

IoT based Water Cleaning System

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Abstract—The IoT-based water cleaning system is an innovative approach to addressing the issue of water contamination and protecting the ecosystem. This system utilizes various devices and modules to sense and remove waste from water bodies, ensuring that the water remains clean and safe for aquatic life. The structure comprises of a boat that is remotely controlled using a Wi-Fi module and an application. The boat is equipped with an ultrasonic sensor and a camera, which help in identifying waste and debris in the water. The temperature sensor ensures that the water is within the optimal temperature range for the sensors to function correctly. The conveyor belt and bin are used to collect and store the waste, while the extendable arm with a net helps to collect waste that is below the water surface while the boat is moving. The pH and TDS sensors are used to detect salt impurities and contamination in the water after the waste is removed. All this information is then uploaded to the cloud using IoT technology for further analysis and management. The system is low-cost and can be easily implemented in various water bodies, making it an ideal solution for maintaining the quality of water bodies. This system not only helps in removing waste from water bodies, but also offers valuable information on the water quality, allowing for prompt action to be taken if any issues arise. The system plays a vital role in maintaining balance in the environment by protecting the marine ecosystem and ensuring that water remains clean and safe for human and aquatic life.

Index Terms— IoT Module, Transducers, Pollution, Garbage collection, Water cleaning.

I. INTRODUCTION

While the world has progressed immensely, the issue of water pollution still persists. In earlier times, the garbage floating on water surfaces was cleaned by small boats or human beings who would risk their lives for environmental protection. However, such approaches not only involved high risks but also took a considerable amount of time. Moreover, the collected waste was often thrown on the river or lake banks, further polluting the environment. In such a scenario, it becomes crucial to find innovative solutions to clean the water and maintain its quality, benefiting not only people but also the surrounding flora and fauna. Our project aims to develop a

low-cost, wireless water quality monitoring system that aids in continuous measurements of water conditions. It utilizes Bluetooth controlled operation, making it easy for people to get used to it. Maintaining good water quality in rivers and streams benefits both humans and aquatic ecosystems. In a country like India, where the population is high, pollution has grown at a visible rate. People often use water bodies as dustbins due to a lack of space, creating significant problems in the future. Our system can play a crucial role in reducing pollution and ensuring clean water. Our system uses cheap and cost-effective components to monitor the acidity, basicity, and residue content in the water. All the data from these sensors are collected and stockpiled in the cloud platform, which can be accessed anytime. Additionally, our system utilizes the Dabble gamepad model to access the motion of the project in real-time via Wi-Fi connection. Simultaneously underneath the boat there is an extendable arm to collect the wastes which are floating below the surface of water. Overall, our project is an innovative solution that can suggestively contribute to the cause of maintaining water quality, benefiting the environment and all living creatures. The impact of water pollution on aquatic life is not limited to a particular region or species. It is a global problem that requires instantaneous attention and action. Governments and non-governmental organizations must work together to reduce water pollution and promote sustainable practices to safeguard the survival of aquatic life. We all have a responsibility to take measures to protect our water resources and prevent further harm to aquatic creatures.

II. LITERATURE REVIEW

In [1] The writers have used an adaptive incremental learning system for water classification. The system is intended to be efficient and can be used for real-time monitoring and water eminence prediction. In [2] focuses on deep transfer learning through automation waste detection in water bodies. The authors show their point of view outperforms traditional waste detection methods and can be used simultaneously for monitoring of water eminence. In [3] The authors present a water eminence monitoring system using IoT and machine learning skills. The system is designed to be very accurate and can be used for real-time water eminence monitoring and forecasting. In [4] It describes a preliminary design of a water eminence monitoring system for a natural pond. The system is built on Lo-Ra WAN, a low power broadband network technology and is designed to be highly scalable and flexible.

