Int. J. Chem. Sci.: 12(4), 2014, 1345-1354
ISSN 0972-768X
www.sadgurupublications.com

CALCUATION OF ENERGY RECOVERY POTENTIAL AND POWER GENARATION POTENTIAL FROM MUNICIPAL SOLID WASTE OF KURNOOL CITY, ANDHRA PRADESH, INDIA

T. RAMACHAR[*], G. CHINNA RAO[a], M. UMAMAHESH[b] and D. NAGAMOULI[b]

Department of Basic Sciences, G. Pulla Reddy Engg. College (Autonomous), KURNOOL (A.P.) INDIA
[a]Department of Chemistry, Vardhaman College of Engg. (Autonomous), HYDERABAD (A.P.) INDIA
[b]Department of Chemistry R. G. M. Engg. College (Autonomous), NANDYAL (A.P.) INDIA

ABSTRACT

The Municipal Solid Waste (MSW) contains huge amount of combustible and decomposable components and has a great energy potential The present study includes calculation of total MSW generated per day in the city, identifying the combustible portion in the MSW generated, calculation of the moisture content, finding the calorific value of the dry combustible constituents and the total MSW separately, estimating the energy recovery potential and power generation potential. The estimated power generation can support substantially the energy requirement of the city.

Key words: Municipal solid waste (MSW), Waste to energy (WTE), Calorific value, Lower calorific value (LCV), Bomb calorimeter, Urban local bodies (ULBs), Refuse derived fuel (RDF).

INTRDUCTION

Human civilization began and developed around river banks. In earlier times, men used to live a simple life and used to have fewer wants. At the end of 19th century, industrial revolution took place and from then onwards, there has been a steady increase in consumerism and consequently, there has been a constant rise in the amount of waste generated. Solid wastes are those materials, which have been produced by various human activities in the society, which have lost their value to the first user. Solid waste can be defined as any solid or semisolid object resulting from human activity, discarded as useless or unwanted. Municipal solid waste or Urban solid waste is a waste type that includes house

[*]Author for correspondence; E-mail: t_ramachar@rediffmail.com; Mo.: 09441232524

hold waste (domestic waste), commercial waste, construction and demolition debris, sanitation residue and street sweepings collected by the municipalities within a given area.

There has been significant increase in the MSW generated in India in the last few decades[1]. This is mainly because of rapid population growth, increase in living standards, and economic development in the country. If the MSW is not properly managed, it will affect public health and leads to the degradation of the environment[2]. The quantities of non-renewable resources are limited and get exhausted soon. Now the world is looking for the alternative energy resources. In the present scenario, MSW is the best alternative source of energy, both in terms of economic and environmental reasons. Awareness among the public with regard to sanitation is growing coupled with increasing pressure on the Government and ULBs to manage the waste more efficiently. With the increase in urban population and their living standards, the quantity and variety of MSW also increasing.

The MSW contains huge amount of combustible and decomposable components and have great energy potential. The MSW forms sustainable energy source and will be available as long as human life exists on this planet. Besides producing energy, WTE concept has environmental benefits as an alternative to disposing of the waste, reduce the dependence on fossil fuels, which is a major contributor of Green House Gases (GHG). The WTE measures also reduce the quantity of waste generated for final disposal or land filling. The present study is confined to MSW generated from Kurnool city, Andhra Pradesh.

Historical importance of Kurnool

Kurnool, the administrative capital of Kurnool district of Andhra Pradesh state is a fast growing city. It is about 212 Kilometres (132 mi) from Hyderabad on NH-7. Kurnool is the one-hundred-fifth largest city in India and the sixth-most populous city of Andhra Pradesh. It is considered the gateway to Rayalaseema and the largest city in the area. Kurnool served as the capital of Andhra state from 1 October 1953 to 31 October 1956. Kurnool lies on the banks of the Tungabhadra and Hundri Rivers. The K. C. Canal (Kurnool-Cuddapah) was built by the Dutch for transportation, but later used for irrigation.

Geographical location

Kurnool is located at 15°50′00″N 78°03′00″E/15.8333°N 78.05°E. It has an average elevation of 273 metres (898 feet). The climate is tropical with temperatures ranging from 26°C to 45°C in the summer and 12°C to 31°C in the winter. The average annual rainfall is about 30 inches (762 mm).

