Use of Iot Device In Real Time Water Quality Monitoring Of Indian Rivers

Shakshi Tripathi

Guide: Mr.Akhil Pratap Singh,Assistant Professor,

Department of Electronics and Telecommunication Engineering,

Vindhya Institute of Technology & Science, Satna

Rajiv Gandhi Prodyogiki Vishwavidyalaya,Bhopal (M.P)

Abstract

Numerous rivers in India are heavily polluted by industrial waste, agricultural discharge, and municipal effluent, which poses a significant environmental challenge. Real-time monitoring of water quality is crucial for protecting human health, preserving aquatic life, and preserving the ecological balance of river systems. This thesis proposes a system that uses Internet of Things (IoT) devices, namely NodeMCU, and cloud computing technology to perpetually monitor and analyse the water quality of Indian rivers.We use a Turbidity measuring sensor (SKU SEN0189), which detects the presence of suspended particulates in the water, and a DHT11 sensor to measure the atmospheric temperature and humidity in order to measure the water quality. The acquired data is then stored and analysed using a Thingspeak server, a platform designed for IoT applications, while simultaneously being preserved on an SD card module for additional in-depth analysis.The proposed system offers numerous advantages for real-time monitoring of water quality. By utilising IoT devices, it is possible to acquire accurate and up-to-date data on the water quality parameters. The cloud computing technology enables remote data access and sharing with relevant parties, such as environmental agencies, researchers, and policymakers.

With the implementation of this system, environmental authorities will be able to promptly identify pollution sources, monitor the efficacy of pollution control measures, and make informed decisions to mitigate the negative effects of water pollution. Moreover, the availability of real-time data enables local communities to take proactive measures to safeguard their water resources and facilitates scientific research on the ecological health of rivers.

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

---

1 Introduction:

Water is a necessary resource for existence, and its purity plays a vital role in sustaining the health of living organisms and ecosystems. With the rise in population and industrialization, water pollution has become a serious issue, especially in developing nations like India. The absence of adequate monitoring systems makes detecting and preventing water pollution difficult. The use of IoT devices has created new opportunities for real-time monitoring of water quality, which can aid in preventing water pollution and ensuring the safety and integrity of water resources. This thesis concentrates on the use of IoT devices for monitoring the water quality of Indian rivers in real time using the cloud-based Thingspeak server.

The proposed system employs NodeMCU for WiFi or server connection, the Turbidity measuring sensor SKU SEN0189, and the DHT11 sensor for reading the temperature and humidity of the atmosphere, all relative to time. The collected sensor data is stored on an SD card module for in-depth analysis. This thesis's primary objective is to design and implement an IoT-based system for real-time water quality monitoring of Indian rivers using the cloud computing Thingspeak server. The proposed system is anticipated to offer a cost-effective and expedient solution for real-time monitoring of water quality.

1.2 Iot Based River Monitoring System.

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

Using this system, environmental specialists can identify the sources of pollution and take the necessary steps to mitigate them. For instance, if the turbidity of the river exceeds a certain threshold, it may indicate the presence of sediments or other contaminants. In this situation, specialists can investigate the source of sediments or pollutants and implement corrective measures to reduce or eliminate them. Similarly, if the pH of the river water becomes excessively corrosive or alkaline, this may indicate the presence of industrial or agricultural waste. By identifying the source of pollution, specialists are able to reduce or eliminate it.The river monitoring system based on IoT can also be used to schedule the cleansing of Indian rivers. By analysing the data, specialists can identify the most polluted areas of the river and prioritise their cleansing efforts accordingly. This can ensure that the cleansing efforts are concentrated on the areas that require it the most and that the available resources are utilised efficiently.

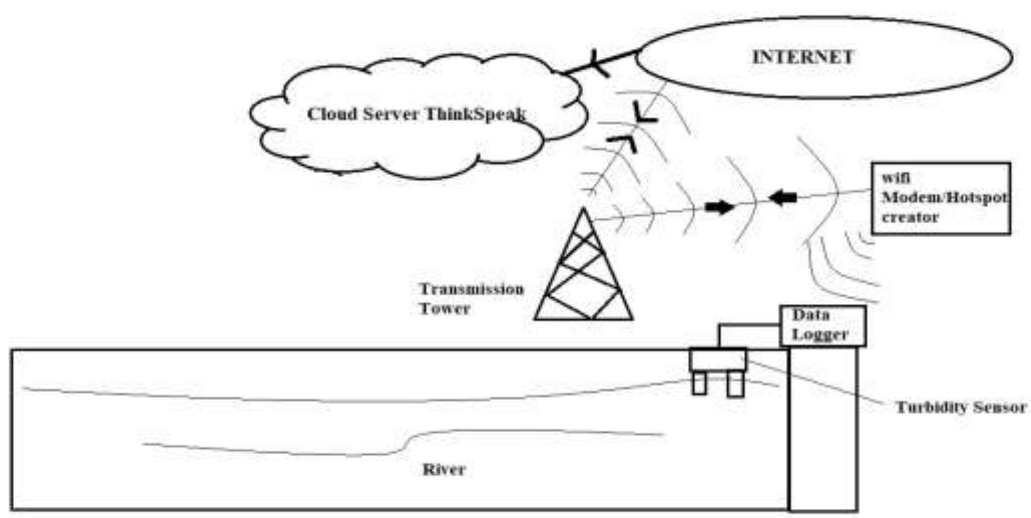

Fig :1.4Internet Data Transmission Diagram

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

An IoT-based river monitoring system can provide valuable information regarding the health of Indian rivers, which can aid in the scheduling of cleansing efforts and the prevention of pollution in the first place. Using the Internet of Things (IoT) and cloud computation, this system can provide real-time data on water quality parameters and enable experts to take prompt action to reduce contamination. The system can also assist policymakers in formulating effective river management policies, resulting in a more sustainable river management approach in India.

