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# Control of Green House Gas Emissions by Energy Recovery from the Organic Fraction of Municipal Solid Waste through Bio Methanation Process

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**Abstract:** Waste disposal is one of the major problems faced by all countries. As urbanization trends are increasing progressively, rapid changes in the pattern of human life are significantly seen, giving rise to generation of larger quantities of wastes leading to increased threats to the environment. It is estimated that about 42 million tonnes of solid wastes and 6000 million cubic metres of liquid wastes are being generated (in India) every year by urban population, besides generation of huge quantities of liquid and solid wastes by the industries. Improper disposal of municipal solid waste leads to degradation of environment and poses health hazards to the public. The latest trend world over is to use urban areas and cities waste to generate energy. One such technology is known as anaerobic digestion or biomethanation technology, which is environmentally safe and indeed a scientific disposal of waste.It means a process which entails enzymatic decomposition of organic matter by microbial action to produce methane rich biogas. Methane ($CH_4$) is a prominent greenhouse gas (GHG) along with carbon dioxide ($CO_2$) and chlorofluorocarbons (CFC), responsible for climate change phenomena. This not only reduces the quantity of wastes, but also improves its quality to meet the required pollution control standards.

This study attempts to analyze the characteristics of the biogas generation and recovery of power. The present work has been conducted at Koyambedu market place, which is situated between latitudes 12.06 º N to longitudes 80.19º E. By observing the result it can be concluded that the average bio gas production from the biomethanation plant at Koyambedu is 340 $m^3$ / day in which Methane content is about 64 %. The Methane gas is converted into electric power. Thus GHG emission can be reduced by implementation of biomethanation process.

**Key Words:** Vegetable Waste, waste to energy, Biomethanation, Green House Gas, Methane.

## Introduction

Managing municipal solid waste is a problem of high significance and growing magnitude[1]. In India, wastes are normally high in biodegradable matter and low in paper, metal and glass. The proportions of the constituents also vary seasonally and place to place depending on lifestyle, food habits, standard of living and degree of commercial & industrial activity[2].

Numerous studies, researches, and implementation of findings have been going on globally to produce biogas from food waste especially from vegetable waste and India is one of the harbingers in this field. Indian researchers Biswas et al., conducted a comprehensive study on biogas kinetics and they used the municipal wastes as the source of biogas[3].

The market complex generates significant quantity of vegetable, fruit and flower waste. At present these wastes are collected by a private agency and are transferred to a transfer station within the market, and are transferred to the Kodungaiyur dumpsite along with the Municipal solid waste. Perishable nature of these wastes couple with high moisture content promotes natural decomposition. This leads to emission of obnoxious odours and gases like methane, carbon dioxide which are potential Green House Gas. Realizing that these waste cause health hazards, Chennai Metropolitan Development Authority (CMDA) has set a biomethanation plant. In India under Waste-to-Energy Programme promoted by Ministry of New Renewable Energy Sources (MNRES) (Formerly Ministry of Non-Conventional Energy Sources), Govt. of India, Demonstration projects on bio-Energy generation from industrial and municipal solid wastes are being implemented[4].

Kameswari et al., established a demonstration plant of capacity 30 tonnes per day for biomethanation of vegetable market waste[5]. The biomethanation plant was designed for 30 tonnes per day, organic loading rate of 2.5 kg of VS/day/$m^3$ with biogas generation of 2500 $m^3$ of biogas per day

Biomethanation projects usually have a number of other environmental benefits. For example, the anaerobic process destroys many pathogens that are usually present in human and animal waste and manure, while the slurry that remains is nutrient-rich and can be treated further and used as fertiliser. In general, biomethanation of urban waste reduces the amount of waste that would otherwise have ended up in open dumps.

The production of biogas under controlled conditions is often referred to as biomethanation and also called anaerobic digestion[6]. Containing methane, the biogas produced is a potentially valuable energy resource. Methane forms a remarkably clean fuel when burnt. The combustion process of methane produces no particulates. If not captured, the gas as valuable resource is not only lost, being a greenhouse gas, it contributes to the global warming.

