

Comprehensive review of solid waste management strategies and disposal approaches

Sumbul Samreen^a  | Manoj Kumar Agarwal^b  | Anupam Kumar Gautam^c  |
Yukti Khajanchi^d 

^aDepartment of General Management, JAIN (Deemed-to-be University), Bangalore, Karnataka, India.

^bTeerthanker Mahaveer University, Moradabad, Uttar Pradesh, India.

^cSchool of Engineering & Technology, Maharishi University of Information Technology, Uttar Pradesh, India.

^dDepartment of ISME, ATLASkillTech University, Mumbai, Maharashtra, India.

Abstract Solid waste management is a worldwide concern with substantial environmental, social, and economic ramifications. This review provides a complete assessment of solid waste management from an Indian viewpoint. It presents an overview of the current state, difficulties, and prospects in solid waste management, focusing on environmental sustainability and public health. The goal is to give a comprehensive overview of many approaches utilized to manage and reduce the expanding problem of solid waste. It examines a variety of waste management techniques, such as landfill disposal, recycling, composting, waste-to-energy practices, and waste elimination and minimizing. Many municipalities across the country prefer landfilling for the removal of solid waste. In landfills, waste is transformed through chemical, biological, and physical processes, functioning as an environmental furnace. Therefore, soil cover thickness, barriers, leachate collecting, landfill gas recovery, and flaring facilities are essential for sustainable landfilling. The benefits of composting and anaerobic breakdown for decreasing the environmental effect of biological waste are examined in this review. Hazardous chemicals in landfills can have severe ecological and public health consequences. It looks into the benefits of effective dangerous waste disposal, such as pollution control and resource recovery. Mining and reusing landfills for diverse uses, such as renewable energy generation and recreational areas, have the potential to be beneficial. The article discusses upcoming solid waste management trends and technologies such as intelligent garbage collection mechanisms, reuse and recycling concepts, and sustainable packaging solutions. It emphasizes the potential of these advances to improve overall waste management effectiveness and sustainability.

Keywords: Solid Waste Management, Landfilling for Solid Waste, Disposal Approaches, Renewable Energy Generation

1. Introduction

Large amounts of solid waste from cities are produced due to the rapid increase in the number of inhabitants, superior quality of life, and massive energy and consumer consumption rates. If these wastes are not properly recycled, they pose severe risks to the planet. The variety of recyclables includes urban solid trash dumped daily as rubbish, thrash, and dismissed by rural and urban inhabitants (Abdallah et al 2020). Solid waste is produced when a municipality collects its solid garbage from citizens, companies, and other modest individuals. Since they include mixed noninorganic components, each urban solid waste differs in structure and classification across various towns' rubbish, which provides textiles, fabrics, biomedical waste, household goods, beauty products, medicines, pet litter, leather, rubber, and crystalline debris and is the most diverse element of public solid waste (Azevedo et al 2021). Urban solid waste management has always represented a paradigm shift between developing and industrialized nations in efficiently managing local solid garbage (Das et al 2021). Through waste-to-energy or energy-from-waste conversion, as well as other vaporization processes, inexpensive and replenished, recyclable materials have significant potential for recovering energy and precious materials, and methods for converting trash to energy, such as thermochemical and biological processes, can be used to reverse waste from cities into solids, fluids, and gases to assist in meeting the growing demand (Das et al 2019). The most common energy from the waste method is burning. It also dramatically lowers the amount of trash. The process involves burning municipal solid waste to produce electricity, steam, and combined heat and power. Nonrecyclable debris is traditionally buried using a technique called landfill. In certain underdeveloped nations, garbage is dumped into pits and piled up instead of covered with dirt. Landfilling is a typical structured method for disposing of municipal solid waste in most industrialized nations. However, it is somewhat less prevalent in developing

countries with open space restrictions because of high population densities (Fadhullah et al. 2022). The healthcare industry has considerable difficulty managing people who need urgent treatment because of the current network and sparse safety equipment. Updating medical standards, extensive testing, and recalibrating public policy have been used to combat this public health concern (Guo et al 2021). An essential component of an effective crisis response is the proper processing and ultimate disposal of this trash. To be managed, biomedical and healthcare waste must be identified, collected, separated, stored, transported, treated, and disposed. The crucial factors of these wastes include sanitation, worker safety, and guidance (Khan et al. 2022). Food waste creation dynamics have been disturbed due to the dread that widespread lockdowns have produced in many nations. This concern has encouraged people to stockpile food and other supplies (Kulkarni and Anantharama 2020). The necessity for creating a resilient supply chain has been highlighted by images and media headlines of food, milk, and fruits thrown by farmers at local landfills or dumpsites along roadways (Kumar and Agrawal 2020).

