Solid Waste Management and Characteristics in Lucknow, Uttar Pradesh, India

Rahul Charles Francis, L.P.Singh, Earnest Vinay Prakash

Department of Mechanical Engineering, Sam Higginbottom Institute of Agriculture Technology and Sciences (Deemed University), Naini, Allahabad 211007,Uttar Pradesh, India

Abstract

Increasing population levels, rapid economic growth and rise in community living standard accelerates the generation rate of muni-cipal solid waste (MSW) in Indian cities. Improper management of SW (Solid Waste) causes hazards to inhabitants. The objectives of the study areto determine the quantitative and qualitative characteristics of SW along with basic information and to create GIS maps for Lucknow city. The samples have been randomly collected from various locations and analyzed to determine the characteristics of SW. A ques-tionnaire survey has been carried out to collect data from inhabitants including SW quantity, collection frequency, satisfaction level,etc. The Geographic Information System (GIS) has been used to analyze existing maps and data, to digitize the existing sanitary ward boundaries and to enter the data about the wards and disposal sites. The total quantity of MSW has been reported as 800 ton/day, and the average generation rate of MSW has been estimated at 0.65 kg/capita/day. The generated Arc GIS maps give efficient information concerning static and dynamic parameters of the municipal solid waste management (MSWM) problem such as the generation rate of MSW in different wards, collection point locations, MSW transport means and their routes, and the number of disposal sites and their attributes.

Keywords : pelletization, biomethanation, incineration, municipal solid waste, geographic information system, arc map, arc catalog and arc toolbox.

IJSER

Introduction

There is a need to reduce the current levels of waste generation and increase in material and energy recovery, which are considered as the essential steps towards an environmental friendly waste management system. Landfill is also no longer the first choice for disposal among the other methods such as recycling, composting and incineration, but a last step after all possible material and energy recovery in solid waste management practices. Initially, incinerators globally were used to reduce waste mass but energy is being recovered from incinerators nowadays. Electricity and heat is produced from the recovered bio-gas from landfill. From a mass view point of material recycling, composting of organic waste is considered as the most important system (Marchettini et al., 2007).

The problems arising from solid waste can be solved by using innovative technologies. Nowadays, different types of waste-to-energy (W-T-E) schemes are available through which energy can be efficiently recovered and used, such as anaerobic digestion (i.e. both dry and wet, thermophilic and mesophilic), thermal conversion (i.e. rotary kiln incineration, mass burn incineration, starved air incineration, fluidized bed combustion, pyrolysis and gasification, plasma technology, thermo-chemical reduction, refuse derived fuel) and landfilling (i.e. landfill gas utilization and bioreactor landfill). Each type of technology handle the specific composition and quantity of solid waste (Tatamiuk, 2007). It seems to be difficult to propose suitable waste management plans and technologies without determining the quantity and composition of generated waste (Idris et al., 2004).

Globally, wastes are used to produce electricity and fertilizer or used for recycling. Recently, Europe and United States (US) are recycling waste about 41% and 32%, respectively. China is also investing US 6.3 billion dollar to achieve 30% recycling of its waste by 2030 Currently, out of more than 800 incineration plants working throughout world, about 236 are in Japan and 400 in Europe. The plants in Europe have capacity to provide electricity approximately 27 million inhabitants .There are two methods used for the treatment of solid waste in India, namely the composting (vermin-composting and aerobic composting) and waste-to-energy technologies (pelletization, biomethanation and incineration). Although the latter method is working successfully in the developed world, it is relatively new in India (Sharholy et al., 2008).

