

Design of Bio Toilet for Railway Coaches & Design of Child Friendly Toilet

Report

**Team RAGNAROK
S Raja Ramanan
S Vishaal Kanna
P Thiruvasakan
Muni Kumar**

Problem in hand:

Bio-toilet system is implemented in trains by the Indian Railways to prevent a direct discharge of human excreta onto the railway tracks. Such a discharge can lead to **corrosion of the tracks** and also cause hygiene problems. In addition, it can also cause difficulties in cleaning the railway tracks due to **generation of poisonous gases from the faecal matter**. Bio-toilet system helps to address the above problems by breaking down the human waste and converting them into simpler substances like methane gas and water.

The Indian Railways has implemented 93,537 bio-toilet systems in trains between the years 2000 and 2009. Although most problems were solved, there were persistent issues reported by both passengers and railwaymen.

A total of **1,02,792** cases of choking in 25,080 bio-toilets have been reported implying that **one bio-toilet got choked four times in a year during 2016-2017**. During the years 2015-2016, for 24,675 bio-toilets, 61,088 cases of choking were seen.¹

The National Federation of Indian Railwaymen (NFIR) in a letter² to the Railway Board pointed out the following problems:

- The bio-toilet system is very sensitive. Chances of choking in the digester are very high even with a bit of 'pan gutka' spit in the toilets by the passengers knowingly or unknowingly, if not flushed properly by the passenger in the moving or stationary trains.
- Choking in these toilets can also take place due to throwing of sanitary napkins, cigarette butts, gutkha pouch, plastic water bottles or their covers, liquor bottles and garbage of food stuff by the passengers, resulting in overflowing of toilet pans and leading to public complaints. This situation has been causing tremendous pressure on staff for no fault of theirs.
- Bio-toilets required inspection and maintenance to ensure working of ball-valve and its operation linked with p-trap and hose connector, mounted and fitted in the narrow gap of the top surface of the tank and through floor of the coach. C&W engineers and staff have been put through a lot of difficulties during maintenance and have been subjected to high physical and mental stress in day-to-day work. While working, they are being compelled to inhale foul smells emanating from the choked tanks containing human waste and have started acquiring diseases.

¹ Source: Economic times

<https://economictimes.indiatimes.com/industry/transportation/railways/almost-2-lakh-complaints-of-choking-foul-smelling-bio-toilets-in-trains-cag/articleshow/62134554.cms>

² Source: <http://www.indiaspend.com/wp-content/uploads/Disadvantages-caused-due-to-Bio-Toilets.pdf>

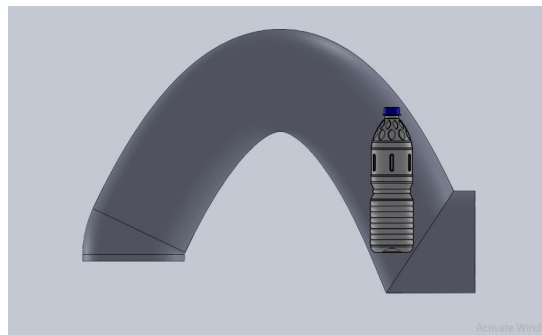
Although biodigester is beneficial to the Indian Railways, the following problems need to be addressed for its better functioning. For that purpose, we need a design

- **To prevent choking of bio-toilets.**
- **Where clogs can be removed easily and inspection can be done without any harm to the workmen.**
- **That limits the water usage while flushing.**
- **To prevent poisonous gas entry into the restroom through the commode.**
- **To make the railway toilet child-friendly.**

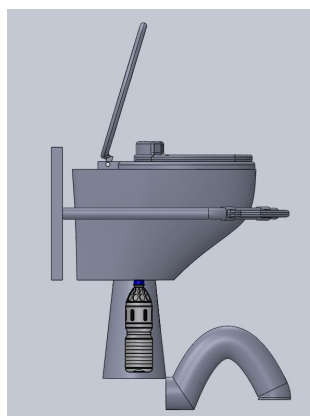
A detailed analysis of the problem:

Choking

Choking of a toilet occurs if a foreign substance clogs the path of flow of the slurry. The primary constituents of slurry are faecal matter and water. The following images best describe the possibilities of clogging.