Nanda and Berruti (2021) suggested that solid waste from municipal buildings can be managed by recycling, incineration, waste-to-energy conversion, and land refilling. In many communities worldwide, landfilling is favored for solid waste disposal. Waste undergoes physical, chemical, and biological changes in landfills, which function as ecological reactors. They outline many subcategories and design iterations of mines, activities, and disposal. Khan et al. (2022) described the primary objective of investigating municipal solid waste in eight eastern coastal regions of India. They learned from this research that, compared to developed countries, most developing nations use significantly less efficient methods of treating municipal garbage, with 52% ending up in landfills, 46% burned, and 3% composted. MSW generation has declined in other eastern coastal cities, provinces, and special zones but has increased in more cities. Sharma et al. (2020) anticipated that home food debris creation would decrease due to an increase in the amount of nonperishable goods purchased during the lockdown and due to worries about food shortages. The study offered some critical advice to policymakers to assist in completely handling any future global epidemic. Guo et al. (2021) presented the factors affecting solid waste management in developing countries such as China. China has experimented with the study of resource use, nontoxic treatment, and concrete waste recycling, and its management system has been regularly enhanced. Changes in the industrial structure impact how industrial solid waste is produced and handled.

Abdallah et al. (2020) described AI models and approaches utilized in SWM, application domains, stated performance metrics and the software technologies these models are implemented on, which are analyzed in this research. The difficulties and discoveries of implementing AI methods in SWM are also discussed. CM et al. (2021) focused on the influence of the global epidemic on management and waste composition as well as the effects of municipal solid waste management (MSWM) on the prevention and regulation of illness seen as indisputable experiences during a coronavirus (CV) outbreak that successfully regulated the method. A systematic review was performed to determine the effect of CV on waste generation and MSWM. Das et al. (2021) suggested different methods for managing trash in different medical countries, the challenges these methods face, and potential solutions for resolving these difficulties. Additionally, it offers helpful perceptions of possible situations for managing hospital solid waste in the depth of the CV pandemic and probable subsequent actions. Lee et al. (2019) described the locations of countries and how their economic standing affects waste property. To assist future employees of organizations in choosing the best waste disposal methods and assessing their potential performance, a number of financial and life cycle assessment (LCA) models have been presented. According to Azevedo et al. (2021), the people's choice to participate in recycling as formal employees or legal entrepreneurs enables a long-term solution that clarifies the social pillar of the triple bottom line. It could help with continuous public education campaigns on significant ecological concerns as well as technical breakthroughs and present a cross-case comparison between the cities of Brazil and Germany that can be useful for enhancing the UHSWM in underdeveloped nations. Kumar et al. (2020) determined feasible MSWM remedies in the Indian context. The unorganized informal trash industry, societal taboos, citizen attitudes, insufficient potential tactics, poorly planned fiscal strategies, and poorly implemented government regulations all contribute to the unsorted solid waste at the source.

Kulkarni and Anantharama (2020) utilized data and information from several educational papers from various fields, official and multinational agency materials, and news stories. Despite the lack of research on managing MSW during such pandemics, this study establishes a worldwide context for managing MSW during the COVID-19 epidemic. It looks at many elements of managing MSW. Singh (2022) determined the importance of solid waste management (SWM), a public health service that is underestimated. The full significance of SWM as an essential service becomes more apparent if a public health emergency such as the COVID-19 epidemic occurs. The primary issues that the SWM sector encountered during the pandemic and the fundamental potential solutions to close the system's gaps.

2. A national scenario for managing municipal solid waste

The Municipal Solid Waste Administration Rules, which are part of the Solid Wastage Management Rules, were published by the Union Ministry of Environment, Forests, and Climate Change. The first recognition and integration of the informal sector into the waste management process is made possible by this national strategy. Each year, 62 million tons of trash are produced in India. Approximately 43 million tonnes of material were collected; 70% of those 12 thousand pounds were processed, and 30 thousand pounds were discarded. Municipal SW output is predicted to increase to 175 thousand tons in 2040 due to changing tastes and strong financial growth. The SWM systems in India have remained the same despite political,

commercial, and ecological advancements. The informal sector is essential for recovering value from waste since 95% of leftover trash is wasted rather than eliminated. Switching to SWM is necessary and necessitates new storage and leadership techniques. The ineffectiveness of current SWM systems results in unresolved waste that has a detrimental effect on finance, the surroundings, and human health. The India Ministry of Environment and Forests developed the Waste Control and Management Rules. However, there is sporadic and insufficient conformity. Table 1 represents the creation of municipal solid garbage in the ten most prominent cities in India. India has experienced remarkable expansion in every area, including population growth, urbanization, transportation, and businesses, and these issues will worsen with future development. Municipal solid waste management entails three steps: transportation, disposal, and collection. The municipal SWM system fails at the collection stage in many developing nations, including India. The ten most prominent cities in India create 0.37 to 0.62 kilograms of municipal solid garbage per person annually.

Table 1 Municipal solid garbage creation in India's ten most prominent cities.

City	Waste generation (kg/capita/day)	Kilo tonnes per year	Tonnes per day
Greater Mumbai	0.46	1942	5321
Kolkata	0.59	969	2651
Bangalore	0.40	610	1671
Pune	0.47	429	1173
Surat	0.42	366	1001
Delhi	0.58	2162	5921
Chennai	0.63	1109	3036
Hyderabad	0.58	799	2186
Ahmedabad	0.38	476	1302
Kanpur	0.44	402	1099