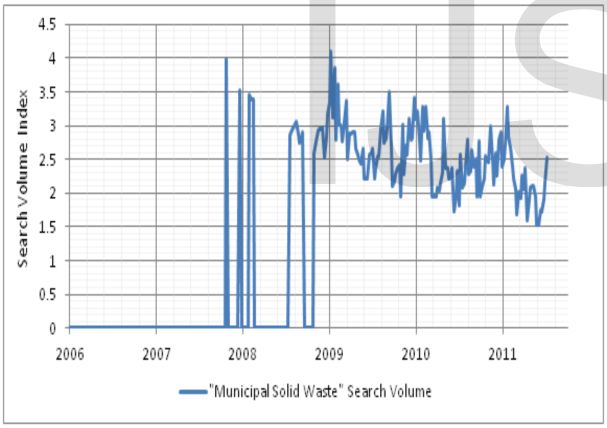
Status of MSW: an overview

Lucknow is a major city and capital of Uttar Pradesh State It is about 525 km from Delhi and about 920 km from Calcutta. Lucknow has always been known as a multicultural city and flourished as a cultural and artistic capital of North India in the 18th and 19th centuries and as a seat of power of Nawabs. Today it continues as an important centre of education, commerce, aerospace, finance, pharmaceuticals, technology, design, culture, tourism, music and poetry. Lucknow stands at an elevation of 123.45 metres above sea level and covers an area of 689.1 km^2. It is surrounded on the eastern side by District Barabanki, on the western side by district Unnao, on the southern side by Raebareli and on the northern side by Sitapur and Hardoi districts. The city is on the north western shore of Gomti river, which flows through it. Lucknow Municipal Corporation (LMC) is responsible for the management of the MSW generated in the city. The entire operation of solid waste management (SWM) system is performed under four heads, namely, cleaning, collection, transportation and dis-posal. In the city area of about 70 km2, the cleaning and collection operations are performed by the public health wing of LMC; while transportation and disposal of MSW are being performed by the transportation wing of LMC. In

Lucknow city the cleaning and collection pro-cess involves collection of MSW from the street in wheel- barrows and thereafter, it is dumped into depots (52 depots). MSW is then loaded into the transportation vehi-cles, which transport the waste to different disposal sites Every year LMC spends on average 21% of its total budget on solid waste management.

MSW sources in Lucknow

Sources of waste	Percentage
Households	**42**
Restaurants	**28**
Street sweeping	**6.8**
Market	**8.3**
Shops and workshop	**7.5**
Offices	**4.2**
Hospitals	**1.7**
Hotels	**1.5**
Total	**100**



3. Geographic information system (GIS)

Arc GIS is a complete and integrated system for the cre-ation, management, integration, and analysis of geographic data. It consists of a geo-referenced spatial database, which includes all required parameters for MSWM. These param-eters involve sanitary wards, collection points, transporta-tion road network, as well as the location and capacity of disposal sites and its connection with different wards. Arc-GIS has the capability to input and store the geographic (coordinate) and tabular (attribute) data, to find specific features based on location or attribute value, to answer questions regarding the interaction between multiple data- sets, to visualize geographic features using a variety of sym-bols and to display the results in a variety of formats, such as maps and graphs. The GIS Desktop includes three integrated applications, i.e., ArcMap, ArcCatalog and ArcToolbox. ArcMap is the primary GIS application for performing analysis and making maps; it is used for displaying, querying, editing,creating and analyzing GIS data. ArcCatalog application helps to organize and manage all GIS data. It includes tools for browsing and finding geographic information, recording and viewing metadata, quickly viewing any data- set and defining the schema structure for geographic data layers. ArcToolbox application provides tools for data conversion, managing coordinate systems, and changing map projections

4. Methodology

The research work is based on primary and secondary data collection in order to respond to the research questions of the study. The secondary data were collected directly from concerned offices, research institutions like universities and NGOs, which are closely dealing with the solid waste management issues. After reviewing their reports, the primary data were also collected on the basic issues, which are not dealing with, or not clearly mentioned in reports through “key informed consent approach”. The secondary data come from a combination of electronic and printed form of materials such as published books, research papers, journals and articles etc. Primary and secondary data consist of composition and quantity of solid waste, socio-economic and environmental related issues of solid waste stream and also about waste-to-energy recovery technologies.

4.1 Methods for data collection

The following methods were adopted for the collection of required data,

- Detailed study of yearly solid waste reports of concerned institutions.
- Key informant interview with solid waste management staff.
- Review of already published literature.
- Personally make visit in the city and to the waste disposal sites to assess the solid waste management system.

4.2 Primary Data Collection

The qualitative data have been collected through focus group interview from relevant top management of Waste Management Company, Lucknow, Uttar Pradesh. The following questions were treated:

Question 1: Do you consider different sectors or towns for the solid waste collection in Lucknow?

Question 2: What are the current collection and segregation methods at sources?

Question 3: Do you have any planning to find out recent solid waste composition? How and this waste composition will be either based on sectors or towns level?