**Study area**

The Koyambedu Wholesale Market Complex (KWMC), being one of the largest in Asia generates large quantity of organic wastes, the point of conglomeration from where vegetables, fruits and flowers are distributed for whole sale in Chennai. This comes as the next step of modernization for the market, which was moved from its chaotic location in Kotwal Chawdi in the congestion of North Chennai to its present location at the modern complex built by Chennai metropolitan development authority (CMDA) at Koyambedu, a decade back. It is located at 13.06°north and 80.19° east. The location map showing Koyambeduis shown in Figure 1. The complex consists of more than 1,000 wholesale shops and 2,000 retail shops. In Phase I, a wholesale market for perishables was developed in an area of around 70 acres (280,000 $m^2$) by constructing 3,194 shops. The market has two blocks for vegetable shops and one each for fruit and flower shops. In Phase II, a textile mark and in Phase III, a food grain market have been planned to be developed in the complex. More than 150 tonnes of waste is being generated per day. At present about 10-15 tonnes of segregated vegetable wastes are being transported to the bio methanation plant and the remaining wastes are transported to the Kodungaiyur dumpsite of the Corporation of Chennai.

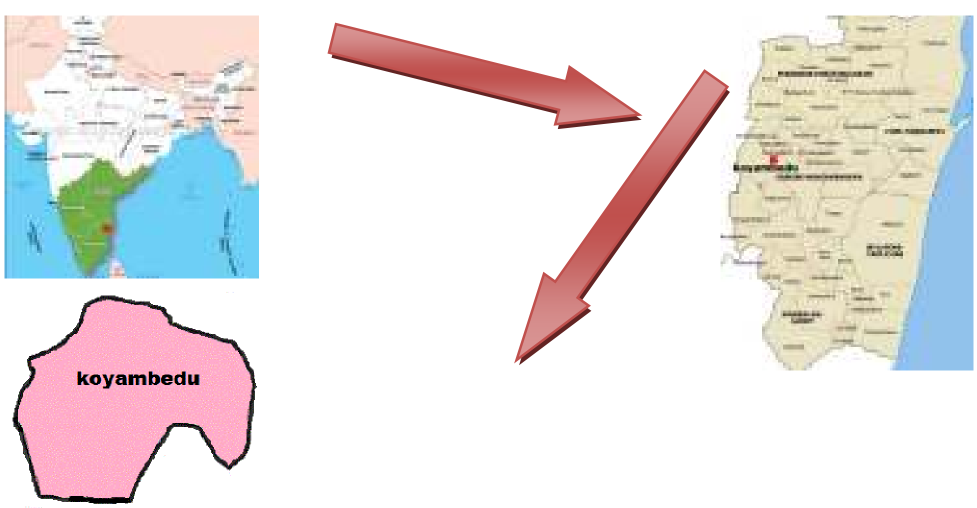


**Fig 1 Koyambedu Location Map**

**Description of the process:**

The desirable range of important waste parameters for technical viability of energy recovery are as follows, Moisture content should be greater than 50 %, Organic/ Volatile matter should be greater than 40 % and C/N ratio should be in the range of 25-30.The process flow diagram shown in Figure 2 shows the step by process involved in the biomethanation plant.

