Smart drainage cleaning System using ESP32 and Water level sensor

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Abstract: **Blocked drains create flooding, blockages, and environmental emergencies. Cleaning blocked drains represents both a manual tiring task and not as effective cleaning as one would think. We have proposed a project of a Smart Drainage Cleaning System based on ESP32 and water level sensor technologies to monitor drains and clean them automatically. The system will monitor water levels, sense the level of blockages, and if necessary will activate a motorized system to clean the blockage. The user can view the enabled water level monitoring and cleaning system on an IoT platform with real time alerts over Wi-Fi. An ultrasonic sensor can also be enabled to sense solid waste accumulation in the drain. Once the solid waste accumulation is above a specified level, the system will enable a cleaning cycle through a motorized motor gate or filter. The user will receive a notification using mobile application or a web portal. This smart system aims to prevent flooding risks, better manage drains cleaning automatically, and reduce human intervention to clean drains. Future enhancements planned for this smart drain include AI clog detection and adapting solar power systems for energy efficiency**

Keywords: Genetic algorithm, timetable, constraints, chromosomes, Scheduling, optimal solution.

I INTRODUCTION

Urban drainage systems are essential for avoiding waterlogging, and for proper disposal of wastewater. However, the blockages of the drainage due to solid waste, sediments accumulation, and environmental factors can pose serious threats to urban flooding, human health, and infrastructure.[1] Traditional maintenance of drainage systems consists of manual inspections and cleaning, which most often prove ineffective, laborious, and delayed-or too late to actually be effective-given the immediate consequences of heavy rainfall or sewage overflow.[2]

In order to overcome these hurdles, the project proposes a Smart Drainage Cleaning System harnessing the integration of ESP32, water level sensors, and motorized cleaning to ultimately lead to autonomous drainage maintenance.[3] The system continuously monitors the water level, looking for possible blockages, in real time.[4] When the water level rises above the prescribed limits, the system activates cleaning mechanisms such as a motorized filter or gate to push debris out of the way and restore good water flow.[5] WiFi on ESP32 allows for remote monitoring and alerting, through an IoT platform, enabling municipal authorities or users to take preventive action.[6]

With this system, the system attempts to automate drainage cleaning hence promising better efficiency, less manual labor, and reduced risk of flooding. Other future improvements could be AI-based clog detection, predictive maintenance through machine learning, and solar-powered operation for sustainability.[7]

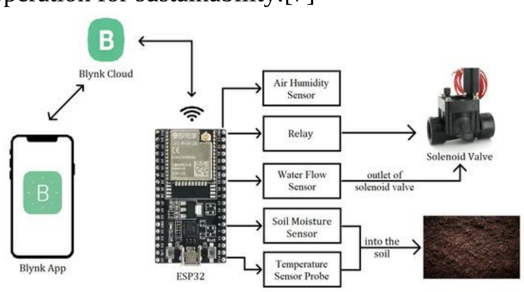

Fig 1. Overview of the IoT-enabled smart drip irrigation system

This project proposes a Smart Drainage Cleaning System leveraging the ESP32 microcontroller, water level sensors, and IoT-based real-time monitoring to ensure an automated and efficient drainage maintenance process. [8] The system continuously monitors water levels and detects anomalies indicative of blockages. Upon detection, an automated cleaning mechanism is activated to remove obstructions, thereby restoring normal drainage functionality.[9]

Fig1: illustrates a smart irrigation system that uses an ESP32 microcontroller, various sensors, a relay-controlled solenoid valve, and the Blynk app for wireless monitoring and control. This setup is designed to automate the watering of plants based on real-time environmental data, improving efficiency and conserving water.

Overall, this smart irrigation system is ideal for optimizing water use, ensuring plants receive the right amount of moisture, and reducing manual effort, especially in agricultural or garden settings. Furthermore, the IoT-enabled telemetry system allows for real-time data transmission to a cloud platform, where authorities can remotely monitor drainage conditions, receive critical alerts, and optimize maintenance schedules.[10] By incorporating sensor fusion, predictive analytics, and adaptive control mechanisms, the proposed system aims to enhance the sustainability, resilience, and operational efficiency of urban drainage infrastructure.

