

AN EXPERIMENTAL STUDY OF WORKING OF BIO- TOILET IN INDIAN RAILWAYS

Athar Hussain^a and Sonu Kumar Sahu^b

^aAssociate Professor, Department of Civil Engineering,
Ch. Brahm Prakash Government Engineering College,
New Delhi 110073, India

^bUG Student, Ch. Brahm Prakash Government Engineering College,
New Delhi 110073, India
E-mail: athariitr@gmail.com, sonukumarsahu5400@gmail.com

Abstract—Indian Railways (IR) is one of the world's largest rail networks, spreading over 68,400 route Km. Indian Railways is the lifeline of the country carrying nearly 23 million passengers every day making it the largest passenger carrying system in the world. Indian Railways are using bio toilets, but it possesses a lot of drawbacks. The present study has been carried out to investigate the effluent of bio toilet emanating from railway station at hazrat nizamuddin. The bio toilets effluent samples were collected from Hazrat Nizamuddin railway station (station code: NZM). From the present study it is inferred that bio toilets do not function efficiently at low temperatures hence bio toilets are not good enough for Indian trains in winter season. All the experiments of collected water samples were carried out in the environmental engineering laboratory of the college and the obtained results has been compared with existing literature. The pH, BOD, COD, Ammonical nitrogen and Ortho phosphate concentration were found to be respectively 7.32, 440mg/L, 335mg/L, 3.8mg/L and 14.12mg/L. The present study indicates that the high pH value accelerates the corrosion in railway lines and tracks as reported by various investigators. The pH value of 7.32 indicates a high corrosive potential that could corrode the railway track at very high rate. However, the methane gas during the anaerobic decomposition contributes to effluent methane gas and CO₂ it causes global warming and air pollution.

Keywords: Bio-Toilet, Waste water, Temperature effect, Indian railways.

1. INTRODUCTION

Indian Railways (IR) is one of the world's largest rail networks, spread over 68,400 route Km. Indian Railways is the lifeline of the country carrying nearly 23 million passengers every day making it the largest passenger carrying system in the world. It is also the 4th largest freight transporter in the world moving 1,160 million tonnes of freight annually, as it traverses the length and breadth of the country (7).

Indian Railways have been working with bio toilets, but a lot of improvements are still needed in this sector as only around 17,388 conventional toilets have been replaced with bio toilets. The bio toilets still discharge the end process water on

the railway tracks which causes corrosion due to the oxidation. The bio toilets were developed by Defence Research and Development Organization (DRDO), have a colony of anaerobic bacteria, kept in a container under the lavatories that convert human waste into water and small amounts of gases. The gases are released into the atmosphere and the water is discharged after chlorination on to the track (1).

1.1 Bio-Toilets

In these bio-toilets, the waste retention tanks are fitted below the coach door underneath the lavatories and the human waste discharged/collected into them is acted upon by a colony of anaerobic bacteria that convert human waste mainly into water, sludge and bio-gas (Methane & Carbon Dioxide). The gases escape into the atmosphere and waste water is discharged after disinfection onto the track (7).

1.2 Construction and Installation of Bio Toilet

Construction of bio toilets is with stainless steel. The length, width and height of the retention tank are respectively 1150mm, 720mm and 540mm. The volume of the tank is 400L. The empty and full tank weight of the retention tank is respectively 115 kg and 415 kg. The construction of the bio-toilet show in the fig.1. (2).The bio toilet is rapidly installed in Indian trains. The installation process is start in 2010-2011 that time only 57 bio-toilets are installed but till 2018-2019, 69166 bio-toilets are installed. All the data shown in fig.2.

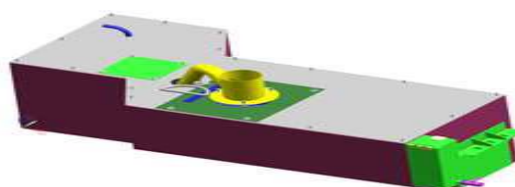


Fig. 1: Overall view of Bio – Toilet tank (7)

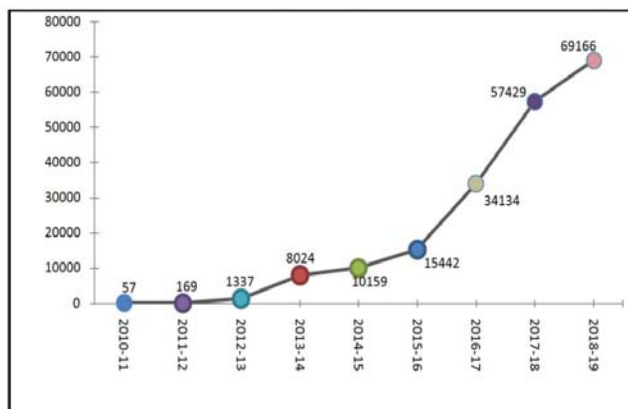


Fig. 2: Year wise progress on installation of bio- toilets in train coaches (7)