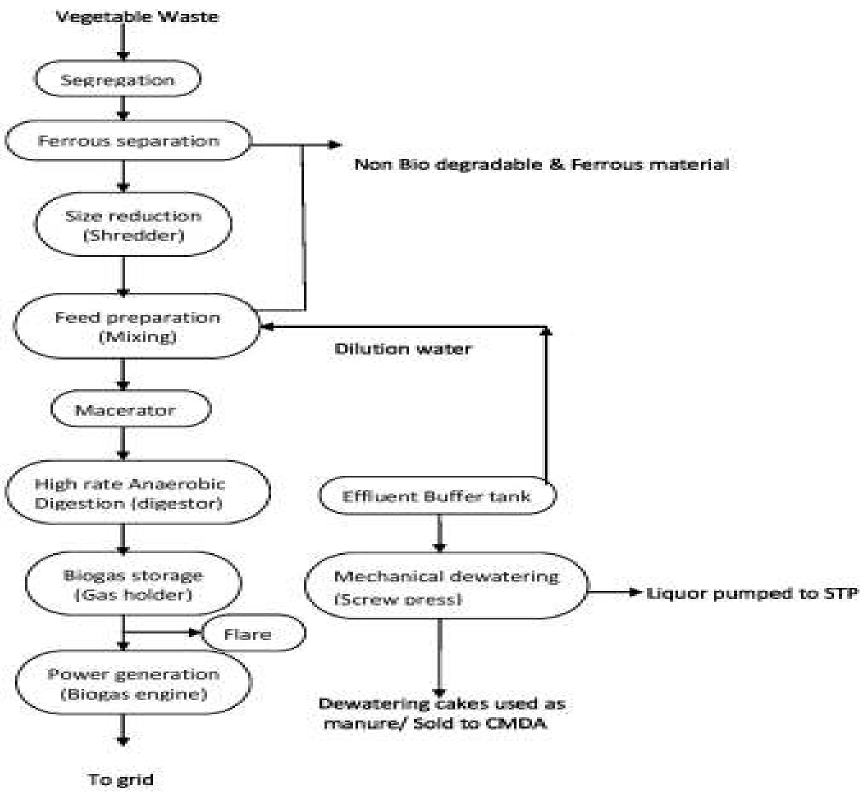


**Fig 2.Process Flow Diagram**

**Approach Method**

The vegetable waste generated shall be delivered into the receiving plat form; and loaded in to the conveyor by a mechanical handling device like grab. Inorganic, like plastic and paper cups, glass etc, shall be manually picked from the raw wastes moving on the conveyor at a low speed. The sorted wastes shall fall into the shredder placed at the other end of the conveyor.

The shredded wastes shall fall into one of the two feed preparation tanks through a distribution trough. Pre-determined quantity of water/ cent rate from the screw press shall be added to the waste.

The homogeneous slurry from the feed preparation tanks shall be pumped to high rate Biogas –Induced –Mixing –Arrangement (BIMA) digesters through a macerator. The main purpose of the macerator is to shred the fibrous wastes that have escaped shredder. The size of the waste after maceration shall be about 10 – 14 mm.

The homogenized wastes shall be pumped into a high rate anaerobic digester with the help of screw pumps. Screw pumps are selected due to their capacity to handle liquids with high solid concentration. Perfectly conditioned flow of homogenized waste will be treated under anaerobic condition in the digester where the bio conversion of organic matter takes place with biogas recovery.

The digesters utilize the biogas produced to mix the contents of the decomposing substrate and the incoming feed. Volatile solids reduction of around 52-55 % is achieved in these reactors. Thus wastes are stabilized and biogas is produced in the digesters. Hydrogen sulphide has to be removed from the gas before the gas is taken in to the gas engine. Biological desulphuration unit has attached in the digester to remove $H_2S$.

The destruction of volatile solids in the anaerobic digester results in biogas production. Quantity of bio gas produced depends on the quantity of volatile solid destroyed. Bio gas produced shall be stored in the gas holder.

Bio gas shall be used as a fuel in gas engine to generate electricity. The gas holder by gas blower and transferred to the gas engine an alternator shall be connected to the engine to produce electricity. Bio gas substrate from digester shall be collected in an effluent buffer tank for dewatering. Dewatering is carried out in a screw press of capacity 8 $m^3$ / hour. The digester substrate shall be pumped to the screw press by screw pumps.

A biological odour control system has been provided to remove odour from these areas. In case of engine during maintenance, the gas shall be flared. A flare of 120 $m^3$ per hour shall be provided for flaring the gas. The gas stored in the gas holder were collected in the toddler bag and subjected to the testing for its composition.

Waste generation details are shown in Table 1 and Gas and power generation details are shown in Table 2.

