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Intelligent Hygiene Monitoring System for Public Toilets

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***Abstract* — Public sanitation in many parts of India and slums is sadly inadequate, with frequent urination and outflow due to public toilets that may be very dirty or poorly maintained. Many governments spend a lot of money and effort in keeping these public toilets clean and tidy. All of these efforts to keep public restrooms clean are in futile because there is no centralized mechanism in place to monitor their cleanliness and cleaner quality. In many regions of India and slums, public sanitation is woefully inadequate, with rampant public urinating and incontinence caused by overpopulation or poorly maintained public toilets. Because of this issue, a system that allows monitoring in one place of all public toilets and a cleaner connection will be helpful in overcoming the problem of pollution. The major goal of this project is to show how an Internet of Things-based toilet monitoring system may be simple to use. The web server and the mobile cleaner application are used in this project. This technology allows the toilet cleaner and the administrator to monitor multiple cleaning metrics and inform the cleaner about the condition of the toilet based on user input.**

Keywords— Internet of Things, MQ-135 sensor, IR sensor, RFID reader, Ultrasonic sensor.

I. INTRODUCTION

Based on the data provided by UNICEF, India has the highest rate of exposure to human waste. An estimated 625 million people do not send toilets. As a result, serious public health problems are on the rise. In India, only half the population use toilets. According to Swacch Bharat Mission Urban, established under the Department of Housing and Urban Development, there are more than 5.1 lakh functional toilets and public toilets in Indian cities, as well as more than 59 lakh reconstructed toilets. The fact that more rural Indians had toilets in 2018 than four years ago, about 44% of the toilets are still ventured out into open areas. It is important to note that 43% to 58% of rural people over the age of two relieve themselves in the open, and 44% is a popular measure.

Despite the fact that our country has plenty of public toilets, there is no other way to check and maintain their cleanliness. There is no procedure in place to ensure that the workers allocated to these restrooms are clean. Toilets should be inspected in person to keep track of their state, which is harmful to employees. As a result of these causes, the quality of public toilets has dropped dramatically, endangering the health of the general public.

In this research, we propose to use an IoT system to collect data on many aspects of toilets to solve the problem of toilet monitoring and maintenance, including air quality, water availability, water closure, and vacant toilets. Using a well-defined web interface, this software may provide centralized data visualization. The system is sophisticated enough to follow the cleaner's work and alert authorities if they do not pay attention.

This system is economical, and most of the system can be maintained with minimal resources. The campaign can take place in a variety of areas, including homes, schools, colleges, hospitals, businesses and industries. Urban sanitation is important in today's environment, and there are a few obstacles to overcome. It is a simple and effective way to keep the standards of cleanliness in check, and it helps to overcome many obstacles, such as reluctance to do so.

II. LITERATURE REVIEW

The indoor settings of heavily contaminated toilets are linked to an increased risk of disease transmission. Improved ventilation efficiency can enhance interior air quality (IAQ) [1]. The aspects of pollutant transmission in a public toilet model were analysed using computational fluid dynamics software, which was subsequently confirmed using experimental data using tracer gas. This research looked at typical pollutant diffusion characteristics, such as ammonia and hydrogen sulphide, as well as the relationship between the number of air changes per hour, pollutant concentrations, and personal exposure in public restrooms using two types of typical ventilation systems: mixing ventilation (MV) and personalised ventilation (PV).The data show that while MV can reduce pollution levels in the toilet, the IAQ cannot reach the goal level. When the entire ventilation rate is kept constant, PV may efficiently remove pollutants in the toilet and reduce pollutant concentrations in the breathing region.

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The findings of this study may help to improve the indoor air quality in public restrooms.

On-site wastewater reuse can help to increase worldwide access to safe drinking water and sanitation [2]. The researchers' treatment method recycles water from hand washing and toilet flushing. It is capable of recycling enough safe and attractive hand washing and toilet flush water for household or public use in real-world applications. They demonstrated that the system could recycle enough water for safe and pleasant hand washing and toilet flushing in a real-world scenario for household or public usage.

Advancements are certainly being made in the modern world, our country's cleanliness is being jeopardised. One of the Clean India scheme's objectives is to keep toilets clean. The Clean India programme may benefit from this report's promotion. In the future, it has the potential to play a big part in the Clean India project. Under the existing system, they are primarily concerned with recognising the filth in the toilets. In [3], the authors suggested a method to keep toilets clean by watching the sweeper's activities. Many syndromes can be avoided with it. It has the ability to enhance public awareness about the proper use of toilets.

