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A Review Study of Waste Management and Initiatives in Indian Railway

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ABSTRACT: The global generates annually 2.01 billion tonnes of municipal solid waste, at least 33 percent of that not managed in an environmentally safe manner. Global waste is expected to grow to 3.40 billion tonnes by 2050. Currently more than 50% of waste is openly dumped, if waste is not handled or disposed of properly, represents a threat to the environment and human health thus requiring urgent action. The Indian Railway handles about 23 million passengers daily, consequential in an enormous quantity of solid waste generation. The solid waste generated at major railway station across the country is nearly 2.45 million tons per year or 675 tons per day. Out of this, about 120 tons per day is food waste, which can be processed at some main stations for composting and about 350 tons per day is recyclable waste including plastics, metal, glass, paper and board. The main part for the recyclable waste comes from plastic which generates from wrapping of food, water and beverages. Garbage generated in trains and stations can be categorized as Biodegradable and Non-biodegradable.

Railways have taken up a pilot project for disposal of solid waste generated at railway terminals in an environment friendly approach, including conversion of waste to energy. Railways and Production Units have taken initiatives to set up solid waste management facilities including separation and waste processing methods such as bio-methanation, vermi composting for bio-degradable waste and recycling of recyclable waste. Indian railway is planning to install Bio-Vacuum Toilet with an objective to provide clean and low consumption water toilets instead of Bio toilets or flush toilets.

The Indian railways have set up world's first patented heterogeneous catalytic process plant which converts various garbage into hydrocarbon liquid fuels, gas, carbon and water. The plant has a capacity of 500 Kgs waste per day. Within 24 hours the waste is processed and reformed without emitting any harmful pollution into the atmosphere.

Studied the system of garbage disposal at 212 stations as per sample selection over 17 zones and observed. A fundamental principle of waste management is to reduce or reuse the waste generated. Adequate infrastructure was not available for proper collection and disposal instantly of different categories of waste. Various initiatives for reducing the waste has discussed in this paper.

KEYWORDS: Solid waste, bio-degradable, non biodegradable, Garbage, Polycrack

I. INTRODUCTION

The world generates 2.02 billion tonnes of municipal solid waste per year (figure 1), with at least 33.1 percent of that extremely conservatively and not managed in an environmentally protected mode. Global waste generated per person per day averages 750 gm but range usually from 120 gm to 4550 gm. While 16 percent of the world's population high-income countries create about 682 million tonnes or 35 percent of the global waste.

In future, global waste is expected to grow to 3.41 billion tonnes by 2050, in excess of double population growth in this duration. In the given regions (figure 1) of global, about 50 percent of waste is openly disposed in atmosphere, and the growth of the waste will have enormous implications for the environment, health, wealth and survival conditions hence urgent action is required.

