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Improve the Calorific Value of Municipal Solid Waste By Adding Additive Material For Incineration Process

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Abstract : *Rapid increase in urbanization and per capita income has lead to high rate of Municipal Solid Waste(MSW) generation (0.34kg/capita/day in 2016) and it is expected to have even higher rate of 0.70 kg/capita/day. In many developing countries solid waste is collected from the source and is disposed by open dumping. There is very minimal treatment and very less human control in open dumping. Open dumping has huge environmental impacts. Hence, a better approach to this situation is needed. Many methods like bioreactor landfill have been successfully implemented in many developing countries but these methods have large area demand and large operational and maintenance costs. Also, these methods are centralized incurring large transportation costs.*
Incineration is successfully practiced in many countries across the world. The high calorific values of the materials in the waste are used to generate thermal energy which can be further transformed to electrical energy. The flue gases can be treated and the pollution load on the environment can be handled easily. Recent trends of MSW composition have shown the reduction in the organic matter content and increased in the material that can be incinerated giving an opportunity to explore the potential of incineration in India.
The present study deals with increasing the calorific value of the municipal solid waste in India by adding the low cost additive materials. The additive materials selected were Wood Coal, Coconut Husk, Rice Husk, Bagasse, Engine Oil. The experimentation consists of two parts finding out initial characteristics of MSW and finding calorific value of MSW after adding additive materials with different proportions. The additive materials selected were cheaper and were added in proportion of 20%, 30%, 40%, 50% with the waste that will be incinerated. For 70% Waste + 30% additive material proportion, calorific value obtained from all additive materials are in desirable range 1500 – 2400 kcal/kg.
Keywords *- Municipal Solid Waste, Calorific value, Incineration, additive materials.*

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I. Introduction

Urbanization and industrialization have resulted into depletion of conventional resources of energy so its need of time to think about other various sources for generation of energy.

Due to the population growth and changing life style rate of municipal solid waste (MSW) generation is also increased. Treatment of such large quantity of MSW is one of the major concerns facing by India. Today average MSW generation rate in India is about 0.45 kg/capita/day. Most of the states like Delhi, Gujarat, Tamil Nadu have higher rates than average. Such vast amount of MSW, nearly hundreds of tons generated every day also generate problems for transportation, treatment and its disposal. So, its need of time to adopt an environment friendly waste to energy technology as effective alternative to conventional method which will overcome all problems raised due to conventional MSW treatment method. Cities in India have shown varied composition depends on various factors. Experimentation was done at Moshi landfill site by using coning and quartering method and observed composition is shown in table.

Table No.1 Composition of MSW

Sr. No.	Components	Percentage
1	Organic matter	57.33
2	Plastic	13.94
3	Paper	11.84
4	Glass	8
5	Cloths	6.5
6	Inert	1.59
7	Metals	0.8

(Source: Experimental study of Landfill site at Uruli Devachi)

1.1 Current MSW disposal techniques

1.1.1 Open dumping-

This technique is used most oftenly in the developing countries. MSW is dumped on open land away from city area. This is cheapest method involves collection and transportation costs only. But ground water pollution caused due to leachate percolation, air pollution and unhygienic condition at dumping site are the major problems and time required for exist degradation is also unpredictable.MSW is also dumped into the sea water but this causes lots of problems to aquatic life and it results into depletion of marine biodiversity

1.1.2 Composting-

Compostable matter and recyclable matter are segregated and compostable matter is decomposed aerobically. One of the major advantage of this method is compost formed. Segregation of MSW is required for composting and this is very tedious and difficult job also this is time consuming process and large area requirement is also one of the disadvantages.

1.1.3 Bioreactor landfill-

Impervious material is laid on which MSW is dumped and then it is buried and sealed. Leachate produced from this MSW is pumped and again spread over MSW to enhance degradation process. According to reactions taking place in the landfill. This bioreactor landfills are classified as –

Aerobic bioreactor landfill, Anaerobic bioreactor landfill, Facultative bioreactor landfill

To achieve the shorter stabilization time hybrid approach can be implemented within landfill sites. Bioreactor landfill operated in anaerobic stage to extract proper amount of methane gas. Once gas is extracted suitable amount of air is supplied to enhance the rate of degradation

1.1.4 Incineration-

This is mechanicall method involving combustion of MSW at very high temperature in a close reactor. This process requires very less time as compare to other treatment method. Volume of MSW up to 80-90 % is reduced by incineration process. By using incineration process MSW can be used as a source for generation of energy. For incineration process calorific value of MSW should be between 1500 to 2400 kcal/kg.