One of the most basic necessities for a stable and healthy economy is cleanliness. Paper [4] focuses on a method that allows for efficient toilet cleaning and maintenance while lowering the danger of disease transmission. A toilet is cleaned on a regular basis in the current toilet management system, with the sweeper cleaning the toilet at regular intervals. The suggested system improves this approach by delivering a notice to the management anytime the toilet becomes unsanitary. It is an endeavour to raise awareness about toilet hygiene and correct upkeep. Sensors and IoT are being used to improve the toilet management system.

In [5], the authors suggest an IoT system to increase restroom safety for the elderly and women. The system employs sensors such as a leak detection sensor, a digital nLight/Lux sensor, a voice detection sensor, and a pressure sensor. This research examines the integration of a wireless sensor local network system. The restroom is one of the most dangerous locations, particularly for the elderly. Older persons often have more difficulty with mobility and balance, leaving them more vulnerable to restroom falls and slips, as well as major health problems in the short and long term. There is presently no IoT application for a bathroom. Bathrooms, unlike other applications, have several distinct characteristics, such as privacy and a wet environment. This study proposes a holistic conceptual approach to the development and deployment of an Internet-of-Things (IoT) system to improve toilet safety. The idea is to employ a major nursing care facility as a pilot testing bed for the concept.

The recommended approach in [6] makes use of a water level sensor, a scent sensor, and a human detection sensor. The entire process is automated. Human intervention is not required for the system to work. The Arduino Controller is connected to the sensors. The Arduino controls the fan, flush, and water tank switches based on the input from the sensors.

In [7], researchers highlight some of the most cutting-edge revolutionary technologies that have been employed in the development of autonomous and smart toilet systems. while considering the essential needs for ecological development in smart cities. Health monitoring using "Smart Toilets with Turbidity Sensor" has been proposed using smart and automatic technology. They propose a strategy for keeping toilets clean, monitoring the sweeper's performance, and prohibiting the use of filthy toilets in this research. The system includes a turbidity sensor, a gas sensor, an Arduino Uno, a GSM module, and an IR sensor. The GSM module allows the sweeper to receive SMS messages. The following findings were reached based on the use of solar power for electricity generation. The latest technologies can be used to construct smart public toilets. The number of individuals who use the restrooms will increase if they are kept clean and well-maintained, helping to keep the environment clean.

Since diabetic patients do not make insulin, drawing blood to check their sugar levels might induce infection. As a result, the authors of [8] created a smart toilet to diagnose diabetes based on urine colour. The goal of this proposal is to make it easier for people to maintain track of their health, especially diabetes. The data acquired in this study will be used to compare the data obtained in the urine of a diabetic and a healthy person. Data pre-processing is a stage in which data is separated into multiple categories. The information in this study is presented in the form of numbers obtained from the urine's RGB value. The k- means are used to process data using the clustering approach. The steps below must be followed in order to cluster using k-means.

In [9], a Mobile Flush Toilet have been suggested. In an emergency, finding a good toilet can be challenging. Damage to essential infrastructure makes it difficult for shelters to clean toilets. As a result, the purpose of this study is to develop a mobile flush toilet that is self-contained in terms of power, water, and drainage. In flood-affected regions, the field test was conducted successfully. Before a disaster, placing this mobile toilet near public buildings that are used as emergency shelters helps improve access to a proper toilet.Furthermore, in underdeveloped nations with little infrastructure, this toilet design might be used.

In the proposed "Smart Toilet" system [13], IoT, fragrance sensor, IR sensor, sound sensor, and RFID sensor are all employed. The smart toilet will open and close the toilet seat for you, while an infrared sensor detects dirt on the toilet seat and informs you. The cleanliness of the toilet will be enhanced by keeping an eye on the sweeper's operations in order to keep the toilet clean and save water. One of the reasons is that the user is too lazy to wipe the toilet after each use. The upshot of this careless behaviour is filthy bathrooms. Furthermore, many public restrooms lack flushing facilities. Even though some of them have flush toilets, they are not utilised owing to a lack of awareness and laziness. The other factor is the sweeper's lack of comprehension of his or her obligation for toilet cleaning. The word "smart" alone is enough to pique people's interest and urge them to use the smart toilet. It also allows for the efficient administration of public bathrooms, with a high degree of hygiene maintained to the public's satisfaction.

