ISSN 2321 –0567
Vol. 2 Issue 1 (April 2014)

Assessment of Municipal Solid Waste Generation and Characteristics in NCT of Delhi

Mr. Ashwani Kumar
Senior Research Fellow,
Department of Geography,
MD University, Rohtak

Ms. Tarun Punia
Academic Officer (Geography),
National Institute of Open Schooling,
Ministry of HRD, Govt. of India,
Noida (U.P.), India

ISSN 2321 –0567
Vol. 2 Issue 1 (April 2014)

ABSTRACT

Municipal solid waste (MSW) is one of the major environmental problems of the urban and sub-urban. Rapid industrialization and population explosion in India has led to the migration of people from villages to cities, which generate thousands of tons of Municipal Solid waste daily. The municipal 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. Solid waste management (SWM) has become a global issue and is of a major concern, especially in developing countries, due to various environmental problems, such as pollution of air, soil and water and generation of greenhouse gases from landfills. Indian cities and towns generate on an average 300–400 grams of solid waste per capita per day. This translates into approximately 80, 000 metric tonne/day or 30 million metric tonne/annum. Presently, in Delhi the municipal solid waste generated about 7000 to 9000 metric tonnes per day and quantity of this has been consistently rising over the years. Delhi had an average size of 5.06 persons in 2005. Assuming a similar average household size, and a population of 15-20 million, there would be 4-5 million households in NCT of Delhi today, these becoming the largest source of solid waste generation. The present study is an attempt to explore the municipal solid waste generation, characteristics and relation with population and GDP in NCT of Delhi. The data has been taken from MCD and various published and unpublished reports from the year 1993-2011. Regression, correlation and statistical quality control approach techniques has been used. There is positive correlation between population, GDP and waste geneartion. The correlation value is 0.69 for the population and waste generation and 0.50 for the GDP and waste generation. The correaltion between GDP, population and waste geneartion is highly significant at 0.01 and 0.05 levels in one tailed test. Waste generation was found to be high during the year 1999-2000 and 2006-06 as compare to 2007-08 and 2008-09. A recourse to 4 R's –as an approach is suggested for management/reduction in generated waste. The 4 R's are Refuse, Reuse, Recycle, and Reduce. This 4 R's approach would help in reducing the generation of waste and hence would contribute to maintenance of clean environment and sustainable living.

Keywords: solid waste, industrialization, environment, population and NCT.

Introduction

Solid waste in the urban areas has become a major challenge for urban administration because it is regarded as one of the most adverse types of pollution. Management of Municipal Solid Waste (MSW) continues to remain one of the most neglected areas of urban development in India. Magnitude and density of urban population in India is increasing rapidly and consequently the civic bodies are facing considerable difficulties in providing adequate services such as supply of water, electricity, roads, education and public sanitation, including Municipal Solid Waste Management (MSWM). Solid waste management (SWM) has become a global issue and is of a major concern, especially in developing countries, due to various environmental problems, such as pollution of air, soil and water and generation of greenhouse gases from landfills. Indian cities and towns generate on an average 300–400 grams of solid waste per capita per day. This translates into approximately 80, 000 metric tonne/day or 30 million metric tonne/annum. Delhi is one of the biggest cities in the world and it is known as most polluted city. Delhi generated 500 tonnes of non-biodegradable plastic and about 50-60 tonnes of hospital waste besides huge amount of municipal solid waste. The quantity of municipal solid waste produced in Delhi has been continuing rising over the years. Presently, NCT of Delhi is estimated to generate about 7000-9000 tonnes of MSW every day. The planning department of Delhi projected that the present population is likely to increase to 22.4 million and the waste generation to 17,000-25,000 tonnes/day by the year 2021. The waste generation in MCD area, NDMC, and Delhi Cantonment Board area is about 6300 tonnes, 900 tonnes, and 100 tonnes daily respectively (City Development Plan, 2006). The present study is an attempt to explore the municipal solid waste generation, characteristics and relation with population and GDP NCT of Delhi. This study also suggested 4 R's –as an approach is suggested for management/reduction in generated waste. The 4 R's are Refuse, Reuse, Recycle, and Reduce. This 4 R's approach would help in reducing the generation of waste and hence would contribute to maintenance of clean environment and sustainable living.