India is one of the fastest growing country. It has been predicted that the population of India in 2051 will be 1823 million and its MSW generation will be 300 tons/day. Large area will be required to dispose this waste by the conventional methods. Incineration method for MSW disposal can be thought of great alternative as it practically required very less land for disposal. Also, the percentage of the material that can be incinerated is increasing in the composition of the waste.

The study in the research paper is focused upon experimentation to enhance the calorific value of waste from 800-900 kcal/kg to 1500-2400 kcal/kg by adding economically viable additive material.

II. Incineration And Need Of Experimentation

Incineration is one of the mechanical treatment which can be used for disposal of MSW. In incineration process, mass burning of solid waste takes place at high temperature and energy is produced. Significantly, volume of waste is reduced by 90%. The incineration process in brief is represented in Fig. No.1

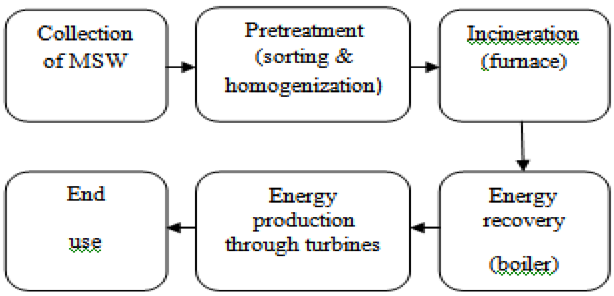

Fig No.1 Flow chart of incineration Process

Metals, Glass and inert materials are sorted from MSW. Pre-treatment in the form of shredding of the waste accelerates the combustion process. The pretreated MSW moves to a furnace. The moisture content of the waste is also removed during movement towards kiln. The waste is incinerated at the temperature range of 850°C -1200°C with supply of air. The heat energy from the flue gases converts the water to steam. Turbines are employed to convert steam energy to electrical energy.

Present calorific value of the composite MSW in India is in the range of 800-1000 kcal/kg. The lower calorific value is due to the higher organic content and its moisture content. To make incineration process work for Indian scenario, the additive material which will enhance the calorific value to the workable range of incineration needs to employed. Present experimentation focuses on use of economic additive materials such as rice husk, coconut husk, waste engine oil, bagasse, etc.

III. Experimentation

3.1 Selection of additive materials

To handle the large quantity of the waste as fuel, the quantity of the additive material required will be large. The additive material selected should be available for maximum period of the year and in enough quantity and should also be economical. Materials selected as additive material were rice husk, coconut husk, waste engine oil, bagasse, etc.

3.2 Determination of appropriate proportion of additive materials

The experimental proportions of the MSW and additive material were selected so as to achieve the calorific value of the mixture within the range. The percentage of the additive material was decreased gradually to get the minimum requirement of additive material, so as to achieve economy. The selected proportions are 50% waste +50 % additive material, 60% waste +40% additive material, 70% waste +30% additive material, 80% waste +20% additive material.

3.3 Characteristics of municipal solid waste

As glass, metal, rubber and inert material are recycled. These materials were neglected during the proportion of the composite waste. The proportion consider for composite waste is in following table no 1.

