PLC Based Automatic Drainage Water Monitoring & Control System

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Abstract - *Managing urban drainage systems is a critical task, often hindered by problems such as blockages, overflows, and water contamination. This paper presents a solution using a Programmable Logic Controller (PLC)-based automatic drainage water monitoring and control system designed to address these challenges with greater efficiency and reliability. The system integrates a range of sensors—including pH sensors to assess chemical quality, turbidity sensors to detect water clarity, and ultrasonic sensors to monitor water levels. These components feed real-time data to the PLC, which processes the information and responds automatically by activating pumps or valves as needed. By continuously monitoring and responding to drainage conditions, the system enhances both environmental safety and operational effectiveness. This approach supports smarter urban water management and contributes to the broader goals of sustainability and infrastructure modernization.*

Key Words: **Industrial Automation System, PLC, Smart drainage system.**

1. INTRODUCTION

Urban drainage systems constitute a vital aspect of contemporary infrastructure, playing a key role in the management of wastewater, the prevention of urban flooding, and the protection of public health. These systems are tasked with efficiently conveying surface runoff and sewage to designated treatment facilities or discharge locations. However, the increasing complexity of urban environments, coupled with the growing prevalence of extreme weather events driven by climate change, has significantly intensified the challenges associated with effective drainage management.

Conventional drainage systems, which predominantly rely on manual inspections and reactive maintenance approaches, are becoming increasingly insufficient in addressing the evolving demands of rapidly expanding cities. Manual monitoring techniques are inherently constrained in terms of coverage, timeliness, and accuracy, often resulting in delayed identification of critical issues such as pipe blockages, water contamination, and overflow events. These delays can cause considerable environmental degradation, compromise water quality, accelerate infrastructure wear, and pose serious public health threats due to exposure to untreated wastewater or stagnant water.

In light of these limitations, there has been a growing emphasis on incorporating automation and real-time control technologies into urban drainage systems. At the forefront of this transformation is the implementation of Programmable Logic Controllers (PLCs), which offer a robust, adaptable, and programmable platform for the automation of drainage system operations.

This study presents the development of an automated drainage water monitoring and control system based on Programmable Logic Controllers (PLCs), aimed at overcoming the limitations associated with traditional drainage management methods. The proposed system integrates a range of environmental sensors—such as water level and gas sensors—to enable continuous, real-time monitoring of water quality and flow dynamics. The collected data is processed by the PLC, which autonomously executes control measures including pump activation, flow redirection, and the initiation of alarms in response to abnormal or hazardous conditions.

Through automation of both monitoring and response functions, the system significantly improves operational efficiency while minimizing reliance on manual intervention and reducing the likelihood of human error. This contributes to faster, more reliable responses to potential drainage system failures. Furthermore, the design supports broader global objectives related to the advancement of sustainable, resilient, and intelligent urban infrastructure. Its adaptability to diverse environmental conditions and scalability across different urban contexts highlights its potential as a foundational model for future drainage management technologies.

2. OVERVIEW OF THE SYSTEM

The principal aim of this project is to develop and implement a fully automated industrial drainage system capable of real-time monitoring and responsive control, thereby eliminating the need for manual operation. To achieve this objective, all system components were selected with careful consideration of their technical performance and adherence to industrial automation standards.

At the core of the system is the **Delta PLC** model **DVP14SS211R**—a compact, high-performance controller recognized for its fast-processing capabilities and flexible input/output configuration. This PLC functions as the system's central control unit, responsible for executing automation logic, interpreting data from various sensors, and managing the operation of actuators in real time.

To ensure continuous monitoring of environmental and operational conditions, the system incorporates water level sensors and a gas detection sensor. The water level sensors provide real-time measurements of fluid levels within drainage channels, enabling the PLC to initiate appropriate responses—such as pump activation or alarm signals—when specific thresholds are reached. Concurrently, the gas sensor detects the presence of hazardous gases, which pose significant safety risks in industrial settings.

Upon detecting unsafe gas concentrations, the system automatically activates a ventilation exhaust fan, which is directly controlled by the PLC based on sensor input. This mechanism ensures the prompt dispersal of harmful gases, thereby maintaining a safe operational environment.

