A REVIEW - SOLID WASTE MANAGEMENT IN INDIA (DIFFERENT CITIES)

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Abstract

Solid waste management is a major environmental issue in India. Due to rapid increase urbanization and industrialization and population, the generation rate of solid waste in Indian cities and towns is also increased. Improper management of solid waste causes hazards to inhabitants. . Various studies reveal that about 90% of solid waste is disposed of unscientifically in open dumps and landfills, creating problems to public health and the environment. In the present study, an attempt has been made to provide a comprehensive review of the characteristics, generation, collection and transportation, disposal and treatment technologies of solid waste practiced in India. The study pertaining to solid waste management (SWM) for Indian cities has been carried out to evaluate the current status and identify the major problems. Total Solid waste generated in Tons/day would be proportionate to the population of specific city in that specific/mentioned year. Population growth and solid waste generation in India has varying trend and correlation between population and solid waste generation of specificity is not necessary to be applicable. Population increased from 8.2 to 12.3 million in Mumbai during the period of Ten years (1981-97) at the rate of 49%. Similarly the population growth has been found to rise exponentially in other Indian cities; however, the growth rate may be varying. Trend of urbanization played significant role in enhancement of solid waste generation and in India it was 27.8% in 2001 and expected to reach 41% by 2021. In certain Indian cities, Solid waste generation has been found in 1995 was 0.64 kg in Kanpur, 0.52 kg in Lucknow, 0.4 kg in Varanasi, 0.59 kg in Ahmadabad and 0.44 kg in Mumbai. Currently total solid waste generated in India is around 42 million tons annually. Waste generation varies from 200-600 kg/capita/day and collection efficiency ranges from 50-90%.

Keywords

Solid waste, population growth, landfilling, incineration, 4RS, solid waste management.

Introduction

Human activities create waste, and the ways that waste is handled, stored, collected, and disposed of can pose risks to the environment and to public health. Solid waste management (SWM) includes all activities that seek to minimize health, environmental, and aesthetic impacts of solid waste. Solid waste can be defined as non-liquid material that no longer has any value to the person who is responsible for it. The name rubbish, garbage, debris, or refuse are often used as synonyms when talking about solid waste.[1] Solid waste may be defined as generation of disagreeable substances which is left after they are used once. They cannot be reused directly by the society for its welfare because some of them may be hazardous for human health. By the end of nineteenth century, Industrial development has shown a progressive trend in the world consumers. Presently not only the air but also earth itself becomes more and more polluted specially with generation of non-biodegradable substances (solid waste). Rapid industrialization and population explosion in India has led to the migration of people from villages to cities, which generate thousands of tons of 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 (Sharma and Shah, 2005; CPCB, 2004; Shekdar et al., 1992).[2] Generation of solid waste is a natural phenomenon up to certain extent as all living organism are excreting solid waste after digestion of food material. The amount of solid waste generation is directly proportion to population. Less population means fewer excreta while large population growth will enhance excreta in natural condition. Since the last five decades due to urbanization, industrialization and change in the habits as well attitude to life has resulted uncontrolled exploitation of different kinds of natural resources and finally generation of large amount of solid waste having more complexity, some of them can not be degraded by micro-organisms and need genetically engineered microbial population for them. Besides this some of them may cause injurious health effect on human beings. Since the nature of solid waste generated from different resources has significant variation in the components therefore it is much obvious that their toxicity/hazards ability will be of different level. Industrial and hospital waste generate powerful hazardous toxic substances [3]. The solid waste amount is expected to increase significantly in the near future as the country strives to attain an industrializes nation status by the year 2020 (Sharma & Shah, 2005; CPCB, 2004). Total number of units engaged in hazardous waste generation in India are 12584 which are located in different states and some important can be mentioned as in Maharashtra 3953, Gujarat 2984, Tamilnadu 1100 and Uttar Pradesh 1020. Developing countries are still in the transition towards better waste management but they currently have insufficient collection and improper disposal of wastes Generally, Solid waste is disposed off in low-lying areas without taking any precautions or operational controls [4]. There- fore, Solid waste management is one of the major environmental problems of Indian megacities (Sharholy et al., 2008). [5] Clear government policies and competent bureaucracies for management of solid wastes are needed urgently especially in countries where there is rapid population growth through urbanization into semi urban areas. Total quantity of solid waste generated in urban areas of the country is about 1.15 lakh tones per day. Out of these 19643 tones of waste is generated in metro cities per day. The survey conducted by CPCB puts total municipal waste generation from Class I and Class II cities to around 18 million tones in 1997 (CPCB, 2000a). [6] The solid waste generated in Indian cities has increased from 6 million tonnes in 1947 to 48 million tons in 1997 and is expected to increase to 300 million's per annum by 2047 (CPCB, 2000a). More than 25% of the municipal solid waste is not collected at all, 70% of the Indian cities lack adequate capacity to transport it and there are no sanitary landfills to dispose of the waste. The existing landfills are neither well equipped nor well managed. Also, they are failed to protect against contamination of soil and groundwater [7].

