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A Review: On Solid Waste Management in Smart Cities

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Abstract: *Waste may be defined as any material that cannot be used again and does not represent any economic value to its owner. Solid Wastes are categorized into municipal wastes, hazardous wastes, medical wastes and radioactive wastes. In Indian cities rate of waste generation ranges between 200 - 870 grams/day, this depends upon the region's lifestyle and the size of the city. The per capita waste generation is increasing by about 1.3% per year in India. The per capita rate of waste generation is strongly correlated to the gross domestic product (GDP) of a country. Now using the technology of new era and strategic approach, the concept of smart cities is coming up all around the world. A smart city is incomplete without a smart waste management system. This paper deals with the review of practices made for management of Solid waste in India. An attempt has been made to provide comprehensive review of the characteristics, generation, collection, transportation and disposal, treatment technologies of SWM practiced in India. This paper, focus on different way in which solid waste can be reducedto least possible amount.*

Keyword: *- Municipal waste, Smart city, waste management.*

I. Introduction

Waste management is an essential requirement for ecologically sustainable development. Efficient sorting of waste is a major issue in today's society. The main goals of this discussion are to come up with solutions for the following problems using technology as a tool reducing waste production, ensuring that wastes are properly disposed, recycling and re-using disposed products. "Swachh Bharat Abhiyan" or the "Clean India Mission" is India's biggest cleanliness campaign that aims to fulfill the vision of "Clean India". Waste management is an integral part of this campaign. To assist the "Swachh Bharat Abhiyan" initiative, projects may be setup to create products which are solar-powered trash receptacle and trash compactor that alerts sanitation crews of municipal authorities, when it is full. Solid waste management is one among the basic essential services provided by municipal authorities in the country to keep urban centres clean. However, it is among the most poorly rendered services in the India—the systems applied are unscientific, outdated and inefficient; population coverage is low; and the poor are marginalized. The situation today is not so simple. The problem is due to both quantity and quality of the wastes we are producing. The natural degradation processes are slow and can take care of only a limited amounts and specific kinds of wastes. The obnoxious fumes produced today by the so called civilized society are too much for the atmosphere to get dispersed, especially in urban environment.Rapid industrialization and population explosion in India has led

to the migration of people from villages to cities, which generate thousands of tons of Solid Waste daily. The Solid Waste 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 Solid Waste is going through a critical phase, due to the unavailability of suitable facilities to treat and dispose of the larger amount of Solid Waste generated daily in metropolitan cities. Unscientific disposal causes an adverse impact on all components of the environment and human health.

Solid waste: - Solid waste is the unwanted or useless solid materials generated from combined residential, industrial and commercial activities in a given area. It may be categorized according to its origin (domestic, industrial, commercial, construction or institutional); according to its contents (organic material, glass, metal, plastic paper etc.); or according to hazard potential (toxic, non-toxin, flammable, radioactive, infectious etc.).

What is Solid Waste Management?

Solid waste management is a term that is used to refer to the process of collecting and treating solid wastes. It also offers solutions for recycling items that do not belong to garbage or trash. As long as people have been living in settlements and residential areas, garbage or solid waste has been an issue. Waste management is all about how solid waste can be changed and used as a valuable resource. Solid waste management should be embraced by each and every household including the

business owners across the world. Industrialization has brought a lot of good things and bad things as well. One of the negative effects of industrialization is the creation of solid waste.

II. Effects of Poor Solid Waste Management

Due to improper waste disposal systems particularly by municipal waste management teams, wastes heap up and become a problem. People clean their homes and places of work and litter their surroundings which affects the environment and the community.

This type of dumping of waste materials forces biodegradable materials to rot and decompose under improper, unhygienic and uncontrolled conditions. After a few days of decomposition, a foul smell is produced and it becomes a breeding ground for different types of disease causing insects as well as infectious organisms. On top of that, it also spoils the aesthetic value of the area.

