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Solid Waste Management-Incineration of Solid Waste of Karachi

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Abstract: Solid waste management in urban areas like karachi is difficult to handle not only because of its varied composition but due to unavailibility of proper disposal sites and it is getting severe as the population growth is increasing. Samples from one of the solid waste disposal sites were examined on the basis of physical composition. Since solid wastes are classified based on municipal, agricultural, mining & quarrying, energy generation and hazardous.

This paper elucidates that heating value was not feasible because of huge quantity of moisture that is due to improper segregation and extreme scavenging action for valuable items in waste. Therefore, different analytical methods are required to calculate heating value of solid waste on the basis of ultimate analysis, proximate analysis and physical composition.

Key words: Waste on energy generation, Solid Waste Management, Incineration of Waste

1. Introduction

Formation of any waste reduces natural resources, utilizes energy and water, exerts stress over land, spoils the environment and, finally, makes economic cost to manage it (Song, Li, & Zeng, 2015). In 1992 as per the UN conference on environment & development that solid waste management which sound environmentally must go beyond the safe disposal of waste, pay more attention on mitigating the waste and make best use of reuse and recycling of waste (Anilkumar & Chithra, 2016). To insure the needs of urban areas organic materials of wastage that contain compounds that might be chemically or biologically in nature are converted into desired products (Pleissner, 2016).

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Waste management is all about input for resources & development, environmental & financial concern and demand supply (Hornsby, Ripa, Vassillo, & Ulgiati, 2017). But we are still far away to achieve our targets in sustainable waste management though much innovative technologies are available along with their advancements (Zaman, 2016). Solid waste, which has all negative characteristics is harmful for human body and health also danger to environment (Lee, Kim, & Chong, 2016). Due to which proper solid waste management has become essential for being protective even for both the environment as well as human health (Younes et al., 2016).

The population of world has grown from 3100 million to 7000 million from 1960 to 2010 and is expected to give rise of 8000 million till 2025 (Scarlat, Motola, Dallemand, Monforti-Ferrario, & Mofor, 2015). Municipal Solid Waste of global collections to approximately 1300 million tons per year and is projected to escalate to approximately from 1300 to 2200 million tons per year till 2025 (Lee et al., 2016). According to the European Environment Agency, increasing, recycling and energy recovery helps not to achieve the emission targets but to mitigate greenhouse gas emission (Cucchiella, D'Adamo, & Gastaldi, 2014). Therefore, this energy which is recovered from waste can have a significant role in diminishing the impact Solid Waste on both the environment as well as health (Scarlat et al., 2015).

The primary objective of this research is to determine energy potential in solid waste at dump site where there is no proper supply of energy. This will not only fulfill resident's demand of energy in terms of thermal source of energy but will also help in reducing volume and mass of solid waste being brought there. The pilot incinerators will lead the direction for mass energy conversion units, if found economical and feasible.

2. Methodology

In urban areas it is difficult to maintain equilibrium between quality of life and protection of natural resources (Conke & Ferreira, 2015). Therefore, waste management comes into reality first by making an identification of different wastes and their origin. After that prevention of these wastes that are generated over span of time (Ion & Gheorghe, 2014).

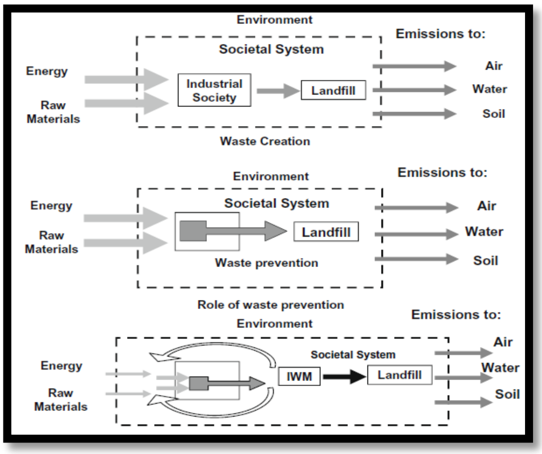

Fig. 1. Basic Role of Waste Management (Al-Salem, Lettieri, & Baeyens, 2009)

In **Fig. 1** Basic role of waste management is described that at the time of waste creation over environment, Energy and raw materials are simply exposed to landfill causing detrimental effect to society while in contrast if waste is being processed prior dumping its lost energy can be utilized.

Enhanced resource efficiency and mitigated greenhouse gas efforts have improved solid waste management by utilizing ample energy resources (Turner, Williams, & Kemp, 2016). Pakistan is maintaining 135 ranks worldwide by contributing 0.8 % to total greenhouse gas emission and its position is expected to rise by 2030 due to numerous factors discussed earlier (Korai, Mahar, & Uqaili, 2016).

