ASSESSMENT OF COLLECTION AND COMPILATION OF DATA FOR MUNICIPAL SOLID WASTE MANAGEMENT AND DESIGN OF BIOGAS PLANT IN THANJAVUR - A CASE STUDY

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ABSTRACT - In this study, open disposal area, unfortunately, stills the means of open burning of solids waste in developing environment. Provide for leachate and gas control system. The untreated dumping encourages the breeding of insects and rodents and causes several health diseases, movement of leachate into the subsurface. Due to the improper lining, raw solids waste from the existing dumping site comes in contact with directly, causing severe deterioration the quality of the water. The solid waste characterization, the effect of leachate in the dumping site, groundwater quality analysis and also for 51 wards question sheet survey has been conducted that results were analyzed using SPSS 17. Various physic and chemical parameters were estimated this includes pH, turbidity, chloride, total hardness, calcium & magnesium hardness, sulphate and TDS, major cations such as calcium, magnesium ion. Everyday Thanjavur dumping ground receives 115 tones of Municipal Solid Waste from the Thanjavur city. In the part of result analysis, groundwater samples showed that dumping ground leachate constitutes a serious warning to the local aquifers. The waste generated in Thanjavur contains a maximum portion of biodegradable material, moisture content high, calorific value low and it is acceptable for biogas production. In this project, a fixed dome type biogas plant is designed because of low cost and a plan/model is recommended to improve the existing MSWM. The recommended model deals with maximize recycling and minimize landfilling of the Municipal Solid Waste. This study also has to be improved to provide efficient and effective MSWM.

Keyword – Municipal Solid Waste Management, Leachate, Biogas

I. INTRODUCTION

A. MUNICIPAL SOLID WASTE

Municipal solid waste is defined as the waste generates daily activity from human and animal activities that responsible for land pollution in the urban and industrial area.

- Population and urbanization increase results in increasing waste generation.
- Most cities finding it difficult not only to cope with the existing situation but also to anticipate future trends, prepare, plan for this.
- No waste collection results in waste accumulating in neighbourhoods and endangers public health.
- No treatment or disposal severely pollutes the environment and contributes to global warming.

B. SOURCES OF MUNICIPAL SOLID WASTE

the major sources of solid waste Residences and homes, biggest contributors of solid waste Industries, another source of solid waste today Commercial facilities and buildings, schools, colleges, prisons, military barracks and other government centres also produce solid waste this come under institutional, contribute to the solid waste problem Construction sites and demolition sites.

The term of solid waste

- Garbage any solid waste material organic waste, biodegradable, decomposable material
- Rubbish any solid waste material non-biodegradable, non-compostable material
- Refuse whatever we have refused to use so it concludes both decompose as well as non-compostable
- Ash is residue from burning, cooking, heating combustible

Adversely Health of the people affected while living near hazardous waste disposal sites

- chemical poisoning through chemical inhalation
- Disease caused by major flooding as a consequence of uncontrolled waste blocking the drains.
- Low birth weight Cancer
- Congenital malformations
- Neurological disease

The health of people living near Nonhazardous waste disposal sites is being adversely

- Nausea and vomiting
- Increase in the hospitalization of a diabetic inhabitant living near hazardous waste sites.
- Fish-eating high levels of mercury it leads to Mercury toxicity

U.S. Environment Protection Agency (2009)

- Waste breaks down in landfills to form $CH_{4,}$ a potent greenhouse gas
- Due to waste biodegradable Change in climate and destruction of the ozone layer
- Leaching Process describes the release of organic and inorganic contaminants illegal dumping from a solid phase into a water phase and contaminating them.

C. IMPACT ON HUMAN AND ENVIRONMENT

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***D. COMPOSITION* AND CHARACTERISATION**

Composition and characterization based on waste generation. it means material identify no longer being value either may be thrown away or gathered together for disposal. Composition based on a group of the region, size, population income level of people High Income, Upper Middle Income, Lower Middle Income, Lower Income, in dumpsite area sample was collected that indicate by the percentage of the volume. Characterization analyzes using physical, chemical and biological parameters. Physical Characterization means information and data of solid waste include bulk density, moisture content and particles sizes are important for the selection and operation of equipment and analysis and design of disposal facilities. Chemical Characterization means to understand the behaviour of wastes it moves through the management system as it includes proximate analysis and ultimate analysis. Biological Characterization means Biodegradability of Organic Waste that give odour due to H_2S odour, it generates breeding of files.

