

## **"PERFORMANCE EVALUATION ON BIO TOILET"**

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#### Abstract:

Bio-toilets are innovative and environmentally-friendly sanitation systems that have gained significant attention in recent years. This study aims to assess the effluent characteristics of bio-toilet systems and their potential implications for water quality and environmental sustainability. The research employs a case study approach to evaluate the effluent characteristics of bio-toilets in a rural community. Various parameters such as pH, temperature, dissolved oxygen, total dissolved solids, conductivity, chemical oxygen demand, and biological oxygen demand are measured to determine the quality of the effluent. The findings highlight the performance and suitability of bio-toilet systems for rural areas, emphasizing their potential to address sanitation challenges while minimizing environmental impacts. The results contribute to the existing knowledge on bio-toilet technology and provide insights into the effluent characteristics that can guide future design and management strategies.

#### **INTRODUCTION :**

Access to adequate sanitation facilities is a fundamental human right and a critical component of public health. However, many rural areas, especially in developing countries, lack proper sanitation infrastructure. Bio-toilets offer a promising solution by combining ecological principles and waste management practices to provide safe and sustainable sanitation. This paper aims to evaluate the effluent characteristics of bio-toilet systems and their implications for water quality and environmental sustainability

India launched the Swachh Bharat Mission, a nationwide cleanliness campaign in 2014 to eliminate open defecation. The problem of open defecation in India cannot be resolved through the mere availability of government-built toilets. According to US sanitation report of 2019, millions of new toilets under the programme of Swachh Bharat mission in rural areas are producing large amounts of solid and liquid waste that rural areas does not have the ability to treat and dispose the waste safely.

The Indian railway develop a toilet system to treat the toilet generated in the train called BIO-TOILET, which we are using trying to use as a solution for the safely and economical disposal of toilet waste generated in the rural area.

Bio-toilet is type of dry toilet. The bio-toilet is thermophilic compacting toilets which decompose anthropoid excretory waste in the digester tank using certain soaring graded bacteria (aerobic and anaerobic) and after that converting them into methane gas and water.

Bio-toilet is differing from traditional toilet because bio-toilet is Environment friendly green toilet it needs only half a liter of water for flush while traditional toilet needs 10 to 15 litter of water. Bio toilet is the portable toilet that has biologically wastewater treatment which is fitted with the toilet. Bio-toilet design in such way that they fulfill the criteria such as: economy, safety functionality and social and environmental affordability.

It is very necessary that the bio-toilet must be constructed with the aim of quickly decomposition of human Excreta, optimizing efficiency, and minimizing environmental problems such as odour and maintains the hygienic condition.

Use of Bio-toilets will be a mitigative steps towards improve of sanitation in the rural areas and to reduce the pollution load caused due to unscientific way of disposal of toilet waste. The problem of unscientific way of disposal of toilet waste are ground water contamination, soil sickness, odour problem.

Hence among all the different alternatives, the bio toilet is the best alternative as it does not cost too much and provides the acceptable effluent characteristic and the modification made was at the source itself, hence it can also be adopted for the existing as well as proposed toilet with a very small modification and the treated effluent water can be discharged directly into the pipe drain or other alternative

The design of bio-Toilet consists of the is a sanitation fixture used primarily for the disposal of waste these tanks are made of stainless steel and having following constructional features The size of the tank is 540 X 1150 X 720 MM with the provision of 04 no's mounting brackets at both the sides along the length of the tank. Each bracket is with the provision of 02 nos. M16 Size bolts which are tighten in the under slung on mounting brackets.

#### Main parts of the Bio digester tank:

- 1. Stainless steel tank with 06 partition walls inside the tank
- 2. Poly grass mats for protection of bacteria inside the walls.
- 3. Ball valve with handle for operation during emergency for making toilet direct discharge in case of choking.
- 4. SS fasteners in place of MS on tank covers.
- 5. Stronger bonding of Colonized rubber mat with vertical walls.

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#### Important Dimensions & Volume of Bio-digester Tank:

1. Length - 1150 mm 2-Width - 720 mm, 3. Height – 540 mm 4. Total Volume of Tank – 400 lt. 5. Effective Volume of Tank – 300 it. 6. Empty Tank weight – 110 Kg. 7. Full Tank Weight – 410 Kg. 8. Height from Rail level - 220 mm

#### **Importance of the Study:**

The main problems associated with rural toilet waste Disposal under Swachh Bharat Scheme are

- The collection and treatment of sewage was not given much importance, the government was interested in construction of toilet but not in treatment/disposal.
- The financial support was given only for the construction of toilet but not for the treatment and disposal of the sewage generated in the toilet, which was not consider as a sustainable scheme.
- The available technology for collection and treatment of sewage will be very difficult and uneconomical to adopt by the government due to the technical limitations and financial concerns.
- Our major concern is that the untreated/the method what was followed to disposal of sewer will create the lot of environmental problems (Ground water pollution, Land sickness, health problem such as infection, diarrhea.

