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Green House Gas Emission Study on Solid Waste Treatment Technologies for South Delhi Municipal Corporation, India

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Abstract: *Municipal Solid Waste is the third largest emitter of methane in the world, contributing to 3% of the world's overall green house gas emissions. There is a huge potential for reducing greenhouse gas emissions in the way of disposing municipal solid waste (MSW). Technology advancements and the movement toward integrated strategies for MSW management have resulted in reduced Green House Gas (GHG) emissions. In South Delhi Municipal Corporation (SDMC), there has been significant increase in the generation of municipal solid waste. A high waste generation rate reflects higher proportion of commercial and industrial activities. In this paper 21 different scenario are generated to analysis Greenhouse Gas Emissions from solid waste treatment technologies for different waste sources. Study revealed that in case of Landfill without landfill gas recovery, GHG mission is very high with comparison to other technologies. GHG emission reduction is more for composting facility, especially this facility is better for waste from commercial source.*

Keywords: *Municipal Solid Waste; Green House Gas; Landfill; Composting; Combustion; waste generation source*

1. Introduction

With the creation of economic growth, vast population increase, urbanization, industrialization and the excessive consumption in modern daily life, a large quantity of waste is generated. Municipal solid waste (MSW) is a heterogeneous mix of different solid waste types, usually collected by municipalities or other local authorities. MSW includes household waste; garden/ park waste and commercial/ institutional waste (Bunrith et al., 2013). Global warming has become a matter of public concern since last few years. This could be mainly attributed to the trapping of enormous quantities of typical gases in the earth's atmosphere resulting in green house gas (GHG) effect thereby increasing the ambient temperatures (Sunil et al., 2004). Municipal Solid Waste is the third largest emitter of methane in the world, contributing to 3% of the world's overall green house gas emissions, where India stands as the second largest anthropogenic methane emitter and the largest green house gas (6%) emitter (DPCC, New Delhi). There is a huge potential for reducing greenhouse gas emissions in the way of disposing municipal solid waste (MSW). Selecting the appropriate processing mode can not only reduce the impact of MSW on local environment, but also reduce greenhouse gas emissions and save fossil fuels and mitigate of global climate warming (Yuan et al., 2012). Technology advancements and the movement toward integrated strategies for MSW management have resulted in reduced GHG emissions. Integrated strategies involving recycling, composting, waste-to-energy combustion and landfills with gas collection and energy recovery play a significant role in reducing GHG emissions by recovering materials and energy from the MSW stream (Susan et al., 2002).

2. Study Area

The area of the National Capital Territory (NCT) of Delhi is located in northern India between the latitudes of 28°24'17" and 28°53'00" North and longitudes of 76°50'24" and 77°20'37" East with area of 1484.46 sq. km. (0.4 percent of total geographical area of India). The Union Territory Delhi is encircled by Utter Pradesh in the East, Haryana on the North, West and South. Delhi spread over an area of 1,484.46 sq-km. The area covered by The Municipal Corporation of Delhi (MCD) approximately 1399.26 sq. km. The 94 percent area and 97 percent populations are under jurisdiction of MCD. MCD that governed 8 of the 9 Districts of Delhi, in the state of Delhi, India was among the largest municipal bodies in the world providing civic services to more than estimated population of 11 million citizens in the capital city. MCD has been trifurcated into three smaller Municipal corporations - North Delhi Municipal Corporation, South Delhi Municipal Corporation (SDMC), East Delhi Municipal Corporation.

SDMC is serving the population of 5.6 million citizens with a responsibility of maintaining, upgrading and developing civic amenities efficiently with a view to create a better tomorrow for citizens of Delhi. It occupies an area of 656.91 sq-km which is further subdivided into 4 zones- Central, South, West and Najafgarh Zone and has 104 wards. (Figure 1)

