Development of Touch Less Smart Toilets and Sewage Monitoring System Using IoT*

1st B Sirisha
MVSR Engineering College
Hyderabad, India
sirishavamsi@gmail.com

2nd Sai Goutham Goli
MVSR Engineering College
Hyderabad, India
saigouthamgoli111@gmail.com

3rd Navya Sahithi Muthavarapu
MVSR Engineering College
Hyderabad, India
sahithimuthavarapu@gmail.com

4th Jitesh Nasigari
MVSR Engineering College
Hyderabad, India
nasigari.jr@gmail.com

***Abstract*—As institutional, commercial and public spaces start to re-open across the nation, experts from medical domain have repeatedly cautioned of the possible dangers of sharing confined spaces with others, which has urged renewed queries concerning the safety of our public Toilets, washrooms and restrooms. Durability and convenience were once the two vital considerations in designing washrooms. Today, user wellbeing and health have become equally significant. Harmful viruses and bacteria are majorly aerosols from toilet basins and urinals. The objective of this project is to build up a smart toilet and smart anaerobic sewage tank system to address the problem of airborne bacteria/virus transmission from sewage tank and toilet basins. In the first phase of this project, this device will restrict the disseminate of harmful virus/bacteria by automatically closes the lid, and does auto flush, even before their ejection into the air. In the second phase, ultrasonic sensor monitors the anaerobic sewage tank system to prevent overflow. The proposed system displays the real time liquid sewage level in the LCD monitor and indicates the maintenance team for the need of disposal as the level exceeds certain threshold. In this project design, a servo motor and a battery operated DC geared motor along with a Turbidity, Ultrasonic and Infrared Sensors operates in unison with an Arduino UNO microcontroller to build the smart toilet device. In addition hygiene monitoring, compliance is embedded in the proposed system using Radio Frequency Identification techniques.**

***Index Terms*—IOT , IR sensor, turbidity sensor, UV sensor, RFID reader**

I. Introduction

As the covid-19 cases started increasing exponentially, worldwide focus re-centered on Corona Virus and its prevention mechanism (See Figure:1). COViD-19 mainly disseminate through droplets either from mouth or nose when speaking or coughing. It is also possible to get affected by touching surfaces with virus droplets [1]. COVID-19 raised consciousness among people worldwide, of the need to remain watchful in the confined spaces where the probability of disease spread is extremely high. A public toilet is most unsafe space. The origination of the communicable aerosols out of the toilet basins is the common source of syndrome transmission, alike to sneezing and coughing, but usage of the toilet is unavoidable. Hence, it is significant to determine methods to prevent transporting the virus outside the confined toilet space.

Preventing interaction with the flush button, toilet seat covers effectively lowers the likelihood of catching any type of bacteria/virus. Flushing without closing the toilet lid will lead to virus and bacteria contaminating the whole toilet space [2]. Toilet basins are un-hygienic places that comprise hazardous viruses and bacteria that contaminate humans when pouring water expels out these viruses and bacteria from the toilet basin. J. Barker and M. V. Jones stated that the toilet flushing action will lead to the complete contamination of the whole confined toilet space. Once flushed, the bacterial (Serratia) denseness in the atmosphere can rise from 14 Colony Forming Unit CFU m3 to 1360 CFU m3, this implies that there are 1000 times more viruses and bacteria units aerosolized, which are highly hazardous, that a person can devour. Such viruses and bacteria stick to the various toilet surfaces for more than 50-60 minutes [3]. National institute of health indicates that new coronavirus-Covid-19 may stay on few surfaces like plastic for few days. The coronavirus, in aerosol form can stay active in a confined toilet space for up to three days, which plays a major route for infection transmission [4]. Hence an automatic toilet lid /seat closure is a suitable technique for stopping the disseminate of these viruses and bacteria. The prime objective of the project is to design a secondary device for the toilets to automatically close the toilet seat lid before flushing to reduce the interaction with the contagious toilet surfaces where different kinds of bacteria and viruses often exist.

