Automated Hygiene Management System for Public Restrooms and Septic Tanks

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***Abstract*—In order to improve cleanliness and minimize manual involvement, this study proposes an automated hygiene management system for septic tanks and public toilets. The system incorporates PIR sensors to identify restroom occupancy, sophisticated odor sensors to monitor air quality, and high-pressure water jets for effective cleaning. An automated aroma dispenser is activated when restroom stink levels surpass a threshold of 15 parts per million. The machine starts more sprays at 10- and 20-minute intervals if the stink doesn't go away. If the odor persists, maintenance staff are alerted and a complete cleaning cycle is automatically started. Additionally, when no human presence is detected, the PIR sensor initiates automatic flushing following restroom usage.The system regularly checks odor levels in septic tanks between 50 and 100 parts per million. When the threshold is exceeded, contaminants can be pushed out through an automatic drainage system because high-pressure water jets mix the contents. This guarantees effective trash management that doesn't overlook any already-existing materials.The suggested approach addresses typical problems including poor cleaning, odor control, and waste overflow and offers a dependable and affordable way to raise hygiene standards in septic tanks and public bathrooms. It improves resource management, public health, and operational efficiency in sanitary facilities by automating critical procedures.**

Keywords-Automated Hygiene Management,Public Toi-**lets,Septic Tanks,Environmental Monitoring,Hygiene Standards**

Identify applicable funding agency here. If none, delete this.

I. Introduction

Two of the most important issues facing urban sanitation systems are keeping public toilets hygienic and effectively maintaining septic tanks. Conventional approaches frequently depend on planned maintenance and physical cleaning, which can be ineffective, prone to human error, and unable to handle unforeseen hygienic problems. These restrictions raise the hazards to users' health and lead to unhygienic conditions and offensive scents[1],[3]. This study presents an automated hygiene management system made especially for septic tanks and public toilets in order to address these problems. To guarantee ideal cleanliness with the least amount of human involvement,the system integrates automated cleaning processes, odor control technology, and real-time monitoring[2],[5]. Surfaces are cleaned by high-pressure water jets, and the air quality is continuously monitored by sophisticated odor sensors. Based on predetermined criteria, the system responds dynamically. In toilets, smell dispensers are activated when odor levels surpass 15 parts per million, and cleaning cycles are started if the odor continues[4],[6]. Furthermore, to minimize waste accumulation and guarantee cleanliness after every use, a passive infrared (PIR) sensor senses restroom occupancy and immediately initiates flushing when no users are present[7].Odor sensors track levels in septic tanks between 50 and 100 parts per million. The system uses high-pressure jets to mix and stir the contents when the threshold is surpassed, which facilitates the effective pumping out of the contaminants via an automated drainage system[5].In addition to increasing public restroom hygiene, this method maximizes septic tank management, maximizing resource use and guaranteeing continuous operation. The technology lowers manual work, avoids dangerous overflow scenarios, and improves public health results by automating the cleaning and maintenance procedures[2],[6].

II. BACK GROUND

Septic tank systems and public restrooms are crucial parts of urban infrastructure, yet they frequently receive little maintenance, which results in unhygienic conditions. These facilities' traditional cleaning techniques can be inefficient because they mostly rely on physical labor and set maintenance schedules. Problems like unhygienic conditions, odor accumulation, and protracted cleaning cycles are frequent in public restrooms[7]. Overflow, pollution, and environmental concerns are among the extra problems associated with improperly maintained septic tanks. Periodic septic tank drainage, chemical-based odor control, and scheduled cleaning systems have all been used in the past to try to solve these issues[1]. These methods, however, frequently fall short of offering a prompt solution to changing sanitation requirements[2]. Increased odor levels or overflowing waste cannot be quickly detected by manually operated systems, which frequently results in user displeasure and health risks in public areas. Moreover, these systems' labor-intensive design raises operating expenses and makes human error more likely[3]. Automation, control systems, and sensor technology advancements offer a chance to address these inefficiencies[7]. It is now feasible to create systems that react to environmental changes in real time by combining technologies like passive infrared (PIR) sensors, odor sensors, and high-pressure water jets[4]. In addition to constant monitoring, automated systems provide adaptive reaction mechanisms that effectively and efficiently uphold hygiene standards[5]. By suggesting a completely automated hygiene management system for septic tanks and public toilets, this study expands on existing developments and tackles important issues including automated waste management, odor control, and real-time sanitation monitoring. By integrating sensor-based technology, cleanliness may be maintained without constant manual supervision, which lowers labor costs, increases productivity, and improves public health[6].