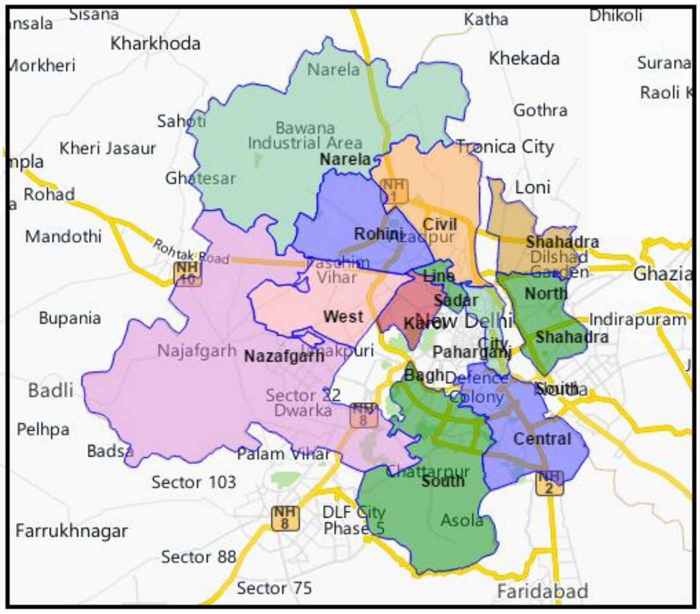

Figure1. *Delhi map showing locations under SDMC*

SDMC has unique distinction of providing civic services from highly posh residential and commercial areas to rural and urban villages, JJ resettlement colonies, regularized and unauthorized colonies. There are 388 approved colonies, 86 rural villages, 81 urbanized villages, 111 unauthorized colonies, 252 unauthorized regularized colonies and 32 JJ resettlement colonies. In SDMC out of 1038 colonies, 221 in central zone, 185 in South zone, 241 in west zone and 391 in Najafgarh zone (MCD, 2014).

There are two types of waste storage system, one is dhalao system covered structure more or less closed to the outside, they are 672 in number and secondly, street dustbins system which accounts 183 in numbers. Street dustbin size varies from place to place. Due to lack of municipal receptacles, open sites have also identified in some areas as local garbage collection points. There are 296 open sites which have been selected for local garbage collection within the SDMC jurisdiction (MCD, 2004).

3. Waste Treatment Technologies in SDMC Area

3.1. Okhla Sanitary Landfill (SLF)

Okhla landfill site is located at Okhla Ph-I, which is about 2 km from National Highway-2 on South East end of the city, Established in 1994. The area of the landfill is 56 acres. Site serves for dumping of solid waste generated from South Delhi and Central Delhi. The SLF receives around 2000 MT of Solid Waste daily. There is no arrangement for leachate collection and treatment. Leachate is being disposed into existing sewer through open drains. The solid waste received at site is leveled and compacted with the help of hydraulic bulldozers.

3.2. Bhalaswa SLF

Bhalaswa SLF is located on National Highway 1, on the North West corner of Delhi on the Northern side of the G.T.K bypass. The landfill was established and commissioned in 1993. It has served well past its designed life. Its designed life ended in 2005. The Area of the landfill is around 40 acres. The SLF receives around 2200 MT of Solid Waste daily. There is no leachate pond existing at site. Leachate is discharged into Supplementary drain through lined drains. Gas control equipment is not installed at this site. The weighing bridge is fully computerized at the landfill run by a private agency. The total estimate of fuel expenditure comes out to be around 500-600 liters of diesel per day. 14 machines are present on the SLF site. Most of them are out of order. Three to four machines are operated at a given time. There is maximum load on the SLF is during the months of April-July. Solid Waste is received from the zones-West, Karol Bagh, Rohini, Najafgarh, Narela, Civil Lines, SP, City, Delhi APMC, DMRC and DDA.

3.3. Incineration Plant of Timarpur

In Delhi, an attempt was made to recover energy from waste by implementing the Timarpur Refuse Incineration-cum-Power Generation Station ("Timarpur Plant") in 1987. This plant was designed to incinerate 300 TPD of Municipal Solid Waste ("MSW") and generate 3.75 MW of electric power. The plant when put on trial could neither incinerate the desired amount of MSW nor generate 3.75 MW of electric power. The plant failed after 21 days of trial operation because of the poor quality of MSW. The plant required waste with a net calorific value of at least 1462.5 kcal/ kg but the supplied waste was in the range of 600-700 kcal/ kg.

3.4. Timarpur-Okhla Waste to Energy Plant

In December 2006, the Govt. proposed another waste to energy plant in Okhla where it was decided that a plant would be set up that will process1300 tons-of MSW per-day (TPD) and would generate 450 tons of RDF per day, along with a 100 TPD biomethanation plant that would generate 16 MW of power The system would operate on MSW having low calorific values of 1,000-1,400 Kcal per Kg.

