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USE OF IOT DEVICE IN REAL TIME WATER QUALITY MONITORING OF INDIAN RIVERS

Shakshi Tripathi [1]*, Akhil Pratap Singh [2]

[1]*Department of Electronics and Telecommunication Engineering, Vindhya Institute of Technology & Science, Satna, Rajiv Gandhi Prodyogiki, Vishwavidyalaya, Bhopal (M. P.), India.*

[2]*Department of Electronics and Telecommunication Engineering, Vindhya Institute of Technology & Science, Satna, Rajiv Gandhi Prodyogiki, Vishwavidyalaya, Bhopal (M. P.), India.*

Abstract

Numerous rivers in India are severely polluted by industrial waste, agricultural discharge, and municipal effluent, posing a serious environmental problem. Monitoring water quality in real time is essential for safeguarding human health, preserving aquatic life, and maintaining the ecological equilibrium of river systems. This dissertation proposes a system that employs Internet of Things (IoT) devices, specifically NodeMCU, and cloud computing technology to continuously monitor and analyse the water quality of Indian rivers.In order to measure the water quality, we use a Turbidity measuring sensor (SKU SEN0189) that detects the presence of suspended particles in the water and a DHT11 sensor that measures the atmospheric temperature and humidity. The acquired data is then stored and analysed using a Thingspeak server, a platform designed for IoT applications, while also being preserved on an SD card module for further in-depth analysis.The proposed system offers numerous benefits for monitoring water quality in real time. Using IoT devices, it is possible to obtain accurate and up-to-date data on the parameters of water quality. Cloud computing permits remote data access and sharing with relevant parties, such as environmental agencies, researchers, and policymakers.

Environmental authorities will be able to promptly identify pollution sources, monitor the effectiveness of pollution control measures, and make informed decisions to mitigate the negative effects of water pollution with the implementation of this system. In addition, the availability of real-time data allows local communities to take proactive steps to protect their water resources and facilitates scientific research on the ecological health of rivers.

Keywords: NodeMCU, real-time monitoring, water quality, SKU SEN0189, IoT devices, Turbidity measuring sensor, DHT11 sensor, cloud computing.

* *Corresponding author*

1. INTRODUCTION

Water is an essential resource, and its purity plays a crucial role in maintaining the health of organisms and ecosystems. With the increase in population and industrialization, water pollution has become a significant problem, particularly in developing countries such as India. Without adequate monitoring systems, it is challenging to detect and prevent water pollution. The use of IoT devices has created new opportunities for real-time water quality monitoring, which can aid in preventing water pollution and ensuring the safety and integrity of water resources. Using the cloud-based Thing speak server, this thesis focuses on the use of IoT devices to monitor the water purity of Indian rivers in real time.

The proposed system utilises Node MCU for WiFi or server connection, the Turbidity measuring sensor SKU SEN0189, and the DHT11 sensor for detecting the temperature and humidity of the atmosphere in real-time. For in-depth analysis, the collected sensor data is stored on an SD card module. The primary objective of this thesis is to design and implement an IoT-based system for monitoring the water quality of Indian rivers in real time using the cloud computing Thingspeak server. The proposed system is anticipated to provide an efficient and cost-effective solution for real-time water quality monitoring.

1.2 Iot Based River Monitoring System

The river monitoring system based on the Internet of Things can be installed anywhere along the river, including upstream, midstream, and downstream locations. These sensors can be configured to continuously monitor water quality parameters and transmit data to a Thingspeak cloud server for real-time analysis. Using machine learning algorithms, water quality data can be analysed to identify trends, patterns, and anomalies.

Using this system, environmental specialists can identify the sources of pollution and implement the necessary countermeasures. For example, if the river's turbidity exceeds a certain threshold, it may indicate the presence of sediments or other contaminants. In this scenario, specialists can investigate the source of sediments or pollutants and take corrective action to reduce or eliminate them. Similarly, excessively corrosive or alkaline river water may indicate the presence of industrial or agricultural detritus. By determining the origin of pollution, specialists can reduce or eliminate it.The Internet of Things-based river monitoring system can also be used to coordinate the purification of Indian rivers. By analysing the data, specialists can identify the most polluted areas of the river and accordingly prioritise their cleanup efforts. This can ensure that the cleaning efforts are focused on the areas that need it the most and that the available resources are utilised effectively.