II LITERATURE REVIEW

Recent research on urban drainage flooding and clogging has highlighted the growing severity of these issues, especially in rapidly urbanizing regions. Traditional drainage systems often fall short due to outdated infrastructure, poor maintenance, and the increasing impact of climate change.[11] As a result, urban areas frequently experience waterlogging, property damage, and health hazards caused by stagnant and contaminated water.[12] To address these challenges, researchers and engineers are actively exploring advanced technological interventions to enhance the performance, reliability, and responsiveness of drainage infrastructure.[13]

One of the most promising developments in this area is the application of smart technologies, particularly those powered by the Internet of Things (IoT).[14] These technologies allow real-time monitoring and management of water levels, blockages, and overall system health. By deploying sensors and microcontrollers, it becomes possible to automate detection of abnormal water levels and debris accumulation.[15] This proactive approach helps reduce manual inspection needs and enables faster, data-driven decision-making.[16] Moreover, smart systems can send instant alerts to maintenance teams and even trigger automatic cleaning mechanisms when blockages are detected.

The following section presents a detailed review of existing research and technological innovations focused on IoT-based automated cleaning and drainage monitoring systems.[17] It explores how water level detection, blockage identification, and remote system control have been integrated into urban drainage networks using embedded systems, wireless communication, and cloud-based platforms. This review aims to identify gaps, assess the efficiency of current models, and highlight the potential for further innovation in building sustainable, self-regulating drainage solutions for modern cities.

2.1 Conventional Methods of Drainage Cleaning

In traditional maintenance, the cleaning of drains is conducted manually, where workers inspect and remove
waste from the drainage system. Research has shown that these methods are inefficient and take up much time, which increases the risk of the workers involved.[18] In addition, manual inspection is not frequent enough, and hence blockage identification is often delayed, leading to urban flooding.

2.2 Automated Drainage Clears

Several automated systems for drain cleaning were presented in the past. Arunkumar et al. (2020) developed a semi-automatic system fitted with mechanical filters, but the system was not meant for real-time monitoring. Sharma et al. (2021) developed a motorized drain cleaner, where a fixed timer operation was used instead of real-time blockage detection. These studies indicate an immediate need for an automated intelligent system that finds the drainage obstruction and takes necessary action. [19]

2.3 IoT-Based Smart Drainage Monitoring

Emerging IoT areas are used by researchers to provide smart drainage solutions by means of sensors, microcontrollers, and cloud monitoring. Ramesh et al. [20] (2019) set an IoT system based on Arduino and ultrasonic sensors, which detects water levels and sends the data to the cloud server. However, the automated cleaning of the system is absent. Patil et al. (2022) used GSM alerts along with IoT for drainage monitoring, yet it has slow response time due to dependency on cellular networks.

However, if no immediate problem is found during the survey, the issue may be deferred and added to a time schedule for future inspection or preventive maintenance. This ensures that even less urgent issues are not overlooked and can be addressed in a systematic and timely manner.

Overall, the flowchart represents a structured approach to sewerage problem management, balancing immediate maintenance needs with planned scheduling for long-term efficiency and reliability.

2.4 Usage of ESP32 for Intelligent Monitoring

Due to WiFi connectivity, low power consumption, and compatibility with various sensors, the ESP32 is among the most preferred microcontrollers for IoT-based drainage systems. A smart water management system was proposed by Kumar et al. (2023), using ESP32 for real-time monitoring via mobile applications. Very few studies make mention of integrating ESP32 with a motorized drainage cleaning system, and this research seeks to address this gap.

2.5 Summary and Research Gap

IoT-based drainage monitoring has thus been feasible, but few studies have attempted to integrate real-time detection of water levels with intelligent automated cleaning systems. Most of the old solutions are either monitoring with no automation or mechanical cleaning devoid of intelligence. This indicates that the current project will fill the gap with the development of a complete automated smart drainage cleaning system that uses ESP32 for real-time water level sensing, motorized cleaning mechanisms, IoT remote monitoring, and alerting.

III METHODOLOGY

The Smart Drainage Cleaning System is designed to monitor and maintain drainage systems efficiently by detecting water levels and controlling cleaning mechanisms using an ESP32 microcontroller and water level sensors. The methodology involves several key stages, including system design, hardware integration, software implementation, and real-time monitoring.

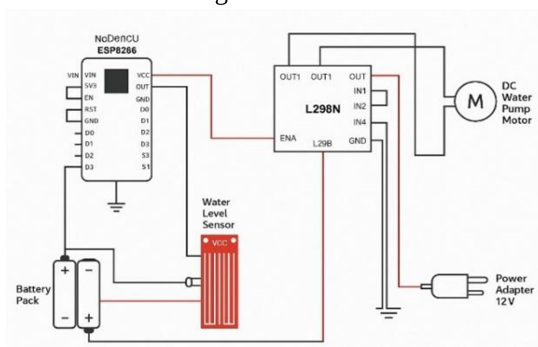

Fig 2: Basic Implementation of the Model

Fig 2 represents an automatic water level monitoring and control system using an ESP8266 NodeMCU, a water level sensor, a DC water pump motor, and an L298N motor driver. The purpose of the system is to automatically control the water pump based on the water level detected in a tank or reservoir, helping to prevent overflow or dry conditions.