Table No.2 Composition of composite MSW

Sr. No.	Components	Percentage
1	Organic matter	63.8
2	Plastic	15.6
3	Paper	13.3
4	Cloths	7.3

Table No.3 Characteristics of composite MSW

Sr. No.	Sample	Moisture Content (%)	Volatile Matter (mg/kg)	Calorific Value (kcal/kg)
1	Waste	49.99	359.469	855.733

3.4 Characteristics of additive materials

Table No.4 Characteristics of Additive Materials

Sr. No.	Additive Material	Moisture Content (%)	Volatile Matter (mg/kg)	Calorific Value (kcal/kg)
1	Coconut Husk	20.2	732	3844.15
2	Wood Coal	0	389.29	4403.45
3	Bagasse	16.4	804	2199.15
4	Rice Husk	7.4	614	2922.95
5	Rice Husk (Powder)	9.6	758	4633.75

3.5 Determination of calorific value

Fig No.2 Bomb Calorimeter Setup

Bomb Calorimeter is used for finding calorific value using following formula:

Calorific Value = $\{(W + w) * (t_2 - t_1) - (C_a + C_f + C_{ct})\} / m$ (Kcal/Kg)

Where: W – Mass of water taken into calorimeter (Kg)

w – Water equivalent of calorimeter bomb, thermometer, stirrer (Kg)

t_1 – Initial temperature of water in calorimeter

t_2 – Final temperature of water in calorimeter

C_a – Acid correction (for 1mg sulphur = 2.25 Kcal/Kg)

C_f – Fuse wire correction (for Nickel chrome wire=35Kcal/Kg)

C_{ct} – Cotton Thread Correction $\{(1.9+1.39) *0.05)/(0.051*10^{-3})$ =3225 Kcal/Kg}

IV. Result

4.1 Results for composition of MSW + Wood Coal

Table No.5 Result for MSW + Wood Coal

Sr. No.	Composition	Moisture Content (%)	Volatile Matter (mg/kg)	Calorific Value (kcal/kg)
1	50%(W) + 50%(AM)	24.371	330.792	4173.2
2	60%(W) + 40%(AM)	31.557	505.805	3208.1
3	70%(W) + 30%(AM)	36.084	297.621	2528.2
4	80%(W) + 20%(AM)	42.065	305.711	1870.2

4.2 Results for composition of MSW + Coconut Husk

Table No.6 Result for MSW + Coconut Husk

Sr. No	Composition	Moisture Content (%)	Volatile Matter (mg/kg)	Calorific Value (kcal/kg)
1	50%(W) + 50%(AM)	27.242	619.579	3120.4
2	60%(W) + 40%(AM)	30.460	528.00	2265
3	70%(W) + 30%(AM)	38.766	480.855	1442.5
4	80%(W) + 20%(AM)	41.567	474.041	1146.4

4.3 Results for composition of MSW + Rice Husk: -

Table No.7 Result for MSW + Rice Husk

Sr. No.	Composition	Moisture Content (%)	Volatile Matter (mg/kg)	Calorific Value (kcal/kg)
1	50%(W) + 50%(AM)	23.88	258.989	3120.4
2	60%(W) + 40%(AM)	30.95	490.428	2561.1
3	70%(W) + 30%(AM)	35.68	436.464	1870.2
4	80%(W) + 20%(AM)	42.43	440.433	1212.2

4.4 Results for composition of MSW + Bagasse: -

Table No.8 Result for MSW + Bagasse

Sr. No.	Composition	Moisture Content (%)	Volatile Matter (mg/kg)	Calorific Value (kcal/kg)
1	50%(W) + 50%(AM)	28.457	712.135	2418.483
2	60%(W) + 40%(AM)	33.227	323.106	1979.817
3	70%(W) + 30%(AM)	37.236	507.051	1519.217
4	80%(W) + 20%(AM)	42.008	532.757	1168.283

4.5 Results for composition of MSW + Engine Oil: -

Table No.9 Result for MSW + Engine Oil

Sr. No.	Composition	Moisture Content (%)	Volatile Matter (mg/kg)	Calorific Value (kcal/kg)
1	50%(W) + 50%(AM)	28.186	660.465	3493.21
2	60%(W) + 40%(AM)	31.812	615.465	3087.45
3	70%(W) + 30%(AM)	34.826	574.999	2495.25
4	80%(W) + 20%(AM)	42.976	488.319	1837.25

