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Insight into the sustainable solid waste management practices and techniques in India

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Abstract
India, the world's second highest populated country with population exceeding a billion and one of the fastest urbanizing countries, is a land of physical, climatic, geographic, ecological, social, cultural and linguistic diversity. Human activities create waste, and it is the way these wastes are handled, stored, collected and disposed off, which can pose risks to the environment and to public health where intense human activities concentrate, such as in urban centers, appropriate and safe solid waste management (SWM) are of utmost importance to allow healthy living conditions for the population. India currently is facing a municipal solid waste dilemma, for which all elements of the society are responsible. The community sensitization and public awareness is low. There is no system of segregation of organic, inorganic and recyclable wastes at the household level. Common problems for municipal solid waste management include landfill area, dumping of waste, disposal of waste, government policies for environmental protection, budgetary planning, manpower planning, schedule for transporting the solid waste. This review research explained various aspects of solid waste management practices, waste to energy conversion, waste reuse and recycle and study also includes suggestions for improving existing solid waste management practices.

Keywords: municipal solid waste management, waste reuse and recycle and pollution etc

Introduction

Waste management is the process that involves the collection, transportation, and recycling or disposal of waste. It encompasses management processes and resources that ensure proper handling of waste products. Management of the resources involves maintenance of the waste transportation trucks and the dumping facilities so that they comply with the environmental regulations as well as health codes. The primary objective of waste management is to avoid the adverse effects of wastes to human health and natural environment, but in most occasions, waste management companies carry out the process to get useful resources. Waste materials can also be in all forms of matter, which are gaseous, liquids, radioactive matter, and solid.

Today more than 45 million tonnes/year of solid waste is generated from the urban centres of India which are collected inefficiently, transported inadequately and disposed unscientifically. The generation is expected to raise 125 million tonnes/year by the year 2025. According to Ministry of Urban Affairs, Govt. of India estimate, India is generating approximately 100,000 metric tons of solid waste every day of which 90 % is dumped in the open place (Barjinder Bhalla *et al*. 2013). Rapid increase in population and change in lifestyle in India have resulted in a drastic increase in the generation of Municipal Solid Waste (MSW). It includes domestic as well as commercial waste that accounts for a relatively small part of the total solid waste stream in developed countries. Accumulation of a large amount of waste may create several problems to inhabiting populations (Gautam *et al*. 2010) [11].

The overpopulated countries like the developing and underdeveloped nations all face the critical problem of waste management or waste disposal. With the negligence of people and recklessness, many of the cities are all facing the difficulties of large landfills and scattered garbage. This not only brings diseases to the common folks but also serves to be harmful to the future of the nation too. The proper disposal and waste management acquaintance is a must for the modern day world. Without this, we nonchalantly pave the way to a filthier and a dying planet.

Waste management is an overall control of the treatment, handling, prevention, monitoring and the reuse of the wastes of a particular area.

Composition and characteristics of Indian municipal solid waste

Following major categories of waste are generally found in MSW of India:

- Biodegradable Waste: Food and kitchen waste, green waste (vegetables, flowers, leaves, fruits) and paper.
- Recyclable Material: Paper, glass, bottles, cans, metals, certain plastics, etc.
- Inert Waste Matter: C&D, dirt, debris.
- Composite waste: Waste clothing, Tetra packs, waste plastics such as toys.
- Domestic Hazardous Waste (also called "household hazardous waste") and toxic waste: Waste medicine, e-waste, paints, chemicals, light bulbs, fluorescent tubes, spray cans, fertilizer and pesticide containers, batteries, and shoe polish.

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 (CPCB Report, 2013).

Sustainable solid waste Management Techniques

1. Disposal

The bulk volume of municipal solid waste requires large areas of land for disposing the same. Especially the bulk volume of waste generated in developing nations is very high, which give rise to additional problems of land pollution, water pollution, growth and transmission of disease producing vectors etc. The landfilling of huge quantities of MSW without treatment is not at all a good choice since land scarcity is a serious issue in urban areas (Varma, 2006) [23].

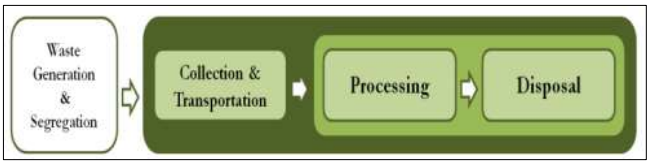

Fig 1: MSW Value Chain (Tchnolobanoglous *et al*., 1993)

The processing of waste involves the application of appropriate technology, depending upon the quantity and quality of wastes, so as to reduce the overall quantity of waste reaching the landfill sites. Technologies that derive value from the waste to the extent possible should be applied and finally the refuse from the processing plant is collected and disposed of at the scientifically engineered landfills (Tchnolobanoglous *et al*., 1993).