E. MUNICIPAL SOLID WASTE MANAGEMENT

Solid waste management refers to a combination of various functional elements associated with the management of solid waste. The functional elements of solid waste management re waste generation, waste storage, waste collection, transfer and transport, processing, recovery and recycling and waste disposal. Solid waste generation in India 0.2 - 0.6 kg/capita/day observed in cities. The municipal solid waste management and handling rule 2000 came into force from 25.9.2000 issued by the Ministry of Environment and Forest (MOEF) of the government of India. the modern concept based on five R's refuse means the use of non-biodegradable materials, reduce means if necessary reduce use, reuse means if some uses then we must reusing the same thing again and again, repair means once it is broken we can go for repair, recycle means when it no uses we can go for recycling. MSW(H&H Rule) contains four schedules namely schedule I mean implementation, schedule II specification from collection to disposal of MSW, schedule III specification for landfill pollution prevention, air quality and water quality monitoring, schedule IV waste processing standards for compositing, leachate treating and incinerators. The implementation of these rules monitors by CPCB. In cities of developing countries leads to problems due to inadequate management of solid waste result losses in environmental, economic.

F.BIOGAS PLANT

Biogas is produced in the absence of oxygen by the breakdown of organic matter solid waste. Sources of organic matter used to produce biogas include animal manure, sewage sludge, municipal solid waste, food-processing wastes, and industrial wastes. The production of biogas two types fixed- dome type and floating gas holder type of biogas plant. It includes CH_4, H_2S, organic acids and other substance. It helps users to generate heat or electricity or both. According to Duggal, (2002) the biogas contains 400-6000 calories/m^3 thus providing a convenient source of energy at low cost. A comparison of biogas with other forms of fuel energies reveals that 1 m^3 (6000 calories) of biogas is equal to alcohol 1.1 litre, petrol 0.8 litres, 0.6 litres of crude oil, gasoline gas 1.5 m^3, charcoal 1.4 Kg and electricity 2.2 Kwh.

The ideal temperature for methane-producing bacteria is about 35 ˚ C. Low temperature reduce gas production and nearly stops at 10 ˚ C. The time required for the organic matter to be digested in the digester is called retention time and is temperature-dependent. Anaerobic bacteria used to producing are anaerobic Methane, thus air should be eliminated. Carbon and nitrogen are chief nutrients utilized by the bacteria and the required ratio should be 25-30:1. At any time, the bacteria will find its pH level and this is usually 7-8.

***E. OBJECTIVES OF* THIS RESEARCH**

- To access the solid waste composition at an open dumping site
- The groundwater samples collected from the surrounded area of the dumping site to analyze the physicochemical characteristics.
- The leachate samples collected from the dumping site to analyze the physic-chemical characteristics.
- Provide suggestions / Recommendations for improving existing MSW management.
- To design the biogas plant (fixed dome type).

II. METHODOLOGY

A. STUDY AREA

The study area was Thanjavur, is a city.Municipal Solid Waste Compost yard, Tanjore municipality which is located in seeinvaspuram village, Tanjore. The dumping operation was started in the year 1959. The Tanjore municipal solid waste compost yard occupies 36.31 acres and it has 51 municipal wards and 27 sanitation wards. The annual rainfall in area 15 mm and the temperature varies from the range of 29 to 33-degree calicoes. It is receiving 115- 120 tons of waste per day from 15 zones and the height of dump is of 2-3 m above the ground level. It has an estimated population of 215725 people (current Census). In this dumpsite, without segregation and compaction waste is disposed of. Every day or between a day No cover is placed over the deposited waste. There will be no lining at the bottom of the dumpsite. The leachate produced due to the biological decomposition of municipal solid waste and entry of rainwater percolated through the soil and eventually pollutes the groundwater in the surrounding area. In addition to the above following gives various information about the study area.

B. SAMPLING PROCEDURE AND METHOD

1) SOLID WASTE

Thanjavur comprises of 51 wards. In this research, the municipality of Thanjavur has divided sampling into three areas namely: high-density population area, medium-density population area and low high-density population area. Each sampling area consists of 17 wards and these 17 wards were selected based upon the population present in that respective ward. For easy access in collection and transportation of waste for per cent composition study, three wards were selected from each sampling area.

Ward number 50 was selected as low-density population area, ward number 42 was selected as medium-density population area and ward number 51 was selected as a high-density population density area. Randomly selected ten households from each sampling study area for the composition and that making a total of 30 households.