In [5] It is presented by a reconfigurable smart water eminence monitoring system using Internet of Things technologies. The structure is designed to be very flexible and can be reconfigured to meet the exact needs of different water monitor programs. In [6] It describes the intelligent allocation of water and an architecture for underground user health monitoring using IoT technologies. The architecture is designed to be highly scalable and can be used for smart devices water management in smart cities. In [7] The authors write has a water eminence monitoring system using Lo-Ra, low power WAN technology and IoT technologies The scheme is designed to have a lot in scalable and can be used for real-time water eminence monitoring. In [8] It describes the smart water treatment plant management system using IoT and cloud computing technologies the system is designed to be very efficient and usable efficient management of water treatment processes. In [9] Wireless communication-based water surface cleaning boats have been gaining increasing interest in recent years. These boats use wireless communication technology to control their operations and collect data from various sensors. In a study conducted by researchers at National Cheng Kung University in Taiwan, a water surface cleaning boat was designed and developed using wireless communication technology. In [10] Autonomous water cleaning bots are designed to operate without human intervention and can perform various tasks such as scooping up debris, filtering water, and monitoring water quality. In a study published in the Journal of Field Robotics, researchers from the University of Southern California developed an autonomous water cleaning bot that used a computer vision system to detect and remove debris from water bodies. In [11] Floating waste scooper robots are designed to remove floating debris from water bodies such as rivers, lakes, and oceans. These robots are typically equipped with sensors and cameras that allow them to detect and navigate around obstacles. Researchers from the Indian Institute of Technology (IIT) Kharagpur developed a floating waste scooper robot that was able to collect plastic waste from a water body. In [12] River water cleaning machines are designed to remove pollutants and debris from river water. These machines typically use a combination of physical, chemical, and biological processes to clean the water. In a study published in the Journal of Water Process Engineering, researchers from the University of Roorkee in India developed a river water cleaning machine that used a combination of coagulation, flocculation, sedimentation, and filtration processes to remove pollutants from river water.

In [13] Remote-controlled unmanned river cleaning bots are designed to be operated remotely and can be used to clean rivers and other water bodies. Researchers from the Indian Institute of Technology (IIT) Roorkee

developed a remote-controlled unmanned river cleaning bot that was able to collect waste and debris from a river. In [14] Aqua dredgers are river cleaning machines that use dredging techniques to remove sediment and debris from riverbeds. These machines are typically equipped with a dredging head and a suction system that removes the sediment and debris from the riverbed. Researchers from the National Institute of Technology in India developed an aqua dredger river cleaning machine that used a combination of dredging and sedimentation processes to clean the river.

In [15] IoT-based water surface cleaning and quality checking boats are designed to collect real-time data on water eminence parameters and to clean water surfaces. These boats typically use sensors to collect data on parameters such as pH, temperature, and dissolved oxygen, and can be controlled remotely. Researchers from the Indian Institute of Technology (IIT) Roorkee developed an IoT-based water surface cleaning and quality checking boat that was able to collect real-time data on water quality parameters and clean water surfaces using a combination of suction and filtering mechanisms.

III. SYSTEM DESIGN

The proposed IoT-based water cleaning system relies on several key components working in tandem, as shown in Figure 1. A temperature sensor ensures the water's moderate level for optimal sensor functionality. An ultrasonic sensor, alongside a camera, acts as the watchful eyes, identifying and pinpointing waste like plastic bottles and covers. A conveyor belt, the system's workhorse, collects the detected waste, transporting it to a designated collection bin. Meanwhile, the TDS sensor keeps track of dissolved solids like minerals and salts, while the pH sensor monitors water quality changes, indicating whether the water is acidic, basic, or neutral. This coordinated effort ensures efficient waste removal and water quality maintenance.

The use of TDS and pH sensors can help detect changes in water quality, which can indicate the presence of harmful pollutants and other contaminants. By continuously monitoring water quality using these sensors, we can take necessary measures to prevent harm to aquatic life and protect human health. It is essential that we continue to invest in water quality monitoring technology and promote sustainable practices to protect our water resources and ensure the health and survival of aquatic life.

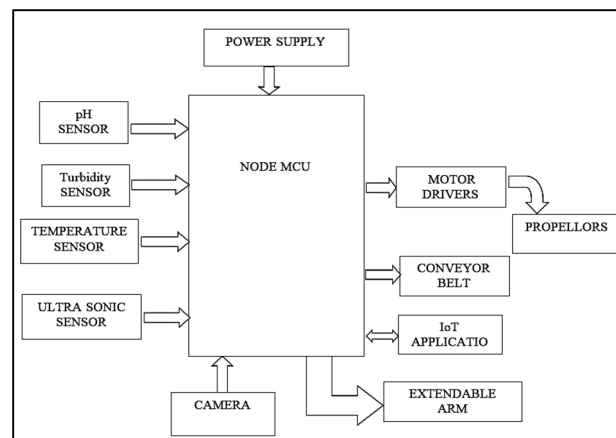


Figure 1: Block Diagram

IV. COMPONENTS USED

A. Node MCU

Node MCU, an open-source LUA firmware, unlocks the potential of the ESP8266 Wi-Fi chip. This versatile microcontroller, operating at 3.3V, supports a TCP/IP stack and seamlessly integrates into diverse IoT applications. Utilizing sensors, it collects and processes data, offering a multitude of variables for user customization. Its primary function is to securely transmit sensor data to the cloud for further analysis and informed decision-making, making Node MCU a key player in the IoT world. Its primary function lies in collecting sensor data and transmitting it securely to the cloud for further analysis and interpretation. This empowers users to gain valuable insights and drive informed decisions, making Node MCU a valuable asset in the ever-evolving world of IoT.