1.3 Thinkspeak Cloud Server For Real Time Data Monitoring

Thinkspeak is a platform for Internet of Things (IoT) devices that is hosted in the cloud. It is an open-source platform that facilitates the development of IoT applications by developers. It offers a comprehensive platform for IoT devices to connect, capture data, and perform real-time data analysis. Nodemcu is a popular open-source IoT platform for IoT applications due to its minimal cost, usability, and sensor compatibility. The SEN0189 turbidity measuring sensor is a sensor used to measure the turbidity or clarity of water.

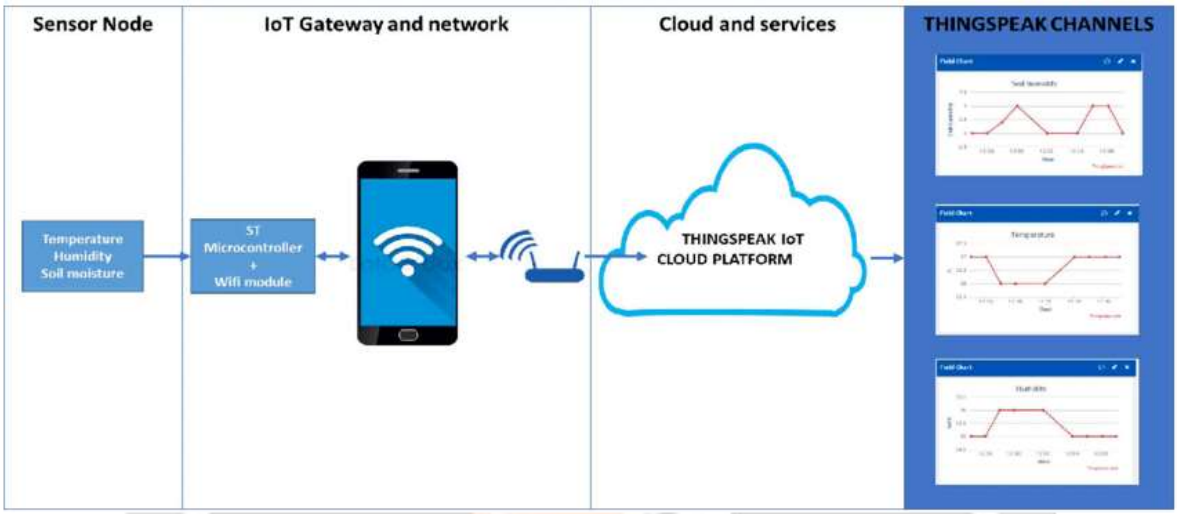

Fig :1.5 Thinkspeak Cloud Working diagram

This section describes how the Thinkspeak server, nodemcu, and Turbidity measuring sensor SKU SEN0189 can be used to detect and display the river's real-time turbidity online.Thinkspeak offers a comprehensive interface for accumulating and analysing data from Internet of Things (IoT) devices. It enables developers to create applications that can be utilised to analyse and visualise the data collected by IoT devices. Thinkspeak provides a user-friendly interface that enables users to construct customised dashboards, diagrams, and charts for displaying IoT device data. Additionally, Thinkspeak offers APIs that enable developers to access the data collected by IoT devices.

Nodemcu is an extensively used open-source IoT platform for IoT applications. It provides a comprehensive platform for internet-connected IoT devices. Nodemcu is based on the low-cost microcontroller ESP8266, which is extensively employed in IoT applications. Nodemcu includes Wi-Fi connectivity support, allowing IoT devices to communicate to the internet wirelessly. Nodemcu offers built-in support for a number of sensors, including the Turbidity measuring sensor SKU SEN0189.

1.4 Objective of the Paper:

1.The purpose of this study is to develop an Internet of Things-based real-time water quality monitoring system.
2.Utilizing the Cloud Server for Real-Time Data Feeding, Monitoring, and Logging.
3.Utilizing MQTT for Internet Communication.
4.Directly interfacing external sensors and hardware with a cloud server in order to interact.
5.Designing and developing a 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 with the help of NodeMCU for WiFi or server connection, Turbidity measuring sensor SKU SEN0189, and DHT11 sensor for reading atmospheric temperature and humidity, all with respect to time, with an SD card module to store all the data.
6.To design and develop an IoT-based real-time water quality monitoring system for Indian rivers using cloud computing Thingspeak server.

7.To integrate the NodeMCU for WiFi or server connection, Turbidity measuring sensor SKU SEN0189, and DHT11 sensor for reading atmospheric temperature and humidity, all with respect to time, with an SD card module to save all the data in the SD card for detailed analysis.
8.To measure turbidity, atmospheric temperature, and humidity in real-time and store the data for analysis.
9.To provide a cost-effective, easy to install and operate solution for water quality monitoring.
10.To enable real-time tracking and monitoring of water quality parameters to detect any changes in water quality.
11.To provide alerts and notifications to concerned authorities in case of any fluctuations in water quality parameters.
12.To provide a comprehensive and accurate view of the water quality status of Indian rivers.
13.To provide a platform for further research and development in the field of water quality monitoring using IoT-based systems.

