

ANALYTICAL STUDY OF VACUUM CONTROLLED GREEN TOILET SYSTEM FOR INDIAN RAILWAYS

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Abstract - The disposal of human waste is a very big problem for Indian railway. Incineration and chemical treatment of human waste has also been used to overcome the problem. However, all these methods are either unhygienic or not practically feasible alternatives. Controlled discharge toilet system having limitation to solve problem of sanitation. Bio-toilet system is used are quite good approach & providing hygienic condition of their biodegradation procedure, but problem of more water consumption, foul smell & chocking. Overcoming these problems with Alteration & upgradation we prefer for modern vacuum controlled green toilet system. Vacuum controlled green toilet for Indian railways, It secured the environment and make eco-Friendly. The aesthetic appearance of track should be good and nuisance from the human excreta on the track can be eliminated. Water consumption also saved & corrosion caused by the fecal matter can be minimized. By using Vacuum controlled green toilet system we can convert the solid waste into the pure water by means of biodegradation with anaerobic bacteria afterword with chlorination of discharged water. We can be utilized this water for washing of track and bogies and the remaining sludge can be used as fertilizer for agriculture purpose. So this vacuum controlled green toilet is very useful and essential for Indian Railways.

Key Words: Human waste, Indian railway, Incineration, Chemical treatment, Green toilet, Bogies, Odour,

1. INTRODUCTION

Indian Railway plays an important role as being a lifeline of India. Railways were the most important development from the point of view of the infrastructure in India from 1852. Railways in India are the only reliable and feasible source on land for transportation. Indian Railways (IR) is one of the largest railway systems in the World. Indian railways having Vision 2020 which would be focuses on Track Enhancement, Environmental Sustainability, Network Expansion of Railway, Capacity Creation, Train Safety, Reducing Carbon Footprint, High Speed Train Introduction and Technological Excellence. There are enormous challenges. It aims to develop a world class rail infrastructure & technology as countries like USA, China, Japan etc.

On any regional or intercity train, the toilet system is an important part and the reliability of the system is critical. Without working toilets, the train cannot be put in service. The disposal of human waste is very big problem in high

altitude areas. In non- glacier region the waste is collected and used as a fertilizer in the field. Incineration and chemical treatment of human waste also has been attempted to overcome problem. However, all this methods are either unhygienic or not practically viable alternatives. Biological treatment is an attractive approach for solving the problems, but decreased metabolic activities of the micro-organisms, freezing of the substrate non-availability of conventional energy sources and hilly terrains are some of hurdles which need to be solving to make the process practically possible. IR-DRDO has developed an innovative technology for disposal of human waste in eco-friendly manner at high altitude location at low temperature. The process culminates into treated effluent, which is free from pathogens and is also environmental friendly.

1.1 Types of toilet system in Indian railways

1. Conventional Toilet System.
2. Controlled Discharge Toilet System.(CDTS)
3. Bio-Toilet system.
4. Vacuum Controlled Bio-Toilet System.

1.1.1 Conventional Toilet System

The traditional method of disposing human waste from trains is merely to deposit the waste onto the tracks using a method known as a 'Hopper Toilet'. This ranges from the toilets being a hole in the floor of the train, to a full flush system. The hole in the floor system where waste is deposited on the track is still in use in many parts of the world but it can be considered crude or unhygienic and it litters Railway lines and can produce health risks if the train is passing over a public waterway. Passengers may be discouraged from using toilets while the train is at a station. Although there are solutions where toilets are automatically locked when the train pulls into a station but that is not the passenger friendly Solution.

1.1.2 Controlled Discharge Toilet System

Controlled Discharge Toilet System is working on the principal of speed of train & and high - flush technology through which the evacuation of toilet bowl is carried out by means of water pressure. It operates with a pressurized water bowl wash that covers 100 % of the toilet bowl area. The human waste is transferred to the retention tank with a

control amount of water. The basic purpose of introduction of Control Discharge toilet system in Indian Railway is to eliminate the practice of spillage of toilet waste on to railway station area & in the populated area of city.

1.1.3 Bio-Toilet system

A Bio-Toilet is a completely biological system. Which convert solid human waste to Bio-gas and water, with the help of a bacterial Inoculum by bio- degradation process. Biological decomposition of Human waste is done in bio-digester tanks with the help of anaerobic bacteria which is developed at bacteria generation plant at Motibagh Workshop SECR, Nagpur & DRDE/Gwalior. Bio-Toilet is an innovative technology for disposal of solid human waste in an eco-friendly, economical and hygienic manner.