2.1. Recycling method

Landfilling is the process of organizing the removal of renewable and recyclable pollutants in a specified landfill that is not close to the suburbs of a town. In many nations, landfills have been the traditional and most profitable method for disposing of trash. Compared to destruction, which necessitates significant expenditures in large infrastructures and extreme conditions, the recovery of waste disposal by resource methods is preferred to incineration and recycling municipal solid waste since it is less expensive and effective. An integrated trash may generate cash by exploiting its landfill gas and leachate for electricity generation. Such waste sites may be converted from "waste storehouses" to "energy powerhouses" by using effective combined systems that deliver green energy and recycled materials. There are significant sources of energy, such as fuel, power, and travel; the dumping and combustion of trash; and needless human work. A recent study of 7500 tons of municipal solid waste included life cycle reviews and techno-economic analyses. Compared to dumping, incineration requires a significant percentage of power—40% for the entire supply of energy—and uses 29% of the total power (Iqbal et al 2020). More specifically, to burn regional debris amounting to 8700 pounds, 422.2 kWh of energy had to be input, and 3827.3 kWh had to be generated. In other words, although more effective techniques and structures might increase the energy supply rate, for every 1.88 pounds of MSW burned for power production, the amount of electricity used in traveling is ascribed to landfilling (21,600 km and 60% of the overall utilization of energy), as opposed to ignition (391.2 km and 20% of the overall utilization of energy). Making advantage of less mileage can reduce the power usage suffered by transportation divisions in landfilling. Examples include using energy-efficient garbage collection vehicles, trucks with increased waste collection volume, or trucks with built-in technology for garage compaction (Karri et al 2021). Municipal solid waste is frequently dumped outdoors, unregulated, and ineffectively handled in certain developed country metropolises, which poses several ecological problems. More than 85% of MSW is discarded in waste dumps due to a lack of oversight in some communities. Figure 1 shows that urban solid waste disposal and burning require less human work, resulting in unhealthy circumstances. Most developing nations do not separate all trash from urban solid garbage, including hazardous industrial and infectious biological waste from medical facilities, which winds up at landfill disposal sites.

Various landfills and disposal facilities, such as residential garbage, explosives, contaminants, hazardous materials, health care waste, contaminants, structural failure, and restoration rubbish, are placed in multiple locations based on the type of garbage. Landfills can be categorized into various types according to the garbage they receive. Another way to order landfills is through the use of a bioreactor, mono-fill, secure, or recyclable waste. Safe dumps enclose trash to delay any adverse environmental effects, while mono-fill dumps house wastes cannot be handled by incineration, recycling, or composting (Khawaja et al 2019). Reusable landfills that enable longer waste storage to recover beaker polymers and fertilizer biological dumps are specially designed to clean dumps with liners and leachate collection and recycling devices to maximize material breakdown and reduce ecological impacts. Open dumps, partially managed dumps and clean dumps are the three types of

dumps in which a landfill that accepts available waste pieces of ground public material is dumped in the open space with access to fresh air. All emerging nations have open dumps, where local trash is haphazardly disposed of in low-lying available regions. Due to inadequate management, these landfills become a haven for thieves, including falcons, turkeys, storks, birds, other wildlife, bugs, bugs, rats, and dangerous bacteria. Due to the lack of oxygen, these operational problems are resolved through anaerobic digestion. It is common for nearby residents to voice concerns about the stench from open landfill regions (Malav et al 2020). Laws in many industrialized nations forbid free disposal because they view it as unlawful. Strict rules are put in place by the Ministry of Environment and Climate Change regarding the removal of garbage and illegal dumping, which can lead to fines, legal investigations, and punishment. Municipal solid trash is sorted, crumbled, and crushed on-site at semicontrolled landfills that are situated in approved dumps before disposal to avoid annoyances such as the reproduction of scavenger birds, animals, vermin, and microbes, and the mounds of trash smashed that levelled using machines or crawling and were dusted daily. The ground cover makes semicontrolled landfills less smelled. They are not designed to regulate leachate outflow, and landfill gas emissions are characterized by the systematic covering of newly dumped trash with dirt, which reduces disease vectors, fires and waste harvesting. Figure 2 shows typical municipal solid wastes among people of different economic levels in affluent nations; these landfills are widespread and equipped with leachate interception and treatment systems. Sanitary landfills will be dug to expand the environment once current, saturated dumps are covered.

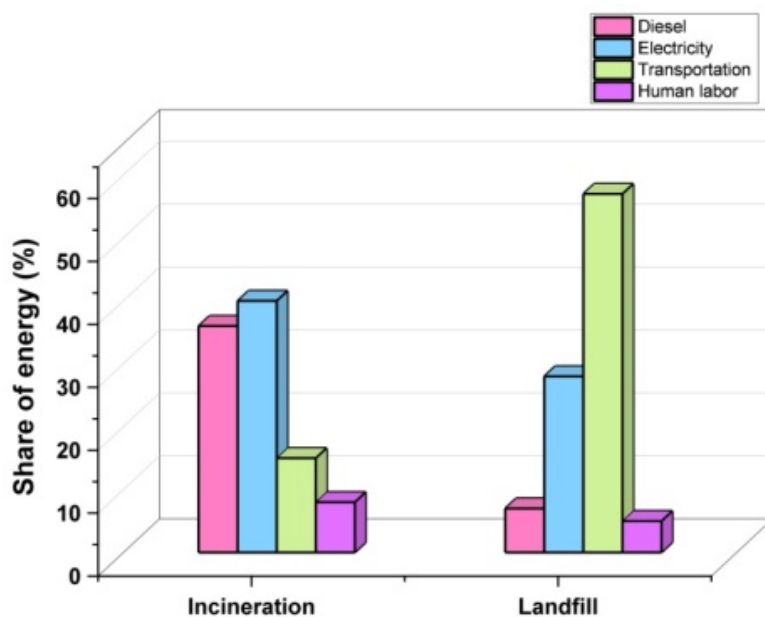


Figure 1 Urban solid waste disposal and burning require significantly less human work.