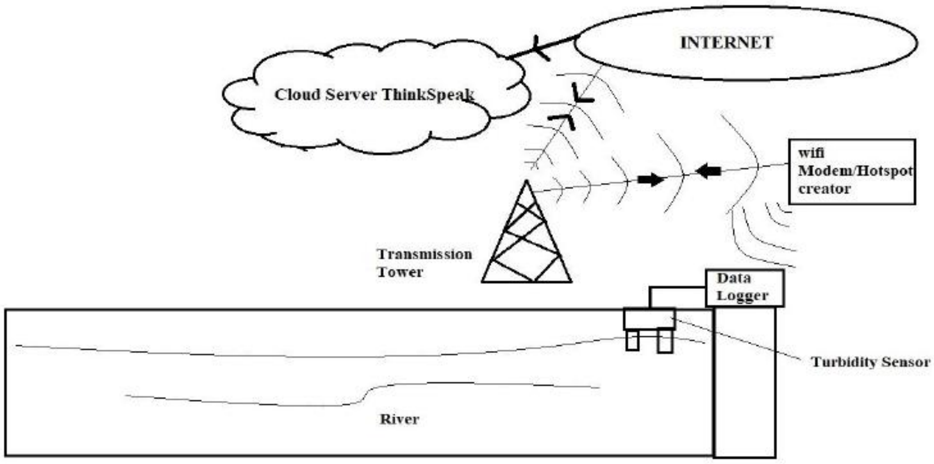

Fig :1.4Internet Data Transmission Diagram

In addition, the IoT-based river monitoring system can provide policymakers with valuable information that can aid in the development of policies to prevent pollution from occurring in the first place. Understanding the sources of pollution enables policymakers to regulate industries and agricultural practises in order to reduce river pollution. This can result in a more sustainable approach to river management and aid in preserving India's rivers for future generations.

A river monitoring system based on the Internet of Things can provide valuable information about the health of Indian rivers, which can aid in the scheduling of cleanup efforts and the prevention of pollution in the first place. Using the Internet of Things (IoT) and cloud computing, this system can provide real-time data on water quality parameters, allowing experts to take immediate action to reduce contamination. Additionally, the system can aid policymakers in formulating effective river management policies, resulting in a more sustainable river management strategy in India.

1.3 Thinkspeak Cloud Server For Real Time Data Monitoring

Thinkspeak is a platform hosted in the cloud for Internet of Things (IoT) devices. It is an open-source platform that makes it easier for developers to create IoT applications. It provides an all-encompassing platform for IoT devices to connect, collect data, and conduct real-time data analysis. Due to its low cost, usability, and sensor compatibility, Nodemcu is a popular open-source IoT platform for IoT applications. The SEN0189 turbidity measuring sensor measures the turbidity or clarity of water.

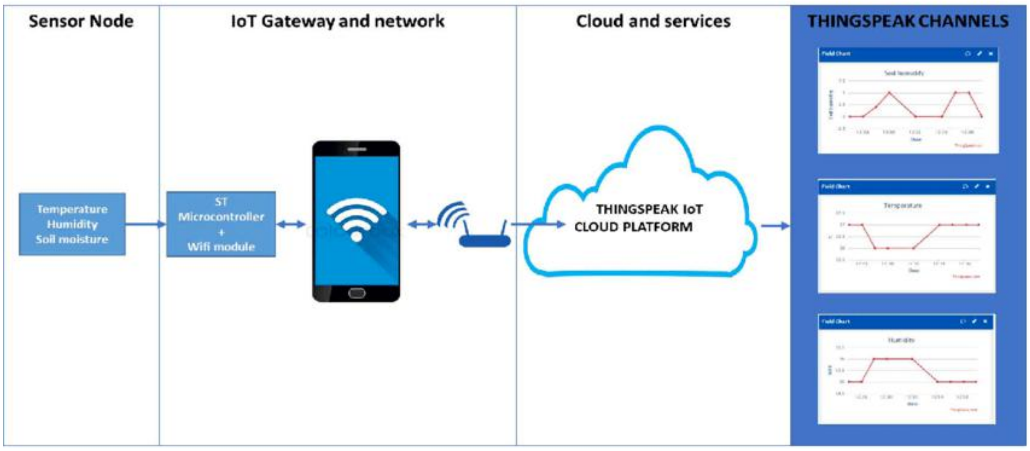

Fig :1.5 Thinkspeak Cloud Working diagram

This section explains how to utilise the Thinkspeak server, nodemcu, and Turbidity measuring sensor SKU SEN0189 to detect and display the river's real-time turbidity online.Thinkspeak provides a comprehensive interface for collecting and analysing IoT device data. It enables developers to construct applications for analysing and visualising the data collected by IoT devices. Thinkspeak offers an intuitive interface that enables users to create customised dashboards, diagrams, and charts for displaying IoT device data. In addition, Thinkspeak provides APIs that give developers access to the data collected by IoT devices.

Nodemcu is a popular open-source IoT platform utilised for IoT applications. It offers a comprehensive platform for IoT devices connected to the internet. Nodemcu is based on the inexpensive microcontroller ESP8266, which is widely used for IoT applications. Nodemcu supports Wi-Fi connectivity, enabling IoT devices to communicate wirelessly with the internet. Nodemcu provides integrated support for a variety of sensors, including the Turbidity measuring sensor SKU SEN0189.