S1.	Authors /Year /Journal		Title of the paper			Inference	
no			tern	otio		R	erearch Journal
1)	Ghatge		Satish	Automatic	Wor	king	Toilet system shall disintegrate/decompose the
	,Sandeep		Pawar	<mark>Bio-</mark> Toilet	Tank	for	waste by the bacteria proliferating due to agents
	Bhagawan	l,	Bhor	<mark>Rail</mark> way Co	aches		add <mark>ed i</mark> n it. The system should be able to work
	Abhishek	(	Vol. 5,				satisfactorily even with foreign objects as above.
	Issue 01, 2	2017	) <mark>IJSR</mark> D				The human waste may be treated in single or
	- Internati	onal	l Journal				multiple stages to ensure complete
	for Scienti	ific	Research	earch			decomposition. The tendered shall clearly
	& Develop	ome	nt				indicate the system for rendering the toilet
							discharge environmentally inert. Chemicals used
							in the toilet if any, shall be dispensed in such a
							manner that there is no chance of their contact
							with the user. The media used in the waste
							treatment tanks should be of proven design
2)	Dhananjay	G	. Dange	Methodolog	gy	for	This paper presents the methodology for design
	Dattapraka	ash	G.	Design and	Fabrica	ation	and fabrication of human waste disposal system

	Vernekar Sagar D.	of Human Waste	for Indian railway with the related search. The
	Kurhade Prashant D.	Disposal System for	study specifies factors influencing the human
	Agwane	Indian Railway	waste disposal and recommends a number of
	(Volume 2   Issue 07		design options for human waste disposal system
	January 2016) IJSTE -		for Indian railway. These are based on a
	International Journal		systematic study of the human waste disposal
	of Science Technology		system and testing of a prototype model of it.
	& Engineering		The main conclusion will be drawn find out
			whether it is possible to automate a human waste
			disposal process which would avoid passengers
			inconvenience and uncleanliness and unhygienic
			condition of railway stations. Also the future
			scope for developing the human waste disposal
			system for any type of railway coaches as simple
			as possible. Above survey has given us guideline
			to accomplish the objective project work.
3)	Devwrat Vegad and	Sewage Disposal	Indian Railways coaches are designed to
	Sunny Paruthi (Jan	System for Trains:	disposed off the human excreta and water from
	2017) International	Current System and	toilets directly onto the tracks which becomes a
	Journal on Emerging	Future Prospects	potential source of environmental and health
	Technologies 🥟		hazards. New technologies are being developed
			to tackle and curb this problem and this paper
			looks into the prospect of one such technology
	Intern	iational R	i.e. Chemical Retention Tanks coupled with a
			technology called Automatic Train Discharge
			System. The aforementioned model is just a
			prototype of what the Indian Railways can adopt
			to tackle the ever increasing problem of sewage
			and waste discharge from trains. Implementing
	Rezo	earch Thro	this system will definitely need a huge amount of
			investment from the government's part as we
			have already pointed out. But what we need to
			look is that in today's world if we do not start
			caring for the welfare of nature then we will have
			a huge price for it in the future.
4)	Virendra Kumar	From Flush to Energy	This paper proposes an approach FFEM (From
	Yadav, Saumya	Model: Solution of	Flush to Energy Model) that not only give
	Batham,Amit Kumar	World's Biggest Open	solution to world's biggest open toilet but also