At the heart of the system is the ESP8266 NodeMCU, a microcontroller with built-in Wi-Fi capability. It receives input from the water level sensor, which is immersed in the water tank. This sensor detects the presence or absence of water at a certain level and sends a corresponding signal to the ESP8266. Based on this data, the microcontroller makes decisions about whether to turn the water pump on or off.

To control the water pump, the system uses an L298N motor driver module. The ESP8266 sends control signals to this module via its IN1 and IN2 pins. The motor driver is responsible for providing the necessary power to the DC water pump motor, which cannot be powered directly by the microcontroller due to its higher current requirements. The 12V power adapter supplies sufficient voltage to the L298N, enabling it to drive the pump effectively.

A battery pack is used to power the ESP8266 and the water level sensor, ensuring that the system can function even if there's a power outage. When the water level drops below a certain point, the sensor alerts the ESP8266, which then activates the pump via the motor driver. Once the water level reaches the required height, the ESP8266 stops the pump to prevent overfilling.

3.1 System Design and Architecture

The smart drainage cleaning system is made up of a few main parts that work together. A water level sensor checks the height of water in the drain. This sensor sends the data to an ESP32 microcontroller, which acts like the brain of the system. If the water level is too high (which means there might be a blockage), the ESP32 turns on a motor to help clean the drain. At the same time, a buzzer or LED gives an alert. The system can also connect to Wi-Fi to send messages to a phone or cloud platform, so users can monitor the drainage system remotely. When the water level goes back to normal, the system stops the motor and alert automatically. This helps keep the drains clean without needing someone to always check them.

Next, a survey is conducted to assess the reported issue. This step is crucial for verifying whether a genuine problem exists and determining the extent of the issue. If the survey finds a problem, the next step is to carry out the necessary maintenance to fix the sewerage system and restore it to proper working condition.

This type of system is commonly used in smart irrigation, automated water tanks, and other fluid control systems. It can be expanded further by utilizing the ESP8266's Wi-Fi capability to send real-time updates to a mobile app or cloud platform, allowing users to monitor and control the water system remotely.

3.2 Hardware Implementation

The hardware part of the smart drainage cleaning system includes setting up all the physical components. The water level sensor is placed inside or near the drainage area to check water height. It is connected to the ESP32 microcontroller, which reads the sensor values. A motor is connected using a relay module, so the ESP32 can turn it on when the water level is too high. A buzzer or LED is added to give alerts. All the components are powered using a battery or adapter. The connections are made on a breadboard or PCB, and the whole setup is tested to make sure it works properly. This hardware setup allows the system to detect blockages and start cleaning automatically.

3.3 Software Implementation

The software part of the system is developed using the Arduino IDE, where the code is written and uploaded to the ESP32. The code reads data from the water level sensor and checks if the water level is above a set limit. If it is, the ESP32 turns on the motor through the relay and activates the buzzer or LED for alerts. The program uses simple logic (if-else conditions) to control when the motor and alerts should turn on or off. If Wi-Fi is used, the ESP32 can also send data to a cloud platform like Blynk or Thing Speak. The code is tested and debugged using the Serial Monitor to make sure everything works as expected.

The Course section outlines a step-by-step educational progression designed to equip learners with both theoretical and practical knowledge of the ESP32 platform. It begins with an introduction to the ESP32 and proceeds to software installation and getting started with the hardware. Subsequent modules cover programming fundamentals, digital and analog input/output (I/O), pulse-width modulation (PWM), and interfacing with sensors. As the course advances, it introduces data logging and Wi-Fi connectivity, culminating in modules on the Internet of Things (IoT) and a final project. This structure ensures that learners build foundational skills before moving on to more complex applications.

3.4 Working Procedure

The smart drainage cleaning system works automatically. First, the water level sensor checks the water level in the drain and sends the data to the ESP32. If the water level is normal, the system does nothing. But if the water level gets too high (which means there may be a blockage), the ESP32 turns on the motor to clean the drain and also activates a buzzer or LED to give an alert. If connected to the internet, it can also send a warning message to a phone or cloud platform. Once the water level goes back to normal, the system turns off the motor and alert. This process keeps repeating to make sure the drain stays clean and safe.