The waste remaining after waste minimisation, reuse and recycling should be treated to reduce the negative impacts to the environment. The different solid waste treatment technologies can be categorised mainly into three types namely biological, thermal and landfilling (Tan *et al*., 2014). The thermal treatment methods used for municipal solid waste management are incineration, pyrolysis and gasification. In biological treatment methods or biochemical conversion processes, the microorganisms (either added or inherently available in the substrate) are used to degrade the waste into various components in the form of solid matter, slurry and gas. Biological technologies are termed the most economical and environmentally safe means of obtaining energy from MSW. Biochemical conversion of waste can be grouped into two namely anaerobic digestion/fermentation and aerobic digestion /composting.

Fig 2: Municipal Solid Waste Treatment Technologies (Tan *et al*., 2014)

2. Composting

Composting is a biological method where the organic component of MSW is aerobically treated to create a product called compost, at relatively low-cost, which is suitable for agricultural purposes (Wolkowski, 2003) [25]. During composting, readily degradable substrates are rapidly consumed and the heating process releases significant energy. Depending on the degradability of the organic substrate, the oxygen supply and heat loss, the temperature of the material can rise up to 70 °C or more which eliminate the pathogens from the material (Neklyudov *et al*., 2006) [15].

A case study on heavy metal distribution in soil and plant in municipal solid waste compost amended plots (Ayari *et al*., 2010) [5] has revealed that there was an important transfer of metal ions from soils to wheat plants. Thus the composting method of solid waste disposal has to be analysed for detrimental effects, especially if industrial wastes are dumped into municipal landfills. Less market value for the fertiliser output from the composting plants is also a limitation for commercial scale composting plants.

3. Incineration

Incineration is a thermal treatment method where the controlled burning of waste materials at a temperature of 870oC–1200°C for a sufficient time will oxidise about 99% of the organic matter to produce high pressure steam for power generation. Waste incineration reduces the volume and weight of the waste by 90% and 70% respectively (Murphy and McKeogh, 2006) [12].

4. Pyrolysis

Pyrolysis is the thermal decomposition of waste in the absence of oxygen. The products of pyrolysis include bio-char, bio-oil and gases (methane, hydrogen, carbon monoxide, and carbon dioxide). The processes involved in pyrolysis can be grouped into three categories as slow pyrolysis, fast (or flash) pyrolysis at high temperatures and flash pyrolysis at low temperatures. At low temperatures below 450°C, pyrolysis may produce bio-char while at high temperatures above 800°C, a significant amount of gases may evolve (Mohan *et al*., 2006) [13].

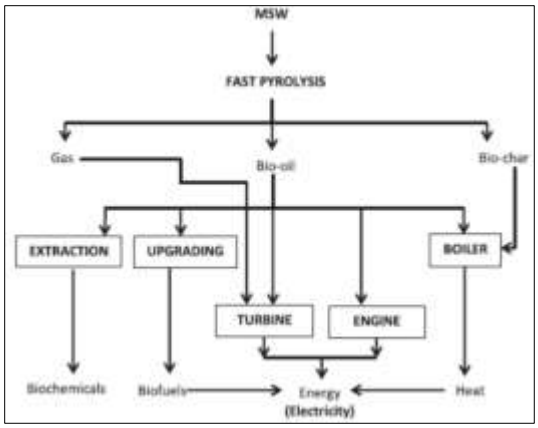

Fig 3: Production of Electricity from Fast Pyrolysis of Municipal Solid Waste

5. Landfilling

The landfill is a land that is built up from deposits of solid refuse in layers covered by soil. It consists of a random mixture of food scraps and other kitchen waste, paper, plastic, metals, and glass.

The organic waste dumped in a landfill site will decompose with time, but the inorganic constituents will be remaining for a long time. Since each landfill has its own particular constituents and the leachate quality of a particular landfill also changes over time; a flexible design is required to treat the varied influent stream. The main environmental problem associated with the landfill is the pollution of ground water. The study by Esmaeili *et al*. (2010) [10] has revealed that soil column had ample capacity to adsorb metal contaminants and hence the determination of soil potential in landfill site selection is inevitable. The methane gas per mole has a global warming potential 3.7 times that of carbon dioxide (Daniel and Dilip, 1990) [9].

A Comparative study of municipal solid waste treatment technologies using life cycle assessment method (Zaman, 2010) [26] has concluded that landfill with energy recovery facilities is environmentally favourable. However, the large land requirement, difficult emission control system and long time span, are the limitations. Therefore the untreated MSW should not be allowed to reach the landfill.

6. Biodrying Process

Biodrying is an aerobic convective evaporation process which reduces the moisture content of the waste, with minimum aerobic degradation (Velis *et al*., 2009) [24]. This process is different from composting in that the output of the composting process is stabilised organic matter, but the output of the biodrying process is only partially stabilised, which is useful for energy production (Rada *et al*., 2005) [17]. Composting stabilises the organic material of municipal solid waste and no final energy value for the product (Nellist *et al*., 1993) [16]. When compared with Composting (40-60 days) the biodrying process requires much less time, in the range of 13-18 days (Roca-Perez *et al*., 2009) [19]. The biodrying reactor pre-treats the waste at the lowest possible residence time to produce high quality solid recovered fuel (SRF), by increasing the energy content (Adani *et al*., 2002) [2]. The biodrying process has a good impact on solid waste management since self-heating and odour reduction takes place simultaneously (Tambone *et al*., 2011) [20].