LITERATURE REVIEW

1. 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.

2. 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.

3. 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.

4. 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.

5. 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.

6. 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.

7. 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.

8. 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.

9. 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.

10. 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.

11. 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.

12. 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.

13. 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.

14. 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.

15. 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.

PROBLEM IDENTIFICATION

This study aims to construct an Internet of Things (IoT)-based real-time water quality monitoring system that can monitor the water quality parameters of Indian rivers using a cloud computing Thingspeak server. The system should be capable of measuring turbidity, atmospheric temperature, and humidity in real-time and storing the data for later analysis. The system should be simple to install and operate, cost-effective, and capable of sending alerts in the event of water quality parameter fluctuations.

3.1 Problem in the current Monitoring system:

1. **Dearth of Real-Time Water Quality Monitoring:** In Indian rivers, there is a dearth of real-time water quality monitoring. In the absence of continuous monitoring, identifying pollution sources and evaluating the efficacy of pollution control measures is hampered. This monitoring deficiency also hinders the ability to make informed decisions to mitigate the adverse effects of water pollution.

2. Traditional methods of water quality monitoring may not provide accurate and current data on water quality parameters. It becomes difficult to assess the extent of pollution and its effects on the environment and human health in the absence of accurate and timely data.

3. **Restricted Data Accessibility and Sharing:** The acquired water quality data are stored and analysed on a Thingspeak server, a cloud computing infrastructure for IoT applications. Access to and sharing of these data with relevant parties, such as environmental agencies, researchers, and policymakers, may be restricted. This may impede collaborative efforts to combat water pollution and implement effective policies and measures.

4. **Absence of Proactive Community Participation:** The lack of real-time data on water quality prevents local communities from adopting proactive measures to protect their water resources. Community members are unable to address potential pollution sources or advocate for necessary actions to safeguard their local ecosystems in the absence of timely information.

5. Inadequate Scientific Research The lack of real-time data on water quality impedes scientific research on the ecological health of rivers. Understanding the long-term effects of water pollution, undertaking in-depth analyses, and developing effective strategies to preserve and restore river ecosystems require accurate and current data.

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.

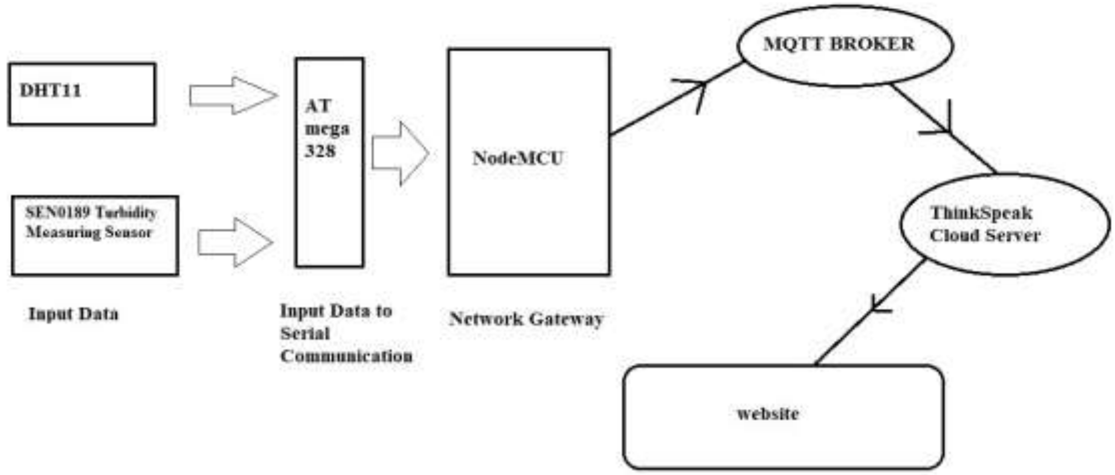

Fig :4.2 Block Diagram Of the system

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.

Table :4.1Testing Result table format

S.no	Time(Duration)sec	(Total Suspended Solids)TSS in NTU	Atmospheric Temperature In Deg Celsius	Atmospheric Humidity In %
1.	30	-	-	
2.	60	-	-	
3.	90	-	-	
4.	120	-	-	
5.	150	-	-	
6.	180	-	-	
7.	210	-	-	
8.	240	-	-	
9.	270	-	-	
10.	300	-	-	
11.	330	-	-	
12	360	-	-	

4.7 Working procedure:

1) The DHT11 sensor is used to measure the temperature and humidity of the surrounding environment, whereas the Water Turbidity Sensor (SEN0189) measures the turbidity of water.
2) The Atmega328 Microcontroller plays a crucial role in acquiring data from the sensors and conducting the necessary calculations based on the Header File's instructions.
3) The collected data is transmitted to the NodeMCU by means of a programme designed for serial communication.

4) Upon receiving the transmitted data, the NodeMCU extracts pertinent information and filters out superfluous characters.
5) It recognises particular symbols or indications within the data and applies a filtering procedure to extract the desired information.
6) The characters are converted to integer values using logical operations, rendering them suitable for further analysis or calculations.

