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Review on Different Techniques to Automate Conventional Drainage System

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Abstract: *The field of urban water management has witnessed significant advancements in automated monitoring and control of drainage systems. This review explores cutting-edge technologies to boost efficiency, enhance safety, and promote environmental sustainability in urban drainage infrastructure. The incorporation of intelligent technologies, novel control techniques, and artificial intelligence methods is emphasized totackle issues confronting urban drainage. The use of Internet of Things (IoT) sensors and intelligent systems is suggested to enhance drainage monitoring, potentially decreasing the need for manual labour and associated expenses while improving safety protocols. Model Predictive Control (MPC) is recognized as a promising approach for more effective management of integrated urban drainage networks, though research methodologies remain diverse. Artificial intelligence technologies have demonstrated potential in addressing various aspects of urban drainage systems, including real-time operational control, flood forecasting, and pipe defect identification. Despite the considerable potential these innovations offer, additional research and practical applications are essential to fully realize their advantages in real-world contexts. This review highlights the current state of research in automated urban drainage monitoring and control, discussing the potential benefits and challenges of implementing these technologies in practice.*

Keywords: Smart Sensors, Real Time Monitoing, Internet of Things (IoT), Model Predictive Control (MPC), Artificial Intelligence, Flood Forecasting, Environmental Sustainability, Energy Efficient

I. INTRODUCTION

The field of urban water management has seen a growing focus on automated monitoring and control of drainage systems. This area of study has attracted significant attention, with researchers exploring cutting-edge technologies to boost efficiency, enhance safety, and promote environmental sustainability. Current literature emphasizes the incorporation of intelligent technologies, novel control techniques, and artificial intelligence methods to tackle the issues confronting urban drainage infrastructure. Researchers have suggested the use of Internet of Things (IoT) sensors and intelligent systems to enhance drainage monitoring. These technologies have the potential to decrease the need for manual labour and its associated expenses while also improving safety protocols (Lakshmi et al., 2022). Model Predictive Control (MPC) has been recognized as a promising approach for more effective management of integrated urban drainage networks, though research methodologies in this domain remain diverse (Lund et al., 2018). Furthermore, artificial intelligence technologies have demonstrated potential in addressing various aspects of urban drainage systems, including real-time operational control, flood forecasting, and pipe defect identification (Kwon & Kim, 2021). Despite the considerable potential these innovations offer for enhancing urban drainage systems, additional research and practical applications are essential to fully realize their advantages in real-world contexts.

II. DIFFERENT TECHNIQUES USED IN COVENTIONAL DRAINAGE SYSTEM

A. The Approach Described is Typically Known as the Design, Fabrication, and Testing Technique:

This system is designed to automate the removal of floating debris, such as plastic bottles, cans, and lids, from drainage systems while maintaining unobstructed water flow through the lower drain section. The device employs a motor-driven chain mechanism equipped with specialized lifters to collect waste and deposit it into a storage container for subsequent disposal. The process begins with the motor's rotation, generating rotary motion that is transferred to an

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upper shaft via a chain and sprocket system.motion is then transmitted to a lower shaft using an identical chain and sprocket arrangement. Teeth attached between the chains on the upper and lower shafts are designed to lift waste materials from the drainage. A mesh barrier is installed between the chains and the storage bin to ensure that collected waste remains contained and does not escape back into the drainage system.[3]

The methodology for developing this system involves several critical steps. The first step is the selection and acquisition of materials, which includes identifying and procuring the necessary raw materials and tools required for the design and fabrication of the drainage cleaner. The second step focuses on design and measurement, where a precise design with accurate measurements is developed to ensure optimal functionality of the system. The third step involves fabrication and assembly, where raw materials are processed and all components are assembled according to the design specifications to construct the final product. The final step is testing and refinement, where the system is rigorously tested to identify and address any issues, followed by final adjustments to optimize its performance.[11]

The prototype was successfully developed using essential components such as shafts, bearings, sprockets, and chains. Shafts serve as rotating machine elements that transmit power, while bearings reduce friction and guide motion in the desired direction. Sprockets, with their toothed design, engage with the chain to facilitate movement, and the chain drive efficiently transmits mechanical power Fig 1.showsThe design process employed an iterative approach, allowing for continuous refinement and improvement, ultimately resulting in a functional prototype capable of effectively clearing drainage systems.