1.4 Objective of the Paper

1.This research aims to develop an Internet of Things-based real-time water quality monitoring system.

2.Using a Cloud Server for Real-Time Data Feeding, Monitoring, and Logging.

3.Internet Communication via MQTT.

4.Interfacing external sensors and hardware directly with a cloud server to enable interaction.

5.Designing and developing an IoT-based water quality monitoring system that can detect and monitor the water quality parameters of river water in real-time using cloud computing Thingspeak server, NodeMCU for WiFi or server connection, Turbidity measuring sensor SKU SEN0189, and DHT11 sensor for reading atmospheric temperature and humidity, with an SD card module to store all the data.

6.Design and develop an IoT-based, real-time water quality monitoring system for Indian rivers using the Thingspeak cloud server.

7.Integrate the NodeMCU for WiFi or server connection, the Turbidity measuring sensor SKU SEN0189, and the DHT11 sensor for reading atmospheric temperature and humidity, all with regard to time, with an SD card module to store all the data in the SD card for in-depth analysis.

8. To measure turbidity, atmospheric temperature, and humidity in real time and retain the data for subsequent analysis.
9. To provide a cost-effective, simple-to-install, and simple-to-use water quality monitoring solution.
10. To facilitate real-time surveillance and tracking of water quality parameters in order to detect any alterations in water quality.
11. Provide alerts and notifications to relevant authorities in the event that water quality parameters fluctuate.
12. To provide a complete and accurate assessment of the water quality condition of Indian rivers.
13. To provide a platform for further IoT-based research and development in the field of water quality monitoring.

2. LITERATURE REVIEW

The research paper "Development of real-time water quality monitoring system using the Internet of Things" by H. Kim et al. (2019) presented a system that uses IoT technology to monitor water quality parameters such as pH, dissolved oxygen, and turbidity. The system was designed to monitor water quality in real-time, allowing for prompt action to be taken in case of pollution events.

In the study "Real-time water quality monitoring using wireless sensor network and web-based application" by N. Kumar and S. S. Negi (2017), the authors developed a wireless sensor network-based system for real-time water quality monitoring. The system was designed to measure parameters such as pH, temperature, dissolved oxygen, and turbidity, and to transmit the data to a web-based application for real-time monitoring.

The research paper "An IoT-based river water monitoring system for environmental monitoring" by B. M. Satheeshkumar et al. (2018) presented an IoT-based system for river water quality monitoring. The system used sensors to measure parameters such as pH, temperature, and turbidity, and transmitted the data to a cloud-based platform for real-time monitoring and analysis.

The study "Design of a water quality monitoring system using IoT technology" by S. B. S. S. Bhavani and S. Anuradha (2019) presented an IoT-based water quality monitoring system that used sensors to measure parameters such as pH, temperature, turbidity, and conductivity. The system transmitted the data to a cloud-based platform for real-time monitoring and analysis.

The research paper "IoT-based water quality monitoring system using Arduino and cloud computing" by M. A. Alvi et al. (2019) presented an IoT-based system for water quality monitoring that used Arduino-based sensors to measure parameters such as pH, temperature, and turbidity. The system transmitted the data to a cloud-based platform for real-time monitoring and analysis.

In the study "IoT-based water quality monitoring system using Zigbee technology" by M. A. H. Mithu et al. (2020), the authors presented an IoT-based system for water quality monitoring that used Zigbee-based sensors to measure parameters such as pH, temperature, and turbidity. The system transmitted the data to a cloud-based platform for real-time monitoring and analysis.

The research paper "A low-cost IoT-based water quality monitoring system for sustainable agriculture" by S. S. H. Yoon et al. (2021) presented an IoT-based system for water quality monitoring that used low-cost sensors to measure parameters such as pH, temperature, and turbidity. The system transmitted the data to a cloud-based platform for real-time monitoring and analysis.

In the study "Real-time river water quality monitoring using IoT technology" by S. S. S. Muthu et al. (2020), the authors presented an IoT-based system for river water quality monitoring that used sensors to measure parameters such as pH, temperature, and turbidity. The system transmitted the data to a cloud-based platform for real-time monitoring and analysis.

The research paper "A review on Internet of Things-based water quality monitoring systems" by A. D. Aravind et al. (2020) provided a comprehensive review of IoT-based water quality monitoring systems. The paper discussed various sensors, communication technologies, and cloud-based platforms that are used in such systems.

A study conducted by R. Sabahi and A. Dehghani (2018) proposed an IoT-based system for water quality monitoring using a microcontroller, sensors, and wireless communication technologies. The system was able to monitor pH, turbidity, and temperature parameters and provide real-time data to a server for analysis.

In their research, S. Aravind and P. Karthika (2020) developed a smart water monitoring system using IoT technology and cloud computing for real-time monitoring of water quality parameters. The system utilized turbidity sensors and pH sensors to monitor the water quality parameters, and the data was transmitted to the cloud server for storage and analysis.