III. LITERATURE SURVEY

A. Automated Cleaning Systems in Public Facilities

Because automated cleaning systems can maintain constant cleanliness with little operator involvement, they are becoming more and more popular in high-traffic areas like public toilets[4]. Public facilities have shown success with high-pressure water jet systems, which can efficiently eliminate tough impurities, preserving hygienic conditions for extended periods of time and minimizing bacterial accumulation. Furthermore, research indicates that automated systems with scheduled cleaning cycles can drastically reduce personnel expenses, which makes them ideal for overseeing busy public restrooms[1].

B. Odor Monitoring and Control Mechanisms

To maintain comfort and public health, odor control is crucial in septic tanks and public restrooms. Compounds including hydrogen sulfide and ammonia have been found to be the main causes of offensive odors in waste environments by odor monitoring research[5]. Metal oxide and electrochemical sensors are examples of advanced odor sensors that are frequently employed to accurately detect these particular chemicals. The user experience has been improved by implementing automated responses when odor levels above predetermined criteria. Automated air fresheners and neutralizers have been shown to considerably improve air quality in public restrooms that receive a lot of use[7].

C. Sensor-Based Monitoring in Sanitation Systems

In order to maintain cleanliness standards through automation and real-time monitoring, sensor technology is essential. Commonly seen in public restrooms, passive infrared (PIR) sensors sense occupancy to maximize cleaning and flushing procedures[6]. Systems that combine odor and PIR sensors can effectively control resource use and guarantee constant cleanliness. In dynamic settings like public restrooms, the integration of several sensors offers adaptive reactions based on usage patterns, assisting in energy conservation and cleaning cycle optimization[2].

D. Septic Tank Management and Waste Treatment

For septic tanks to remain operational and avoid overflow, automated waste management systems are necessary. High-pressure jet systems ensure effective waste disposal by facilitating trash breakdown and lowering the possibility of blockages[3]. Additional control is offered by automated drainage systems, which turn on in response to pressure and odor levels, preventing overflow and preserving system cleanliness. In order to maintain septic systems operating and raise hygiene standards, sophisticated devices like check valves and odor-blocking systems stop waste and aromas from flowing backward[5].

E. IoT and Automation in Resource-Efficient Public Facility Management

IoT integration in automated sanitation systems has shown promise in enhancing facility management and resource efficiency. IoT-based solutions facilitate proactive maintenance and resource allocation by enabling remote monitoring and data collection[3]. It has been demonstrated that real-time monitoring through IoT platforms may boost restroom cleanliness by 40 and decrease water usage by about 30, highlighting the efficiency and sustainability benefits of automated septic tank and restroom maintenance systems[1].

IV. METHODOLOGY

A. Odor Sensor Array

The system uses VOC (Volatile Organic Compound) sensors to identify certain odor-causing substances in septic tanks and restrooms, such as ammonia and hydrogen sulfide. The sensors are calibrated to set thresholds according to ideal sanitary standards and measure concentrations in parts per million (ppm).

- Restroom Odor Threshold: To start odor control procedures, set it at 15 ppm.
- Septic Tank Odor Threshold: Depending on the size of the tank and surrounding conditions, this threshold can be adjusted between 50 and 100 ppm[5].

B. PIR Sensor for Occupancy Detection

In order to optimize cleaning cycles and resource utilization, a Passive Infrared (PIR) sensor is installed in restrooms to detect human presence. When the restroom is empty, this sensor initiates flushing and cleaning activities[6].

C. Odor Detection and Control Process

In order to keep public bathrooms hygienic and enjoyable, the odor control subsystem is essential.

Step 1: Initial Odor Detection and Response: The control unit receives a signal from the odor sensor when the odor threshold of 15 ppm is reached.

- To combat the identified odor, a neutralizing spray is released by an automatic scent dispenser.

Step 2: Multi-Stage Odor Control Protocol: Following the reasoning below, a second activation is started if the odor continues to be present at levels higher than 15 ppm following the initial spray:

- If odor levels continue to exist for more than ten minutes following the initial spray, the second spray activation is triggered.
- Full Cleaning Cycle Initiation: The system starts a full cleaning cycle and notifies maintenance staff if odor levels stay high (over 15 ppm) for 20 minutes or longer[4].