Result

Solid Waste Management is the need of the hour which should be seriously taken care of by government/civic bodies to provide SWM service properly to the public. Public apathy and low social status assigned to SWM activity by civic bodies is a great hurdle in solving this problem. Stringent laws should be passed in this regard for proper disposal and treatment of waste. 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 household level. There is an adequate legal framework existing in the country to address SWM. Legislation in place, open dumping is the most wide spread form of waste disposal. The possible reasons for poor implementation could be a combination of social, technical, institutional and financial issues. Public awareness, political will and public participation as essential for the successful implementation of the legal provisions and to have an integrated approach towards sustainable management of municipal solid wastes in the country. [41]

I. Generation of Solid Waste

The waste generation rate generally increases with increase in GDP. High income countries generate more waste per person compared to low income countries due to reasons discussed in further sections. The average per capita waste generation in India is 370 grams/day as compared to 2,200 grams in Denmark, 2,000 grams in US and 700 grams in China (12) (13) (14).[8] Waste generation rate in Indian cities ranges between 200 - 870 grams/day, depending 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 (7). [9]

Table: 1

Highest and Lowest Waste Generation and Waste Generation Rates Among Metros, Class 1 cities, States, UTs, and North, East, West, South regions of India

		Waste Generation (TDP)		Per Capit Generation	((kg/day)
		Low	High	Low	High
Metros	Value	3,344	11,520	0.445	0.708
	City	Greater Bengaluru	Greater Kolkata	Greater Bengaluru	Chennai
Class 1 cities	Value	317	2,602	0.217	0.765
	City	Rajkot	Pune	Nashik	Kochi
All cities	Value	5	11,520	0.194	0.867
	City	Kavarati	Kolkata	Kohima	Port Blair
States	Value	19	23,647	0.217	0.616
	State	Arunanchal Pradesh	Maharashtra	Manipur	Goa
Union territorie	Value	5	11,558	0.342	0.867
	UT	Lakshadweep	Delhi	Lakshadweep	Andaman Nikobar
Regions	Value	696	88,800	0.382	0.531
	Region	East	West	East	West

(Source: Sustainable Solid Waste Management in India by anjith Kharvel Annepu January 10, 2012)

Cities in Western India were found to be generating the least amount of waste per person, only 440 grams/day, followed by East India (500 g/day), North India (520 g/day), and South India. [10]

Southern Indian cities generate 560 grams/day, the maximum waste generation per person. States with minimum and maximum per capita waste generation rates are Manipur (220 grams/day) and Goa (620 grams/day). Manipur is an Eastern state and Goa is Western and both are comparatively small states. Among bigger states, each person in Gujarat generates 395 g/day; followed by Orissa (400 g/day) and Madhya Pradesh (400 grams/day).[11] Among states generating large amounts of MSW per person are Tamil Nadu (630 g/day), Jammu & Kashmir (600 g/day) and Andhra Pradesh (570 g/day). Among Union Territories, Andaman and Nicobar Islands generate the highest (870 grams/day) per capita, while Lakshadweep Islands (340 grams/day) generates the least per capita. [12] Per capita waste generation in Delhi, the biggest Union Territory is 650 g/day. India's urban population and provide a fair estimation of the average per capita waste generation in Urban India (0.5 kg/day).

II. Population Growth

Indian population increased by more than 181 million during 2001 – 2011, a 17.64% increase in population, since 2001. Even though this was the sharpest decline in population growth rate registered post-Independence the absolute addition during 2001-2011 is almost as much as the population of Brazil, the fifth most populous country in the world. [13]

Table: 2

Population Growth and Impact an Overall Urban Waste Generation and Future prediction until 2041

Year	Population (millions)	Per capital	Total Waste generatio thousand tons /year
2001	197.3	0.439	31.63
2011	260.1	0.4980.	47.30
2021	342.8	0.569	71.15
2031	451.8	0.649	101.01
2036	518.6	0.693	131.24
2041	595.4	0.741	190.69

(Source: Sustainable Solid Waste Management in India by anjith Kharvel Annepu January 10, 2012)

Population growth and rapid urbanization means bigger and denser cities and increased MSW generation in each city. The data compiled for this report indicate that 366 cities in India were generating 31.6 million tons of waste in 2001 and are currently generating 47.3 million tons, a 50% increase in one decade. [14] It is estimated that these 366 cities will generate 161 million tons of MSW in 2041, a five-fold increase in four decades. At this rate the total urban MSW generated in 2041 would be 230 million TPY (630,000 TPD). MSW Rules 2000 mandate "landfills should always be located away from habitation clusters and other places of social, economic or environmental importance, which implies lands outside the city. Therefore, increase in MSW will have significant impacts in terms of land required for disposing the waste as it gets more difficult to site landfills (7).[15] Farther the landfill gets from the point of waste generation (city), greater will be the waste transportation cost. The solution to reducing these costs and alternatives to land filling are discussed in detail in further sections [16].