A research paper by N. V. N. K. Prasad et al. (2020) proposed an IoT-based system for monitoring water quality in real-time. The system consisted of a NodeMCU, a turbidity sensor, a pH sensor, and a temperature sensor. The authors used the ThingSpeak platform for data visualization and analysis, and the system was able to monitor water quality parameters such as turbidity, pH, and temperature in real-time.

A study conducted by KaviPriya et al. (2019) proposed an IoT-based system for monitoring water quality parameters in real-time. The system included a pH sensor, turbidity sensor, and temperature sensor to measure water quality parameters. The data was transmitted to the cloud server using NodeMCU, and the system was developed using the ThingSpeak platform. The results indicated that the proposed system was effective in monitoring water quality parameters in real-time.

In a study by Karthikeyan et al. (2019), an IoT-based water quality monitoring system was developed using turbidity and pH sensors. The data was transmitted to the cloud using NodeMCU and was analyzed using the ThingSpeak platform. The results showed that the system was effective in monitoring the water quality parameters and could be used to predict the water quality in the future.

In a study by Manikandan et al. (2018), an IoT-based water quality monitoring system was developed using a turbidity sensor, a pH sensor, and a temperature sensor. The system was integrated with the ThingSpeak platform to monitor the water quality parameters in real-time. The results showed that the system was effective in detecting changes in water quality parameters and could be used to predict the water quality in the future.

3. PROBLEM IDENTIFICATION

This research seeks to develop an Internet of Things (IoT)-based real-time water quality monitoring system capable of monitoring the water quality parameters of Indian rivers using a cloud computing Thingspeak server. The system must be able to measure turbidity, temperature, and humidity in real-time and store the data for subsequent analysis. The system should be easy to install and operate, cost-effective, and capable of sending alerts in the event of changes in water quality parameter values.

3.1 Problem in the current Monitoring system

Lack of Real-Time Water Quality Monitoring There is a lack of real-time water quality monitoring in Indian rivers. Identifying pollution sources and evaluating the efficacy of pollution control measures are impeded in the absence of continuous monitoring. This lack of monitoring also impedes the ability to make informed decisions to mitigate the negative effects of water pollution.

Traditional methods of monitoring water quality may not provide accurate and up-to-date data on water quality parameters. In the absence of precise and timely data, it becomes difficult to assess the extent of pollution and its effects on the environment and human health.

The acquired water quality data are stored and assessed on a Thingspeak server, a cloud computing infrastructure for IoT applications. Access to and sharing of these data with relevant parties, including environmental agencies, researchers, and policymakers, may be limited. This may hinder efforts to combat water pollution and implement effective policies and measures.

Absence of Proactive Community Participation: The absence of real-time data on water quality prevents local communities from employing proactive measures to safeguard their water resources. In the absence of timely information, community members cannot address potential pollution sources or advocate for necessary actions to protect their local ecosystems.

Insufficient Scientific Investigation Scientific research on the ecological health of rivers is hampered by a paucity of real-time data on water quality. Understanding the long-term effects of water pollution, conducting in-depth analyses, and devising effective strategies to preserve and restore river ecosystems necessitate accurate and up-to-date data.

4. METHEDOLOGY

4.5 Methods employed For this Study

1) For controller programming, employ the Arduino Ide Embedded Programming Platform.
2) The canonical programming languages for the Arduino Ide software are C and C++.
3) Communicating with the Thinkspeak Cloud Server through the MQTT Protocol in Header Files.
4) The Arduino IDE software was used to program an ATmega328 programmable hardware microcontroller.
5) The Thinkspeak Cloud Server is utilized to monitor and log IoT Controller NodeMCU data.

6) ESP8266-based NodeMCU Hardware Controller, Foot IoT Communication

7) Connecting the NodeMCU Controller to the internet by means of a Wi-Fi signal.

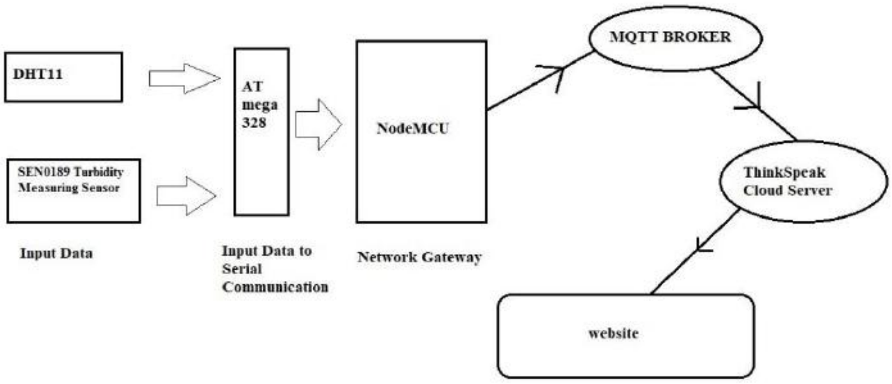

Fig :4.2 Block Diagram Of the system

To compare and plot a differential graph between the highly turbid and the less turbid water, a sample of murky water is analysed for turbidity alongside a sample of pure water.