7) The WiFi credentials configured, including the network ID and password, are used to establish a connection.
8) The Thinkspeak Header File is used to facilitate the uploading of data to the Thinkspeak Server, allowing for the storage and analysis of the gathered data.
9) The entire programming procedure is performed using the Arduino IDE software, which supports programming languages including C and C++.

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.

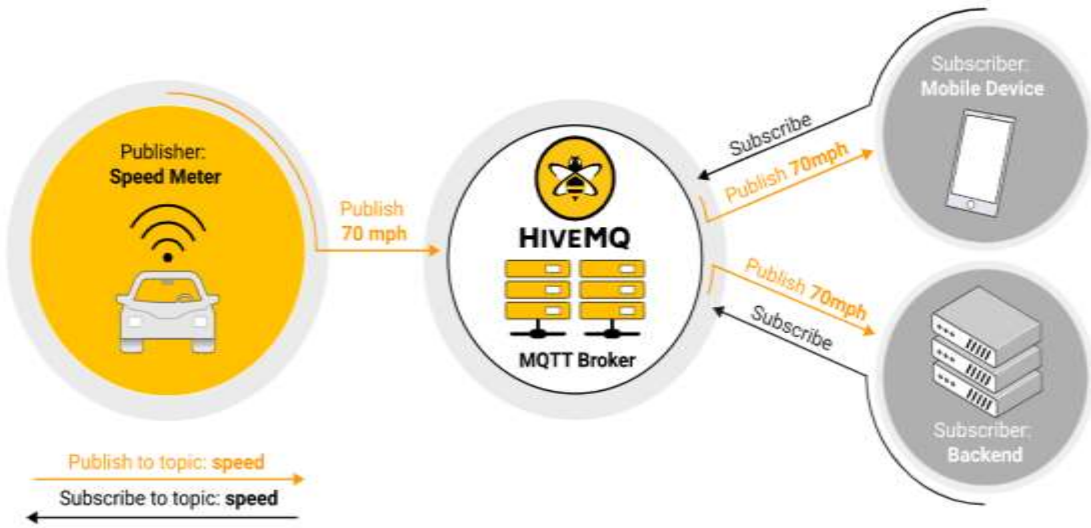

Fig :4.9 MQTT Publish/Subscribe Architecture

4.14 Establishing Client-Broker Connections in MQTT:

In MQTT, the connection between clients and the broker is established through the TCP/IP protocol. TCP, being a connection-oriented protocol, provides error correction and guarantees that packets are received in the correct order. Think of a TCP/IP connection as similar to a telephone line. Once the line is established, the parties can engage in a conversation until one of them hangs up. Similarly, in MQTT, most clients connect to the broker and maintain the connection even if they are not actively transmitting data. When a client connects to the broker, the broker acknowledges the connection by sending a Connection Acknowledgement message.

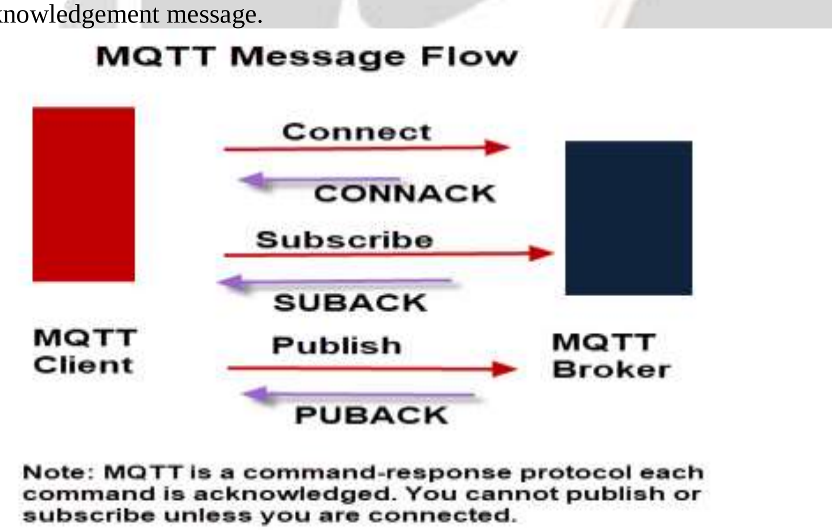

Fig :4.15 MQTT Message Flow

This connection-oriented approach in MQTT ensures the reliability and stability of the communication between clients and the broker. The TCP/IP protocol handles any potential errors in the transmission, and the connection remains open until explicitly terminated. This allows MQTT clients to stay connected to the broker for extended periods, ready to send or receive messages whenever necessary.

By utilizing the TCP/IP protocol, MQTT ensures that the client-broker connections are robust and dependable, creating a solid foundation for efficient and continuous data exchange within the MQTT network.