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III. METHODOLOGY

A. IoT Device to Monitor the Toilet

The MQ-135 sensor detects the stench of the toilet. The presence of ammonia gas in the atmosphere is detected by this sensor. The presence of Ammonia is responsible for the toilet's foul odour. Ammonia has a pungent odour that can only be perceived at a concentration of 5 parts per million (parts per million).Fans automatically turn on when the ammonia content in the toilet exceeds the set threshold of 5 ppm, while levels below 5 ppm have no impact. Moving on to the next component, an infrared sensor is used to check for the presence of soap in the toilet.

Fig. 1 shows the block diagram of the proposed system with following blocks.

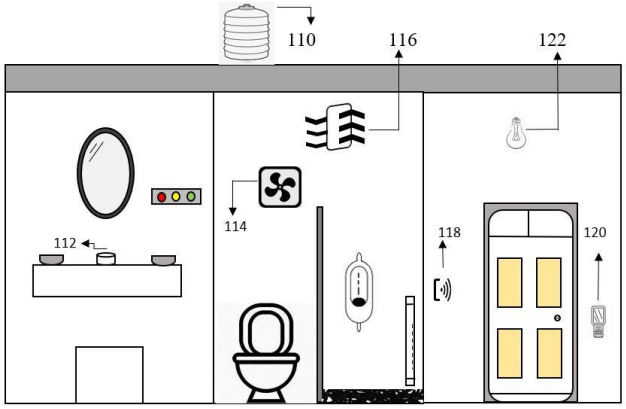

Fig. 1. Block diagram of proposed system.

110- Water Tank. 120- Odour detection MQ-135.

112- Soap detector. 122- Automatic lights.

116- Ventilation fan 124- Frequency counter.

126- Cleaners attendance.

The sensor is utilised by placing it near the soap. The cleaner is informed when the soap goes missing via the mobile app. The Water Sensor is used to monitor the water level in the tank that delivers water to the toilet. It is the most appropriate sensor and the threshold status as well as an action done for the same.A luminosity sensor detects the brightness of the toilet and determines whether it is well lit or not. The lights switch on automatically when the toilet's brightness falls below the chosen threshold. The RFID Scanner was chosen since it is ideal for this task. The RFID Scanner is used to keep track of cleaners' attendance so they don't forget to clean. Outside the toilet, there is an RFID scanner. Every toilet has a rating system with rating buttons where users may offer feedback after using the toilet so that the toilets can be altered based on the feedback status. Using the Node MCU, which allows them to connect to the internet through Wi-Fi, all the sensors send data to the cloud every five minutes.

B. Calibration of Sensors

On the market, there are many distinct types of ammonia gas sensors, each with its own size, sensitivity, and price. We intend to employ the MQ135 gas sensor, which can detect NH3, C2H6O, and even CO. These MQ135 sensors are commonly utilized in factories and houses due to their compact size and lightweight. Tin Oxide (SnO2) is an element that is present inside the sensor and is used to detect various gases. With the use of a potentiometer, the sensor's sensitivity can be changed to meet the needs. When gases in the air come into contact with SnO2, the resistance changes, and the output voltage changes as well, indicating which gas has been identified.

C. Data Processing is done over the cloud

To begin, data from IoT devices is pre-processed depending on the sensor parameters' values. There might be gaps in this data, as well as false measurements. Erroneous readings are removed from the data, which is then normalized and recorded with a timestamp in Thingspeak database storage. This Thingspeak is a suitable choice for a system that requires real-time data updates.

IV. RESULTS

A. Simulation of Gas sensor

Within the toilet, the MQ-135 sensor detects smells. This MQ-135 sensor measures the amount of ammonia gas present in the toilet's air.

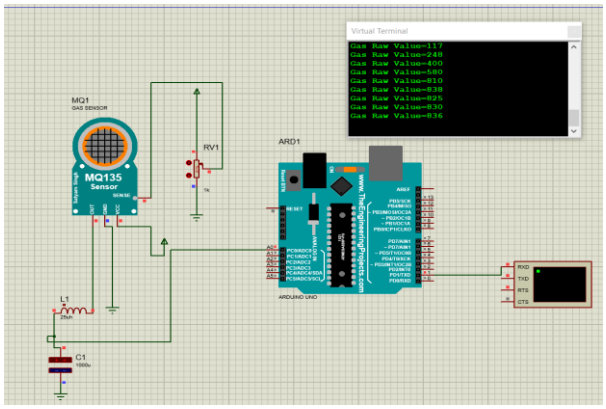

Fig. 2. Simulation of gas sensor.