The system's automated response functionality significantly enhances its safety, efficiency, and reliability, making it particularly suitable for complex industrial drainage environments where continuous human oversight may not be feasible. Within the proposed setup, two water level sensors are strategically deployed to monitor and distinguish between low and high-water levels in the drainage channel. These sensors function as critical diagnostic tools, aiding in the detection and localization of potential blockages within different segments of the pipeline.

When water levels drop below the threshold of the lower sensor, the system interprets this condition as indicative of an upstream blockage—often resulting from sediment buildup or structural obstructions that restrict flow. In response, a red warning indicator is activated, and the motorized pump is engaged to initiate water movement or notify maintenance personnel of the issue.

Conversely, activation of the upper-level sensor suggests a downstream blockage, typically caused by accumulated debris, silt, or non-degradable materials beyond the current monitoring point. Such obstructions impede water flow, leading to elevated water levels that trigger a high-level alert.

Unresolved blockages of this nature can severely compromise drainage efficiency and may result in overflow or localized flooding. The system's ability to detect these anomalies in real-time enables the issuance of early warnings, facilitating timely interventions and minimizing potential damage. This proactive approach is essential for maintaining uninterrupted drainage operations.

The dual-sensor configuration not only allows for the detection of blockages but also provides insight into their likely location within the network. This intelligent feedback mechanism supports faster fault identification, reduces the time and effort needed for diagnostics, and empowers maintenance teams to shift from reactive to preventive maintenance strategies.

The block diagram of the proposed system is presented in Fig. 1.

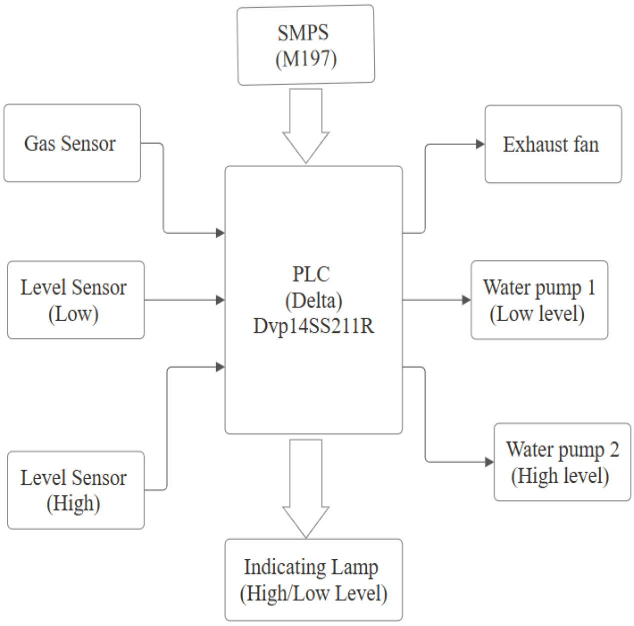

Fig.1. Block Diagram of a PLC Based Automatic Drainage Water Monitoring & Control System.

The system architecture is structured around a centralized Programmable Logic Controller (PLC), which serves as the brain of the monitoring and control operation. The input terminals of the PLC—typically located on the left side of the module—are interfaced with essential sensors, including a liquid level sensor and a gas sensor. These sensors continuously monitor environmental parameters within the drainage system. The PLC is powered through a stable external power supply, ensuring uninterrupted operation. Sensor data is transmitted in real time to the PLC, where predefined logic determines appropriate control responses based on the current system conditions.

On the output side of the PLC, which is typically configured on the right side of the module, key actuators are connected. These include two water pumps and an exhaust fan, each serving a distinct purpose. One pump is dedicated to discharging excess water from the drainage tank, thereby preventing overflow and reducing the risk of water blockage in the drainage system. The second pump maintains a stable water level within the system by regulating inflow or circulation as needed. Additionally, the exhaust fan—also connected to both the PLC and a power supply—is controlled directly by readings from the gas sensor. When hazardous or elevated gas levels are detected, the PLC activates the exhaust fan to ensure proper ventilation and minimize safety risks. This integrated design enables automated, efficient management of both fluid dynamics and air quality in the drainage environment.

