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Solid Waste Management Practices in India: Implications for Human Well-Being

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Abstract: ***Solid waste management (SWM) has appeared as a major environmental and public health concern in India due to rapid urbanization, population expansion, and changing consumption patterns. Ineffective waste management techniques endanger human health by contaminating the air, water, and soil. In response, India has launched a number of programs to improve solid waste management through community involvement, technology advancements, and governmental changes. The SWM framework has been considerably enhanced by important efforts including the Swachh Bharat Mission, Solid Waste Management Rules (2016), waste segregation at source, encouragement of recycling and composting, and waste-to-energy projects. In addition to promoting environmental sustainability, these initiatives aim to improve public health by lowering disease vectors, strengthening sanitation, and guaranteeing cleaner living circumstances. Awareness campaigns and the inclusion of informal trash workers have also improved social and economic well-being. Despite advancements, there are still issues with infrastructure, behaviour modification, and implementation. In order to attain long-term health and environmental advantages, this abstract emphasizes the importance of integrated, inclusive, and sustainable approaches. It also underlines the role that solid waste management initiatives in India play in supporting human well-being.***

Keywords: Solid waste; human well-being; biodegradable; recycle; landfill

1. Introduction

Environmental degradation brought on by human actions, such as pollution and overuse of natural resources, is a significant worldwide problem. The continual development of the human population has led to an increase in garbage output, which considerably contributes in the environmental degradation. Any material that has lost its usefulness and is no longer required by the owner, manufacturer, or processor is considered waste. The sources of garbage are different from each other (Hajam et al., 2023; Ali and Rahman, 2024).

Controlling the production, storage, collection, transportation, transfer, processing, and disposal of solid waste materials in a way that effectively addresses the range of public health, conservation, economics, aesthetics, engineering, and other environmental considerations is known as solid waste management (SWM). These materials are categorized according to their categories, including plastic, paper, metal, organic waste, glass, radioactive elements that are combustible but non-toxic, industrial waste, household waste, etc (Chandrappa and Das, 2024; Basavaraju et al., 2025). Solid waste is the portion of raw materials that remain after objects have been used for the first time. These solid wastes are produced in the environment as a result of different human activities (Khalid et al., 2022).

The collection, transportation, processing, recycling, treatment, disposal, management, monitoring, and regulation of waste materials are all included in waste management. The phrase typically refers to the management of waste products generated by human activity and the process of lessening the impact of waste on the environment and public health (Singh et al., 2014). Both industrial and residential waste producers, as well as developed and developing countries, may use different waste management techniques (Kumari and Raghubanshi, 2023). In metropolitan areas, local government authorities are typically in charge of managing non-hazardous residential and institutional waste, while the generator is typically in charge of managing non-hazardous commercial and industrial waste, subject to local, national, or international regulations.

Classification of waste

There may be numerous forms of waste such as domestic waste, waste from oil factory, factory waste, E-waste, agricultural waste, construction waste, food processing waste, Bio-medical waste, nuclear waste, Slaughter house waste etc (Chaturvedi and Khare, 2022; Kumawat et al., 2024). Waste can be categorized as follows:

- Solid waste, such as household, kitchen, and vegetable waste.
- E-waste: abandoned electronics, including computers, televisions, music players, and more.
- Liquid waste: water used in thermal power plants, tanneries, and several sectors
- Plastic garbage, such as buckets, bottles, and bags.
- Metal waste, such as metal fragments and unwanted metal sheets.
- Unused materials from nuclear power facilities are known as nuclear waste.

Additionally, all of these waste types are divided into two categories: dry waste (non-biodegradable) and wet waste (biodegradable) (Agarwal et al., 2015).

Biodegradable wet waste comprises the following:

- Kitchen waste, which includes all types of food waste, both cooked and raw, such as bones and eggshells
- Fruit and flower trash, including juice peels and garbage from houseplants
- Sweeping the garden or picking up green or dry leaves from the yard
- Waste that is sanitary
- Green waste from stores and vendors of fruits and vegetables
- Trash from food and tea vendors, stores, etc.