Study Area of the Present Study

The area selected for the present research study has a unique position with regard to its location. National Capital Territory of Delhi (NCT) is the second–largest metropolis in India and it is the sixth metropolis in the world by population. Delhi is located in North India between the latitude of 28°24'17" to 28° 53' 00" North and longitude of 76°50 '24" to 77°20' 37" East. It has 13.8 million populations, 7.6 million male and 6.24 million females' population (Census of India, 2001). Delhi has divided into nine district 27 tehsils and 165 villages, as per 2001 census. The area of the National Capital Territory of Delhi is 1483 sq. kms. (0.4 percent of the total geographical area of India). It is encircled by Utter Pardesh in the East, Haryana on the North, West and South.

Objectives of the Study

The study was undertaken with the following objectives:

- To assessment of waste quantity and waste characteristics of municipal solid waste.
- To explore the relationship between waste generation and GDP, and waste generation and population.
- To suggest some approaches for waste reduction.

Database and Research Methodology

The study is based on secondary statistics. The data has been accumulated from census publication of India for the year 2001 and 2011. The other data collected from Municipal Corporation of Delhi, Directory of Economic and Statistics of Delhi. The data has been analyzed keeping Zones as unit of observation. The simple percentage, mean and other statistical techniques has been used. Statistical methods like Regression, Correlation and Statistical Quality Control Approach techniques have been used. Further, suitable graph has been made for the better presentation of research. SPSS software has used for the calculation of regression, correlation and statistical quality control approach techniques.

Concept of Solid Waste

Solid waste can be defined in terms of unwanted residues, solid or semi–solid that is thrown away by domestic, industrial and commercial sectors. According to World Health Organization, the term "Solid Waste" is applied to unwanted and discarded materials from houses, street sweepings, commercial and agriculture operations arising out of mass activities. **U**rban solid waste consist of household wastes, construction and demolition debris, sanitation residues, industrial and hospital waste (Planning Commission, 1995).

Solid waste defined as a mixture of vegetables and non–vegetables, paper, plastics, rags, fabrics, dust, ash and a variety of biodegradable and non–biodegradable matter. These materials are generally known as garbage or solid waste (Kappayantula, 2006).

Classification of Solid Waste

The solid waste generated in cities can be classified on the basis of its source of origin are as follows:

a) Domestic Waste: Kitchen and food wastes, plastics, papers and floor sweepings.
b) Market Refuse: Generally wastes from vegetable and non vegetable matters, packing materials such as bamboo baskets, leaves, plastics cardboard, timber boxes.
c) Hospital Refuse: Wastes such as syringes, needles, ampoules bottles, cotton, plasters and spoiled medicines.
d) Road Sweepings: Wastes such as leaves, animal dropping, human wastes, litter and dust.
e) Garden Refuse: Wastes such as leaves, branches, plants and broken pots.
f) Business Area Refuse: Various types of paper, cigarette and beedi butts, match sticks and bus tickets etc.
g) Cattle Shed Refuse: Animal wastes and general litters.
h) Trade Refuse: Cloth cuttings from tailoring shops and waste from auto repair centers.
i) Building Construction Refuse: Earth, concrete, brick and plaster.
j) Industrial Wastes: Oil soaked racks, timber scant lings, and chemical refuse including toxic matter. (Rao, 2006)