The core functionality of the system lies in the control logic programmed into the PLC using ladder logic or function block diagrams. This logic governs the sequence of operations based on sensor inputs, ensuring that responses are both timely and appropriate. For instance, if the gas sensor detects a rise in harmful gas concentration beyond a set threshold, the exhaust fan is automatically activated to expel the gas and maintain safe air quality levels. Similarly, when water levels fluctuate—either dropping below or rising above critical points—the corresponding pump is engaged to restore balance. This autonomous decision-making process not only reduces the need for manual intervention but also enhances the reliability and safety of the entire drainage system. By leveraging real-time feedback and intelligent automation, the system exemplifies a practical application of smart infrastructure technologies aimed at improving urban utility management.

3. SYSTEM DESIGN

In this project, a range of electromechanical and electronic components are integrated to enable automated monitoring and control of drainage water and toxic gases. The key components include gas sensors, liquid level (float) sensors, an SMPS (Switched Mode Power Supply), an exhaust fan, water pumps, indicator lamps, relays, and semiconductor devices such as the 7812 voltage regulator, BJT 3904 transistor, and a thyristor. Each component is carefully selected to fulfill a specific function within the system. The gas sensor is used to detect the presence of harmful gases in the drainage environment, while the float sensors monitor the water level to identify overflow or low-water conditions. The SMPS supplies stable DC power to the PLC and connected devices.

The heart of the control logic lies in the configuration of the PLC, which consists of both input and output terminals for interfacing with external devices. The **input pins** include: COM (0V reference), **X0 (Start switch)**, **X1 (Stop switch)**, **X2 (Float Sensor 1 – Low Level)**, **X3 (Float Sensor 2 – High Level)**, and **X4 (Gas Sensor)**. These inputs serve to initiate operations, control system status, and provide real-time data to the PLC for decision-making. The **output pins** are powered via COM (24V) and include: **Y0 (Water Pump 1 – for releasing excess water)**, **Y1 (Low Water Level Indicator Lamp)**, **Y2 (Water Pump 2 – for maintaining water level)**, **Y3 (High Water Level Indicator Lamp)**, and **Y4 (Exhaust Fan).** The PLC uses these outputs to activate devices based on the programmed logic and sensor conditions.

This configuration is designed to ensure the system operates with minimal human intervention, relying on real-time data from sensors to make intelligent decisions. As water levels fluctuate or gas concentrations increase within the drainage system, the Programmable Logic Controller (PLC) interprets these inputs and activates the appropriate output devices. For example, if the water level falls below a predefined threshold, the system engages the water-level maintenance pump and illuminates the low-level indicator lamp. Similarly, when the upper float sensor detects a potential overflow, the second pump is triggered to discharge excess water, and the high-level lamp is activated to alert maintenance personnel. In the presence of toxic gases, the PLC energizes the exhaust fan to improve air circulation and prevent hazardous build-up.

The system's control components—including relays, voltage regulators, and transistors—play a crucial role in ensuring safe and stable operations. Relays are employed to interface low-power control signals with high-power devices such as pumps and fans, preventing electrical overload. The 7812 voltage regulator maintains a consistent 12V supply to sensitive components, enhancing the system's durability and electrical safety. The BJT (3904) and thyristor are used to manage switching operations and provide additional protection from voltage spikes or short circuits. Overall, the modular integration of these components allows for scalability, ease of troubleshooting, and reliable performance in complex urban drainage environments.

The operational logic of the proposed system is visually represented in Figure 2, which outlines the step-by-step flow of processes from system initiation (START) to conclusion (END). The figure delineates how the system responds to two primary types of input—liquid level and gas concentration—by triggering specific outputs through the PLC. Each input activates a dedicated sensing and decision-making process, allowing the system to carry out two independent but interrelated control functions in real time. The flowchart provides a clear visualization of how input conditions are evaluated, compared against predetermined thresholds, and how appropriate control actions are executed in a closed-loop cycle.

In the case of **liquid level monitoring**, the process begins with the "Liquid Level Detect" block. Here, float sensors measure the current water level in the drainage system. The information is then passed to the "Check Liquid Level & Compare" block, which evaluates whether the detected level matches a predefined set point. If the liquid level exceeds this threshold, the system sends a signal to the PLC to activate the associated pump motor, allowing excess water to be discharged. Once the water level returns to a safe range, the system resets to its initial state. However, if the detected water level does not match the set point, the system continues to monitor until the desired level is achieved, ensuring a stable and controlled drainage condition.