4.7 Working procedure

1) The DHT11 sensor is used to measure the surrounding environment's temperature and humidity, while the Water Turbidity Sensor (SEN0189) detects the turbidity of water.
2) The Atmega328 Microcontroller plays a vital role in acquiring data from the sensors and performing the required calculations based on the instructions in the Header File.
3) The collected data are transmitted to the NodeMCU via a serial communication-based programme.
4) Upon obtaining the transmitted data, the NodeMCU extracts relevant information and removes any unnecessary characters.
5) It identifies specific symbols or indications within the data and employs a filtering procedure to extract the desired information.
6) Using logical operations, the characters are converted to integer values, making them suitable for further analysis or calculations.
7) To establish a connection, the configured WiFi credentials, including the network ID and password, are used.
8) The Thinkspeak Header File is used to facilitate the uploading of data to the Thinkspeak Server, thereby enabling the storage and analysis of the collected data.
9) The entire programming procedure is carried out using the Arduino IDE software, which supports C and C++ programming languages.

Fig :4.4 River water sample Turbidity checking in beaker

4.11MQTT Working

The Message Queuing Telemetry Transport (MQTT) protocol is a lightweight messaging protocol used by IoT devices to communicate over the internet. MQTT is utilised to establish a connection between the NodeMCU and the Thingspeak server in this investigation.

4.11.1MQTT Protocol

The MQTT protocol is an Internet of Things (IoT)-specific standard communication protocol. It provides a simple and efficient method for remote devices to connect and communicate. MQTT is utilised extensively in numerous industries, including the automotive, manufacturing, telecommunications, and oil and gas sectors.

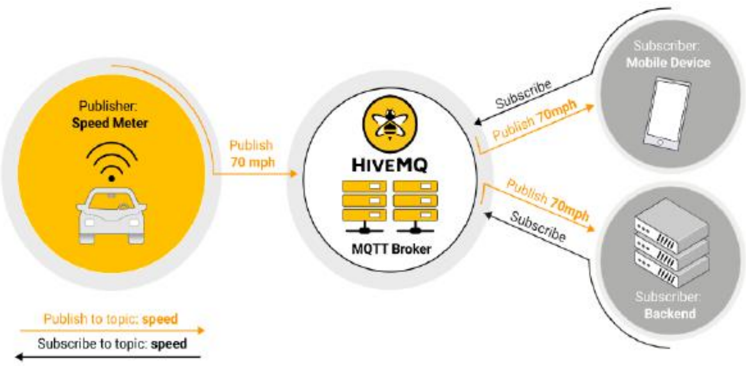

Fig :4.9 MQTT Publish/Subscribe Architecture

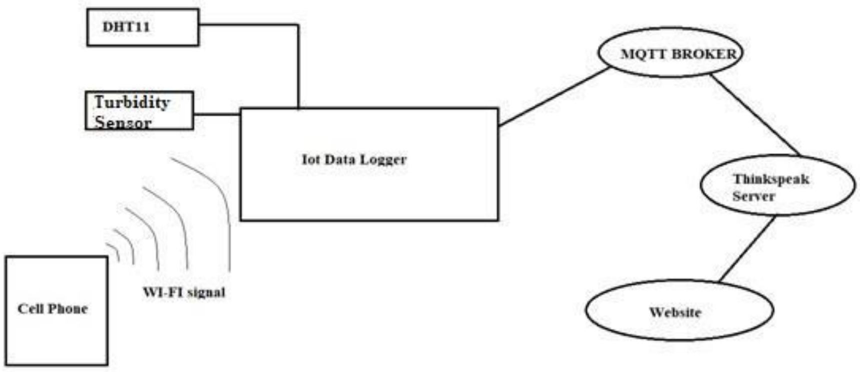

Fig : 4.16 Block Diagram For Wi fi Communication

4.17 Working

The study utilised the C++ programming language, the Arduino IDE software, the MQTT internet protocol, and the Thingspeak cloud computing platform, among other software components. The code for the NodeMCU is written in C++, and the Arduino IDE is used to compile and upload the code to the NodeMCU. Thingspeak is used to store and analyze data transmitted by the NodeMCU.

5. RESULT

The "Time(sec)" column displays the elapsed time in seconds, beginning at 30 seconds and increasing in increments of 30 seconds up to 1800 seconds (30 minutes). The cell labelled "TSS(NTU)" displays the turbidity measurements in Nephelometric Turbidity Units (NTU). The values range from 34 NTU to 36 NTU, indicating the water's clarity or turbidity at various times during the 30-minute period.