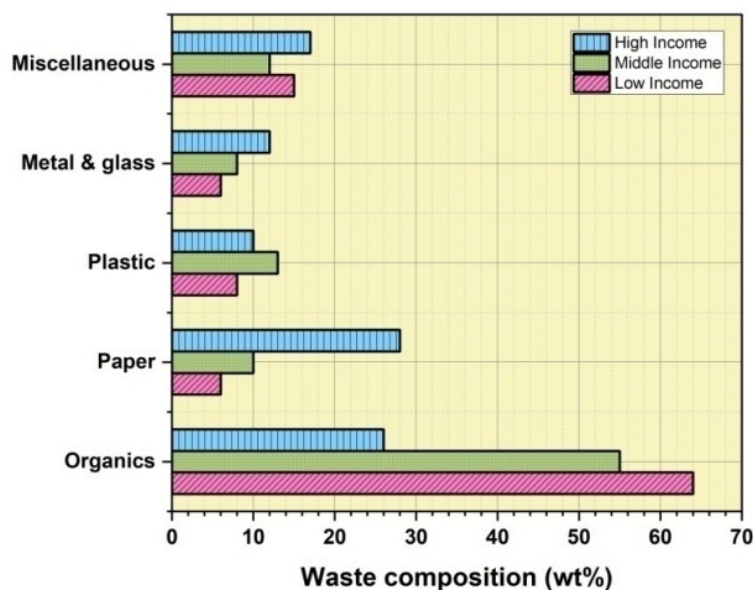


Figure 2 Typical municipal solid waste among people at different economic levels.

Urban garbage is divided, destroyed, and compressed on site at semicontrolled graves situated in approved landfills before disposal. To avoid annoyances such as the reproduction of collecting wildlife, vermin, and microbes, mounds of trash are levelled using groundwater cover, which makes semicontrolled wastes less smel. They are not designed to regulate leakage outflow and gaseous emissions. Clean dumps, modern variations of supervised wastes. The safe dumps have designed comforts for gathering fluid effluent and in-place recycling, composting, land creation, and separating waste coatings along with emissions from landfills. Hygienic dumps are distinguished by covering waste with dirt to lessen odors, insect vectors, fire hazards, and missed rubbish. Sanitary landfills are suitably delimited at local borders away from homes. In affluent nations, these dumps are widespread and equipped with leachate collection and clean-up systems. Clean landfills will be dug to expand the ground once current, saturated dumps are covered.

2.2. Planning and maintenance of wastes

To reduce the leakage of landfill gases that might cause fire danger. To prevent persistent groundwater contamination and increase the impact of methane emissions on environmental concentrations and leachate sewers, efficient waste removal is crucial. To reduce the effects of municipal solid waste disposal on the environment, specifically how it affects aquifers and the natural world, designing a hygienic landfill structure in terms of its structure and performance is essential. The base, lining, cover of soil, landfill gas collection station, effluent gathering system, flare-up terminal, and dump gas collecting platform are essential for creating a modern dump (Palomar et al 2019). Leachate from landfills full of harmful compounds, dissolved organics, and floating solids is produced from water found in MSW, rain, and winter. The solidity of the landfill base and covering can prevent any water from escaping into the soil. The relative permeability of the dump liner affects leachate from municipal solid waste leaks under designed hygienic dumps. A landfill liner is placed to serve as an impenetrable wall. It is advised to use hermetic to restore the dumps in older dumps for use as a liner. Earthy materials such as soil and clay must meet specific hydraulic conductivity standards. Engineered landfills are built with a base deposit of an extensive sufficient layer of solid clay to support hydraulic pressure. They are covered with a material made of high-density plastic. Leachate is one substance examined for use as insulation for landfill liners. Sand for collection, broken tires, polyurea foam, polystyrene boards, and fiberglass have been captured; although a landfill liner can degrade over time (Rizvanoğlu 2020), it prevents leachate from seeping into rivers or underground aquifers. Tensile stresses, splitting, elasticity, and antibodies to slash, effect, and perforation affect the lifetime, effectiveness, and profitability of dump barriers. Figure 3 demonstrates that a regular, clean dump in a contemporary waste facility has the necessary elements.