Any solid that is small enough to enter the p-trap but large enough to get stuck in the p-trap forms a clog blocking the entire flow of slurry.



Repeated use of the clogged toilet leads to accumulation of faecal matter. Due to the blockage, the flushed water gathers over it leading to flooding of the toilet.



Fig 7: Choked Bio-toilet in Train No. 19270 (WR)



Fig 8: Choked bio-toilet in Train No 22443/44 (NCR)

In order to clear out the clog, the workmen use anti-clog equipment to apply a huge amount of



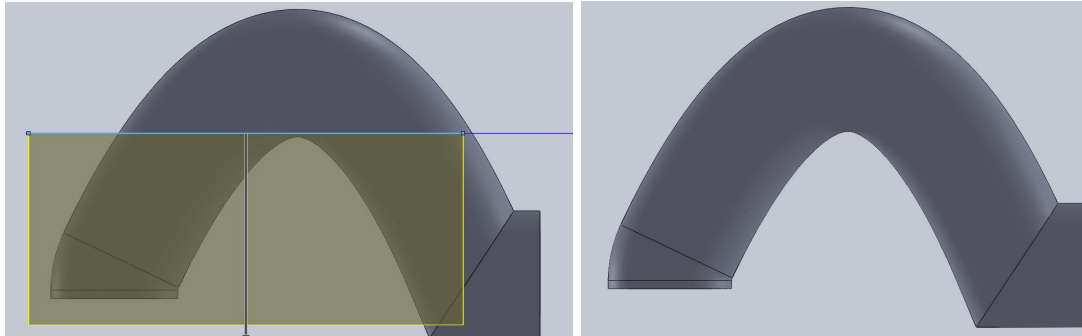
pressure on the foreign substance and push it through the path. Though this method removes the clog, the foreign material gets into the biodigester thereby, affecting its functioning. The only method to remove the clog is by dismantling and opening the biodigester and removing the foreign particle physically, which exposes the workmen to hazardous conditions, making them prone to many diseases.

Excessive water usage:

The present bio-toilet system requires **1.5 to 2 lts of water per flush** to completely flush out the faecal matter through the p-trap.

Poisonous gas entry:

Once the CDTs system is actuated, no water is retained in the p trap and hence entry of poisonous gas is possible through the commode opening.



The Yellow zone represents the water. Once the ball valve is opened, the water level drops thus the poisonous gases from the digester are free to move to the commode.

Not safe for children:

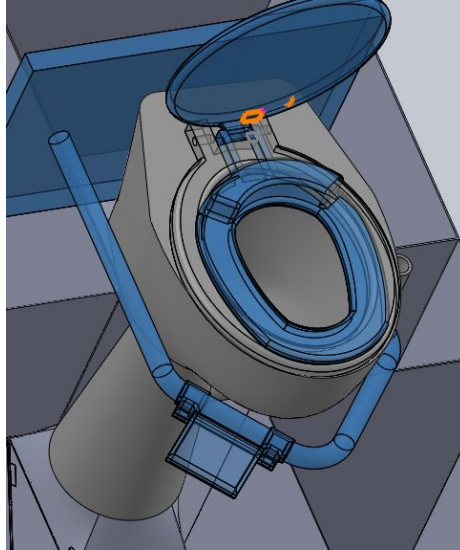
The average height of the commode surface from the floor is 40cm. Children find it difficult to climb and sit on the sit plate. They are forced to place their hands on the unhygienic surface and are exposed to hazardous health conditions. Also, the wide opening of the commode makes it even harder for the children to use it.