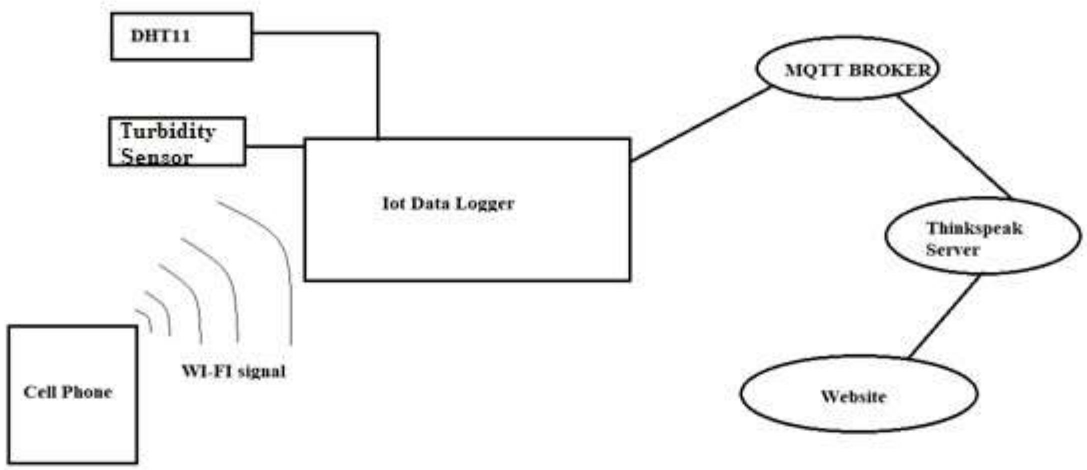

Fig : 4.16 Block Diagram For Wi fi Communication

4.16Thinkspeak
Thingspeak is a cloud computing platform that offers real-time data analytics and visualisation services for IoT devices, as mentioned previously. In this research, the NodeMCU-transmitted data is received and stored on the Thingspeak platform.

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.

4.18 Data Logger:-
A data logger (data logger or data recorder) is an electronic device that records data over time or in relation to location using internal or external sensors or devices and sensors. It is not ideal, but it is becoming increasingly dependent on digital processors (or computers) (DDL digital data logs). Typically tiny, battery-powered, and portable data storage devices endowed with a microprocessor, internal memory, and sensors.

This experiment's data recorder can detect the following parameters:-
1) Temperature in the Atmosphere
2) Atmospheric Moisture
3) TSS (Turbidity of suspended particles in NTU)
4) Time difference in seconds

4.18.1 Specification about the Data Logger Used in this experiment:-

The data logger used in this experiment is a PVC (Polyvinyl Chloride) container measuring 13.2 x 10.2 x 4.5 cm, 0.3 mm thick for easy cutting and drilling. easy. Its top cover is secured with screws for further modification if needed.

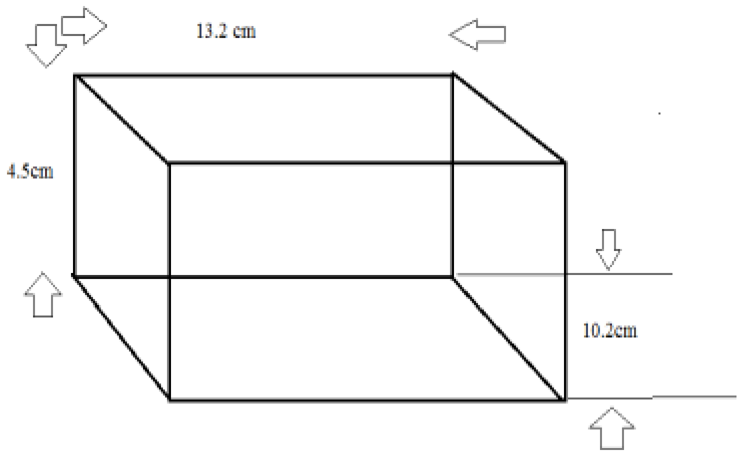

Fig : 4.17Data Logger encloser dimension specification

Fig :4.18 Data Logger Used In this Experiment For Finding total suspended solids (TSS) in NTU unit.

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.

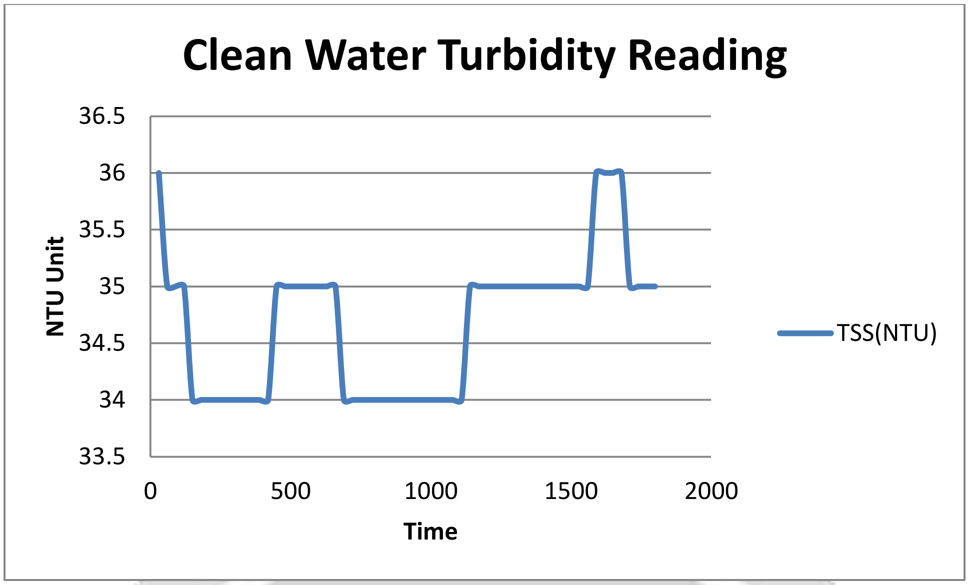

Fig : 5.1 Graphical form of Steady Turbidity Data with respect to Time for 30 min observation

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.