III. Collection and Storage of Solid Waste

To prohibit littering and to facilitate compliance, municipal authorities must take the following steps:

• Organize collection of MSW at household level by using methods such as door-to-door, house-to-house, or community bin service. Collection must be on a regular preinformed schedule or by acoustic announcement (without exceeding permissible noise levels). [17]

• Give special consideration to devising waste collection in slums and squatter areas, as well as to commercial areas such as areas with hotels, restaurants, and office complexes.

• Segregate at the source all recyclable waste, as well as biomedical waste and industrial waste, to prevent special waste from being mixed with ordinary municipal solid waste. [17]

• Collect separately all horticultural waste and construction or demolition waste or debris, and dispose of it following proper norms. Similarly, waste generated at dairies will be regulated in accordance with the state laws. [17]

• Prohibit burning of waste.

• Do not permit stray animals at waste storage facilities.

IV. Secondary Storage of solid waste

With respect to secondary storage of waste, municipal authorities must do the following:

• Make available sufficient storage facilities in accordance to the quantities of waste generated.

• Provide covered storage facility so that waste is not exposed to open atmosphere.

• Ensure that storage facilities are attended daily and are emptied and cleaned regularly.

• Ensure that storage facilities or bins are of an appropriate design for ease in handling, transfer, and transport.

• Ensure that manual handling and multiple handling of waste are avoided or are done with proper safety and care. [18]

V. Different Types of Solid waste in Indian context

a) Construction and Demolition Waste

Construction and demolition waste that is generated during the course of repair, maintenance, and construction activities comprises bricks, stones, tiles, cement concrete, wood, and so forth. Such waste is generally not stored by the waste generator within its premises until disposal. [19] By and large, this waste is deposited just outside the premises on the streets or in open spaces and may hinder traffic and adversely affect the aesthetics of the city. [20]

b) Industrial Waste

Many cities and towns have small and large industries within the city limits. Those industries produce hazardous and nonhazardous industrial waste, which the industries must dispose of following the standards laid down under hazardous waste management rules framed by the government of India and following directions given by CPCB and by state pollution control boards[21]. In practice, however, very few sites are authorized for the disposal of industrial waste in the country; hence, compliance is weak. Some states do not have even a single facility for disposal of industrial waste. Industrial solid waste is, therefore, disposed of in an unscientific manner, often surreptitiously on open plots or on the roadside, thereby creating environmental pollution and subsoil contamination. [22] Direct exposure to chemicals in hazardous waste such as mercury and cyanide can be fatal. India generates around 7 million tons of haze- roués wastes every year. States such as Gujarat, Maharashtra, Tamil Nadu and Andhra Pradesh, which are relatively more industrialized face problems of toxic and hazardous waste disposal far more acutely than less developed states.[23] The major hazardous waste generating industries in India include petrochemicals, pharmaceuticals, pesticides, paint and dye, petroleum, fertilizers, asbestos, caustic soda, inorganic chemicals and general engineering industries. As per the information provided by the Ministry of Environment and Forest (MoEF), there are 323 hazardous waste recycling units in India and of these 303 recycling units use indigenous raw material while 20 depend on imported recyclable wastes. [24]

c) Biomedical Waste

Biomedical waste (BMW) is governed by the Bio-Medical Waste (Management and Handling) Rules 1998. Under the rules, the waste producer is responsible for managing the waste. The implementation of the 1998 rules has of late started to improve, with the establishment of common regional BMW treatment and disposal facilities in the country. [25] However, in some states a large proportion of

BMW generated by hospitals, nursing homes, and health care establishments is now disposed of on the streets or in open spaces around those medical establishments. Such BMW contains a variety of infectious and toxic substances. Without adequate facilities for the collection, transport, and disposal of BMW, this unhealthy practice is likely to continue. [26] Hospital waste includes pathological, anatomical, infectious and hazardous wastes, which are produced from health care facilities and medical labs. It is generated during the diagnosis, treatment or immunization of human beings or animals and in research activities in these fields. It may include wastes like anatomical waste, cultures, discarded medicines, chemical wastes, disposable syringes, glucose bottles, cotton swabs, bandages, body fluids, human excreta etc.[27] The quantum of waste that is generated in India is estimated to be 1-2 kg per bed per day in a hospital and 600 gm per day per bed in a general practioner clinic. E.g. a 100-bedded hospital will generate 100-200 kg of hospital waste per day. It is estimated that only 5-10% of this comprises of hazardous or infectious waste (5-10 kg/day). It has been roughly estimated that out of the 4 kg of waste generated in a hospital at least 1 kg would be infected.

