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Solid waste management: A review

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Abstract
Solid wastes are major problem for our environment. It is useless or discarded material which increasing year by year and they are many options for handling and disposing of these wastes. The management of solid waste occurs at various methods like segregation, collection, transfer and transport, reuse and recycling etc. This study recommended that municipal solid waste management has become a major problem due to increased economic activities. Increasing population enhanced the solid waste generation as a result waste disposed in an unplanned manner and burned by the residents in their backyards. In this paper greater emphasis has been given to use the various techniques for the management of solid waste like landfilling, composting, sanitary landfilling, thermal treatment etc.

Keywords: Solid waste, management, collection, segregation, municipal solid waste

1. Introduction
Waste is the outcome of human activity which is produced since humans started living in smaller and larger societies. In modern times, the size of the town and cities are increasing at a very fast rate and therefore solid waste generated daily has a very high magnitude and therefore its collection and disposal is necessary, to maintain good hygienic condition in the society. Waste, in general is a derogatory term which implies something unwanted, useless, pejorative and filthy. The term waste is very complicated to define, as concepts, views or attitudes towards waste are usually very subjective and often exceedingly distinctive and conflicting (Atalia *et al.*, 2015) [1]. Rapid industrialization and population explosion in India has led to the migration of people from villages to cities, which generate thousands of tonne of Municipal Solid Waste (MSW) daily. The MSW amount is expected to increase significantly in the near future as the country strives to attain an industrialized nation status by the year 2020. Poor collection and inadequate transportation are responsible for the accumulation of MSW at every nook and corner. The management of MSW is going through a critical phase, due to the unavailability of suitable facilities to treat and dispose of the larger amount of MSW generated daily in metropolitan cities [Siddiqui *et al.*, 2013] [2]. Solid waste management may be defined as the discipline associated with the control of generation, storage, collection, transfer transport, processing, and disposal of solid wastes in a manner that is in accordance with the best principles of public health, economics, engineering, conservations, and that is also responsive to public attitudes. The United Nations Conference on Environment and Development stressed that "solid waste production should be minimized, reuse and recycling, maximized, environmentally sound waste disposal and treatment promoted and waste service coverage extended" [Sridevi *et.al.*, 2012] [3].

2. Literature Review
- Vilas Mane Ashish [2015] [7], Studied on "A Critical Overview of Legal Profile on Solid Waste Management in India". This paper showed that the legal profile and policies available on solid waste management in India, responsibilities of the concerned departments and future need to enhance legal regime for better management of Indian environment. It was seen that the current laws are unable to ensure environmentally sound and sustainable ways of dealing with waste generation to disposal practices. The laws are not well understood and efficaciously implemented.
- Njoroge *et al.*, [2014] [8], investigated on "Review of Municipal Solid Waste Management: A Case Study of Nairobi, Kenya". Study indicated that the Nairobi's solid waste situation, which could be taken to generally represent Kenya's status, was largely

characterized by low coverage of solid waste collection, pollution from uncontrolled dumping of waste, inefficient public services, unregulated and uncoordinated private sector and lack of key solid waste management infrastructure. Solid waste generated on daily basis is 4,016 tonnes. The collection rate was as low as 33% which leaves about 2,690 tonnes uncollected.

- Upadhyay *et al.,* [2012], found that the "Solid Waste Collection and Segregation: A Case Study of MNIT Campus, Jaipur", A detailed investigation was made regarding the methods of practices associated with sources, quantity generated, collection, transportation, storage, treatment and disposal of solid waste in MNIT Campus. Photographic evidences were also made about generation, storage, collection, transportation, treatment and disposal of Solid Waste. Study indicated that the present system of SWM in MNIT is not satisfactory Solid Waste Management.
- Rana *et al.,* [2015] [9], studied on "An Assessment of Solid Waste Management System in Chandigarh City, India", In this paper investigator found that 370 tons/day of solid waste is generated in Chandigarh municipal corporation area. The budget allocated for the financial year 2013-2014 to the Chandigarh municipal corporation for management of so solid waste generated was INR 5737.49 crores. 80% of total SWM budget was allocated for salary of sweepers and rag pickers and only about 7-8% was allocated for collection purposes, the collection efficiency was about 70% from registered households and 20% from the slums and surrounding villages. lid waste generated was INR 5737.49 crores which was insufficient.

3. The sources and types of waste [Keisham and Paul, 2015] [4]:

Source	Typical waste generators	Types of solid wastes
Residential	Single and multifamily dwellings	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes, and household hazardous wastes.
Industrial	Light and heavy manufacturing, fabrication, construction sites, power and chemical plants	Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes
Commercial	Stores, hotels, restaurants, markets, office buildings, etc.	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes
Institutional	Schools, hospitals, prisons, government centers	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes
Construction and Demolition	New construction sites, road repair, renovation sites, demolition of buildings	Wood, steel, concrete, dirt, etc.
Municipal services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants	Street sweepings; landscape and tree trimmings; general wastes from parks, beaches, and other recreational areas; sludge
Process	Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing	Industrial process wastes, scrap materials, off-specification products, slag, tailings

4. Environmental and health impacts of improper MSWM: Improper MSWM causes all types of pollution, whether be it air, soil, or water. It does not end here. Their impacts on economy, environment and society are mentioned in Table 1.