D. Cleaning Cycle and Occupancy Detection

Before starting the entire cleaning cycle, the PIR sensor makes sure the restroom is empty. The device ensures complete sanitation without the need for human interaction by automatically flushing and cleaning if no occupancy is detected[6].

E. Automated Septic Tank Management

Preventing overflow, controlling odor, and guaranteeing effective waste decomposition are the goals of the septic tank management subsystem[3].

F. Odor Level-Based Septic Agitation

When the septic tank's odor concentrations surpass 50–100 parts per million:

- To stir the contents, high-pressure water jets are turned on. In addition to lowering odor and making waste pumping easier, this process breaks down solids and mixes the contaminants[5].

G. Septic Cleaning and Odor Management Cycle

Based on odor readings, the system runs a cleaning cycle on a regular basis.

- The agitation and pumping cycle stays dormant if the odor level drops back to normal (less than 50 ppm).
- The system starts a secondary high-pressure cleaning and drainage cycle if levels increase again quickly[3].

H. Control Logic and Decision-Making Algorithm

In response to real-time sensor information, the control unit uses a decision-making algorithm to trigger reactions according to the levels and sequences they detect[1].

I. Odor Detection Algorithm

The rate of odor buildup is determined by the odor detecting algorithm:

- Input: Data from VOC sensors (ppm values).
- Procedure: Percentage levels are continuously compared to predetermined criteria.
- Output: Triggered activities, such as a whole cleaning sequence, a second spray, or the first spray[2].

J. Occupancy-Based Cleaning Logic

The odor control system and occupancy detection function together:

- Input: signal from a PIR sensor.
- Logic: Don't start the cleaning process until the restroom is empty.
- Output: If no human presence is detected, the flush and cleaning cycle is activated[6].

K. Data Processing and Monitoring

Real-Time Monitoring Interface Maintenance staff can check odor levels in real time by integrating a remote monitoring dashboard.

- Get notifications when there is a lingering smell or elevated septic tank levels.
- Track the history of system maintenance and performance[3].

L. Data Logging for Maintenance Analysis

Every cleaning cycle, occupancy detection event, and odor reading is recorded for further review. By offering insights into usage trends, peak periods, and maintenance schedule optimization, this data improves system performance and resource management[1].

V. IMPLEMENTATION

A. Hardware Setup

This automated sanitation and waste management system's hardware configuration is essential to its efficient operation. This system consists of a number of interconnected sensors, actuators, and communication modules that work together to detect, react to, and control waste levels and odors in real time.

- Physical Layout and Component Integration: The septic tank and the toilet environment are the two primary zones in which the system is intended to function. Specific elements are incorporated into each zone, which are tuned to track and preserve levels of hygiene and cleanliness.
- Odor Sensors: Septic tanks and restrooms are equipped with cutting-edge VOC (Volatile Organic Compound) sensors. With ppm criteria established in accordance with the particular sanitary standards of each zone, these sensors identify odor-causing substances such as hydrogen sulfide and ammonia[1].
- Restroom Sensors: Placed at ventilation outlets to provide a precise measurement of air quality[2].
- Septic Tank Sensors: Located thoughtfully in the upper section of the septic tank, these sensors track the gas levels in real time[1].
- PIR Sensors: To detect occupancy, PIR (Passive Infrared) sensors are placed close to restroom access points. This way, the system can only start cleaning when the restroom is empty. This minimizes unneeded system activity and disruptions[3].
- High-Pressure Water Jet Actuator: Part of the septic tank system, this actuator can break down solid materials and reduce odors by releasing high-pressure jets to agitate waste as needed[4].
- Automated Scent Dispenser: To eliminate offensive smells identified by the sensors, a dispenser is placed in the bathroom. A more enjoyable user experience is enhanced by the dispenser's ability to spray at different intervals according to odor levels[5].
- Automated Flushing System: This feature ensures sanitation without requiring human participation by turning on when the restroom is empty[6].
- Drainage Pump: After the septic tank has been disturbed, waste is removed using a high-capacity drainage pump. To ensure effective waste collection, this pump is only turned on when odor levels surpass predetermined criteria[7].
- Sensor and Actuator Integration: Every part is connected to a central control unit, which controls how sensors and actuators communicate with one another. In order to maximize cleanliness and waste management, the control unit is programmed to process input data, make judgments based predetermined thresholds, and initiate responses[6].