On the other hand, the Project section represents the practical implementation process of an IoT-based functional prototype. It begins with ideation, followed by component selection, procurement, and testing. If the component testing phase reveals any issues, the process loops back to selection and testing to ensure only suitable components are used. Once the components are validated, the workflow branches into three parallel streams: PCB design and manufacturing, enclosure design and fabrication (often using 3D printing), and IoT platform selection paired with ESP32 firmware development. After individual components and subsystems are ready, they are integrated into a single prototype. The integrated system then undergoes testing to verify functionality, leading to the completion of a working prototype.

If the system identifies a normal condition, where the water level is within limits and no blockage is detected, no action is taken, and the system continues to operate passively. However, if abnormal conditions are detected — such as a blockage or unusually highwater level — the system triggers a response mechanism.

This dual structure—combining theoretical instruction with practical project execution—ensures that learners not only understand core concepts but also gain hands-on experience in developing real-world IoT applications using the ESP32 platform. It reflects a well-rounded educational model for training in embedded systems and prototyping.

3.5 Testing and Validation

The system is tested under different water level conditions to ensure reliability.
Performance is evaluated by analyzing response time and cleaning efficiency.
Remote monitoring functionality is verified through IoT-based cloud access.

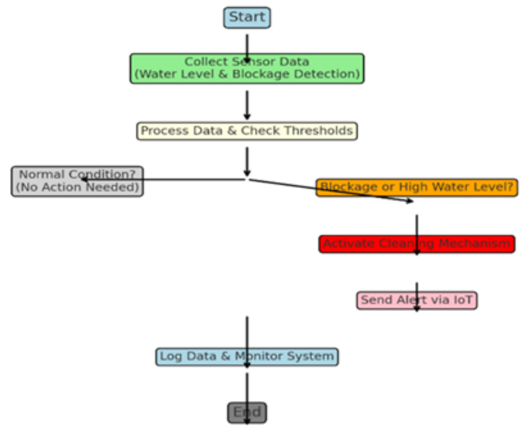

Fig.3: General view of Flow Chart

Fig 3 illustrates the working logic of an automated water level and blockage detection system integrated with IoT. The process begins with the collection of sensor data, specifically targeting parameters like water level and blockage detection in a drainage or pipeline system. Once the sensor data is gathered, it is then processed and compared against predefined thresholds to determine the current condition of the system.

This methodology ensures an automated, efficient, and real-time drainage cleaning system, reducing manual intervention and improving urban drainage management.

3.6 Flow Diagrams & observations

The Smart Drainage Cleaning System operates in a structured manner, ensuring effective detection, monitoring, and cleaning of drainage systems. The execution begins with the input data collection, where water level sensors continuously monitor drainage conditions. Additionally, ultrasonic or infrared sensors detect any blockages caused by debris accumulation. The ESP32 microcontroller collects real-time data from these sensors and sends it for processing.

Once the data is collected, the system proceeds to the data processing and validation stage. Here, sensor readings are analyzed to determine whether the water levels and drainage conditions fall within predefined thresholds.

In response to the detected issue, the system first activates a clearing mechanism (e.g., a motor or valve to remove the blockage). Simultaneously, it sends an alert through an IoT interface, notifying relevant personnel or triggering a remote monitoring system. Regardless of the condition, whether normal or abnormal, the final step involves logging the data and monitoring the system for continuous feedback and analysis. The flow then concludes, ready for the next data cycle. In the decision-making and automated cleaning phase, if the water level crosses the critical threshold or an obstruction is confirmed, the automated cleaning mechanism is triggered. The system activates motorized cleaning units to remove debris from the drainage system. If the blockage is severe or requires manual intervention, an alert is sent to administrators, notifying them of the issue.

The IoT-based monitoring and alert system ensures real-time communication and control. The ESP32 transmits sensor data to a cloud-based platform, where users can monitor the system's status through a mobilezor web interface. If an emergency arises, alerts are sent to relevant personnel, allowing them to respond promptly. Additionally, users can manually activate or adjust the cleaning mechanism through the IoT dashboard.

Finally, the output generation and feedback phase helps in maintaining long-term system efficiency. All data is logged for future analysis, enabling predictive maintenance and optimization of drainage management strategies. If required, administrators can fine-tune system parameters to improve its overall performance. This structured flow ensures that drainage systems remain clean and functional with minimal human intervention, reducing the risk of blockages and overflow-related issues.