Solid wastes from industries are a source of toxic metals, hazardous wastes, and chemicals. When released to the environment, the solid wastes can cause biological and physicochemical problems to the environment and may affect or alter the productivity of the soils in that particular area.

Toxic materials and chemicals may seep into the soil and pollute the ground water. During the process of collecting solid waste, the hazardous wastes usually mix with ordinary garbage and other flammable wastes making the disposal process even harder and risky.

III. Solid Waste Management in Kota Smart City.

In Kota city, approximately 500 metric tonne of solid waste is generated. Out of which approximately 450 metric tonne of solid waste is carried to trenching ground, which is situated at Anta. According to census of 2011 the total population of the city is 1,101,365; there are 65 wads in the city which are sub-divided in 15 sectors for the purpose of cleanliness. In developed countries per generation of waste is around 1 – 1.5 kg/per person /per day. For example: - America, china etc. 65000 crore rupees, are invested per year for the management of waste in the city by the state Gov. In Kota city electricity generation plant is available which uses solid waste for the generation of electricity, but it is not yet brought to use. It could be the most helpful resource of reusing and managing the solid waste. Government has proposed a solution of constructing road by converting the solid waste in useful material like dumber and tar.

Need of Solid Waste Management

1. In India, a proper waste management system is urgent necessary for the following reasons:
2. To control different types of pollution, i.e., air pollution, soil pollution, water pollution etc.;
3. To stop the spread of infectious diseases.;
4. To conserve all our environmental resources, including forest, minerals water etc.;
5. To recycling of hazardous wastes for further production.
6. To implement proper wastes management policy, successful and safe disposal of solid and liquid wastes are very necessary.

Advantages Waste Management:

1. Keeps the environment clean and fresh:-These waste disposal units also make the people go disease free as all the resultant wastes are properly disposed and taken care of. More number of waste disposal units can be placed in all the tier-1 and tier-2 cities, so that the waste disposal process can be prepped up.

2. Saves the Earth and conserves energy: This characteristic of waste management includes specifically the recycling aspect. As recycling of waste helps in reducing the cutting down of trees. This cutting of trees is mainly done for the production of paper. By using this method, we can use the recycled waste to make quality papers rather than relying on trees. Also, recycling needs only a minimal amount of energy for utilization and complete processing. The resultant product we obtain is a renewable source of energy and is eco-friendly.

3. Reduces environmental pollution, As explained above, waste management if done in a proper manner not only eliminates the surrounding waste, but also will reduce the intensity of the greenhouse gases like methane, carbon monoxide which is emitted from the wastes accumulated. The depth of the existing landfills and incinerations will be curbed, thereby cutting down the harmful factors that affect the environment. Also, the amount of fossil fuels will get reduced in this manner, leading to a cleaner and a greener environment

IV. Various Sources of Solid Waste

Everyday, tonnes of solid waste is disposed off at various landfill sites. This waste comes from homes, offices, industries and various other agricultural related activities. These landfill sites produce foul smell if waste is not stored and treated properly. It can pollute the surrounding air and can seriously affect the health of humans, wildlife and our environment. The following are major sources of solid waste:

1. **Residential**: Residences and homes where people live are some of the major sources of solid waste. Garbage from these places include food wastes, plastics, paper, glass, leather, cardboard, metals, yard wastes, ashes and special wastes like bulky household items like electronics, tires, batteries, old mattresses and used oil.
2. **Industrial:**Industries are known to be one of the biggest contributors of solid waste. They include light and heavy manufacturing industries, construction sites, fabrication plants, canning plants, power and chemical plants.
3. **Commercial**: Commercial facilities and buildings are yet another source of solid waste today. Commercial buildings and facilities in this
4. case refer to hotels, markets, restaurants, go downs, stores and office buildings.
5. **Institutional:**The institutional centers like schools, colleges, prisons, military barracks and other government centers also produce solid waste..

