

## Analysis of Solid Waste Management Strategies in Major Cities of Uttar Pradesh in India

Divya Agarwal<sup>1,\*</sup>, Anil Kumar Gupta<sup>2</sup> and Manoj Kumar Agarwal<sup>3</sup>

<sup>1,\*</sup>Accurate Institute of Management & Technology, Applied Sciences & Humanities Department, Greater Noida

<sup>2</sup>National Institute of Disaster Management (Division of Policy & Planning), Government of India, IIPA Campus, New Delhi 110 002, India

<sup>3</sup>DJ College of Engineering & Technology, Modinagar, India

*India is a developing country with growing economy, indicating high resource consumption and waste generation particularly in urban sector. Municipal solid waste is disposed unscientifically in most of the urban Indian cities, breaking environmental pathways. Present study aims at developing an inventory of solid waste disposal facilities in densely populated major cities of Uttar Pradesh by gathering and analysing relevant data on primary and secondary collection and disposal systems e.g. per capita generation, per capita disposal, collection efficiency, collection & storage facility, transportation facilities, treatment & disposals and the major hindrances in Solid Waste Management (SWM). Solid Waste Management is poor with respect to collection efficiency and segregation of waste.*

**Keywords:** Solid Waste Management (SWM), Municipal Solid Waste (MSW).

### 1. INTRODUCTION

Municipal Solid Waste Management (MSWM) is a key concern for the developing countries to facilitate optimal utilization of natural resources. Most of the MSW is disposed unscientifically in India[1]. Environmental pathways are being broken. Managing municipal solid waste is a problem of high significance and growing magnitude[2]. Uncollected MSW end up in drains, causing blockages, resulting in flooding and insanitary conditions (water-borne and water induced diseases). Plague spread in Surat, India 1994. Hazardous chemicals e.g. Furans and Dioxins are released due to open burning of wastes. Aerosols and dusts can spread fungi and pathogens from uncollected and decomposing wastes. Leachate flowing from waste dumps and disposal sites cause ground water pollution. Chemical wastes (especially persistent organics) may be fatal. Fires on disposal sites can cause major air pollution, causing illness and reducing visibility and making disposal sites dangerously unstable.

A reliable data generation system of MSW of waste generation, collection & storage, transportation and treatment & disposal facilities of Indian cities is an important step towards sustainability. The main objective of the study was to gather relevant data and information regarding the primary and secondary collection, treatment and disposal of municipal solid waste in Uttar Pradesh. A detailed study was conducted through the field trips and postal surveys in all the major cities of U.P.

The ultimate repository of a city's MSW management is well designed landfills which are in accordance with appropriate local health and environmental standards. Waste is deposited in 0.9-4.5m thick layers in depressions and then compacted and covered at least once a day by earth with bulldozers. State of the art landfills are expensive to operate as there are requirements concerning daily cover, liners, leachate collection, gas collection, monitoring, hazardous waste exclusion, closure and post closure requirements and financial assurances. Selecting the site, certain restrictions e.g. water supplies, endangered or threatened species, scenic rivers, recreation or preservation areas utility or transmission lines. Sanitary landfill design is a complex process involving disciplines such as geomechanics, hydrology, hydraulics, wastewater treatment and microbiology.

Burning MSW at high temperature and pressure can reduce its 90% volume and 75% weight. The primary products of combustion are CO<sub>2</sub>, water vapour, nitrogen and solid residue of glass, ceramics, mineral ash etc. The cost involved is high. Hence, incineration method is commonly adopted for disposing only hazardous toxic waste. Anaerobic composting is a slow process, for 4-2 months, carried out at low temperature in the absence of oxygen and produces offensive odour. Aerobic compost is formed rapidly in the presence of oxygen at high temperature with bad odours. MSW offers good possibilities for recovery of energy in its organic fraction for gainful utilization and reduction of total quantity of waste by nearly 60% to over 90% cost of transportation and demand for land & net environmental pollution also get reduced. The latent energy present in the organic fraction of MSW can be recovered by Thermo-chemical conversion (Incineration/Pyrolysis/Gasification) (preferable low moisture containing wastes) and Bioconversion (preferable high percentage of organic biodegradable matter and high moisture content) (Anaerobic Digestion or Biomethanation/Alcohol fermentation).

## **2. STATUS OF SOLID WASTE MANAGEMENT IN INDIA**

Urban solid waste management in India is the most neglected area. No system of segregation of organic, inorganic and recyclable wastes exists at the household level[3]. In most of the Indian cities and towns, waste from hospitals and nursing homes is also coming in MSW. However, as per legislation it is required to be collected and treated separately[4]. Quantitative generation of MSW varied from place to place along with consistent correlation with the average standard of living[5]. Increase in population and MSW of Mumbai from 1981 to 1991 is 49% and 67% respectively[1].