	Mallik (April 2013	Toilet (Indian	utilizes the toilet waste to generate the
	Volume 67– No.20)	Railways)	environment friendly energy, Biogas energy.
	International Journal		This biogas energy can be utilized in lighting or
	of Computer		some other useful purposes according to the
	Applications		need. This paper is organized as follows. Our
			proposed model (FFEM) will not put any
			restriction on its user. Passengers can use toilet
			when they want, even if the train is standing on
			the platform. Also it converts human solid waste
			to biogas energy which can be utilized in lighting
			the lamp post at the platform (as requirement) or
			some other useful purposes. Approach of this
			model will not only solve the world's biggest
			open toilet problem (Indian Railways) but gives
	-		alternate source of energy.
5)	Aeshiti Patel, Mahak	MASS	This study aims to trace the total coverage and
	Mehra Arora,	COMMUNICATION	prominence given to sanitation by Indian media.
	Manushreya Sharma	MODEL FOR	The research also tries to examine the role of
	and Dr. Aahana	RAISING	media in raising awareness in urban households
	Bhatnagar	AWARENESS	towards bio toilets as well as its installation in
	Co-Author: Dr.	TOWARDS BIO-	community spaces where even traditional toilets
	Aahana B. Chopra (Jan	TOILETS	aren't installed. The type of research is
	2022 Volume:07,	allo al D	exploratory, using mixed methods. The research
	Issue:01) International	iational K	methods are content analysis and survey. The
	Journal <mark>of</mark> Social		objective of the study is to suggest a
	Science a <mark>nd E</mark> conomic		communication model in order to raise awareness
	Research		among residents vis a vis usability of bio toilets
			and sanitation in the communities using the
			principles of science communication.
6)	JOVITA	CHARACTERISTICS	The residual albizzia sawdust from bio toilet is
	TRIASTUTI,NENI	OF COMPOSTED	benefit soil conditioner due to high porosity, low
	SINTAWARDANI,	BIO TOILET	bulk density, high water retention and neutral ph
	MITSUTERU IRIE	RESIDUE AND ITS	compared to other soil which increased leaf
	(2009) Indonesian	POTENTIAL USE AS	number, area, and stem diameter Bad odor was
	Journal of Agricultural	A SOIL	not created during composting. It was concluded
	Science 10(2)	CONDITIONER	mixtured wood sawdust could be used as matrix
			for composting human excreta.

					Class-A that safe for food and non-food plant.
					Application of mixture wood sawdust as matrix
					in Biotoilet for composting human excreta could
					improve sanitation, prevent water degradation, at
					once increase soil quality for agricultural
7)	Sunzid Hass	san and	EVALUATION	ON	This paper discusses the existing toilet system
	K.M. Iqbal		THE IMPACTS	AND	(Hopper toilet) of trains in Bangladesh. It
	(2016) Acader	mia	ALTERNATIVE	ES OF	analyzes the negative impact of Hopper toilet on
			PASSENGER 7	RAIN	environment and proposes better alternatives.
			TOILETS	IN	Toilets are important part of long route trains
			BANGLADESH		journey. In Bangladesh, trains use Drop Chute
					toilets or Hopper toilets. It is also used in India,
		_			but they've started to implement alternative
					toilets due to its harmfulness. These type of
		-			toilets discharges human waste directly on the
					rail tracks. Discharged untreated human wastes
					pollute nearby environment and waterbody.
					Hopper toilet is getting replaced with improved
					toilet system (such as Multrum toilet, Chemical
					toilet, toilet with storage, Bio toilet etc.) in many
					countries. Study was conducted on Chitra train
					(Khulna to Jessore route). The existing toilet
					system, discharge rate and impacts was surveyed
		ren			under this study. The proposed alternative is
					based on chemical retention tank, which can be
					easi <mark>ly im</mark> plemented in trains with Hopper toilet.
8)	Shwetank	Shekhar	Developing	smart	In the first phase, RF transmitter and receivers are
	Singh,	Ra <mark>jwa</mark> nt	railway toilets		used. The transmitters are placed at the platform
	Pandey, Pawa	n Kumar			and the receivers are at the fitted in the train. As
	Agrawal,	Vartika			the train reaches the platform it receives the RF
	Dubey (2019	volume 4			signal. At the same time, the PIR sensor is used
	, issue 4) Inte	rnational			to discover if any person is in the toilet. If any
	Journal of	Advance			person is there in the toilet then the door does not
	Research	and			lock. The mechanism of the toilet in use changes
	Development				and the waste is stored to a tank. The mechanism
					is done with the help of water relays that works
					on 24volts.In case two if no person is there in the
					toilet then it locks the door of the toilet till the

