IOT BASED MASTER SLAVE WASTE WATER MANAGEMENT FOR INDUSTRIES

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ABSTRACT

Wastewater treatment in industrial settings is essential for guaranteeing environmental sustainability and regulatory compliance. This overview describes a cloud-based industrial Internet of Things (IoT) system designed for real-time wastewater monitoring. The suggested IoT system integrates sensors, actuators, and cloud-based platforms to provide continuous monitoring and control of multiple parameters related to wastewater management. The sensors are positioned throughout the wastewater system to pick up on crucial elements including pH levels, temperature, turbidity, and certain gases. We are using an Arduino board, which is connected to all of our sensors. The NodeMcu, the project's master NodeMcu, gets sensor-sensing data from the Arduino and transmits it to the cloud. A cloud-based platform receives the acquired data and stores, processes, and visualises it. Operators in the industry and employees in environmental management can get real-time data on the state of wastewater parameters through the cloud-based platform. This makes it possible to take proactive decisions and move quickly to address any deviations or irregularities. To notify the appropriate individuals of urgent conditions, such as excessive pollution levels or equipment breakdowns, alerts and notifications can be sent to the administrator. The use of the ThingSpeak cloud platform for wastewater data monitoring is covered in this abstract, along with how the MIT application was integrated for better analysis and decision-making. The MIT programme uses advanced analytics to extract valuable insights from the gathered data whereas ThingSpeak is a cloud-based Internet of Things (IoT) platform that offers real-time data gathering, storage, and visualisation capabilities.

Keyword: - *Arduino, NodeMcu, Internet of Things(IoT).*

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1. INTRODUCTION

Humanity was able to evolve farther into the twenty-first century with the advent of the Industrial Revolution. Science advanced, technology advanced quickly, and the manufacturing period emerged. Industrial pollution was one more impact that came along with all of them. Industries used to be small operations that mostly produced smoke as a pollutant. Industrial waste water contains contaminants that, when dumped carelessly into river bodies, cause physical and chemical changes in the environment. These changes include colour, biological condition, reduction in quality and quantity of the biotic floral of the human aesthetical assets, and reduction in biological quantity. As a result, the price of pollution control is rapidly increasing. Untreated waste water can produce significant amounts of foul fumes if it is allowed to build up and the organic elements it contains begin to decompose. Numerous harmful or disease-causing microorganisms that live in the human digestive tract or may be present in some industrial waste are frequently found in untreated waste water. Additionally, harmful substances found in waste water are released by companies. The goal of the suggested system was to provide real-time monitoring of water quality that was simple and affordable by measuring the water's temperature, turbidity, pH, and gases using an Arduino board and several sensors in an Internet of Things environment. letting the appropriate authorities know how the water is The Arduino board serves as the main controller in our design. A specialised IoT module is used by the design system to save sensor data from the core controller to the cloud in a simulated manner. A unique IP address can be used to access the sensor data in the cloud. Test results are saved in the cloud, so it is simple to access any earlier test data. Owners receive the results so they can take the necessary measures. If the proper steps are not taken, the factory's details will be posted on social media.

2. LITERATURE WORK

We discuss the current work in this section. The issue raised by the current system is addressed in our paper, which also provides users with clear guidance on how to address such issues and find solutions.

The array of sensors that are connected to an Arduino uno board are used to treat and monitor the waste water, and the measured value is shown on an LCD. In an IOT setting, we have created a coffee cost system for real-time water quality monitoring. The Arduino Uno is used as a key component in this design. A specialised IOT module is used by the planning system to access sensor data from essential components stored in the cloud.In [1], The estimation of water quality parameters, such as PH, turbidity, temperature, BOD, and TDS, is the main goal of this project. These parameters help to identify deviations in parameters and provide an alert message when there is an abnormal level, that is, when the value exceeds the standard value set within the Arduino Uno Controller. This must be put into practise by placing sensor devices throughout the environment for data collection and analysis. We will make the environment more realistic by placing sensor devices there so that it can communicate with other items across a network. The user will then have access to the gathered data and the analysis's findings over Wi-Fi.