Polythene bags of 5 Kg we used two for waste carrying capacity were provided to selected households of the residents for the collection of daily generated waste. One bag for biodegradable waste (food waste) and another bag for no biodegradable waste. These bags were gathering properly and should be sorted into different categories manually by handpicking and weighed individually.

- Food waste - Vegetable and food waste.
- Paper -Newspapers, book, printed materials and magazines.
- Plastics - Plastic bottles and packaging.
- Glass - Glass bottles and jars.
- Metals -Cans and bottle caps, ferrous metals and aluminium items.
- Textiles - Textile, rags, jute.
- Fines -Ash, dust and sand.
- Miscellaneous- Stones and pebbles, waste electrical and electronic types of equipment and batteries, used paints and solvents.
- Garden waste- Leaves, small twigs.

Portable electronic scales using for the weight measurements and the per cent composition of the waste was calculated. This study was carried for one week. The polythene bags containing MSW.

2) RUNOFF LEACHATE

Leachate sampling from the actual leachate streams was collected in 5 L plastic carboys, transported to the laboratory, stored at 4ºC and analyzed within ten days, according to the respective standard methods. A total of 10 leachate samples (L1- L10) were collected, out of which L1-L5 were collected in old dumping are referred to as 'old leachate', whereas the remaining leachate called as 'fresh leachate 'collected near to the new dumping area. The following parameters such as pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total hardness, Total solids, Total dissolved solids, Suspended solids, Organic solids and Inorganic solids were estimated as per APHA standards.

3) GROUNDWATER

To assess the quality of groundwater aquifers, 5 dug wells and 5 bore wells were chosen in the vicinity of the dumping site. The residents are not using the water for drinking purpose. The physical and chemical parameters were determined by analytical methods based on standard methods (APHA 1998). The following illustrates the details procedure for the analysis of leachate and groundwater.

i) pH

The pH was measured by using the pen-type pH meter after the calibration. Calibration was done by using the buffer tablets such as pH 4.7 and 9.2

ii) Turbidity

The turbidity was measured by using Nephelometric Turbidity Meter after calibration. Calibration was done by using the 400 NTU solutions.

iii) Chloride

Using titration method sample was determined with Silver Nitrate ($AgNO_3$), using the Potassium chromate (K_2CrO_4) as an indicator.

iv) Total Hardness

Using titration method sample was determined with Ethylene demines tetra acetic acid (EDTA) using the Enrichromate black T (EBT) as an indicator.

v) Calcium Hardness

Using titration method sample was determined with Ethylene demines tetra acetic acid (EDTA) using the Ammonium purpurate as the indicator.

vi) Magnesium Hardness

Total hardness minus calcium hardness

vii) Total Alkalinity

Using titration method sample was determined with Hydrogen sulphate oxide (H_2SO_4), using the mixed indicator.

viii) Sulphate

The sulphate of the sample was measured by using Nephelometric Turbidity Meter with the reagents such as conditioning reagent, diluted Hydrochloric acid solution and Barium Chloride. Calibration of Nephelometric Turbidity Meter was done by using the 400 NTU solutions.

xi) Total Solids

Hot air oven using for total solid

x) BOD

Biological Oxygen Demand for five days (BOD_5) was determined for the leachate samples; used BOD sensor system "FTC 901 Refrigerated" at 20ºC, the BOD_5 in (mg/l) was read.

xii) COD

Chemical Oxygen Demand (COD) was determined for the leachate samples every collection by COD reactor. The sample was put in the COD reactor for two hours at 150ºC, titrated it with ferrous ammonium, sulfate, where ferrous used as an indicator, the COD in (mg/l) was calculated.

4) QUESTIONNAIRE SURVEY

Aimed to conduct a questionnaire survey to obtain the outlook and report of residents about the current status of solid waste management in the household. 30 households selected for the composition of waste study, questionnaires were regulated to get primary data required for this research such as the number of household members, annual income, types of solid waste being generated from their houses, etc. survey has been managed for 51 wards and the results were analyzed using statistical software SPSS 17.

5) PER CAPITA WASTE GENERATION

Per day the total amount of waste collected from each area divided by the number of persons in the area.