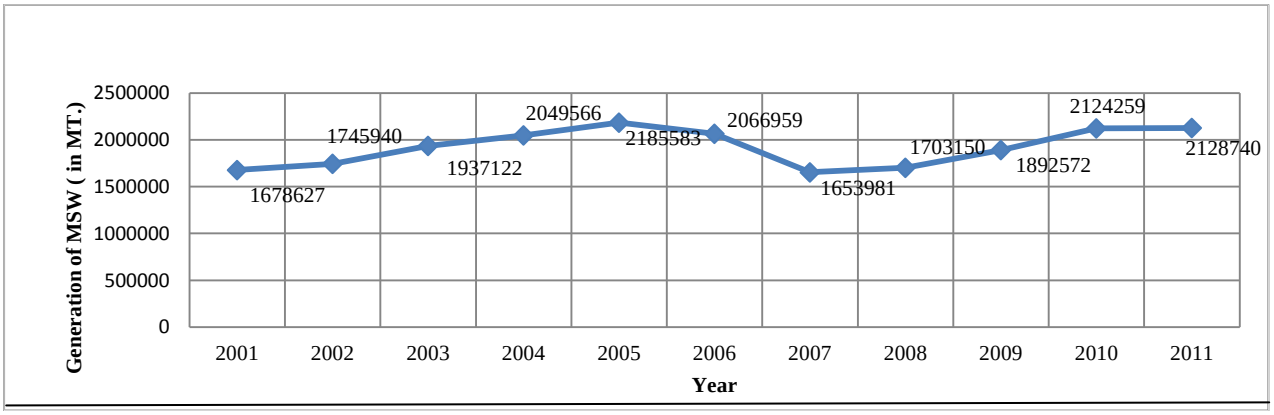
The above ten classification relates to solid waste. The present study included only municipal solid waste. Hospital waste and industrial waste is not included in the municipal waste. Municipal waste is the responsibility of urban local bodies in Delhi.

Trends in Municipal Solid Waste Generation

Data collected on daily quantity of municipal solid waste generated in Delhi since (2001-2011) indicates that there were ups and down. There were continued rise in municipal solid waste in the years 2001, 2002, 2003, 2004 and 2005. The mean daily generation increased 5816.23 metric tonnes in 2011 from 4598.98 metric tonnes in 2001. This trend clearly shows that there has been significant increase in the generation of solid waste in the last few decades. From 2001-2011 about 27 percent growth has been recorded in MSWG. In 2005 the MSWG was more than in the comparison of 2006.

But during 2007 it was less than the previous year, after that it is in progressing every year. In 2008 and 2009 the waste generation increased because of hectic construction activity was in progress related to hosting of Commonwealth Games in 2010. The trend line of MSWG is clearly shows that waste generation is continuing up side (Figure 1).

Figure 1: Growth of Municipal Solid Waste Generation in Delhi (2001-2011)



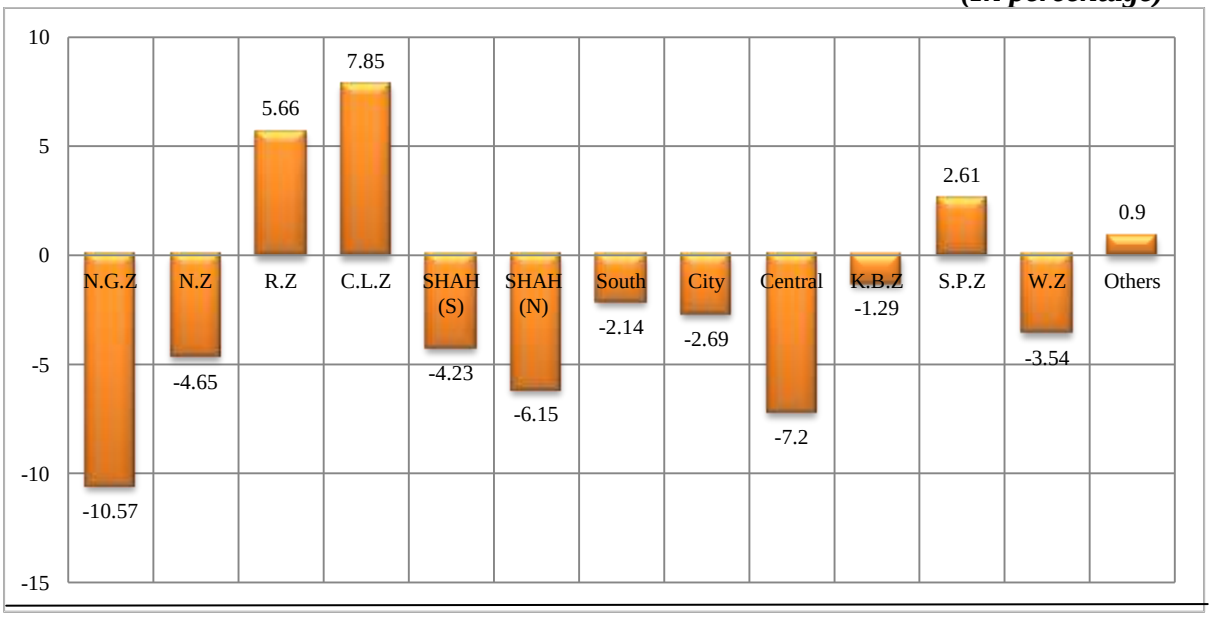
Spatio-Temporal Aspects of Waste Generation