B. ESP32 CAM

The ESP32-CAM, a compact and low-power camera module, seamlessly integrates into diverse IoT applications. It leverages the ESP32 microcontroller and boasts a built-in OV2640 camera, capable of capturing images up to 2 megapixels. Programming the ESP32-CAM is a breeze using the Arduino IDE, facilitating development and integration into IoT projects. Additionally, the module features Wi-Fi and Bluetooth connectivity, allowing communication with other devices or cloud platforms. Thanks to its compact size and minimal power consumption, the ESP32-CAM emerges as the ideal solution for applications ranging from surveillance cameras to smart home automation and remote monitoring systems.

C. Driver IC

A Driver IC is a crucial component in the circuit that splits the power supplied to the motors for their proper and smooth rotation. It receives a high amount of supply voltage which is then distributed into smaller amounts of power and supplied to the motors. Directly providing power to the motors from the source can result in circuit malfunctioning or short circuiting, which can cause problems in the entire system. The Driver IC is designed to run the motors in both forward and backward directions, allowing them to rotate in any desired direction. The IC has an Enable pin that acts as a switch to turn it on or off, as well as basic input and output terminals.

D. pH Sensor

The pH sensor plays a crucial role in maintaining water quality across various fields. Connected to an ESP8266 microcontroller, it continuously monitors the water's pH, providing real-time insights and historical data for analysis. This enables proactive maintenance, ensures optimal conditions for specific applications, and ultimately contributes to a healthier environment and improved outcomes in diverse industries. From environmental monitoring to food processing, the pH sensor and ESP8266 combination empowers us to safeguard water quality for the benefit of all.

E. Ultrasonic Sensor

An ultrasonic sensor is a device that is used to measure distances using sound waves. It emits high frequency sound waves and then listens for their echo to determine the distance to an object. Ultrasonic sensors are often preferred over other types of sensors because they are non-contact, meaning they can detect objects without physically touching them. The sensor works by sending out a sound wave at a frequency above the range of human hearing. When the sound wave hits an object, it bounces back and is picked up by the sensor. It senses and detects any obstacles in its path of contact while the boat is moving around.

F. TDS Sensor

A Turbidity sensor is used to measure the level of suspended sediments present in a liquid that can't be seen with the naked eye, such as those caused by particles or sediments. Higher turbidity levels in a liquid can lead to a lower oxygen level, which is inversely proportional to the turbidity level. When the oxygen level of the water decreases, it becomes challenging for underwater living creatures such as fish and plants to breathe. Therefore, it is crucial to maintain the turbidity of the water. The Turbidity Sensor is connected to a microcontroller, and its readings are shared on the Blynk Cloud platform for easy monitoring.

G. Temperature Sensor

A temperature sensor in a boat can be used to measure the temperature of the water in which the boat is sailing. This is important because the temperature of the water can affect the performance of the boat's motor and other systems. If the water is too cold, it can cause the motor to run less efficiently, while if the water is too hot, it can cause the motor to overheat. The temperature sensor is connected to the microcontroller, which gathers the readings and processes the data attained from the sensor. The microcontroller then sends this data to the cloud for storage and future reference.

H. Propellor

A propeller is a type of fan that is designed to convert rotational motion into thrust, which moves a boat through the water. The propeller consists of two or more blades that are angled to produce a force that propels the boat forward or backward. The angle of the blades and their shape are carefully designed to produce the most efficient thrust possible while minimizing vibration and noise. The propeller is usually powered by a motor that rotates the blades at high speed, and the force generated by the rotating blades is what moves the boat through the water. The size and pitch of the propeller are important factors in determining the speed and productivity of the boat.