Population

As per provisional data of 2011 census, Kurnool urban agglomeration had a population of 4,78,124, out of which males were 239,401 and females were 238,723. The city has agricultural market yard and number of business establishments. Kurnool is also known as medical capital of Rayalaseema. On an average, the domestic power consumption in the Kurnool city alone amounts to 5,08,000 KWh per day. The details of Kurnool is obtained from the official web site of Government of Andhra Pradesh[3].

Fig. 1: Picture showing ward wise boundaries of Kurnool

The city is divided into 50 wards comprising of one lakh houses (Fig.1). For administrative supervision of MSW collection, city is divided into 12 divisions. There are number of MSW power and RDF making plants[4-7]. A detailed study of the municipal waste management was made by the author in his previous article[8].

EXPERIMENTAL

The MSW is collected from households, commercial establishments, vegetable markets, hotels etc. It is being transferred to community dust bins and tricycles. From there, it is being transported to the transit point by various transport vehicles like minilorries, tractors etc, from where the MSW is being transported to the dumping site by means of Tippers. Dumper placers will carry MSW collected directly to the dumping yard Gargeyapuram, which is 12 Km from the city (Fig. 2).

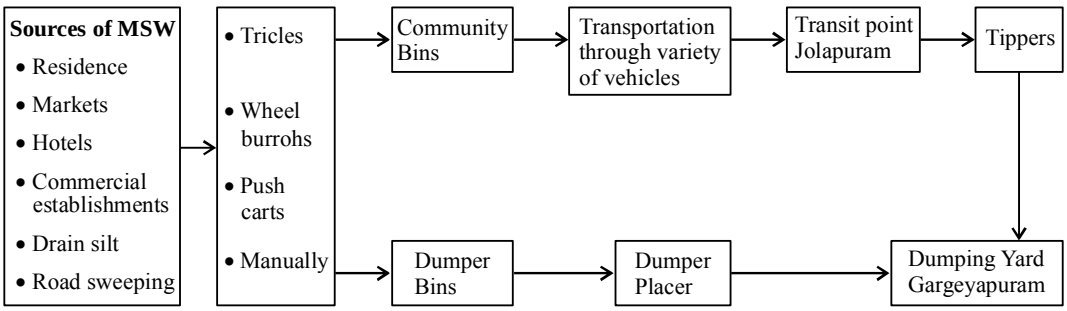

Fig. 2: Existing MSW management system in Kurnool City

Calculation of total amount of MSW per day

The number of trips made by the tippers and dumper placers is arrived at by taking the average over a period of 15 days. The data is provided by the Kurnool Municipal Corporation. The tippers and dumper placers are weighed in the weigh bridge with and without MSW. On an average, 210 MT of MSW is being transported to the dumping site per day.

Estimation of MSW from house hold survey

House-to-house survey of 50 houses has been done in 5 selected localities. The sampling process is repeated on alternative days in a weak to predict average value of waste generation. The samples were weighed and segregated. The moisture of the segregated samples is determined by means of hot air oven maintained at 80^{o}C to avoid the loss of volatile matter in the sample. The calorific value of dried sample has been determined by Bomb calorimeter. To ascertain combustible, decomposable and inert portion in the MSW, sample survey has been done in all the 12 divisions. The related pictures are shown in the Fig. 3 to 5.

Fig. 3: Picture showing house-hold waste collecting

Fig. 4: Picture showing weighing of the segregated MSW

Fig. 5: Pictures showing transporting the MSW to the dumping site

Estimation of MSW from dump yard

The sampling is made from the dumping yard by standard procedures and as per MSW Management and Handling Rules, 2001, MoEF[9,10]. 200 Kg of MSW is collected from various points from the dumping site and large pieces are cut into small pieces. From this about 10 Kg of representative sample is taken by following quartering method, which is done as follows. The MSW sample is mixed and divided into four sections. Any one diagonal sections are again mixed and again divided into four sections. This process in repeated to get about 10 Kg of MSW sample, which is taken as representative sample. The representative sample from the dumping yard is segregated. The segregated samples were cut to uniform size and their moisture content has been determined in the hot air oven. The calorific value of the dried combustible component has been determined. The dried unsegregated sample is sent for MoEF recognised lab for elemental analysis[11]. The calorific value of representative sample is determined by the author using Bomb calorimeter. The related pictures is shown in the Fig. 6 to 9.