3.5. Biomethanation Plant in Timarpur

The project has a biomethanation facility for a combined treatment of 50 tons per day of segregated vegetable market waste and 6 million gallons per day (MGD) of sewage, which could produce biogas, equivalent of 2500 kg LPG, to be used as fuel for generating electricity. A two phase modified Up-flow Anaerobic Sludge Blanket (UASB) is adopted for this project activity. This biogas will be used as supporting fuel for the boiler and dryer in RDF plant. The disadvantage of this process is that some of the gases tend to escape through cracks and crevices by diffusion (concentration gradient) or convection (pressure gradient) mechanism posing threat to nearby structures and vegetation.

3.6. Composting Plant at Okhla

The first composting plant was set up at Okhla in 1980. The compost Plant in Okhla is spread over an area of 2hectares. It was semi mechanized plant of 150 tonnes per day capacity for composting the waste. Later this plant was expanded with its some additional capacity in 1985. However, this plant was not in an operational condition during 1991-1995 due to low quantity of waste material and higher operational cost. In May 2007 IL&FS Company signed a concession agreement with the municipal corporation of Delhi to rehabilitate the Okhla compost plant with carbon support. The project applies a multi treatment of municipal waste to avoid possible pollution. It involves the mechanical sorting and composting of organic waste. The materials like metals, plastics and paper are recycled. The residual organic waste is treated using the composting process. This plant converts 73,000 tonnes of MSW into compost every year. This is equivalent to 200 tonnes of municipal solid waste per day. It is a total 200 TPD capacity plant. It generates around 506TPM of compost out of which it sells around 200 tons @Rs.117 per 50 kg bag. It gets its waste from south zone, North zone & central zone. The rejects from the plants are Combustibles (498 Tons/ month) which are sent to Waste to Energy plant in Okhla & Inert (212TPM) disposed at Okhla Sanitary Landfill.

3.7. Composting Plant at Bhalswa

Composting plant was setup in Bhalswa with the private sector named Exnora Private Limited. The Bhalswa composting plant was established in 1999. Bhalswa plant is spread over an area of area of 4.9 hectares. It is operated and maintained by M/s Nature Waste Management Pvt. Ltd (M/s Excel Industries Private Ltd.). It is operating at about 300-350 MT/day as against the installed capacity of 500 MT/day. Compost is approximately 24% of the total garbage received. It gets waste from West zone (100%), Rohini zone (10%), Najafgarh zone (3%), Narela (100%), Karol Bagh.

4. METHODOLOGY

4.1. Data Collection

The composition of solid wastes varies from one place to another place within the study area. Following table shows waste composition for different areas of SDMC region (Table 1).

Table1. *Composition of waste (COBI feasibility report on solid waste, 2004)*

Location	Area type	Biodegradables	Recyclables
Hauz khas	HIG (HIG)	71.9	23.1
Vikas puri	MIG (MIG)	75.9	21.1
Sadhnagar	LIG (LIG)	63.2	16.6
Ring road, opposite nagla machi village	JJ Cluster (JJC)	72.2	16.2
Okhla vegetable market	Vegetable markets (VEM)	97.2	2.3
Najafgarh road, motinagar to drain culvert	Streets sweeping (STS)	28.4	12
Indian institute of foreign trade	Institutional area (INA)	59.7	33.8
Nehru place	Commercial area (COA)	15.6	68

Note: *COBI feasibility report on solid waste, 2004*

4.2. MSW Treatment Technologies Consideration

Integrated waste management options are now been applying with recycling, recovery, land fill gas recovery and energy generation from the solid waste. There are three main different technologies are available for managing MSW: Brief descriptions of these three technologies are given bellow.

- *Composting:* It is a process of biodegradation of waste under aerobic (oxygen-rich) conditions. Waste that can be composted must contain solid biodegradable organic material.
- *Combustion:* Combustion is a thermal waste treatment process where raw or unprocessed waste can be used as feedstock.
- *Landfill:* A landfill is a facility in which solid wastes are disposed in a manner which limits their impact on the environment. Most of the landfill does not have the energy production facilities. Landfill gas are generated from the landfill site in different gas generation phases.

