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Transforming Waste Management in Indian Railways with the Control Bio-Digester Toilet System

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A B S T R A C T

Eliminating the practice of spilling lavatory waste onto train stations and in densely populated regions of cities is the primary goal of the Control Bio-Digester toilet system. Train rails with toilet waste spilt on them get corroded and smell pungent. Railways spend enormous sums of money painting and maintaining their tracks every year. It spreads waterborne illnesses like cholera, typhoid, and hepatitis B in inhabited places. To solve every problem, the excrement should not be dumped across railroad tracks. Next, the Control Bio-Digester toilet system introduces a pressurized water bowl wash that fills the toilet bowl. The toilet system that is being proposed uses a retention tank and a specific volume of water to move waste to. The human excreta is then broken down into liquid and gas phases by bacteria. The methane gas holder stores the gaseous state, while the excretion system stores the liquid state. This proposal will address and discuss the problems that Indian railways have when it comes to releasing garbage into the environment. In addition, it lowers maintenance expenses and offers substantial environmental protection benefits. The railway system will have a sustainable answer in this toilet system. More research will be required to ascertain the influence in real time.

Keywords: Control Discharge, Toilet System, Bio-Digester, Indian Railways, Waste Management, Environment

1. Introduction

With the advancement of civilization and the quickening of long-distance train travel, trains have become incredibly practical for individuals. However, the need for energy conservation and environmental protection has grown as the size of railway construction projects and traffic volume increase steadily.

Worldwide development of a new excrement collection system that can minimize or even eradicate environmental pollution was undertaken to save the environment, enhance the quality of train transportation, and bolster competition. Vacuum, circulation, depuration, drain, and automatic opener are the closed toilet systems in our nation. One benefit of the vacuum-type Toilet is that it uses less water and is odorless and clean.

Nevertheless, because the bore diameter of the pipe and valve is small, debris frequently clogs the channel, which is a complex issue to resolve. The circulation type uses wastewater to flush the toilet system after adding chemicals to deal with the dirt. It can conserve water.

Nevertheless, using chemicals will increase pollution, and the waste from post-processing makes excrement collecting difficult. People have found the Train very convenient, particularly in our populous nation. The Train is our first option when traveling for work due to its affordability and security. In our nation, direct emissions toilets are frequently utilized on trains.

The direct release of urine and dung is seriously polluting the environment, endangering the local population's health, and shortening the rail's lifespan, negatively impacting the train maintenance engineer's working conditions. The direct emissions toilet is now a source of infection due to the constant increase in train speed. These considerations led to the invention of a new toilet system.

2. Review of Literature

Jeevan Gowda [1] proposed that a bio-toilet is a dry Toilet. The bio-toilet is a thermophilic compacting toilet that uses particular aerobic and anaerobic bacteria to break down human excretory waste in the digester tank. The process produces water and methane gas. A bio-toilet is different from a typical toilet in that it is a green, environmentally friendly toilet that requires just half a liter of water to flush, compared to ten to fifteen liters for a traditional toilet. The bio-toilet is a portable toilet equipped with a biological system for treating wastewater. Bio-toilet designs that satisfy requirements, including cost for the social and environmental spheres, economy, safety, and functionality.

Ghatge Satish [2] suggested that the issue of open defecation in trains can be resolved by installing bio-toilets to improve sanitation. The continuous anaerobic microbial decomposition of human excreta into biogas is a bio-toilets foundation. Biogas typically contains 25–50% carbon dioxide and 55–75% methane. Gases escape into the atmosphere, and cleaned wastewater is released after chlorination in these bio-toilets.

Dhananjay G. Dange [3], The system employed in this paper is predicated on the idea that a train's speed gradually decreases as it gets closer to a station and gradually increases when it departs. The governor, which is utilized to operate the human waste disposal system, is operated by this change in railroad speed.