The given Figure (2) showing the average compound growth rate from the year 2009-10 to 2011-12 for comparison the zone-wise MSW generation in the state. It is clear from the figure that only 4 zone out of 12 zone of MCD shows positive growth rate while, remaining shows negative growth rate during the same period. Further, we also found that the negative ACGR much higher in Najafgarh -10.57 Shahdara (N) -6.51 and Central zone -7.2. The average ACGR as a whole of all zones of the state was -2.12 during the period under consideration. Rohini zone, Civil Lines zone and Sadar Paharganj zone have been emerged

leading MSW generation zones out of the total in the state. So, there is a strong need of identification of the reasons of generation of municipal solid waste in these zones. To conclude that there is a need of additional efforts for MSW collection in Rohini zone and Civil Lines zone as compare to others.

Figure 2: Growth of Municipal Solid Waste Generation in different Zone (2009-10 to 2011-12)

(In percentage)



Source: *Auther Calculations*

Relationship between waste generation and population and GDP

Table (1) dipict the correlation amoung MSWG (Municipal Solid Waste Generation), GDP and population for the different zones of the state. It is clear from tha Carl Pearson's co-efficient was found positive and statistical significant between MSWG and GDP, MSWG and population. The total amount of waste genartaion is directly related to density of population, economic status and land use pattern of the particular area. There is positive correlation between population, GDP and waste geneartion. The correlation value is 0.69 for the population and waste generation and 0.50 for the GDP and waste generation. The correaltion between GDP, population and waste geneartion is highly significant at 0.01 and 0.05 levels in one tailed test. As population is higher in Shahdara (S), Shahdara (N), West, South, and Central Zones of MCD in comparison to other remaining zones, all the high density zones have high rate of waste production and low density of population zones, corrosponding with

low quantity of waste generated. Beyond this, some zone are situated in core areas of Delhi like Sadar Paharganj and Karol Bagh zone are highly producer of waste because of there commercial activities and higher concentration of population. The average amount 5816.23 metric tonnes of waste generated by MCD zones in 2011 and it is continuesly rising with the increasing of per capita income. Therfore, it is clear that waste generation incresing with the population growth and per capita income.

Table 1: Correlation Matirx amoung MSWG, GDP and Population

Particulars		MSWG	GDP	Population
MSWG	Pearson Correlation	1		
	Sig. (1-tailed)			
	N	18		
GDP	Pearson Correlation	.504*	1	
	Sig. (1-tailed)	.016		
	N	18	18	
Population	Pearson Correlation	.695**	.900**	1
	Sig. (1-tailed)	.001	.000	
	N	18	18	18
*. Correlation is significant at the 0.05 level (1-tailed). **. Correlation is significant at the 0.01 level (1-tailed).				

Source: *Auther Calculations*

Further, to find out the quantitative impact of population and GDP on MSWG in the state, multiple regression model are given in the Table (2). It is clear from the table that the impact of population on MSWG is found positive and statistical significant while GDP per capita (current price) in negative and statistically associated to it. The regression equation model predict the 54 percent variation in MSWG in the state. Morover, D-W statistics also reavles the absense of serail correlation in the series. In addotion the table reveals that 1.843 perecnt MSW increase due to change in 1 percent population, while -0.276 percent MSW decreses due to 1 percent increase in income or GDP per capita. In sum, we suggest that the 4R's approach (Reuse, Recycle, Redue, Refuse) should be incorporate in Delhi for reducing the municipal solid waste genartion.