**Table 1 Waste Generation Details**

| Day | Flower market | Fruit market | Vegetable market A-G | Vegetable market H-N | Total Qty MT |
|---|---|---|---|---|---|
| 1 | 7.0 | 10.4 | 26.1 | 14.5 | 58 |
| 2 | 15.2 | 22.85 | 57.15 | 31.8 | 127 |
| 3 | 20.2 | 30.0 | 76.0 | 42.0 | 168 |
| 4 | 22.6 | 30.2 | 85.2 | 51.0 | 189 |
| 5 | 21.3 | 32.1 | 80.1 | 44.5 | 178 |
| 6 | 17.5 | 26.45 | 66.15 | 36.9 | 147 |
| 7 | 35.0 | 30.0 | 89.0 | 44.0 | 198 |
| 8 | 34.4 | 51.6 | 129.15 | 71.85 | 287 |
| 9 | 20.0 | 30.0 | 76.0 | 42.0 | 168 |
| 10 | 16.2 | 23.4 | 62.1 | 32.4 | 135 |
| 11 | 19.5 | 29.3 | 73.3 | 40.9 | 163 |
| 12 | 16.0 | 25.0 | 60.3 | 32.7 | 134 |
| 13 | 10.0 | 16.0 | 41.0 | 23.0 | 90.0 |
| 14 | 17.1 | 25.7 | 64.35 | 35.85 | 143 |
| 15 | 16.2 | 24.3 | 60.75 | 33.75 | 135 |
| 16 | 14.0 | 21.0 | 52.0 | 29.0 | 116 |
| 17 | 12.95 | 19.45 | 49.0 | 26.6 | 108 |
| 18 | 11.8 | 18.0 | 45.0 | 24.2 | 99 |
| 19 | 16.0 | 24.0 | 60.0 | 33.0 | 133 |
| 20 | 15.0 | 23.0 | 57.0 | 32.0 | 127 |
| 21 | 14.3 | 21.4 | 53.55 | 29.75 | 119 |
| 22 | 15.0 | 23.0 | 58.0 | 32.0 | 128 |
| 23 | 17.4 | 26.1 | 69.25 | 32.25 | 145 |
| 24 | 17.4 | 26.1 | 69.25 | 32.25 | 145 |
| 25 | 15.0 | 24.0 | 59.0 | 34.0 | 132 |
| 26 | 11.0 | 15.0 | 40.0 | 22.0 | 88 |
| 27 | 19.0 | 29.0 | 72.0 | 39.0 | 159 |
| 28 | 17.0 | 25.0 | 63.0 | 36.0 | 141 |
| 29 | 17.8 | 26.8 | 67.0 | 37.4 | 149 |
| 30 | 17.0 | 26.0 | 65.0 | 35.0 | 143 |

**Table 2. Gas and power generation details**

| Day | Input (MT) | Gas production ($M^3$ ) | Power generation (KW) |
|---|---|---|---|
| 1 | 6.300 | 245 | 245 |
| 2 | 6.050 | 242 | 362 |
| 3 | 6.650 | 252 | 325 |
| 4 | 6.560 | 255 | 357 |
| 5 | 6.520 | 250 | 250 |
| 6 | 6.290 | 252 | 252 |
| 7 | 6.000 | 234 | 280 |
| 8 | 9.620 | 360 | 396 |
| 9 | 6.750 | 255 | 280 |
| 10 | 9.570 | 368 | 440 |
| 11 | 7.470 | 295 | 383 |
| 12 | 10.420 | 395 | 470 |
| 13 | 6.120 | 226 | 260 |
| 14 | 6.600 | 250 | 300 |
| 15 | 5.190 | 200 | 260 |
| 16 | 6.370 | 245 | 305 |
| 17 | 6.180 | 240 | 360 |
| 18 | 8.830 | 340 | 400 |
| 19 | 7.830 | 300 | 390 |
| 20 | 6.180 | 245 | 295 |
| 21 | 6.090 | 230 | 230 |
| 22 | 9.900 | 366 | 435 |
| 23 | 8.690 | 345 | 410 |
| 24 | 8.830 | 330 | 425 |
| 25 | 9.630 | 365 | 438 |
| 26 | 8.690 | 330 | 330 |
| 27 | 6.300 | 236 | 248 |
| 28 | 6.050 | 230 | 275 |
| 29 | 6.650 | 260 | 442 |
| 30 | 10.400 | 400 | 480 |