I. Blynk IoT

Blynk IoT is a great platform for our project as it allows us to easily create a mobile app to control and monitor our project remotely. With Blynk, we can create a custom user interface on our mobile device that connects to microcontroller via Wi-Fi or cellular data using the Blynk library. For our boat, we can use Blynk to create a user interface that allows us to remotely control the boat's direction and speed, monitor the water temperature, pH level, turbidity, and receive alerts when any of these values fall outside of the desired range. We can also use Blynk to track the boat's location using GPS and display it on a map in the mobile app.

V. ALGORITHM

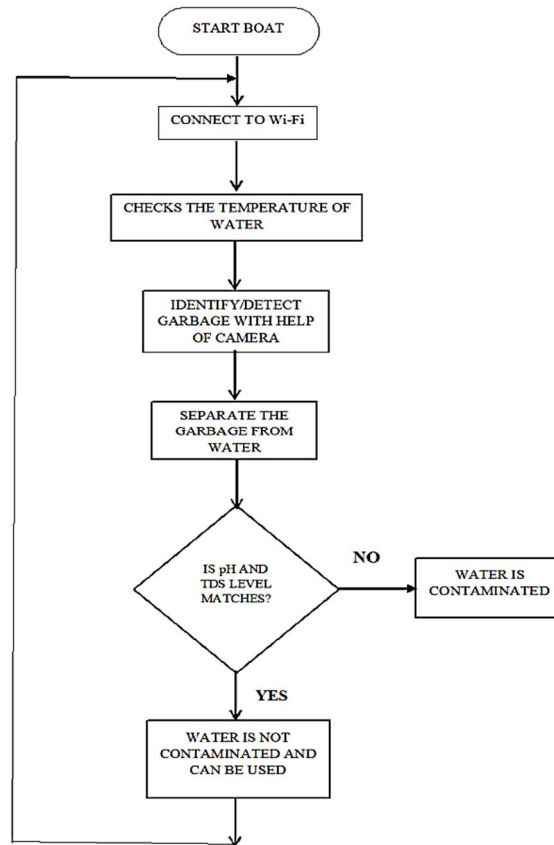


Figure 2: Flow Chart

The Algorithm is as explained below and is indicated in a flow chart as shown in Figure 2.

Step 1: The boat is connected to a Wi-Fi module and deployed onto the surface of the water.

Step 2: A temperature sensor is utilized to measure the water temperature, ensuring it falls within a moderate range (-5°C to 100°C) suitable for the operation of other sensors.

Step 3: An application controls the boat, utilizing a camera (such as ESP32) and an ultrasonic sensor to identify any material waste or garbage present in the water.

Step 4: Upon detection of waste, the boat is maneuvered towards it. A conveyor belt mechanism is activated to collect the waste and deposit it into a collector/bin. If the bin reaches its capacity, an alarm buzzer sounds to indicate that it needs to be emptied.

Step 5: An extendable arm equipped with a net is deployed to collect waste below the water surface while the boat continues its movement.

Step 6: pH and TDS (Total Dissolved Solids) sensors are employed to detect salt impurities and contamination in the water once the waste is removed.

Step 7: The collected data, including water temperature, waste detection, pH, and TDS levels, is uploaded and stored in the cloud using IoT (Internet of Things) technology for further analysis and monitoring.

VI. METHODOLOGY

The IoT-based water cleaning system stands as a beacon of innovation in the ongoing battle to safeguard the purity and sustainability of our water resources. This groundbreaking system embodies a comprehensive approach, meticulously engineered to confront the multifaceted challenges posed by water pollution. Its intricate design incorporates an impressive array of state-of-the-art components, each meticulously selected and integrated to synergistically tackle the complex dynamics of environmental remediation.

Central to the system's functionality are cutting-edge technologies such as the Node MCU and ESP32 CAM, which serve as the backbone of its operations. These sophisticated platforms provide the computational power and connectivity necessary to orchestrate the intricate dance of sensors, actuators, and data streams that form the system's operational fabric. Complementing these core technologies are an array of sensors, including temperature, ultrasonic, and pH sensors, strategically deployed to continuously monitor the ever-changing conditions of the water body.

At the heart of the system lies its ability to remotely command and control a specialized watercraft, a marvel of engineering equipped with an arsenal of advanced sensors and imaging systems. This autonomous vessel, guided by the intelligent algorithms encoded within its digital brain, navigates the waterways with precision and purpose, tirelessly scanning for signs of pollution and ecological distress. Equipped with cameras and ultrasonic sensors, this robotic sentinel patrols the waters, its vigilant gaze penetrating the depths in search of waste and debris that threaten the delicate balance of aquatic ecosystems.