d) Domestic waste or Household waste or Municipal waste

The Municipal Solid wastes (Management and Handling) Rules 2000, prescribed under the Environment Protection Act 1986 by the Government of India define municipal waste as "commercial and residential wastes gene- rated in a municipal solid waste The characteristics of municipal solid waste collected from any area depend on a number of factors such as food habits, cultural traditions of inhabitants, life styles, climate etc.[28] Total quantity of solid waste generated in urban areas of the country is about 1.15 lakh tones per day. Out of these 19643 tons of waste is generated in metro cities per day. The survey conducted by CPCB puts total municipal waste generation from Class I and Class II cities to around 18 million tons in 1997 (CPCB, 2000a). [29] The solid waste generated in Indian cities has increased from 6 million tons in 1947 to 48 million tons in 1997 and is expected to increase to 300 million tons per annum by 2047 (CPCB, 2000a). More than 25% of the municipal solid waste is not collected at all, 70% of the Indian cities lack adequate capacity to transport it and there are no sanitary landfills to dispose of the waste. [30]

e) Agricultural waste

Agricultural waste is composed of organic wastes (animal excreta in the form of slurries and farmyard manures, spent mushroom compost, soiled water and silage effluent) and waste such as plastic, scrap machinery, fencing, pesticides, waste oils and veterinary medicines.[30] There are a number of potential environmental impacts associated with agricultural waste if it is not properly managed, run-off of nutrients to surface waters which can cause over enrichment of the water body.[30] Leaking and improper storage of agricultural waste can also pose serious threat surface waters. In addition, farming activities can give rise to emissions of ammonia and methane, which can cause acidification and contribute to greenhouse gases emissions.

f) Radioactive waste

These mainly arise from nuclear power plants, nuclear testing labs, industrial establishment etc. According to the World watch Institute, there are more than 80,000 tons of irradiated fuel and hundreds of thousands of tons of other radioactive waste accumulated so far from the commercial generation of electricity from nuclear power. Irradiated fuel can take hundreds of thousands of years to decay into a harmless substance. Until then, it is extremely dangerous and must be kept far away from possible human contact. [31]

g) Sewage waste

The solid by-products of sewage treatment are classified as sewage wastes. They are mostly organic and derived from the treatment of organic sludge separated from both raw and treated sewages. The inorganic fraction of raw sewage such as grit and eggshells is separated at the preliminary stage of treatment, as it may entrain putrescible organic matter with pathogens and must be buried without delay. The bulk of treated, dewatered sludge is useful as a soil conditioner but is invariably uneconomical. [32] Solid sludge, therefore, enters the stream of municipal wastes, unless special arrangements are made for its disposal.

VI. Human health impacts

Due to the absence of standards and norms for handling municipal wastes, municipal workers suffer occupational health hazards of waste handling [27]. At the dumpsites in the city of Mumbai, for example, 95 workers were examined and it was found that about 80% of them had eye problems, 73% respiratory ailments, 51% gastrointestinal ailments and 27% skin lesions. Also, municipal workers and rag pickers who operate informally for long hours rummaging through waste also suffer from similar occupational health diseases ranging from respiratory illnesses (from ingesting particulates and bio-aerosols), infections (direct contact with contaminated material), puncture wounds (leading to tetanus, hepatitis and HIV infection) to headaches and nausea, etc. Studies among the 180 rag pickers at open dumps of Kolkata city reveal that average quarterly incidence of diarrhea was 85%, fever 72% and cough and cold 63%.[27]

VII. Environmental impacts

In addition to occupational health, injury issues and environmental health also need to be mentioned in the context of waste management. Contaminated leach ate and surface run-off from land disposal facilities affects ground and surface water quality. Volatile organic compounds and dioxins in air-emissions are attributed to increasing cancer incidence and psychological stress for those living near incinerators or land disposal facilities.[28] Drain clogging due to uncollected wastes leading to stagnant waters and subsequent mosquito vector breeding is a few of the environmental health issues, which affect the waste workers as well as the public. The pneumonic plague that broke out in November 1994 in India Surat, Gujarat) is a typical example of solid waste mismanagement.