1.3 Working of Bio- Toilet

Bio-toilet works on the principle of anaerobic process. The human waste collects in the bio-toilet retention tank. These human wastes go through anaerobic process where anaerobic bacteria convert waste into sludge, CO₂ and methane gas. After this liquid waste goes through chlorination process and finally liquid and gasses are released to the atmosphere. All the processes have been shown through fig.3.

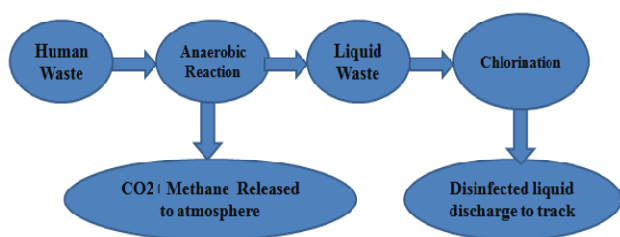


Fig. 3: Working of bio-toilet

1.4 Limitation/ Drawback

It is seen that passengers habits of throwing of items like plastic bottles, paper cups, cloth rags, sanitary napkin, nappies, plastic/poly bags, Gutkha pouches on the floor of wagons (7). However the bio toilet in Indian railways is facing some drawbacks including degradation of human waste where the end products such as liquid discharges are being thrown in open areas and the produced gasessuch as methane & CO₂are released in open atmosphere directly. These wasted gases are good source of energy and the wasted sludge can be used as manure. The wastages of these products ultimately increase the unnecessary burden on environment. (2). Typical composition of biogas is 55–75% methane and 25–50% carbon dioxide. In these bio-toilets, gases escape into the atmosphere and treated waste water is discharged after chlorination (8). They are an economically viable solution,

with one bio-toilet costing Indian rupees 15,000 (US\$ 280). The Indian Railways may look for engineering solutions to capture and store methane released from the bio-toilets (8).

2. METHODOLOGY

The data for comparison of existing systems and parameters has been collected from various sources and available literature. The obtained data has been processed and is compared. However, the lab studies pertaining to the analysis of the wastewater emanating from bio-toilets has been carried out in the environmental engineering laboratory of college. The analysis of all the parameters has been carried out as per the standard method examination of water and wastewater APHA, 2005.

3. RESULT AND DISCUSSION

Through all the above discussion we are come to the result that the bio toilet is not effective and sufficient solution for Indian railways. Due to the wide range of temperature difference in various regions in India bio-toilet are not work properly. The outputs of bio-toilet are water and gas which effect our environment. The output water is the reason of rail track corrosion and output gas is one of the reasons of global warming.

4. EFFECTS OF VARIOUS PARAMETERS ON WORKING OF BIO-TOILET

Considering the above mention facts in view a study has been carried out in order to evaluate and asses the various factors that effect the working of bio toilet and environment.

4.1 Temperature effect on bio toilet

Various investigators and researchers have reported that the biodegradation activity decreases with the decrease in temperature in a system. However in a UASB Reactor as shown through Fig. 4 at up flow velocity of 0.35 m/h the total COD removal of 82%, 68% and 44% at a temperature value of 28°C, 14°C and 10°C respectively has been reported. COD removals of ~65% at 20°C and of 55–65% at 13–17°C were observed by several authors (Lettinga *et al.*, 1981; Grin *et al.*, 1983; Vieira and Souza, 1986; Elmitwalli *et al.*, 1999; Seghezze, 2000). At 28°C the average effluent TSS concentration was 17.7 mg/L, which increase to 26.6 mg /L at 20°C, 60.3 mg TSS/Lat 14°C and reached 120 mg TSS/L at 10°C.

During the winter temperature conditions when the temperature of sewage decreases about 14°C, the bacterial hydrolytic activity drastically decreases(6). The maximum and minimum temperature of various regions in India of the December month has been summarized and is shown in table 1, 2, 3 and 4. The maximum temperature of north, east, south and west regions are respectively 27°C, 28°C, 31°C and 32 °C. The minimum temperature of north, east, south and west

regions are respectively -2°C, 5°C, 15°C and 9°C. The maximum and minimum temperatures of various regions in India of the January month. The maximum temperature of north, east, south and west regions are respectively 27°C, 29°C, 31°C and 32°C. The minimum temperature of north, east, south and west regions are respectively -2°C, 4°C, 15°C and 8°C. Due to irregularity of temperature in India bio-toilet are not working properly and also not give effective results.