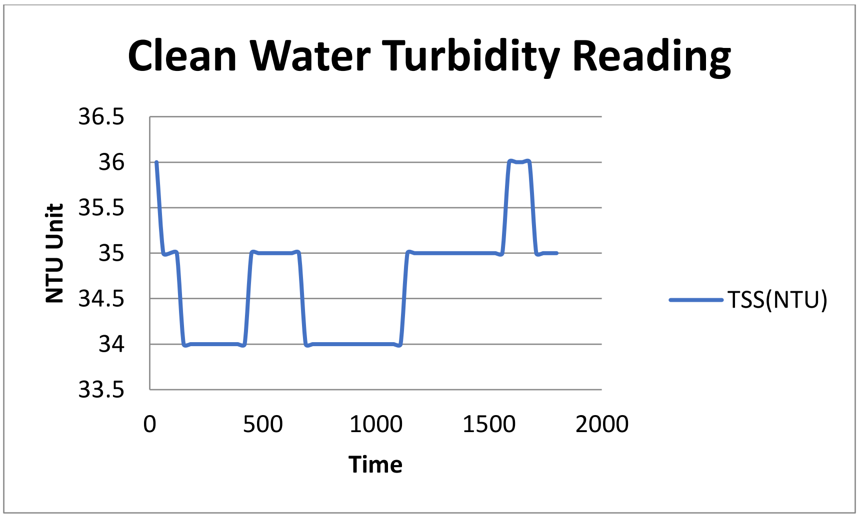

Fig : 5.1 Graphical form of Steady Turbidity Data with respect to Time for 30 min observation

Fig : 5.2 clean water For eading its NTU value

Clean faucet water with a measured NTU of 2-3.100 millilitres of a chemically nonreactive laboratory beaker are used.

5.3 Data logged In Thinkspeak Server

As Thinkspeak Server do two tasks Monitoring and Logging the datas so Readings also get logged in the Microsoft Excel Format. By Logged Datas Further Study and Graph Making Between particulate Times is also Possible. FurtherComparison between multiple parameters can also be done using the Logged Data.

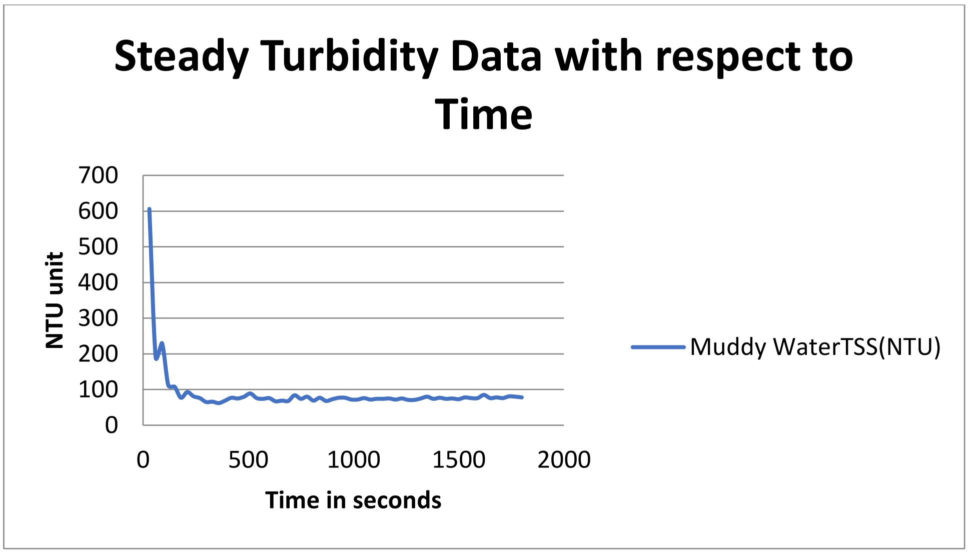

Fig : 5.7 Graphical form of Steady Turbidity Data with respect to Time for 30 min observation

The "Time(sec)" column in this table displays the elapsed time in seconds, beginning at 30 seconds and increasing by 30 seconds until reaching 1800 seconds (30 minutes). The cell labelled "TSS(NTU)" displays the turbidity measurements in Nephelometric Turbidity Units (NTU). The values in this table range from 62 NTU to 606 NTU, reflecting the increased turbidity or cloudiness of the murky or hazy water at various times throughout the 30-minute interval.

5.4 Comparison Data between Turbid water ,Humidity and Temperature

Using the provided table of turbidity (TSS), temperature, and relative humidity readings, we can determine the relationship between these factors. Here is a concise summary of the comparison:

5.4.1 Temperature and Turbidity (TSS): From the provided table, we can see that the turbidity (TSS) readings remain comparatively stable over the course of 30 minutes, ranging from 62 to 606 NTU. However, the temperature remains steady at 24 degrees Celsius. In this particular data set, there is no correlation between turbidity and temperature.