Construction and Demolition Areas
Construction sites and demolition sites also contribute to the solid waste problem. Construction sites include new construction sites for buildings and roads, road repair sites, building renovation sites and building demolition sites.

Municipal services
The urban centers also contribute immensely to the solid waste crisis in most countries today.

Treatment Plants and Sites
Heavy and light manufacturing plants also produce solid waste. They include refineries, power plants, processing plants, mineral extraction plants and chemicals plants. **Agriculture**
Crop farms, orchards, dairies, vineyards and feedlots are also sources of solid wastes. Among the wastes they produce include agricultural wastes, spoiled food, pesticide containers and other hazardous materials.

Biomedical
This refers to hospitals and biomedical equipment and chemical manufacturing firms. In hospitals there are different types of solid wastes produced

V. Methods of Solid Waste Disposal and Management

Methods of solid waste disposal and management are as below:

- Open burning
- Dumping into the sea
- Sanitary Landfills
- Incineration
- Composting
- Ploughing in fields
- Hog feeding
- Grinding and discharging into sewers
- Salvaging
- Fermentation and biological digestion

(a) Open burning of Solid Wastes

Not an ideal method in the present day context

(b) Dumping into Sea

- Possible only in coastal cities
- Refuse shall be taken in barges sufficiently far away from the coast (15-30 km) and dumped there
- Very costly
- Not environment friendly

(c) Sanitary Landfilling of Solid Wastes

- Simple, cheap, and effective
- A deep trench (3 to 5 m) is excavated
- Refuse is laid in layers
- Layers are compacted with some mechanical equipment and covered with earth, leveled, and compacted
- With time, the fill would settle
- Microorganisms act on the organic matter and degrade them
- Decomposition is similar to that in composting
- Facultative bacteria hydrolyze complex organic matter into simpler water soluble organics
- These diffuse through the soil where fungi and other bacteria convert them to carbon dioxide and water under aerobic conditions
- Aerobic methanogenic bacteria utilize the methane generated and the rest diffuses into the atmosphere
- Too much refuse shall not be buried – fire hazard
- Moisture content – not less than 60% for good biodegradation

Refuse depth more than 3m – danger of combustion due to compression of bottom layers – hence should be avoided

- Refuse depth is generally limited to 2m
- Temperature in the initial stages of decomposition – as high as 70 degree C – then drops
- Reclaimed areas may be used for other uses

(d) Engineered Landfills of Solid Wastes

- Bottom of the trench is lined with impervious material to prevent the leachate from contaminating groundwater
- A well designed and laid out leachate collection mechanism is to be provided
- Leachate so collected is treated and then disposed off

Component	% by volume (dry)
Methane	45 to 60
Carbon dioxide	40 to 60
Nitrogen	2 to 5
Oxygen	0.1 to 1
Ammonia	0.1 to 1
Hydrogen	0 to 0.2