4.3. Scenarios

In this paper 21 different scenario are generated to analysis Greenhouse Gas Emissions from all three solid waste technologies. As in composting segregated bio degradable are disposed, the remaining treated as recyclables. So both technology are considered together besides the other two combustion and sanitary land fill with following three condition viz. no land fill gas recovery, land fill gas recovery with flare and land fill gas recovery for energy (Table 2).

Table2. *MSW Treatment technologies and scenarios*

Sr. No.	Waste Disposal Technology	Diversion (%)
1	Sanitary Land Fill without Land Fill Gas, SLF (NO LFG)	100%
2	Sanitary Land Fill with Land Fill Gas-Flare, SLF (LFG-FLARE)	100%
3	Sanitary Land Fill with Land Fill Gas-Energy, SLF (LFG-ENERGY)	100%
4	Combustion, COMB	100%
5	Composting, COMP	100%
6	Sanitary Land Fill without Land Fill Gas + Combustion, SLF (NO LFG)+COMB	50%+50%
7	Sanitary Land Fill with Land Fill Gas-Flare + Combustion, SLF (LFG-FLARE)+COMB	50%+50%
8	Sanitary Land Fill with Land Fill Gas-Energy + Combustion, SLF (LFG-ENERGY)+COMB	50%+50%
9	Sanitary Land Fill without Land Fill Gas + Composting, SLF (NO LFG)+COMP	50%+50%
10	Sanitary Land Fill with Land Fill Gas-Flare + Composting, SLF (LFG-FLARE)+COMP	50%+50%
11	Sanitary Land Fill with Land Fill Gas-Energy + Composting, SLF (LFG-ENERGY)+COMP	50%+50%
12	Combustion + Composting, COMB+COMP	50%+50%

13	Sanitary Land Fill without Land Fill Gas + Combustion + Composting, SLF(NO LFG)+COMB+COMP	50%+25%+ 25%
14	Sanitary Land Fill with Land Fill Gas-Flare + Combustion + Composting, SLF(LFG-FLARE)+COMB+COMP	50%+25%+ 25%
15	Sanitary Land Fill with Land Fill Gas-Energy + Combustion + Composting, SLF(LFG-ENERGY)+COMB+COMP	50%+25%+ 25%
16	Combustion Sanitary Land Fill without Land Fill Gas + Composting, COMB+SLF(NO LFG)+COMP	50%+25%+ 25%
17	Combustion + Sanitary land fill with Land Fill Gas-Flare + Composting, COMB+SLF(LFG-FLARE)+COMP	50%+25%+ 25%
18	Combustion + Sanitary land fill with Land Fill Gas-Energy + Composting, COMB+SLF(LFG-ENERGY)+COMP	50%+25%+ 25%
19	Composting + Sanitary land fill without Land Fill Gas + Combustion, COMP+SLF(NO LFG)+COMB	50%+25%+ 25%
20	Composting + Sanitary land fill with Land Fill Gas-Flare + Combustion, COMP+SLF(LFG-FLARE)+COMB	50%+25%+ 25%
21	Composting + Sanitary land fill with Land Fill Gas-Energy + Combustion, COMP+SLF(LFG-ENERGY)+COMB	50%+25%+ 25%

4.4. Greenhouse Gas Emissions Calculation

Greenhouse Gas Emissions are calculated with the Excel Version of the Waste Reduction Model (WARM). WARM calculates GHG emissions for baseline and alternative waste management practices, including source reduction, recycling, combustion, composting, and land filling. The model calculates emissions in metric tons of carbon dioxide equivalent ($MTCO_2E$) and metric tons of carbon equivalent (MTCE) across a wide range of material types commonly found in municipal solid waste (MSW). The GHG emission factors were developed following a life-cycle assessment methodology using estimation techniques.

5. Result and Analysis

Using Waste Reduction Model excel sheet $MTCO_2E$ equivalent, GHG emission data are generated to do comparative study of treatment technologies for GHG emission in different scenarios and for different waste generation source for one short ton of waste (Table 3).