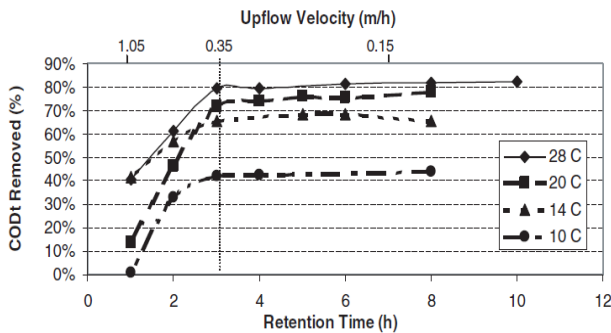


Fig. 4: Total COD removal (6)

Northern India

Table No.1:- Variation of temperature in December month of northern region

Average December temperatures

Locations	State	Temperature (°C)	
		High	Low
Agra	UP	24	9
Allahabad	UP	25	10
Amritsar	Punjab	21	4
Bhopal	MP	26	11
Chandigarh	Chandigarh	22	7
Dehradun	Uttarakhand	21	7
Indore	MP	27	11
Lucknow	UP	24	8
Ludhiana	Punjab	21	7
Mukteswar	Uttarakhand	14	3
New Delhi	DELHI	23	9
Patna	Bihar	25	10
Shimla	Himachal Pradesh	11	4
Srinagar	J&K	8	-2
Varanasi	UP	25	10

Eastern India

Table 2:- variation of temperature in December month of Eastern Average daily temperatures in December

Place	State	Temperature (°C)	
		High	low
Agartala	Tripura	27	12
Balasore	Odisha	27	14
Bhubaneshwar	Orissa (Odisha)	28	16
Cherrapunji	Meghalaya	17	8
Dibrugarh	Assam	24	10
Gopalpur	West Bengal	28	17
Guwahati	Assam	24	12
Kohima	Nagaland	18	9
Kolkata (Calcutta)	West Bengal	27	15
Raipur	Chhattisgarh	27	13
Ranchi	Jharkhand	23	10
Shillong	Meghalaya	16	5

Southern India

Table no. 3: Variation of temperature in December month of southern region

December temperatures: daily averages

Place	State	Temperature (°C)	
		High	low
Bangalore	Karnataka	26	16
Chennai	Tamil Nadu	28	22
Madurai	Tamil Nadu	30	21
Minicoy	Lakshadweep	31	24
Hyderabad	A.P	28	15
Vijayawada	A,P	20	20
Port Blair	Andaman & Nicobar	29	22
Mysore	Karnataka	28	17

Western India

Table 4:- Variation of temperature in December month of western region

December temperatures: daily averages

Place	State	Temperature (°C)	
		High	low
Ahmedabad	Gujarat	29	13
Aurangabad	Maharashtra	29	11
Jaipur	Rajasthan	25	9
Kota	Rajasthan	25	12
Mumbai	Maharashtra	32	21
Nagpur	Maharashtra	28	13
Nasik	Maharashtra	29	11
Panaji	Goa	33	21
Pune	Maharashtra	29	12
Rajkot	Gujarat	30	14
Surat	Gujarat	32	16
Vadodara	Gujarat	31	14

3.2 Effects of Bio Toilet Effluent on Climate Change

Climate change as a result of global warming is one of the most serious global environmental problems, as it is a potential threat to our biosphere with huge social, environmental, and economic consequences, and as Lenzen et al. (2002) claims it is also linked to the problem of the inequity between industrialized and developing countries as the wealthy 20% of the world's population causes about three quarters of global greenhouse gas emissions. The main greenhouse gases are carbon dioxide, water vapour, methane, CFCs, and nitrous oxides. Of these, carbon dioxide seems to be the most important as, according to calculations, it will be responsible for about two thirds of the expected global warming in the future(11). Typical composition of biogas is 55–75% methane and 25–50% carbon dioxide. In these bio-toilets, gases escape into the atmosphere (8).