Figure1: A Typical Sanitary Landfill for Solid Waste

Figure2: A Typical Sanitary Landfill

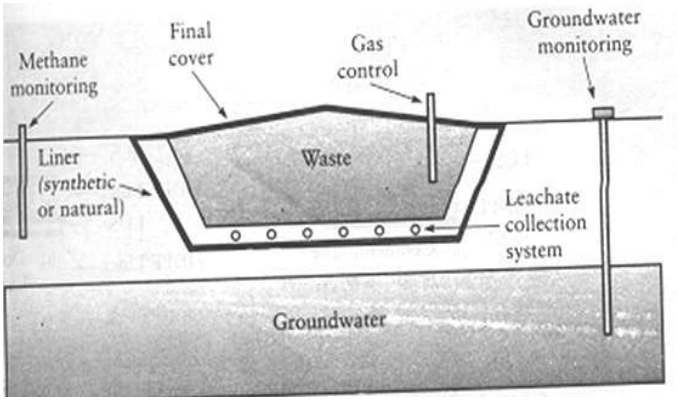


Figure3: Composting

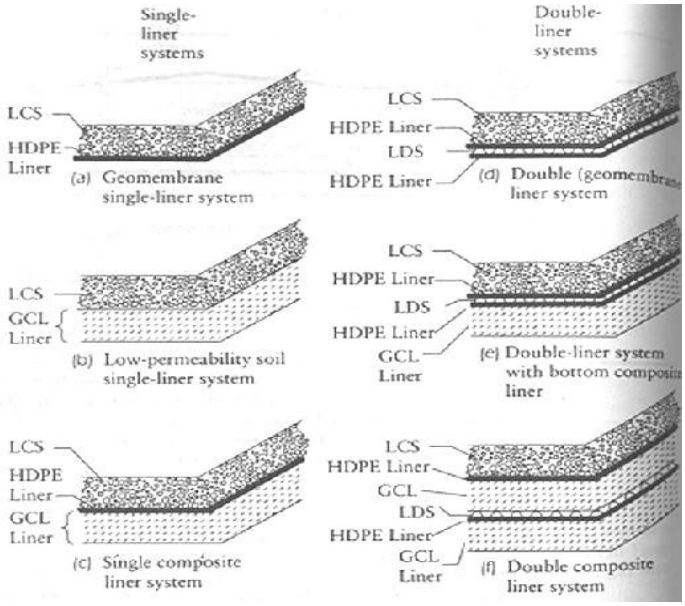


Figure4: Examples of systems in municipal solid waste landfills

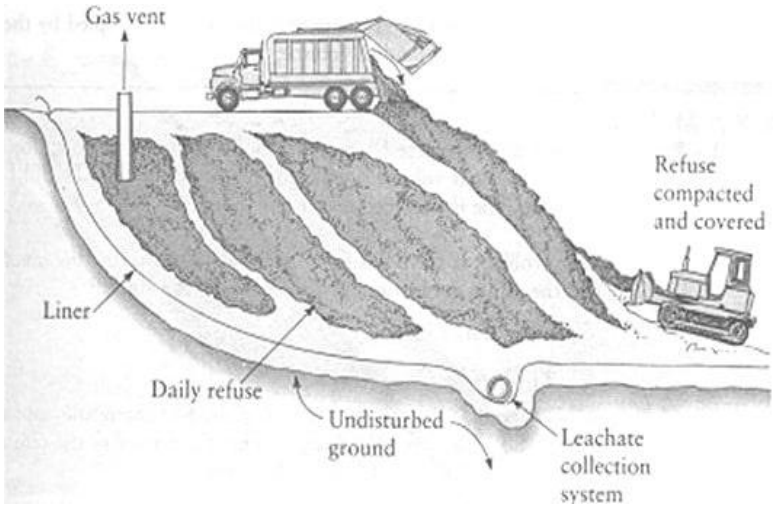
Where LCS = Leachate collection system

GCS = Geosynthetic clay liner

LDS = Leachate detection system

(e) MSW Landfill Gas

Table1: Typical Constituents of municipal solid waste landfill gas



(f) Incineration of Solid Waste

- A method suited for combustible refuse
- Refuse is burnt
- Suited in crowded cities where sites for land filling are not available
- High construction and operation costs
- Sometimes used to reduce the volume of solid wastes for land filling
- Primary chamber – designed to facilitate rapid desiccation of moist refuse and complete combustion of refuse and volatile gases
- A ledge or drying hearth is provided for this purpose
- Secondary chamber – between the primary chamber and the stack – temperatures above 700 degree C
- All non-burnt and semi burnt material are completely burnt here
- Waste to Energy Combustors
- Incinerators – Refuse was burned without recovering energy – exhaust gas is very hot – exceeds the acceptable inlet temperature for electrostatic precipitators used for particulate emission control
- Modern combustors – combine solid waste combustion with energy recovery

Combustors for Solid Waste

- Storage pit – for storing and sorting incoming refuse
- Crane – for charging the combustion box
- Combustion chamber consisting of bottom grates on which combustion occurs