Fig. 6: Picture showing segregation of MSW

Fig. 7: Weighing of segregated MSW

Fig. 8: Hot air oven

Fig. 9: Calorific value determination by Bomb calorimrter

RESULTS AND DISCUSSION

The percentage composition of MSW from house to house collection in the selected from five localities and the moisture content of the samples has been presented in the Table 1.

Table 1: Percentages of various components in the garbage collected from five residential localities

S. No.	Description of the Item	Jammichettu & Kummarigeri	Old market	Balaji colony	Nehru nagar	Narasingarao Pet	Average
1	Food, vegetable & fruit waste	65.54	63.15	50.82	42.0	55	55.30
2	Paper and card board	7.58	7.03	5.84	12.15	6.13	7.75
3	Plastic, packings, artificial leather, rubber	8.13	8.53	9.48	12.45	8.15	9.35
4	Yard trimmings, leaf & wood	2.15	3.78	7.22	8.15	7.01	5.66
5	Textiles	1.95	3.05	1.64	2.35	2.89	2.37
6	Coconut	2.53	1.9	15.78	14.01	12.5	9.36
7	Coconut shells	3.15	4.85	2.58	2.1	0.95	2.73

Cont…

S. No.	Description of the Item	Jammichettu & Kummarigeri	Old market	Balaji colony	Nehru nagar	Narasingarao Pet	Average
8	Dust & mud	8.15	7.07	5.34	4.03	4.52	5.86
9	Diapers	0.08	0.06	0.17	1.25	2.08	0.72
10	Glass	0.6	0.43	0.9	0.8	0.7	0.68
11	Metals	0.15	0.21	0.23	0.09	0.05	0.15

Table 2 presents the results obtained from sample localities from 12 divisions.

Table 2: Composition of MSW in various divisions

S. No.	Division	Sample location	Combustible %	Decomposable %	Inert %
1	I	Old Market	33.3	40.7	26.0
2	II	Jammichettu Area	35.1	40.9	24.0
3	III	Osmania College Area, Telugugeri	27.0	45.8	27.2
4	IV	Police Control Room	64.3	15.5	20.2
5	V	III Town & Budhawar Pet	63.2	22.4	14.4
6	VI	Zillah Perished	70.7	17.3	12.2
7	VII	Venkata Ramana Colony & Ashok Nagar	41.7	37.0	21.3
8	VIII	Municipal Office & Prakash Nagar	38.7	35.5	25.6
9	IX	Narasingarao Pet	35.1	38.0	26.9
10	X	Nandyal Road	33.7	38.3	28.0
11	XI	Bellary Chowrasta & Kalluru	46.5	28.0	25.7
12	XII	Maddur Nagar, C-Camp & Masters College	42.3	39.1	22.5
		Average	44.28	33.2	22.5

The calorific value of the dried MSW samples from the dump yard determined in the laboratory is presented in the Table 3.

Table 3: Calorific value of the dried MSW samples

Trial	Weight of the sample	Weight of water in the calorimeter (m grams)	Water equivalent calorimeter system (m + 456 grams)	Initial temp. (^oC)	Final temp. (^oC)	Rise in temp. (^oC)	Calorific value Kcal/Kg
I	0.717	1977	2433	32.60	33.76	1.16	3390.51
II	0.901	1971	2427	28.08	28.98	0.96	2693.45
III	1.013	2053	2509	28.84	29.66	0.82	2475.80
IV	0.841	2041	2497	29.13	29.97	0.84	2966.96
V	0.581	2054	2510	29.91	31.39	1.48	4315.40
VI	0.793	1964	2420	32.75	33.95	1.20	3049.40
VII	0.856	2023	2479	29.01	30.03	1.02	2896.00
VIII	0.713	2076	2532	30.36	31.62	1.26	3547.00
Average calorific value (HCV)							3166.81

Representative sample from the dump yard after quartering method is segregated, moisture content of the components was determined. The moisture, the calorific value of the combustible components and their contribution to the heating value was determined and the results are presented in Table 4

Table 4: Moisture and calorific values of the combustible components from the dump yard