Table3. *$MTCO_2E$ equivalent GHG emission*

Sr.No.	Waste Disposal Technology	HIG	MIG	LIG	JJC	VEM	STS	INA	COA
1	SLF (NO LFG)	83	84	69	76	83	36	84	82
2	SLF (LFG-FLARE)	-3	-2	-1	0	9	-2	-9	-29
3	SLF (LFG-ENERGY)	-13	-12	-9	-9	0	-7	-20	-43
4	COMB	-20	-20	-16	-17	-15	-9	-23	-31
5	COMP	-79	-74	-59	-60	-26	-39	-107	-194
6	SLF (NO LFG)+COMB	31	32	27	30	34	13	30	26
7	SLF (LFG-FLARE)+COMB	-11	-11	-8	-8	-3	-6	-16	30
8	SLF (LFG-ENERGY)+COMB	-17	-16	-13	-13	-7	-8	-22	-37
9	SLF (NO LFG)+COMP	2	5	5	8	28	-2	-11	-56
10	SLF (LFG-FLARE)+COMP	-41	-38	-30	-30	-8	-21	-58	-111
11	SLF (LFG-ENERGY)+COMP	-46	-43	-34	-34	-13	-23	-63	-118
12	COMB+COMP	-49	-47	-38	-38	-20	-24	-65	-112
13	SLF (NO LFG)+COMB+COMP	17	19	16	19	31	6	10	-15
14	SLF (LFG-FLARE)+COMB+COMP	-26	-24	-19	-19	-6	-13	-37	-71
15	SLF (LFG-ENERGY)+COMB+COMP	-31	-29	-23	-24	-10	-16	-43	-78
16	COMB+SLF (NO LFG)+COMP	-9	-7	-5	-4	7	-5	-17	-43
17	COMB+SLF (LFG-FLARE)+COMP	-30	-29	-23	-23	-11	-15	-40	-71
18	COMB+SLF (LFG ENERGY)+COMP	-33	-31	-25	-26	-14	-16	-43	-75
19	COMP+SLF (NO LFG)+COMB	-24	-21	-16	-15	4	-13	-38	-84
20	COMP+SLF (LFG-FLARE)+COMB	-45	-42	-34	-34	-14	-23	-61	-112
21	COMP+SLF (LFG-ENERGY)+COMB	-48	-45	-36	-36	-16	-24	-64	-115

1. In scenario 1 GHG emission is low if 100% street sweeping waste of similar quantity treated in sanitary land fill site without land fill gas recovery. The GHG emissions from other waste sources are high comparative to emission from street sweeping (Figure 2).

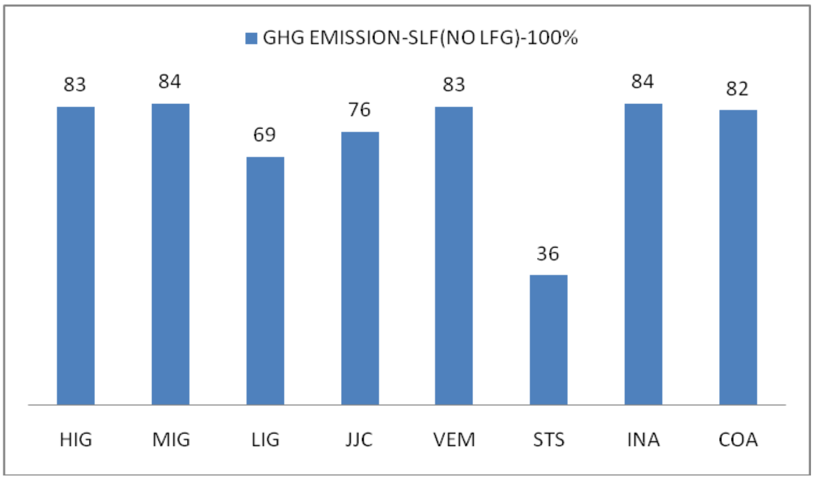

Figure2. *MTCO$_2$E equivalent GHG emissions for Scenario 1*

2. There is reduction of emission in case of scenario 2 than the scenario 1. There is remarkable reduction in emission for commercial waste (Figure 3).