The ammonia inside the toilet produces a nasty odour. It has a strong odour that can be detected at concentrations more than 5 parts per million (parts per million).The ventilation fans are automatically switched on when the ammonia concentration in the toilet surpasses the predetermined threshold of 5 ppm; however, if the concentration falls below 5 ppm, no action is performed, as shown in Fig. 2.

B. Simulation of RFID Sensor

The RFID (Radio Frequency Identification) technology, is a key enabling technology of the IoT sensing layer. As shown in Fig. 3, when the cleaner enters the toilet and when he scans his ID in the RFID scanner, It displays his name with the valid tag, and in another case when he scans other than his ID it shows that the ID is invalid. This helps to monitor the cleaner’s attendance.

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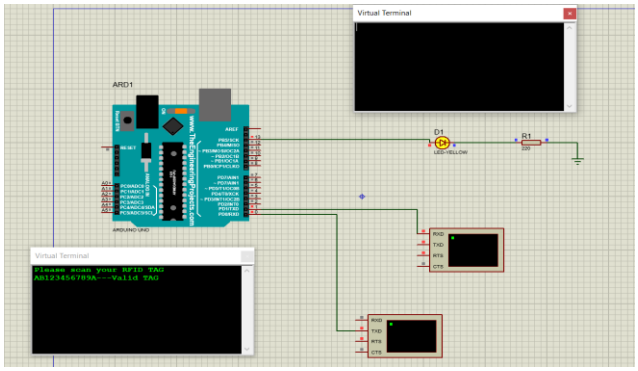

Fig. 3. Simulation of RFID reader.

C. *Real time interface*

We employed five sensors in our project. The first is an RFID sensor, which is used to track the cleaner's attendance. The MQ-135 sensor was the second sensor we utilized to assess air quality. For soap detection, we employed an IR sensor as the third sensor. Ultrasonic sensor for tank water level measurement is the fourth sensor. The fifth sensor is an infrared sensor that counts how many people enter the restroom. These sensors are all connected to Arduino, which collects all sensor data and sends it to the cloud via the ESP8266 Wi-Fi module. Here we have used Thingspeak open-source website for storing the collected sensors data. All the sensors' data is even displayed on LCD screen as well.

Fig. 4 Shows the Thingspeak website where all the data are stored. It shows Smell status, Soap status, user count, water level, cleaner id. Soap and smell status is determined using red light as shown in Fig. 4. If the soap is present in the container then the red LED will turn on, similarly if there is smell in the toilet then the red LED for smell status will turn on. Water level is determined using percentages in water level block. It also counts number of people entering the toilet in user count block.

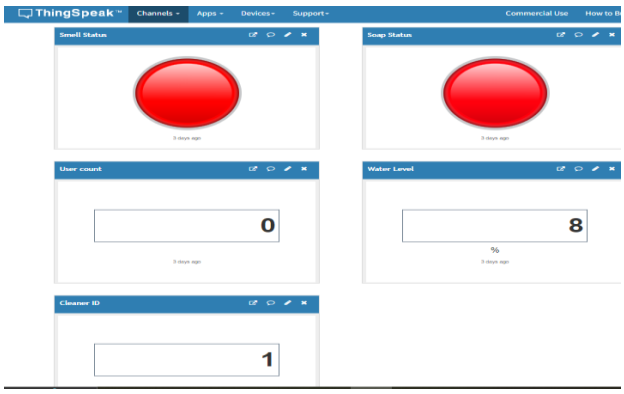

Fig. 4. Public view in Thingspeak software.

At the end, it also displays the cleaner ID and displays all the sensors data in graphical format as shown in the Fig. 5.

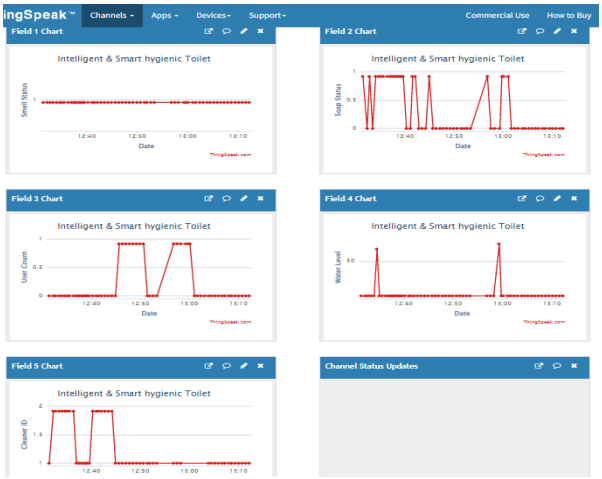

Fig. 5. Graphical representation of sensor data.