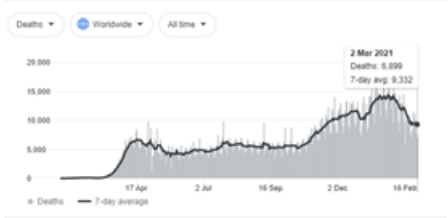

Fig. 1. COVID-19 World Wide-Death Rate-2nd March 2021

The rest of the paper is catalogued as follows, Section 2, presents related work of smart toilet designs. In Section 3 we introduce the proposed smart toilet and sewage monitoring system design using IoT. In Section 4 presents the working model and discussion and Section 5 concludes the work.

II. Related Work

Banait, P. (2019), used array of sensors like gas and UV sensor to detect the water level and smell. Arduino UNO mi-

crocontroller is used in this process. The objective of this paper is once dirt is detected, it triggers the fan, water motor and automatic flusher [5]. Begam, S. A. (2019) used sonic, gas, IR sensor and RFID to detect smell and dirt level and signals the monitoring team through LCD display and buzzer [6]. Mithya, V. (2019) used turbidity, gas sensor for determining the dirt, unwanted gas and bacteria in the toilet area. GSM and Wi-Fi module is used for alerting and messaging the maintenance team [7]. Sujeetha R (2019). Developed a system to monitor water quality and detect foul odour using NodeMCU microcontroller / ESP8266, alert system is used for messaging the need for maintenance [8]. Sudha, V. (2018) reviewed modern technologies which are used in public toilets. The objective is to reduce the water consumption, assist visually challenged to use the lavatory and monitor user health using array of sensors [9]. Elavarasi, K. (2018) , the objective is to detect unwanted gases present in the toilet and also the depth of septic tank, using array of sensors and PIC 16F877 . Once the dirt is detected the system sends the message through GSM module . In this paper RFID scanner is also used for monitoring and storing the maintenance log [10] . Katariya, D. (2018), used MQ4 , MQ135 sensor with microcontroller UNO, to detect the Odour, Methane and Ammonia content in the toilet. A robotic arm type of brush is used to automatically clean the toilet basin without human intervention. This appliance is developed for railway toilet management [11]. Muntashar, N. (2018) used array of sensors to detect toilet health and to monitor the water level. GSM module is used for alerting the maintenance team [12]. Sangwan, S. (2017), the objective is to detect the user health by collecting the urine, stool and spit samples. Post processing of these samples are done to determine Kidney stone, Sugar level, Urinary tract infection, Pregnancy, Fecal occult blood, fecal pH / Acidity test and alcohol presence [13]. Hashemi, S. (2015), used array of sensors and controllers to detect unwanted odor and gas. The prime objective is to reduce the water usage in toilets. This project also focus to separate solid and liquid waste [14].TableI shows the review of smart toilet designs in detail.

It is observed from the literature, most of the smart washrooms focus mainly on sewage maintenance and disposal, collecting urine and stool samples for health monitoring and minimizing water consumption by auto flushing. Though most of the proposed systems claim smart toilets, their main set back is their appliances does not focus on touch less activities to prevent spread of bacteria and viruses. Most of the medical analysis done based on urine and stool collection in smart toilets, leads to faulty identifications. The main objective of our proposed system is to develop a cost effective battery operated smart toilet system that controls the disseminate of noxious viruses and bacteria by automatically closing the toilet cover/ lid even before flushing the waste. When toilet cover/ lid is automatically closed, noxious bacteria and virus can no more be expelled from toilet basin.