Question 4: Is there any waste-to-energy recovery technology is operating in Lucknow? If yes which type of technology is implemented?

Question 5: If no then, are you thinking about the implementation of any waste-to-energy recovery technology in Lucknow?

Question 6: What do you think, if waste to energy recovery technology implemented in Lucknow, how much quantity of waste will be handled and what types of positive impacts will generate?

Question 7: According to your knowledge, which type of energy recovery technology is the most beneficial and suitable based on current solid waste composition and quantity of Lucknow?

IJSER

Question 8: What are the most important influencing factors while selection of waste-to-energy recovery technology in case of Lucknow and in general as well?

Question 9: At what extent economic factor is important while selection of technology?

Question 10: Political decision makers will have their own decisions regarding waste to energy technology selection or they will follow and consult with experts or relevant professionals?

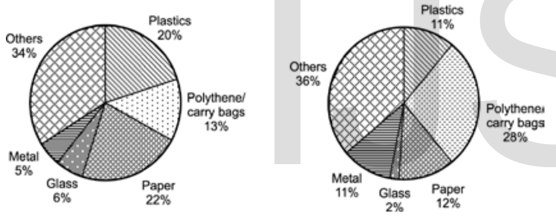
Question 11: Do you have any planning to construct sanitary landfill sites in Lucknow?

Question 12: What types of socio-economic-environmental issues specifically related to Lucknow solid waste?

Question 13: What types of health impacts on the workers and associated societies of produced solid waste in Lucknow?

4.3 Data Analysis

The statistical analyses were carried out on waste composition, quantity and population density variables and results are drawn in the form of percentage, mean, range and standard deviation. In regression analysis, 0.05 significance level is used. Data are presented in tables and diagrams (pie diagrams, bar diagrams). The secondary data on costs of the waste-to-energy recovery facilities is analyzed and compare on the basis of cost/ton of waste processing in different technologies.



Data Analysis of Lucknow City

Generation rate kg/capita/day

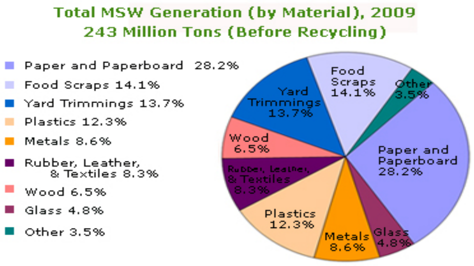
=Quantity of solid waste kg/day

Population capital

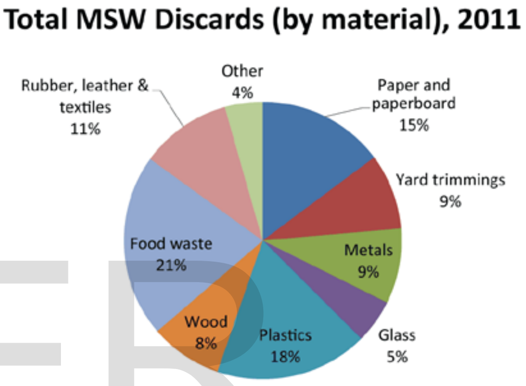
5. Results and Discussion

5.1 Quantity and composition of generated waste

The quantity and composition of waste has important value for the selection of different energy recovery technologies. The quantity of waste stream relatively has more importance for waste-to-energy recovery technology compared to composition because without sufficient amount of waste it becomes difficult to recover capital cost and also to maintain and operate a waste-to-energy technology in a cost effective manner (Tatarniuk, 2007). The amount of generated waste from different 9 towns of Lucknow is estimated by multiplying the used 0.67 and 0.9 same common factors with increasing population trends of each town in 2009 and 2012 respectively. The estimated total amount of waste was 5245 tons per day in 2009 and in 2012 this estimated waste was 5890 tons/day. Lucknow is divided into towns and not into sectors for the proper solid waste management. The composition of generated solid waste in Lucknow remained same for both 2004 and 2008 years (Imtiaz, 2008). The composition of generated waste for 2013 is not yet determined and it is estimated by looking at the previous year's increasing trends in composition of waste. This is also the same in composition like all past years but the total increase in quantity of waste has occurred over the period of time.