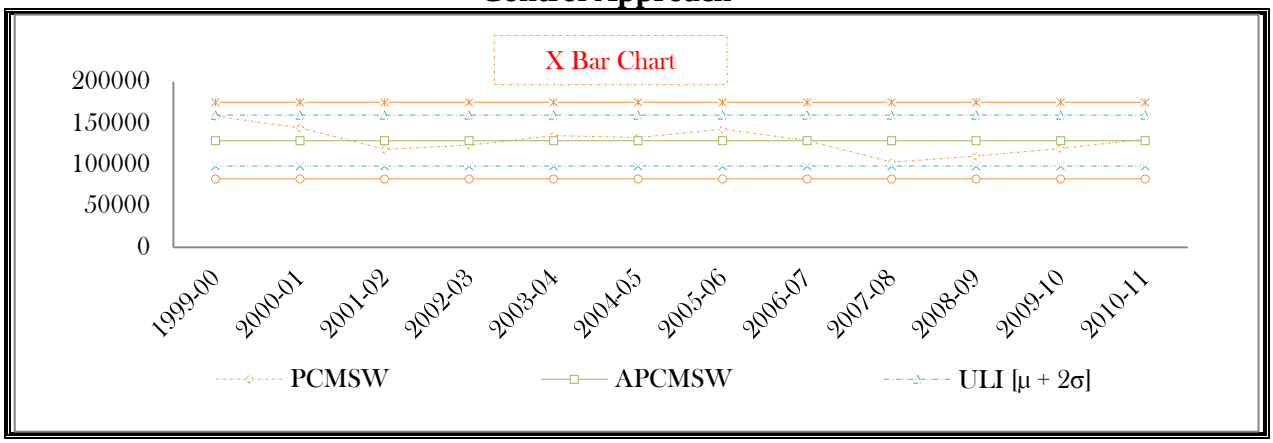
ISSN 2321 –0567
Vol. 2 Issue 1 (April 2014)

Table 2: Determents of Municipal Solid Waste Generation

Particulars	Unstandardized Coefficients		t-value	p-value
	B	Std. Error		
(Constant)	2.885	0.229	12.590	0.000
GDP Per Capita [Current Prices]	-0.276	0.199	-01.385	0.186
Population	1.843	0.757	02.435	0.028
R-Square	0.594/59.40%			
Adj. R-Square	0.540/54.00%			
F-Statistics	10.940			0.001
Standard Error of the Estimate	0.052			
No. of Observations	17.00			
D-W Stat.	1.021			
Note: All the variables were used in natural log form. Thus, in this study, the following mathematical form of the model was used. $\text{Log [Y]} = a + b_1 \log [GDP] + b_2 \log [Population] + \mu$ …… [i]				

Source: *Auther Calculations*

Figure 3: Movement of Per Capita Municipal Solid Waste in Delhi: A Statistical Quality Control Approach



Source: *Auther Calculations*

Note: ***PCMSW****: Per Capita Municipal Solid Waste;* ***APCMSW****: Average per Capita Municipal Solid Waste;* ***ULI****: Upper Limit Inner;* ***ULO****: Upper Limit Outer;* ***LLI****: Lower Limit Inner;* ***LLO****: Lower Limit Outer;* ***μ****: Average and* ***σ****: Standard Deviation*

ISSN 2321 –0567
Vol. 2 Issue 1 (April 2014)

The municipal solid waste generation [MSWG] in MTs in Delhi was 2078260 in 1999/2000 and it increased to 2172138 in 2010/11 with the 0.37 per cent average compound growth rate [ACGR]. While, per capita MSWG in MTs have been decreased from 158645.80 to 130694.22 during the same period. The average per capita MSWG [in MTs] in Delhi has 128999.30. Further, the SD of the per capita MSWG [in MTs] in Delhi has 15454.75 over the period under consideration.