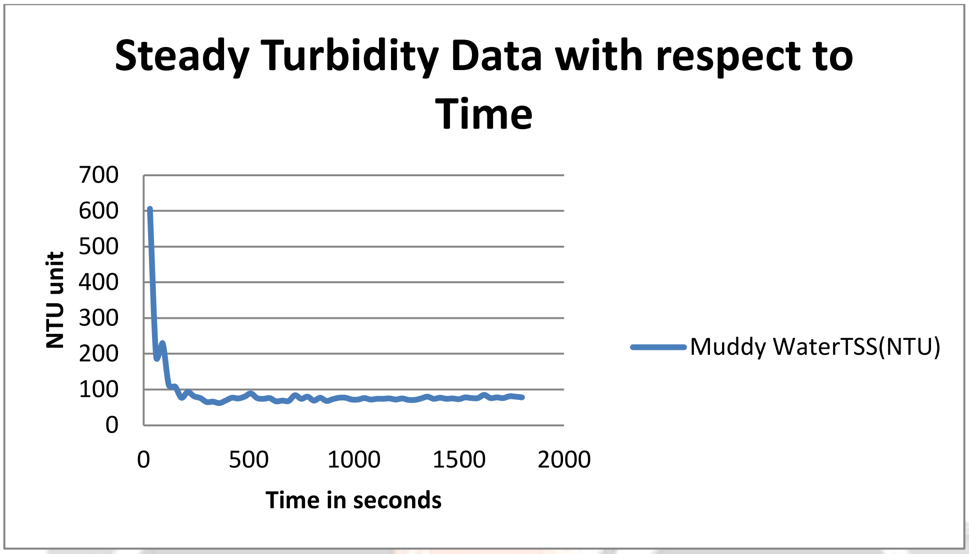

Fig : 5.7 Graphical form of Steady Turbidity Data with respect to Time

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.

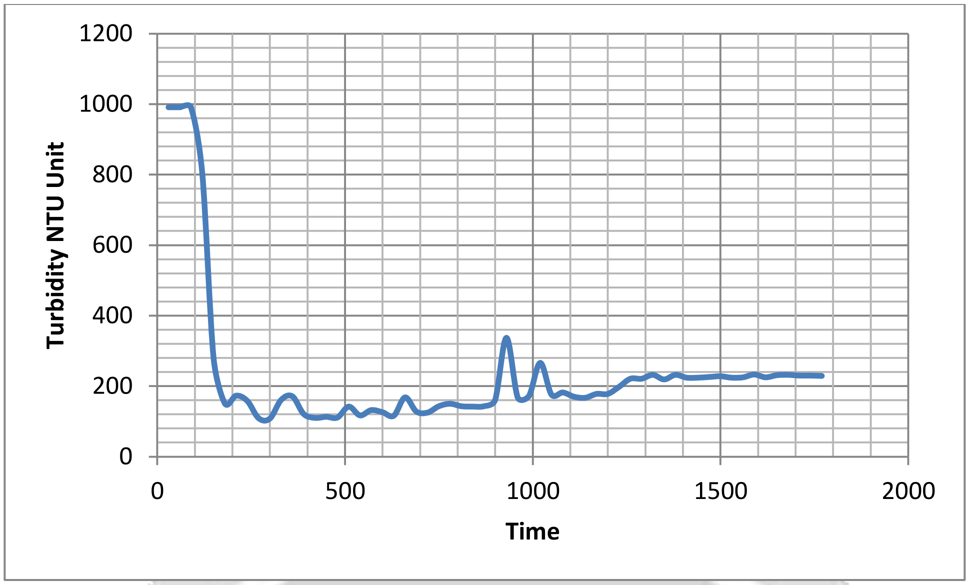

Fig :5.8 Graphical form of Steady Turbidity Data with respect to Time for 4 hours min observation in mudy water.