Non-biodegradable dry waste comprises the following:

- All types of paper and plastic
- Cartons and cardboard
- All types of containers, excluding those that hold dangerous materials
- Packaging of all kinds
- All types of glass
- All types of metals
- Rubber and rags
- Sweeping the house (dust, etc.)
- Ashes
- Tetra packs (rinsed), foils, wrappings, pouches, and sachets
- Discarded electronic items from offices, cassettes, computer printer cartridges and electronic parts.
- Equipment, furniture, and clothes that were thrown away

Fundamentals of Solid Waste Management

1) 4Rs: Refuse, Reduce, Reuse & Recycle

- Refuse: Do not buy anything which we do not actually need.
- Reduce - Reduce the amount of rubbish generated. Alter our lifestyle so that minimum rubbish is generated.
- Reuse - Reuse everything to its maximum after carefully cleaning it. Utilize other articles as a secondary source.
- Recycle: Store items that can be recycled so they can be given to waste or rag pickers. Turn the recyclable waste into manure or other products that can be used (Agarwal et al., 2015; Cockayne, 2020).

2) Source segregation: Put in separate containers for organic or biodegradable and inorganic or non-biodegradable solid trash. Recycle every component for the least amount of money and labour (Middha et al., 2024).

3) Different treatments for different kinds of solid waste: The methods that are appropriate for the particular kind of trash must be used (Demirbas, 2011).

4) Treatment at the closest location: The solid waste should be handled as locally as feasible. Garbage should ideally be handled at the point of generation, which is every home (Pasang et al., 2007).

5) Sanitary Landfill: This is currently the most widely used method for disposing of solid waste. This technique is helpful for disposing of all kinds of residual trash, both organic and inorganic, as well as inert and mixtures of all kinds of garbage, on land that is a significant source of greenhouse gasses like carbon dioxide and methane. When the landfill is filled, it is covered with layers of sand, clay, topsoil and gravel to prevent seepage of water (Hoque and Rahman, 2020; Nanda and Berruti, 2021).

6) Incineration: This method involves burning solid trash at a high temperature till it turns into ashes. When solids are burned using this approach, very little heat is released. This approach is helpful for towns, organizations, and even individuals to manage solid waste (Tillman, 2012: Devidasrao, 2023).

7) Pyrolysis: This process uses heat pressure and a temperature of around 431^0C to chemically break down trash. Then the solid wastes are transformed into gasses, solid residue of carbon and ash. This approach's primary benefits include maintaining a clean environment and lowering health and settlement issues (Olam and Karaca, 2022; Devidasrao, 2023).

8) Composting: Decomposition of organic stuff in the garbage in the presence of oxygen with the help of micro-organisms or worms. Organic waste is transformed into stable, nutrient-rich, toxin-free manure through a natural biotransformation process. Animal manure, industrial waste, agricultural straws, and municipal solid waste can all be managed economically and sustainably by composting (Sayara et al., 2022). Composting is the practice of placing organic materials in containers and letting microorganisms like fungi and bacteria break them down. Composting is a good way to manage municipal solid waste because of the waste composition of developing nations, which frequently has a high moisture content (Ayilara et al., 2020; Sayara et al., 2022). This method is frequently used to turn organic waste into organic manure, or compost, which is appropriate for agricultural activities since it recycles mineral minerals including potassium, phosphate, and nitrogen (Ahmad et al., 2019). The pH of the composting substance also changes during this procedure, with an initial fall due to the generation of organic acids from the synthesis of starch and lipids, and subsequently an increase when the bacteria destroy proteins (Ayilara et al., 2020; Zhang et al., 2026).

8) Biomethanation: Anaerobic decomposition, also known as biomethanation, is a more sophisticated technique for the biochemical conversion of biodegradable waste. Microbes break down organic matter in the absence of oxygen, releasing biogas that contains methane (Krishania et al., 2013). The gas can be used in place of conventional fuels like LPG or CNG. Additionally, it can be condensed and bottled into compressed biogas, which can then be used with generators to produce power with an efficiency of 30%. However, over 70 % of the energy is wasted as heat in the process of conversion. Slurry, a byproduct of biomethanation, is a great liquid manure for farming. Thus, biomethanation provides nutrients for soil in addition to producing energy (Khan et al., 2015).

9) Biodegradable waste Processing: Living things may break down biodegradable trash, which is usually derived from plants or animals. A significant portion of municipal solid trash is made up of biodegradable garbage, such as food waste from homes and restaurants, waste from slaughterhouses, and waste from horticulture. When the organic matter in waste material decomposes in the presence of oxygen, it breaks down into simpler compounds with the emission of carbon dioxide and water, and generates compost which is helpful for feeding of the soil. Alternatively, the organic material in the biodegradable waste is broken down by anaerobic decomposition in the absence of oxygen to produce methane and liquid slurry, which can be used as manure and biofuel, respectively (Ahluwalia and Patel, 2018).