Jovita Triastuti [4] states that, in a bio-toilet, human waste is encased in a lignocellulose soil matrix, such as sawdust, and subsequently broken down by aerobic bacteria to produce organic compost that is rich in minerals like phosphorus, potassium, and nitrogen. The study aimed to describe the bio-toilet residue and explore its possible application for Jatropha curcas as a soil conditioner.

In this paper's first phase, Shwetank Shekhar Singh [5] proposed using RF transmitters and receivers. The receivers are installed within the Train, while the transmitters are positioned at the platform. The Train picks up the RF signal when it gets to the platform. The PIR sensor is also utilized to detect the presence of people in the restroom. The door does not lock if someone is inside the restroom. The waste is kept in a tank and the Toilet's working mechanism changes. During the second phase, the Train's ability to receive the RF signal deteriorates as it moves farther from the station. All doors unlock when the RF receiver detects no signal, indicating that the Train has passed the platform. PIR sensors are turned off. Since the RF receivers are still operational, it is simple to determine whether the Train has arrived at the platform.

Kartik Kumar Soni [6], In this Paper, waste from toilets is converted by FFEM into energy that can be used for platform lighting and other beneficial uses. Sustainable human excreta management can be achieved with eco-friendly bio-toilets, which are affordable and straightforward to install. In addition to causing environmental problems, discharge on schedule causes difficulties for workers. A multidirectional approach has been put into place to encourage the installation of environmentally friendly restrooms on IR passenger coaches.

K.Santhapriyan [7] denotes that everyone riding the Train may have to use the restroom, increasing the amount of solid and liquid waste released into the air. These discharge effluents were flushed into the toilet basin, where a pipe that feeds into the universal retention tank via gravity is connected. Following overflow, this wastewater enters the main storage tank via an inlet valve, where gravity forces the solid waste to settle at the bottom of the tank.

Jovita Tri Astuti [8], Every passenger on a train may have to use the restroom, which increases the amount of solid and liquid waste released. These discharge effluents were flushed into the toilet basin, where a conduit was connected to a universal retention tank so that it would fill naturally. Following its overflow, this study aimed to assess the properties and potential of waste lignocelluloses, such as mixed wood sawdust, as a matrix for composting human excreta in a bio-toilet. Initially, the Biotoilet chamber was filled with 26.4 kg of mixed wood sawdust (+4/-32 mesh) with 11.84% moisture content. 20L of tap water was then added to attain ±50% moisture. The Biotoilet mixer was set to run intermittently at intervals of 15 minutes, each for two minutes, or one minute each to rotate clockwise and counterclockwise. An exhaust fan operating at a flow rate of 0.04 m3/sec-1 was continually run to guarantee adequate aeration. Every day for ninety days, human excreta was placed into a bio-toilet chamber to be composted. Data indicated that the composting system's temperature ranged from 25.70 to 43.67 °C. pH was 6.20–7.00, moisture content was 22.27–53.20, and the composted residual sawdust had a 25:1 C/N ratio. In that order, the contents of ash, N, P, and K were 11.78, 1.78, 0.85, and 0.95%. Composting did not produce an unpleasant stench. It was determined that sawdust from mixed wood might be utilized as a matrix for composting human waste. The compost may fall under Class-A and be suitable for food and non-food plants.

In this paper, Jayshri S. Nandardhane [9], Bio-Toilets made the environment safe and environmentally friendly. The track should have a nice visual aspect, and any annoyance caused by human waste can be removed. Using bio-toilets can reduce the amount of corrosion brought on by fecal waste. Using a bio-toilet, we can use a chlorination tank to turn solid waste into pure water. This water can be used to clean the tracks and bogies, and the leftover sludge can be used for crops as fertilizer. For Indian Railways, therefore, this bio-toilet is quite helpful and necessary.

In this paper, Lee Hyun-Kyung [10] states that the toilet system can distinguish between urine and excrement in the source and handle each separately. This approach resolved the issue of urine and waste directly polluting the surrounding environment. The air surrounding the high-speed Train created negative pressure, which powered the cleansing mechanism. In the flushing system, a specific volume of recovered water and rinse was kept apart for storage. When flushing the Toilet, the reclaimed water was the first option. Wind and recycled water combined can conserve water and accomplish energy and environmental conservation goals. The numerical simulation results of the air and flush flow field were used to optimize the toilet system's structure.