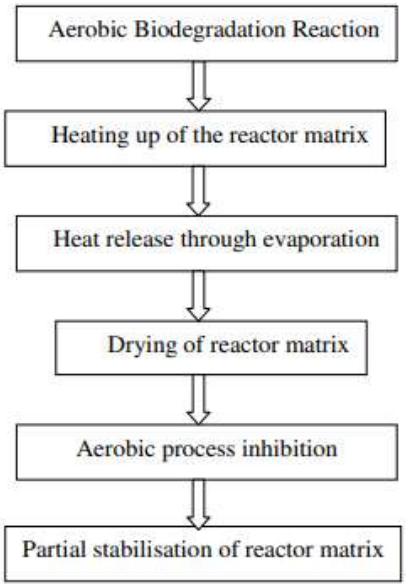

Fig 4: The Process Flow Diagram of Biodrying

7. Reduce, Recycle and Reuse

Alice sharp *et al*. carried out a research which aims to study the current situation of MSW management system in Monagar, an urban town in eastern Bhutan, to identify appropriate integrated solid waste management system for various waste streams that will ultimately lead to a zero-waste city (http://www.ipcbee.com).

The authors recommend two major aspects to minimize the waste generation in the town: one is reduce, raise awareness through educational campaigns, seminars, researches and academic involvement as a method for raising awareness and knowledge in SWM for the people of Monagar district. The second one is to turn organic waste into fertilizers through composting, which ensures the "reuse" of the waste materials; convert the unwanted materials into a useful product and energy.

8. Waste to Energy Conversion

During the combustion of Municipal Solid Waste (MSW), energy is produced which can be used to generate electricity. Chalita Liamsanguan *et al*. studied and compared the conventional waste management system and waste incineration system where waste management as well as electricity production can be achieved. They stated that in case of incineration of waste with energy recovery system, a large portion of the waste has significant energy potential which can be utilized. They emphasized that incineration, of course, cannot play a role in electricity production as a main function, but electricity production from incineration as a benign waste management option provides approximately deNOx and dioxin removal process is added.

9. Public–Private Partnership in MSWM

Nabukeera Madinah (2016) [14] suggested that public–private partnership is an important process for improving and modernizing the urban waste management system. However, to institutionalize the active participation of other private service providers, regulations pertaining to SWM must be formulated with a view of promoting and enhancing partnerships between the city council and other private service providers.

Avani Chopra & Kapoor (2016) [4] emphasized that, in municipal solid waste management, involving private sector will result in an efficient and professional SMW system. The private sector is usually best in providing efficient service and is capable to infuse the latest technology by resorting to collaboration with leaders in the technology, while the public sector is best at doing the jobs of monitoring and enforcement. Therefore, a suitable combination of the private and the public sectors will be necessary to provide an efficient management system.

10. Zero Waste Management

Abhilash Rajendra & Ramu (2014) [1], their research aims to assess the present status of municipal solid waste management and to suggest measures to improve them for Mysore city, India. Author emphasized the importance of MSW management and stated that selection of the system for the collection, transportation, recycling, treatment, and disposal can determine the number of recycling bins needed, the day people must place their garbage at the curb, the truck routes through residential streets, and the cost of waste services to households. It must be ensured that MSW management is environmentally safe and

follows sustainable disposal. Thus, MSW management can be a significant issue for municipalities. The waste collection, transport and transfer methods depend on the specific site, waste generated, distribution road network, work force, vehicles, treatment methods, etc. The issue of waste is not only because of the increasing quantities but also largely because of an inadequate management system.

11. Creation of awareness

Management of waste is an area that requires proper awareness and education for global preservation. Creating awareness is critical for the perseverance of the security of the humankind and global health. Education on waste management involves the introduction of the reverse vending machines to supermarkets and public institutions. The advantage of employing these machines is that they are affordable and hence, cut down cost on waste management.

Rajesh *et al*. (2014) [18] the author stated that with the increase in population there is an exponential increase in the MSW generation, hence it is necessary to reduce either by disposing it or recycling periodically. Conducting awareness programs about waste generation and its effects on human health and sustainability for the people, proper planning in industries may create a healthy environment both for the humans and animals to live.

Conclusion

The technological options for different municipal solid waste treatment methods have been studied in detail. It was observed that waste to energy technologies for municipal solid waste treatment are the need of time to prevent the accumulation of the same in landfills and dumping yards. Mixed municipal solid waste treatment technologies are better for situations where the segregated collection of municipal solid waste at source is lacking. Another advantage of mixed municipal solid waste treatment systems is that high calorific value of components like plastics and textiles which will increase the total energy value of the solid waste. Also the inherent bulking agents like paper, textiles and plastic can be utilised for the bio-drying process with the use of mixed municipal solid waste as substrate. Because waste management is an overall control of the treatment, handling, prevention, monitoring and the reuse of the wastes of a particular area.

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