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Food Waste Management: An Innovative Approach

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Abstract: ***Biodegradable component of municipal solid waste (MSW) may vary but generally is about 60 %, and food waste is about 60 % of the biodegradable component. In a city like Delhi a total of 8000 MT day-[1] MSW is generated (CPCB 2012) and food waste may account for about 2700 MT. Food waste is generated by households, hotels and restaurants etc, and marketplaces. Due to deficient collection and ineffective monitoring and control, food waste is thrown on the street and footpath eventually being swept away in drains causing choking of drains and eutrophication. Cooked food to the extent of 40 – 60 % is wasted in different countries, and India is no exception. Putrefying food waste attracts flies, rodents, rats, dogs, birds, and all sorts of scavengers, emit foul smell, and causes environmental degradation. Flies are a known vector of many communicable diseases. Birds get attracted to the putrefying waste by itself as well as by the maggots which may breed in the putrefying food waste. Bird hits are a common cause of aircraft disability, including disasters. Current system of collection transportation and disposal by composting has not been successful in any urban locality in India. Composting require large area of land (not easily available). Treated compost by compost machines also require storage for curing for a period, at least for 7-10 days before it can be used as manure. Energy recovery requires sophisticated equipment and transfer of the waste in shortest possible time so that energy content in food waste does not get dissipated, and may be a factor for climate change. As per Indian rules (MSW Rules 2000) food waste is to be composted and not sent to landfill. Considering the inadequacy in proper food waste management, and its damaging fallout on the environment and human health a system of food waste management by application of thermal energy, a non burn process has been developed and tested. Putrefaction process in the food waste is arrested by destroying the enzymes and the end product can be used as manure or source of fuel, as the treated waste retains nutrients and calorific value. Advantages are that it is environment friendly process; end products are reusable, and the saves on carbon dioxide and methane emission. Being non burn process it qualifies for carbon credit.***

Keywords: Municipal Waste, Non-Burn Technology, Carbon Credit, Food Waste, Putrefaction, Eutrophication.

1. Introduction

Biodegradable component of municipal solid waste (MSW) may vary but generally is about 60 %, and food waste is about 50-60 % of the biodegradable component. Food waste is generated by households, hotels, and restaurants etc., and marketplaces where food hawkers are in abundance on the streets and footpaths. Due to deficient collection, ineffective monitoring and control food waste is thrown on the street and footpath eventually being swept away in drains causing choking and eutrophication. Putrefaction continues in food waste by enzyme activity. Cooked food to the extent of 40 – 60 % is wasted in different countries and India is no exception. America throws away 43.6 million tons of food each year (US EPA 2000), and as per another report 50 % of its food (foodnavigator-usa.com 2009). In the UK 6.7 million tonnes food waste gets generated in a year amounting to £ 10.2 billion per year (The Observer 2007). In the food processing industries, up to 30% of incoming raw materials becomes waste rather than a value-added product (Schaub 1996). In another study it was found that food waste comprised of 50 % of domestic waste (Qdais H. A. Abu 1997). Food waste impacts environment and eventually human health in many ways. Environmental impact of food waste has been reported to have eutrophication potential, acidification potential, and global warming potential (Bernstad 2012).

Putrefying food waste attracts flies, rodents, rats, dogs, birds, and all sorts of scavengers, emits foul smell, and causes environmental degradation. Flies are a known vector of many communicable diseases. Birds get attracted to the putrefying waste by itself as well as by the maggots which may breed in the putrefying food waste. Bird hits are a common cause of aircraft disability, including aviation disasters (Hindustan Times 2011). Current system of collection transportation and disposal by composting has not been successful in any urban locality in India. Composting require large area of land-not easily available. Treated compost by compost machines also requires storage for curing for a few days before it can be used as manure. Energy recovery (waste to energy concept) requires sophisticated equipment and transfer of the waste in shortest possible time so that energy content in food waste does not get dissipated. As per Indian rules-MSW 2000, food waste is to be composted and not sent to landfill as in the landfill methane is released which may be 21 times more damaging to the environment compared to carbon dioxide (Asnani 2008).