- Grates on which refuse moves
- Heat recovery system of pipes in which water is turned to steam
- Ash handling systems
- Air pollution control systems
- Grates – Provide turbulence so that the MSW can be thoroughly burned, moves the refuse down, provides under fire air to the refuse through openings in it (to assist in combustion as well as to cool the grates)
- Operating temperature of combustors ~ 980 to 1090 degree C

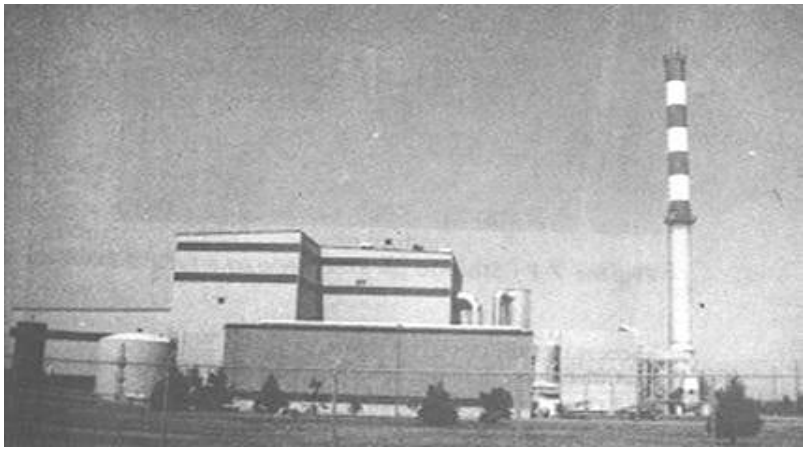


Figure5: A typical MSW Combustor

Grates of MSW Combustor

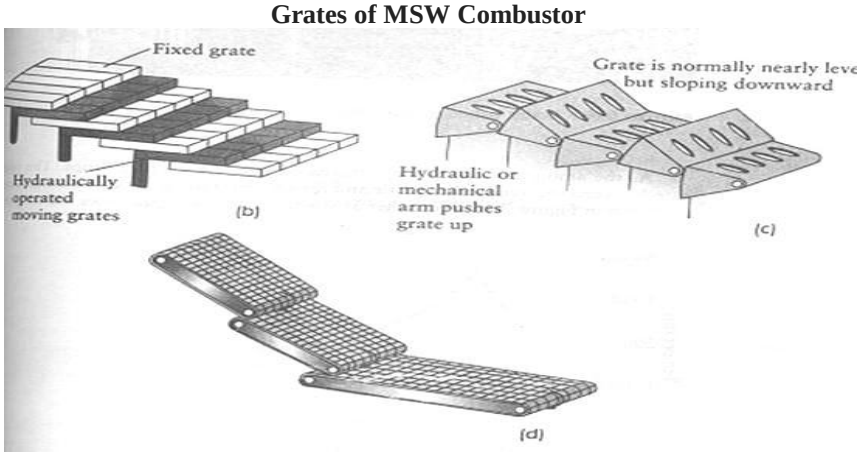


Figure6: Grates of MSW combustor. The under fire air is blown through the holes in the drawings show three types grates. (b) reciprocating (c) rocking (d)travelling

- **Composting**

- Similar to sanitary landfilling
- Yields a stable end product – good soil conditioner and may be used as a base for fertilizers
- Popular in developing countries
- Decomposable organic matter is separated and composted

Methods

1. Open window composting
2. Mechanical composting

Open window composting

- Refuse is placed in piles, about 1.5m high and 2.5m wide at about 60% moisture content
- Heat build up in the refuse piles due to biological activity – temperature rises to about 70 degree C
- Pile is turned up for cooling and aeration to avoid anaerobic conditions
- Moisture content is adjusted to about 60%
- Piled again – temperature rises to about 70 degree C
- The above operations are repeated
- After a few days (~ 7 to 10 weeks) temperature drops to atmospheric temperature – indication of stabilization of compost