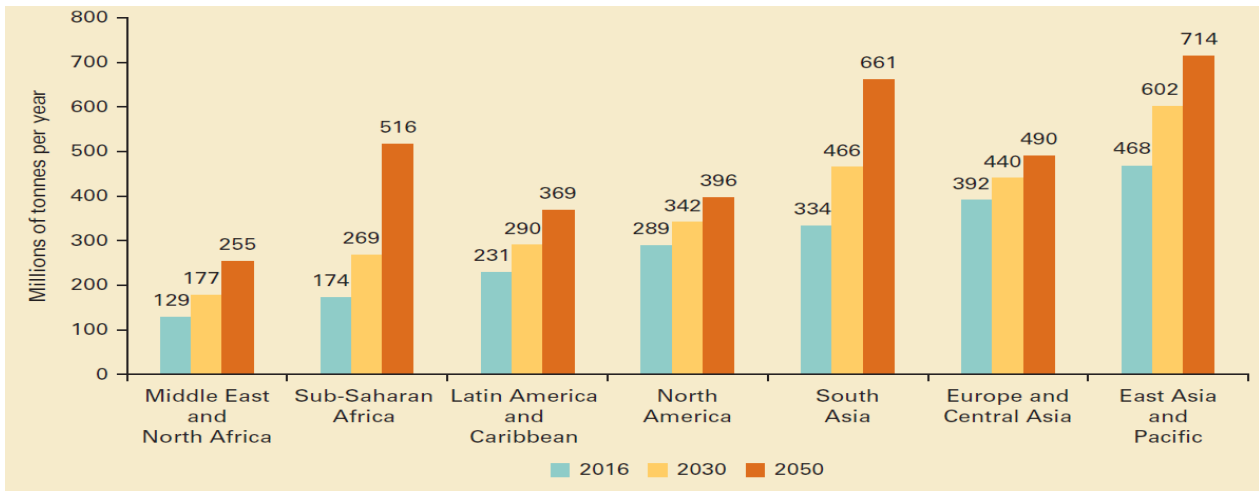


Figure 1: Global waste

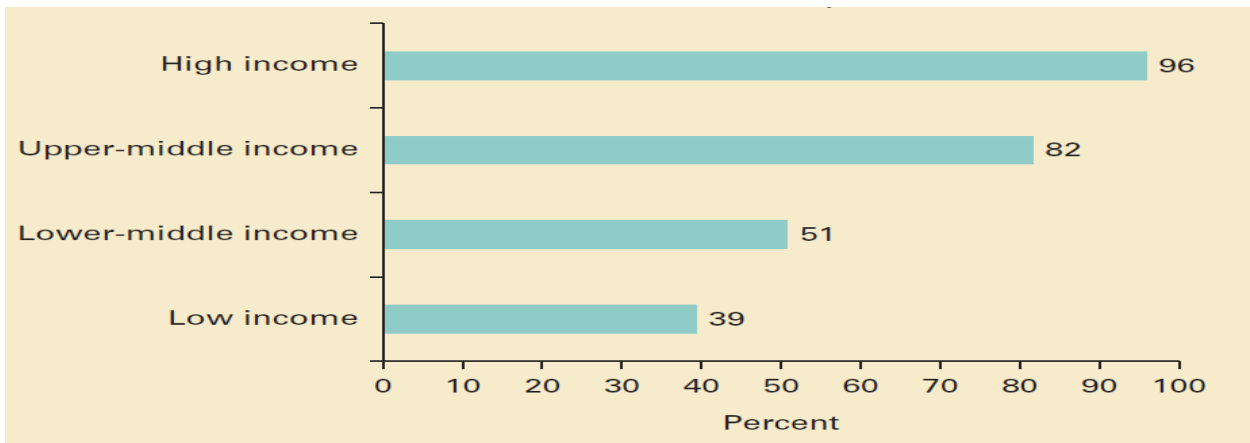


Figure 2: Waste composition differs across income levels

According to varied income level waste generation are different generally waste generation is directly proportional to the income level. It is reflecting in given figure 2. High-income countries create comparatively less food and green waste about 30 percent of total waste, and create more dry waste. Middle income countries produce 52 percent and low income countries generate 58 percent food and green waste, respectively. Materials that could be recycled account for only 22 percent of the waste stream in low income countries. Global waste composition (in percent) is shown in Figure 3 and Global treatment and disposal of waste (in percent) is shown figure 4. Plastics are integral part of way of life and have various applications. Plastics are composed of a network of molecular monomers bound together to form macromolecules [1]. The main focus is primarily on municipal solid waste (MSW), exposure to bioaerosols from composting facilities and to pathogens from sewage treatment plants are considered [4].

In order to find efficient, sustainable solutions to reduce occupational risks of waste workers, a methodological risk assessment has to be performed and counteractive measures have to be developed according to an internationally acknowledged hierarchy [5]. The processing of waste involves, sequentially, the collection, transportation, sorting, treatment, recycling for recovery of diverse value-added products and monitored final disposal in a landfill [6].