IV RESULTS AND DISCUSSIONS

The Smart Drainage Cleaning System proved to be a highly effective solution for the automated monitoring and maintenance of urban drainage networks. By integrating sensor-based technologies and real-time data processing, the system addressed one of the most persistent challenges in urban infrastructure—drainage clogging and flooding. Through continuous data collection, the system ensured a proactive approach rather than relying on reactive, manual inspection methods, which are often delayed and inefficient.

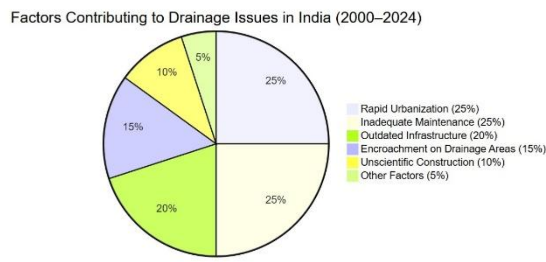

Fig 4: Factors Contributing to Drainage Issues in India

Fig 4 shows key causes of drainage issues in India from 2000–2024.
Rapid urbanization and inadequate maintenance are the top contributors, each at 25%.
Outdated infrastructure (20%) and encroachments (15%) also play major roles.
Irregular construction (10%) and other factors like climate change (5%) add to the problem.

At the core of this system were water level sensors and blockage detection mechanisms that enabled real-time assessment of drainage conditions. These components continuously monitored environmental parameters and transmitted data to a centralized unit for analysis. Based on the readings, the system intelligently classified the water levels into three categories: Normal, Warning, and Critical. This classification helped maintenance teams prioritize interventions and take timely action, reducing the likelihood of severe blockages or overflows.

By automating the detection and alert system, the Smart Drainage Cleaning System significantly improved response time and operational efficiency.

In critical scenarios, the system could trigger alerts via IoT and even initiate mechanical cleaning operations autonomously. This proactive model not only reduced human labor and maintenance costs but also minimized environmental and public health risks caused by stagnant or overflowing drainage. Overall, the system marked a significant step toward the future of smart urban water management.

The automated cleaning mechanism, controlled by the ESP32 microcontroller, performed well in clearing debris whenever a blockage was detected. The integration of motorized cleaning units ensured that minor obstructions were removed without manual intervention, thereby minimizing human effort and maintenance costs. In cases where severe blockages occurred, the IoT-based alert system efficiently notified administrators, allowing for quick response and necessary corrective actions.

Additionally, the IoT-based monitoring platform provided a user-friendly interface for real-time system updates. The cloud-based integration allowed remote access, ensuring that drainage conditions could be checked and controlled from anywhere. This feature proved particularly useful in urban areas where drainage blockages are common, enabling authorities to take immediate action before flooding or water stagnation occurred.

Overall, the results highlight that the Smart Drainage Cleaning System is a reliable and scalable solution for urban drainage management. The combination of automated cleaning, IoT-based monitoring, and real-time alerts makes it an effective tool for preventing drainage issues and ensuring proper wastewater flow. Future enhancements, such as AI-based predictive maintenance and advanced debris detection algorithms, could further optimize the system's efficiency and adaptability.

V. CONCLUSION

The Smart Drainage Cleaning System using ESP32 and water level sensors has proven to be an effective and automated solution for monitoring and maintaining drainage systems. By integrating real-time data collection, automated cleaning mechanisms, and IoT-based monitoring, the system ensures efficient drainage management while reducing manual intervention. The ability to detect blockages, categorize water levels, and activate cleaning mechanisms in response to critical conditions significantly enhances the reliability and functionality of drainage systems.

One of the key advantages of this system is its proactive approach to drainage maintenance. By utilizing real-time alerts and cloud-based monitoring, authorities can take immediate action before severe blockages or flooding occur. The automated cleaning unit effectively removes minor debris, minimizing the need for manual cleaning and reducing maintenance costs. Additionally, the historical data logging feature allows for predictive maintenance, which can help in long-term drainage management and infrastructure planning.

Overall, this project demonstrates a scalable, cost-effective, and efficient solution for modern drainage systems, particularly in urban areas where drainage blockages are a common issue. Future improvements, such as AI-based predictive analytics, advanced debris detection, and integration with smart city infrastructure, could further enhance the system's capabilities. By adopting such innovative technologies, cities can ensure better water flow management, reduce flooding risks, and create a more sustainable urban environment.

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