In the relentless pursuit of environmental stewardship, the system's capabilities extend far beyond mere detection, encompassing a sophisticated suite of mechanisms for waste collection and containment. When pollutants are identified, the system springs into action, activating a choreographed sequence of conveyors, bins, and retrieval mechanisms to swiftly and efficiently remove the offending material from the water. An extendable arm, equipped with a finely woven net, reaches out like an intrepid explorer, plucking submerged debris from the depths and ushering it into the waiting embrace of the system's containment infrastructure.

But the system's mission does not end with the removal of pollutants; rather, it marks the beginning of a journey towards restoration and renewal. Leveraging advanced sensors for pH and total dissolved solids (TDS), the system conducts a meticulous post-mortem analysis of the water quality, probing for traces of contamination and chemical imbalance. This data, transmitted seamlessly to the cloud via IoT technology, serves as the foundation for a comprehensive understanding of the ecological health of the water body, guiding informed decisions and interventions aimed at mitigating future risks and restoring equilibrium to the ecosystem.

To ensure the seamless operation and responsiveness of the system, an integrated network of GSM modules provides robust communication channels, enabling real-time alerts, notifications, and remote diagnostics. This agile communication infrastructure empowers stakeholders with the insights and actionable intelligence needed to proactively address emerging threats and optimize system performance, ensuring that the system remains vigilant and effective in its mission to combat water pollution.

In essence, the IoT-based water cleaning system represents a triumph of human ingenuity and technological innovation, a testament to our collective commitment to safeguarding the precious resources upon which all life depends. Through its holistic approach to environmental remediation, this visionary system offers a beacon of hope in the face of mounting environmental challenges, forging a path towards a more sustainable and resilient future for generations to come.

VII. RESULTS



Figure 3: Boat placed on water

When the boat is placed on water as shown in Figure 3, the ultrasonic sensor, temperature sensor, pH sensor, and TDS sensor start collecting data regarding the water quality. The camera captures images of the waterbed and

helps in detecting garbage and waste that may be hidden from view. The conveyor belt and extendable arm with a net help in collecting waste and debris from the water surface and beneath it, respectively. The waste is then stored in the bin, and the boat can continue its cleaning process. All of this data can be uploaded to the cloud using IoT technology, where it can be analyzed to provide insights into the water quality and the efficiency of the cleaning process.



Figure 4: pH before cleaning

pH can vary depending on a variety of factors such as location, time of day, and human activities in the area, as shown in Figure 4. A pH test can be conducted using a pH meter or pH test strips to determine the acidity or alkalinity of the water.



Figure 5: Measuring Temperature

Upon placing the boat on the water surface, the Blynk IoT application measured the water temperature, as shown in Figure 5. Additionally, the turbidity sensor detected the water's clarity, as shown in the image at the bottom.

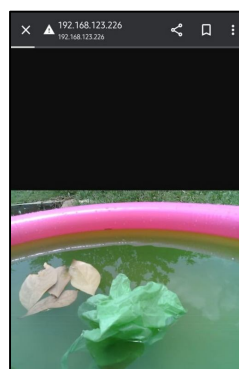


Figure 6: Camera view

The IoT-based water cleaning system utilizes a camera system to live stream and monitor the water surface for debris, as shown in Figure 6. Once debris is detected, the boat navigates towards it using the camera system for precise location.



Figure 7: Collection of garbage with conveyer belt

The conveyor belt system is used to collect the waste from the water surface and deposit it into the collecting bin, as shown in Fig 7.

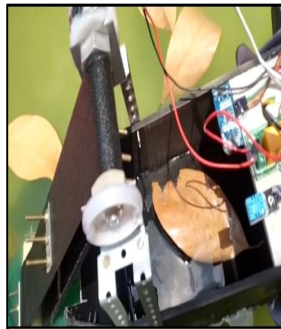


Figure 8: Garbage inside collecting bin

After the boat navigates towards the debris with the help of the camera, the waste is separated from the water using the conveyor belt and is then dumped into the collecting bin, as shown in Figure 8.



Figure 9: Ultrasonic Sensor indication in Blynk App

The ultrasonic sensors are utilized to detect when the collecting bin is full, as shown in Figure 9

After removing the waste, the pH sensor indicates the quality of water. In the meter it indicates the water is alkaline which means that the water can be used for regular chores, as shown in Figure 10.