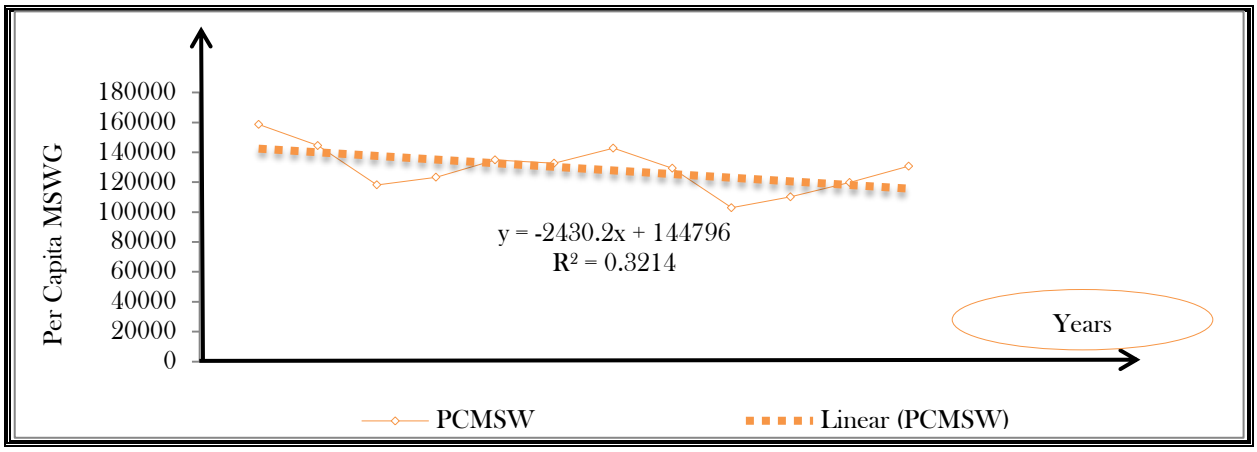
To check the fluctuating in per capita MSWG [in MTs] in Delhi over the period under study, Statistical Quality Control [SQC] method and X bar chart technique was used. It is clear from the figure that the per capita MSWG [in MTs] in Delhi during the period under study was below the ULI and LLI.

Moreover, the one sample-t test was also used to find out the statistical significant difference in per capita MSWG [in MTs] from the average per capita MSWG in Delhi during the period under consideration. The calculated value of the test was 28.915, while the tabulated values of the test are 1.80 and 3.11 at the 10 and 1 per cent level of significant respectively at 11 degree of freedom. It means, per capita MSWG [in MTs] from the average per capita MSWG in Delhi during the period under consideration was reasonable high in the year of 199/2000 and 2005/06, while it was low in 2007/08 and 2008/09.

In addition, I also found that the coefficient of correlation between per capita income and per capita MSWG was positive but not statistically significant.

Figure 4: Linear Trend of Per capita Municipal Solid Waste in Delhi

[In MTs]



Source: *Author Calculations*

Figure (4) reveals the linear trend of per capita MSWG in Delhi from 1999/2000 to 2010/2011. It is clear from the figure that the per capita MSWG in Delhi has been decreased significantly over the period under consideration. Further, in 1999/2000, 2000/2001, 2003/04, 2004/05, 2005/06, 2006/07, 2009/10 and 2010/11 higher per capita MSWG were increased occasionally not sustainable increased in the State.

Characteristics and Composition of Municipal Solid Waste

The composition and characteristics of municipal solid wastes vary throughout the world. Even in the same country it changes from place to place as it depends on number of factors such as social customs, standard of living, geographical location, climate etc. MSW is heterogeneous in nature and consists of a number of different materials derived from various types of activities. Physical and chemical characteristics of MSW in Indian cities vary depending on population size and geographical location. Though composition of urban waste is changing with increasing use of packaging material and plastics, yet, as compared to developed countries, Indian solid waste still comprises mostly, of large proportions of organic matter as well as inert material (India Infrastructure Report, 2006).

Physical Composition of Waste

Several studies have been conducted in Delhi by different organizations and institutions (IHPH 1982, NEERI 1996, TERI 2002) to determine the physical and chemical composition of MSW. The Table (4) reflects that biodegradable waste is generated maximums in all the three years (1982, 1995, 2002) but in 1995 and 2002 the composition is almost unchanged. The Inert matter is produced in huge quantity (i.e. 37.4 percent in 2002 & 1995) because of high pace of construction and demolition activities in Delhi. The other major component of the MSW like paper, plastic metal, glass and crockery, and non biodegradable waste (leather, rubber, bones and synthetic material) in the MSW stream has increased. As the economy grows and the population becomes more urbanized, the substantial increase in use of paper and paper packaging in probably the most obvious change. However, the percentage of paper remained unchanged in last two decades. The proportion of plastic and non-biodegradable material is increasing continually. This may be the

result of a shift towards plastic packaging, a reflection on the improved living standards and change in attitude of residents.