			train is at the platform. In the second phase, as
			the train starts to move away from the platform
			the RF signal that was received by the train start
			to become weaker and weaker. A point comes
			when no signal is received by the RF receiver
			which means the train has passed the platform
			this point, all the door gets unlocked. PIR sensors
			get deactivated. The other 24-volt relay gets
			activated and the mechanism is switched such
			that the waste is dumped off from the tank. RF
			receivers are still activated so it can easily detect
			whether the train has reached the platform or not.
9)	Kirithika S Madhan	SMART PUBLIC	The main abstract of the paper is to improve the
	Kumar L R Kingson	TOILETS USING IOE	condition of public toilets and make them
	Kumar M Keerthana <mark>E</mark>		accessible to every citizen in a hygienic way.
	Lohalavanya R (2020)		"SwachhBharath"(Clean India) project is one of
	International		the most trending schemes in our country. One of
	Conference on		the objectives of the scheme is to provide
	Emerging Trends in		uncontaminated toilets and to design and develop
	Information		a user-friendly universal toilet which will be
	Technology and		sustainable and should be successfully used by
	Engineering (ic-ETITE		the people across all socioeconomic spectrum.
	leker	alia al D	This scheme is named as "NAMMA TOILET".
	Interr	iacional K	The question now arises, If the toilets are
			maintained properly and are they clean to use? To
			monitor cleanliness, autonomously flush and to
			avoid the bad odor we have proposed this system.
			We have made use of the proximity sensor,
			biometric system, gas sensor and a dashboard to
	Rezo	earch Thro	monitor and store the data of the cleaners activity.
			With the help of these, we can bring in an
			effective way to maintain public toilets
10)	Shashi Gandhar,	Optimisation of smart	The proposed optimized SMART MOBILE
	Srilakshmi Yedavilli,	mobile toilet using	TOILET is an innovative sanitation model which
	Shreya Tiwari,	maximum power point	is based on emerging technologies (Automation
	Yashmita Tomar &	tracking	and Sensors based monitoring), Renewable
	Aniket Kumar (2022		integration (PV Pumps & Solar panels) and
	vol 41 pp. 163–171)		provides for efficient Waste management

			techniques. It is an interdisciplinary research
			model which is designed keeping in view of the
			national flagship programs like "Swachh
			Bharat", "Swasth Bharat" and "Make In India".
			It involves continual and unmanned operations of
			the toilets, hygienic facilities, automated doors,
			remote monitoring through SMT App and
			provides for a self sustainable ecosystem.
			Basically, the project's goal is to Create "Smart
			Slums" or "Smart Villages" just like Smart cities.
			This working model focuses on self-
			sustainability, energy efficiency, hygienic
	_		factors, water and land resources conservation,
			Maximum Power Point Tracking
11)	Sudhakar M. Ra <mark>o,</mark>	Performance of	A modified twin pit that performs anaerobic,
	Lydia Arkenadan and	modified twin pit toilet	aerobic, anammox, and denitrification reactions
	Nitish V. M <mark>ogi</mark> li	in Mulbagal town,	to reduce nitrate load in discharged sewage is
	(2018) Journal of	Karn <mark>atak</mark> a, Ind <mark>ia</mark>	functional in Mulbagal town, Karnataka, for
	Water, Sanitation and		nearly one year. The first pit serves as an
	Hygiene for		anaerobic chamber that reduces COD level by
	Development		72%. The second pit facilitates aerobic reactions
			in the upper half and its lower half is equipped
			with a bio-barrier. COD/N ratio of 1.49 to 1.73 is
	Intern	iational K	favorable for ammonium oxidation in the aerobic
			chamber. Annamox reactions reduce ammonium
			and nitrite concentrations in the bio-barrier
			chamber. Passage of liquid through the bio-
			barrier removes nitrite and nitrate by
			denitrification reactions. Consumption of organic
	Rezo	earch Thro	carbon in the anaerobic and aerobic reactions
			reduced the thermotolerant coliform counts by
			2.5 log cycles. Sewage treatment by modified
			twin pit besides removing nitrate, reduces COD,
			ammonium, and thermotolerant coliform levels
12)	Kartik Kumar Soni,	A review on Uses of	Sanitation in Indian Railways had become a need
	Amit Kumar and Ankit	Bio Toilets in Indian	of time and an important aspect for Indian
	Kumawt(2014)	Railway Passenger	Railway's complete success. Responsible
	Academia	Coach	authorities are also putting efforts in this
		•	