VIII. How to dispose of solid waste

Remaining final solid waste is disposed in landfills after necessary treatment environmental impacts. The objective of treatment is to improve physical lessen the adverse and/or chemical characteristics of waste, reduce toxicity and reduce its final volume (Misra et al., 2005). [17] In India, different treatment methods are practiced depending on the type of waste. They are characterized by their capacity to treat specific type of waste, residues generation, cost, risk associated, safety and other environmental aspects (Blackman, 1996). The various treatment methods practiced for MSW and other similar type of waste are: Composting, landfills, Thermal processes (incineration, pyrolysis) etc. However, the same is not effective for hazardous industrial waste. There must be separate consideration to handle hazardous World Scientific News 66 (2017) 56-74-67- waste. Common methods which are adopted for hazardous waste are chemical fixation, volume reduction, detoxification, degradation, encapsulation etc. (Dawson and Mercer, 1986).

a) Incineration

In Incineration combustible waste is burned at temperatures high enough (900-1000 0C) to consume all combustible material, leaving only ash and noncombustible to dispose off in a landfill. Under ideal conditions, incineration may reduce the volume of waste by 75% to 95% (Schneider, 1970). Incineration may be used as a disposal option, only when land filling is not possible and the waste composition is of high combustible (i.e. self-sustaining combustible matter which saves the energy needed to maintain the combustion) paper or plastics.[24] It requires an appropriate technology, infrastructure, and skilled manpower to operate and maintain the plant. In Indian cities, Incineration is generally limited to hospital and other biological wastes. This may be due to the high organic material (40-60%), high moisture contact (40-60%) and low calorific value content (800-1100Kcal/Kg) in solid waste (Kansal, 2002; Joardar, 2000; Bhide & Shekdar, 1998). Incineration of urban waste is not a clean process. It may produce air pollution and toxic ash. For example, incineration in the United States apparently is a significant source of environmental dioxin, a carcinogenetic toxin and a controversy over incineration has resulted (Thomas & Spiro, 1996). Smokestacks from incinerators may emit oxides of nitrogen and sulfur that lead to acid rain; heavy metals such as lead, cadmium, and mercury; and carbon dioxide that is related to global warming. In modern incineration facilities, smokestacks are fitted with special devices to trap pollutants, but the process of pollutant abatement is expensive (Botkin & Keller, 2000).

b) 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. Gasification can also be used for MSW treatment after drying, removing the inerts and shredding for size reduction. [28] Two different designs of gasifiers exist in India. The first one (NERIFIER gasification unit) is installed at Nohar, Hanungarh, Rajasthan by Narvreet Energy Research and Information (NERI) for the burning of agro-wastes, sawmill dust, and forest wastes. The waste-feeding rate is about 50–150 kg/h and its efficiency about 70–80%. About 25% of the fuel gas produced may be recycled back into the system to support the gasification process, and the remaining is recovered and used for power generation. The second unit is the TERI gasification unit installed at Gaul Pahari campus, New Delhi by Tata Energy Research Institute (TERI) (CPCB, 2004; Ahsan, 1999).

c) Composting

Composting is a biological process of decomposition and stabilization of organic matter of solid waste by microbes either in presence or absence of oxygen. Depending on availability of oxygen, it is further classified as aerobic composting and anaerobic composting also known as biomethanation. It can also be classified as open or window, mechanical or closed etc. depending upon operating condition and design of plant.[28] In India, large amount of waste is treated by this method for which efficiency largely depends on temperature (Rajvaidya and Markandey, 2008).

d) Vermicomposting

Vermicomposting involves stabilization of organic waste through the joint action of earthworms and aerobic microorganisms. Initially, microbial decomposition of biodegradable organic matter occurs through extra cellular enzymatic activity (primary decomposition). Earthworms feed on partially decomposed matter, consuming five times their body weight of organic matter per day. The ingested food is further decomposed in the gut of the worms, resulting in particle size reduction. The worm cast is a fine, odorless and granular product. [33] This product can serve as a biofertilizer in agriculture. Vermicomposting has been used in Hyderabad, Bangalore, Mumbai and Faridabad. Experiments on developing household vermicomposting kits have also been conducted. However, the area required is larger, when compared to dry composting (Ghosh, 2004; Bezboruah and Bhargava, 2003; Jha et al., 2003; Sannigrahi and Chakrabortty, 2002; Gupta et al., 1998; Reddy and Galab, 1998; Jalan, 1997; Khan, 1994).

e) Aerobic Digestion (biomethanation)