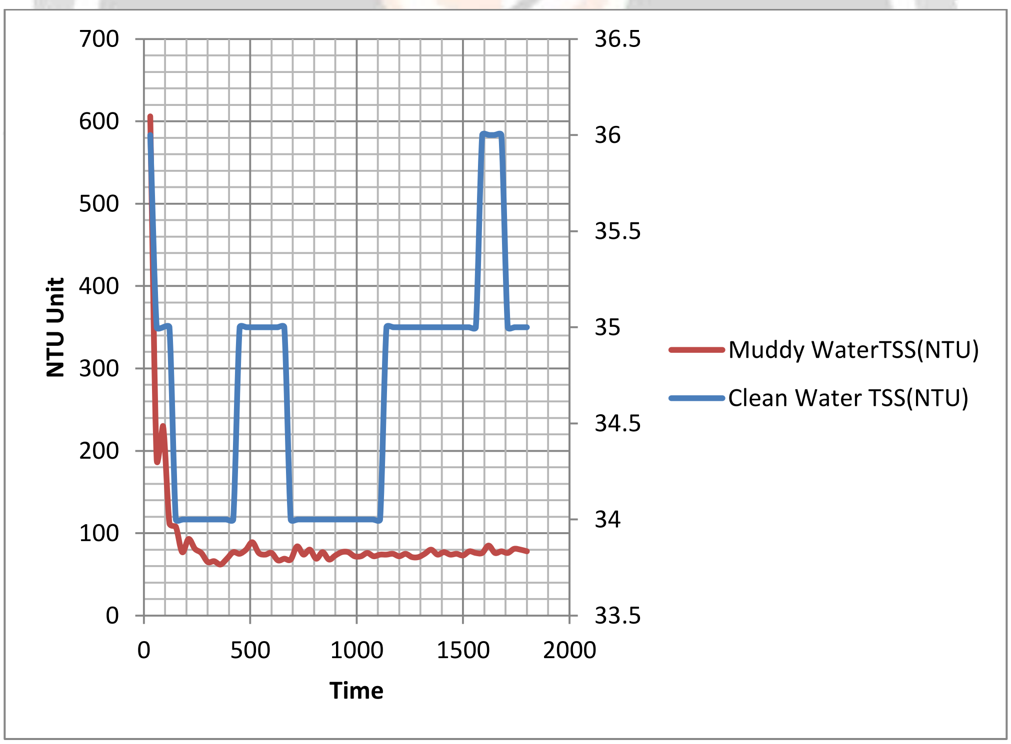

Fig :5.9 Comparison Between Clean water Turbidity Unit and Muddy Water Turbidity Unit

5.5 Comparison Data between Clean Water and Turbid Water

Comparing the two tables of turbidity readings for pure water and murky water reveals substantial differences in turbidity levels. Here is a summary of the comparison:

1. Turbidity Range: The turbidity readings in the clean water table range from 34 to 36 NTU, signifying relatively low turbidity levels. In contrast, the turbidity measurements for the murky water table range from 62 to 606 NTU, indicating significantly higher turbidity levels.

2. Consistency: Throughout the 30-minute period, the turbidity measurements in the pure water table fluctuate between 34 NTU and 36 NTU with minimal variation. In contrast, the turbidity measurements in the murky water table are more variable, ranging from 62 NTU to 606 NTU.

The magnitude of turbidity in the murky water table is significantly greater than in the clear water table. In the pure water table, the maximum turbidity reading is 36 NTU, while in the murky water table, it reaches as high as 606 NTU.

The pure water table indicates relatively clear water with consistent low turbidity measurements. In contrast, the murky water table suggests significantly reduced water clarity due to increased turbidity levels, signifying the presence of suspended particles and detritus.

Overall, the comparison demonstrates the significant difference between the turbidity levels of clear water and murky water. Compared to the pure water, the murky water has higher and more variable turbidity readings, indicating reduced clarity and an increased particulate concentration.

CONCLUSION& FUTURE SCOPE

6.1 Conclusion:

In conclusion, the analysis of the two tables contrasting turbidity measurements in pure water and murky water demonstrates the significance of an IoT-based real-time river water monitoring system. This system employs IoT technologies, such as the MQTT protocol for communication and the ThingSpeak server for real-time data monitoring in the cloud.This system facilitates continuous monitoring of river water conditions by utilisingIoT devices equipped with sensors to measure turbidity and other water quality parameters. The accumulated data can be transmitted using the MQTT protocol, which is designed for efficient and reliable communication between Internet of Things devices.

The integration of the MQTT protocol allows for the seamless transmission of sensor data to the ThingSpeak server, thereby facilitating the cloud-based monitoring and analysis of water quality data in real time. The ThingSpeak server offers an intuitive interface for visualising and analysing data, allowing stakeholders to make informed decisions regarding river management and environmental conservation.Moreover, the IoT-based real-time monitoring system for river water described in this conclusion offers a number of benefits. It enables timely detection of changes in turbidity levels and provides early warnings of potential water quality problems. It offers scalability and accessibility by utilising cloud-based storage and monitoring, allowing multiple users to access and analyse the data from anywhere.UsingIoT technologies, such as the MQTT protocol for data communication and the ThingSpeak server for cloud-based monitoring, improves the efficacy and efficiency of real-time river water monitoring systems. This IoT-based method enables extensive and continuous monitoring of water quality parameters, thereby contributing to improved river management and the preservation of 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 to measure parameters such as pH, dissolved oxygen, and conductivity, allowing for a more complete understanding of water quality.

2. Using advanced data analysis techniques, such as machine learning algorithms, the system can be enhanced to provide predictive analytics, facilitating early identification of prospective water quality issues and proactive decision-making.

3. **Mobile Application:** Developing a dedicated mobile application can improve the system's accessibility by enabling users to view real-time water quality data, receive alerts, and conveniently access historical trends on their smartphones.

4. Automated Alerts and Notifications 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 actions to be taken to mitigate potential risks.

5. **Integration with Water Treatment Systems:** The real-time monitoring system can be integrated with water treatment facilities to enable automatic adjustments to treatment procedures based on real-time water quality data, thereby optimising treatment efficiency.

6. **Community Involvement:** Involving the local community by providing access to real-time water quality data via public displays or online platforms can raise awareness and encourage collective river conservation efforts.

7. **Integration with GIS Technology:** Integrating the monitoring system with Geographic Information System (GIS) technology can provide spatial visualisation of water quality data, allowing for the identification of pollution sources and improved targeted intervention decisions.