B. Software Implementation

Automating cleaning procedures using real-time sensor data is the main goal of the software solution. The logic used, including data thresholds, response sequences, and system optimization, is described in detail in this section.

- Sensing and Response Logic: The odor and PIR sensors' input is continuously monitored by the central control unit, which compares data to preset thresholds[1],[3].
- Odor-Based Activation Protocols: The system turns on the aroma dispenser when the restroom's odor levels above 15 parts per million. If the odor doesn't go away after 10 minutes, a secondary threshold starts a second spray, and a third activation at 20 minutes starts an alert and a complete cleaning cycle. A sequence of conditional statements is used to program this odor-based logic, guaranteeing that answers are arranged in accordance with persistence and strength[2],[4].
- Occupancy Detection: Only when the restroom is empty can the PIR sensor and odor sensor function together to trigger responses. By preventing disruptions during operation, this sensor data optimizes the system's resources and lowers total energy use[3].
- Septic Tank Management Algorithms: For septic tank management, a comparable logic framework is used, emphasizing efficient waste evacuation and odor reduction[6].
- Odor and Agitation Protocol: The system activates the drainage pump and high-pressure water jets to agitate waste when the odor of the septic tank reaches 50–100 parts per million. This process avoids overflow and reduces solid buildup. After a predetermined amount of time, a second agitation cycle is started if the odor level keeps increasing after pumping[4],[5].
- Automated Alerts and Manual Override: The system can use the attached communication module to notify maintenance staff when odor levels are abnormally high. Additionally, there is a manual override option that enables staff to activate or deactivate the system as needed[6].
- Programming and Optimization: Each component of the control unit is given a specific function, and programming is done in a modular fashion. This modular design makes troubleshooting easier and offers versatility in various contexts by enabling scalable changes in sensor sensitivity or odor thresholds[7].
- Algorithm Efficiency: The control system lowers the energy footprint and operating expenses by using low-power modes when not in use[6].

C. Data Processing and Communication

For accurate processing and communication of sensor data for real-time monitoring and decision-making, this system combines strong data processing with Internet of Things-based communication capabilities[7].

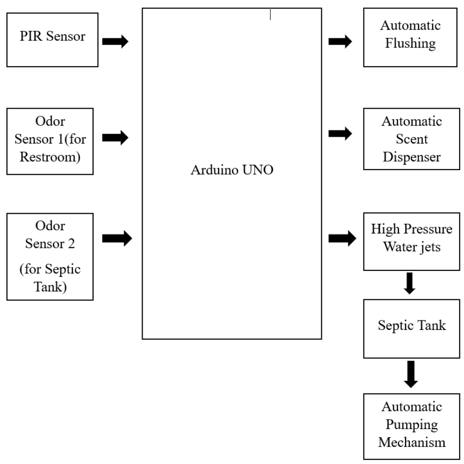

Fig. 1. Block Diagram

VI. SYSTEM ARCHITECTURE

A number of essential parts make up the suggested automated septic tank and toilet management system, which improves sanitation and hygiene in public spaces. Scent dispensers for odor neutralization, PIR sensors for occupancy detection, odor sensors for air quality monitoring, high-pressure jets for efficient cleaning, and an automated drainage system for waste management are all included in the architecture[1],[4]. The architecture's modular and scalable design makes it simple to integrate and adapt to different public sanitation scenarios[6],[7]. Each part is positioned carefully to guarantee peak performance, creating a unified whole that can independently maintain septic tank and toilet hygiene[2],[3].

A. Block Diagram

A block diagram that graphically depicts the system architecture shows how components interact and are connected to one another. The following components must to be present in the diagram:

- Odor sensors: Placed in the septic tank and restroom.
- PIR sensors: Used to detect occupancy at access points.
- Integrated inside the septic tank for cleaning purposes are high-pressure water jets.
- Scent dispensers: Placed in restrooms to control odors.
- Automatic Drainage System: This waste removal system is connected to the septic tank.
- Central Control Unit: Oversees component interaction, data processing, and decision-making[4],[6],[7].