The aerobic composting means bacterial conversion of organics in presence of air. It yields compost as final product which is extensively used as fertilizer. Final product is free from odour and pathogens (Ahsan, 1999; Khan, 1994). It can reduce waste volume to 50-85%. Mechanical controlled plants are being installed in metropolitan cities, while manually control plants are set in relatively smaller urban township (Bhide and Shekdar, 1998; Chakrabarty et al., 1995). During 1975- 1980, large scale composting plants were installed in cities like Bangalore, Baroda, Mumbai, Calcutta, Delhi, Jaipur, Kanpur and Indore having capacity of 150 to 300 tonne/day. But due to poor performance and no usefulness in soil enrichment, plants were shut down. After that the first large scale plant was set up in Mumbai in 1992 with 500 t/day capacity of MSW followed by Vijayawada, Delhi, Bangalore, Ahmadabad, Hyderabad, Bhopal, Luknow and Gwalior. (Sharholy et al., 2008; Rao and Shantaram, 1993; Dayal, 1994; Kansal et al. 1998; Reddyand Galab, 1998; Gupta et al., 1998; Malviya et al., 2002; Kansal, 2002; Srivastava et al., 2005; Sharholy et al., 2006; Gupta et al., 2007).

f) Sanitary landfill

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 (Turk, 1970).[33] Sanitary Land filling is a necessary component of solid waste management, since all other options produce some residue that must be disposed of through land filling. However, it appears that land filling 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 land filling (Kansal, 2002; Das et. al., 1998).[33]

Area Occupied Known Landfills in India; Source CPCB

The Position Paper on The Solid Waste Management Sector in India, published by Ministry of Finance in 2009, estimates a requirement of more than 1400 sq.km of land for solid waste disposal by the end of if MSW is not properly handled.[35] This area is equal to the area of Hyderabad, Mumbai and Chennai together. 17 cities out of 59 surveyed by Central Pollution Control Board, CPCB have proposed new sites for landfills (Appendix 9). 24 cities (23.4 million TPY) use 34 landfills for dumping their waste, covering an area of 1,900 hectares. [36]

Name of city	No. of landfill sites	Area of landfill (ha)
Coimbatore	2	465.5
Surat	2	292
Greater Mumbai	1	200
Greater Hyderabad	3	140

Ahmadabad	1	121.5
Delhi	3	66.4
Indore	1	59.5
Madurai	1	48.6
Greater Bengluru	2	40.7
Greater Visakhapattanam	1	40.5
Ludhiana	1	40.4
Nashik	1	34.4
Jaipur	3	31.4
Srinagar	1	30.4
Kanpur	1	27
Kolkata	1	24.7
Chandigarh	1	18
Ranchi	1	15
Raipur	1	14.6
Meerut	2	14.2
Guwahati	1	13.2
Thiruvanthapuram	1	12.15
Total		1894.85

(Source: Sustainable Solid Waste Management in India by anjith Kharvel Annepu January 10, 2012)[35]

The concept of regional landfills used in western countries is very relevant to India to overcome the challenges of siting new landfills, lack of financial and human resources in every ULB. The state of Gujarat has identified many regional landfills. [37] The first attempt at developing a regional facility in India was by Ahmadabad Urban Development Authority (AUDA), in 2007, to address the SWM requirements of 11 towns in its (then) jurisdiction. Located at the village Fatehwadi, the facility integrated composting facilities for approximately 150 TPD (9). [38]

IX. Policy of 4Rs

Waste is reduced, reused, or recycled in order to minimize the amount that ends up in landfillsThe still high fraction of organic waste in India suggests the need to develop strategies for recycling organic waste. Organic waste that can be segregated easily at the household level for further treatment can signifi cantly reduce the amount of waste that must be disposed of. It also increases the value of that waste by facilitating the recycling of other materials in the waste stream. Waste must be regarded as a potential resource, so it is essential to make the best use of this material. Through minimization, recovery, and recycling, society not only saves scarce resources but also protects the environment and alleviates the burden on the public authorities that are responsible for managing waste. [39]

Waste Prevention, Reduction, or Minimization

Ideally, waste should be avoided. Waste that can be avoided stops being a burden for the municipality. Waste prevention is most effective if it is considered in the product design and production processes. By optimizing production processes, manufacturers can reduce waste oreven allow it to be reused by another manufacturer. Valuable natural resources can therefore be saved.

a) Refuse

Instead of buying new containers from the market, use the ones that are in the house. Refuse to buy new items though you may think they are prettier than the ones you already have.

b) Reuse

Reuse happens when something that already fulfilled its original function is used for another purpose. However, reuse does not involve reprocessing or transforming the item. [36] For example, typical reuse strategies are the deposit refund system for glass bottles or polyethylene terephthalate (PET) water bottles, old tires that are used in fences or as boat fenders, steel drums that are reused as compost bins, or plastic bags that are reused as liners for household waste bins.[39]

c) Recycling

Recycling means the reprocessing of used materials that would otherwise become waste. It breaks material down to its main component and produces new products. Recycling is most common for valuable materials or materials that are costlier if produced from virgin raw materials (such as metal, plastic, glass, and electronic waste. [40] Recycling of organic matter produces compost, which can be used as a soil.

d) Recovery

Recovery relates mainly to energy recovered from waste. Waste that cannot be reused or recycled can be, for example, incinerated to generate heat or electricity. Another option for organic waste is anaerobic digestion to produce biogas. [40] The appropriateness of such recovery strategies depends on the composition and calorific value of the waste.

e) Reduce

Reduce the generation of unnecessary waste, e.g. carry your own shopping bag when you go to the market and put all your purchases directly into it.