2. Concept

Considering the inadequacy in proper food waste management, and its damaging fallout on the environment and human health a machine for food waste management by application of thermal energy under controlled condition based on non burn process has been fabricated (VEGMA FOODSTER), and tested. Putrefaction process in the food waste is arrested by destroying the enzymes, and proteins get stabilized by denaturing-an irreversible process (www.friedli. com) and the end product can be used as manure or source of fuel as the treated waste retains all ingredients, including calorific value. Advantages are that it is rendered non attractive to flies, birds, and other scavengers and is environment friendly process. The end products are treated food waste which can be used as manure or fuel pallets, and steam/water which may be used as

distilled water for commercial purposes, and the process qualifies for carbon credit.

The technology offered works at the doorstep of waste generation, thus ensuring 100 % collection of waste. It can work in close proximity to the households through Resident Welfare Associations (RWA), and market places, eating joints, hotels and cafeteria etc, thus eliminating the requirement of transportation. Power Consumption would be about 3-4 KW /hr and cost would be about INR 250 per day assuming that the machine runs 16 cycles day-[1]. One cycle would be of about 30 to 50 minutes duration (depending upon moisture content). About 15 Kg waste would be treated in one cycle (as per the capacity of the vessel of the prototype developed). Treated waste would have a monetary value as manure/fuel pallets and distilled water. There will be no expenditure on transportation stage II and III (carrying the waste in motor vehicles), intermediary storage (*Dhalaos)*, and land requirement for composting or landfill.

It is an innovative approach to the perpetual problem of management of food waste. Food waste is a global problem. When left on streets and pavements etc it gets washed in drains, thus choking it and higher nitrogen content would cause eutrophication of water bodies. A pilot study was undertaken which supports the hypothesis that food waste once subjected to thermal application under controlled process become stable and further putrefaction is arrested. Empirical observation confirms that once treated in the process it becomes non-attractive to flies, birds, scavengers etc even if left in the open for a few days.

3. Material and Method

3.1 Material

The machine for food waste management has been fabricated (figure 1) with help from one engineering firm – "Micro Engineering, New Delhi". The materials used were:

a) Boiler-5kg/hr capacity of steam
b) Feed water pump with 1hp motor
c) 3hp variable speed motor fitted with shredder blade assembly
d) Outer shell of 18'' diameter having length of 700-750mm
e) Inner shell of 16 inches diameter of same length
f) Shredder blades are of SS sheet of thickness 3-4mm
g) Water level controller for boiler, pressure gauge, temperature, Gauge, safety valve, and auto cut-off.
h) Electrical panel fitted with MCBs for boiler, feed water pump, motor of machine and other control devices.

Note – Once the boiler is heated electricity consumption would reduce substantially. Shredder is operated intermittently. Feed water pump also works intermittently and is controlled by an auto cut arrangement.