In India, wastes are normally high in biodegradable matter and low in paper, metal and glass. The proportions of the constituents also vary seasonally and place to place depending on lifestyle, food habits, standard of living and degree of commercial & industrial activity[6]. Significant increase has been observed in MSW generation in India in the last few decades because of rapid population growth, economic development and change in lifestyles, food-habits, living standards and increasing consumerism in urban centres.

MSW is collected and dumped on the identified disposal or unidentified dumping sites, which are normally the low-lying areas on the outskirts of the city. Open dumping of

garbage facilitated serious health problems, ground water contamination by leachate production and emission of atmospheric pollutants. Estimates given by Tata Energy Reserach Institute (TERI) for open-refuse burning, indicated highest TSP load of annual emission among  $PM_{10}$ ,  $SO_2$  and  $NO_x$ . The sources of MSW are households, offices, shops, hotels and other institutions. Calorific value of the Indian solid waste has been reported to be between 600 and 800 kcal/kg and the density of the waste between 330 and 560 kg/m<sup>3</sup>[7].

**Table 1:** Composition of Municipal Solid Waste

Ingredients of MSW	Year 2000 (%)	Year 2025 (%)
Organic Waste	40	60
Plastic	4	6
Metal	1	4
Glass	2	3
Paper	5	15
Other [ash, sand, grit]	47	12

The level of economic development of the country has the strong impact on the waste generation pattern. India is a low-income country with a per capita waste generation lying between 0.3-0.5 kg/day. High income countries (e.g. Indonesia, Malaysia, Thailand) generate significantly higher amount of solid waste i.e. 1.5-2.0 kg/capita/day and 0.75-1.0 kg/capita/day respectively. In Asia, the East-Asia has the highest calculated share of MSW generation of about 46%. In 1947 indian cities and towns generated an estimated 6 million tonnes of solid waste. In 1997 about 48 million tonnes of solid waste was generated, of which more than 25% is not collected at all[4].

The quantity of MSW is usually expressed on a per capita basis. By applying the total urban population of the corresponding states, the MSW in gms/day can be transformed in per capita terms[3]. The per capita of MSW generated daily, in India ranges from about 100g in small towns to 500 g/person/day in India. Respective variation has also been observed in the per capita waste generation between lower and higher income group people. As per TERI [1998] average collection efficiency for MSW in Indian cities is about 72.5%. Around 70% of Indian cities lack adequate waste transport capacities[4]. Transportation of waste from the community bins to disposal sites by vehicles which are not designed specifically for the purpose[3]. Partial private participation is in practice in some municipalities towards convenient transport. Indian MSW needs to be segregated extensively before it is treated. It involves 30% cost of MSW segregation as per Ministry of Non-Conventional Energy Sources, New Delhi and Syncoms estimates.

The TEAM (TERI Enhanced Acidification and Methanation) process offers a clean and 'Best Available Technology Not Entailing Excessive Cost (BATNEEC)' for production of a good quality biogas fuel with methane content 70-75% and nutrient rich organic manure (N, P,  $P_2O_5$ ,  $K_2O$ )[8,9].

### 3. METHODOLOGY

Keeping in view, a strict need of reliable data-book on collection and generation of MSW quantities, transportation and treatment & disposals facilities in Uttar Pradesh, a strategic plan for analyzing the status of solid waste disposal facilities is developed. Waste generation being directly proportional to population size, the cities were classified with respect to the population sizes as Class-I, 1 Lac-5 Lakhs; Class-II, 50,000-1 Lac, Class III and less than 50,000 Class-IV survey cites respectively (Table 2). Thus major cities of Uttar Pradesh studied fall under class-I category.

**Table 2:** Division of Cities in Uttar Pradesh

Class	Population Size	No. of Towns
Class I	5 Lakhs and above	11
Class II	1 Lac-5 Lakhs	34
Class III	50,000-1 Lac	13
Class IV	Less than 50,000	10
All Classes		68

A detailed study of municipal profile of Uttar Pradesh was made and a survey questionnaire was designed evaluating the steps of solid waste management i.e. generation, collection, treatment and disposal. Field trips and postal surveys were included. Based on the municipal profile, the selected survey sites were classified according to their population size.