Due to the increasing number of cities more consumption and urbanization can have damaging effects on urban communities which in turn demands a zero waste city (Mesjasz-Lech, 2014). The society practice on their environments in perspective of waste and its consequences on are termed as the “sense of cleanliness” (Permana, Towolioe, Aziz, & Ho, 2015). Solid waste management most of the times requires a substantial proportion of the total persistent municipal budget indeed (Lohri, Camenzind, & Zurbrügg, 2014).

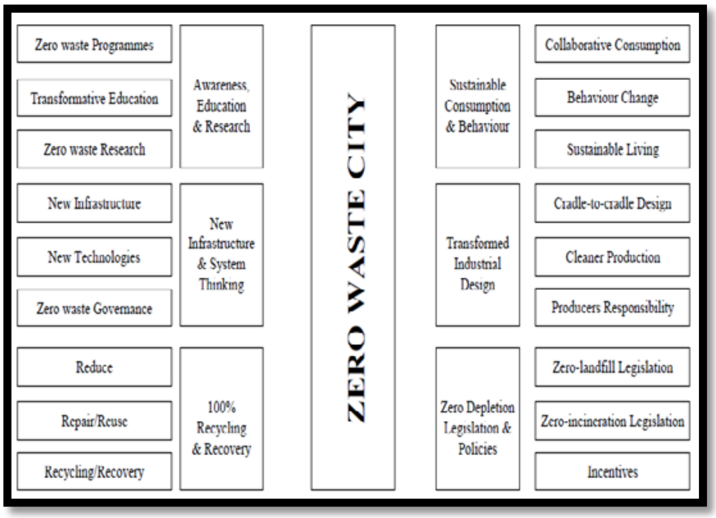

Fig. 2.Zero Waste City (Mesjasz-Lech, 2014)

Fig. 2 describes that in order to have Zero Waste City there must be new infrastructure that must be in conjunction with new technologies so that Zero waste research can be progressed leading towards 3R i.e. Reduce, Reuse & Recycle. The outcomes of Zero Waste City have tremendous effect over human health and environment.

It is a process of recovering energy from waste in the form of electricity and heat. As we go in past, in order to inhibit dangers to human health, waste incineration was the sole technology to lessen the quantity. Nowadays energy recoveries go hand in hand with waste incineration. The example for energy recoveries are Denmark and Sweden because they have been generating energy for more than a century (Bosmans, Vanderreydt, Geysen, & Helsen, 2013).

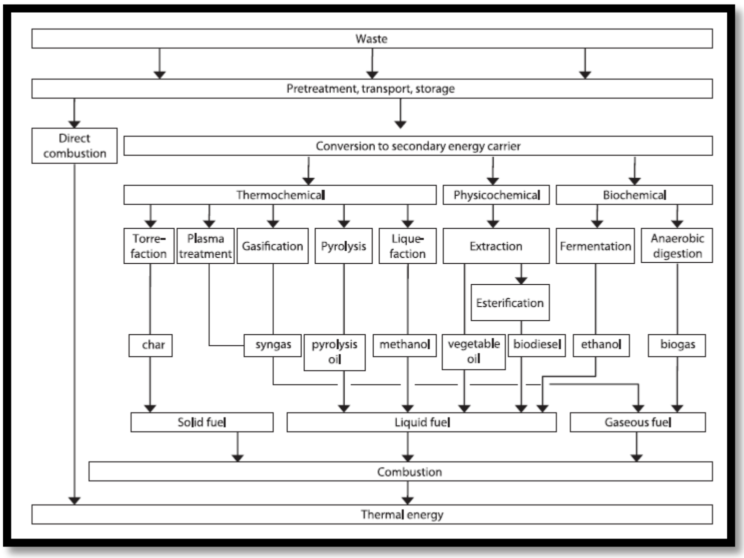

Fig. 3. Waste to Energy Generation (Bosmans et al., 2013)

In **Fig. 3** the hierarchy of energy generation from waste is given that either thermal energy is generated by direct combustion or by simply combustion followed by Solid, Liquid and Gaseous Fuel. As primary sources of these are many but they all are simply conversion to secondary energy carrier.

Therefore, a considerable percentage of municipal solid waste is being involved in usage of waste to energy plants because in waste incineration most toxic organic wastes are demolished (Brunner & Rechberger, 2015).

Waste creation that it requires energy and raw material. Waste management is not only the responsibility of local authorities but its efficiency depends upon the participation of both the municipal agency and people (Guerrero, Maas, & Hogland, 2013).

Samples of solid wastes were collected from the dumping site Jam Chakro. Jam is Chakro is government designated waste dumping site which is spread over 1600 acres near Surjani. The road leading to the Jam Chakro waste-dumping site was found covered with Smoke blowing up from garbage dumps.