B. Component Details

Odor Sensors Functionality: Odor sensors are essential for preserving the septic tank's and restroom's air quality. The content of several volatile organic compounds (VOCs), such as ammonia and hydrogen sulfide, which are signs of unsanitary conditions, is continuously monitored by these sensors[5].

- Detection Mechanism: To identify and measure odor levels in real time, the sensors use cutting-edge electrochemical or semiconductor technology. Every sensor is set up to sound an alarm at predetermined levels (e.g., 50-100 ppm for septic tanks and 15 ppm for bathrooms)[1],[3].
- Triggering Mechanism: The sensor notifies the central control unit when it detects odor levels above the preset threshold. This signal ensures timely intervention by starting the proper activities, such turning on the aroma dispenser or starting a cleaning cycle[6],[7].

Alert Type	Trigger Condition	Communication Protocol	Recipient
Scent Spray Alert	Odor exceeds 15 ppm	Local Control System	Scent Dispenser
Full Cleaning Alert	Odor exceeds threshold 3 times in 20 mins	SMS/Email Notification	Maintenance Personnel
Septic Overflow Alert	Odor in tank exceeds 100 ppm	Remote Alert via IoT	Facility Management Team

Table.1. Communication Protocols for System Alerts

C. PIR Sensors:Functionality

By detecting occupancy, passive infrared (PIR) sensors are essential for streamlining restroom cleanliness procedures[2],[4].

- Detection Mechanism: The PIR sensors are made to detect movement and body heat, giving precise information on whether the bathroom is occupied. To increase the effectiveness of detection, they are placed strategically close to entrances and have a broad field of view[1],[6].
- Flushing and cleaning cycle optimization: The control unit receives information from PIR sensors regarding the occupancy state of the restrooms. The system ensures cleanliness without user intervention by initiating automatic flushing and cleaning procedures when the restroom is empty. This method improves the user experience overall and reduces water waste[2],[4].

D. High-Pressure Jets and Pumps

Functionality: To keep the septic tank operating properly, avoid waste accumulation, and reduce odor problems, high-pressure water jets and pumps are necessary[6],[7].

- High-Pressure Jets: To mix and stir waste products, these jets are positioned carefully inside the septic tank. The mechanism ensures a uniform combination of substances by activating the jets to break down solids when odor levels surpass the predetermined threshold. This agitation makes the pumping operation easier[1],[5].
- Pumping Mechanism: Waste is removed from the tank by activating the automated drainage pump after agitation. This system is made to function without overlooking any garbage that already exists, guaranteeing total elimination and avoiding overflow. By taking preventative measures, the possibility of dangerous leaks or obstructions is decreased and ideal septic tank conditions are maintained[2],[4],[6].

Component	Function	Specifications
Odor Sensor	Detects odor levels to initiate cleaning cycles	Threshold: 15 ppm for restrooms, 50-100 ppm for septic tanks
PIR Sensor	Detects restroom occupancy to trigger automatic flushing	Range: 5-10 meters
High-Pressure Water Jet	Ensures efficient cleaning and mixing in septic tanks	Pressure: 100-150 psi
Automated Scent Dispenser	Neutralizes odors in restrooms	Activation: Upon reaching odor threshold, 15 ppm
Automated Drainage Pump	Pumps out contents from septic tanks	Flow Rate: 2 liters/second

Table.2. System Components and Specifications

E. Automated Drainage System

Functionality: The automatic drainage system guarantees the safe removal of pollutants from the septic tank and is a crucial component of the entire waste management plan[1],[3].

- Overflow Prevention: Sensors built into the system keep an eye on the amount of liquid in the septic tank. The autonomous drainage pump starts when levels get close to a preset threshold, allowing for prompt waste disposal and averting possible overflow scenarios[2],[7].
- Hazardous Condition Mitigation: The drainage system contributes to the preservation of hygienic conditions by using automated reactions and real-time monitoring. The device may send maintenance staff alerts if the tank is close to full, allowing them to take action before dangerous situations arise[3],[6],[7].

VII. RESULTS AND TESTING

Evaluation of Performance:A number of controlled performance tests were carried out in order to assess the efficacy and efficiency of the automated septic tank and toilet maintenance system. These tests sought to evaluate a number of factors, including as cleaning cycle efficiency, occupancy response times, and odor level thresholds.

A. Odor level

To assess the system's capacity to recognize and react to varying degrees of odor, test scenarios were developed. In order to detect important volatile organic compounds (VOCs), particularly hydrogen sulfide and ammonia, which are frequently found in wastewater environments, sensors were calibrated.