This methodology provides a comprehensive and efficient framework for developing an automated solution to drainage cleaning, significantly reducing the risks associated with manual labour, such as exposure to unsanitary conditions and hazardous waste. By automating the process, the system not only enhances operational efficiency but also minimizes the health risks faced by sanitation workers. The successful development and implementation of this system demonstrate its potential to address a critical environmental and public health challenge, offering a sustainable and effective solution for maintaining clean and functional drainage systems.an easy way to comply with the Journalpaper formatting requirements is to use this document as a template and simply type your text into it.

This setup contains Dc motor, Sprocket, bearings, chain, gear, lift mounters, fastener, dc motor, shaft.

Fig 1. Mechanical System Based

B. Design and Implementation of a PLC-Based Automatic Industrial Drainage System:

The technique developed by Md. Atikur Rahman et al. (2021) introduces an automated system for managing industrial waste, encompassing solid, liquid, and gaseous waste, utilizing a Programmable Logic Controller (PLC) as the central control unit. This system is designed to minimize human intervention, enhance operational efficiency, and mitigate environmental hazards in industrial settings. The methodology is structured into key phases, including system design, component integration, programming, and implementation. The system is tailored to handle three types of waste, with the PLC interfacing with various sensors and actuators to automate waste management. Key components include sensors such as a gas sensor for detecting toxic gases, a liquid level sensor for monitoring liquid waste levels, and a load cell for measuring solid waste weight. Actuators, including a conveyor belt, pump motor, and exhaust fan, are employed to manage solid, liquid, and gaseous waste, respectively. Additionally, an Arduino Nano microcontroller is utilized to process signals from the load cell and interface with the PLC.[9]

The system operates based on sensor inputs. For solid waste management, when the load cell detects that the weight of solid waste exceeds a predetermined limit, the PLC activates a DC gear motor to open the solid waste tank door, allowing waste to fall onto a conveyor belt for removal. In liquid waste management, the liquid level sensor monitors the liquid waste tank, and when the liquid level reaches a predefined threshold, the PLC activates a pump motor to remove the liquid waste. For gaseous waste management, the gas sensor continuously monitors the concentration of toxic gases, and if the concentration exceeds 40%, the PLC activates an exhaust fan to expel the gases from the environment shows in Fig 2. The PLC is programmed using Logo Soft Comfort software, with a Ladder Diagram as the programming language, ensuring sequential operation based on sensor inputs. The Arduino Nano is used to calibrate and amplify the load cell signal, ensuring accurate weight measurement.

The system is implemented in a controlled environment, and its performance is rigorously tested to verify the functionality of sensors and actuators. The PLC successfully controls the entire process, demonstrating high reliability and efficiency in waste management. Key features of the system include automation, which eliminates the need for manual intervention, reducing health risks for workers and improving operational efficiency. The system is versatile, capable of handling multiple types of waste simultaneously, and scalable, allowing adaptation for various industrial applications such as garment factories, coal mining, and pharmaceutical industries. Advantages include reduced human intervention, cost-effectiveness, and environmental protection through efficient waste management. However, the system has limitations, including the complexity of precise sensor and actuator calibration and higher energy consumption due to continuous operation. Future enhancements could involve integrating renewable energy sources like solar panels and incorporating advanced sensors to improve accuracy and efficiency. This system represents a significant advancement in industrial waste management, offering a sustainable and efficient solution to a critical environmental challenge.[6]