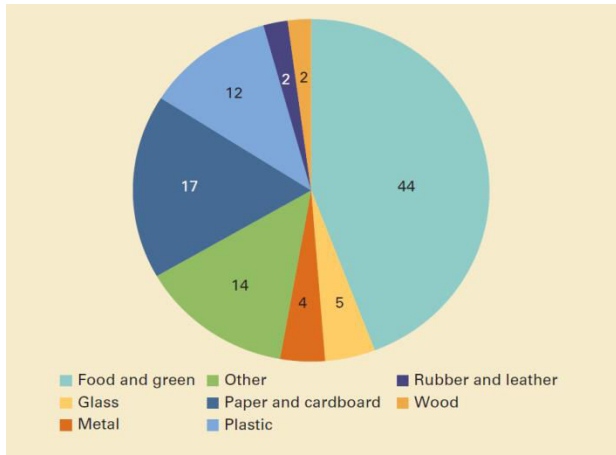


Figure 3: Global waste composition (%)

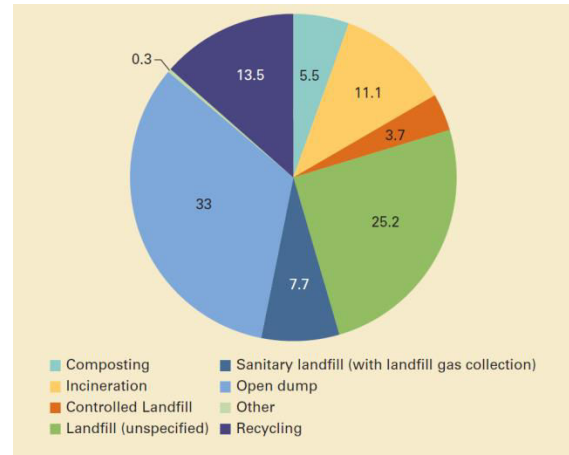


Figure 4: Global treatment and disposal of waste (%)

II. WASTE MANAGEMENT OF INDIAN RAILWAYS

Waste management is the reduction of the volume of waste by using various methods and Technology without producing any pollution or hazardous effect and reuse, recycle and up cycling the waste material, simultaneously prevention of various way to control the generating waste by modifying the existing systems. If Waste substance not handled appropriately or disposed, indicates a danger to the environment and human health.

The Indian Railway (IR) handles about 23 million passengers daily, ensuing in a enormous amount of solid waste generation. The solid waste generated at major railway station across the country is nearly 650 tons per day or 2.5 million tons per year and 4200 tons of human excreta per day. Per capita waste generation is around 70 gm (solid waste). Out of this, about 120 tons per day is food waste, which can be nearby processed at main stations for composting. Approx 350 tons per day is recyclable waste including paper, glass, board, plastics, and metal. The main part for the recyclable waste comes from plastic waste which originates from wrapping of food, water and beverages. The garbage accumulated in the trains and station premises are collected either departmentally or through outside agencies. The Indian Railways needs a comprehensive strategy for management of waste requiring efforts at different levels [3].

2.1 Categorized the garbage generated in trains and stations

Indian Railway generates vast quantities of dissimilar kind of wastes. Passengers of train and service providers to travelers generates commonly solid waste during the journey and at railway stations of the country.(As per Report No. 21 of 2012-13 of Indian Railways).

The waste generated in trains and stations can be categorized as-

1. Biodegradable: This means all things that can be decomposed by natural agents. Natural agents contain water, oxygen, acid rains, ultraviolet rays of the sun, microorganism’s recyclable waste as like foods, paper, newspapers, food containers, disposable cups etc.

2. Non biodegradable: Non -biodegradable substances are never broken down or decomposed by Environmental aspects. This include mainly of plastic waste from mineral water bottles, aluminum foil etc.

The accumulated garbage in the railway station premises are collected either departmentally or through external agencies. Initially collected waste dumped at a dumping yard from station and transported later to a centralized dumping yard or Municipal dumping yard.

III. WASTE GENERATION OF INDIAN RAILWAY AND ITS PREVENTION

1. Rules 2016 of Solid Waste Management, identifies Indian railways as a bulk waste generators. Segregation in three separate categories namely biodegradable, non biodegradable and domestic hazardous wastes is highlighted. Waste hierarchy of the solid waste is to be managed on priorities basis giving emphasis to prevention, reduction, reuse, recycling, recovery, up-cycling and disposal, with prevention being the most preferred option and the disposal at the landfill being the smallest amount.