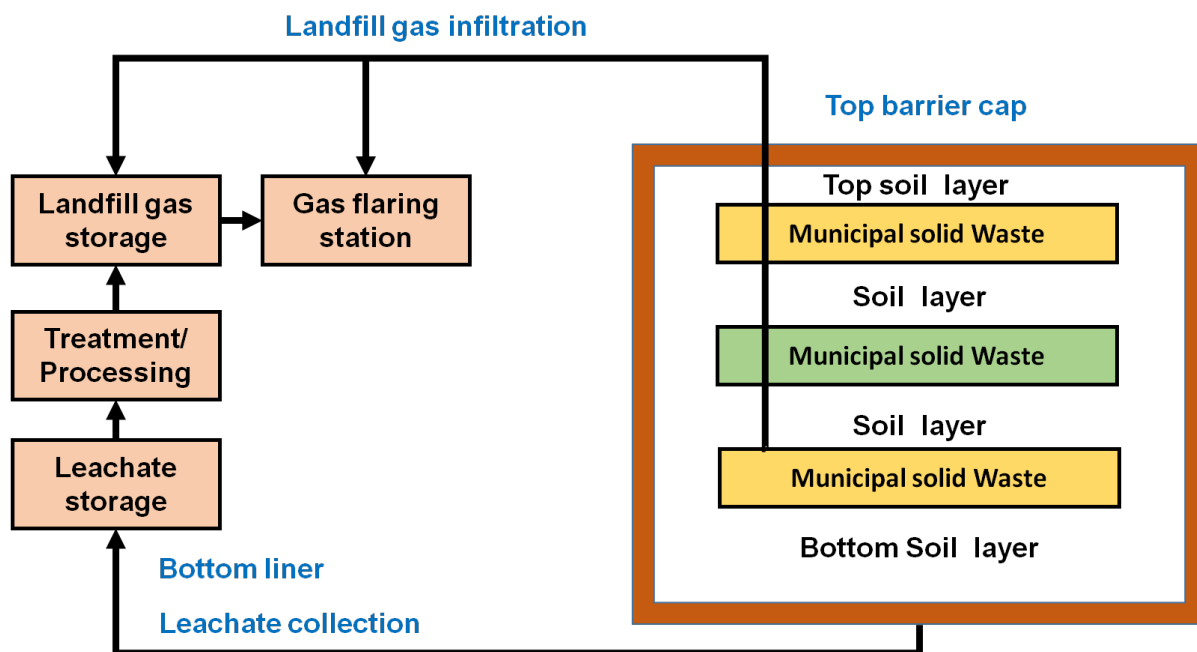


Figure 3 Regular clean dump in a contemporary waste facility with the necessary elements.

The release of liquid into aquifers can be controlled, and liquid can be reliably collected in storage tanks aided by an effective leachate-containing mechanism at the base layer of dumps. The effluent migrates downhill in a landfill, propelled by gravity, until it reaches the sloped system, is mechanically pumped through a massive punctured pipe and collected. The design of the leachate collection system is under the supervision of national legislation and guidelines. When it is pumped out, legal regulations and standards permit the building of a collecting device that can contain a specific quantity of water owing to the existence of multiple layers of soil covering the untreated waste that is dumped; aerobic bacteria exist inside landfills, which



cause anaerobic digestion and the production of landfill gas (Hoang et al 2020). Gas from landfills may be extracted and upgraded as fuel alternatives since nitrogen predominates. A system for collecting and storing landfill gas is a part of an organized dump. The trash is piled up at a landfill. Therefore, landfill gas is prone to escaping into the environment, and soil cover is produced at high pressures. Its combustibility creates fire risks, while the lingering presence of harmful gases such as CO₂, petroleum, volatile organic carbons, and organosulfur compounds generates health risks. In addition, if not sequestered, the high levels of CO₂ and CH₄ in dump gas can cause an increase in the amount of harmful gases released, which is an environmental issue. To collect the gases, the vertical wells of the extraction points in the landfill were placed in contact with other garbage. The recovered gas is collected in tanks or flared on the waste site. Mechanisms and methods for removing gas gather landfill gas before directing it to plants for gas cleaning and conversion. Modern landfills have a specific volume to hold dumped garbage before covering it. A substrate covering and a layer of defense. The procedure lessens the likelihood of landfill gas generation by preventing water from snow or rain penetrating the landfill. Highly absorbent layers are distributed above and below it to assist in the evacuation of gas by rainfall and the flow of stormwater; alternately, by grazing the topsoil cover, landfill closure should also guarantee that soil erosion from the barrier cap surface is prevented. A designed dump facility's top layer and bottom bed are crucial in deciding how it will affect the planet. The top layer, or dirt, restricts smell and nesting of pests, mice, forage birds, reptiles, other creatures, and pathogenic bacteria. In contrast, the bottom bed stops the leakage of leachate and the release of garbage gas.

2.3. Container leaching

Municipal solid waste (MSW) treatment facilities, dumps, aerobic digesters, or composted heaps are the sources of landfill leachate due to the high levels of organic materials; this raises major environmental problems for the cleanup of hazardous substances such as invasive organic matter, metallic metals, ammonium, metallic salts, pollutants, and others (Vyas et al. 2022). The organic part of landfill leachate is dominated by refractory or recyclable chemicals, such as minerals such as fulvic and humic acids. These substances, which come from factories, homes, beauty, and medical items, are found in high amounts in wastewater because they may contaminate water and promote metabolism, and landfill leachate is dangerous both acutely and chronically (Raj et al. 2023). Leachate from landfills seeping into the soil is a widespread issue in landfills worldwide. The landfills consisted of both aerobic and semiaerobic bioreactors. For facultative and anaerobic bacteria, oxygen biological reactors generate a hostile atmosphere.