This essay suggests an mechanism for detecting water quality scheme using the NB-IOT protocol to collect node data and implements that through a web browser to visit the evaluation of water quality platform. The paper does this by looking at the flaws of current water quality monitoring techniques,, such as the lack of data collection points, large power consumption, and small coverage. The prototype system executes functions such as water quality data inquiries and node online status queries [2].The technology still allows for the following tasks to be done, though: A smaller number of sensor nodes in the prototype system results in a coarser granularity of lake water detection. Second, the prototype system was only capable of performing the most fundamental tasks; automatic evaluation of the water's quality was not possible. These improvements will be made in the future. Monitoring water quality is a crucial part of keeping an eye on the environment, combating pollution, and safeguarding water resources. Research on water quality has significant practical implications for environmental preservation. This work suggests a technique for monitoring the quality of water online employing NB-IOT protocol communication to address the drawbacks of current water quality monitoring technologies, high node power consumption, for example, and and limited coverage. The prototype system demonstrates that it can satisfy Bolong Lake's needs for water quality monitoring.

The report provides specifics on the instruments and methods employed in the smart water monitoring system. An elaborate building is used in the piece. In this instance, the layers are data transport, data collection, and data processing. The project used the EXO Sonde, GSM, and flask server to produce the desired result of water monitoring. The performance and monitoring procedures have both increased because of EXO Sonde's features. The server receives and displays the sensor data [3]. The future scope of this effort will include analyses of the water's quality. Based on the current requirements, water analytics can determine the water quality index. [3] It is possible to bring improvements to communication technology in the future. As a software interface, several communication technologies can be implemented, and the application can select the communication channel based on the situation. In the event of a network failure, the sensor node stores the sensor data on a file system. GSM is the technology used for communication between nodes and sensors. The data is kept and shown in a web UI on the server.

In this work, a brand-new concept for Bangladesh's real-time Smart Wastewater Monitoring System (SWMS) using the Internet of Things (IoT) is proposed. Different industries have unique production processes and use various raw materials and chemicals. In addition, untreated industrial wastewater quickly threatens water security, both directly and indirectly. The proposed SWMS, which is made up of a microcontroller coupled to five smart sensors, including temperature, pH, turbidity, total dissolved solids (TDS), and dissolved oxygen (DO), has just been created in Bangladesh to address the aforementioned issues. Additionally, the suggested model sends data to a web server using a GSM-GPRS module [4]. A website with the URL http://swwmbd.com has been created with the goal of expanding this initiative to allow for continuous online data monitoring. The authorization ID and password are contained on the web page for security reasons. The parameters' upper and lower limits have also been set through filtering, and the data have been organised in a table-like manner. Finally, the suggested model was able to produce the expected outcomes, which are shown on the website and deemed analytical [4]. The website was also developed using IDE software and three programming languages, including HTML, CSS, and PHP. When the sensor detects any undesired data in the field, this type of data is displayed using a different colour for simple identification. It is hoped that more water parameters will be introduced in future studies so that all of the water parameters can be analysed. Improvements to the sensor precession and smart phone control of the SWMS are also required. Finally, a feedback system must be added so that the authority can alert the customer.

In the proposed framework, an array of sensors collects data that shows the deviation of water exceptional parameters and additionally transmits the measured data to the microcontroller through IoT. It then sends an alert message to the farmers or consumers in order to activate the module. It also gathers statistics in real time that show an increase in the level of the parameters in the water used by the GSM foundation without any human intention. In the suggested framework, the parameters pH, turbidity, temperature, TDS, and BOD would be monitored. [5] The current system treats and monitors waste water using a variety of sensors, and it only checks for the presence of foreign particles. It also displays any deviations in water quality parameters like hydrogen potential, acidity or alkalinity, total dissolved solids, biochemical oxygen demand, and the amount of suspended particles. [5] The data is gathered from the sensor displays and is then displayed on an LCD screen. After a predetermined amount of time, the old value is replaced with the new one, and the water value is updated to reflect the ongoing changes in industrial, domestic, and urban waste water. to automatically gather data in real time on an LCD without human involvement.