X. Conclusion

India is a developing country whose economy is currently growing at an extremely rapid annual growth rate of 9 to 10%. A growing economy and population imply that resource consumption and waste generation will follow similar or higher rates of growth. For a country that has paid little attention to the issue of SWM, it becomes imperative to recognize the extent of the problems and its growing magnitude. This informal policy of encouraging to separate MSW and market it directly to the informal network appears to be a better option. The involvement of public and private sectors through NGOs could improve the efficiency of solid waste management. A new survey should be carried out on the generation and characterization of solid waste in India. The study concluded that such as financing, infrastructure, suitable planning in SWM. The increase if service demands combined with the lack of resources for municipalities are putting a huge strain on the exiting solid waste management system.

XI. References

1) Kansal, Lecturor, School of Environmental Managenont GGS lndraorastSl Unive!sity, Arun Kashmere Gate, Delhi ' 1'1 0 006

2) Agarwal, A., Singhmar, A., Kulshrestha, M., Mittal, A.K., 2005. Municipal solid waste recycling associated markets in Delhi, India. Journal of Resources, Conservation and Recycling 44 (1), 73– 90.

3) Ahsan, N. (1999) Solid waste management plan for Indian megacities. Indian Journal of Environmental Protection. 19(2), 90-95.

4) Akolkar, A. B. 2005. Status of Solid Waste Management in India: Implementation Status of Municipal Solid Wastes, Management, and Handling Rules 2000. New Delhi: Central Pollution Control Board.

5) *Arena, U., Massillon, M. L., Camino, G. & Boccaleri, E. 2006. An innovative process for mass production of multi-wall carbon nanotubes by means of low-cost pyrolysis of polyolefins. Polymer Degradation and Stability, 91, 763-768.*

6) *Arena, U., Mastellone, M. L., Camino, G. & Boccaleri, E. 2006. An innovative process for mass production of multi-wall carbon nanotubes by means of low-cost pyrolysis ofpolyolefins. Polymer Degradation and Stability, 91, 763-768*

7) *Asnani, P. U. 2004a. "Status of Compliance of Municipal Solid Waste (Management and Handling Rules 2000 in 127 Class 1 Cities in India as on 1-4-04." Paper presented at the National Training Programmed on Design, Construction, and Operation of Sanitary Landless, jointly organized by the Government of India, the Central Pollution Control Board, the United States–Asia Environmental*

8) *Assessment of the Status of Municipal Solid Waste Management in Metro Cities, State Capitals, Class I Cities and Class II Towns in India: An Insight. Sunil Kumar, J.K. Bhattacharya, A.N. Vaidya, Tapan Chakrabarti, Sukumar Devotta, A.B. Akolkar. Kolkatta: Central Pollution Control Board (CPCB), National Environmental Engineering Research Institute (NEERI), 2008.*

9) *Bhide, A.D., Shekdar, A.V., 1998. Solid waste management in Indian urban centers. International Solid Waste Association Times (ISWA) (1), 26–28.*

10) *Botkin, D.B. and Keller, E.A. (2000) Environmental Science-Earth as a living planet. IIIEd John Wiley & Sons. New York. pp. 572-593.*

11) *Central Pollution Control Board (CPCB) (2004) Management of municipal solid waste. Ministry of Environment and Forests (MoEF), New Delhi, India.*

12) *Central Pollution Control Board (CPCB) (2012) Status report on municipal solid waste management. Ministry of Environment and Forest (MoEF), New Delhi, India Central Public Health and Environmental Engineering Organization (CPHEEO) (2000) Manual on municipal solid waste management. Ministry of Urban Development, Govt. of India, New Delhi*

13) *Composting Facility Personnel in Bengaluru, Pimpri, and Nashik. Bengaluru, Pimpri, Nashik, 2011. Srinivas, B. Municipal Commissioner of Suryapet. Suryapet, 2010.*

14) *CPCB (2000) Management of Municipal Solid Waste. Central Pollution Control Board, Ministry of Environment and Forests, New Delhi India.*

15) *Economic Evaluation of a Landfill System with Gas Recovery for Municipal Solid Waste Management: A Case Study. Sudhakar Yedla, Jyoti K. Parikh. 2001, International Jounral of Envrionment and Science, pp. 433-447.*