For **toxic gas detection**, the operation begins with the "Gas Levels Detect" block, where gas sensors measure the concentration of harmful gases present in the drainage atmosphere. This data is then evaluated in the "Check Gas Value & Compare" block, where the measured value is compared to a critical threshold—set at 40% gas concentration for this project. If the sensor reading reaches or exceeds this threshold, the PLC is instructed to open a solenoid valve and activate the exhaust fan. The fan continues to operate until the gas concentration is reduced to a safer level, specifically down to 20%. If the detected gas concentration is below the 40% threshold, the system loops back to re-evaluate the gas levels continuously. This ensures that any build-up of hazardous gases is addressed promptly and efficiently, enhancing safety within the drainage environment.

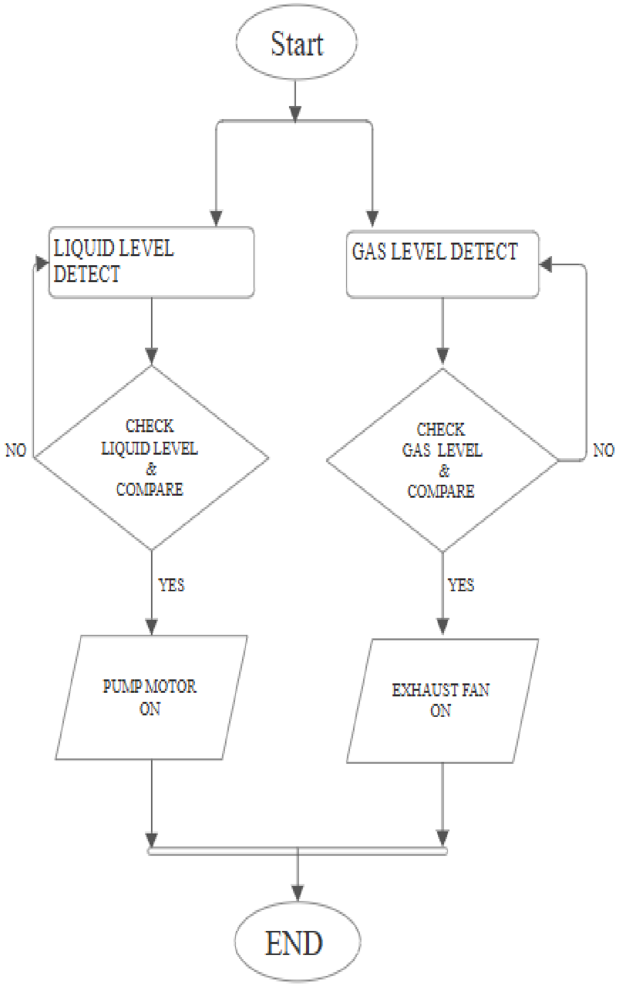

Fig.2. Design flow chart of a PLC Based Automatic Drainage Water Monitoring & Control System

Figure 2 presents the flowchart that outlines the operational logic of the PLC-based automatic drainage monitoring and control system. The chart illustrates the sequential flow of data and control signals within the system, beginning with continuous monitoring from the level sensors and gas sensor. When the water level in the drainage tank drops below or rises above the predefined thresholds, the respective float sensors (low and high level) detect the change and transmit a signal to the input terminal of the PLC. The PLC, using pre-programmed logic, processes this information and activates the appropriate motor (pump). If the water is below the minimum level, the pump responsible for maintaining the water level is switched on. In contrast, if the water exceeds the upper threshold, the second pump is engaged to discharge the excess water and prevent overflow.

Simultaneously, the gas sensor constantly monitors for the presence of harmful or flammable gases within the drainage environment. When toxic gases are detected beyond the safety threshold, the sensor sends a signal to the PLC. In response, the PLC immediately triggers the exhaust fan through its output terminal. The fan then starts operating to ventilate the area by extracting the toxic gases, thus ensuring safer air conditions in and around the drainage system. This automated response eliminates the need for manual inspection and reduces exposure risks for maintenance personnel.

