International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 07 | July - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

Domestic Solid Waste Management, Bio remedial Approach: A Review

L.M. Vinathi Priyadarshini* [1] and Dr. S. Anitha[2]

[1] Department of Biotechnology, Sri Krishnadevaraya University, Ananthapuramu.
[2] Department of Biotechnology, Sri Krishnadevaraya University, Ananthapuramu.
*Corresponding Author e-mail: priyadarshini.richmond@gmail.com

Abstract:

As quantum of waste generation is raising around the world it has become a challenge for many developing countries to establish proper waste management system. The present status of waste management and the prospects of introducing improved means of disposing municipal solid waste (MSW) in India is the theme of study created. Bioremediation is the most effective management tool to manage the polluted environment and recover contaminated soil. Bioremediation, both in situ and ex-situ have strong scientific growth in SWM. Microbes are very helpful to remediate the contaminated environment. Number of microbes including aerobes, anaerobes and fungi are involved in bioremediation process. This review concludes with some simple and effective trends in waste management, with a vision of refining in current Indian systems.

Key words: Municipal Solid waste, Bioremediation, Waste Management strategies.

Introduction

As waste generations are intensifying, Proper waste management remains a challenge for many developing countries around the world. Global waste is expected to grow to 3.40 billion tonnes by 2050, more than double the population growth over the same period. In 2025, the world was estimated to generate 5.28 billion tonnes of solid waste, amounting to a footprint of 1,24 kilograms per person per day [1]. With rapid population growth and urbanization, annual waste generation is expected to increase by 83% from 2025 levels to 6.98 billion tonnes in 2035[2]. Land pollution leads to the loss of 24 billion tons of topsoil every year. The increasing level of urbanization in the developing countries gives rise to population, growth of slums, commercial centers and industries, which generate a large amount of solid waste [3]. Environmental degradation as a result of indiscriminate disposal and dumping of solid waste from the community is receiving more and more attention in recent years. Lack of funds with municipality and indifference of public, aggravate the problem of solid waste disposal in Indian towns. [4]. Effective waste management is expensive, often comprising 20%–50% of municipal budgets. A technological approach to solid-waste management began to develop in the latter part of the 19th century. Even then, however, most of the largest cities were still using primitive disposal methods such as open dumping on land or in water [5].

Urbanization effect on Municipal Solid Waste [MSW]

India is facing a sharp contrast between its increasing urban population and available services and resources. The level of urbanization of the country has increased from 26.5% to 38% in the least 50-60 years and is expected to rise to 44% by the year 2026 [6]. It has been projected that the world will produce approximately 27 billion tonnes of waste by 2050. Asia will cause a third of this, with the maximum contributions coming from fast-developing countries like China and India [7]. Due to increase in population and shifting lifestyles in India, it is noted that urban India possesses approximately 170 000 tonnes of waste formation daily. This amalgamates to an annual figure of approximately 62 million tonnes, which is estimated to rise by 5% every year [8]. It is believed that by 2025 each person will generate approximately 0.7 kg of solid waste within urban India which surmounts to a value which is four to six times higher than in 1999. As a result of population growth, challenges relating to waste increase resulting in the need for decentralized waste management [9]. The composition of waste varies dependent on local area economy, higher earners are deemed to use more packaged products thus this results in the accumulation of more materials like paper, plastic, glass and metals. The typical MSW components formed by cities within Indian for organic is approximately 41 wt.%, inert is 40 wt.%, and materials that can be recycled is 19 wt.% (CPCB, Composition) [10]. Maximum organic waste is produced from domestic usage, while construction, road sweeping and demolition produces inert waste. However, the MSW composition differs within cities and is illustrated through comparing solid waste collected from cities of different states. The total waste generated in different states of India and its overall MSW status is listed below and it depicts total amount of uncounted waste generated by each state.(CPCB,2021; Table 1). [11]

% of the total waste generated remains un-accounted. State-wise details of solid waste management is given in **Table 1.0**.