A new wastewater management system with cloud assistance is shown. Most countries do not currently take into account all the factors that should be part of their water management system when managing their wastewater. Wastewater is cleansed and purified for reuse to prevent water problems during the summer. [6] The suggested CWMS refreshes data in the cloud for simple access. The wastewater is initially handled in three separate phases after being collected at one location from various sources. Each parameter has a threshold value that has been established and tested. The findings collected indicate that the suggested CWMS accurately detected the reuse of wastewater for a specific purpose [6]. Two different types of wastewater were used in this study for testing. The outcome demonstrates that the first type of water is appropriate for use in agriculture, while the second type suggests that it is appropriate for use in washing. It demonstrates the effectiveness of the suggested CWMS. Additionally, it's crucial to remember that the cloud should be used to control the treated water. Sharing information about the plant and controlling wastewater reuse are simple tasks. Most farmers use this downstream-flowing wastewater for irrigation since untreated or only partially treated wastewater contains nutrients. In addition to nutrients, this untreated wastewater also includes industrial effluents. Despite the potential benefits of utilising wastewater, improper use can occasionally be dangerous. Reusing wastewater is the main strategy for dealing with the problem in Bangalore. In order to preserve water for Bangalore city, many town subdivisions, town divisions, neighbourhoods, and individuals must take responsibility. Moreover, it will be difficult to maintain STPs and the quality of the water released into the environment without the use of appropriate new technology.

The suggested system design monitors the parameters of temperature, pH, dissolved oxygen, water level, bad odour detector, and ammonia to determine the quality of water used in aquaculture. the suggested system architecture with the sensors. The appropriate sensors are used to measure these parameters. The measured data are taken at predetermined intervals and supplied to the core processor. The core processor examines the parameters that have been sent, and if any of the parameters are greater than the threshold values, it triggers the associated relay and sounds the buzzer [7]. This research suggests an Internet of Things-based method for monitoring and managing water quality in aquaculture. For aquaculture to provide a good supply of fish, proper water quality is essential. Fish will perish if the water quality is not adequately maintained. Therefore, a system has been constructed in this study employing an Arduino CPU and many sensors, including temperature, water level, ammonia, pH, dissolved oxygen, and foul odour sensors. These sensors take the appropriate reading from the water and then transmit the readings to the processor for processing. The appropriate relay is actuated to return the measured value to the normal level if the values are not at the intended level. IoT is used in the control room to continuously monitor the measured quantities.

In this study, a reconfigurable smart sensor interface device for a mechanism for monitoring water quality in an IoT environment is presented. The Field Programmable Gate Array (FPGA) design board, sensors, a Zigbee-based wireless communication module, and a personal computer (PC) compose the smart WQM system. The basis of the proposed system is an FPGA board, which is programmed using the Quartus II software and Qsys tool in very high-speed integrated circuit hardware description language (VHDL) and C. The five water quality parameters of pH, level, turbidity, carbon dioxide (CO2) on the surface of the water, and temperature are all collected simultaneously, in real time, and at high speed by the proposed WQM system[8]. High execution speed and reusable intellectual property (IP) design are attributes of the suggested system. The suggested system would help safeguard the ecological surroundings of water supplies. As part of environmental management, the smart WQM system reduces the time and expenses associated with determining a reservoir's water quality. The WSN network will expand its node count in the future in order to increase its coverage area.