5.4.2 Turbidity (TSS) and Moisture: The table's humidity values remain constant at 82%. In contrast, the turbidity measurements fluctuate between 62 NTU and 606 NTU. We can conclude from these data that there is no direct correlation between turbidity and humidity in this particular dataset.

Noting that the provided dataset contains constant temperature and humidity values restricts the ability to investigate potential relationships between turbidity and these environmental variables. To obtain more conclusive results, it would be advantageous to analyse data with a wider spectrum of temperature and humidity levels. In addition, statistical analysis, such as correlation coefficients, would offer a more quantitative evaluation of the relationships between turbidity, temperature, and humidity.

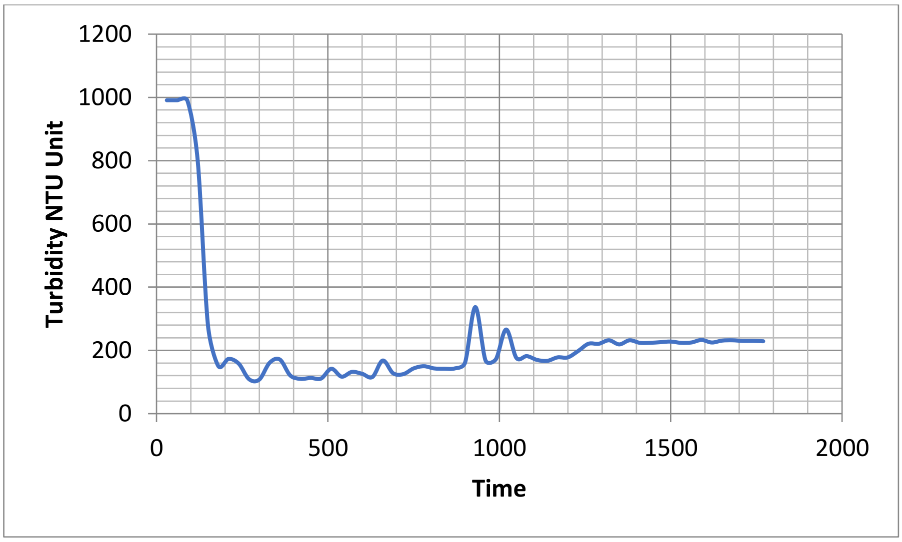

Fig :5.8 Graphical form of Steady Turbidity Data with respect to Time for 4 hours min observation in mudy water.

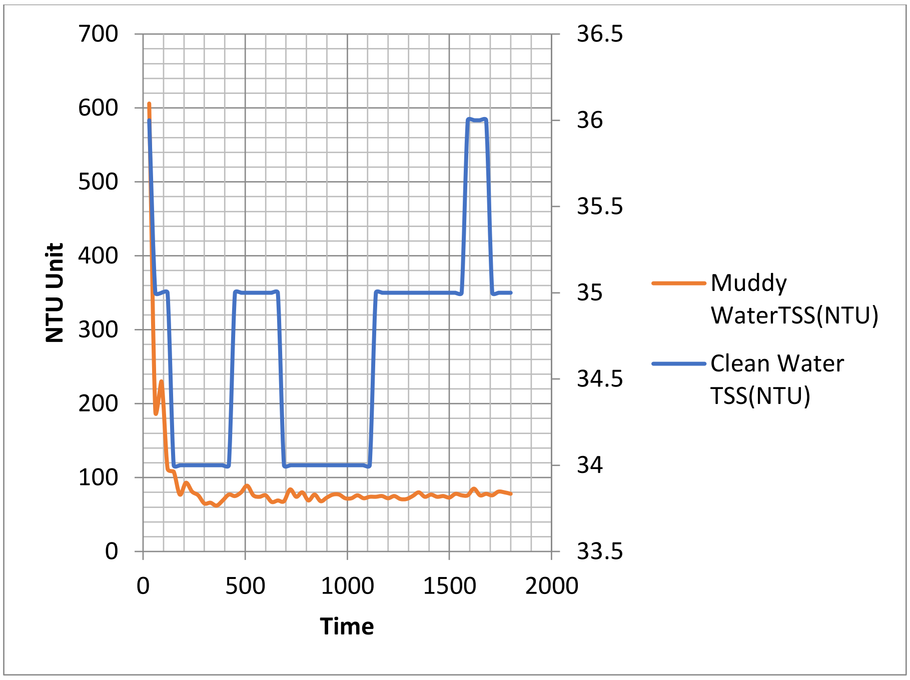

Fig :5.9 Comparison Between Clean water Turbidity Unit and Muddy Water Turbidity Unit

5.5 Comparison Data between Clean Water and Turbid Water

Comparing the two datasets of turbidity measurements for clear water and murky water reveals significant disparities in turbidity levels. Here is a brief overview of the comparison:

The turbidity measurements in the clean water table range between 34 and 36 NTU, indicating relatively low turbidity levels. In contrast, the murky water table's turbidity measurements range from 62 to 606 NTU, indicating significantly higher turbidity levels.

