces pH in wastewater, making it suitable for reuse in non-potable applications such as irrigation and toilet flushing.

Wastewater recycling is a sustainable and environmentally friendly approach to water management. By reusing wastewater, we can conserve freshwater resources, reduce wastewater discharge into water bodies, and minimize the environmental impact of human activities.

The wastewater recycling system developed in this study has the potential to be applied in various settings, including residential complexes, industrial facilities, and agricultural operations.

5.2 Future Work

5.2.1 Optimization for Diverse Wastewater Types:

Investigate the effectiveness of the system in treating different types of wastewater, including domestic wastewater, industrial wastewater, and agricultural wastewater.

5.2.2 Long-term Performance Evaluation:

Conduct long-term studies to assess the durability, reliability, and cost-effectiveness of the system under real-world conditions.

5.2.3 Advanced Sensor Integration:

Develop and integrate advanced sensors and control algorithms to improve the system's accuracy, efficiency, and adaptability to varying wastewater conditions.

5.2.4 User-friendly Interface Development:

Design a user-friendly interface that provides easy monitoring, control, and data visualization capabilities for the system's operation.

Smart Grid Integration Exploration: Investigate the potential for integrating the system with smart grid technologies to optimize energy consumption and water usage patterns.

5.2.5 Potential Application:

Setting	Application
Residential complexes	Toilet flushing, irrigation
Industrial facilities	Process water, cooling water
Agricultural operations	Irrigation

Table 5.1 Potential Application

5.2.6 Recommendations for Future Work:

1. **Enhanced Monitoring Capabilities:** Expand the sensor network to include additional parameters for comprehensive wastewater analysis. This could involve the integration of more advanced sensors to measure specific pollutants, pH levels, dissolved oxygen, or other relevant water quality indicators.

2. **Scalability and Upgradation:** Explore options for scaling up the system to handle larger volumes of wastewater or expanding it for use in other locations. Consider modular designs or additional units to accommodate increased demand.

3. **Remote Monitoring and Control:** Develop a robust remote monitoring and control system using IoT technologies. This would allow users to monitor the wastewater treatment process, receive alerts for any anomalies, and remotely control the system from anywhere via a user-friendly interface.

4. **Water Reuse Applications:** Investigate possibilities for the treated water's reuse. Explore how the recycled water can be utilized within the hostel premises for non-potable purposes like irrigation, toilet flushing, or other appropriate uses after ensuring its safety and quality.

5. **Long-Term Performance Analysis:** Conduct a long-term study to assess the system's durability, reliability, and overall performance over an extended period. Evaluate maintenance requirements, system degradation, and efficiency fluctuations over time.

Appendix

1. ARDUINO UNO CODE:

```
#include <SoftwareSerial.h>
SoftwareSerial Serial1(11, 10); // RX, TX

#include <LiquidCrystal.h>
LiquidCrystal lcd(3, 4, 5, 6, 7, 8);

#define pump_pin 9

#define SensorPin1 A0      //pH meter Analog output to Arduino Analog Input 0

float calibration_value = 21.34 + 0.7;
unsigned long int avgValue;  //Store the average value of the sensor feedback
int buf[10], temp;
float phValue;

byte sensorInterrupt = 0;  // 0 = digital pin 2
byte sensorPin2       = 2;// The hall-effect flow sensor outputs approximately 4.5
pulses per second per
// litre/minute of flow.
float calibrationFactor = 4.5;
volatile byte pulseCount;
float flowRate;
unsigned int flowMilliLitres;
unsigned long totalMilliLitres;
unsigned long oldTime;
float litre;


void setup(){
Serial.begin(9600); // Open the serial port
Serial1.begin(9600);

pinMode(pump_pin, OUTPUT);
pinMode(SensorPin1, INPUT);
pinMode(sensorPin2, INPUT);
digitalWrite(sensorPin2, HIGH);
pulseCount        = 0;
flowRate          = 0.0;
flowMilliLitres   = 0;
totalMilliLitres  = 0;
```

```
oldTime          = 0;
// The Hall-effect sensor is connected to pin 2 which uses interrupt 0.
// Configured to trigger on a FALLING state change (transition from HIGH
// state to LOW state)
attachInterrupt(sensorInterrupt, pulseCounter, FALLING);

lcd.begin(20, 4);
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Welcome To");
lcd.setCursor(0, 1);
lcd.print("     pH Meter");
lcd.setCursor(0, 2);
lcd.print("     Flow Meter");

delay(2000);
lcd.clear();
}
void loop(){

if((millis() - oldTime) > 1000){    // Only process counters once per second
detachInterrupt(sensorInterrupt);
flowRate = ((1000.0 / (millis() - oldTime)) * pulseCount) / calibrationFactor;
oldTime = millis();
flowMilliLitres = (flowRate / 60) * 1000;
totalMilliLitres += flowMilliLitres;
unsigned int frac;
// Reset the pulse counter so we can start incrementing again
pulseCount = 0;
//Enable the interrupt again now that we've finished sending output
attachInterrupt(sensorInterrupt, pulseCounter, FALLING);
}

 for(int i=0;i<10;i++){ //Get 10 sample value from the sensor for smooth the value
    buf[i]=analogRead(SensorPin1);
    delay(10);
  }
  for(int i=0;i<9;i++){ //sort the analog from small to large
    for(int j=i+1;j<10;j++){
      if(buf[i]>buf[j]){
        temp=buf[i];
        buf[i]=buf[j];
        buf[j]=temp;
      }
    }
  }
```

```
avgValue=0;
for(int i=2;i<8;i++)avgValue+=buf[i];  //take the average value of 6 center sample

phValue=(float)avgValue*5.0/1024/6; //convert the analog into millivolt
phValue = -5.70 * phValue + calibration_value; //convert the millivolt into pH
value

lcd.setCursor(0, 0);
lcd.print(" pH Value: ");
lcd.print(phValue);
lcd.print("  ");

lcd.setCursor(1, 1);
    if(phValue<4)               lcd.print(" Very Acidic ");
else if(phValue>=4  && phValue<5)  lcd.print("    Acidic   ");
else if(phValue>=5  && phValue<7)  lcd.print(" Acidic-ish  ");
else if(phValue>=7  && phValue<8)  lcd.print("   Neutral   ");
else if(phValue>=8  && phValue<10) lcd.print("Alkaline-ish ");
else if(phValue>=10 && phValue<11) lcd.print("  Alkaline   ");
else if(phValue>=11)              lcd.print("Very alkaline");

litre = flowMilliLitres/999.99;

lcd.setCursor(0, 3);
lcd.print("Flow Rate:");
lcd.print(litre);
lcd.print("L/M ");

wifi();
}

void wifi(){
Serial1.print("A");Serial1.println(phValue);delay(500);
Serial1.print("B");Serial1.println(litre);delay(500);
}

void pulseCounter(){// Increment the pulse counter
  pulseCount++;
}
```