Waste Management System in India

Municipal waste, industrial waste, biomedical waste, and electronic waste make up the four segments of the waste management market. Depending on the type of waste, each of these four categories is subject to various rules and regulations. Actual trash generation, primary storage, primary collection, secondary collection and transportation, recycling activities, treatment, and disposal all influence waste management practices in India (Agarwal et al., 2015). Together with the public health department, municipality corporations in India are crucial to the management of trash in each city. Food adulteration, epidemic control, street cleaning, and cleanliness fall within the purview of the public health department. The Municipal Corporation has a robust and well-defined hierarchy of positions (Amasuomo and Baird, 2016).

Street cleaning, collection, transportation, and disposal are the four main categories under which the SWM system operates. The transportation department of City Municipality Corporation handles trash transportation and disposal, while the public health department handles cleaning and collecting (Sharholy et al., 2008). It is possible to partition the entire city into various zones. For the purpose of collecting and transporting solid waste, these zones are further separated into various sanitary wards. In India nowadays, waste management primarily entails collecting rubbish from homes and businesses and disposing of it in landfills (Dharwal et al., 2022).

Solid waste generated within its specific boundaries must be handled by the authorities, which are typically municipal. Typically, solid garbage is lifted from the point of origin and transported to far-off locations known as dumping grounds and/or landfill sites for disposal. Once the waste has been removed, its treatment is limited to dispersing the pile across a wider area to hide it from public view. Typically, waste collection is carried out on contract. Rag pickers, small-time vendors, and municipalities handle it in the majority of cities (Agarwal et al., 2015; Dharwal et al., 2022).

Initiatives of Waste Management in India

The Central and State Governments as well as local (municipal) authorities in India have given solid waste management a lot of attention lately. In the area of solid waste management in Indian cities, there are several collaborations and alliances. These partnerships are private-private, public-private, and community-public. The different players involved in waste management must first be identified in order to determine the current state of alliances in the study area (Agarwal et al., 2015). These actors can be categorized as follows:

1) Public sector: this includes city-level local government agencies and public departments;
2) Private-formal sector: this includes both small and large registered businesses that handle recycling, disposal, transportation, and treatment;
3) Private-informal sector: this is the small-scale, unrecognized private sector and includes traders, non-registered small-scale businesses, waste pickers, dump pickers, and itinerant waste buyers; and
4) Representatives of the community, such as NGOs, etc.

These players form alliances to offer a range of solid waste management-related services. These collaborations may take the following forms:

a) Public-private (private businesses and local authorities);
b) Public-community (NGOs and local authorities); etc.
c) Private-private (trash pickers, traveling waste purchasers, waste dealers and traders, wholesalers, small and large recycling businesses); and• Public-private community (NGOs, private businesses, and local authorities).

The National Solid Waste Association of India (NSWAI) is India's sole preeminent professional non-profit organization for managing solid waste, including hazardous and toxic waste as well as biomedical waste (Rath and Swain, 2023).

2. Conclusion

In India, solid waste management programs are essential for preserving public health, environmental sustainability, and human well-being. Solid waste creation has dramatically expanded due to rapid urbanization, population growth, and shifting consumer habits, creating major issues for current waste management systems. In response, India has implemented a number of community-based and policy-driven programs, including the Swachh Bharat Mission, the Solid Waste Management Rules, 2016, recycling, composting, waste-to-energy projects, and the promotion of trash segregation at the source.

By reducing landfilling and promoting resource recovery, these programs have improved sanitation, lowered health hazards, and improved environmental quality. It has been demonstrated that efficient solid waste management lowers the spread of illness, enhances living conditions, and promotes sustainable livelihoods, especially for unorganized garbage workers. But there are also gaps in infrastructure, public awareness, technology uptake, and regulatory enforcement, particularly in rural and smaller cities.

An integrated and inclusive strategy is necessary for SWM projects to reach their full potential for human well-being. Important first measures include bolstering institutional capacity, fostering public involvement, supporting behavioural change, and utilizing cutting-edge technologies. Building a cleaner, healthier, and more sustainable India will require ongoing cooperation between public and corporate entities as well as local communities.

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