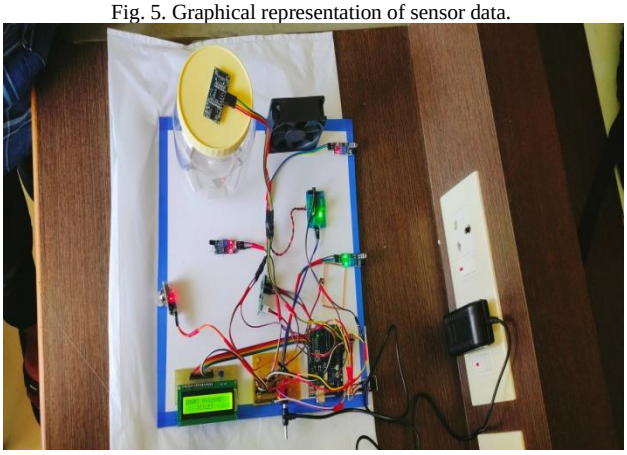

Fig. 6. Hardware connection of proposed system.

Fig. 6 shows the hardware connection of our proposed system, where all the sensors are interfaced with the Arduino and the sensors data is updated to the thingspeak every 15 seconds with the help of ESP -8266 module.

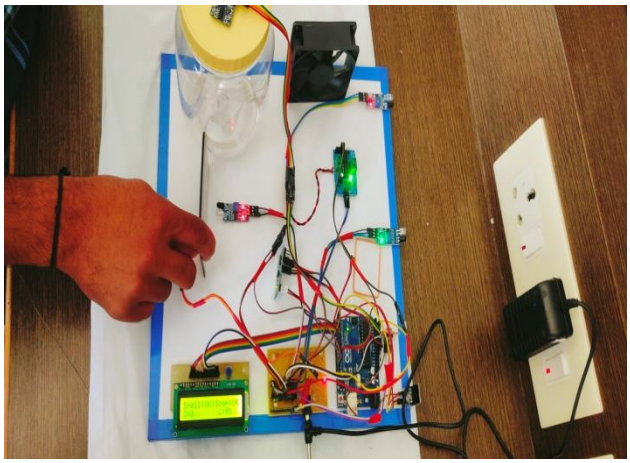

Fig. 7. Sensors values displayed in LCD.

Fig. 7 shows the sensor output on the LCD screen. As displayed here it shows the smell status, if there is smell in the room or threshold value of the MQ-135 sensor is reached then the ventilation fan is turned on. The fan is turned on by the L293 motor drive module. Here the smell is in ok

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condition, so fan will be in off state. similarly goes with the soap detection, if soap is present then the status of the soap will be OK as shown in Fig. 7. If the soap is missing then N.A will be displayed. It also counts number of people entering the toilet. As you can see in Fig. 7, the 'C' value in the LCD display is zero. Whenever person enters the toilet, it goes on increasing the count value. Similarly, whenever the person exits the toilet, the count is decremented from one to zero.

For water level detection we have used ultrasonic sensor to measure the level of the water in the tank. In our hardware we have used small container to store the water so based on the distance, the ultrasonic sensor can detect the water level which in turn displays the results on the LCD display as well as in Thingspeak in percentage format.

V. CONCLUSION

The initiative met its goal of creating an economical, user-friendly interface between the cleaning company and public restrooms, allowing for more effective staffing. This program's installation is straightforward. Time series forecasts can be utilized to conduct simultaneous toilet research. If this toilet condition is utilized in the toilet, it assists in keeping the toilet clean before it becomes unclean. The mobile app is considerably easier to use now that the data display has been updated. The Internet of Things device is both inexpensive and portable.

In future, this study might be enhanced by employing sensitive and modern sensors to generate more precise data. By learning from sample data and increasing the amount of test data, machine learning increases prediction accuracy. When this approach is used on a large scale, better storage systems and cloud servers can be used.

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