Fig.5: Waste hierarchy

2. Railways have taken up a pilot project for disposal of municipal solid waste (MSW) generated at railway terminals in an environment friendly manner, including conversion of waste to energy. Pilot plants are being set up at Jaipur and New Delhi Railway Stations which will convert bio-degradable waste to energy through biomethanation process. Energy produced from these plants would be utilized for suitable services at near Railway Stations. One more such plant is being set up at Chennai.

3. Bio-degradable waste to energy (bio-methanation) plants was set up earlier at Jaipur and Kishanganj-New Delhi. Recently bio-degradable waste to energy Bio-gas plants has been set up Puri, MMCT Stations and Liluah Workshop.

4. Zonal Railways and Production Units have taken initiatives to set up solid waste management facilities including segregation and waste processing methods such as composting, vermi-composting, bio-methanation for bio-degradable waste and recycling of recyclable waste. Integrated waste management system is commissioned at ICF where about 6 ton per day bio-degradable waste from the colony is converted as compost.

5. Instructions about waste management of Indian Railway have been issued for quick disposal of waste arising out of catering services in trains and at stations and to keep separate dustbins for dry waste and wet waste to enable separation. Dustbins are provided in sleeper coaches and AC coaches. Dust bins are also being provided in bio toilets in all coaches.