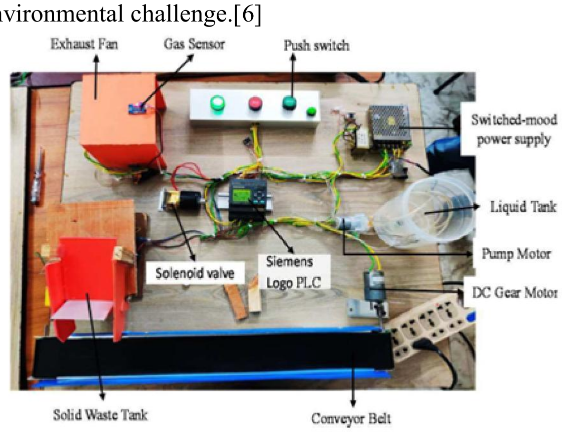

Fig 2. Experimental setup plc based [14]

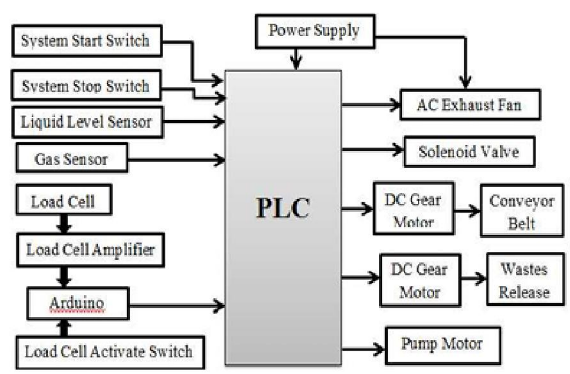

Fig 3. Block Diagram [15]

C. This technique of Smart Drainage Monitoring and Controlling System Using IOT:

The technique presented in the paper "Smart Drainage Monitoring and Controlling System Using IoT" by Tushar Pathak et al. (2021) outlines the development of an IoT-based system designed to monitor and manage underground drainage systems in urban areas. This system addresses critical issues such as blockages, toxic gas leaks, and water overflow by enabling real-time monitoring and automated alerts. The methodology is structured into key phases, including system design, sensor integration, data processing, and IoT-based real-time monitoring. The system is equipped with sensors such as ultrasonic sensors for water level measurement, MQ135 gas sensors for detecting toxic gases, and LM35 temperature sensors for environmental monitoring. These sensors are integrated with microcontrollers, including Arduino Uno and Node MCU, with the latter facilitating IoT connectivity through its Wi-Fi module. Communication modules such as GSM and GPS are employed to send SMS alerts and provide location data for identifying problematic manholes, while an LCD display and buzzer offer real-time data visualization and audible alerts represents the Fig 4.[22]

Data processing and IoT integration are central to the system's functionality. The Blynk IoT platform serves as a central hub for data aggregation and visualization, with sensor data transmitted wirelessly via the Node MCU. This setup allows municipal authorities to monitor drainage conditions remotely and receive alerts in case of anomalies. The system operates by continuously monitoring water levels, gas concentrations, and temperature. If predefined thresholds are exceeded, the system triggers alerts via SMS, updates the Blynk platform, and displays data on the LCD. A structured algorithm ensures seamless operation, from initializing hardware modules to processing sensor data and triggering alerts.[17]

Key features of the system include real-time monitoring, IoT integration, and automated alerts, which collectively enhance operational efficiency and safety. The system reduces the risk of exposure to toxic gases and unsafe working conditions for manual labourers, offering a cost-effective and scalable solution for urban drainage management. However, the system's reliance on stable internet connectivity and a continuous power supply presents limitations, particularly in remote areas. Future enhancements could involve integrating renewable energy sources like solar panels and incorporating advanced analytics, such as machine learning algorithms, to improve predictive maintenance and anomaly detection. Overall, this IoT-based smart drainage monitoring system demonstrates significant potential for revolutionizing urban infrastructure management by automating monitoring processes and ensuring timely interventions.