The flowchart serves as a visual representation of how each component interacts within the system based on real-time environmental feedback. It highlights the conditional decision-making process embedded within the PLC program—where actions are taken only when specific sensor inputs meet or exceed defined criteria. This logical, step-by-step operation ensures the system remains energy-efficient, responsive, and safe under various operating conditions. Ultimately, the flowchart simplifies the understanding of a complex control system, making it easier to troubleshoot, optimize, or scale in future applications.

Table -1: PLC pin and connected to the specific element

Sr. No.	PLC Pin	Element
	INPUT	
1	Com	0v
2	X0	start
3	X1	stop
4	X2	float sensor 1
5	X3	float sensor 2
6	X4	gas sensor
	OUTPUT	
7	Com	24V
8	Y0	pump 1
7	Y1	low lamp
10	Y2	pump 2
11	Com	24V
12	Y3	high lamp
13	Y4	fan

Here table show PLC Pin connected to desired elements.

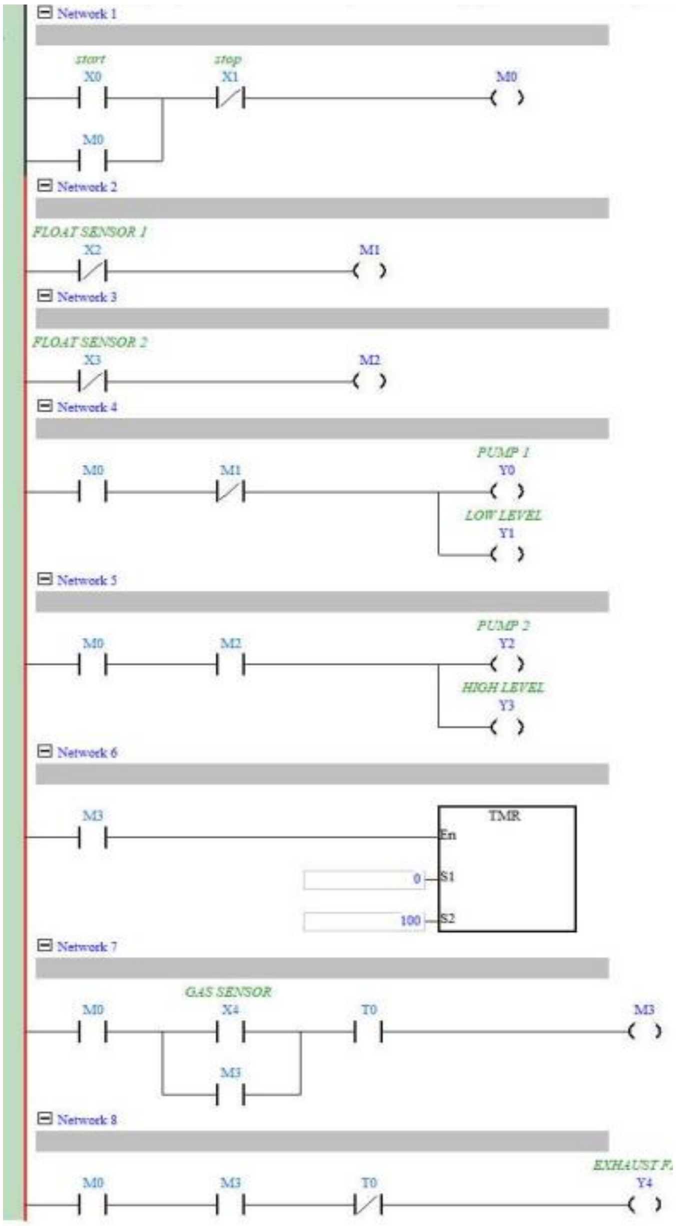

Fig.3. Ladder diagram of a PLC Based Automatic Drainage Water Monitoring & Control System

To program the PLC ISP Soft programming software is used in this project. Ladder Diagram (LD) method is used as a programming language. The Delta PLC was enabled to be programmed using this software. In Fig.4 the ladder diagram for this project was drawn using this software.

4. SYSTEM IMPLEMENTATION

Figure 4 illustrates the experimental setup of the PLC-based automatic drainage water monitoring and control system. The diagram showcases the integration of two primary sensing components: a gas sensor and a liquid level sensor. The gas sensor is responsible for detecting the concentration of toxic gases within the surrounding environment. Upon identifying the presence of harmful gases above the preset threshold, the sensor sends a signal to the PLC, which in turn activates the exhaust fan. The fan operates to extract the toxic gases and facilitate the inflow of fresh air, thereby restoring safe atmospheric conditions. This real-time response ensures rapid mitigation of hazardous gas exposure, especially in enclosed or poorly ventilated drainage environments.