Several sensors are employed in this system to measure the pH, turbidity, conductivity, temperature, and flow of the water. The ADC transmits the measured values to the core controller. A core controller with high speed, Wi-Fi, and Bluetooth capability is the Raspberry Pi 3. Raspberry Pis boot the Raspbian operating system. Raspbian is an operating system for computers built on the Linux kernel. The sensors' terminals, which will automatically read and process the observed readings, are accessed using a Python programme. For interfaces, the Raspberry Pi has a variety of drivers installed. It is not practical to load every driver at startup because doing so would drastically lengthen boot time and consume a lot of system resources for redundant tasks [9]. Then the IoT module transmits the water monitoring parameters from the sensors to the gateway. On the Raspberry Pi, a gateway is constructed, which is in charge of data analysis and transmitting the sensed data to the server [11]. The UDP packets are created by the gateway and contain a sample of the data that will be sent to the remote server. The server gathers UDP packets, which it then saves in a database. With a separate IoT account, detected values may be examined, and solenoid valves can be operated via the internet from any location in the world. Mobile devices can be accessed over Wi-Fi.

present a novel cloud-based industrial IoT model for regulating and monitoring wastewater in real-time. The suggested system keeps track of the temperature and hydrogen power (pH) levels in the wastewater entering the treatment facility, preventing the entry of prohibited industrial effluent that the facility is unable to handle. The system collects and uploads real-time sensor data to the cloud via an IIoT Wi-Fi module. Additionally, it controls the gates' valves and issues SMS alerts and notifications when unexpected industrial wastewater inlets are seen or detected. [10]To redirect the flow of water to a facility that can handle this kind of industrial waste, this is necessary. Comparing the effectiveness of the suggested system to previous research, experimental work demonstrates this. [10] Our suggested system should address the following requirements to overcome these limitations:

- Scalability by adding several additional sensors as needed at the lowest cost.
- Providing temporal and spatial coverage by monitoring data in real-time, monitoring more parameters at the same station, and managing and monitoring several stations at the same time
- Adding more security options to protect the system from attacks.
- Analysing data and preparing reports, This have to be carried out in a manner that is simple to comprehend.

Aquaponics is a cutting-edge and rising farming method that has made fish farming and vegetable production more effective and precise. This strategy makes use of the newest hydration and supplying fish and plants with food. This paper discusses various technical problems that aquaponic farmers have and offers a technical fix for a recognised difficulty in conventional aquaponics using wireless sensors, a communication network, and a GUI application. The GUI solution for the problems is called AWSM [12]. Even when the farmer is not home, the AWSM-based end-user mobile application notifies him or her online about the water quality and offers advice. When an AWSM-based IoT application was installed for the aquaponics system in comparison to the traditional way, results indicated significant improvements. [12] The AWSM app may eventually be improved to provide a full farming solution, including automatic device control when sensor data deviates from expected values with the farmer's approval. Additionally, AWSM may be expanded to include planting, fish culture recommendation systems, and calculations of water nutrients that will provide farmers with predictions. about which veggie is best for the weather and soil conditions.