### 4. RESULTS AND DISCUSSION

#### 4.1. MSW Scenario in Class-I Cities

Class-I cities are mostly densely populated urbanized part of India. More than 65.2% of the urban population is living in these Class-I cities. They form the commercial hub, providing employment opportunities and accelerating the pace of urbanization, resulting in a corresponding increase in MSW generation.

Above 65% of urban population live in Class-I cities generating piles of wastes (Table 3). Findings of National Environmental Engineering Research Institute (NEERI) indicate the per capita generation rate increases with the size of city and vary between 0.3 to 0.6 kg/day. In metropolitan areas, values up to 0.5kg/capita/day have been recorded.

Heavy expenditure on MSW management is done due to lack of technical and managerial support and reliable & updated information. The process of segregation of waste is almost negligible. Very little resource recovery is opted. Rag picking is unorganised. Limited collection of health care wastes is there. Most of transportation vehicles are not covered appropriately. Poor monitoring and supervision with lack of sense of responsibility is followed. Overall, it remains the area of high concern.

**Table 3:** MSW Generation, Collection, Disposal Figures in Class-I Cities\* of Uttar Pradesh

Municipal Authority (Nagar Nigam)*	Municipal Area (sq. Km)	Municipal population (census 2001)	Total MSW generated daily (MT)	Per Capita Generation Daily (gm)	Total MSW collected (daily)	Per capita disposal (daily)	Collection efficiency (%)
Agra	123.22	12,59,979	600	476.19	520	412.70	86.6
Aligarh	32.37	6,67,732	400	599.04	300	449.28	75.0
Allahabad	63.87	9,90,298	400	403.91	325	328.18	81.2
Bareilly	106.05	6,99,839	500	714.45	400	571.56	80.0
Ghaziabad	63.78	9,68,521	400	413.00	350	361.37	87.5
Gorakhpur	136.58	6,24,570	300	480.33	240	384.26	79.9
Kanpur	261.69	25,32,138	1100	434.41	680	268.54	61.8
Lucknow	337.50	22,07,240	1500	679.58	1100	498.35	73.3
Meerut	141.89	10,74,229	600	558.54	468	435.66	78.0
Moradabad	34.17	6,41,240	380	592.60	270	421.05	71.0
Varanasi	79.12	11,00,748	600	545.08	450	408.81	75.0

\*Only these 11 cities in Uttar Pradesh are having a civic status of Municipal Corporation.

The present study has generated a baseline data by ground-level surveys, helps in predicting the cause of negligence. An integrated approach to collect baseline data, analysis & prediction along with application of modern technology & tools like remote sensing, Geographic Information System (GIS) and mathematical optimization methods would help in sustainable allocation of resources and equilibrium is set with respect to generation rates and waste management strategy.

## **4.2. Solid Waste Management Scenario in Class-I Cities of Uttar Pradesh**

### **4.2.1. Composition**

The biodegradable content of solid waste is much higher. Proportion of ash and fine earth is also high in Indian MSW due to construction and demolition, drain silt and street sweeping which is gradually reducing due to continuous cementation. Albeit, the legislative framework been also constructed to strengthen the MSWM in India. Series of MSW environmental legislation also depicts its importance in the sustainability framework. It includes 74<sup>th</sup> amendment to the constitution [12<sup>th</sup> schedule, function number 6], the Uttar Pradesh 'Municipal Corporation Act of 1959', Uttar Pradesh 'Plastic & other non-biodegradable garbage ordinance' of July 2000, Municipal waste [Management & Handling] Rules 2000, Ministry of Urban Development issued manual on MSWM, The Supreme Court Report on SWM in class-I cities [March, 1999]. In addition, as part of the National Environment Policy 2006, the action plan for soil pollution comprises strengthening the capacities of Urban Local Bodies (ULB) for segregation, recycling, and reuse of municipal solid wastes, and setting up and operating sanitary landfills, in particular through competitive outsourcing of SWM services.

### **4.2.2. Collection and Transport**

Poor collection efficiency is attributed to shortfall in manpower, containers and transportation facilities. Transportation of solid waste continues to be perceived as risky and is associated with negative externalities that affect the quality of life including truck, traffic, odors and stigma. Containers are often placed in in-appropriate locations where collection vehicles cannot access them frequently and unlifted or left open.

### **4.2.3. Treatment**

Waste component is separated manually at source by the generators and rag-pickers after the waste has been dumped. Some degree of pre-treatment, which includes separation of contaminating materials from waste, is done at composting plants prior to composting. However, no large-scale materials recovery facility for mechanized separation of waste has been setup in India.