V. Discussion

1.2 Moisture Content

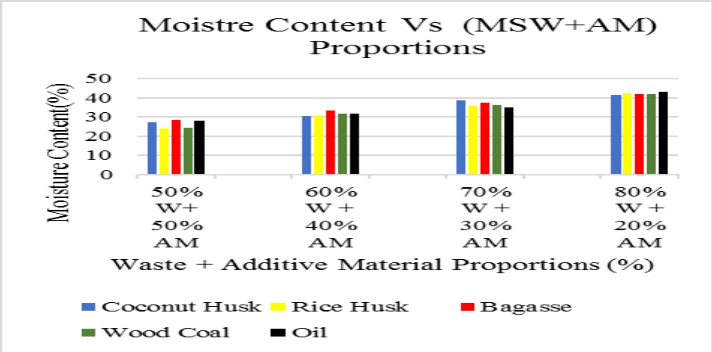

Fig. 3 Moisture Content of all Compositions

Minimum value of moisture content obtained was 23.87% by 50%W+50%AM proportion for rice husk additive material. Maximum value of moisture content obtained was 42.97% by 80%W+20% proportion for Engine oil additive material. As the quantity of MSW increases in the proportion, the value of moisture content also increases.

5.2 Volatile Matter

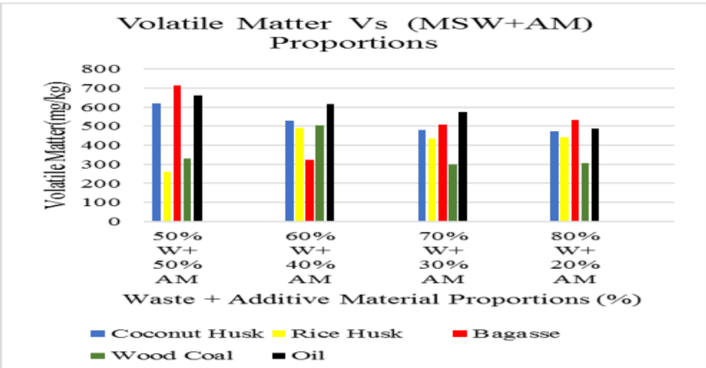

Fig. 4 Volatile Matter of all Compositions

Minimum value of Volatile Matter obtained was 305.71 mg/kg by 80%W+20%AM proportion for wood coal additive material. Maximum value of Volatile Matter obtained was 712.13 mg/kg by 50%W+50%AM proportion for bagasse additive material. As the quantity of MSW increases in the proportion, the value of volatile matter decreases.

5.3 Calorific Value

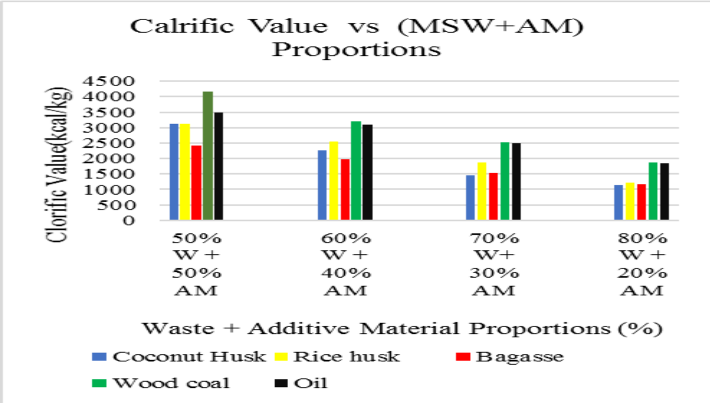

Fig. 5 Calorific Value of all Compositions

Maximum calorific value obtained was 4173.15kcal/kg by 50%W+50%AM proportion for Wood coal. Minimum calorific value obtained was 1146.35kcal/kg by 80%W+20%AM proportion for coconut husk. As the quantity of MSW increases in the proportion, the calorific value is decreases.

VI. Conclusion

As the quantity of waste increases in the proportion it increases the moisture content and decrease the volatile matter and calorific value.

Following proportions gives the required range of calorific value-

i) 80%W+20%AM wood coal
ii) 80%W+20%AM oil
iii) 70%W+30%AM rice husk
iv) 60%W+40%AM bagasse
v) 60%W+40%AM coconut husk

From decided proportions, 70%W+30%AM proportion is the best suitable option for incineration process as calorific value obtained is in the desired range 1500 to 2400 kcal/kg.

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