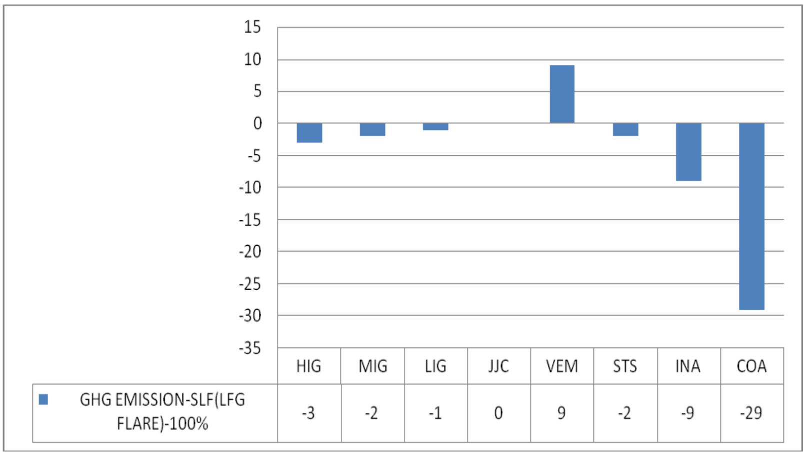

Figure3. *MTCO$_2$E equivalent GHG emissions for Scenario 2*

3. There is significantly reduction of emission in case of scenario 3 than the scenarios1 and 2. There is remarkable reduction in emission for commercial waste (Figure 4).

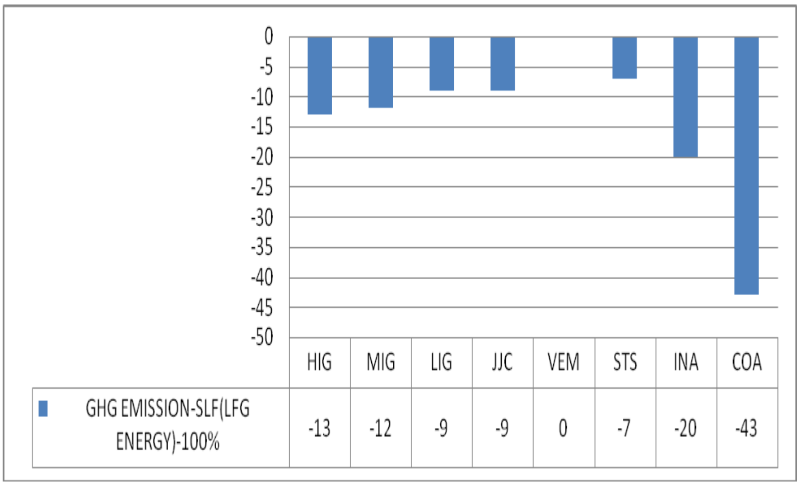

Figure4. *MTCO$_2$E equivalent GHG emissions for Scenario 3*

4. In this scenario 4 waste emission reduction is nearly similar for all generation sources except the street sweeping where emission reduction is very less. Waste reduction is highest in case of commercial waste (Figure 5).

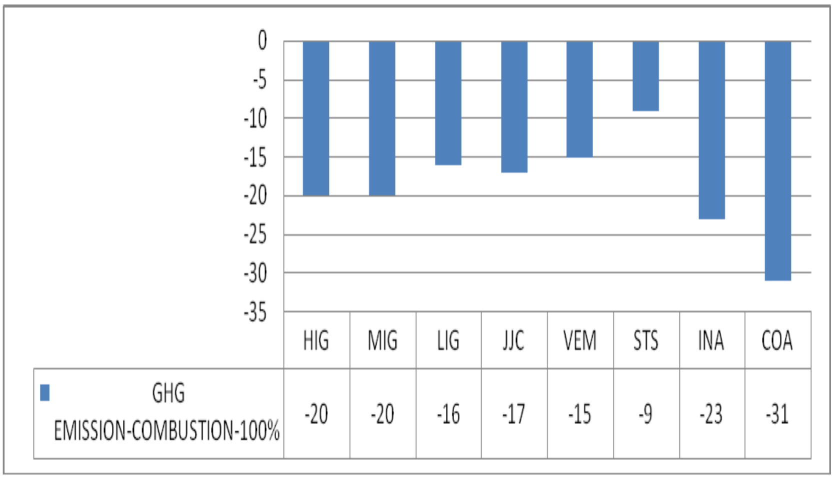

Figure5. *MTCO$_2$E equivalent GHG emissions for Scenario 4*

5. In the figure 11 composting treatment facilities have been analyzed. In that case waste emission reduction is more than any other scenarios, varies from -26 units to -194 units for vegetable markets to commercial places (Figure 6).