Table 1.0: OVERALL SOLID WASTE MANAGEMENT STATUS

Sl. No.	State	Solid waste generated (TPD)	Collected (TPD)	Treated (TPD)	Landfilled (TPD)
1.	Andhra Pradesh	6898	6829	1133	205
2.	Arunachal Pradesh	236.51	202.11	Nil	27.5
3.	Assam	1199	1091	41.4	0
4.	Bihar	4281.27	4013.55	Not provided	No
5.	Chhattisgarh	1650	1650	1650	0
6.	Goa	226.87	218.87	197.47	22.05
7.	Gujarat	10373.79	10332	6946	3385.82
8.	Haryana	5352.12	5291.41	3123.9	2167.51
9.	Himachal Pradesh	346	332	221	111
10.	Jammu & Kashmir	1463.23	1437.28	547.5	376

Hierarchy of waste management:

India to progress in MSW management, civil infrastructure is mandatory. Thus, to achieve active economic growth, it is important to build a superior infrastructure that realizes the public requirements and safeguards the environment [12]. To lessen the environmental impact, municipal solid waste management (MSWM) comprises of segregation, collection, processing and disposal [13].Currently in India, segregation of waste has no organized and systematically planned method, regardless of domestic or community related. Door-to door collection, segregation at source, covered transportation, proper treatment, and disposal are the primary steps to resource recovery [14]. The conditions and efficiency that segregation and sorting processes occur are usually insecure, adverse and low.

Methods used for MSW management

Solid waste collection and transportation steps of every SWM system comprises of waste collection, storage and transport, however cities are challenged in this process. Indian municipal corporations are duty bound to collect waste and are usually provided bins to separate biodegradable and inert waste materials[15]. Despite these initiatives they are frequently mixed, dumped and burnt openly. Reuse/recycle Recycling involves collecting materials from waste, appearing to produce profit and are used for producing new goods. Simultaneously, nonsegregated waste is discarded in community bins, where recycling that waste is unlikely. However, materials like plastics, glass are extracted and separated by ragpickers who trade recyclable materials, is vastly established [16]. Disposal and treatment UNEP (2004) reported that composting is comparatively one of the appropriate treatments followed in developing countries of

Asia, such as incinerator [17]. Open dumping constituted to over 50%, while 10- 30% was landfill; composting less than 15% and incineration 2 -5% [18].

A) Recycling: Reducing and Reusing are the most effective ways to prevent generation of wastes. It is known that as much as 95% of a product's environmental impact occurs before its discard [19]. Recycling requires a separated stream of waste, whether source separated or separated later on after the collection. Due to limitations in source segregation, wastes are collected in a mixed form which is referred to as municipal solid waste (MSW) [20]. Mixed waste is difficult to separate. The separation done manually of paper, plastic, glass and metal can then be recycled. It is highly energy and time intensive to separate these materials from SW and generally is not carried out. Therefore, mixing of waste will always result in a fraction of residues, which can neither be recycled nor composted and needs to be combusted in Refuse Derived Fuel (RDF) or waste to energy (WTE) plants to avoid landfilling and generate energy [21].

B) Sanitary Land Filling: United Nations Environmental Program (UNEP) defines sanitary landfilling as the controlled disposal of wastes on land in such a way that contact between waste and the environment is significantly reduced and wastes are concentrated in a well-defined area [22]. Sanitary Landfills (SLFs) are built to isolate wastes from the environment and render them innocuous through the biological, chemical and physical processes of nature. UNEP also recognizes three basic conditions to be fulfilled to be designed as an SLF:

- Compaction of wastes,
- Daily covering of wastes (with soil or other material) and
- Control and prevention of negative impacts on public health and environment

On the hierarchy of waste management, sanitary land filling is expanded into three different categories:

1. SLFs recovering and using methane (CH4)
2. SLFs recovering and flaring CH4
3. SLFs without any CH4 recovery

Changes expected in disposal of MSW in the near future are More extensive integration of informal waste sector into the formal systems, further increase in the construction of composting facilities, New RDF, WTE and Sanitary Landfill facilities and Capping of some landfills for landfill gas (LFG) recovery [23].