TABLE I
REVIEW OF SMART TOILET DESIGNS

Year	Author	Scope	Function	Controller Used
2019	Banait, P. et.al [5]	Smell detector, Water level detector	once dirt is detected, it triggers the fan, water motor and automatic flusher	Arduino UNO
2019	Begam, S. A. et.al [6]	Unwanted smell and gas detector	detect smell and dirt level and signals the monitoring team through LCD display and buzzer	8051 Microprocessor
2019	Mithya, V. et.al [7]	Dirt, Gas and Bacteria Detector	used turbidity, gas sensor for determining the dirt, unwanted gas and bacteria in the toilet area. GSM and Wi-Fi module is used for alerting and messaging the maintenance team.	Arduino UNO , ESP8266 WiFi Module
2019	Sujeetha R (2019) et.al [8]	Foul Odour and water quality detection	Developed a sytem to monitor water quality and detect foul odour , alert system is used for messaging the need for maintenance	NodeMCU microcontroller / ESP8266,
2018	Sudha, V. et.al [9]	Reduction of water consumption, assist visually challenging people,User health is monitored	reviewed modern technologies which are used in public toilets. The objective is to reduce the water consumption, assist visually challenged to use the lavatory and monitor user health using array of sensors	Arduino UNO
2018	Elavarasi, K. et.al [10]	Unwanted gases and depth detection	to detect unwanted gases present in the toilet and also the depth of septic tank, using array of sensors and PIC 16F877 . Once the dirt is detected the system sends the message through GSM module . In this paper RFID scanner is also used for monitoring and storing the maintenance log .	PIC 16F877
2018	Katariya, D. et.al [11]	Odour,methane,Ammonia Detector	detects the Odour, Methane and Ammonia content in the toilet. A robotic arm type of brush is used to automatically clean the toilet basin without human	Arduino-UNO

TABLE II
REVIEW OF SMART TOILET DESIGNS

Year	Author	Scope	Function	Controller Used
2018	Muntashar, N.et.al [12]	Water Level,odour detector	used array of sensors to detect toilet health and to monitor the water level. GSM module is used for alerting the maintenance team.	Arduino-UNO
2017	Sangwan, S. et.al [13]	Urine:Kidney stone,Sugar level,urinary tract infection,Pregnancy. Stool: Fecal occult blood,Fecal pH / Acidity test. Spit:Alcohol presence	health maintenance technology through which the user can identify any health condition	Arduino-UNO
2015	Hashemi, S. et.al [14]	detect unwanted odour and gas	reduce the water usage in toilets. This project also focus to separate solid and liquid waste	Arduino

III. PROPOSED SMART TOILET AND SEWAGE MONITORING SYSTEM DESIGN USING IOT.

The proposed work has two major phases. The first phase includes automatic closure of toilet seat lid and automatic flushing based on smell detection sensor inputs. This is with help of servo motor and battery operated DC motor along with a turbidity, Ultrasonic and Infrared Sensors operates in unison with an Arduino UNO microcontroller. In addition based on the signal received from the turbidity, gas sensor a decision is made and toilet status is displayed in the LCD monitor. RFID scanner is used by the maintenance team to update the maintenance status.

Anaerobic sewage tank 'system are a type of onsite sewage facility (under-ground sewage chamber), they are majorly used in rural areas which are not linked to a proper sewerage system. Once the sewage tank is full of solid waste, sewage backups in toilets basin, this will lead to airborne diseases. Hence, it is essential to pump the sludge into transport containers. In second phase of our system Ultrasonic sensors monitors the anaerobic sewage tank 'system to prevent overflow. The proposed system displays the real time liquid sewage level in the LCD monitor and indicates the maintenance team for the need of disposal as the level exceeds certain threshold. The proposed system architecture is shown in the figure 2.