					direction by carrying out outfield trials and
					putting notice board in toilets such as requesting
					passenger not to use flush when train is stationary
					at platform. Our proposed model (FFEM) will
					not put any restriction on its user. Passengers can
					use toilet when they want, even if the train is
					standing on the platform. Also it converts human
					solid waste to biogas energy which can be
					utilized in lighting the lamp post at the platform
					(as requirement) or some other useful purposes.
					Approach of this model will not only solve the
					world's biggest open toilet problem (Indian
					Railways) but gives alternate source of energy
13)	K.SANTHAPRI	YAN	DESIGN (	OF	In order to overcome this failure the blockages
	,R.RAJADESIN	ig 💪	VACUUM		inside tanks can be eliminated by Vacuum
	S.SASIKUMAR	ξ,	CONTROLLED		Controlled Discharge Lavatory System
	M.THIRUM <mark>O</mark> O	RTHY	DISCHARGE		(VCDLS). Vacuum Controlled Discharge
	(March 2015 vol	lume 3	LAVATORY		Lavatory System (VCDLS) retains the black
	issue 1 ) Intern	ational	SYSTEM (VCDL	S)	water/toilet waste and discharges when the speed
	Journal of Research in		OF RAILWAY CAR	ł	of the coach is equalto more than the designated
	Engineering	&			speed and a pre-programmed number of flush
	Advanced Techr	nology			cycles have been completed. This specification
					covers the design & general requirements
		GII			including supply, installation & commissioning
					of controlled discharge toilet system along with
					stainless steel inlays for low cost stainless steel
		_			coaches
14)	JOVITA	TRI	ECOLOGICAL		This study was aimed to evaluate the
	ASTUTI,	DEWI	APPROACH C	ON	characteristic and prospect of lignocelluloses
	NILAWATI,	NENI	SANITATION:	0	waste material, mixtured wood sawdust as matrix
	SINTAWARDA	NI	COMPOSTING (	OF	in composting human excreta using Biotoilet.
	(Feb 2016 volume 16,		HUMAN EXCRET	ГA	Initially, 26.4 kg mixtured wood sawdust (+4/-32
	No 1 ) Jurnal	Bumi	USING BIOTOILI	ET	mesh) moisture 11.84% was filled into Biotoilet
	Lestari,		WITH		chamber, and added with 20L tap water to
			LIGNOCELLULOS	ES	achieve $\pm 50\%$ moisture. Mixer in Biotoilet was
			WASTE MATERIA	4L	adjusted to run-on intermittently with interval 15
			AS MATRIX		min, each for 2 min, i.e. 1 min to clockwise and
					counter-clockwise, respectively. Exhaust fan

with flow rate of 0.04m3 .sec-1 was operated continuously to ensure proper aeration. Human excreta were loaded daily to Biotoilet chamber for 90 days which would be composted. Data showed that temperature of composting system was 25.70-43.67oC. Moisture was 22.27-53.20% and pH 6.20-7.00. C/N ratio composted residual sawdust was 25:1. Ash, N, P, and K content were 11.78; 1.78; 0.85; and 0.95%, respectively. Bad odor was not created during composting. It was concluded mixtured wood sawdust could be used as matrix for composting human excreta. The compost could be categorized into Class-A that safe for food and non-food plant. Application of mixture wood sawdust as matrix in Biotoilet for composting human excreta could improve sanitation, prevent water degradation, at once increase soil quality for agricultural.

#### **OBJECTIVES**

### International Research source

- To understand the working of biological toilet and vacuum system
- To study the performance of biological toilet
- To evaluate the possibility of using bio toilets and vacuum systems in rural areas

## METHODOLOGY :

The study was conducted in a rural community where bio toilets were implemented as part of a sanitation intervention program. A systematic approach was followed to evaluate the performance of the bio toilets and analyze the effluent characteristics. The following parameters were measured: pH, temperature, dissolved oxygen, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), and nutrient content (nitrogen and phosphorus).Provide details of the study area, including geographical location, climate, and local sanitation challenges. Describe the bio toilet systems used in the study, including their design, installation, and operational parameters. This section describes the study location, the bio toilet system under investigation, and the methods used for effluent sampling and analysis. It outlines the sampling procedure, sample preservation, and laboratory analysis techniques employed for each effluent characteristic parameter



#### **Results and Discussion:**











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pH and Temperature The pH values of the effluent ranged from 8.4 to 8.12, indicating the neutral to slightly acidic nature of the effluent. Temperature measurements indicated a range of 27.5°C to 27°C, reflecting the ambient conditions of the study area.

Dissolved Oxygen and Biological Oxygen Demand The dissolved oxygen content of the effluent ranged from 8 mg/L to 2mg/L, indicating sufficient oxygen availability for aquatic life. Biological oxygen demand values ranged from 300 mg/L to 120 mg/L, suggesting the efficiency of the bio-toilet systems in organic matter decomposition.

Total Dissolved Solids and Conductivity The total dissolved solids levels in the effluent were found to range from 1200 mg/L to 1037mg/L, indicating the presence of dissolved ions and minerals. Conductivity measurements reflected the ion concentration and ranged from 5 µS/cm to 1.612 µS/cm.

Chemical Oxygen Demand Chemical oxygen demand values of the effluent ranged from X mg/L to Y mg/L, indicating the presence of organic compounds that can exert oxygenconsuming effects on the receiving water bodies.

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