3. Methodology

Overseeing the operation of India's vast railway network, it has the fourth-largest national railway network in the world as of 2023, with 104,647 km (65,025 km) of running track and 68,426 km (42,518 mi) of route, of which 60,451 km (37,563 mi) are electrified. It is the second-largest employer in India and the ninth-largest employer globally, employing more than 1.2 million people.

This chapter introduces the Control Bio-Digester Toilet System used by Indian Railways, which attempts to eliminate the dangerous release of toilet waste into urban areas and railway station regions, thereby revolutionizing sanitation procedures. This novel technology uses pressurized water bowl washing to ensure the entire toilet bowl is covered to uphold hygienic and clean standards.

Bacteria break down human excreta into liquid and gaseous states by transferring the waste from the toilets and water to a retention tank. The excretion system is responsible for managing liquid waste. Concurrently, the gaseous byproduct, mainly methane, is kept in a unique gas holder. This eco-friendly method improves cleanliness in the railway infrastructure and supports long-term waste management strategies.

5. Workflow

Figure 1 states that the water tank gets filled when the Train is OFF. Unless the Train is in an ON state, The water tank filling will be stopped. The Toilet

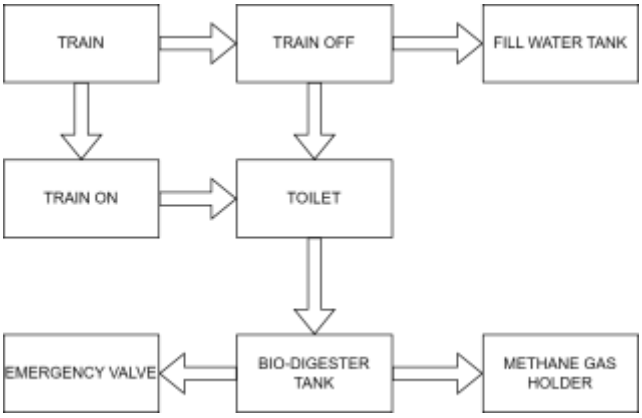

Fig. 1 - Work Flow of CBDTS in train toilets

will be available whether the Train is ON or OFF. When the flush is enabled, the waste gets moved to the septic tank, which is the Bio-Digester tank. The Bio-Digester tank consists of anaerobic bacteria that break solid waste into liquid and gaseous states.

The liquid state gets stored in the Bio-Digester tank. When the emergency level of the Bio-Digester tank is reached, the emergency valve opens, informing the driver about the tank level. In the meantime, the gaseous state is moved to a nearby Methane storage tank, the Methane Gas Holder. Further, liquid state wastage is used as a fertilizer.