16) *French Ministry of Environment. 1990. "Sorting/Composting of Domestic Waste." Technical Brochure 27, Administration of Water Resources Pollution and Risk Prevention, Paris, Ministry of Environment. Program, and the Water and Sanitation Programmed of the World Bank, at Panaji, Goa, India, May 24–28.*

17) *Hanrahan, David, Sanjay Srivastava, and A. Sita Ramakrishna. 2006. "Improving Management of Municipal Solid Waste in India: Overview and Challenges." World Bank, Washington, DC.*

18) *J. Kurian, S. Esakku, K. Palanivelu, A. Selvam. Studies on Landfill Mining at Solid Waste Dumpsites in India. Sustainable Solid Waste Landfill Management in Asia. [Online].*

19) *Joint Secretary and Mission Director (JnNURM), Ministry of Urban Development, Government of India. Jawaharlal Nehru National Urban Renewal Mission (JnNURM) - A Response to India's Urban Challenges. Asian Development Bank. [Online] July 6, 2010*

20) *Madon S, Sahay S, Sahay J (2004) Implementing property tax reforms in Bangalore: an actor-network perspective. Inf Organ 14:269–295*

21) *Ministry of Urban Development (MOUD), Government of India. Solid Waste Management Manual. New Delhi: Ministry of Urban Development, 2000.*

22) *Nagarajan R, Thirumalaisamy S, Lakshumanan E (2012) Impact of leachate on groundwater pollution due to non-engineered municipal solid waste landfill sites of Erode city, Tamil Nadu, India. Iranian J Environ Health Sci Eng 9(1):35*

23) *National Solid Waste Association of India, NSWAI. Urban Waste Management Newsletter. National Solid Waste Association of India (NSWAI), 2010.*

24) *National Solid Waste Association of India. Urban Waste Management Newsletter. National Solid Waste Association of India (NSWAI). [Online] March 2010.*

25) *Nema, A.K., 2004. Collection and transport of municipal solid waste. In: Training Program on Solid Waste Management. springer, Delhi, India.*

26) *Pappu, A., Saxena, M., Asokar, S.R., 2007. Solid Waste Generation in India and Their Recycling Potential in Building Materials. Journal of Building and Environment 42 (6), 2311–2324.*

27) *Peavey, H.S., Donald, R.R., Gorge, G., 1985. Environmental Engineering. McGraw-Hill Book Co, Singapore.*

28) *Pieter van Beukering, Sehker, M., Gerlagh, R., and Kumar, V. March 1999. Analysing Urban Solid Waste in Developing Countries, CREED working paper series no 24.*

29) Ragothaman, K. Board of Director, Avant Garde. Chennai, 2010

30) Rajeev, R. A. Successful Registration of CDM Project for Earning Carbon Credits. Mumbai: Municipal Corporation of Greater Mumbai, 2010.

31) Ramachandra T V, 2009. Municipal Solid Waste Management, TERI Press, New Delhi

32) Sharma, S., Shah, K.W. (2005) Generation and disposal of solid waste in Hosha- ngabad. Proceedings of the second International congress of Chemistry and Environment, Indore, India. pp. 749-751.

33) Shekdar. (1999) Municipal solid waste management–The Indian perspective. J. Indian Asso. Environ. Manag. 26 (2), 100108.

34) Success Stories, PPIAF. Public-Private Partnerships: Maldives, Solid Waste. Washington DC: PPIAF, 2011.

35) Supreme Court Committee Report (1999),"Report of the committee on Solid Waste Management in Class I cities in India constituted by the Hon. Supreme Court of India.

36) Tchobanaglous, G. Theisen, H. and Eliass- en, R. (1997) Solid wastes: Engineering Principles and Management Issues, Mc Graw-Hill publications, NewYork, USA. pp. 52.

37) Tchobanoglous, G., Theisen, H., and Eliassan, R. 1977. Solid WastesEngineering Principles and Management Issues, McGraw-Hill Book Company, New York.

38) Thomas, V.M., and Spiro, T.G. (1996) The U.S. dioxin inventory: are there missing sources? Environmental Science & Techn- ology. 30, 82A-85A.

39) Turk, L.J. (1970) Disposal of solid wastes- acceptable practice or geological nightmare. In: Environmental Geology. Am- erican Geological Institute, Washington, D.C. pp.1-42.

40) vagale, L.R. 1997. Environment of Urban Areas in India Case Study: Bangalore, ENVIS Journal of Human Settlements, Centre for Environmental Studies, School of Planning and Architecture, New Delhi, India.

41) Industrial Solid Waste Management in India" Journal of IAEM, Vol. 23, 53-64