3. SYSTEM ARCHITECTURE

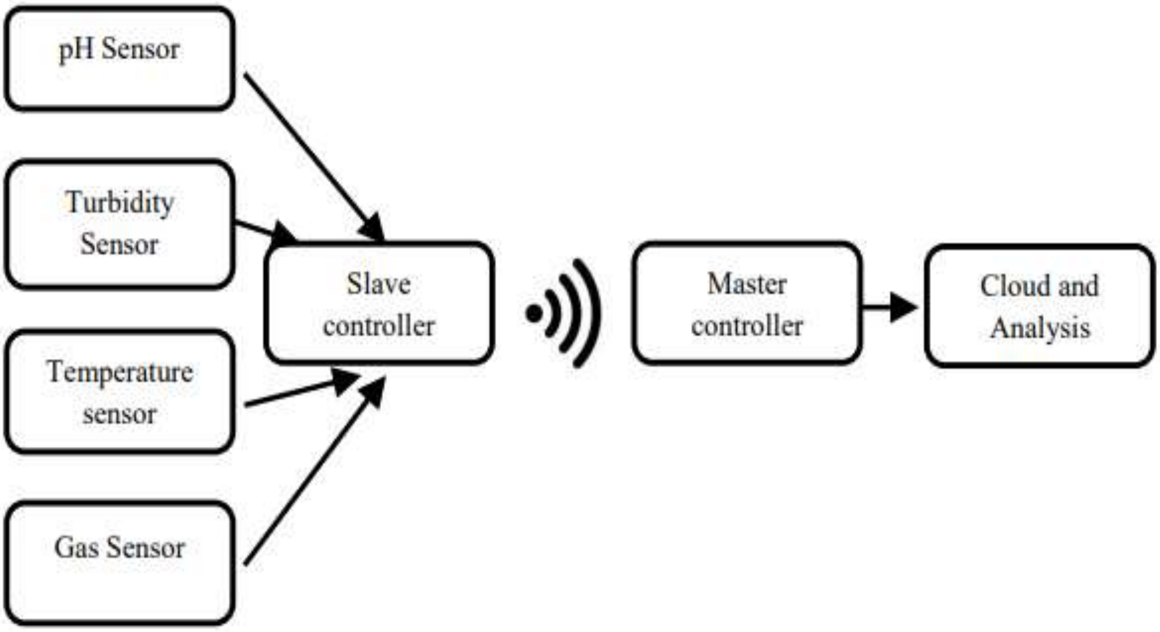

Fig-1: System Architecture.

The system architecture defines the overall structure of the system, including its components, their interactions, and the data flow between them. In this system, we have identified the following components:

- **pH sensor:** An instrument called a pH metre is used to determine the solution's acidity or alkalinity, often known as pH. The unit of measurement used to express how acidic or alkaline something is is called pH.
- **Turbidity Sensor:** In a variety of industries, turbidity sensors are used to decrease waste, increase yields, and evaluate water quality.
- **Temperature Sensor:** Devices called temperature sensors are employed to gauge the temperature of gases, liquids, and solids. They have numerous commercial uses in addition to being employed in industrial applications.
- **Gas Sensor:** The gas sensor, one of the most important devices for hazardous gas detection, provides a vital means to monitor the concentration and environmental data of gas in order to guarantee the safety of production.
- **NodeMcu(Master Controller):** A cheap open source IoT platform is NodeMCU. It originally included hardware based on the ESP-12 module and firmware that runs on Espressif Systems' ESP8266 Wi-Fi SoC.
- **Arduino Uno(Slave Controller):** The innovative RISC design of the ATmega328P, an 8-bit AVR microcontroller with excellent performance and low power consumption, allows it to execute 131 strong instructions in a single clock cycle.
- **ThingSpeak Cloud:** With the help of the IoT analytics service ThingSpeak, you can gather, visualise, and examine real-time data streams online. Data sent through your gadgets to ThingSpeak is instantly visualised by ThingSpeak.
- **ThingSpeak MIT Application:** Users can build mobile applications that retrieve real-time data from their ThingSpeak channels, show it to users, and even update the data based on user inputs or other sources by integrating the MIT App Inventor with ThingSpeak. This makes it possible to monitor and operate IoT systems and devices linked to ThingSpeak in a personalised, interactive, and real-time manner.

3.1 SLAVE ARCHITECTURE

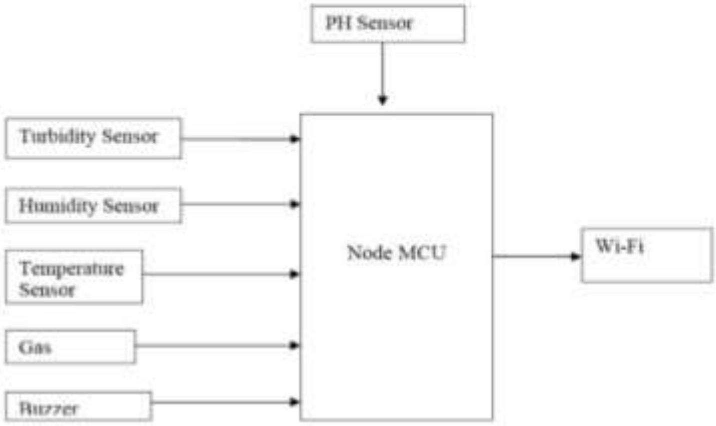

Fig-2: Slave Architecture.