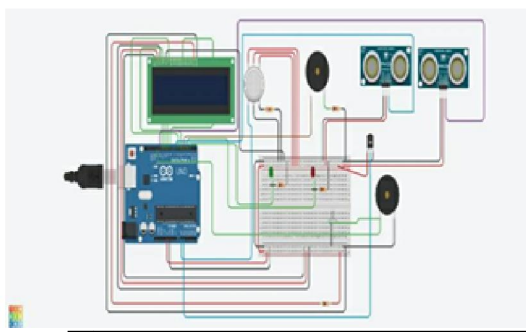

Fig 4. Prototyping of working model

D. This technique of Smart Drainage Monitoring and Controlling System Using Artificial Intelligence:

The methodology presented in the paper revolves around the development of an Artificial Intelligence (AI)-based Smart Drainage System that leverages Internet of Things (IoT) technology to monitor and manage urban drainage networks effectively. The system is designed to address the challenges of drainage blockages, overflow detection, and urban flooding, which are exacerbated by poor maintenance and increasing urbanization. The core of the methodology involves the integration of sensors, actuators, and cloud-based monitoring to create a real-time, automated drainage management system.[28]

The system employs ultrasonic sensors (HC-SR04) to measure water levels within drainage conduits, detecting blockages by identifying abnormal water level changes. These sensors are strategically placed along the drainage network, particularly between manholes shown in Fig 5 and Fig 6. to monitor the flow and identify potential obstructions. The data collected by the sensors is processed by an Arduino UNO microcontroller, which acts as the computational node. The microcontroller analyses the sensor data and communicates the information to a cloud-based server via a Wi-Fi module (ESP 8266), enabling real-time monitoring and decision-making. In case of a blockage or overflow, the system sends alerts to the responsible authorities through a mobile application, providing precise location details and the severity of the issue.[21]

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To manage water flow dynamically, the system incorporates smart gates (actuators) that can be controlled remotely. These gates are designed to redistribute excess water from overloaded conduits to less congested ones, thereby preventing overflow and flooding. The system also includes flow sensors to measure the rate of water flow, which helps in identifying blockages when the flow rate drops below a predefined threshold. The entire network operates as a distributed system, where each computational node communicates with its neighbouring nodes to optimize water flow across the drainage network.

The methodology was initially validated using MATLAB simulations, which model the behaviour of an urban drainage system under heavy rainfall conditions. The simulations demonstrated the system's ability to reduce overload times and distribute water flow more evenly across the network. Following successful simulations, the system was implemented in a real-world urban drainage network, with sensors and actuators deployed at strategic locations. The system's performance was further validated using Storm Water Management Model (SWMM) software, which confirmed its effectiveness in managing urban flood risks.[35]

Overall, the proposed methodology offers a cost-effective, low-maintenance, and efficient solution for urban drainage management. By integrating IoT, AI, and cloud-based monitoring, the system provides real-time data, early warning of blockages, and automated control of water flow, significantly reducing the risk of urban flooding and improving the overall efficiency of drainage systems.

Fig 5. Position of sensor at smart drainage

Fig 6. Smart sensor (Vertical View)

E. The Proposed System:

The proposed Automatic Drainage System Monitoring and Control is an advanced, PLC-based solution designed to efficiently manage and monitor drainage operations in industrial, municipal, or residential settings. This system integrates various sensors, actuators, and control mechanisms to ensure optimal performance, safety, and reliability. By automating processes such as water drainage, gas detection, and system control, it significantly reduces manual intervention and minimizes risks associated with overflow, gas leaks, or system failures. The system's core components include a Programmable Logic Controller (PLC) as the central control unit, which processes input data from sensors like level float sensors and gas sensors, and executes pre-programmed logic to control actuators such as water pumps, solenoid valves, and gas exhausters. A cylindrical tank represents the drainage or storage area, equipped with sensors to monitor water levels and gas concentrations. The water pump is automatically activated or deactivated by the PLC based on water level data, preventing overflow. Gas sensors detect hazardous gases like methane and hydrogen sulphide, triggering safety measures such as gas exhausters and audible alarms via buzzers. Level float sensors provide real-time feedback to the PLC for controlling the water pump and solenoid valve, while push buttons allow manual control or system override. LED lamps and buzzers provide visual and audible alerts for system status and emergencies. The system is powered by a Switched-Mode Power Supply (SMPS), ensuring stable DC power to all components. A DC motor drives the water pump, and relays interface between the PLC and high-power devices, ensuring safe and efficient control. The Human Machine Interface (HMI) offers a user-friendly platform for operators to monitor system status, view sensor data, and control the system, displaying real-time information such as water levels, gas concentrations, and system alerts.