Hardware Interface

- Ardunio Uno R3 -2 qty
- Gas sensor Mq3
- Gas sensor Mq2
- LCD with L2C Module
- Ultrasonic sensor

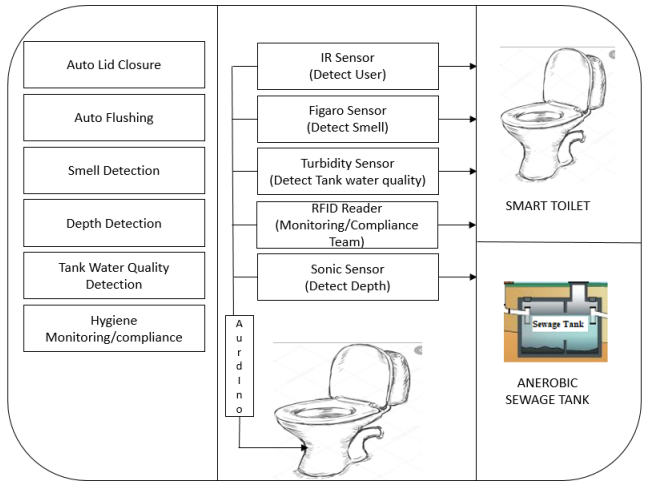

Fig. 2. System Architecture

- Motor driver
- IR sensors
- Servo pro sg90
- Bo Motor
- RFID with reader and writer
- Micro DC 3 to 9v Submersible water pump
- Power supply Units
- Buzzer
- LED indicator

Software Interface

- Arduino IDE 1.6.13
- Catia V5

A. WORKING MODEL

The gas sensor is placed below the rim of the Toilet basin, to detect undesirable gases present in the confined toilet space. If the sensor detects the foul smell, it activates the motor and closes the lid. Once the lid is closed, touch sensor get pressed, which initiates the motor for automatic flushing. The gravity aurdino turbidity sensor detects quality of water by determining the intensities of turbidity. This sensor is deployed in the flush water tank to determine the quality of water and to check bacterial presence. If the turbidity level rises, it generates a signal and alerts the toilet maintenance team and displays Service Required message in the LCD Monitor connected to the door(See Figure:3).

As the user enters the washroom, he/she reads the LCD display connected to the door, if it displays Ready to Use message , user enters the toilet and put the hand over IR sensor to activate the motor, once the motor gets activated, it closes the toilet lid and automatic flushing is done. Once the toilet basin is clean, IR sensor is used to open the lid and the toilet seat cover. If foul smell is detected continuously it alerts the toilet maintenance team. The maintenance monitoring team worker will be provided with Radio Frequency Identification (RFID) tag, with identification code. The RFID reader is fixed to the door and manually aligned over the RFID Tag earlier

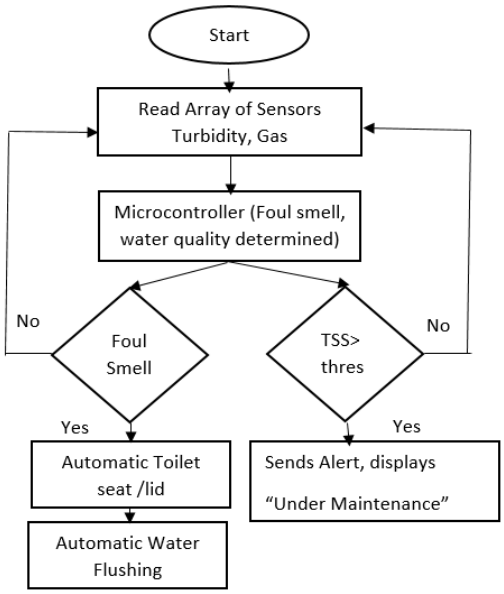

Fig. 3. Phase:1.1 Flow Chart

to the cleaning process. The RFID reader scans the tag and updates a database with details such as toilet ID, cleaning time, cleaning process status so on. The data updated in the database will help the concerned authorities to monitor and ensure timely cleanliness of public toilets and cleaning activities of the sanitary workers. (See Figure:4).