3.3 Treated Bio-Toilet Effluent and Its Effect on Environment

The discharge water sample of bio-toilet was collected from Hazrat *Nizamuddin railway station* (station code: NZM). All the experiments from the collected samples were carried out in the environmental engineering laboratory of the college and the obtained results has been summarized and is shown in table no. 5. The pH value of collected treated water is found to be 7.32. Summarised in table No.9 and from the fig.no.5 it is clear that corrosion rate is high at this temperature. The corrosion rate is higher at pH 7.0 than at pH 5.5 (11). Bio-toilet discharge water is the one of the reason of corrosion of rail track.

Table no. 5:- Experimental results of effluent treated water

Parameter	pH	COD (mg/L)	BOD (mg/L)	Ammonical nitrogen (mg/L)	Orthophosphat (mg/L)
Concentration	7.32	440	335	23.8	14.12

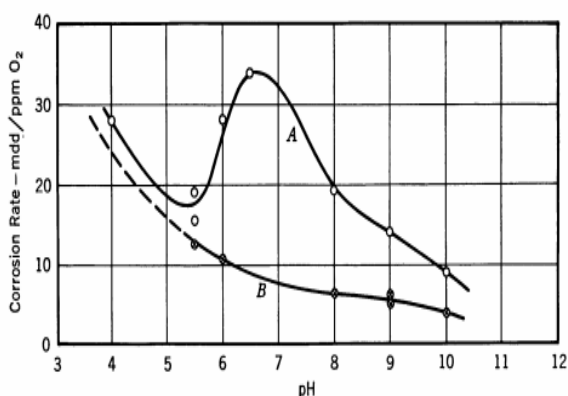


Fig. 5: Effects of pH and Velocity on Corrosion Rate of Steel (10)

Curves A and B, representing controlled velocities of 1.0 and 0.33 fps, respectively, indicate higher corrosion rates at pH 7.0 than at pH 5.0 for short-term tests of 10 days duration. At zero velocity, Curve C, the corrosion rate did not change over this pH range in short-term studies

5. CONCLUSION

From the present study it can be concluded that working of Bio toilet is temperature dependent and its efficiency decreases with the decrease in temperature. In a tropical country like India the temperature varies largely from season to season. Thus bio toilet is not an effective solution of wastewater emanating from Indian railways. Also the treated wastewater possesses high pH value that generally corrodes the railway tracks at a very high rate. Therefore an alternative solution is required for the treatment of wastewater emerging from Indian railways and its disposal.

REFERENCES:

- [1] V. P Sakhare, A Wadgure, R Sanghi and N Wadaskar , Advances of Bio Toilets in Railways, International Advanced Research Journal in Science, Engineering and Technology, Vol. 4, Issue 5, (2017), DOI 10.17148
- [2] P. Gunaki, Karthik.S and S. Prabha, A Concept for Eco-Friendly Sanitary System in Indian Railways, Vol.3, Special Issue 1 (2017).
- [3] V. Vasudevan, Technology for Eco-friendly Solution of Human Waste Disposal, Defence Research & Development Establishment, Gwalior.
- [4] Handbook on IR-DRDO bio-toilets for open line maintenance, draft, Govt. of India Ministry of Railways, IRCAMTECH/2014/M/GWL/Bio-Toilets, (2014).
- [5] D.G. Dange, D.G. Vernekar, S.D. Kurhade and P.D. Agwane, Methodology for design and fabrication of human waste disposal system for Indian railway- A Review, International Journal of Science Technology & Engineering ,vol-2 issue-07, (2016).
- [6] B.Lew, M. Belavski, S.Admon, S. Tarre and M. Green, Temperature effect on UASB reactor operation for domestic wastewater treatment in temperate climate regions, Water Science and Technology Vol 48 No 3, (2003), pp 25–30.
- [7] Environmental sustainability Annual report 2018-19 (Indian Railways)
- [8] Foster, K. R. and Chopra, K. L, (2012) N Charles Sturt University, PO Box 883, Orange, NSW 2800, Australia e-mail: (2012), 103, 1258–1259.
- [9] India Meteorological Department and World Meteorological Organization. World Weather Information Service World Data Centre for Meteorology. Climate of the World
- [10] R. Eliassen, C. Pereda, A.J. Romeo and R.T. Skrinde, Effects of pH and Velocity on Corrosion of Steel Water Pipes , Journal (American Water Works Association), Vol. 48, No. 8, (August 1956), pp. 1005-1018
- [11] V. Papadimitriou, Prospective Primary Teachers' Understanding of Climate Change, Greenhouse Effect, and Ozone Layer Depletion, Journal of Science Education and Technology, Vol. 13, No. 2, (2004).