6) BULK DENSITY

Bulk density (kg/m^3) = Mass / Volume

7) DATA ANALYSIS

The results of the study were analyzed using data analysis tool Microsoft Excel 2007. Pearson correlation explains to correlations between household and waste generation

8) COMMERCIAL SITE WASTE COMPOSITION

There are 51 wards in Thanjavur. One grocer's shop, one vegetable market, one vegetable/fruit market and that making a total commercial three units and they randomly used for waste composition analysis. The study was carried out for 7 days.

9) WASTE COMPOSITION AT DISPOSAL SITE

To study the waste composition in the disposal site, the samples were collected from Thanjavur waste dumping spot. All types of waste were thoroughly mixed and then separated into different categories and weighed individually. The study was carried for 7 days.

10) SOLID WASTE CHARACTERISATION

To study solid waste characteristics the data were collected from the residential area and dumping yard. The proximate analysis includes the following tests they are moisture content, volatile matter content, ash and fixed carbon.

11) MOISTURE CONTENT

Weighing 20g in an oven at 105˚C to a constant weight.

% Moisture content = [(wet weight – dry weight) / wet weight] x 100

12) VOLATILE MATTER CONTENT

Weighed and placed in a muffle furnace for 7 minutes at 950˚C.

% Volatile matter content = (loss in weight / Dry sample weight) x 100

13) ASH

Dried the samples at 750˚C for 1 hour.

% Ash content = (Ash weight / weight of sample) x 100

13) FIXED CARBON

% Fixed carbon = 100 – (% moisture content + %volatile matter content + %ash content)

14) CALORIFIC VALUE

Calorific value was calculated as follows:

CV = 4.2 * (44.75 VM – 5.85 W + 21.2)

CV = Calorific value, KJ/Kg

VM = Volatile matter, %

W = Moisture content, %

15) MANAGEMENT OF MSW

Secondary information regarding solid waste generation, collection system, transportation, processing and disposal methods were collected from Thanjavur Municipal Corporation.

16) DESIGN OF BIOGAS PLANT

i) GAS PRODUCTION RATE G

G = W x 0.04….. (Equation 1)

W = weight of waste available per day (Kg/day)

G = gas production rate (cu.m/day)

ii) ACTIVE SLURRY VOLUME V_S

V_s = HRT x (2W/1000) ….. (Equation 2)

HRT = Hydraulic Retention Time (days)

V_s = active slurry volume in the digester (cu.m)

Taking HRT as 50 days and using equation (1), the above equation can be written as

$V_s = 2.5G$….. (Equation 3)

iii) CALCULATION OF H AND D

Let D/H ratio be 2.0. Knowing the active slurry volume from equation (3), H can be calculated from the equations

$(\pi/4) \times D^2 \times H = V_s$….. (Equation 4)

D=2H….. (Equation 5)

$H = (V_s/\pi)^{1/3}$….. (Equation 6)

H = height of the cylindrical portion of the digester up to the top edge of the inlet/outlet opening (initial level), for flat bottom digesters (m)

D = diameter of the digester (m)

iv) SLURRY DISPLACEMENT INSIDE DIGESTER D

The selection of a suitable value of d depends upon gas usage pattern. If the total gas utilization time is about 8 hours, the variable gas storage volume V_{sd} is obtained from the equation

$(8 / 24) \times G + V_{sd} = 0.5G$….. (Equation 7)

$V_{sd} = 0.2\ G$

D is then obtained as

$(\pi/4) \times D^2 d = V_{sd} = 0.2g\ G$….. (Equation 8)

Using equations (3) and (4), we get

$d = (H/2.5) \times 0.2 = 0.08\ H$….. (Equation 9)

V_{sd}= slurry displacement volume (cu.m)

d = slurry displacement inside digester (m)

v) SLURRY DISPLACEMENT IN THE INLET AND OUTLET TANKS H

The maximum pressure attained by the gas is equal to the pressure of the water (slurry) column above the lowest slurry level in the inlet/outlet tanks and this pressure is usually selected to be 0.85 m water gauge as a safe limit for brick/concrete domes.