S. No.	Description of the Item	% By weight	% Moisture	Weight of dry component (in 210 MT of MSW) MT	Calorific value kcal/Kg	Contribution to the heating value kcal/Kg
1	Paper & card board	11.90	18.0	20.50	3800.0	3800*20.50 = 779.0
2	Plastic, packing, synthetic leather, thermocole	12.19	12.9	22.30	6625.0	22.30*6625.0 = 1477.4
3	Textile	8.95	26.0	13.92	4080.0	13.92*4080.0 = 567.9
4	leaves, coconut shells & Food	40.0	82.0	15.28	1650.0	15.28*1650.0 = 252.1
Total heating value						3076.4

Table 5 presents the comparison of the calorific values obtained from the experiments by the author and calorific value obtained from MoEF recognised Lab.

Table 5: Comparison of the calorific value of the MSW sample

Calorific value Kcal/Kg	Sum of the heating value of the combustible constituents	Determined experimentally using Bomb calorimeter	MoEF approved lab analysis report
HCV	3076.4	3166.81	3350.0
Latent heat of water formed	253.5	253.5	253.5
NCV	2822.9	2913.31	3096.50

The values are almost agreed with each other.

Total weight of the dry combustible from 210 MT of total mixed garbage = 72.22 MT

The energy recovery potential and power generation potential is calculated from the standard calculations[12].

Calculation of energy recovery potential

Energy recovery potential = NCV x Weight of combustible MSW in metric tons (MT) x 1000/860

= 3096.50 x 72.22 x 1000/860

= 2, 60,000 KWh

Calculation of power generation potential

Power generation potential = 1.16 x NCV x Weight of combustible MSW in metric tons (MT)/24

= 1.16 x 3096.50 x 72.22/24

= 10.8 MW

From the results presented, it is concluded that the MSW from the Kurnool Municipal Corporation has huge potential to generate electric power. The power produced has great significance in the current power deficit coupled with increasing consumption. It is suggested to establish a MSW power plant in the Kurnool city, which is a best alternative for handling ever-increasing quantity of MSW and in showing the source for power generation.

ACKNOLEDGEMENT

The author is thankful for the financial support provided by the UGC Minor Project entitled "Waste to Energy from the Municipal Solid Waste of Kurnool City, Andhra Pradesh, India". Special thanks to G. Pulla Reddy Engineering College (Autonomous), Kurnool authorities for providing all facilities and encouragement.

REFERENCES

1. A. Pappu, M. Saxena and S. R. Asokar, Solid Waste Generation in India and their Recycling Potential in Building Materials, J. Build. Environ., **42(6)**, 2311-2324 (2007).
2. S. Rathi, Alternative Approaches for Better Municipal Solid Waste Management in Mumbai, India J. Waste Management, **26(10)**, 425-721 (2006).
3. http://www.aponline.gov.in/quick%20links/apfactfile/info%20on%20districts/kurnool.html.
4. R. Balasubramanian, Secretary, Tamil Nadu Electricity Regulatory Commission, Chennai. Interview 2008-09-24.
5. New Energy India, available at http://www.newenergyindia.org.
6. Report on Status on Municipal Solid Waste Management in Gwalior City 2010-11 by Central Pollution Control Board, Central Zonal office, Bhopal.
7. Ministry of Non-Conventional Energy Sources, Government of India, Energy recovery from waste, available at http://mnes.nic.in/booklets/Book5-e.pdf
8. T. Ramachar et al., Municipal Solid Waste Management (MSW) Scenario in Kurnool City, Andhra Pradesh, India. Global J. Res. Engg. (C), **12(II)**, Version I (2012).
9. H. S. Peaey, D. R. Rawe and G. Tehobanoglous, Enviuronment Engineering, Mc Graw-Hill Book Company, Singapore (1985).
10. Ministry of Environment and Forest, Govt. of India, MSW (Management and Handling Rules 2000) Available on Line at www.mnef.nic.in (2000).
11. Bhagavati Ana Labs Pvt. Ltd.7-2-C14, Industrials Estate, Sanathnagar, Hyderabad, Test Report No.BALPL/13-14/ITD-2425.
12. urbanindia.nic.in/publicinfo/swm/chapter15.pdf.

Accepted : 21.08.2014