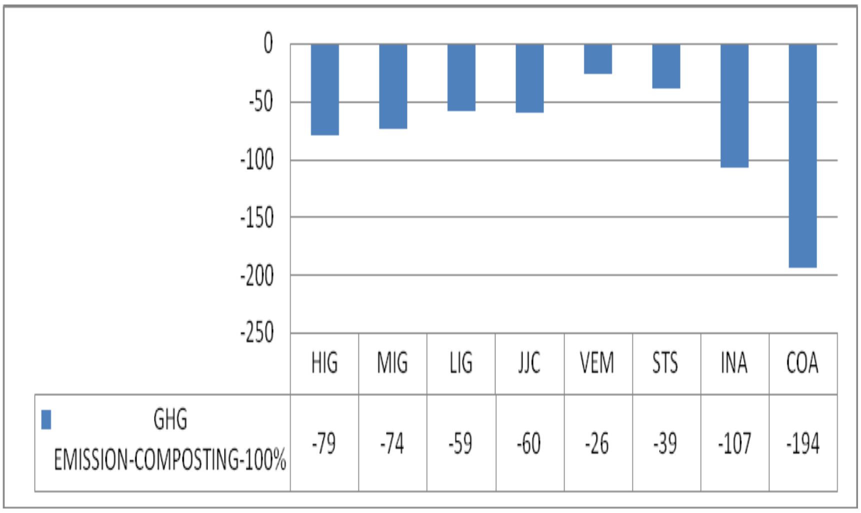

Figure6. *MTCO$_2$E equivalent GHG emissions for Scenario 5*

6. There is no significant difference in emission reduction in scenarios 2 and 3 for all waste generation sources but for sanitary land fill with no land fill gas, there is variation in emission with minimum in street sweeping (Figure 7).

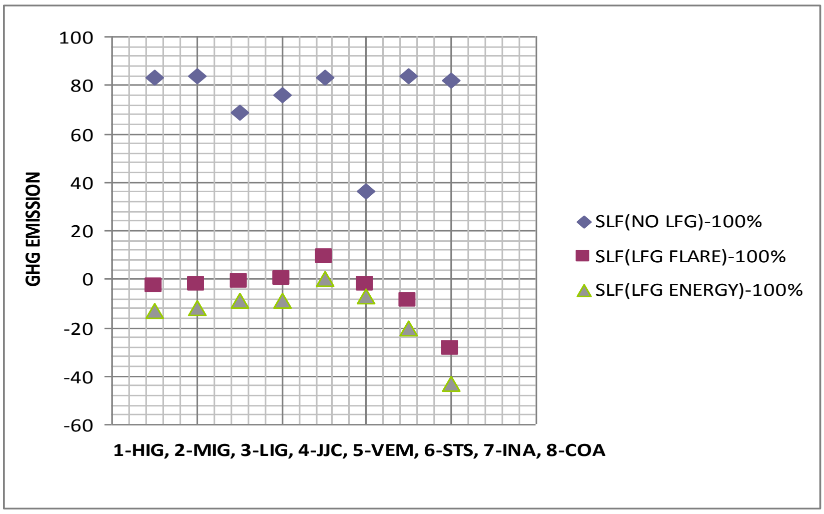

Figure7. *Comparative studies for MTCO$_2$E equivalent GHG emissions for Scenario 1, 2 and 3*

7. If compare scenarios 3, 4 and 5 of independent waste disposal technologies then waste emission reduction in above two scenarios are same. Waste reduction by composting is dependent to particular waste generation source. Maximum waste reduction for composting followed by Institutional areas. Waste emission reduction for vegetable market is lowest if composting is used. There is not major difference in waste reduction in technology used for disposal of residential waste with different socio-economic status in case of composting treatment (Figure 8).