Leachate may infiltrate and pollute streams if disposal sites, both public and semicontrolled, are located in shallow seaside locations. MSW leachate may leak into aquifers combined with exterior waters in polar regions due to heavy rains and frozen melting in underdeveloped and third-world nations where dumps lack standard liquid collection methods and disposal services because leachate's greater penetration of dirt and aquifers obviously affects the geochemistry of the soil and its mechanical characteristics, which determine how pollution is concentrated, deposited, and permeated, and these factors affect how landfill leachate is transported through the soil to water. Advection, spread, and scattering are the primary mechanisms by which the contaminants in leachate are mixed and transported to the aquifer, as previously indicated; the implementation of appropriate liquid collection equipment at dumps' base beds may stop landfill leachate from seeping and releasing into aquifers. A total of 95 groundwater pollutants were found, along with inorganic salts, heavy metals, antibiotics, and microbial pathogens. These pollutants were detected near municipal solid waste landfill sites in India. Polluting groundwater first became an issue halfway into the landfill stage and became more severe; as the landfill became older than 20 years, the pollution level decreased (Koka et al 2020).

2.4. Chemicals from dumps

In dumps, heat, substances, and chemical reactions result in the production of dump gases. Due to the increased temperature in landfills, volatile chemicals such as alcohol and those in public solid waste may evolve into gases. After being mixed during disposal, different waste species may undergo several chemical reactions in landfills, which may result in gas emissions. Finally, bacterial transpiration, breakdown, and fermentation can also occur within a dump (Kundariya et al 2021). Due to the absence of air or oxygen in the landfill bed, which promotes anaerobic decay, the action of microorganisms that produce methane is significantly superior to the processes of various chemical reactions, including hydrolysis, fermentation, anaerobic oxidation, acidogenesis, and methane creation, which contribute to the generation of landfill gas. The anaerobic decay of organic matter generates bacterial populations engaged in landfill gas. Municipal solid waste undergoes early hydrolysis, which causes anaerobic oxidizers and fermentative microbes to produce nutrients such as glucose, aspartic acid, and fats. Acidogenic bacteria further breakdown these organic monomers into intermediate acetate, butyrate, propionate, and lactic acid metabolites. Early in a landfill, high moisture levels and organic waste promote acid fermentation, which results in the production of hydrophobic acids such as lactate, propane, and acetic acid. The foul smells created by landfill gases, viewed as an annoyance rather than a health issue, are a source of public worry. Prolonged contact with gaseous waste is thought to put surrounding communities and disposal managers at risk for adverse health effects. Asthma, bronchitis, respiratory issues, suffocation, asphyxiation, chronic obstructive pulmonary disease, eye and skin irritation, congenital anomalies, neurological



disorders, liver issues, and cancer are more common conditions that may result from frequent breathing in landfill gases (Ibrahim et al 2022). There are insufficient findings about the medical effects and causes of death from waste fumes.

2.5. Biological waste

A constructed contemporary landfill called a bioreactor flips the usual waste disposal model from storage to recovery. By increasing the anaerobic decomposition of organic elements, biosensor dumps can hasten the mineralization and stabilization of MSW (Jain et al. 2022). In contrast to conventional dumping technologies, a biological landfill uses leachate recycling to increase bacterial activity and accelerate the decomposition and transformation of organic pollutants to dumps to facilitate trash breakdown, which is another trait that distinguishes bioreactor landfills from regular landfills. Bioreactor landfills can recycle leachate in various ways, control conditions, provide minerals for microbial life, such as pH buffers, and collect waste gases for on-site burning and partial storage. Leachate circulation in anaerobic fermenter dumps is primarily performed to increase the humidity for biological development. Through the processes of hydrolysis, acid production, methanation, and the ultimate outcome, the leachate uniformly distributed across the scraps in each stratum of a biological dump is stabilized.

Anaerobic, aerobic, and semiaerobic landfills are several types of bioreactor waste. Figure 4 shows the settings of waste gas permeation sewage recovery connections, and possible atmospheric delivery devices are vital variations between these fermenter systems. The basic idea behind an aerobic bioreactor is to create a situation where facultative and anaerobic microbes may thrive, notably germs that produce acid, acetate, and methane. The advantages of aerobic maceration landfills include shorter durations for stabilizing waste and elevated levels of carbon dioxide, oxygen, and phosphate occurring naturally. Trashes may create new materials that considerably alter these benefits (Vyas et al. 2022). The significant H₂S level in landfill gases necessitates stripping, which adds to the cost. The leachate produced by bioreactor landfills contains substantial amounts of aromatic fats and ammonium, which requires additional treatment and expense. Aerobic bioreactor landfills accelerate waste decomposition by providing aerobic bacteria with oxygen surpluses. Aerobic bacteria in these landfills obtain energy by oxidizing organic molecules, which mainly results in the production of CO₂ and water. When breathing oxygen is more efficient at providing power than anaerobic respiration, these organisms can increase rapidly. Aerobic degradation occurs rather than catabolic depreciation. The process is encouraged in aerobic bioreactor landfills by injecting fresh air into a trash mound and SM by adding air to dumps. Methane creation and aerobic microbial development are slowed. The residual waste components in the bioreactor landfill over time are uncertain. They are expected to continue to degrade biologically and chemically (Wojnowska-Baryła et al 2020). Refusal of the business application stems from the idea that bioreactor landfill technology is relatively new, lacking demonstrable proof, has uncertain costs, and is subject to regulations. Less knowledge is available on the ecology of garbage dumps, which might illuminate the complementary and competing functions found in diverse ecosystems such as dumps. Leachate hydrodynamics, the addition of air, techno-economic evaluation, conservation, lifespan evaluation, and other technical hurdles need further examination.