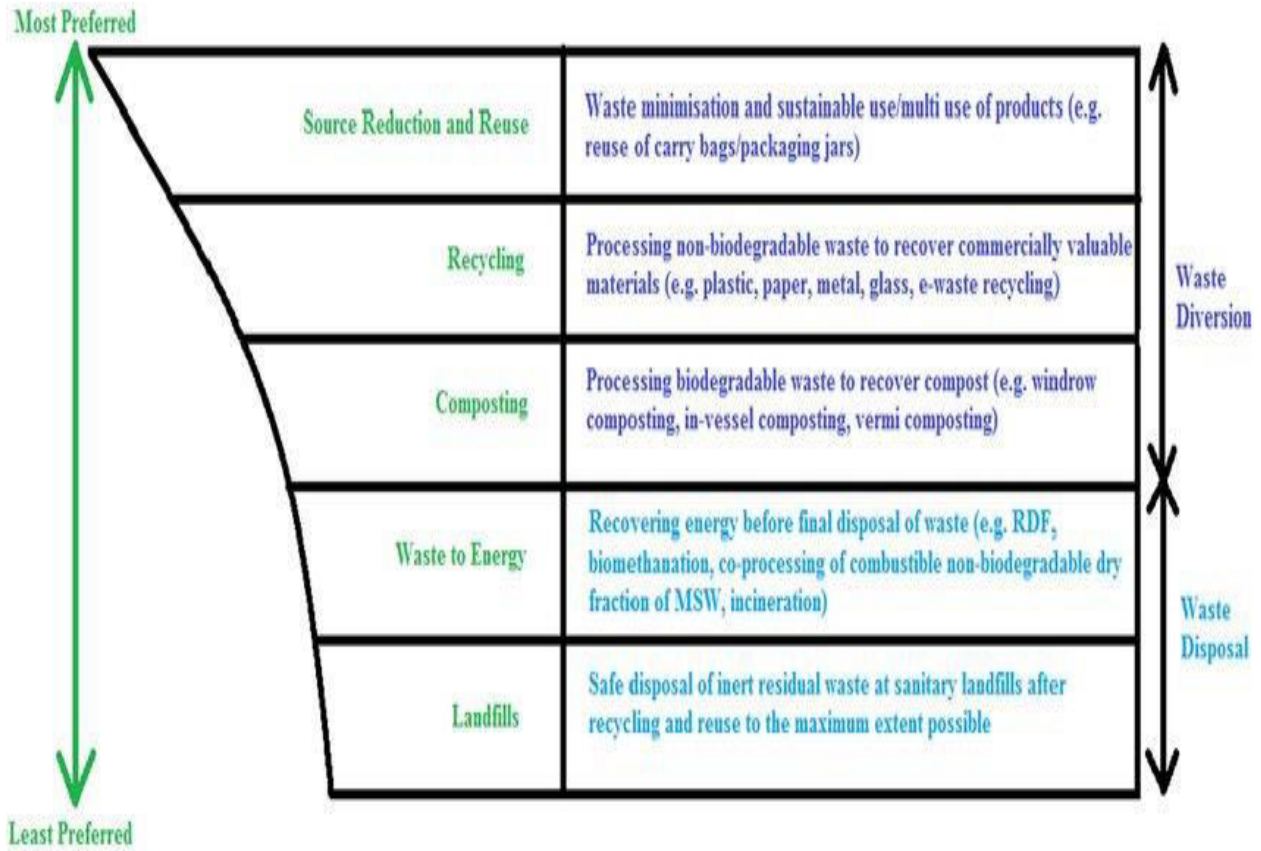


Figure 6: Disposal of waste management

IV. PREVIOUS AUDIT REPORT OF INDIAN RAILWAY

Audit Report on “Cleanliness and sanitation in Indian Railway”, no.6 of 2007 of Comptroller & Auditor General of India (Railways) [11], highlighted the following issues:-

1. Absence of any mechanism to assess the quantum of waste generated at Railway stations and trains.
2. The solid waste generated at trains and stations was not being segregated into biodegradable and non-biodegradable. Further, as most of the catering was with IRCTC, the contract entered into with them needs to include provisions about disposal and separation of waste before its dumping.

Public Accounts Committee (PAC) in their eighty third reports (2008-09) also pointed out limitations in the management of waste. This Committee observed that while making use of plastic, the Ministry of Railways must not lose sight of environmental concerns and ensure that applicable rules are adhered to. The action taken note of Ministry of Railway was however silent regarding use of plastics and plastic waste.

The Ministry of Railways has taken action on the recommendations of Public Accounts Committee, are indicated below:



PAC Observations	Public Accounts Committee Recommendations	Action taken by the Ministry of Railway
1. There was no system to realistically assess the huge amount of garbage generated at stations and separation of wastes before disposal.	Indian Railways should formulate a policy on waste management and put in place a system whereby a realistic assessment of the huge volume of waste generated at stations can be done so as to facilitate adequate collection, segregation and disposal by the authorities with the necessary infrastructure can be installed.	Garbage disposal system was already in place on Indian Railway. To determine the suitable agency for this work, its quantity was being determined before tendering.
2. Several shortcomings in collection and disposal of waste.	Suggested for adequate condition of VATs and penal provision in the contracts for garbage disposal through outside agencies and regular analysis of the performance of contractors. The Committee also suggested transportation of waste to disposal sites by resorting to highest professional standards.	Waste disposal system was already in place and was being monitored at various levels. IRCTC had been advised to take corrective measures in adherence to the observations of Public Account Committee.
3. Up gradation of toilet standard in Trains.	Indian Railway should advance the process of providing Controlled Discharge Toilet System or zero Discharge Toilet System in as many trains or coaches as possible.	Field trials were being conducted with different designs or types of environment friendly 'Green Toilets' and based on evaluation of those trials, a final view would be taken.

Table 1: action taken by the Ministry of Railways on the recommendations of PAC

V. SOME IMPORTANT POLICY INITIATIVES TAKEN BY INDIAN RAILWAY TOWARDS REDUCTION OF WASTE MANAGEMENT

It is examined the initiatives of Indian Rail to obtain reasonable assurance whether the instructions issued by Railway Board and the commitments of Ministry of Railways actually translated into improvement of cleanliness and hygiene standard at surrounding of stations and its impact on passengers. The results of examination are given below.

5.1 Reducing the production and consumption of plastic bottles

Affordable potable drinking water In order to provide potable drinking water on affordable rates to the railway passengers, Ministry of Railways has mandated IRCTC to install Water Vending Machines (WVM) on stations. Detailed policies guidelines have been issued in this regard vide CC No. 36/2015 dated 16/06/2015. This policy also stipulates that the reject water shall be used by Railway for platform washing, apron cleaning, toilets etc. i.e. conservation of water, being a precious natural resource. This is also an important step in the direction of reducing the production and consumption of plastic bottles.