1.1.4 Vacuum Controlled Bio-Toilet System

The main purpose of introduction of this toilet is saving the water .As the tank capacity for waste and fresh water is limited, the most suitable toilet for trains is the vacuum toilet, which only uses about 0.5-1 liter of water per flush. The common set-up for the onboard toilet system comprises a vacuum toilet module, which has all the required equipment to generate the vacuum, flush and empty the bowl, a holding tank for the waste and supplies for water, compressed air and electrical power.

Saving space as well as resources, this microprocessor controlled, all-in-one unit features a local vacuum system, removing the need for a vacuum-proof waste water tank. It is available with both sliding gate valve and pinch valve. Use depends on customer preferences and specifications. The customer has a choice between sit-down, squatting pan and urinal styles

1.2 Problem Statement

Due to conventional toilet system & Bio toilet system various problems are produced like,

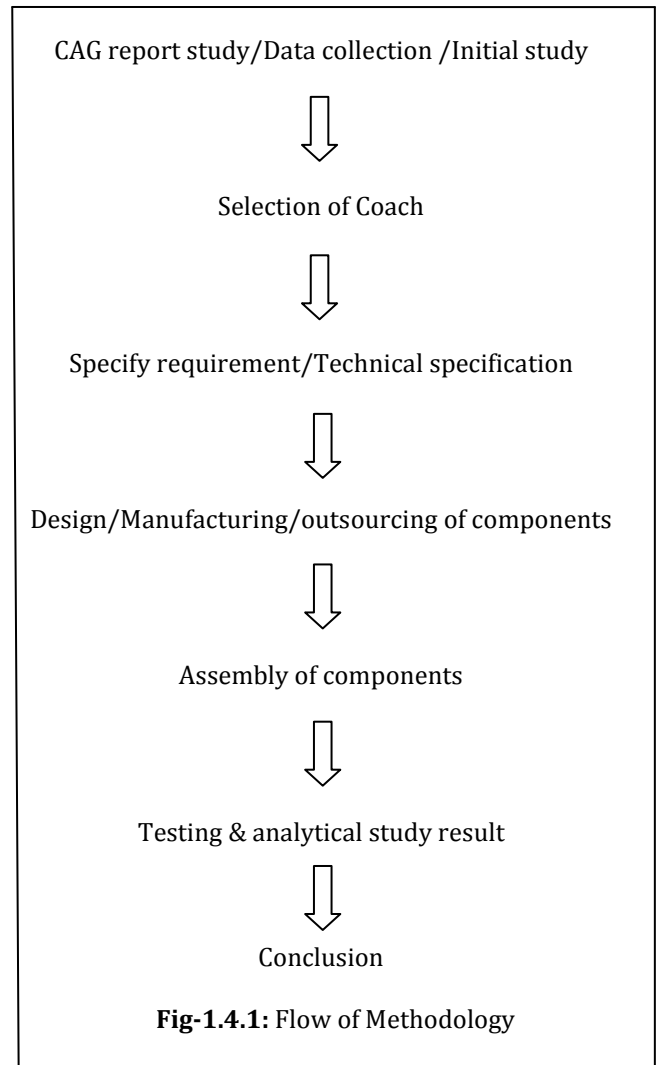
- I. The Comptroller and Auditor General in a 2017 report had found that almost two lakh complaints regarding choking & foul smell, and non-functional bio-toilets.
- II. More water consumption.
- III. Blockage & poor efficiency of Toilet.
- IV. Improvement in cleaning and Corrosion of railway track.

1.3 Objective

- I. Eliminate foul smell & chocking.
- II. Minimize the water consumption.
- III. Increase the life of railway track.
- IV. Provide efficient working condition to green toilet.
- V. Reduce the cost required for cleaning of platform.

- VI. Provide hygienic & healthy condition to Railway workers, railway staff, track man etc.

1.4 Methodology



1.4.1 Steps in Methodology

1. Study and analysis of conventional toilet system.
2. Study of bio-toilet system, Controlled discharge toilet system.
3. Searching drawbacks of different toilet systems.
4. Inventing new systems that overcome the drawbacks of early systems & also upgrade the system.
5. Specify technical parameter & requirement for our coach.
6. Collection of material & which are required for
7. Manufacturing new system with the help of industrial manufacturing unit.
8. Assembly of the different parts on unit.
9. Analysis and testing of new invented system.
10. Conclusion of new invented system.