Table 1: Economic, Environment and Social impacts of MSWM [Keisham and Paul, 2015] [4]

Economic impacts	Environment impacts	Social impacts
Function of the internal market	Climate	Social inclusion and protection of particular groups.
Investment costs	Energy	Non-discrimination
Operating costs	Air quality	Individuals, private and family life, personal data.
Administrative burdens	Biodiversity, flora, fauna, and landscapes	Governance, participation, good administration, access to justice, media, and ethics.
Property rights innovation and research	Water quality and resources	Public health and safety
Economic effects on consumers and households	Soil quality or resources Land use	Security
Economic effects on industry and business	Renewable or non-renewable resources	Culture
-	Environmental consequences of firms and consumers	Access to and effects on social protection, health, and educational systems
-	Likelihood or scale of environmental risks	
-	Animal welfare	

5. Solid waste management practices and challenges in India

In India, MSWM is governed by MSWR. However, majority of ULBs do not have appropriate action plans for execution and enactment of the MSWR (CPCB Report, 2013). Unfortunately, no city in India can claim 100% segregation of waste at dwelling unit and on an average only 70% waste collection is observed, while the remaining 30% is again mixed up and lost in the urban environment. Out of total waste collected, only 12.45% waste is scientifically processed and rest is disposed in open dumps. Critical examination of important parameters of MSWM practice with respect to Indian Scenario is delineated below [Joshi and Ahmed, 2016] [6]:

5.1 Segregation

There is no organized and scientifically planned segregation of MSW either at household level or at community bin. Sorting of waste, is mostly accomplished by unorganized sector and seldom practiced by waste producers. Segregation and sorting takes places under very unsafe and hazardous conditions and the effectiveness of segregation is reasonably low as unorganized sector segregates only valuable discarded constituents from waste stream which can guarantee them comparatively higher economic return in the recycling market [Joshi and Ahmed, 2016] [6].

5.2 Collection

In residential areas, the most common collection methods are curb or alley, setout-setback, and backyard carry. In curb or alley service, the residents carry the single-use plastic bags and containers to the curb or collection point, and then return the empty container after pickup. Setout service utilizes a crew that carries the containers to the collection point. A separate collection crew empties the containers and residents return the empty containers. In setout-setback service, a third crew returns the empty containers. In backyard carry service, the collection crew transfers the solid waste into a wheeled barrel, and then unloads it into the collection truck. The containers remain in the backyard [Singh *et al.,* 2014] [11].

5.3 Transfer and transport

The innovative idea of synchronisation that has been adopted by the municipality to transfer waste from pushcarts to trucks has proved to be successful. This has reduced the spillage, no space is occupied for intermediate storage and collection happens on time as the workers and trucks have to meet at a specified time and location for the transfer. The transfer of small drums is also much easier and safer than the transfer of waste from large community bins. The trucks that are currently used do not have provision for separate collection of waste. This results in the mixing of waste even if the waste is collected separately. Trucks can either be provided with partition or two trucks can be provided – one truck for the collection of organic and mixed waste and another truck for collection of recyclable waste. The truck for recyclable waste can have a frequency of once in three days as the quantity of recyclable waste generated is less when compared to organic waste. Transfer of waste is carried out manually so it is very important to have proper safety gear like gloves, apron, masks and goggles during transfer. The vehicles used for the transportation of waste should be in a good condition. Most of the trucks have a mesh covering and about 50–60% also has polythene covering. However, there is no proper enclosure provided to prevent the wet waste from leaking on to the road. It is very essential that all trucks have mesh and polythene covering with a proper enclosure to prevent scattering of waste, foul odour and leakage while travelling on crowded roads [Ramachandra and Bachamanda, 2007] [10].

5.4 Recovery and Recycling

5.4.1 Material Recycling

Recycling is the reprocessing of discarded materials into new useful product [Rajput *et al.,* 2009] [12]. There are several reasons such as recycled material may contain increased levels of foreign materials that could interfere with product quality, uncertainty of supply and price variation of secondary material, methods of quality control of recycled material are not developed as for virgin materials. Many components of MSW are currently recycled. Among these are paper and paper products. These products are recycled in manufacturing building materials such as roofing felt, insulation and wallboard, and are also used to manufacture cartons and containers. Plastic is recycled to produce insulating material, sheets, bags, and structural material. Energy is recovered from combustion of organic wastes [Singh *et al.*, 2014] [11].

5.4.2 Separation Methods

The separation of material is performed by the users at the source, or separated from mixed refuse at a central processing facility. Handpicking is a long-used form of separation of a few components of solid wastes. In this operation, a conveyor moves the solid waste pass by a group of workers who pick up the designated components by hand. This method of separation is costly, and only a few bulky components, such as bundled newspapers and cardboard, can be separated. A mechanized material recovery method provided by utilizes shearers that break open the bags and liberate cans and bottles. Trammel screens separate cans, glass and other inorganic material. The organic material is shredded and passed through air classifiers, which separate the components desired for recovery of fibers for paper making or for producing refuse derived fuel. Magnetic and electromechanical systems separate ferrous and nonferrous metals [Singh *et al.,* 2014] [11].