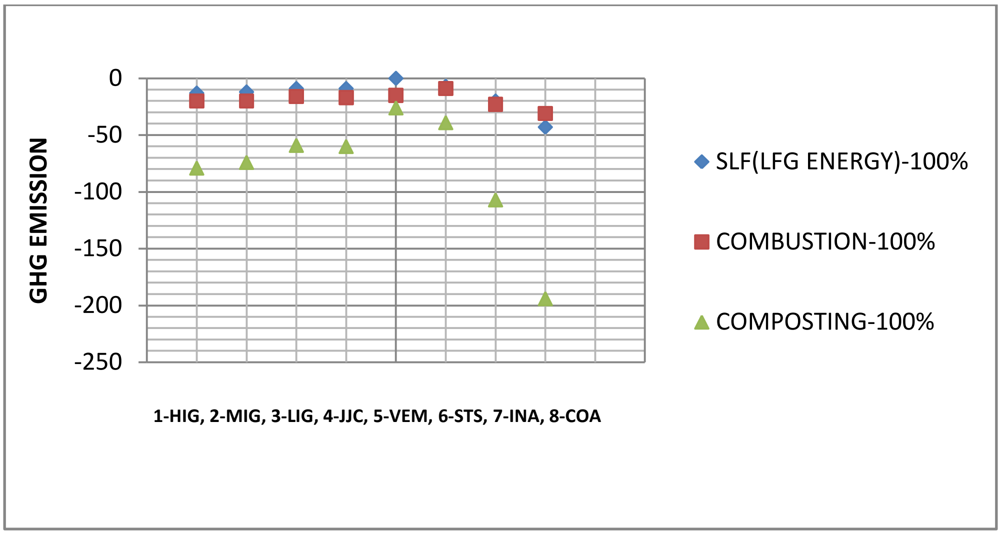

Figure8. *Studies for MTCO$_2$E equivalent GHG emissions for Scenarios 3, 4 and 5*

8. In figure 14 waste reduction values are highest in case of commercial waste in scenarios 8, 11 and 12. Scenarios 11 and 12 are best for commercial waste source. Scenarios 11 and 12 are nearly same in case of waste emission reduction. There is not major difference in waste reduction in technology used for disposal of residential waste with different socio-economic status (Figure 9).

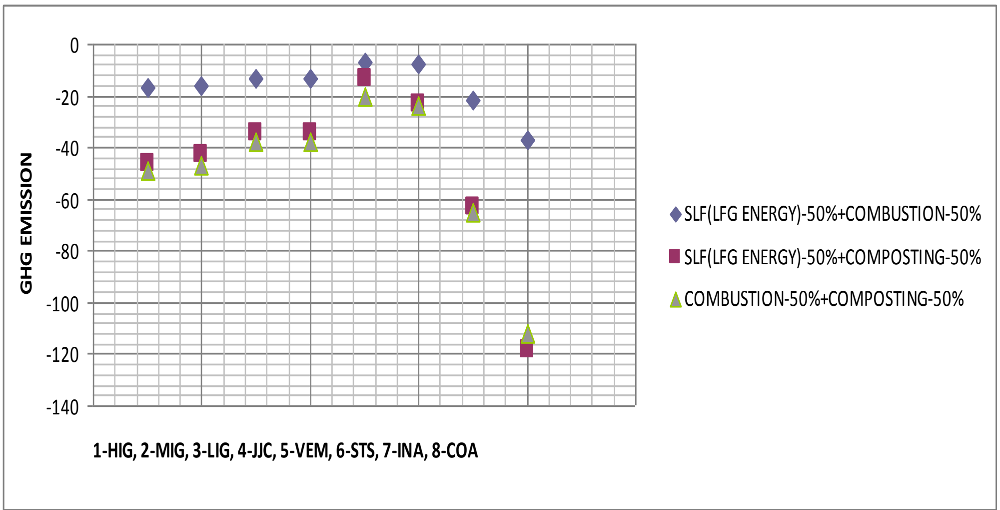

Figure9. *Studies for MTCO$_2$E equivalent GHG emissions for Scenarios 8, 11 and 12*

6. CONCLUSION

Increased concerns about global warming, as well as awareness of the environmental problems caused by inadequate waste management in developing countries, provide an important additional rational for a sustainable management of the fraction of the waste. If total waste diverted towards land fill without land fill gas recovery then GHG emission is very high with comparison to other technologies. GHG emission saving is more for composting especially for commercial waste has highest reduction in GHG. Technologies SLF (LFG Flare) and SLF (LFG Energy) with composting have significant GHG emission reduction. For all types of waste generation source composting is better technology to reduce GHG emission reduction.

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