1.5 Literature Gap

The Research work done by most of researchers brief in

- I. Controlled discharge toilet system.(CDTS)
- II. Automatic discharge toilet system.(ADTS)
- III. Central vacuum toilet system.
- IV. Bio-toilet
- V. Bio-gas generation
- VI. Sanitation technology.

Very few of researchers had carried out research in vacuum green toilet for Indian railways & had focused on water conservation for Indian railways toilet system. Hence I had chosen this area as my research area.

1.6 Parts of vacuum control green toilet System

1. **Vacuum commode/latrine pan**-To holds human waste in bowl. It has water nozzle to supply high pressure water.
2. **Biodigester Tank** -It is divided in to 7 partitions It consist anaerobic bacteria which is used for degradation of human waste.
3. **Intermediate tank**- To hold the waste during the flush cycle.
4. **Inlet valve** -Will open briefly for the waste to be moved from the bowl to the intermediate tank
5. **Outlet valve**- Will open briefly to expel the waste from the Intermediate tank to the holding tank.
6. **Ejector**-Generates the vacuum by a flow of Compressed air
7. **Pinch (hose) valve**-Normally open, but closed when the intermediate tank is pressurized
8. **Water pressuriser**- Amplifies the water pressure to generate enough flow through the flush nozzles to clean the toilet bowl
9. **Air filter/regulator**- Cleans and regulates the air to nominated working pressure for the toilet
10. **Solenoid valves**-For actuating all operations.

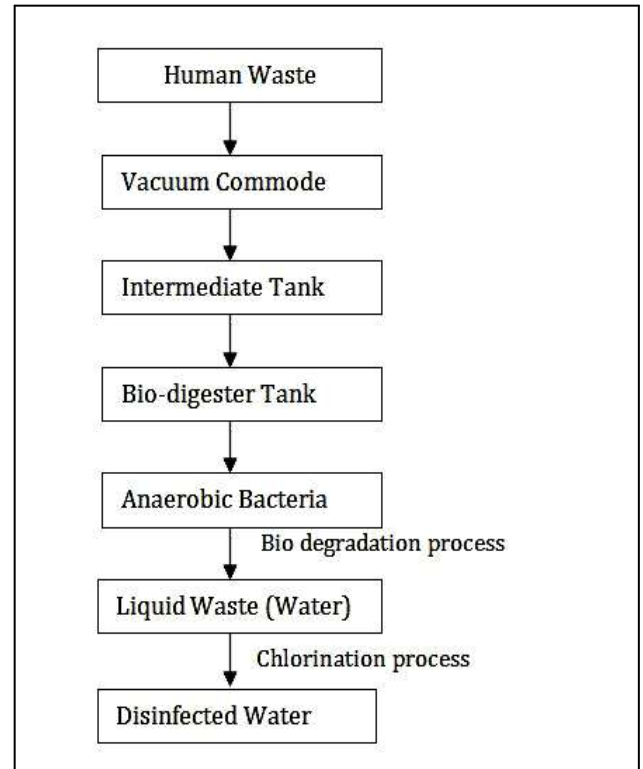


Fig-1.6.1: Flow process of vacuum green toilet system

1.7 Working of vacuum control green toilet System

1. Firstly Human waste is hold in vacuum commode bowl.
2. High pressure water is supplied to nozzle in bowl through water pressuriser.
3. By actuating solenoid valve ejector generates vacuum in intermediate tank.
4. Inlet valve is open by actuating solenoid valve & human waste sucked in retention tank.(out let valve is closed at that time)
5. Then Inlet valve is closed and air is passing through pinch valve and pressure is created in retention tank.
6. Then outlet valve is open and with high pressure human waste is discharged to Bio-digester tank.
7. In bio-digester bio degradation of human waste take place & human waste is converted to water. Later this water is chlorinated & discharge.