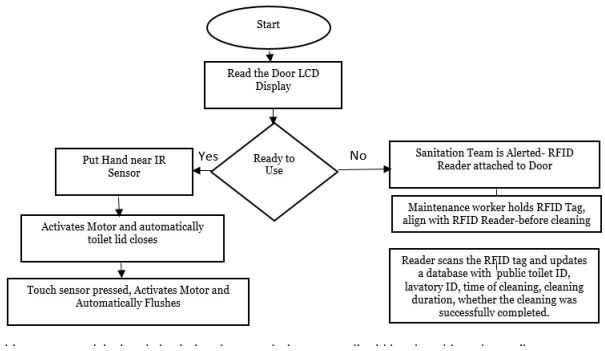

Fig. 4. Phase:1.2 Flow Chart

Anaerobic sewage tank is deeply buried and covered, the sewage liquid level could not be easily monitored. Traditional techniques like floating ball liquid sewage level determination requires to soak the floating ball in sewage liquid, the major setback is the floating ball gets strained over time and leads to malfunctioning. In our proposed system Ultrasonic sensor is fixed below the lower part of the tank cover plate. MAX-485 is a low slew rate and low power transceiver, ported with Ultrasonic sensor for signal reception and transmission to microcontroller. The microcontroller output is connected to liquid crystal display, which displays real time liquid sewage level, if the level exceed the threshold alert signal is sent through buzzer.(See Figure:5).

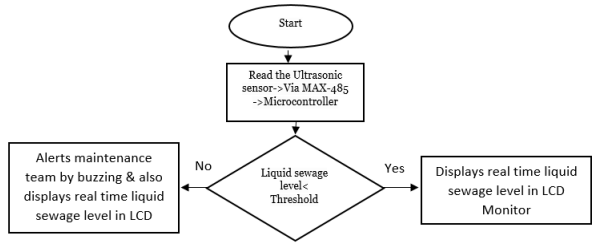

Fig. 5. Phase:2 Flow Chart

IV. Results and Discussion

Figure6 shows the prototype of our proposed smart toilet system. Two arduino UNO boards are used in our system.One for controlling automatic toilet lid closure and flushing and other controller board for sewage tank monitoring. Before user entering the toilet, a LCD monitor fixed to the door will display the status of the toilet(See Figure 7 and 8).If toilet needs service, maintenance team is alerted, **Cleaning in progress** status is displayed in the LCD monitor (See Figure 9 , this service will prevents other user to use the dirty washroom. If the washroom status is **ready to use**, user enters the toilet, a battery operated system controls the spread of noxius by automatically closing the toilet cover/ lid even before flushing the waste. When the toilet cover/lid is closed, noxious viruses can not ejected from the toilet basin (See Figure 10 and 11.

Fig. 6. Prototype of Proposed Smart Toilet

V. Conclusion

As the planet continues to curl into confusion due to Coronavirus, there is a dire need to stop the transmission of this pandemic in the common public spaces. The project mainly focus to build a smart toilet system that will intend to provide the impact on decreasing the disseminate of noxious

Fig. 7. LCD Monitor Displaying Status of Smart Toilet

Fig. 8. LCD Monitor Displaying Status of Smart Toilet

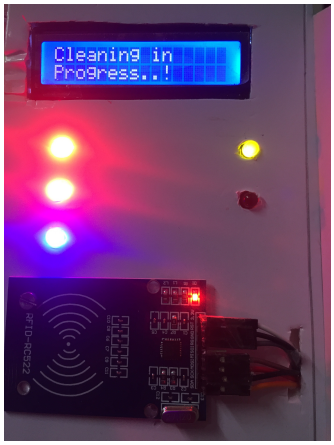

Fig. 9. LCD Monitor Displaying Status of Smart Toilet

viruses and bacteria. This is achieved using small-scale, cost-effective electrical components like servo motor , battery operated DC geared motor, array of sensors operates in unison with an Arduino UNO microcontroller. In addition Hygiene monitoring, compliance is embedded in the proposed system using Radio Frequency Identification techniques. In future we would like to embed Ultraviolet lights into the system design

Fig. 10. Automatic Lid Closure

Fig. 11. Automatic Lid Opening

to ruin the viruses and bacteria that dwell in the toilet basin.

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