Biotechnology in MSW Management:

Biotechnology can be applied to assess the well-being of ecosystems, transform pollutants into benign substances, generate biodegradable materials from renewable sources and develop environmentally safe manufacturing and disposal processes [24]. Biotechnology utilizes the application of genetic engineering to improve the efficiency and cost, which are key factors in the future widespread exploitation of microorganisms to reduce the environmental burden of toxic substances [25]. Keeping in view of the urgent need of a most efficient environmental biotechnological process, researchers have devised a technique called bioremediation, which is an emerging approach to rehabilitating areas contaminated by pollutants or otherwise damaged through ecosystem.

Bioremediation

Bioremediation offers the possibility to destroy or render harmless contaminants using natural biological activity [26]. It uses relatively low-cost, low technology techniques, which have a high public acceptance and can often be carried out on site. However, as the range of contaminants on which it is effective is limited, the time scales involved are relatively long and the residual contaminant levels achievable may not always be appropriate [27]. There is need to thoroughly assess a site for suitability and optimize conditions to achieve a satisfactory result. Bioremediation has been used at a number of sites worldwide, including Europe, with varying degrees of success [28]. Techniques are improving as greater knowledge and experience are gained and there is no doubt that bioremediation has great potential for dealing with certain types of site contamination [29]. The principles, techniques, advantages and disadvantages of bioremediation are not widely known or understood and it's a gap to be addressed by the research.

Principles of Bioremediation: Bioremediation techniques are typically more economical than traditional methods such as incineration and some pollutants can be treated on site, thus reducing exposure risks for clean-up personnel, or potentially wider exposure as a result of transportation accidents [30]. Since bioremediation is based on natural attenuation the public considers it more acceptable than other technologies. Most bioremediation systems are run under aerobic conditions, but running a system under anaerobic conditions [31] may permit microbial organisms to degrade. For bioremediation to be effective, microorganisms must enzymatically attack the pollutants and convert them to harmless products. As bioremediation can be effective only where environmental conditions permit microbial growth and activity, its application often involves the manipulation of environmental parameters to allow microbial growth and degradation to proceed at a faster rate. Like other technologies, bioremediation has its limitations. Some contaminants, such as chlorinated organic or high aromatic hydrocarbons, are resistant to microbial attack [32]. They are degraded either slowly or not at all, hence it is not easy to predict the rates of clean-up for a bioremediation.

Aerobic: In the presence of oxygen. Examples of aerobic bacteria recognized for their degradative abilities are Pseudomonas, Alcaligenes, Sphingomonas, Rhodococcus and Mycobacterium [33]. These microbes have often been reported to degrade pesticides and hydrocarbons, both alkanes and polyaroaromatic compounds.

Anaerobic: In the absence of oxygen. Anaerobic bacteria are not as frequently used as aerobic bacteria. There is an increasing interest in anaerobic bacteria used for bioremediation of polychlorinated biphenyls (PCBs) in river sediments, dechlorination of the solvent trichloroethylene (TCE), and chloroform [34].

Ligninolytic fungi: Fungi such as the white rot fungus Phanaerochaete chrysosporium have the ability to degrade an extremely diverse range of persistent or toxic environmental pollutants [35]. Common substrates used include straw, saw dust, or corn cobs.

Types of Bioremediations: On the basis of removal and transport of wastes for treatment there are basically two methods:

1.In situ bioremediation
2.Ex situ bioremediation.

In situ bioremediation: These techniques [36] are generally the most desirable options due to lower cost and less disturbance since they provide the treatment in place avoiding excavation and transport of contaminants. In situ treatment is limited by the depth of the soil that can be effectively treated [37]. In many soils effective oxygen diffusion for desirable rates of bioremediation extend to a range of only a few centimeters to about 30 cm into the soil, although depths of 60 cm and greater have been effectively treated in some cases.

The most important land treatments are:

Bioventing is the most common in situ treatment and involves supplying air and nutrients through wells to contaminated soil to stimulate the indigenous bacteria [38]. Bioventing employs low air flow rates and provides only the amount of oxygen necessary for the biodegradation while minimizing volatilization and release of contaminants to the atmosphere. Generally, this technique includes conditions such as the infiltration of water-containing nutrients and oxygen or other electron acceptors for groundwater treatment.