The Machine

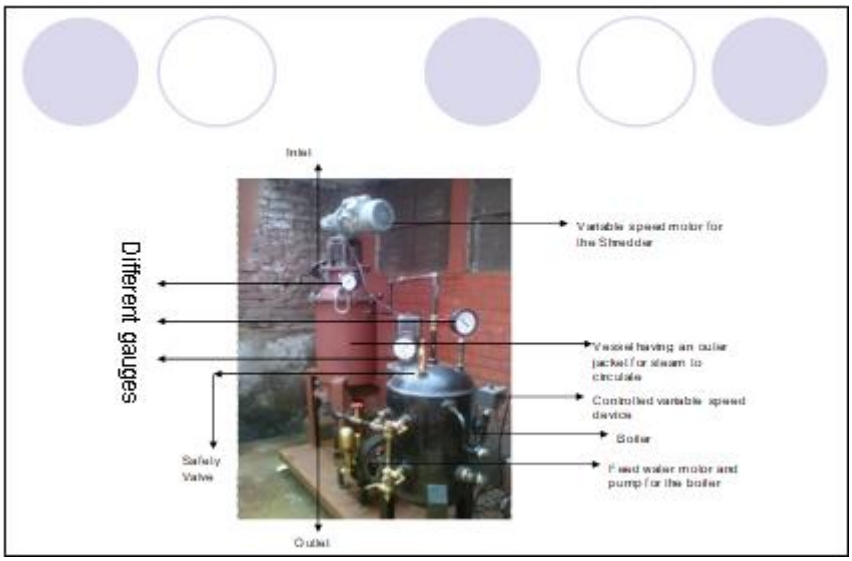

Figure 1: Vegma Foodster

2. Assorted food waste collected from households and roadside eateries.

3.2 Methodology

Having conceived the idea that food waste can be treated by application of thermal energy a series of meetings with the designers-the Micro Engineering were held where the concept was further examined and design finalized. Based on the concept that proteins get denatured by application of thermal energy a machine was fabricated and run as pilot project. The denaturation process presumably involves an unfolding or at least an alteration in the nature of the folded structure of protein molecules. Protein gets denatured by application of thermal energy.

The process is simple. Assorted food waste was collected, measured by weight and fed into VEGMA FOODSTER through the inlet port. The lid was secured and boiler switched on. When it started giving steam the temperature climbed up and on reaching the desired temperature of 130^0 C steam was allowed to enter the outer jacket of the machine. The steam then circulated in the outer jacket-a sealed unit, and heat transfer took place incident on the heap of waste kept in the inner vessel. An in built shredder was operated intermittently to increase the surface area of waste for greater impact of thermal energy. Operating temperature

was maintained at 130-135^0 C for 40-50 minutes. Sample of food waste before and after treatment was collected for testing.

4. Findings and Discussion

Test runs indicated arrest of further degradation of food waste and it was observed that treated food waste no more attracted flies, birds and scavengers. Treated food waste was subjected to analysis in an accredited laboratory-Food Research & Analysis Centre, New Delhi (FRAC). Test results have been tabulated and placed at Table 1.

Test Results

Table 1: Test results

Parameters	Inlet Sample	Outlet Sample
Moisture %	66.59	55.16
Ash %	2.14	3.06
Fat %	1.78	3.21
Protein %	4.47	4.7
Carbohydrates %	25.02	33.87
Energy Kcal/100 gm	133.98	183.17
Phosphorus, mg/100 gm	78.98	99.58
pH	4.02	4.43
Enzymes	Present	Absent**

** Analysis of protease, amylase, and lipase only was done.

As a comparative study an assumed model of population of 50, 000 (10, 000 households) has been considered generating about 20000 Kg municipal solid waste day^{-1} [12, 000 Kg food waste (60 %, including food waste from hotels, restaurants, and roadside eateries etc in the community)]. Cost consideration under the present system and with the suggested food waste management system has been compared. Certain assumptions have been made in consultation with the municipal authorities (personal interview with the Chief Engineer, MCD, May 20, 2005) and assumptions made may be approximate, but valid.

Current system of collection, transportation and disposal by the municipal authorities and cost involved were studied. For this the transportation has been viewed in three components (stages 1 to 3) as under:
Stage 1-households to the kerb collection points,
Stage 2-kerb collection points to intermediary stotage stations,
Stage 3-intermediary storage stations to the composting area/landfills.

Stage 1 would remain the same for the current system and the proposed system, whereas stage 2 and 3 would be different. Assumptions made were:

- That solid waste generation from every household (comprising of 4 members on an average) would be 2 kg day-$^{1[at]}$0.5 kg per capita,
- That it will be a 2 bin system – one for biodegradable and another for non degradable for each household, replaced everyday.
- That 60 % of the waste would be food waste,
- That cost of collection bins, each hand cart, trucks/tippers, construction of intermediary storage stations, computed cost of landfill etc as shown in different tables,
- Similarly, pay of different workers for waste collection, transportation and disposal costs as shown in different tables,
- Commercial value of end products – manure or fuel pallets and reusable water as shown in respective tables.