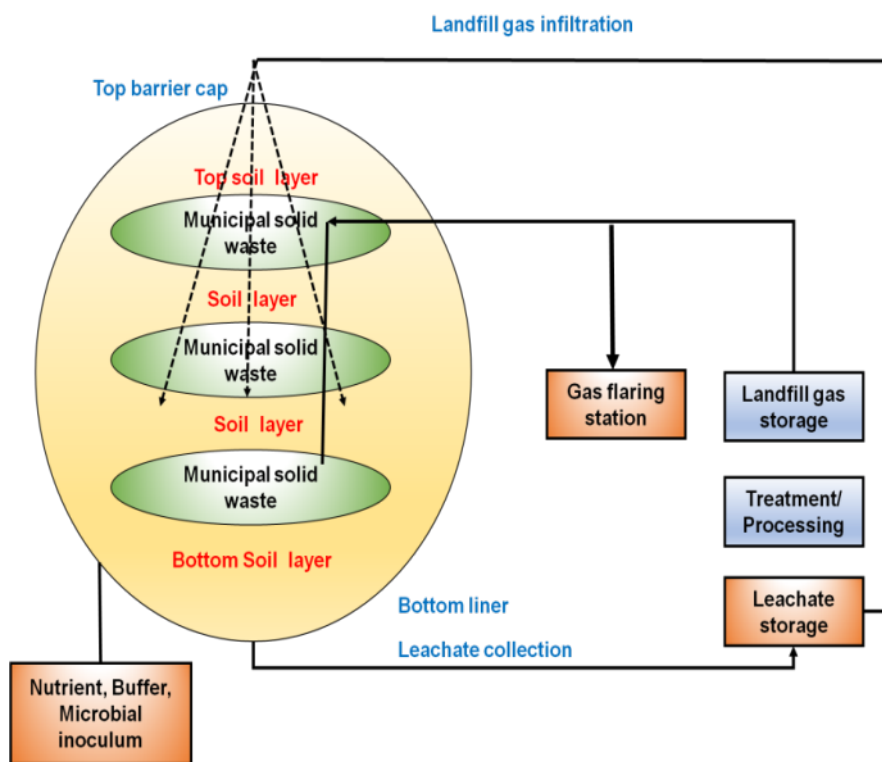


Figure 4 Comparison of ecological dumps and traditional dumps in common bioreactors.



2.6. Mining and repurposing of landfills

Disposal has been used to store different types of garbage over extended periods at the lowest possible cost. A few permanent effects of socioenvironmental worries, such as global warming caused by greenhouse gases, including propane, and soil contamination caused societal efforts to dig, manage, cure, and recycle buried garbage, reclamation, and land mining, have been conceptualized as such issues. Trashes are categorized as recyclable, biodegradable, or nonbiodegradable. Once closed landfills are removed, organisms and acidic chemicals are found in soil, concrete, stone, and stones. When waste is utilized in energy methods such as pyrolysis melting and gasification for energy and material exchange, acidic substances may be utilized as natural nutrients, minerals are recoverable, and high-calorie recyclables can be handled (Ganguly and Chakraborty 2021). These astounding results demonstrate how a run-down dump may be changed into a bustling dump. Requirements for landfill liners, appropriate leachate collecting structures, subsurface tracking, and waste soil restoration were covered by environmental legislation.

In addition to removing space from the dumpsite, the waste collects valuable recyclables, fertilizer, and flammable waste gases. Reducing the amount of total garbage masses contained in closed garbage is a crucial component of landfill extraction, mainly to remove additional debris by digging partially/completely decomposed organic materials and possibly recyclable items. Because organic wastes are more readily filtered with access to nonrecyclable elements, it is possible and economical to remove stable wastes from existing sanitary landfills and bioreactor dumps. The conditions of nonrecyclable debris, such as dust, sand, clay, and other elements in soil, polymers, waste tires, rubber products, and glasses, are ideal for recycling and reprocessing. However, it is possible that copper, steel, tin, iron, and metal can be used again once mined. Trash mining and excavation provide other benefits, such as increased ventilation, which may increase anaerobic bacterial activity and decrease methanogenic bacterial numbers, reducing methane production in waste gases. By eliminating dangerous elements and ensuring that appropriate safety precautions are taken before the entire waste mass is replenished, landfill mining may be essential for adhering to green rules because the cleanup of certain landfills might result in the production of highly offensive dump gasses, which might have severe dangers as well as fire risks. Security for workers should be the highest priority, as higher breakdown rates are caused by methanogenic bacteria that are concentrated in core regions inside dumps that lack oxygen. The rising pressure in a landfill may result from the accumulation of methane-rich waste gases in such micro activity zones because of the compaction of trash and periodic soil layers due to abrupt gas pockets. Mining such locations inside landfills might result in gas leaks, landslides, and death, leaving removal operators vulnerable. Mining may cause release to the surface or into the groundwater system of the collected trash for older landfills that lack suitable liquid-containing devices. Possibilities, dangers, and ideal methods for managing local solid garbage.