Biosparging: Biosparging involves the injection of air under pressure below the water table to increase groundwater oxygen concentrations and enhance the rate of biological degradation of contaminants by naturally occurring bacteria. Biosparging increases the mixing in the saturated zone and there-by increases the contact between soil and groundwater [39]. The ease and low cost of installing small-diameter air injection points allows considerable flexibility in the design and construction of the system.

Bioaugmentation: Bioremediation frequently involves the addition of microorganisms indigenous or exogenous to the contaminated sites [40]. Two factors limit the use of added microbial cultures in a land treatment unit: 1) nonindigenous cultures rarely compete well enough with an indigenous population to develop and sustain useful population levels and 2) most soils with long-term exposure to biodegradable waste have indigenous microorganisms that are effective degrades if the land treatment unit is well managed.

Ex situ bioremediation: These techniques involve the excavation or removal of contaminated soil from ground. Landfarming is a simple technique in which contaminated soil is excavated and spread over a prepared bed and periodically tilled until pollutants are degraded. The goal is to stimulate indigenous biodegradative microorganisms and facilitate their aerobic degradation of contaminants [41]. In general, the practice is limited to the treatment of superficial 10–35 cm of soil. Since landfarming has the potential to reduce monitoring and maintenance costs, as well as clean-up liabilities, it has received much attention as a disposal alternative. Composting is a technique that involves combining contaminated soil with non-hazardous organic materials such as manure or agricultural wastes. The presence of these organic materials supports the development of a rich microbial population and elevated temperature characteristic of composting. Biopiles[42] are a hybrid of landfarming and composting. Essentially, engineered cells are constructed as aerated composted piles. Typically used for treatment of surface contamination with petroleum hydrocarbons they are a refined version of landfarming that tend to control physical losses of the contaminants by leaching and volatilization. Biopiles provide a favourable environment for indigenous aerobic and anaerobic microorganisms.

Steps to improve SWM in India:

In India, all children in schools should be educated on the importance of waste management, their impacts upon the environmental and health, simultaneously promoting individual responsibilities to control waste management in educational systems [43]. Segregation and recycling initiatives can create enhanced employment options in waste management. This will enable the poorer people in India to be self-sufficient and develop their lifestyles, thus viewed as a business opportunity [44]. Public awareness is paramount in order to create realization of the importance of source segregation at the source. This will ensure that biodegradables, inert and recyclable materials in waste are correctly managed from the outset. Research and establishment of advanced techniques like bioremediation should be encouraged by the government.

CONCLUDING REMARKS:

Solid waste management (SWM) is one such service where India has an enormous gap to fill. Proper municipal solid waste (MSW) disposal systems to address the escalating number of wastes are absent. The current SWM services are inefficient, incur heavy expenses and are so low as to be a potential threat to the public health and environment quality. From the study, it was found that various gaps present in municipal solid waste management such as waste collection, transport and disposal generation can be reduced. Bioremediation provides a technique for cleaning up pollution by enhancing the natural biodegradation processes. So, by developing an understanding of microbial communities and their response to the natural environment and pollutants, expanding the knowledge of the genetics of the microbes to increase capabilities to degrade pollutants, conducting field trials of new bioremediation techniques which are cost effective, and dedicating sites which are set aside for long term research purpose, these opportunities offer potential for significant advances. There is no doubt that bioremediation is in the process of paving a way to greener pastures. Regardless of which aspect of bioremediation that is used, this technology offers an efficient and cost-effective way to treat contaminated ground water and soil. Its advantages generally outweigh the disadvantages, which is evident by the number of sites that choose to use this technology and its increasing popularity.

References:

[1] Urban Development Sector Unit, East Asia and Pacific Region, The World Bank. What a Waste: Solid Waste Management in Asia. Environmental Strategies for Cities, Massachusetts Institute of Technology. 1999.

[2] P. Modak, Y Jiemian, Y U Hongyuan and C R Mohanty, 2010 "Municipal solid waste management: turning waste into resources," in Shanghai manual: guide for sustainable urban development in the 21st century, Shanghai, United Nations Department of Economic and Social Affairs (UNDESA), pp 1–36

[3] Division of Technology, Industry and Economics. State of Wase Management in South East Asia, Types of Wastes - Sources and Composition. United Nations Environment Programme. [Online].