India being an agriculture based country, major proportion of solid waste comprises 70%-80% organic matter, dirt and dust, wherein composting is the best practicable solution of solid waste management. Recycling plays important role in solid waste management of

non-biodegradable waste. Many large scale composting plants were established and failed for various reasons due to lack of application of simple scientific methods to treat organic matter. Increase in population causes rise in waste generation. This fact makes landfill disposal practicably not feasible. The landfill sites are exhaustible and very expensive because of rising costs of construction and operation. Cost of incineration is also very high. Lack of reliable & updated information and its inefficient dissemination is another major problem.

With respect of energy perspective in Indian scenario, biomass energy carries maximum potential i.e. generating ecofriendly biogas and biofuels. Due to lack of innovative, practically feasible, ecologically sound and simple technology, biomethanation plants has not been functional. A self-sufficient combustion reaction cannot be obtained in a majority of Indian MSW and auxiliary fuel will be required to carry out waste combustion. An incineration plant of 300 tpd capacity set up at Delhi, has not been operational due to low calorific values encountered. A biomethanation plant was proposed at Pune and Mumbai, but its viability is yet to be proven. A project for producing 105 tpd fuel pellets for municipal solid wastes in Hyderabad has been installed. Work on a four megawatt MSW-based power plant in Nagpur has commenced. A few other projects for generation of power from MSW in cities such as Chennai, Lucknow, etc, have matured[10].

#### **4.2.4. Disposal**

Landfill disposal is unsuccessful in India due to increasing population, consequent rising waste generation leading to limited time frame of usage and the rising cost of construction and operation is also involved. Incineration is also not a viable environmental option due to high cost and generation of hazardous materials. Waste management technology with R's i.e. Reduce, Reuse, Recycling is to be promoted wherein recycling is recommended as an effective SWM technique in India. Community sensitization and public awareness is a most important factor to enhance segregation of waste at source.

The present state of municipal solid waste management in Delhi as the most neglected area of concern. About 70–80% of generated MSW is collected and the rest remains unattended on streets or in small open dumps. Only 9% of the collected MSW is treated through composting, the only treatment option, and rest is disposed in uncontrolled open landfills at the outskirts of the city. Unfortunately, the existing composting plants are unable to operate to their intended treatment capacity due to several operational problems. Therefore, along with residue from the composting process, the majority of MSW is disposed in landfills. In absence of leachate and landfill gas collection systems, these landfills are a major source of groundwater contamination and air pollution (including generation of greenhouse gases)[11].

MSW disposal policies are to be economically efficient, constitutionally supported and perceived to be fair. The economic theory of WM interprets landfill as a depletable natural resource indicating landfill space is an essential article of commerce. Waste management

policy tools are to withstand judicial scrutiny and achieve economic efficiency with policy suggestions as waste-to-energy plants, material recovery facilities and recycling plants. Energy recovery from various treatment and disposal methods is recommended[12].

A system's engineering model was developed for the strategic planning of an integrated solid waste management more specifically with tourist development[13]. In study inf Zarqa city of Jordan, solid waste management is one of the most vital issues in the contemporary urban environments. Lack of techniques, financial funds and awareness among public and private sectors was the major associated problem[14]. This is also a factor governed by the lack of technical and managerial inputs and lack of up-to-date information to public and practitioners in the field[15]. Economic, social and ecological sustainability of the various disposal strategies is to be reconsidered[16]. Cost-benefit analysis is an economic tool in the context i.e. monetary aspects of environmental harms and benefits to the waste management[17]. Effective waste management approach should integrate the various management tools with respect to varieties of waste contents, geographic regions, urbanization, rate of population increase, economic status of a country[18].

Waste management needs to be ascertained as a flexible system approach associated with the identification, reduction, storage, collection, transfer and transport, reuse and recycle, and processing and disposal of waste keeping in view environmental and socio-economic (health, economics, engineering, conservation, aesthetics etc.) conditions.

Biomedical waste is generated in very large quantity and is highly infectious, if lead unattended can cause epidemics. Incineration is the recommended disposal option. Thus information of quantitative estimation of treated and non-treated bio-medical waste collected by municipalities and the status of installed incinerators had been incorporated. Recycling is an important step with which many resources (e.g. tins, cans, plastic & glass bottles) can be put in use, again and again. Thus the cost of manufacture & disposal automatically reduces, simultaneously reducing the pressure on natural resources and environmental pollution.

## ACKNOWLEDGEMENTS

Study has been supported by Ministry of Environment and Forests, Govt. of India, in form of a project entitled 'Status of Solid Waste Disposal in Uttar Pradesh'. Authors are grateful to the management of their institutes for providing academic environment.

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