Classification of solid wastes based of their resources are (Peavy, 1985):

- Municipal Wastes
- Industrial Wastes
- Agricultural Wastes
- Mining and Quarrying Wastes
- Energy Generation Wastes
- Hazardous Wastes

Table 1 Solid waste of Karachi (Ali & Hasan, 2011)

Waste Source	***Quantitie (tons/day)***
Households	4500
Large Markets	50
Street Sweepings	200
Large Hospitals	8
Cantonment	500
Airport	6
Karachi Port Trust	6
Buffaloes Yard (Landhi)	50
Slaughter House	10
Total	**5330**

Table 1 shows Waste sources that are collected from different roots. Among all these sources, Households waste has no comparison with rest of waste sources as it contributes significant amount in tons/day.

Solid Waste dumpsters in Karachi

The solid waste from all over the city is being dumped openly, legally and illegally out of which a small fraction reached properly to the dumping sites. The following are major legal and illegal dumped sites in Karachi:

Table 2 Dumping Sites in Karachi (Ali & Hasan, 2011)

Site Name	***Tons/day***
Jam Chakro	1200
Gond Pass	1600
North Karachi, Saba Cinema	200
Korangi 5	250
Lalabad Landhi	250
Korangi 3.5 (Ibrahim Haidri Police Station)	250
Korangi 1.5 near 100 quarters	300
Total	**4050**

Table 2 shows Dumping Sites in Karachi, these are the official dumping sites as per the source. Major wastage dumps in Gond Pass and Jam Chakro which almost represent 45% of the total.

Table 3 Population scenario of Karachi (Qureshi, 2010)

S.No	***Towns***	***Population Projection for 2005 @ 5% AAGR (Million)***	***Population Projection for 2010 @ 4.5% AAGR (Million)***	***Population Projection for 2015 @ 4.5% AAGR (Million)***	***Population Projection for 2020 @ 3.5% AAGR (Million)***
1	Keamari	0.5836	0.7309	0.8927	1.0635
2	SITE	0.7099	0.8891	1.0859	1.2936
3	Baldia	0.6167	0.7723	0.9433	1.1237
4	Orangi	1.0989	1.3761	1.6808	2.0023
5	Lyari	0.9232	1.1561	1.4121	1.6821
6	Saddar	0.9356	1.1716	1.4310	1.7047
7	Jamshed	1.1142	1.3954	1.7043	2.0303
8	Gulshan e Iqbal	0.9494	1.1889	1.4521	1.7298
9	Shah Faisal	0.5099	0.6386	0.7800	0.9291
10	Korangi	0.8298	1.0392	1.2693	1.5120
11	North Nazimabad	0.7534	0.9435	1.1524	1.3728
12	North Karachi	1.0389	1.3010	1.5890	1.8929
13	Gulberg	0.6886	0.8623	1.0532	1.2547
14	Liaquatabad	0.9856	1.2343	1.5075	1.7958
15	Malir	0.6048	0.7574	0.9250	1.1019
16	Bin Qasim	0.4809	0.6022	0.7355	0.8762
17	Gadap	0.4397	0.5506	0.6725	0.8011
18	Cantonment	0.4649	0.5822	0.7111	0.8471
19	Defence	0.3796	0.4754	0.5806	0.6918
Total		**14.1074**	**17.6671**	**21.5786**	**25.7055**

Table 3 includes population projection scenario of 19 towns of Karachi. It can be seen in just 15 from 2005 to 2020 that there is almost 100 & rise at 3.50% AAGR.

There are different analytical methods to determine the heating values of Solid wastes on the basis of: Ultimate analysis, proximate analysis and physical composition. We have calculated the heating value based on Physical Composition.

Composition analysis of solid waste at dumped site

Composition of solid wastes varies from place to place because it extremely depends on the life style and class of the residents of respective area. For this purpose a dumping site was selected for the determination of composition of solid waste rather than considering a small locality or area and to get an approximate true sample. Jam Chakro, one of the biggest dumping sites located at 10 km from North of Karachi was visited and sampling process was carried out by the scavengers of that area. The people revealed that they use to liter the solid wastes being dumped there in order to get any valuable remaining pieces of metals, glass etc; they sell these stuff to pass their lives. For this purpose they have distributed the dumping site among them and have their own manual weight balances. For sampling purpose a newly arrived dumper of Al-Khalid Agencies was selected and 10 samples each of 50 kg were taken out, segregated by local people and composition of samples were statistically determined on mass basis. The following is the statistical data for samples:

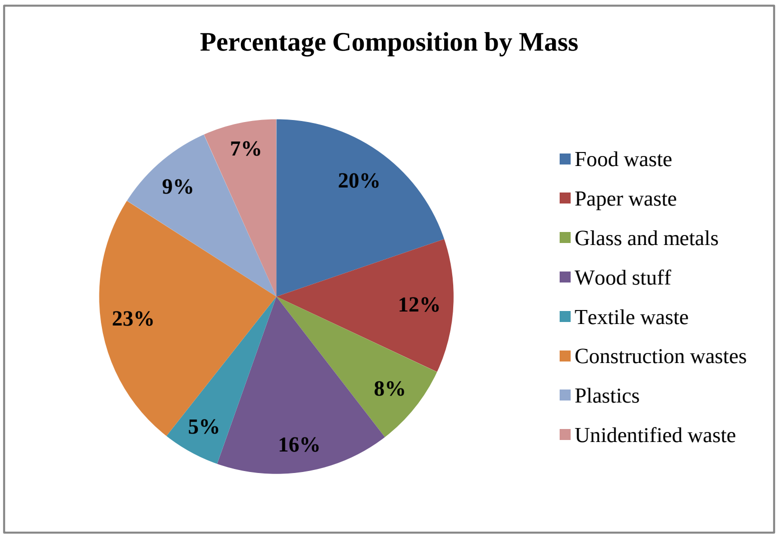

Fig.4 Composition by mass

Fig.4 is showing the percentage composition of different sources that contribute to create waste, but as it can be seen that construction and food waste are having significant contribution.

Calculations for Higher Heating Value

Higher heating value (HHV) is calculated by following formulas (Kathiravale, Yunus, Sopian, Samsuddin, & Rahman, 2003):

$$HHV\left(\frac{kJ}{kg}\right) = 112.157Ga + 183.386Pa + 288.797PI + 5064.701 \text{ …. Eq. (1)}$$

$$HHV\left(\frac{kJ}{kg}\right) = 81.209Ga + 285.035PI + 8724.209 \text{ …. Eq. (2)}$$

$$HHV\left(\frac{kJ}{kg}\right) = 112.815Ga + 184.366Pa + 298.343PI - 1.920W + 5130.380 \text{…. Eq. (3)}$$

Where,

HHV = net calorific value

W = wt% of total moisture

Pa = wt% of paper

Ga = wt% of garbage/food

Te = wt% of textile

Pl = wt% of plastics

By using Eq. (1)

$$HHV\left(\frac{kJ}{kg}\right) = (112.157 * 17) + (183.386 * 8) + (288.797 * 8) + 5064.701$$

= 8668.354 KJ/50Kg

By using Eq. (2)

$$HHV\left(\frac{kJ}{kg}\right) = (81.209 * 17) + (285.035 * 15) + 8724.209$$

= 14380.287 KJ/50Kg

By using Eq. (3)

$$HHV\left(\frac{kJ}{kg}\right) = (112.815 * 17) + (184.366 * 8) + (298.343 * 15) - (1.920 * 20) + 5130.380$$

= 12959.908 KJ/50Kg

Average Higher Heating value comes out to be = 12002.85 kJ/ 50kg

Average Higher Heating value = **240 kJ/kg**

<u>Calculations for Lower Heating Value</u>

Lower heating value (LHV) is calculated by following formula (Chang, Lin, Chyan, Chen, & Chang, 2007; Peavy, 1985):

$$LHV\left(\frac{kJ}{kg}\right) = \left\{[88.2PPL + 40.5\ (PFO + PPA)]\left(\frac{100-W}{W}\right) - 6W\right\} \ldots \text{ Eq. (4)}$$

$$LHV\left(\frac{kJ}{kg}\right) = 229.91 + 7.9PPA + 28.16PPL + 4.87PGA - 37.28W \ldots \text{ Eq. (5)}$$

Where

PPL = wt% of plastics

PFO = wt% of food waste

PPA = wt% of paper

W = wt% of moisture Content

PGA = wt% of garbage.

By using Eq. (4)

$$LHV\left(\frac{kJ}{kg}\right) = \left\{[(88.2 * 15) + 40.5\ (17 + 8)]\left(\frac{100 - 20}{20}\right) - (6 * 20)\right\}$$

= 9222 kJ/50kg

Similarly by using Eq. (5)

$$LHV\left(\frac{kJ}{kg}\right) = 229.91 + (7.9 * 8) + (28.16 * 15) + (4.87 * 17) - (37.28 * 20)$$

= 52.7 kJ/50kg

Average Lower Heating value comes out to be = 4637.35 kJ/ 50kg

Average Lower Heating value = **92.75 kJ/kg**

3. Conclusions

The minimum calorific value for an economical incinerated waste should be 2000 KJ/Kg but from above numbers it can be easily concluded that solid wastes at Jam Chakro is week in calorific value and cannot be used for energy recovery. The main reason that can be is the scavenging process within the city which basically takes away all the materialistic or energy rich stuff for reuse, recycle and resale with highly biodegradable waste left behind that ultimately comes to the dumping site. Therefore, any of the biodegradable energy recovery process can be considered to get rid of this waste in fruitful manner.

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