2. <u>NODE MCU ESP8266 CODE:</u>

```
#include <SoftwareSerial.h>
SoftwareSerial uno(D6,D7); //TX,RX

#define BLYNK_TEMPLATE_ID "TMPL6EF965QkQ"
```

```
#define BLYNK_TEMPLATE_NAME "IOT Project"
#define BLYNK_AUTH_TOKEN "ck3FQRmmL1KcvinphbpJbR-
EUR1RhNDG"

// Your WiFi Credentials.
// Set password to "" for open networks.
char ssid[] = "Wifi";
char pass[] = "78655465";

// define the GPIO connected with Sensors & LEDs
#define button_pin  D2
#define pump_pin    D3
#define WIFI_LED    D4

//#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>

String data="";
float pHValue, flow;

int pump=0, flag=0;

bool isconnected = false;
char auth[] = BLYNK_AUTH_TOKEN;

BlynkTimer timer;

BLYNK_WRITE(V0) {
  pump = param.asInt();
  digitalWrite(pump_pin, pump);
  Serial.print("Pump State = "); Serial.println(pump);
}


void checkBlynkStatus() { // called every 2 seconds by SimpleTimer
  isconnected = Blynk.connected();
  if (isconnected == true) {
    digitalWrite(WIFI_LED, LOW);
    sendSensorData();
    //Serial.println("Blynk Connected");
  }
  else{
    digitalWrite(WIFI_LED, HIGH);
    Serial.println("Blynk Not Connected");
  }
```

```
}

void sendSensorData(){
Blynk.virtualWrite(V1, pHValue);
Blynk.virtualWrite(V2, flow);
}

void setup(){
  Serial.begin(9600);
  uno.begin(9600);

  pinMode(button_pin, INPUT_PULLUP);
  pinMode(pump_pin, OUTPUT);
  pinMode(WIFI_LED, OUTPUT);

  digitalWrite(WIFI_LED, HIGH);

  WiFi.begin(ssid, pass);
  timer.setInterval(2000L, checkBlynkStatus); // check if Blynk server is
connected every 2 seconds
  Blynk.config(auth);
  delay(1000);
}

void loop(){

if(digitalRead(button_pin)==0){
 if(flag==0){flag=1;
 pump = !pump;
 Blynk.virtualWrite(V0, pump);
 digitalWrite(pump_pin, pump);
 delay(100);
 }
}else{flag=0;}

while(uno.available()>0) {
char inChar = (char)uno.read();
    if(inChar == '\n' or inChar == '\r'){
    }else{data += inChar;}

 if (inChar == '\n' or inChar == '\r') {
  String dataInS = data.substring(1, data.length()); // Extract only the number. E.g.
from "A120" to "120"
     if(data.charAt(0) == 'A'){ pHValue=dataInS.toFloat();}
else if(data.charAt(0) == 'B'){ flow=dataInS.toFloat();
Serial.print(pHValue); Serial.print("\t");
```

```
Serial.println(flow);
  }
uno.flush();
data="";
  }//END OF ONE LINE
 }//END OF SERIAL AVAILABLE

  Blynk.run();
  timer.run();
}
```

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