[4] Department of Economic Affairs, Ministry of Finance, Government of India. Position Paper on the Solid Waste Management Sector in India. Public Private Partnerships in India. [Online] November 2009.
[5] Department of Economic Affairs, Ministry of Finance, Government of India. Position paper on the solid waste management sector in India. Public private partnerships in India. November 2009.
[6] CPCB (2019). Central Pollution Control Board of India (CPCB). Annual Report for the year 2018-19 on implementation of solid waste management rules (as per provision 24(4) of SWM Rules,16. Available at https://cpcb.nic.in/uploads/ (Accessed November 23, 2020)
[7] Aayog, N. I. T. I. (2018). National institution for transforming India (N.I.T.I). Contributing to sustainable development in the Indian regions. Available: https://niti.gov.in/writereaddata/files/document_publication/Doc2.pdf (Accessed November 25, 2020).
[8] National Environmental Engineering Research Institute, NEERI. Air Quality Assessment, Emissions Inventory and Source Apportionment Studies: Mumbai. New Delhi: Central Pollution Control Board (CPCB), 2010.
[9] R Joshi and S Ahmed, 2016 "Status and challenges of municipal solid waste management in India: A review," Cogent Environmental Science, India
[10] MSW Components of Indian cities, Available: https://cpcb.nic.in/waste-generation-composition/doc.pdf
[11] MSW composition differs within cities., Central Pollution Control Board data 2021 .(CPCB,2021; Table 1).
[12] Studies on Environmental Quality in and around Municipal Solid Waste Dumpsite. Arun K. Biswas, Sunil Kumar, S. Sateesh Babu, J. K. Bhattacharyya, Tapan Chakrabarti. 2, Kolkata, Nagour : Resources, Conservation and Recycling, 2010, Vol. 55.
[13] Sharma, S., Shah, K.W., 2005. "Generation and disposal of solid waste in Hoshangabad". In: Book of Proceedings of the Second International Congress of Chemistry and Environment, Indore, India, 749 – 751.
[14] Solid Waste Management in India: Options and Opportunities. Shuchi Gupta, Krishna Mohan, Rajkumar Prasad, Sujata Gupta, Arun Kansal.: Resources, Conservation and Recycling, 1998, Vol. 24.
[15] Assessment of the Status of Municipal Solid Waste Management in Metro Cities, State Capitals, Class I Cities and Class II Towns in India: An Insight. Sunil Kumar, J.K. Bhattacharya, A.N. Vaidya, Tapan Chakrabarti, Sukumar Devotta, A.B. Akolkar. Kolkata: Central Pollution Control Board (CPCB), National Environmental Engineering Research Institute (NEERI), 2008.
[16] An Assessment of Municipal Solid Waste Compost Quality Produced in Different Cities of India with the Perspective of Developing Quality Control Indices. J. K. Saha, N. Panwar, M. V. Singh. 2, Bhopal : Waste Management, 2010, Vol. 30.
[17] Kumar, Sunil. Municipal Solid Waste Management in India: Present Practices and Future Challenge. Clean Development Mechanism, United Nations Framework Convention on Climate Change. [Online].
[18] Poornima Chikarmane, Deshpande M., Lakshmi Narayan. Study of Scrap Collectors, Scrap Traders and Recycling Enterprises in Pune. Institute for Global Environmental Strategies. [Online] 2001.
[19] Ministry of Urban Development, Government of India. Guidance Note: Municipal Solid Waste Management on a Regional Basis. Ministry of Urban Development, Government of India. [Online].
[20] SNDT Women's University, Chintan Environmental Research and Action Group. Recycling Livelihoods: Integration of the Informal Recycling Sector in Solid Waste Management in India. GIZ, Deutsche Gesellschaft fur Internationale Zusammenarbeit GmbH. [Online] 2010.
[21] P. Commission, 2014 "Report of the task Force on waste to energy (Volume I) in the context of integrated municipal solid waste management," Government of India
[22] Ministry of New and Renewable Energy, Government of India. National Master Plan for Development of Waste-to-Energy in India. Ministry of New and Renewable Energy. [Online] 2003.
[23] UNEP, 2005 "Solid waste management volume I," United Nations Environment Program
[24] Singh, S. and Gupta, V.K., 2016. Biodegradation and bioremediation of pollutants: perspectives strategies and applications. *International Journal of Pharmacology and Biological Sciences*, *10*(1), p.53.
[25] Azad, M.A.K., Amin, L. and Sidik, N.M., 2014. Genetically engineered organisms for bioremediation of pollutants in contaminated sites. *Chinese science bulletin*, *59*, pp.703-714.
[26] Garg, S., 2020. Bioremediation of agricultural, municipal, and industrial wastes. In *Waste Management: Concepts, Methodologies, Tools, and Applications* (pp. 948-970). IGI Global.
[27] Gomes, H.I., Dias-Ferreira, C. and Ribeiro, A.B., 2013. Overview of in situ and ex situ remediation technologies for PCB-contaminated soils and sediments and obstacles for full-scale application. *Science of the Total Environment*, *445*, pp.237-260.
[28] UNEP, 2005 "Solid waste management volume I," United Nations Environment Program