The described scenario outlines an IoT-based water cleaning chores, as shown in Figure 10. The described scenario outlines an IoT-based water cleaning chores, as shown in Figure 10. The described scenario outlines an IoT-based water cleaning chores, as shown in Figure 10.

The system aims to improve water quality and efficiency in the cleaning process. Its break down the logical flow of events:

1. Placement of the boat on water: The boat, equipped with the necessary sensors and equipment, is placed on the water surface to begin the cleaning process.
2. Data collection using sensors: The ultrasonic sensor, temperature sensor, pH sensor, TDS (Total Dissolved Solids) sensor, and turbidity sensor start collecting data regarding water quality. Each sensor serves a specific purpose:

- Ultrasonic sensor: Detects the fill level of the collecting bin.
- Temperature sensor: Measures the water temperature, providing insights into environmental conditions.



Figure 10: pH after cleaning

- pH sensor: Determines the acidity or alkalinity of the water, indicating its quality.
- TDS sensor: Measures the concentration of dissolved solids in the water, providing further water quality information.
- Turbidity sensor: Detects the level of water clarity by measuring suspended particles in the water.

3. Image capture and garbage detection: The camera system captures images of the waterbed, assisting in detecting garbage and waste that may be hidden from view. These images can be analyzed for the presence of debris or pollutants.

4. Waste collection using conveyor belt and extendable arm: Upon detecting garbage or waste through the camera system, the boat navigates towards it using the camera's precise location information. The conveyor belt collects waste from the water surface, while the extendable arm with a net collects waste from beneath the water surface.

5. Waste storage in the collecting bin: The collected waste is then deposited into the collecting bin, where it is stored temporarily until it can be properly disposed of.

6. IoT-based data upload and analysis: All the collected data, including sensor readings and images, can be uploaded to the cloud using IoT technology. This enables centralized storage and analysis of the data, providing insights into water quality and the efficiency of the cleaning process.

7. pH indication and water quality assessment: The pH sensor readings are analyzed to determine the acidity or alkalinity of the water. Based on the provided information, it can be inferred whether the water quality is suitable for regular chores. The alkaline reading suggests that the water is within an acceptable range for general use.

Overall, the logical flow of events involves data collection, garbage detection, waste collection, waste storage, data analysis, and water quality assessment. This IoT-based water cleaning system aims to efficiently remove waste from water bodies while providing insights into water quality for further evaluation and decision-making.

VIII. CONCLUSION

In the current scenario of climate change and global warming, the pollution caused by surface garbage in water bodies cannot be ignored. The large amount of waste material thrown into water sources poses harmful hazards and creates an unhealthy environment. This project focuses on the proposal and implementation of an inexpensive water-quality monitoring system that utilizes sensors and open-source tools to provide timely measurements of water quality at significantly reduced cost. The government spends a significant amount of money on cleaning up waste, as it depletes the oxygen supply for aquatic life such as flora and fauna and creates harmful hazards in the water creature life cycle. The traditional methods of waste disposal and collection are labor-intensive and require a significant workforce in India. Hence, there is a need for efficient methods of cleaning the surface of water bodies. The proposed system includes a conveyor belt with a management system to collect garbage and reduce human labor for such tasks. The implemented prototype is suitable for field deployment and provides continuous water quality measurements at a lower cost than existing methods. This scheme can significantly advance the spatial and temporal resolution of water condition detection, enabling construction managers to make informed decisions. To further improve efficiency, larger water bodies can be cleaned by modifying the size and capacity of the system. Overall, this project aims to protect the marine ecosystem and promote a healthy environment by utilizing IoT and transducers to monitor and maintain water quality.

FUTURE SCOPE

In addition to the current system, there is potential for future enhancements to further improve the efficiency and sustainability of the water cleaning process. One possible addition is the integration of a camera system underneath the boat to capture images of the waterbed and detect garbage and waste that may be hidden from view. This would provide more accurate data and enable the system to identify and remove waste more effectively. Another potential improvement is the incorporation of solar panels as a power supply. This would reduce the reliance on external power sources and make the system more sustainable and cost-effective in the long run. With the increasing availability and affordability of solar technology, it could be a viable and environmentally friendly option for powering the IoT-based water cleaning system. Additionally, there is potential for further research and development into more advanced sensors and data analysis techniques that could improve the accuracy and speed of water quality monitoring. By continually refining and enhancing the system, it may be possible to achieve even greater levels of efficiency and effectiveness in keeping water bodies clean and healthy for both aquatic life and humans.

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