$h + d = 0.85$….. (Equation 10)

h = slurry displacement in the inlet and outlet tanks (m)

vi) LENGTH (L) AND BREADTH (B) OF THE INLET AND OUTLET TANKS

Let l = 1.5 b is selected. If the inlet and outlet cross-sectional areas are selected to be identical, we get

$$2 \times l \times b \times h = V_{sd} = 0.2G$$

Substituting l = 1.5b in the above equation and rearranging, we get

$$b = (0.1G / 1.5h)^{1/2} \text{ ….. (Equation 11)}$$

Using the values of h and G, b can be calculated from the above equation and l is then obtained as

$$l = 1.5b \text{….. (Equation 12)}$$

l, b = length and breadth of the inlet and outlet tanks (m)

vii) CALCULATION OF THE DOME HEIGHT D_H

The volume of the dome, which is a section of a sphere, is given by

$$V_d = (\pi/6)\, d_h\, [3(D/2)^2 + d_h^2] \text{….. (Equation 13)}$$

The total volume of the gas space, as mentioned earlier, is taken as equal to G.As the slurry or gas displacement volume V_{sd} is already fixed as 0.2G, the remaining gas space volume, which is the volume of the dome, will be equal to (G – 0.2G) or 0.8G. Substituting this in the above equation we get

$$0.8 = (\pi/6)\, d_h\, [3(D/2)^2 + d_h^2] \text{….. (Equation 14)}$$

d_h has to be obtained by solving the above equation; which is cubic. An algebraic solution exists, which is obtained by the following steps. First, obtain the parameters

$$P = 0.75D^2 \text{….. (Equation 15)}$$

$$Q = -0.8(6/\pi)\, G \text{….. (Equation 16)}$$

$$R = (p/3)^3 + (q/2)^2 \text{….. (Equation 17)}$$

$$A = [(-q/2) + \sqrt{R}]^{1/3} \text{….. (Equation 18)}$$

$$B = [(-q/2) - \sqrt{R}]^{1/3} \text{….. (Equation 19)}$$

Then d_h is given by

$$d_h = A + B \text{….. (Equation 20)}$$

d_h = height of the dome (m)

viii) RADIUS OF THE DOME R

The radius of the dome is obtained by the equation

$$r = [(D/2)^2 + d_h^2] / 2\, d_h \text{….. (Equation 21)}$$

r = radius of the dome (m)

ix) OTHER DIMENSIONS

The sizes of the inlet and outlet openings in the digester are normally 0.6 x 0.6 m and the digester walls are 230 mm thick.

III. RESULTS AND DISCUSSIONS

A. GENERAL

The physic-chemical characteristics of leachate and groundwater have been discussed in it.

B. CHARACTERISTICS OF RUNOFF LEACHATE

The physic-chemical characteristics of runoff leachate were presented in table 1. This gives detailed about the characteristics of leachate in the dumping site at ten different locations. From table 1. It was observed that the value of COD may vary from 6528 mg/l to 11360 mg/l for fresh leachate sample and vary from 4608 mg/l to 5568mg/l for old leachate samples. That the value of BOD may vary from the relatively high value of leachate conductivity indicates the presence of dissolved inorganic materials in the samples. The presence of magnesium in the leachate is due to the disposal of construction waste along with MSW. The concentration of total dissolved solids also fluctuates widely. Other inorganic containments also follow the trend of decreasing concentration with increasing leachate age and stability. In general, leachate generated from young acidogenic landfills is characterized by high concentrations of organic and inorganic pollutants. The presence of nitrate in leachate samples is mainly due to the discharge of septic waste and municipal wastewater adjacent to the dumping site without any treatment. Fresh leachate samples showed a higher degree of metal Solubilisation, due to lower p^H values caused by the and the BOD and COD values are higher in fresh leachate. In the case of partially stabilized leachate, the BOD and COD values are comparatively less. It was also found that the leachate characteristics in the nearer distance of sampling points due to the variation in the composition of solid waste and the variation in the decomposition of solid waste.D:\New folder\PROJECT\files\New folder\LEACHATE QUALITY ANALYSIS.doc

C. WATER QUALITY ASSESSMENT

The physic-chemical characteristic of water quality assessment is presented in Table 2, 3, 4. This gives details about the characteristics of water quality in the dumping site at different locations; the underground water to the study area is primarily used for domestic purposes mainly for washing. The physical and chemical characteristics of the water samples collected from various wells around Thanjavur dumping site D:\New folder\PROJECT\files\Newfolder\DEC.doc, D:\New folder\PROJECT\files\New folder\JAN.doc, D:\New folder\PROJECT\files\New folder\FEB.doc

D. MUNICIPAL SOLID WASTE MANAGEMENT

1) TOTAL AMOUNT OF WASTE GENERATED IN THREE SAMPLING AREAS

The total amount of waste generated from the low-density population area examined is presented in Figure No 1. The amount of waste in the fourth day is very high compared to other days.