Simultaneously, the liquid level sensor continuously monitors the volume of waste liquid in the drainage or storage tank. When the liquid level reaches or exceeds a defined limit, the sensor communicates with the PLC, prompting it to activate the pump motor. The motor then evacuates the excess liquid from the tank, maintaining the system's operational stability and preventing overflow. This experimental configuration clearly demonstrates the role of the PLC as the central control unit, processing data from both sensors and coordinating the corresponding actuator responses. The result is a fully automated system capable of managing two critical aspects of drainage safety—gas ventilation and fluid level regulation—without manual intervention.

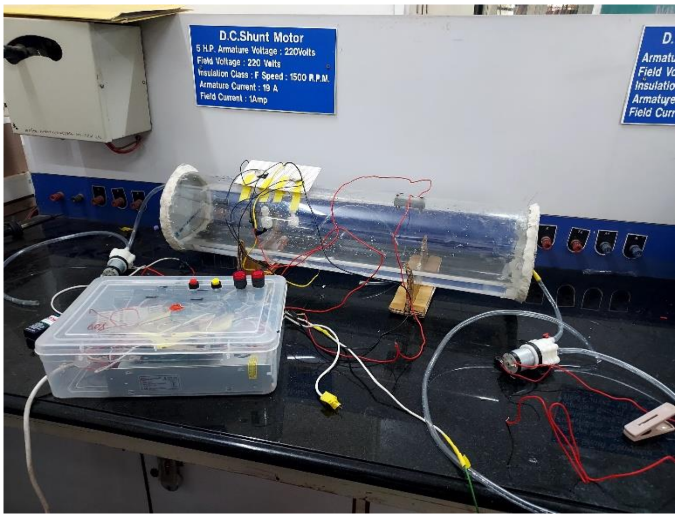

Fig.4. Experimental setup of the PLC Based Automatic Drainage Water Monitoring & Control System

During the system's performance evaluation, all integrated sensors—including the gas sensor and the liquid level sensors—functioned as expected, accurately detecting environmental conditions and transmitting real-time data to the Programmable Logic Controller (PLC). The sensors exhibited high sensitivity and responsiveness, promptly identifying variations in both water levels and toxic gas concentrations. This real-time data acquisition was critical in enabling timely decision-making within the PLC, which then executed the appropriate control actions such as activating the exhaust fan or initiating pump operations.

The PLC successfully managed the entire process, validating its role as the central controller of the system. It not only processed sensor input with precision but also effectively coordinated actuator responses, ensuring smooth system functionality. Additionally, the system provided visual feedback by displaying both water levels and gas concentration values, allowing for better monitoring and transparency. This confirmed that the PLC-based control mechanism is both reliable and efficient for continuous drainage system automation, aligning with smart infrastructure objectives.

The PLC demonstrated robust and consistent performance in managing the entire system, reinforcing its role as the central processing and control unit. It accurately interpreted input signals from both the gas and liquid level sensors and coordinated timely responses by activating the corresponding actuators, including the exhaust fan and water pumps. This ensured uninterrupted operation and quick adaptation to changing environmental conditions. Furthermore, the system featured real-time visual feedback, effectively displaying water levels and gas concentrations. This added layer of transparency enhances monitoring efficiency and supports rapid decision-making. The successful operation confirms the reliability, responsiveness, and suitability of the PLC-based automation framework for smart drainage system applications within modern urban infrastructure.