The wastewater management system's slave devices are fitted with sensors to gather information about a range of characteristics, including pH levels, flow rates, temperatures, water levels, and chemical concentrations. These sensors measure the necessary data points while continuously monitoring the wastewater infrastructure. The master controller receives the collected data after that and processes and analyses it further. A communication network, which may be wired or wireless depending on the application, links slave devices to the master controller. The communication network enables the slave devices to send the gathered data in real-time or at predetermined intervals to the master controller. To establish a dependable connection between the slaves and the master, common IoT communication protocols like MQTT, HTTP, or Modbus can be used.

3.1 MASTER ARCHITECTURE

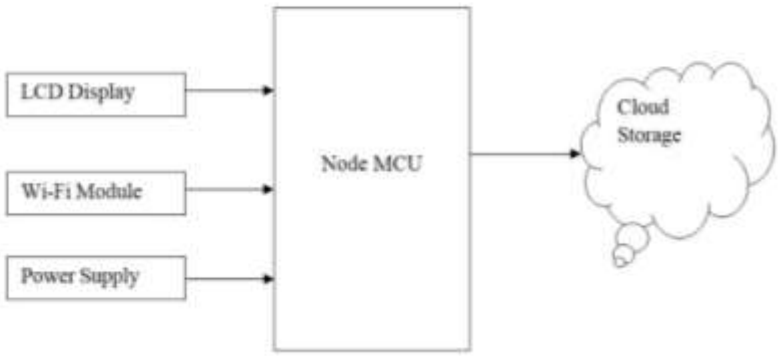

Fig-3: Master Architecture.

The master device controls and directs the complete wastewater management system from a central location. It oversees the coordination and communication among the slave devices, ensuring the smooth and efficient operation of the system. The master device connects to the slave devices, collects data from them, and, when necessary, delivers control commands. Data sent by the slave devices is received by the master device. It gathers information from a variety of sources, including pH sensors, flow metres, temperature sensors, and level sensors, to produce an in-depth picture of the wastewater management procedures. The data that is received is prepared, compiled, and saved for later analysis and decision-making. The master device analyses the data collected using algorithms, models, and data analytics techniques. To derive actionable insights from the data, it applies powerful machine learning algorithms, statistical analysis, trend analysis, and data validation. The master device decides on wastewater management procedures, optimisations, or control measures based on the findings of the analysis. The master device generates control commands based on the analysis results and established control methods. These control instructions are delivered to the corresponding slave devices in order to modify settings, turn on actuators, or carry out particular tasks inside the wastewater management system.

4. RESULTS AND PERFORMANCE ANALYSIS

Real-time monitoring of numerous factors connected to wastewater management in companies is made possible by the use of IoT. Monitoring water flow, pH values, temperature, chemical concentrations, and other pertinent information are all included in this. Real-time monitoring enables early detection of deviations or anomalies, enabling prompt response and efficient control actions. For enterprises to comply with regulatory requirements and compliance standards, effective wastewater management is essential. IoT-based technologies make it possible to continuously monitor and record parameters connected to wastewater, ensuring that businesses follow environmental standards. Industries may demonstrate their commitment to environmental stewardship and stay out of trouble by keeping accurate records and having real-time data available. Processes for wastewater management can be remotely monitored and managed using IoT-based master-slave systems. Authorised workers can access the system's dashboard or mobile applications to track treatment plant performance, modify process variables, and quickly address emergencies. In particular for geographically dispersed industries, this remote accessibility increases operational flexibility and decreases the need for on-site personnel.