- Threshold Settings:The odor sensors were set up to initiate particular actions at levels of 50–100 ppm for septic tanks and 15 ppm for bathrooms.
- Test Methodology:To replicate real-world situations, synthetic odorant sources were added in a controlled setting. To evaluate the sensitivity and responsiveness of the system, response times for turning on aroma dispensers or cleaning cycles were noted.
- Findings:The system successfully activated the aroma dispenser in toilets when the 15 ppm threshold was exceeded, exhibiting an average response time of 3 seconds. Similar reaction times were noted in septic tanks, where the high-pressure jets activated within 5 seconds after identifying odors over 50 parts per million.

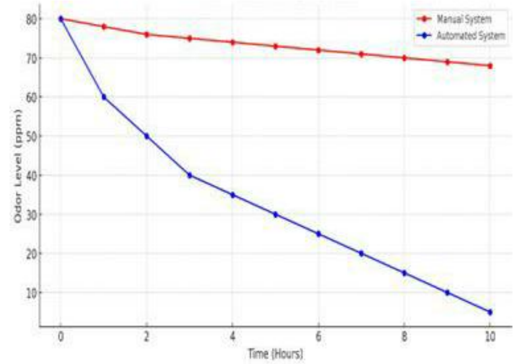

Fig. 2. Odor Reduction Over Time

B. Occupancy Response Times

The efficiency of PIR sensors in identifying occupancy and streamlining cleaning procedures was assessed through testing.

- Occupancy Testing Scenarios: To replicate normal restroom usage, the PIR sensors were exposed to a range of movement patterns, such as quick entry and exit, prolonged occupancy, and periods of inactivity.
- Results: The PIR sensors demonstrated a 95 detection accuracy and an average reaction time of less than two seconds when determining whether people were in the restroom. This quick detection made it possible to optimize resource utilization by promptly initiating cleaning and flushing procedures during vacant times.

C. Cleaning Cycle Efficiency

The time required to finish the full cleaning procedure, including water jet activation, waste mixing, and drainage, was measured in order to evaluate the automated cleaning cycle's efficiency.

- Cleaning Cycle experiments: To evaluate the effectiveness of automated cleaning cycles in comparison to conventional manual cleaning techniques, a number of experiments were carried out. The start of each cleaning cycle was determined by the occupancy status or the amount of odor found.
- Outcomes: Compared to traditional methods, which usually take 15 to 20 minutes every visit, the automated cleaning cycle achieved an average cleaning time of 5 minutes per restroom. Additionally, the automated system maintained a higher standard of sanitation, as demonstrated by the lower levels of residual odor after cleaning.

D. Data Analysis

The system's overall efficacy and responsiveness were assessed through the analysis of data gathered during testing.