According to the data,

Average Waste Generation per day = 140.75 MT / Day.
Average gas production = 340 $m^3$ / day or 38.20 $m^3$ per tonne waste
Average Power generation = 1.25 KW / $m^3$ of gas or 380 Kwh per day
Total waste generated in the market = 140.75 MT per day.
Total quantity of gas generated] = 140.75 ×38.20 **= 5376.65 $M^3$** per day.

Methane content % volume = 64.00%

Methane generation per day = 5376.65 ×0.64
**= 3441.05 $M^3$.**

**Performance analysis:**

The gas produced in the digester is collected in the toddler bag and subjected to testing for its performance. The results obtained from the Chennai petroleum Corporation Limited are listed in Table 3.

**Table 3.Composition of Bio Gas**

| Description | Sample 1 | Sample 2 | Sample 3 |
|---|---|---|---|
| $CH_4$ % volume | 63.7 | 64.26 | 64.76 |
| $CO_2$ % volume | 33.69 | 33.80 | 32.77 |
| Hydrogen % volume | NIL | NIL | NIL |
| Nitrogen % volume | 2.06 | 1.41 | 1.81 |
| Oxygen % volume | 0.65 | 0.46 | 0.65 |
| Hydrogen sulphide % volume | NIL | 0.07 | 0.01 |
| Moisture% volume | 500 | NIL | 250 |
| Calorific value K cal / Kg | 4741 | 4797 | 4877 |
| Molecular value | 25.8 | 25.7 | 25.5 |

The average bio gas production from the biomethanation plant at Koyambedu is 340 $m^3$ / day in which Methane content is about 64 %.The graphical representation is shown in figure 3. The Methane gas is converted into electric power. Thus GHG emission can be reduced by implementation of biomethanation process. The manure production from the plant is about one tonne per day.

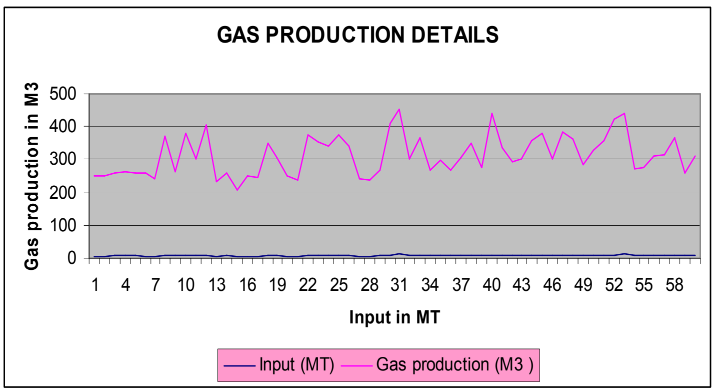


**Fig 3. Graphical representation showing Gas Production**

## Conclusion

From the waste generated in the Koyambedu market, around 3500 $M^3$ of methane was produced per day. Using this technology, the methane produced is converted into power. Thus we reduce the emission of GHG in the atmosphere. The overall efficiency of the biogas plant yield depends on biodegradable nature of constituents present in the waste.

- This project is environment friendly and provides a means of keeping the premises clean.
- The slurry produced by biomethanation technology serves as a good fertilizer.
- By using this process, total organic waste is reduced in to 10%.
- This process is considered to be the feasible option for management of vegetable market waste.
- Every new construction like hotels, hostels should accommodate with biomethanation plant. This will reduce the emission of green house gas and reduce the disposable quantity.
- With less wastes to dispose of, the demand of landfills is reduced, thereby saving land, which is already scarce in cities

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