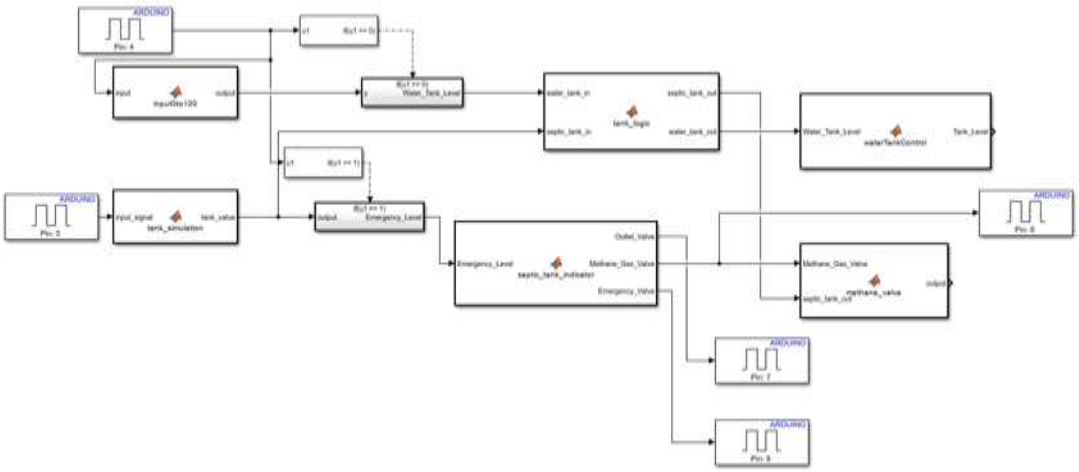

Fig. 2 - SIMULINK program with Arduino Toolbox

The gas state Methane gas is used for Cooking. When the tank limit is full in both bio-digest tank and methane gas holder scenarios, it needs to be cleaned up at the nearby station, which consists of an excretion system.

6. Result

- The Fig 2 and Fig 3 SIMULINK CODE and PROTEUS CODE are used in the Prototype.
- The SIMULINK code is the Program Logic, which performs the Bio-Digester toilet work on Train.

- The PROTEUS code is the Prototype, which performs the logic mentioned in the SIMULINK code.

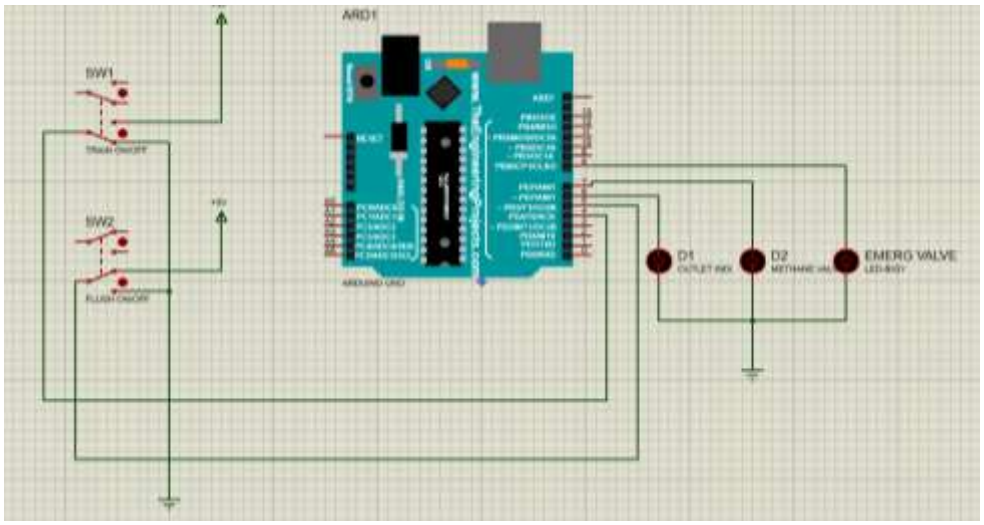

Fig. 3 - : PROTEUS Simulation for Simulink Program

7. Future Work

To simulate this project, we used SIMULINK Toolbox and MATLAB software. This project focuses on a single train compartment. We can use this to connect each compartment in the serial. Additionally, we can obtain more efficient results by using SIMSCAPE Blocks to develop this project. These blocks mandate the inclusion of parameters like flow rate, inlet pipe size, circumference, diameter, ratio, and radius, and they require absolute values for components like pipes, toilet bowls, tanks, etc. The values we obtain during real-time implementation are closely correlated with the outcomes.

8. Conclusion

Train restroom waste spills onto tracks can contaminate the environment and human health with bacteria and diseases. It affects the surrounding towns, railroad personnel, and passengers, producing offensive odors, unhygienic conditions, and drawing bugs. The practice damages biodiversity and ecosystems in delicate environments near railroad lines. In order to address these problems and adhere to safety, health, and environmental regulations, proper waste management techniques and infrastructural upgrades are crucial. This project has been completed. Due to the direct discharge of wastes, Indian Railways had to spend more money maintaining the rails, substantially impacting their earnings.

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