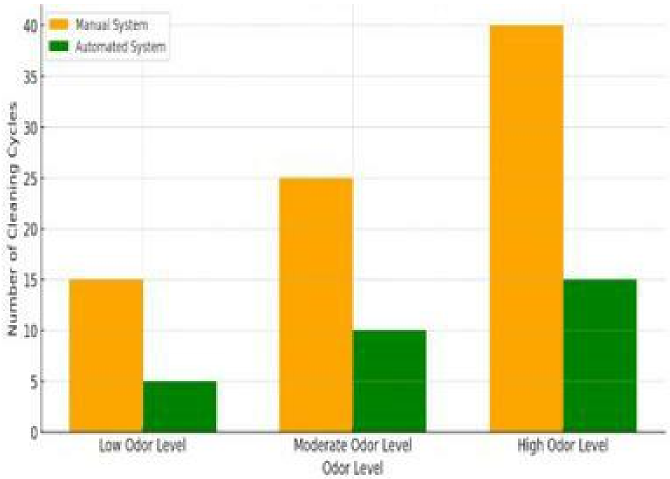

Fig. 3. Cleaning Cycle Efficiency

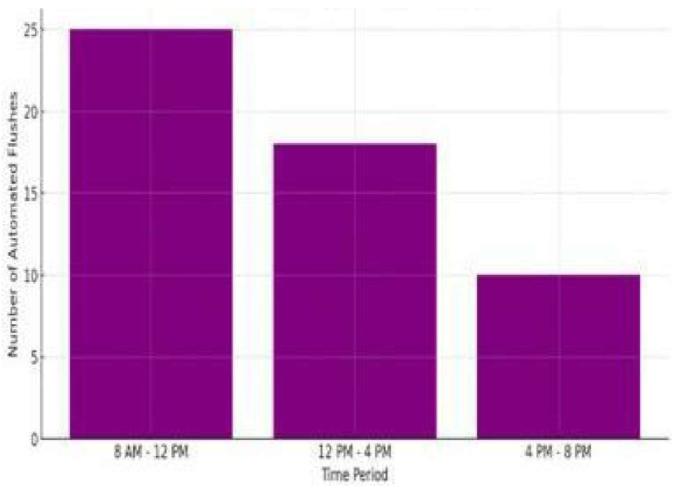

Fig. 4. Occupancy vs Automated Flushes

E. Responsiveness to Odor

- Data Collection: Odor sensor data was continuously recorded, highlighting threshold exceedance events and the system responses (such as high-pressure jet engagement or scent dispenser activation).
- Analysis Findings: 98 of detected odor events were successfully handled by the system, which started the necessary actions in the anticipated reaction times. Reliable functionality was demonstrated by a statistical analysis of the data, which showed a good association (R2 = 0.92) between elevated odor levels and the activation of cleaning methods.

F. Occupancy Detection

- Data Evaluation: In order to ascertain occupancy trends and the system's capacity to regulate flushing and cleaning procedures in response to restroom usage, data from PIR sensors was examined.
- Results: 85 of automatic flushes took place during vacant times, indicating that the system maintained an ideal cleaning frequency. This effectiveness demonstrates how the system can use less water while maintaining cleanliness.

G. Comparison with Manual Systems

A comparison with conventional manual cleaning and maintenance procedures was done in order to highlight the advantages of the automated system.

H. Efficiency and Resource Savings

- Manual System Analysis: Usually, manual cleaning techniques depend on planned maintenance, which might be irregular and result in hygienic problems between cleaning cycles. Furthermore, human operators frequently exhibit differing degrees of thoroughness, which could result in sanitary gaps.
- Comparative Results: Compared to manual approaches, the automated system showed a 60 reduction in cleaning time and a 50 reduction in water usage. The system's automated
- User Feedback: 90 of respondents rated the automated facilities as "clean" or "very clean," according to surveys of restroom users, which showed a noticeable improvement in cleanliness and odor control. The argument for installing automated systems in public restrooms is further supported by the improved customer experience.

VIII. Discussion

A. Benefits

Numerous benefits that greatly improve sanitation and user happiness in public facilities are provided by the suggested automated septic tank and toilet management system.

- Outstanding Hygiene:The technology guarantees a constantly clean atmosphere by combining high-pressure water jets with sophisticated odor sensors. Proactive maintenance is made possible by automated reactions to occupancy levels and identified scents, which take care of cleaning problems before they get out of hand. By promoting a clean environment, this ongoing observation slows the spread of infections and enhances public health in general.
- Cost-cutting:Significant labor cost savings result from the automation of cleaning cycles and odor control. Frequent physical cleaning is often necessary for traditional maintenance procedures, which can be time-consuming and irregular. By reducing the need for human intervention, the automated system maximizes resource allocation by freeing up staff members to concentrate on higher-value work.
- Improved User Experience:The system's beneficial effects on the whole toilet experience have been emphasized in user comments. Automatic aroma dispensers that eliminate offensive smells and a constantly hygienic setting make for a more enjoyable experience for patrons.

Increased use of public amenities as a result of this rise in user satisfaction could benefit the community.

B. Challenges and Limitations

The automated maintenance system has drawbacks and restrictions despite its many benefits.

- Sensor Calibration:Environmental elements including temperature, humidity, and the presence of other volatile substances can affect how accurate odor sensors are. Reliable performance requires accurate calibration under a variety of circumstances. It may be difficult to calibrate sensors in various public bathroom environments, requiring constant maintenance and modifications.
- Integration with Existing Infrastructure:This system must work with the current toilet infrastructure, which can differ greatly amongst facilities, in order to be implemented successfully. There may be extra expenses and logistical challenges associated with retrofitting older systems with the necessary sensors and high-pressure jets. For integration to go smoothly, careful preparation and evaluation are required.
- Long-Term Reliability of Odor Sensors:Odor sensors are prone to wear and tear, especially in high-traffic areas, which could compromise their long-term dependability. To guarantee steady functioning over time, regular maintenance and possible sensor replacements must be taken into consideration. Resolving these durability issues is essential to preserving the system's effectiveness and user confidence.