Our design:

Top and side view:

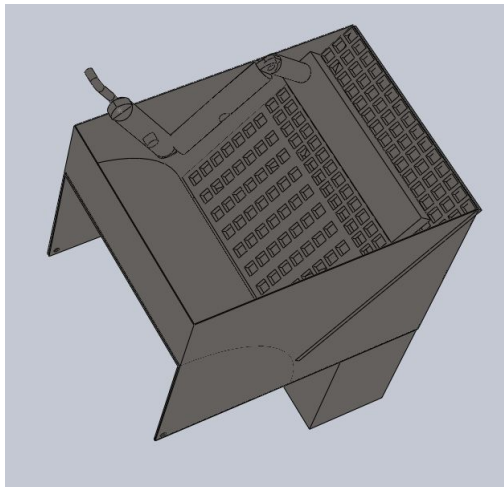
The design comprises of a **zeroth chamber** (cubical box setup) added to the present biodigester design **replacing the ball valve and the p-trap**. It consists of a **cylindrical valve along one of the base edges** that is actuated through CDTs. There is also a plate inclined to one of the walls of the chamber. The upper half of the plate is grided with square holes of side 1 cm and the lower half of the plate covered with poly-grass mat along with the holes. This box is connected through a pipe like arrangement to the first chamber of the biodigester. There is an inlet pipe arrangement to add inoculum periodically. The box **also consists of a mechanical pusher** above the plate to push the non faecal material outside.

In order to make the toilet child friendly, a **tubular frame is fixed** around it with which a **flapper** is attached for support. Also a **smaller lid is attached** to ensure the child doesn't fall into the commode.

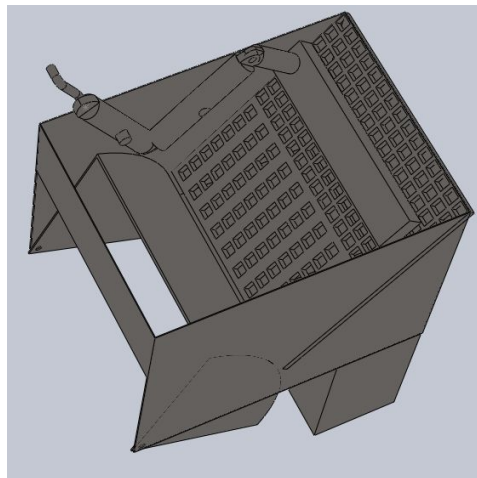


Working:

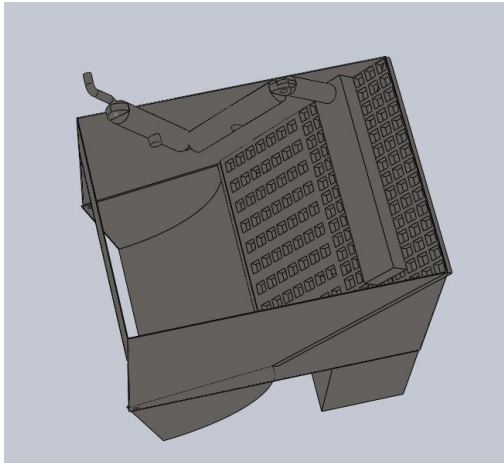
Faecal Matter along with water (slurry) falls on to the sieve directly. Being in semi solid form, it will pass through the sieve along with the flush water. Other foreign materials like plastic water bottles, polythene covers, cannot pass through the slotted plate. On activation of CDTs, the cylindrical valve and the mechanical pusher are simultaneously actuated. The foreign material that does not go through the sieve will be disposed on to the tracks through the cylindrical valve opening. Faecal matter that does not go through the sieve will eventually be digested by the bacteria in the polygrass mat.



Closed Condition



Intermediate Condition



Open Condition

Design calculations:

A wet slurry was made by mixing mud and water in the ratio 4:1 by volume (125 ml of water to 400ml of mud). The mixture was dropped from a height of 1 ft on the grilled plate followed by pouring of 250 ml of water from the same height. Almost all of the slurry passed through the sieve with a trifle amount of it sticking on to the slots, which will eventually be digested by the bacteria in the polygrass mat.

Manufacturing:

A differential connector with the commode end as circle and the other end as a square will connect the commode and the zeroth chamber.

- Area of sheet metal required: 1830 sq cm.
- Sieve: Stainless Steel plate of thickness 5 mm and area 22 sq cm
- Link lengths: 85 mm, 86 mm, 44 mm.

Implementability:

The zeroth chamber will also be made of stainless steel as the rest of the biodigester. The zeroth chamber will be mounted on top of the fourth chamber. It will then be welded using gas welding to the existing digester.

Disadvantages:

- The setup will lead to the generation of foul odour when the train is stationary.
- It adds to the weight of the the entire system.