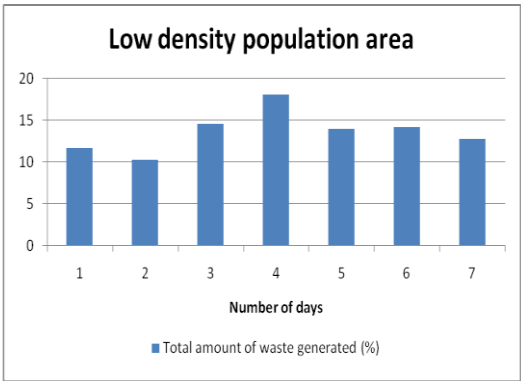

Figure No 1- low-density population area

The total amount of waste generated from the medium-density population area examined is presented in Figure No 2. The amount of waste in the fourth day is very high compared to other days

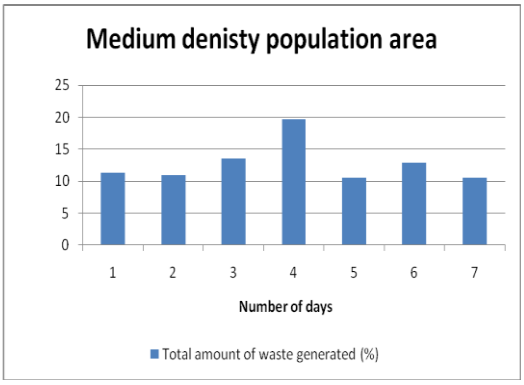

Figure No 2- Medium density population area

The total amount of waste generated from the high-density population area examined is presented in Figure No 3. The amount of waste in the fourth day is very high compared to other days.

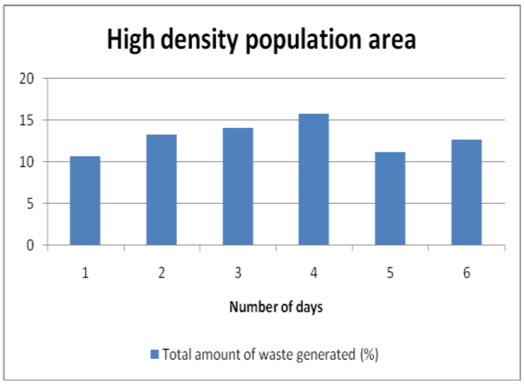

Figure No 3- High-density population area

In all three sampling areas very high amount of waste generated in the fourth day. Due to the festival time, all residential households cleaned their houses and that leads to the generation of more quantity of municipal solid waste. The quantity of MSW depends on several factors such as food habits, the standard of living, degree of commercial activities and seasons. Data on quantity variation and generation are valuable in planning for collection and disposal systems (Sharholy M., 2008).

2) PHYSICAL COMPOSITION OF MUNICIPAL SOLID WASTE CATEGORIES IN THREE SAMPLING AREAS

The representative solid waste samples were collected from the dumping site. Samples were collected daily for seven days. The collected samples segregated into different categories such as vegetables, kitchen waste, paper, plastic, textile, glass, debris waste and metals, segregated samples were weighted individually and weight percentage was calculated. (Figure No 4, Figure No 5, Figure No 6)