All tables relate to a population of 50, 000 and the projected cost etc is for 5 years. The cost consideration has been worked out in three aspects – firstly common to both the systems (current practice and the suggested system), secondly, capital and recurring expense for the current practice, and thirdly, capital and recurring cost for the suggested food waste management based on VEGMA FOODSTER, and are depicted in the tables 2-8.

Cost Consideration Common to both Systems (All figures in INR)

Table 2: Cost consideration common to both systems

S. No.	Item/Number	Basis of calculation	Remarks	Cost
1.	Collection Bins/40, 000	2 bin system **2x2x10, 000x50**	Assumption – Bins cost INR 50 per piece	2 million
2.	Replacement of bins	10 % per year (Assumed)		1 million
3.	Waste Handlers/150	[at]3 per 1000 population	Average Pay – 5, 000 per month	45 million
4.	Supervisors/15	[at]1 for every 10 waste handlers	Average pay – 8, 000 per month	7.2 million
5.	Carts/100	[at]1 cart for every 100 household	Average cost 3000 per cart	0.3 million
6.	Cart Pullers/100	[at]1 for each cart	Average pay 2000 per month	12 million
7.	Total			67.5 million

Capital Cost Consideration: Current Practice (All figures in INR)

Table 3: Capital Cost: Current Practice

S. No.	Item/Number	Basis of Calculation	Remarks	Cost
1.	Landfill/1	Computed for 50, 000 population for 5 years based on MCD* inputs	Operational and Maintenance cost may vary widely	5 million
2.	Intermediary Storehouses/10	[at]0.5 million each	As per the MCD inputs	5 million
3.	Trucks/10	Considering volume of waste and distance etc.[at]6 million per truck	1 truck may be sufficient to cart not more than 3000 kg considering the volume	60 million
4.	Total			70 million

* Municipal Corporation of Delhi

Recurring cost Consideration: Current Practice (All figures in INR)

Table 4: Recurring Cost: Current Practice

S. No.	Item/Number	Basis of Calculation	Remarks	Cost
1.	Truck drivers/10	1 for each truck	[at]15, 000 per month	9 million
2.	Helpers/20	2 for each truck as per MCD* Norms	[at]5000 each	6 million
3.	Cost of Fuel	Approximate		3 million
4.	Maintenance	Approximate	10 % 0f cost of trucks per year	30 million
5.	Total			48 million

* Municipal Corporation of Delhi

Thus the total capital and recurring cost for the present system where the trucks have to be bought and maintained with drivers, helpers etc and the municipality has to incur cost of fuel would be 118 million. No offsets are available in the present system as the food waste is generally being sent to land dumps and not composted due to unavailability of land for composting. Fuel-mostly high speed diesel cause serious environmental pollution. In the current practice cost per kg would be INR 5.56, and cost per person per day would be INR 1.311, As against this, in the proposed system the capital cost would be INR 41.5 million (Table 5), and recurring cost would be INR 42.5 million (Table 6) totaling INR 84 million. It would be INR 1.55 per kg and INR 0.37 per person per day in the proposed system with offset (Table 8).

Capital Cost: Proposed System (All figures in INR)

Table 5: Capital Cost: Proposed System

S. No.	Item/Number	Basis of Calculation	Remarks	Cost
1.	Equipment/50	12, 000/240 (kg)	Assumption: Each machine may treat 240 kg of food waste in a day in 16 cycles	**[at]0.8 million x 50 = 40 million**
2.	Housing for the Equipment/50	Approximate	0.3 million each	**0.3x 50 = 1.5 million**
3.	Total			41.5 million

Recurring Cost: Proposed System (All figures in INR)

Table 6: Recurring Cost: Proposed System

S. No.	Item/Number	Basis of Calculation	Remarks	Cost
1.	Maintenance cost of the machines/50	Approximate	10 % of the cost of machines per year	20 million
2.	Electricity and water consumption/50	Based on test runs conducted	[at]250 per machine per day	22.5 million
3.	Total			42.5 million

Thus total expenditure in the proposed system would be INR 41.5 (capital) + INR 42.5 (recurring) = INR 84 million.