Fig-4: Live graph of uploaded data.

The Web Server is used to visualize the uploaded sensor data. Because the system is configured in continuous mode, it is refreshed every 5 seconds, the data is monitored often and displayed on every action. The sensing period has been set at fifteen minutes; however, the monitoring interval can be modified as needed. As shown in Fig-4. The obtained values will be graphed and stored for future use. Web server live graphs plot live pH and Temperature sensors data as they are being uploaded to the database via IoT device. The variations of the sensor's measurements of the monitored parameters (pH and Temperature) with time for the pumping stations may be seen in Fig-4.

Real-Time Measurements

Station 1	Pumping Station 1	p.H	6.88	28/07/2021 06:50:30
Station 1	Pumping Station 1	Temp	25	28/07/2021 06:49:30
Treatment Plant	WWTPC9-Inlet	p.H	6.91	28/07/2021 06:20:28
Treatment Plant	WWTPC9-Inlet	Temp	33.13	28/07/2021 06:19:28
Station 3	Pumping Station 3-Inlet	p.H	6.86	28/07/2021 06:05:27
Station 3	Pumping Station 3-Inlet	Temp	25.4	28/07/2021 06:04:27
Station 2	Pumping Station 2	p.H	6.91	28/07/2021 05:50:26
Station 2	Pumping Station 2	Temp	29.1	28/07/2021 05:49:26
Station 1	Pumping Station 1	p.H	5.18	28/07/2021 05:35:25
Station 1	Pumping Station 1	Temp	33.12	28/07/2021 05:34:25
Treatment Plant	WWTPC9-Inlet	p.H	5.42	28/07/2021 05:05:23
Treatment Plant	WWTPC9-Inlet	Temp	31.28	28/07/2021 05:04:23
Station 3	Pumping Station 3-Inlet	p.H	7.59	28/07/2021 04:50:22
Station 3	Pumping Station 3-Inlet	Temp	30.22	28/07/2021 04:49:22
Station 1	Pumping Station 1	p.H	5.18	28/07/2021 04:36:33
Station 2	Pumping Station 2	p.H	8.3	28/07/2021 04:35:21
Station 1	Pumping Station 1	Temp	33.12	28/07/2021 04:34:33
Station 2	Pumping Station 2	Temp	28.36	28/07/2021 04:34:21
Station 1	Pumping Station 1	p.H	7.82	28/07/2021 04:20:20
Station 1	Pumping Station 1	Temp	28.7	28/07/2021 04:19:20
Treatment Plant	WWTPC9-Inlet	p.H	7.92	28/07/2021 03:50:18
Treatment Plant	WWTPC9-Inlet	Temp	28.6	28/07/2021 03:49:18
Station 3	Pumping Station 3-Inlet	p.H	6.91	28/07/2021 03:35:17
Station 3	Pumping Station 3-Inlet	Temp	33.13	28/07/2021 03:34:17
Station 2	Pumping Station 2	p.H	6.86	28/07/2021 03:20:16

12345678910...

Fig-5: Measurements records.

5. CONCLUSION AND FUTURE ENHANCEMENTS

Our primary goals in doing this research were to develop a compact, affordable, adaptable, portable system that could monitor and regulate industrial wastewater discharged into wastewater treatment plants and avoid damage to the equipment and treatment process, while also defending people who are not trained to handle this type of water. By checking the water parameters and the warning messages, the system may achieve dependability and viability in the monitoring processes, making the system more adaptable and manageable. The natural ecosystem of water resources is safeguarded by this research. The comparison analysis revealed that the proposed system outperformed the current system and related work.

It is hoped that more water parameters will be introduced in future studies so that all of the water parameters can be analysed. The sensor precession will furthermore must be improved.

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