2.7. The possible advantages, difficulties, and suggested tactics for managing local solid waste

Municipal Solid Waste Management Decentralizing: An autonomous approach to managing municipal solid trash may be realized through active public engagement and awareness campaigns. The fundamental amount of garbage collection at the source is improved since the inhabitants rely less on the municipality's waste collection division system. A distributed leadership structure for MSW must be planned and implemented with solid local and state backing (Srivastava et al. 2015).

The source of solid waste from municipalities should be separated: nonbiodegradable components, such as plastic and glass, hamper municipal solid waste management (Mihai 2020). The labor and operational expenses of garbage processing facilities for segregation and sorting before disposal, recycling, or waste-to-energy technologies also increase. There is additional demand for alternative recycling methods such as burning this process or gasification. Even waste management systems become ineffective without separation by sorting garbage into compostable, recyclable, glass, steel, and inert categories, clothing, and cardboard. Due to the diverse makeup of municipal solid waste streams, homes, structures, and businesses must segregate garbage at the source first (Olatayo et al 2021). This might lower the price of garbage treatment in subsequent stages due to the diverse makeup of municipal solid waste streams; homes, structures, and businesses must first segregate garbage at the source. This might lower the price of garbage treatment in subsequent stages. The notion of trash categorization, including reusable, nonrecyclable, flammable, fireproof, noncombustible, composite, rubber, document, food debris, electronics, medicinal waste, and building, collapse, and restoration wastes, should be understood by citizens. Large municipal solid trash collection vehicles and their integrated collection techniques are unfamiliar with this concept (Teymourian et al 2021). As part of this, the municipality or waste management organization must give households their rubbish pickup bags or containers, complete with distinguishing colors, readable language, and waste-specific pictograms.

Managing municipality solid waste in a hygienic and secure manner: These wastes are very contagious for those who handle solid trash and producers who use solid waste composting. In developing nations' open waste dumps and composted zones, issues with insect, vermin, fly and mosquito breeding are also frequent. Additionally, managing municipal solid garbage and compost can result in bodily harm from organic contaminants, flammables, chemicals, threads, pieces, and other items. Workers in all industrial fields, particularly the disposal of MSW, must finish vocational instruction activities related to staying safe on the job and mindful of any risks in most industrialized nations; however, such security education is available in developed nations and not strictly applied, which results in operators' lack of knowledge and readiness for strength risks from

managing MSW in an unsanitary manner (Xiao et al 2020).

Hazardous landfill gases: Landfill gases that can leak through top-deposited soil waste are uncommon in emerging nations because of the high amounts of CO, CH₄, and CO₂ in waste and biogas digestion gases, and operators may be in danger. In solid waste workers or those who live close to municipal solid waste disposal facilities, these gases may cause asphyxia, drowning, allergies, and other bronchial cardiac problems. In addition, gas from landfills has the potential to build up tension, making them very combustible and susceptible to unintentional explosives or fires (Yousefi et al 2021). To guard against potential vulnerabilities, governmental solid waste collection facilities for solid waste from city incinerators also produce fly ash, which contains hazardous chemicals such as heavy metals, dioxins, furans, particle pollution, air pollution, aerosols, pollutants, and particle transfer to the sky, and persistence in water, air, and soil may be avoided by capturing and recovering the particles. Additionally, suitable precautions must be taken to protect the handlers of municipal garbage from health risks. For the immediate security of waste managers, ecological surveillance should include physical and chemical analyses on a regular and periodic basis of the waste substrate, effluent, and fumes.

For municipalities to manage MSW and choose the most favorable options for resource disposal, recycling, and energy recovery, it is essential to understand the characteristics, composition, and variety of the rubbish created. Furthermore, the absence of available land for new landfills in highly dense urban areas is driving research and development solutions for recycling nonhazardous materials. The lack of open space and the presence of dumps near many people are driving the implementation of technologies for solid waste recycling. Due to fewer adverse surrounding effects, the emissions of greenhouse gases, which have enormous potential for energy recovery, decreased. Instead of dumping it in a dump, using MSW for energy production is better since it reduces pollutants. While landfills serve as long-term geological repositories for trash, they also pose risks to the environment, the economy, and individual safety. To meet these requirements, it is necessary to install dump barriers and topsoil for collecting sludge, recovering fuel, burning it away, and restoring complete dumps. Dumps, anaerobic digestion facilities, and composting plants produce the effluents. These substances are contaminated with hazardous organic and inorganic pollutants that can contaminate groundwater and aquifers.

3. Conclusions

Landfills release volatile substances and landfill gases, endangering operators' health due to the high methane content in landfill gas, which is frequently combustible; the full potential of energy recovery has not been fully achieved with bioreactor dumps, which are modern designed garbage dumps that can speed up stabilizing waste due to the cycling of leachate and gas absorption. Aerobic, anaerobic, and semiaerobic bioreactor landfills can be categorized based on leachate recirculation and ventilation geometry. Reducing Dump extraction is the process of extracting valuable material from landfills for later use, either inside the same site or elsewhere in the city. It is essential to plan for waste removal when creating new rubbish designs to ensure that deposited waste may be easily collected, retrieved, and reclaimed once a specific amount of time has elapsed.

Ethical Considerations

Not applicable.

Conflict of Interest

The authors declare no conflict of interest.

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