6. Waste Management Techniques: Waste management includes collection, transportation, processing, treatment, recycling or disposal of waste materials to reduce their adverse effects human health or amenities. The type of waste management techniques that should be applied for proper management of waste depend on the composition of waste [Atalia *et al.,* 2015] [1].

6.1 Landfilling

In many metropolitan cities, open, uncontrolled and poorly managed dumping is commonly practiced, giving rise to serious environmental degradation. More than 90% of MSW in cities and towns are directly disposed of on land in an unsatisfactory manner. Such dumping activity in many coastal towns has led to heavy metals rapidly leaching into the coastal waters. In the majority of urban centers, MSW is disposed of by depositing it in low-lying areas outside the city without following the principles of sanitary landfilling. Compaction and leveling of waste and final covering by

earth are rarely observed practices at most disposal sites, and these low-lying disposal sites are devoid of a leachate collection system or landfill gas monitoring and collection equipment. As no segregation of MSW at the source takes place, all of the wastes including infectious waste from hospitals generally find its way to the disposal site. Quite often, industrial waste is also deposited at the landfill sites meant for domestic waste [Atalia *et al.,* 2015] [1].

6.2 Sanitary Land filling

Sanitary landfill is a fully engineered disposal option, which avoids harmful effects of uncontrolled dumping by spreading, compacting and covering the wasteland that has been carefully engineered before use. Through proper site selection, preparation and management, operators can minimize the effects of leachates (polluted water which flows from a landfill) and gas production both in the present and in the future. In this process the waste is disposed and is covered with a layer of soil. The compact layer of soil restricts continued access to the waste by insects, rodents and other animals. It also isolates the refuse, minimizing the amount of surface water entering into and gas escaping from the waste. Sanitary Landfilling is a necessary component of solid waste management, since all other options produce some residue that must be disposed of through landfilling. However, it appears that landfilling would continue to be the most widely adopted practice in India in the coming few years, during which certain improvements will have to be made to ensure the Sanitary landfilling [Rajput *et al.,* 2009] [12].

6.3 Composting

Composting is a biological process of decomposition carried out under controlled conditions of ventilation, temperature, moist- ure and organisms in the waste themselves that convert waste into humus-like material by acting on the organic portion of the solid waste. If carried out effectively, the final product is stable, odour-free, does not attract flies and is a good soil conditioner. Composting is considered when biodegradable waste is available in considerable fraction in the waste stream and there is use or market for compost. This is a popular technique in Europe and Asia, where intense farming creates a demand for the compost. Centralized composting plant for sector may only be undertaken if adequate skilled manpower and equipment are available, hence at household level and small level composting practices could be effective which needs the people's awareness. Many large-scale compost plants with capacities of ranging from 150 to 300 tonnes/day were set up in the cities of Bangalore, Baroda, Mumbai, Calcutta, Delhi, Jaipur and Kanpur during 1975-1980. Now, about 9% of solid waste is treated by composting. After composting the final product obtained is called compost, which has very high agricultural value. It is used as fertilizer, and it is non-odorous and free of pathogens [Rajput *et al.,* 2009] [12].

6.4 Thermal treatment techniques

- **Incineration:** In an Integrated Waste Management approach, incineration occupies the next to last priority, after waste prevention, reuse, recycling and composting have been undertaken. Incineration is the burning of wastes under controlled conditions, usually carried out in an enclosed structure. Incineration may include energy recovery. Wastes generated in developing countries, however, usually do not allow energy recovery, due to their high moisture and high content of organic matter. Experience with incineration in developing countries has been mostly negative. Incinerators built in Africa, Asia and Latin America did not function as promised. In Lagos, Nigeria, incinerators were built at a cost of U.S. $ 10 million. The moisture content of wastes was so high that fuel had to be added to maintain combustion, which increased costs significantly. The incinerators never operated normally, one was abandoned and the other turned into a community center. Similar experiences have been observed in India, Mexico, the Philippines, Indonesia, and Turkey. Therefore, incineration of MSW is likely to fail in many Third World cities [Sridevi *et al.,* 2012] [3].
- **Gasification technology:** Incineration of solid waste under oxygen deficient conditions is called gasification. The objective of gasification has generally been to produce fuel gas, which would be stored and used when required. In India, there are few gasifiers in operation, but they are mostly for burning of biomass such as agro-residues, sawmill dust, and forest wastes [Sharholy *et al.,* 2008] [4].

7. Conclusion

The improper management of solid wastes causes infectious diseases which is harmful for human health and environment. The study revealed that the waste disposal situation is worse due to rapid urbanization so public awareness should be created as to minimize waste generation. Various management techniques are developed for proper management of solid waste. Greater efforts need to be made to segregation and collection of solid waste which reduce foul odour and unaesthetic appearance of bins. Government bodies must also appoint private agencies to implement solid waste management rules on ground level.

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