Waste generation in tons per day of Lucknow in 2009



Estimated average composition of solid waste in % for 2011 (Lucknow Solid Waste Management Department)

When we compare the different fractions of Lucknow Solid Waste, it can be seen that the quantity of waste is increased over time. However each component of waste increased in quantity with same ratio. Vegetable and fruit residues make the highest quantity over 6 years time period. Similarly the same case happened with leaves, grass and straw and dust, dirt, ash, stones and bricks fall on the second and third highest levels respectively. The glass, metals and unclassified components make the least quantity of waste stream respectively. There is a dramatic increase in total organics over past six years time period i.e. organic waste 2522 tons/day, 3407 tons/day and 3726 tons/day for 2004, 2008 and 2010 years respectively. Similarly the same case happened with inert components (i.e. increase from 1072 tons/day in 2004 to 1568 tons/day in 2010 year) of waste stream over this time period, having enormous quantity but with no value for either as recyclable or energy recovery. Recyclables are in low quantity but may play a major role by getting some revenue, can be helpful by reducing the total waste volume and also reducing burden on extraction of natural resources. However, recyclables increased from 256 tons/day in 2004 to 377 tons/day in 2010 year.

S.No.	Income Group	Percent of Total Population	Waste Generation (gm per capita per day)	Waste Generation(tonnes per day)
1	High	17	797	94.8
2	Middle	38	560	149.0
3	Low	30	200	21.0
4	Slums	15	200	21.0
Total				325.7

Relationship of economic conditions of different communities with per capita waste production in 2009

Estimation of the MSW constituents in Lucknow

Constituent	Quantity generated in million tonnes p.a.
Soil, sand and gravel	4.20 to 5.14
Bricks and masonry	3.60 to 4.40
Concrete	2.40 to 3.67
Metals	0.60 to 0.73
Bitumen	0.25 to 0.30 MT
Wood	0.25 to 0.30 MT
Others	0.10 to 0.15 MT

Table 1 : Quantity of Constituent of C & D waste Generated in million Tonnes p.a.
Source : Technology Information , Forecasting And assessment Council, Dept. Science and Technology, Gov. of India.

IJSER

The results from data analysis in GIS are products of the appropriate format maps concerning static and dynamic parameters of the MSWM problem, such as the productiv- ity of MSW in the different wards, collection point loca- tions, types of MSW transport means and their routes, and the number of disposal sites and their attributes.

6. Concluding Remarks

The segregation of waste at source and promotion of recycling or reuse of segregated materials reduces the quan- tity of waste and the burden on landfills, and provides raw materials for manufacturers. The composition of MSW shows mostly organic matter (45.3%), so composting is a good method for the treatment and production of soil amendment. The rapid increase in the quantities of MSW and the inability to provide daily collection service cause a nuisance and health hazards. The study presents the current scenario of MSWM, which will be helpful in creating aware- ness among the people. The MSWM data obtained from ArcGIS maps are responsible for the retrieval, update and visualization of the information required.

REFERENCES

Alternative Resources, Inc. (ARI). (2006). Focused Verification and Validation of Advanced Solid Waste Management Conversion Technologies-Phase 2 study.

Arena, U., Mastellone, M. L., Perugini, F. (2003). The Environmental Performance of Alternative

Solid Waste Management Options: A Life Cycle Assessment Study. Chemical
Engineering Journal 96:207-222.

Bandara. N. J. G. J., Hettiarachchi, P. J. (2003). "Environmental Impacts Associated with Current Waste Disposal Practices in a Municipality in Sri Lanka – A Case Study." Sustainable Landfill Management 19-26
.

Bryman, A. (2004). "Social Research Methods-2nd edition", Oxford University Press.

Marchettini, N., Ridolfi, R., Rustici, M. (2007). An Environmental Analysis for Comparing Waste Management Options and Strategies. Waste Management 27:562-571.

Psomopolos, C. S., A. Bourka, et al. (2009). "Waste-to-energy: A review of the status and benefits in USA." Waste Management 29(5, Sp. Iss. SI): 1718-1724.

R.W.BECK. (2010). Conversion Technologies Update, An SAIC Company: 1-14. SCS ENGINEERS. (2005). Pre-feasibility study for landfill gas recovery and utilization at the Muribeca landfill Pernambuco, Brazil.