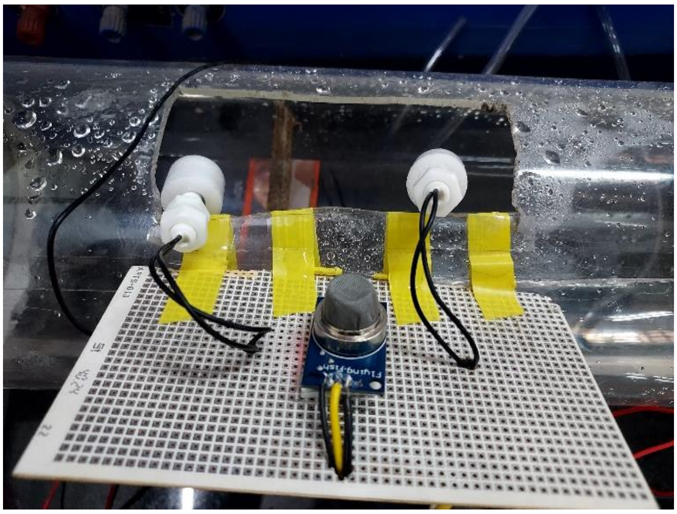

Fig.5. Sensors of the PLC Based Automatic Drainage Water Monitoring & Control System

Figure 5 illustrates the primary sensing components employed in the PLC-based drainage monitoring and control system. The setup includes two liquid level sensors and one gas sensor, each playing a critical role in environmental monitoring. The two float-type level sensors are strategically positioned to detect both low and high water levels in the drainage tank. These sensors provide the PLC with continuous feedback regarding fluid status, enabling it to determine whether to activate the pump for drainage or maintain water at a desired level.

The gas sensor, positioned within the drainage area, is responsible for detecting the presence and concentration of hazardous gases. It communicates real-time data to the PLC, which processes the input and, when necessary, triggers the exhaust fan to ventilate the area. The inclusion of these sensors ensures a comprehensive monitoring mechanism for both water and air quality, making the system reliable and responsive in managing drainage operations under varying environmental conditions.

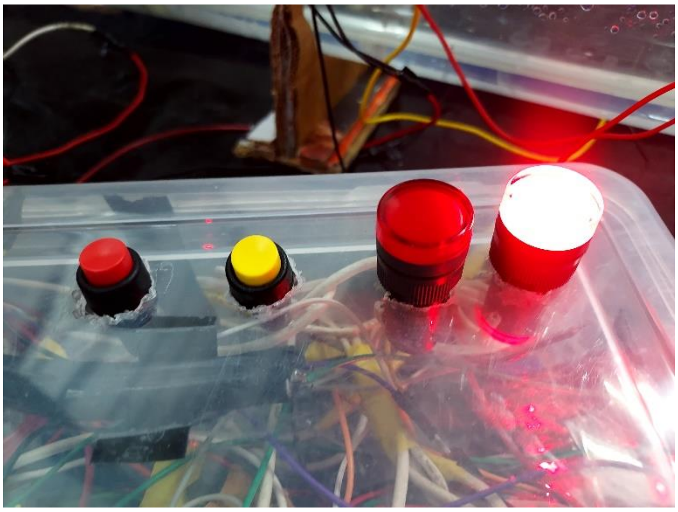

Fig.6. Switches and indicating lamp of the PLC Based Automatic Drainage Water Monitoring & Control System

Figure 6 depicts the interface components used for user interaction and system status indication within the project. The setup includes two push-button switches and two indicator lamps, each assigned a specific function to support the operation and monitoring of the drainage system. The first switch functions as the START switch, initiating the system's operation by supplying power to the PLC and activating the sensors. The second switch serves as the STOP switch, allowing the user to safely terminate system activity when required.

Additionally, the two indicating lamps provide real-time visual feedback based on water level status. The first lamp is configured to illuminate when the water level falls below the lower threshold, indicating a low-level condition and signalling that the pump for water level maintenance should be activated. The second lamp lights up when the water level exceeds the high-level threshold, alerting users to potential overflow and triggering the pump for excess water discharge. Together, these switches and indicators enhance the system’s usability, safety, and monitoring clarity, ensuring operators are informed of key conditions without relying solely on sensor data displays.

5. CONCLUSION

In conclusion, the PLC-based automatic drainage water monitoring and control system offers a reliable, intelligent, and efficient solution for managing urban drainage infrastructure. By integrating level sensors and a gas sensor with a programmable logic controller, the system enables real-time detection of water levels and toxic gases, ensuring timely activation of pumps and exhaust fans. This automation reduces manual intervention, enhances operational safety, and minimizes the risk of environmental contamination or overflow. The project successfully demonstrates the potential of smart control systems in transforming conventional drainage networks into responsive and sustainable infrastructure components, aligning with modern smart city objectives.

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