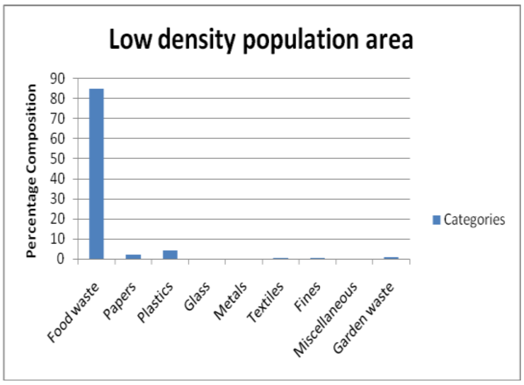

Figure No 4- Low-density population area

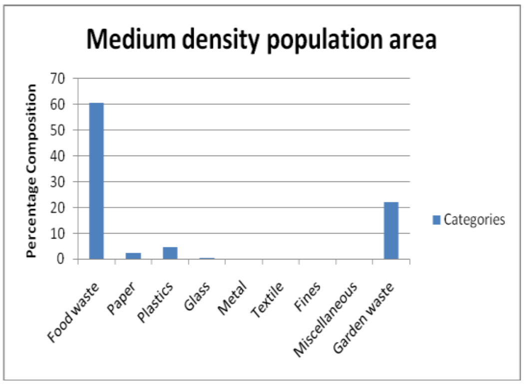

Figure No 5 - Medium density population area

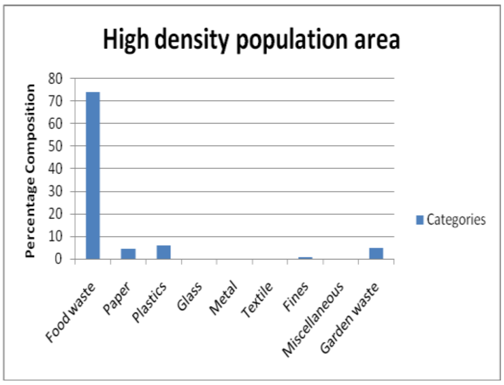

Figure No 6 - High-density population area

3) The physical composition of municipal solid waste categories in the low, medium, high-density population area

From the physical composition the amount of biodegradable and non-biodegradable waste in three sampling areas was evaluated and presented in Figure No 7.The degradable fraction is quite high in Indian MSW, essentially due to the habit of using fresh vegetables (Amul late *et al.*, 2012)

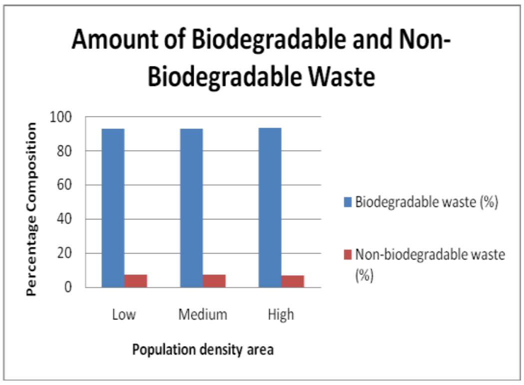

Figure No7 - Total amount of degradable and non-degradable waste in three sampling areas

E. QUESTIONNAIRE SURVEY

The questionnaires were analyzed using statistical software SPSS 17 to study the existing solid waste management

The conclusions from the questionnaire analysis are as follows:

a) There is no proper door to door collection service in many areas.
b) Waste storage facilities exist in some area. Community bins are required in many wards and proper unloading of waste from the community bin is needed to avoid spreading of diseases by the mosquito, insects, etc. Proper cleaning of roads/streets is needed.
c) The waste collected by the sweepers is burned improperly in the public place and it leads to air pollution and wastes generated were not treated properly.
d) All the respondents agreed that they sell/reuse the waste materials to a lesser extent and they didn't have the composting facility in their home.
e) The approach of the respondents on willingness to participate and willingness to pay money to improve solid waste management varies widely.
f) All the respondents strongly agreed that the improper municipal solid waste management leads to serious problems on human health and the environment.
g) There is no awareness among people about MSWM services.

Finally, analysis of the questionnaires reveals that the wastes are improperly disposed of, thus it leads to a fire accident at the disposal site. This leads to air pollution and emits greenhouse gases. It will affect the health of people and workers those who live in that region and cause respiratory problems.

F. CHARACTERISTICS OF SOLID WASTE

Types of waste	**Moisture content**	**Volatile matter content**	**Ash content**	**Fixed carbon content**
Residential waste	30%	33%	13%	21%
Disposal site	33%	20.09%	8.81%	33%

Table no: 5 CHARACTERISTICS OF SOLID WASTE

i) CALORIFIC VALUE

Calorific value for residential waste and disposal site was found to be 5731.21 KJ/Kg (1361.827Kcal/Kg) and 3157.375KJ/Kg (745.937 Kcal/Kg). The results are somewhat similar to that reported by Pradhan *et al.,* 2012.

ii) PRIMARY COLLECTION OF MSW

In Thanjavur, street cleaning and collection involves the collection of MSW from streets and households in handcarts. Through the door to door, collection sweepers collect the MSW from the households and carry these wastes to the nearest community bin. Sometimes improper open burning of MSW has been performed and this should be prohibited to avoid serious problems.

iii) STORAGE OF MSW

The MSW is temporarily stored in the community bin. Two types of bins are used in Thanjavur. The first one has its wheels and its capacity is 1 m^3. The bin is placed along roadside. The second type of community bin is without wheels and its capacity is 4 m^3. These type bins are placed in a big market and high-density population area.

iv) TRANSPORTATION OF MSW

In Thanjavur, the disposal sites are generally within 15 Km of the collection points,
therefore there is no need for transfer station facility. MSW is loaded into vehicles, which transfer the MSW into a disposal site. If the loading and unloading of waste are done by a mechanical system, then it will reduce the burden on workers and direct contact of workers with waste can be avoided.