Plastic Bottle Crusher Machines are being installed at Railway Stations. 110 such machines were provided up to March 2019.

5.2 Saving paper saving Trees

Saving paper Saving Trees Railway Recruitment Boards have introduced online examination through Computer Based Test (CBT) for all Group 'C' posts since 2015 and recently in 2018 for Group 'D' posts. RRBs have dispensed with paper pen examination (OMR sheets). This initiative is estimated to have saved 332460 trees in 2015-16 and 795535 trees in 2018-19. MCDO portal has been developed with CRIS for online submission of monthly MCDO to Railway Board. Portal has the facility to generate instant reports for performance comparison. The practice of sending hard copies has been discontinued. This initiative has resulted in saving of about 6000 sheets of paper in a year. Only limited



copies of Budget books/ booklets like Pink Book are printed now and all required books are available online. With merger of Rail Budget with General Budget, the requirement has further come down.

5.3 Environment friendly Bio – Toilets for Passenger Coaches

Indian Railways is developing environment-friendly Bio-toilets for passenger coaches, in their commitment to provide hygienic environment to passengers and to keep station premises and tracks clean. The technology has been developed jointly by Indian Railways (IR) and Defence Research & Development Organization (DRDO). A MoU has been signed between IR and DRDO for development of bio-toilets. This environment friendly, low cost and robust technology is the first of its kind in Railway Systems in the world. The efficacy of the bacteria used in this system has been tested by DRDO in extreme climates and conditions like those at Siachen Glacier. The anaerobic bacteria used in the bio-digester are hardly enough to survive extreme cold and heat and also survive when subjected to commonly available disinfectants. This technology is being used by Indian Army deputed at high altitude in Himalaya region as stationary use.

5.4 Use of bio-toilets in Trains

Bio-toilet is a dry toilet that treats human waste by a biological process called composting. Distinctive advantages of bio-toilets. It generates odorless, colorless inflammable biogas and recycled nutrients water suitable for gardening and no human waste is discharged from coaches on tracks. Indian Railway is investing a great deal of energy to defeat this issue by actualizing eco-friendly toilet systems which are implemented as bio toilets [2]

In these bio-toilets, the waste retention tanks are fitted below the coach floor 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 and bio-gases (mainly Methane CH₄ & Carbon Dioxide CO₂). The gases escape into the atmosphere and waste water is discharged after disinfection onto the track. Raw human waste thus does not fall on the railway tracks and this keeps station premises / tracks clean.

The first train, Gwalior-Varanasi Bundelkhand Express, fitted with IR-DRDO bio-toilets was introduced in service in January 2011. After receiving encouraging feedback, these bio-toilets were fitted in more coaches for in-service trials. The pace of fitment of bio toilets has been increased substantially in last 3 years. Upto March 2021, more than 2,58,906 bio-toilets have been installed in nearly 73,078 coaches including 69,166 bio toilets fitted in 19,137 coaches during 2018-19. IR has committed to eliminate direct discharge toilet system from its entire coaching fleet by 2019 in line with 'Swachha Bharat Mission'.

The technology adopted by IR to eliminate direct discharge system from passenger coaches is the best suited one as it is developed indigenously. However, it is sensitive to misuse by passenger's habits of throwing of items like plastic bottles, paper cups, cloth rags, sanitary napkin, nappies, plastic/poly bags, Gutkha pouches etc. in toilets that causes choking of these toilets and makes the toilet non-functional. Here, the passengers' cooperation is of paramount importance for the success of these bio-toilets. For this, awareness programme to educate the passengers on "How to use Bio-toilets - Dos & Don'ts" are regularly being conducted by Zonal Railways by means of providing stickers in coach toilets, playing audio/video clipping, display of models etc.

5.5 Bio-Vacuum Toilet in Indian Railways

Bio-Vacuum Toilet in Indian Railways with an objective to provide clean and low water consumption toilets. Indian Railway is doing a trial of Bio-Vacuum toilets. The faecal matter gets digested in the bio-tanks on board. During the year 2018-19, ICF has provided bio-vacuum toilets in 230 AC coaches, MCF has provided in 24 coaches and RCF in 92 coaches. Vacuum toilet technology is used in aero plane, aircraft and ships, it's not new. It is used from last 35 years.