The system methodology involves continuous water level monitoring and control, where the level float sensor detects high water levels, prompting the PLC to activate the water pump and solenoid valve for drainage. Gas detection mechanisms ensure safety by triggering gas exhausters and alarms when hazardous gas concentrations exceed safe limits. Manual control options via push buttons and the HMI allow operators to intervene when necessary. The SMPS ensures consistent power supply, while the alarm system, comprising buzzers and LED lamps, provides immediate alerts for critical conditions. The PLC automates the entire process, enhancing efficiency and reducing the need for manual supervision. The integration of PLC and HMI is achieved through communication protocols like Ethernet, RS-232, RS-485, or Modbus, enabling real-time data exchange and control. The HMI interface is designed for intuitive operation, featuring real-time monitoring, control options, alarm management, and trend analysis. Comprehensive testing ensures proper integration and functionality, verifying sensor inputs, control logic, and HMI displays. This configuration enhances operational efficiency, improves diagnostics, and offers scalability, making it a reliable and user-friendly solution for modern drainage system management. The proposed system demonstrates significant potential in enhancing safety, efficiency, and reliability in drainage operations, paving the way for smarter urban infrastructure management

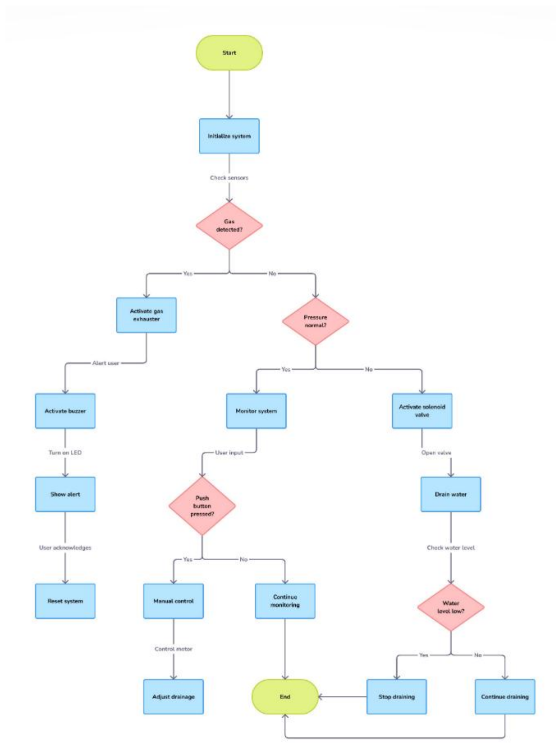

Fig 7. Flow chart

This flowchart outlines a process for an automated drainage system with gas detection and manual control capabilities. The system starts by initializing and checking sensors for gas presence. If gas is detected, it activates a gas exhauster and checks pressure; if abnormal, it alerts the user with a buzzer, LED, and on-screen alert. The system can be reset and monitored, allowing for manual control via a push button to adjust drainage by controlling a motor and solenoid valve. It continuously checks the water level to decide whether to stop or continue draining.

III. CONCLUSION

This review paper highlights the transformative role of advanced technologies, including IoT, AI, and PLC-based systems, in modernizing urban drainage management. The integration of ultrasonic sensors, flow sensors, and cloud-based platforms enables real-time monitoring, automated alerts, and dynamic control, addressing critical issues such as blockages, overflow, and toxic gas leaks. These systems significantly reduce manual intervention, enhance operational efficiency, and mitigate environmental risks, offering scalable solutions for urban and industrial settings. While the advancements demonstrate substantial potential, challenges like dependency on stable connectivity, power consumption, and sensor calibration persist. Future research should focus on integrating renewable energy, improving sensor accuracy, and leveraging machine learning for predictive maintenance and anomaly detection. Overall, the reviewed methodologies underscore the potential of smart technologies to create sustainable, efficient, and resilient drainage systems, paving the way for smarter urban infrastructure and improved public health safety.

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