Serial Number	**Type of vehicle**	**Number of vehicles**
1	Auto	25
2	Lorry	2
3	Tractor	1
4	Mini Lorry	3
5	Tipper	5
6	Dumper Placer	3

Table No 6. Vehicles

v) DISPOSAL

Thanjavur does not contain sanitary and secured landfill sites for proper disposal of waste. Open dumping is the only option that is presently used in Thanjavur for the management of MSW. At present, no treatment is provided for collecting solid waste. Most often workers are not provided with protective hand gloves and shoes and they are directly exposing to the waste. Protective measures should be taken to avoid allergies and respiratory problems.

G. BIOGAS PLANT

Description	Symbol	Dimensions
Gas production rate	G	400 m^3/day
Active slurry volume in the digester	V_s	1000 m^3
Height of the cylindrical portion of the digester up to the top edge of the inlet/outlet opening (initial level).	H	5.828 m
The diameter of the digester	D	12.656 m
slurry displacement inside the digester	d	0.446 m
slurry displacement in the inlet and outlet tanks	h	0.204 m
Length of the inlet and outlet tanks	l	13.084 m
The breadth of the inlet and outlet tanks	b	8.389 m
Height of the dome	HD	2.934 m
The radius of the dome	r	6.892 m

Table No. 7 - Dimensions of different components present in the biogas plant

H. RECOMMENDATIONS

Considering the situation and field observation, the following recommendations for MSWM are as follows:

a) MSWM plan has been proposed for better waste management.
b) Involvement of both public and private operators should be considered for effective MSWM in Thanjavur.
c) Recycling should be given priority to reduce waste generation volume and it will reduce the burden on treatment and disposal. This will reduce the cost of expenditure on treatment and disposal.
d) It will be needed to increase the number of waste collection bin, of cleaners, the number of vehicle, waste collection efficiency, source reduction at source by recycling, composting and biogas production for ensuring better MSWM system.
e) Efficient routing and rerouting of waste collection and vehicles can reduce labour, equipment and fuel costs. This will also save money and time.
f) Systematic collection of MSW should be employed for the effective collection of MSW. Planned collection of waste from slums and the quarter area should be done.
g) Disposal of waste in the streets, open spaces, in vacant areas should be banned.
h) Levy of administrative charges for littering of streets.
i) The waste collection should be performed regularly.
j) Protective hand gloves and shoes should be given to the sweepers and to other workers, those who involved in collection, segregation, transportation, treatment and disposal.
k) Litter bins should be avoided in a public place. Open burning of MSW should be prohibited.
l) Polythene bags manufacturing should be banned

m) The safe and environmentally friendly process of composting should be implemented in a larger extent. Biogas production should be implemented to generate electricity.

n) Construction and operation of sanitary and secured landfills should be done.

o) Vehicles used for the transportation of waste shall be covered. Waste should not be visible to the public, nor exposed to open environment preventing their scattering.

p) The community should be cleaned before overflowing. Roads/streets should be cleaned regularly.

q) Public awareness strategies should be taken into consideration.

IV. CONCLUSION

The indiscriminate disposal of MSW without covering dumping site is and ultimately enters the food chain, the consumption of which can cause adverse health effects. From the results of the water quality study, it was found that the groundwater is non-potable because most of the physical and chemical parameters examined exceed the permissible limits. This is to be expected because these sites are located very close to the dumping site. Ultimately, all results presented show that the Thanjavur dump site constitutes a serious threat to local aquifers. The characterization of residential and disposal site waste in Thanjavur reveals that the moisture content, volatile matter, ash and fixed carbon were found to be in the moderate range. The moisture content of the residential and disposal site samples was found to be 30% and 36% respectively. The waste contains high moisture content and low calorific value and this exposed that waste generated from Thanjavur area is suitable for the production of biogas. In this project work, fixed dome (flat bottom) type biogas plant has been designed because of low cost and a plan/model has been proposed for effective MSWM. Biogas can be used to generate electricity and it will provide a clean environment. Finally, this will reduce the burden on landfill