[29] U.S. EPA. Handbook on In Situ Treatment of Hazardous Waste Contaminated Soils, EPA/540/2-90/002.
[30] U.S. EPA Seminars. Bioremediation of Hazardous Waste Sites: Practical Approach to Implementation, EPA/625/K96/001.
[31] Gupta R. and Mahapatra H,. Microbial biomass: An economical alternative for removal of heavy metals from waste water. Indian Journal of Experimental Biology 41: pp 945966 (2003)
[32] Pande, V., Pandey, S.C., Sati, D., Pande, V. and Samant, M., 2020. Bioremediation: an emerging effective approach towards environment restoration. *Environmental Sustainability*, *3*, pp.91-103.
[33] Bhandari, S., Poudel, D.K., Marahatha, R., Dawadi, S., Khadayat, K., Phuyal, S., Shrestha, S., Gaire, S., Basnet, K., Khadka, U. and Parajuli, N., 2021. Microbial enzymes used in bioremediation. *Journal of Chemistry*, *2021*, pp.1-17.
[34] Kumar, A., Bisht, B.S., Joshi, V.D. and Dhewa, T., 2011. Review on bioremediation of polluted environment: a management tool. *International journal of environmental sciences*, *1*(6), pp.1079-1093.
[35] Norris, R.D., 1993. *Handbook of bioremediation*. CRC press.
[36] Maitra, S., 2018. In situ bioremediation—An overview. *Res. J. Life Sci. Bioinfo. Pharmaceu. Chem. Sci*, *4*, pp.576-598.
[37] Sharma, J., 2019. Advantages and limitations of in situ methods of bioremediation. *Recent Adv Biol Med*, *5*(2019), p.10941.
[38] Sayqal, A. and Ahmed, O.B., 2021. Advances in heavy metal bioremediation: an overview. *Applied Bionics and Biomechanics*, *2021*.
[39] Brar, S.K., Verma, M., Surampalli, R.Y., Misra, K., Tyagi, R.D., Meunier, N. and Blais, J.F., 2006. Bioremediation of hazardous wastes—a review. *Practice Periodical of Hazardous, Toxic, and Radioactive Waste Management*, *10*(2), pp.59-72.
[40] Sharma, I., 2020. Bioremediation techniques for polluted environment: concept, advantages, limitations, and prospects. In *Trace metals in the environment-new approaches and recent advances*. IntechOpen.
[41] Pavel, L.V. and Gavrilescu, M., 2008. Overview of ex situ decontamination techniques for soil clean up. *Environmental Engineering & Management Journal (EEMJ)*, *7*(6).
[42] Gomez, F. and Sartaj, M., 2014. Optimization of field scale biopiles for bioremediation of petroleum hydrocarbon contaminated soil at low temperature conditions by response surface methodology (RSM). *International Biodeterioration & Biodegradation*, *89*, pp.103-109.

[43] Sørensen, K., 2018. Health Literacy: A Key Attribute for Urban Settings. *Optimizing Health Literacy for Improved Clinical Practices*, pp.1-16.

[44] Heidari, R., Yazdanparast, R. and Jabbarzadeh, A., 2019. Sustainable design of a municipal solid waste management system considering waste separators: A real-world application. *Sustainable Cities and Society*, *47*, p.101457.