5.51 Working principle

The modern vacuum toilet system is extremely simple and effective. The toilet looks and feels exactly like any toilet used in buildings and homes around the country. The difference is in the "behind the scenes" design.

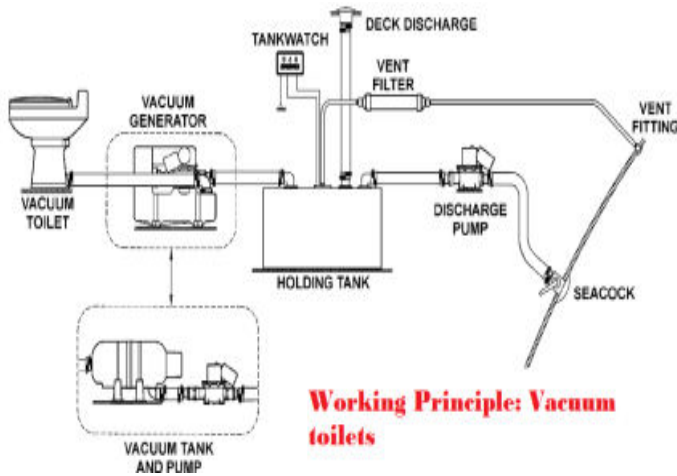


Figure 7: Mechanism of Bio-Vacuum Toilet



Figure 8: Bio-Vacuum Toilet

A small diameter pipe connects the toilet to an in-line vacuum pump. When the toilet is flushed, a strong vacuum is created inside the pipe which pulls the waste out of the toilet. The waste is carried along quickly and efficiently using air instead of precious water. Waste passes through the pump and is discharged to the collection or treatment point of your choosing. During the flushing cycle, a small amount of water is used to hygienically rinse the inside of the toilet bowl. At the conclusion of the flush, a small amount of water remains in the bottom of the toilet bowl, just like you are used to. The entire flushing sequence takes about 4 seconds. It is fast yet effective way of saving a lot of water. Indian railway is also going to introduce the same technology in new coaches. Indian railway network is vast and adopting this technology is going to save enormous quantity of water.

Vacuum toilets are flush toilets that use suction for the removal of faeces and urine resulting in a minimal requirement of water around 0.5 to 1.5 liters. Vacuum toilets provide the same level of comfort as traditional flush toilets and they help saving costs due to the minimized amount of flush water while on an average a bio-toilet uses 10 to 15 liters of water per flush.

5.6 Country's first Waste to Energy plant

The Indian railways have set up the country's first Waste to Energy plant in Bhubaneswar on 22nd January 2020, Based on its patented technology called POLYCRACK, is first-of-its-kind in Indian Railways and fourth in India. It is world's first patented heterogeneous catalytic process which converts multiple feed stocks into hydrocarbon liquid fuels, gas, carbon and water. The capacity of the Plant is 500 Kgs waste per day and take 24 hours for processing and reform waste without emitting any harmful pollution in the atmosphere.

All types of plastic and e-waste can be transformed to Light Diesel Oil which is used to light furnaces. All types of Plastic, Petroleum sludge, Un segregated, Municipal Solid Waste with moisture up to 50 percent, e waste, Automobile fluff, Organic waste including bamboo, garden waste, Jatropha fruit and palm bunch can be used in Polycrack Plant.

Polycrack Plant does not emit any harmful pollution into the environment because processing of this plant is closed loop system. The exit gases are re-used for utilizing energy to the whole system and thus the only emission comes from the combustion of gaseous fuels.