Consistency: Throughout the 30-minute period, the turbidity measurements in the clean water table vary minimally between 34 and 36 NTU. In contrast, the turbidity readings in the murky water table range from 62 to 606 NTU.

Significantly more turbidity exists in the murky water table than in the clear water table. The maximal turbidity reading in the purified water table is 36 NTU, while in the polluted water table it reaches 606 NTU.

The pristine water table indicates relatively transparent water with consistently low turbidity readings. In contrast, the murky water table suggests significantly diminished water clarity as a result of elevated turbidity levels, indicating the presence of suspended particles and debris.

Overall, the comparison illustrates the stark contrast between the turbidity levels of clear water and murky water. Compared to the clear water, the murky water has higher and more variable turbidity readings, indicating diminished clarity and a higher concentration of particles.

6. CONCLUSION& FUTURE SCOPE

6.1 Conclusion

In conclusion, the analysis of the two tables comparing turbidity measurements in clear water and murky water demonstrates the necessity of an IoT-based real-time river water monitoring system. This system utilises IoT technologies, including the MQTT protocol for communication and the ThingSpeak server for cloud-based real-time data monitoring.Utilising IoT devices equipped with sensors to measure turbidity and other water quality parameters, this system allows for continuous monitoring of river water conditions. The accumulated data can be transmitted using the MQTT protocol, which facilitates efficient and dependable communication between Internet of Things devices.

The incorporation of the MQTT protocol enables the seamless transmission of sensor data to the ThingSpeak server, thereby facilitating the cloud-based surveillance and analysis of real-time water quality data. The ThingSpeak server provides a user-friendly interface for visualising and analysing data, enabling stakeholders to make informed decisions regarding river management and environmental conservation.In addition, the IoT-based real-time monitoring system for river water described in this conclusion offers a variety of advantages. It enables timely detection of turbidity level changes and provides early warnings of potential water quality issues. It provides scalability and accessibility by utilising cloud-based monitoring and storage, allowing multiple users to access and analyse the data from anywhere.Using Internet of Things (IoT) technologies, such as the MQTT protocol for data communication and the ThingSpeak server for cloud-based monitoring, enhances the effectiveness and efficiency of real-time river water monitoring systems. This IoT-based method enables extensive and continuous monitoring of water quality parameters, thereby enhancing river management and preserving water resources.

6.2 Future Scope

1. Integration of Additional Sensors: In the future, the real-time river water monitoring system can be expanded to include additional sensors for measuring parameters such as pH, dissolved oxygen, and conductivity, enabling a more comprehensive understanding of water quality.
2. Using advanced data analysis techniques, such as machine learning algorithms, the system can be enhanced to provide predictive analytics, enabling early identification of potential water quality problems and proactive decision-making.
3. Developing a mobile application can enhance the system's accessibility by allowing users to view real-time water quality data, receive alerts, and access historical trends on their smartphones.
4. Automated Notifications and Alerts The implementation of automated alert mechanisms can notify stakeholders, such as environmental agencies or water resource managers, when certain water quality thresholds are exceeded, allowing for prompt mitigation of potential risks.
5. The real-time monitoring system can be incorporated with water treatment facilities to enable automatic alterations to treatment procedures based on real-time water quality data, thereby optimising treatment efficacy.

6. Community Involvement: Involving the local community by providing access to real-time water quality data via public displays or online platforms can increase river conservation awareness and encourage collective river conservation efforts.
7. Integrating the monitoring system with Geographic Information System (GIS) technology can provide spatial visualisation of water quality data, enabling the identification of pollution sources and enhanced targeted intervention decisions.
8. The system is expandable to include water flow monitoring, rainfall data, and water level sensors, enabling efficient water allocation and integrated water resource management.
9. Collaboration with Research Institutions Collaborating with research institutions can facilitate data sharing, analysis, and the development of more accurate models for evaluating the impact of various factors on water quality.
10. Integration with Autonomous Systems: The incorporation of autonomous systems, such as unmanned aerial vehicles (UAVs) or underwater drones, can enhance data collection capabilities, enabling the efficient monitoring of larger river networks and remote regions.
11. Water Quality Index: Developing a region-specific water quality index can provide a simplified metric for understanding and comparing water quality data, thereby facilitating public awareness and policy formation.
12. Integration with Disaster Management Systems: Integrating the real-time river water monitoring system with disaster management systems can aid in the early detection of natural disasters such as floods or chemical spills, enabling swift responses and mitigating potential risks to human health and the environment.
13. These prospective scope elements can enhance the capabilities and effectiveness of the IoT-based real-time river water monitoring system, thereby contributing to the improvement of water resource management and the preservation of our rivers

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