C. Potential Improvements

In the future, a number of improvements could be made to better maximize the system's functionality and resource efficiency.

- Machine Learning Integration:By examining past data on cleaning cycles, occupancy trends, and odor levels, machine learning systems may be able to facilitate predictive maintenance. A predictive strategy like this would improve system flexibility, enabling more effective use of resources and focused interventions according to utilization patterns. Proactive maintenance plans that lower costs and increase responsiveness can result from this data-driven approach.
- Enhanced User Interaction:User interfaces that enable real-time feedback and reporting of toilet conditions may be included in future revisions of the system. The technology may encourage a cooperative approach to facility management by giving users the ability to speak with maintenance staff directly about problems. To further improve the user experience, mobile applications might also tell consumers about the state of restroom cleanliness.
- Advanced Sensor Technology:Further developments in sensor technology may enhance durability and detection power. The creation of resilient sensors that can resist challenging circumstances without losing their accuracy would solve present issues and improve system dependability over the long run. Investigations into alternate sensing technologies, including nanosensors, may yield more accurate readings with less upkeep.

IX. CONCLUSION

An appealing answer to common sanitation issues in public spaces is the automated septic tank and toilet maintenance system. The obstacles of sensor calibration, infrastructure integration, and sensor dependability must be taken into consideration, even though the benefits of increased cleanliness, cost savings, and user experience are obvious. Through the pursuit of possible enhancements using machine learning and sophisticated sensor technologies, the system can develop to successfully satisfy the ever-changing demands of public health management. In addition to helping users, an all-encompassing approach to toilet maintenance advances larger public health goals.

REFERENCES

1) Khan,F.,Kargupta,H.,Dutta,S.(2021)."Automated Odor Control System for Public Restrooms." Journal of Environmental Management, vol.299, no. 113787, pp. 1-10. DOI: 10.1016/j.jenvman.2021.113787. This paper discusses the implementation of automated systems for odor management in public restrooms, highlighting the importance of maintaining hygiene in high-traffic areas.
2) Zhang, Y., Zhou, Z., Yu, C. (2020). "Design and Development of a Smart Toilet System for Urban Public Restrooms." Sensors, vol. 20, no. 12, pp. 1-14. DOI: 10.3390/s20123694. This article describes a smart toilet system integrating various sensors to enhance user experience and maintain cleanliness in urban public restrooms.
3) Gupta, A., Yadav, A. (2019). "IoT-Based Smart Waste Management System." International Journal of Computer Applications, vol. 182, no. 12, pp. 25-29. DOI: 10.5120/ijca2019919265. This reference provides insights into IoT applications in waste management, which can be related to your project's automated drainage and maintenance features.
4) Davis, K., McCoy, J. (2018). "The Role of Automated Cleaning Systems in Improving Sanitation in Public Facilities." Journal of Facilities Management, vol. 16, no. 3, pp. 234-245. DOI: 10.1108/JFM-11-2017-0125. This paper reviews automated cleaning technologies and their effectiveness in enhancing sanitation and user satisfaction in public facilities.
5) Kumar, A., Singh, V. (2017). "An Overview of Odor Control Technologies for Wastewater Treatment." Environmental Science and Pollution Research, vol. 24, no. 12, pp. 10456-10470. DOI: 10.1007/s11356-017-8360-y. This reference covers various technologies for odor control in wastewater treatment, providing foundational knowledge relevant to your odor management component.

6) Santos, R., Bianchi, A. (2022). ”Smart Sanitation Systems: The Future of Public Health Infrastructure.” International Journal of Environmental Health Research, vol.32,no.4, pp.375-390.DOI:10.1080/09603123.2021.1926762. This article discusses the evolution and future directions of smart sanitation systems, emphasizing their significance in public health management.
7) Gupta, M., Sharma, R. (2019). ”Automatic Odor Control Systems in Public Restrooms: A Review.” Waste Management Research, vol. 37, no. 5, pp. 497-505. DOI: 10.1177/0734242X19837747. This review focuses on existing odor control systems and their effectiveness in maintaining cleanliness in public restrooms.