In Delhi, the recyclable material available in high quantity like paper, plastic and metal, but it is not properly processed because of lack of knowledge, man power, machinery and financial support by the Government. If the bio-degradable and recyclable matter will be handled properly it will reduce the heavy burden from the landfill site which is facing by the city presently.

Table 4: Physical Composition (as wt. %) of MSW in Delhi

Parameters	**2002**	**1995**	**1982**
Biodegradable	38.6	38.0	57.7
Paper	5.6	5.6	5.9
Plastic	6.0	6.0	1.5
Metal	0.2	0.3	0.6
Glass and Crockery	1.0	1.0	0.3
Non biodegradable (leather, rubber, bones and synthetic material)	13.9	14.0	5.1
Inert (stones, bricks, ashes, etc.)	34.7	34.7	28.9

Source: *TERI (2002), NEERI (1996), IHPH (1982)*
Note: Cited from V. Talyan et al. (2008)

Chemical Composition of Waste

The Table (5) described the chemical composition of municipal solid waste in Delhi. Various studies have been conducted by different agencies which are already discussed above for the calculation of chemical composition of MSW. It has been observed that the waste is characterized by high moisture content i.e. 43.8 percent. The organic carbon, Nitrogen, Phosphorus, Potassium, C/N Ratio and Calorific value of MSW is recorded at 20.5 percent, 0.9 percent, 0.3 percent, 0.7 percent, 24.1 percent and 713 kCal/kg respectively. If we compare the two studies which were conducted by TERI 2002 and IHPH 1995 we found the situation is almost unchanged. In Delhi, it has been observed that due to the intervention of rag pickers, the composition of waste has a distinct profile. The composition of waste indicates that it is not conducive for optimum extraction as the moisture and biodegradability character of the garbage is higher.

Table 5: Chemical Composition (as wt. %) of MSW in Delhi

Parameters	2002	1995	1982
Moisture	43.8	43.7	15-40
Organic carbon	20.5	20.5	22.8
Nitrogen as N	0.9	0.9	0.86
Phosphorus as P_2O_5	0.3	0.3	0.74
Potassium as K_2O	0.7	0.7	0.52
C/N ratio	24.1	24.0	28.0
Calorific value (kCal/kg)	713.0	712.5	661-1200

Source: *TERI (2002), NEERI (1996), IHPH (1982)*
Note: Cited from V. Talyan et al. (2008)

The 4 R's Approach

In present scenario, a recourse to 4 R's- i.e (Refuse, Reuse, Recycle and Reduce) as an approach is suggested for management/reduction in generated waste.

Refuse

We should preference for use of items already in possession and refusal to buy new ones. We can use old products as possible as like old plastics mugs, old electronic equipments and many other items which we sent into dustbins. Refuse for the new items can play a significant role in minimizing the municipal solid waste.

Reuse

The process of reusing started with the assumption that the used materials that flow through our lives can be a resource rather than refuse. We can 'reuse' many materials in their original from, instead of throwing them away, or pass them on to others who can use them. Once we have our minds set on the fact that we can use trash positively, we can begin to brainstorm and generate ideas. For this, we need to analyze our activities very closely and pick out things that can be reused. Reusing products or materials also helps in generating less waste, which again reduces the cost of managing solid waste and conserves natural resources. The idea of reuse has always been there largely due to prevailing socio-economic condition and partly due to traditional practices. Reusing items by repairing them donating them to charity and community groups particularly poor people or selling them also reduce waste. Reuse things is also a great practise to reduce the waste.