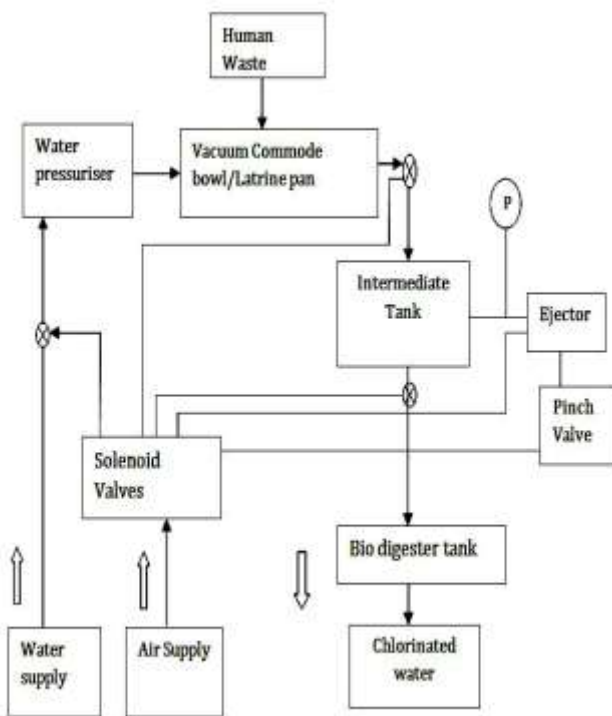


Fig-1.7.1: Vacuum control green toilet system

3. ADVANTAGES & DISADVANTAGES

3.1 Advantages

1. As there is no sludge formation, there is no need for de-slugging and treatment.
2. No bad smell in toilets from the tanks.
3. Fecal matter in the tank not visible
4. Effluent is free from off odor and solid waste
5. Indication facility of Choke up & failure.
6. It is more economical in the long-term as it conserves water
7. Night soil degradation occurs through microbial reaction which converts it into biogas and odorless water.
8. Permits use of toilet cleansing agents.
9. Lifelong usage bio-digester tank does not need recharging, re-shifting or maintenance.
10. Easy to transport and install.
11. One-third to one-fourth capacity of septic tank
12. Space requirement is less.

3.2 Disadvantages

1. Relatively high initial cost.
2. Robust construction.
3. Depended on electric power & air supply
4. Due to new technology for maintenance required skilled staff
5. Coarse materials can lead to blockage of collection system
6. By pass system or dual mode system not available in the case of enroute failure
7. Requires space for connection
8. Passenger Awareness Required.

4. CONCLUSIONS

From the Present study of vacuum controlled Green-Toilet system following points are concluded

1. Using Vacuum green toilet water conservation can be done.
2. Unhygienic environment changed to healthy & clean environment.
3. Problem of foul smell & bad odor in Lavatories can be resolved.
4. Better environment for biodegradation process can be maintained.
5. Vacuum green toilet system is future of Indian Railway Toilet system.

5. APPLICATION

1. Indian Railways.
2. High speed trains & foreign railways.

2. CALCULATION & STATISTICAL ANALYSIS

1. Approx use of toilet by passenger in per day per coach 100 times toilet and 500 times urinal used per coach per day.
2. Water consumption in one use of Toilet 8-9litre & for urinal 4-5litre
3. Water consumption per coach in one day = $(100 \times 8.5) + (4.5 \times 500) = 3100 \text{lit/coach/day}$
4. for vacuum toilet in one use - 1 to 1.5 liter
5. Water consumption per coach in vacuum toilet in one day = $(100 \times 1.25) + (500 \times 1) = 625 \text{ liter/coach/day}$
6. Water conservation per day per coach = $3100 - 625 = 2475 \text{ liter}$
7. Water conserved per coach by vacuum toilet in service = $(2475 \times 344 \times 25) = 2,12,85,000 \text{ liters}$
- a. Note -21day per year are assumed for POH,
8. Life of vacuum controlled unit 25years
9. Average rate of water 0.1Rs Per liter
10. Cost of water saved by vacuum toilet in his life span = $2,12,85,000 \times 0.1 = 21,28,500 \text{Rs.}$
11. Difference in the cost of Bio toilet and Cost of vacuums toilet - 2.5 lakh /unit

Using Vacuum toilet we can save Revenue of railway for water is **Rs 11.28 lakh** per coach in life span.

ACKNOWLEDGEMENT

The author's gratefully acknowledge the Technical support provided by Central Railway, Mumbai division. This work would not have been materialized without the great guidance given by our guide, Prof.J.J Salunke who had given a constant source of ideas and inspiration. The author expresses gratitude towards Dr. Ulhas Shiurkar (Director of Deogiri Institute of Engineering And Management Studies) and Prof. P.G.Taur (Head of Mech. Department) for their continuous motivation and encouragement.

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