Mechanical composting

- Process of stabilization is expedited by mechanical devices of turning the compost
- Compost is stabilized in about 1 to 2 weeks
- To enrich compost – night soil, cow dung etc. are added to the refuse
- Usually done in compost pits
- Arrangements for draining of excess moisture are provided at the base of the pit
- At the bottom of the pit, a layer of ash, ground limestone, or loamy soil is placed – to neutralize acidity in the compost material and providing an alkaline medium for microorganisms
- The pit is filled by alternate layers of refuse (laid in layers of depth 30 – 40 cm) and night soil or cow dung (laid over it in a thin layer)
- Material is turned every 5 days or so
- After ~ 30 days – it is ready for use

Methods used in India

Indore method – aerobic – brick pits 3 x 3 x 1 m – up to 8-12 weeks materials are turned regularly in the pits and then kept on ground for about 4-6 weeks – 6 to 8 turnings in total

Bangalore method – anaerobic – earthen trenches 10 x 1.5 x 1.5 m – left for decomposition – takes 4 to 5 months

- **Vermicomposting**

- Ideal for biodegradable wastes from kitchens, hotels etc.
- At household level, a vessel or tray more than 45 cm deep, and 1 x 0.60m may be sufficient
- A hole shall be provided at one end in the bottom for draining the leachate out into a tray or vessel
- Lay a 1" thick layer of baby metal or gravel at the bottom of the tray
- Above that lay an old gunny bag or a piece of thick cloth, a layer of coconut husk upside down over it and above that a 2" thick layer of dry leaves and dry cow dung (powdered)
- Lay the biodegradable waste over it
- Introduce good quality earthworms into it (~ 10 g for 0.6 x 0.45 x 0.45 m box)
- If the waste is dry, sprinkle water over it daily
- Rainwater should not fall into the tray or vessel or box
- Keep it closed
- If the box is kept under bright sun earthworms will go down and compost can be taken from the top

- Compost can be dried and stored
- Continue putting waste into the box
- Add little cow dung at intervals
- Do not use vermiwash directly. Dilute in the ratio 1:10 before use

Disposal by Ploughing into fields

- Not very commonly used
- Not environment friendly in general

Disposal by hog feeding

- Not common in India
- Refuse is ground well in grinders and then fed into sewers
- Disposal of garbage into sewers – BOD and TSS increases by 20-30%
- Disposal of residual refuse – still a problem

Salvaging

- Materials like paper, metal, glass, rags, certain types of plastic etc. can be salvaged, recycled, and reused

Fermentation or Biological Digestion

- Biodegradable Waste – convert to compost
- Recycle whatever is possible
- Hazardous wastes – dispose it by suitable methods
- Landfill or incinerate the rest

Solar trash compactor:- solar powered, rubbish-compacting bin, manufactured by U.S. company BigBelly Solar for use in public spaces such as parks, beaches, amusement parks, and universities. The bin has a capacity of 567 litres. Its compaction mechanism exerts 5.3KN of force, increasing the bin's effective capacity by five. The compaction mechanism is chain-driven, using no hydraulic fluids. Maintenance consists of lubricating the front door lock annually. The mechanism runs on a standard 12 volt battery, which is kept charged by the solar panel. The battery reserve lasts for approximately three weeks. Wireless technology-enabled units report their status into the CLEAN (Collection, Logistics, Efficiency and Notification system) dashboard that gives waste management and administration insights for monitoring and route optimization. BigBelly Solar also provides companion recycling units that allow cities, parks and universities to collect single-stream or separated recyclable materials in public spaces.

V. Conclusion

This paper reviews on management of solid waste in smart cities. The concept of smart city and the need of solid waste management in the smart cities are well explained. The different ways in which the demand of solid waste management is fulfilled are summarized with practical examples being used in our country. This paper reviews on the different plans of government, which are focused on the smart management of solid waste in smart cities. Solar trash compactor is another way of minimizing the solid waste.

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