Figure 9: first Waste to Energy plant in Bhubaneswar

5.61 Description of waste to Energy Plant

- Total plant installation cost : Rs 179 millions
- Date of commissioning : 22 Jan 2020
- Estimated income from the byproducts : Rs 17.5 Lakhs per annum
- Maintenance cost : Rs 10.5 Lakhs per annum
- The capacity is : 500kg / Day

5.62 Features of Polycrack Technology

Polycrack has the following advantages over the conventional approach of treating solid waste:-

1. Pre-segregation of waste is not required to reform the waste. Waste as collected can be directly provided into Polycrack Plant.
2. It has high acceptance to moisture hence drying of waste is not required.
3. Waste is processed and reformed within 24 hours.
4. It is an enclosed unit hence the working environment is dust free.
5. Excellent air quality surrounding the plant.
6. Biological decomposition is not allowed as the Waste is treated as it is received.
7. The foot print of the plant is small hence the area required for installing the plant is less when compared with conventional method of processing.
8. All constituents are converted into valuable energy thereby making it Zero Discharge Process.
9. Gas generated in the process is re-used to provide energy to the system thereby making it self-reliant and also bring down the operating cost.
10. There is no atmospheric emission during the process.
11. Operates around 450 degrees, making it a low temperature process when compared with other options.
12. Safe and efficient system with built-in safety features enables even an unskilled user to operate the machine with ease.
13. Low capital cost and low operating cost.
14. Fully automated system requires minimum man power.

VI. GARBAGE DISPOSAL

According to the Municipal Solid Wastes Rules 2000, waste materials should be segregated into bio-degradable and non bio-degradable. Sufficient storage facilities of waste generated should be established and the wastes stored are not exposed to open atmosphere and are aesthetically acceptable and user- friendly. Bins for storage of biodegradable wastes shall be painted green, for recyclable wastes storage are painted blue and for non-bio degradable wastes are painted red.



It is examined the system of garbage disposal at 212 stations as per sample selection over 17 zones and observed that the garbage disposal were being handled either departmentally or through outside agencies. Out of 212 stations testchecked, 123 stations were in the major category and 89 in minor category. The main stations (A1, A and B category) handle large passenger traffic, proper disposal of garbage for the environmental point of view.

Audit examined the system of garbage disposal in 212 stations over 17 zones which revealed the following:

- i. Total stations 212 test checked in audit in which at 135 stations (64 percent) centralized dumping yard was not available within the station premises resulting in littering near station premises and along tracks. Further, there were instances when shipping of garbage was not being done hygienically that is covered by tarpaulin.
- ii. In 105 Railway Stations disposal of garbage from stations to Municipal Corporation notified areas was done by engaging outside agencies out of 123 main stations,. The quantity of garbage generated was, however not assessed and incorporated in the agreements entered into with the outside agencies in 43 out of 105 agreements.
- iii. Disposal of garbage was done in-house in the remaining 18 main stations. The garbage disposal was done departmentally; quantity of waste generated was not estimated.
- iv. In 16 contracts entered into in four zones (SER, WR, CR and SR) for disposal of waste through outside agencies out of 23, no separate clause was incorporated for separation of wastes as biodegradable and non- biodegradable. Even where there was a provision for segregation of waste in one contract at Lokamanya Tilak Terminus (CR), the same was not followed.
- v. in spite of entering into a contract with outside agencies, disposal of garbage was being done either by burning or dumping in Railway premises in 37 stations across zones.
- vi. At 54 stations test checked over 17 zones where the cleaning was done departmentally out of 212 stations, besides disposal of garbage in the Municipal or Corporation notified area, the Railway organization resorted to disposal by burning, dumping into adjacent canal, low lying areas, dumping on Railway land near the track, thereby causing environmental pollution.

VII. CONCLUSION

Adequate infrastructure was not available for proper collection and disposal instantly of different categories of waste. The monitoring of garbage disposal system is weak resulting in serious health hazards from contamination of ground water, surface water and affecting ambient airquality in and around the station.

A basic principle of waste management is to reduce or reuse the waste generated. Indian Railway is the largest transporter of passengers in the country and hence generates a large amount of waste including plastic waste. The Indian Railway has taken a number of initiatives in reusing the waste generated. Attempts are applying to reuse the waste generated by employing rag pickers. Waste management in Indian Railway was confined to disposal of garbage only but now some railway stations are producing energy by waste.

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