Recycle

Recycle is a stage where the reusable material is remade into either the same or new product. So, it is a resource recovery method involving separating, collecting, processing, marketing and using material that would have otherwise been thrown away. However, recycling must be based in the overall production and consumption cycle. It should not be looked upon as an activity that can exist on its own merely as an alternative disposal means. In fact, it is one component of integrated waste management. The entire recycling process is a dynamic mechanism in itself. With increase in supply of materials, manufacturing facilities, in both organized and unorganized sectors, have emerged to find uses for recyclable materials. This subsequently has created jobs or livelihood for a number of persons. This also helps in reducing the quantity of wastes going to landfills. The major component of MSW that have some economic value and are recyclable includes paper, cardboard, glass, plastic and metal. Out of total recyclable materials in Delhi, plastic and paper contribute about 47 percent and 43 percent respectively. About 1,22,000 tonnes per year of paper and cardboard is thrown away as rubbish in Delhi. Plastics constitutes approximately of 76,000 tonnes per year and metal 8,000 tonnes per year of Delhi's MSW. The market value of these components runs into millions of rupees. It makes economic sense to recover these materials for reuse (ISEM, 2000). There is urgent need to mandate the process of source segregation for reducing the SWM problems in NCT of Delhi.

Reduce

Reducing the waste stream is the most significant of all the options to manage waste. The problem of waste management is reduced to the extent we are able to reduce the generation of wastes. Thus, we can conserve our resources and reduce disposal costs and pollution. We can start by analyzing what we throw away at home. This will include thinking about the goods and services we buy and the activities we support, and in what ways do they contribute to the solid waste problem. There are many ways to reduce the waste amount generated. For example, businesses could use e-mail in place of paper for inter office memos, both sides of paper when printing and copying, and durable mugs instead of styrofoam cups for coffee, use of cloth bags not paper and plastics. MCD should emphasis on these types of activities to reduce the quantity of waste because in Delhi there is no land for landfilling and neighbouring states such as Haryana, Uttar Pradesh clearly refused to hand-over any land to dispose Delhi's garbage in.

Conclusion

The generation of waste is a big problem for urban local bodies because in the city like Delhi, there is no land left for landfilling the huge amount of waste. The problem of waste management is reduced to the extent we are able to reduce the generation of wastes. The mean daily generation increased 5816.23 metric tonnes in 2011 from 4598.98 metric tonnes in 2001. This trend clearly shows that there has been significant increase in the generation of solid waste in the last few decades. From 2001-2011 about 27 percent growth has been recorded in MSWG. Rohini zone, Civil Lines zone and Sadar Paharganj zone have been emerged leading MSW generation zones out of the total in the state. There is positive correlation between population, GDP and waste geneartion. The correlation value is 0.69 for the population and waste generation and 0.50 for the GDP and waste generation. The correaltion between GDP, population and waste geneartion is highly significant at 0.01 and 0.05 levels in one tailed test. Further, to find out the quantitative impact of population and GDP on MSWG in the state, multiple regression model used and it is clear that the impact of population on MSWG is found positive and statistical significant while GDP per capita (current price) in negative and statistically associated to it. To check the fluctuating in per capita MSWG [in MTs] in Delhi over the period under study, Statistical Quality Control [SQC] method and X bar chart technique was used. It is clear from the figure that the per capita MSWG [in MTs] in Delhi during the period under study was below the ULI (upper limit inner) and LLI (lower limit inner). The present study suggested the 4 R’s approach for the reduction of municipal solid waste production because there is no land for landfill and shortage of money for the processing of waste. Refuse, Reuse, Recycle and Reduce are most appropriate technique for lower down of waste generation.

References

- **Asnani, P.U., 2006.** "Solid Waste Management", Urban Infrastructure, India Infrastructure 2006, 160-183.
- **City Development Plan 2006**, Department of Urban Development, Government of Delhi
- **Kappagantula, S.R. 2006.** "Solid Waste Management – A Study of Municipalities in West Godavari District, Andhra Pradesh", *Nagalok*, Vol. XXXVIII, No. 1, pp. 31–39.
- **Planning Commission 1995.** Report of high power committee: Urban solid waste management in India, New Delhi: Planning Commission, Govt. of India. pp 58.
- **Rao, S. 2006.** "Solid waste management- A study of municipalities in West Godavari district, Andhra Pradesh, Nagarlok, Vol. XXXVII, No.1, pp 31-39.
- **Talyan, et.al 2008.** "State of Municipal Solid Waste Management in Delhi", *Journal of Waste Management*, Vol. 28, pp. 1276-1287.