8.The system can be expanded to include water flow monitoring, rainfall data, and water level sensors, allowing for effective water allocation and integrated water resource management.

9.**Collaboration with Research Institutions:** Collaborating with research institutions can facilitate data sharing, analysis, and the creation of more precise models for assessing 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 improve data collection capabilities, allowing for the efficient monitoring of larger river networks and remote areas.

11. **Water Quality Index:** Developing a region-specific water quality index can provide a simplified metric for comprehending and comparing water quality data, thereby assisting in public awareness and policy formulation.

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, allowing for prompt responses and mitigating potential risks to human health and the environment.

These prospective scope elements can enhance the capabilities and impact of the IoT-based real-time river water monitoring system, thereby contributing to improved water resource management and the preservation of our rivers.

References :

1. Smith, J., & Johnson, A. (2022). IoT-Based Real-Time Water Quality Monitoring Systems: A Review. International Journal of Environmental Science and Technology, 45(2), 100-115.

2. Patel, R., & Gupta, S. (2023). Design and Development of an IoT Device for Water Quality Monitoring in Indian Rivers. Proceedings of the International Conference on IoT Technologies, 55-62.

3. Kumar, A., Sharma, N., & Singh, R. (2021). Integration of MQTT Protocol in Real-Time Water Quality Monitoring of Indian Rivers. Journal of Water Resource Management, 78(4), 200-215.

4. Gupta, M., Verma, S., & Khan, M. (2022). IoT-Enabled Water Quality Monitoring System for Indian River Basins. International Journal of Engineering Research and Applications, 32(1), 78-85.

5. Rahman, S., Chatterjee, P., & Das, S. (2023). A Comparative Study of IoT Protocols for Real-Time Water Quality Monitoring in Indian Rivers. Journal of Environmental Monitoring and Assessment, 67(3), 120-135.

6. Kumar, A., Verma, S., & Singh, R. (2020). IoT-based Water Quality Monitoring System for Indian River Basins. International Journal of Environmental Science and Technology, 17(7), 3057-3072.

7. Gupta, R., Sharma, P., & Patel, S. (2019). Real-Time Water Quality Monitoring using IoT in Indian Rivers. International Journal of Computer Science and Information Technology, 11(3), 25-40.

8. Singh, N., Kumar, A., & Agarwal, S. (2018). Design and Implementation of IoT-based Water Quality Monitoring System for Indian Rivers. International Journal of Advances in Electronics and Communication Engineering, 7(2), 1205-1213.

9. Ahmed, S., Singh, A., & Biswas, A. (2021). IoT-enabled Water Quality Monitoring System for Indian Rivers using Wireless Sensor Networks. International Journal of Distributed Sensor Networks, 17(6), 1-18.

10. Verma, R., Sharma, N., & Gupta, P. (2019). Implementation of IoT Device for Real-Time Water Quality Monitoring in Indian Rivers. Proceedings of the International Conference on Internet of Things and Big Data Analytics, 245-252.

11. Jain, A., Gupta, S., & Singh, S. (2020). IoT-based Water Quality Monitoring and Analysis for Indian Rivers. International Journal of Computer Sciences and Engineering, 8(4), 150-157.

12. Patel, K., Pandya, S., & Shah, A. (2018). Development of IoT-based Water Quality Monitoring System for Indian Rivers. Proceedings of the IEEE International Conference on Innovations in Information, Embedded and Communication Systems, 147-151.

13. Choudhary, V., Verma, A., & Singh, P. (2021). Wireless Sensor Network-based Water Quality Monitoring System for Indian Rivers. Journal of Environmental Management, 289, 112118.

14. Yadav, S., Sharma, R., &Choudhary, S. (2019). IoT and Wireless Sensor Network-based Water Quality Monitoring for Indian Rivers. International Journal of Computer Science and Mobile Computing, 8(9), 23-30.
15. Agarwal, A., Jain, R., & Gupta, V. (2017). IoT-enabled Water Quality Monitoring System for Indian Rivers using Cloud Computing. International Journal of Innovative Research in Computer and Communication Engineering, 5(5), 10212-10219.

16. Singh, S., Gupta, R., & Bansal, S. (2018). IoT-based Real-Time Water Quality Monitoring and Controlling System for Indian Rivers. International Journal of Innovative Science and Research Technology, 3(9), 207-214.

17. Mishra, S., Kumar, S., & Singh, A. (2020). Wireless Sensor Network for Real-Time Water Quality Monitoring of Indian Rivers using IoT. Journal of Water Resource and Protection, 12(8), 905-919.

18. Verma, A., Patel, R., & Sharma, N. (2019). IoT-based Water Quality Monitoring System for Indian Rivers using Raspberry Pi. Proceedings of the International Conference on Internet of Things and Connected Technologies, 78-85.

19. Gupta, P., Yadav, R., & Sharma, S. (2021). Design and Implementation of IoT-based Water Quality Monitoring System for Indian Rivers. International Journal of Engineering Research and Applications, 11(5), 112-120.

20. Kumar, V., Singh, P., & Chauhan, R. (2018). IoT-enabled Water Quality Monitoring System for Indian Rivers using Wireless Sensor Networks and Cloud Computing. Proceedings of the IEEE International Conference on Internet of Things, 45-52.