There will be offset value of INR 50.4 million thus reducing the cost of food waste management to INR 33.6 million in the proposed system (Table 7).

Offset Value: Proposed System (All figures in INR)

Table 7: Offset in the Proposed System

S. No.	Item	Basis of calculation	Remarks	Commercial value
1.	Treated waste (manure or fuel cake)	40 % of input weight, may yield 4800 treated waste per day (dry weight)	Generally, 60 % is the moisture content in food waste in India. Assumption – manure or fuel cake may have value of INR 5 per kg (dry weight)	[at]5 per kg=5x16x24, 000 per day= 43.2 million in 5 years
2.	Re usable water	[at]5 liters per machine per cycle	Total quantity may be 2000 liters per day after deducting process loss	[at]2 per liter = 2000x2x30x12x5=7.2 million
3.	Total offset value			50.4 million

Total expenditure in the proposed system works out to INR 84 (-) 50.4 million=INR 33.6 million, whereas expenditure in the current practice is INR 118 million. Thus a saving of INR 84.4 million (118-33.6 million) in 5 years for a population of 50, 000 can be realised. The process would also eliminate second and third stage transportation thus saving on burning of HSD and saving on environmental pollution.

Table 8: Showing Cost Comparison between the Current and Proposed Systems

Cost Comparison

Assumed model of 5 years for a population of 50,000 generating 12,000 kg food waste day-^{1} (all figures in INR)

Current Practice		Proposed System	
Landfill	5 million	Equipment	40 million
Dhalaos	5 million	Housing of Equipment	1.5 million
Trucks	60 million	Yearly Maintenance @ 10 %	20 million
Manpower	15 million	Electricity & Water Cost	22.5 million
Fuel	3 million	Total	84 million
Maintenance	30 million	Offset Value	(-) 50.4 million
Total	118 million	Revised total	33.6 million
Cost Per Person per day	1.311	Cost per person per day	0.37
Per kg cost	5.46	Per kg cost	1.55

5. Conclusion

It can thus be concluded that the innovative approach to treat food waste through VEGMA FOODSTER may be advantageous to the current practice and may be less polluting and cleaner system. Deployed near household clusters, eateries, hotels, cafeteria, and market places would be providing waste management system near to the points of generation and will be in sync with the principle of decentralization. It will be a system – environment friendly and supportive to human health.

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References

[1] Asnani PU. (2008), Zurbrugg C, Annapolsky S, Mani S. *Improving Municipal Solid Waste Management in India*, World Bank Institute, p.8.
[2] Bernstad A, Jansen J la Cour. (2012). *Separate Collection of Household Waste for Anaerobic Degradation – Comparison of different Techniques from a System Perspective*, Waste Management (available online February 2012).
[3] CPCB Report at http: //cpcb. nic. in/Highlights/2006/MUNICIPALSOLIDWASTEMANAGEMENT [1]. pdf, (March.25, 2012)
[4] Hindustan Times November 29, 2011.
[5] Ministry of Environment & Forest, Government of India. *Municipal Solid Waste Rules 2000.*
[6] Qdais H. A. Abu et al. *Analysis of Residential Solid Waste At Generation Sites*, Waste Management & Research August 1997 vol.15 no.4.395-405.
[7] Schaub S. M. Leonard J. J. *Composting: An alternative waste management option for food processing industries*, Trends in Food Science & Technology, Volume 7, Issue 8, August 1996, Pages 263-268.
[8] The Observer.28 October, 2007.
[9] US EPA. (2000). *America throws away 43.6 million tons of food each year, Waste not, want not: feeding the Hungry and reducing solid waste through food recovery*, EPA 530-R-99-040. <http: //www.epa. gov/epaoswer/non-hw/reduce/wast_not. pdf>.
[10] Protein Denaturation, www.friedli. com/herbs/ phytochem/ proteins. html#protein_structure (March.26, 2012)