CDM AND LANDFILLING (MSW): STUDY OF THE INTEGRATED MUNICIPAL WASTE PROCESSING COMPLEX AT GHAZIPUR, DELHI

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&

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Abstract:

The clean development mechanism (CDM) of Kyoto protocol is the first global, environmental investment and credit scheme of its kind, providing a standardized greenhouse gas emissions offset instrument. Reduction in one country benefits all other countries. Through CDM, the industrialized countries with GHG reduction obligations under the Kyoto protocol can provide financial support for GHG reduction projects in developing nations. CDM comprises of projects like methane utilization, energy saving, carbon sequestration, fossil fuel switch, biomass energy and other technologies useful in carbon off setting directly or indirectly.

Landfilling is one of the most common ways of municipal solid waste (MSW) disposal. Landfill gas based CDM project offers the change to reduce GHG emissions while upgrading landfill management practices using revenues generated by the sale of emission reductions. Also with the advent of the Kyoto Protocol and its recognition of the use of forestry activities and carbon sinks as acceptable tools for addressing the issue of the build-up of atmospheric carbon, the potential role of planted forests as a vehicle for carbon sequestration has taken on a new significance. Additionally, the emergence of tradable emission permits and now tradable carbon offsets provides a vehicle for financially capturing the benefits of carbon emission reductions and carbon offsetting activities.

Keywords:

Clean development mechanism (CDM), certified emission reduction (CER), Municipal solid waste (MSW), Intergovernmental panel on climate change (IPCC), United nations framework convention on climate change (UNFCCC), Life cycle assessment (LCA).

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Abbreviations:

CER: Certified emission reduction
CDM: Clean development mechanism
DOC: Degradable organic carbon
EPA: Environment protection agency
GHG: Green house gases
GWP: Global warming potential
IPCC: Intergovernmental panel on climate change
LCA: Life cycle assessment
LFG: Land filling gas
MCF: Methane correction factor
MSW: Municipal solid waste
OECD: Organization for Economic Co-operation and Development
PDD: Preliminary design document
PPP: Public private partnership
RDF: Refused derived fuel
SWDS: Solid waste disposal site
TPD: Tonnes per day
UNFCCC: United Nations framework conventions on climate change

Introduction:

Municipal solid waste is made up of different organic and inorganic fractions like food, vegetables, paper, wood, plastics, glass, metal and other inert materials. Typically the landfill gas consists of 50-60 percent by volume of methane and 30-40 percent by volume carbon dioxide with numerous chemical compounds such as aromatics, chlorinated organic compounds and sulfur compounds.

Landfills comprise the principal source of anthropogenic methane emission and are estimated to account for 3-19% of anthropogenic emission globally. The earliest landfill was started in 1975 in Delhi near Ring road. In 1978 two other landfills were started at Timarpur and Kailash Nagar. To date 17 landfill sites have been filled and closed. At present there are three large functioning landfill sites at Ghazipur, Okhla and Bhalswa.

The Gazipur landfill site covers an area of 73 acres (3.0×10^5 m^2) and is operational since 1983.The average waste depth is estimated around 12 m and it mainly comprises of the waste from slaughterhouse, hospital, municipal, residential, construction and demolition waste, and dairy industry. A computerized scale of 25 metric ton weighs all the vehicles transporting the waste to the site.

Land filling is commonly being developed as a renewable source of energy through the systematic recovery and utilization of biogas generated during anaerobic decomposition of municipal solid wastes. In India there is good scope for the development of landfill gas technology as municipal solid waste contains a high proportion of degradable organic matter. Biogas generation from various sources is also seen as a key renewable energy source in the National Energy Policy.

Land filling gas (LFG) technology involves: (i) estimation of ultimate yield and generation rates of LFG on the basis of waste composition; (ii) design of an LFG abstraction system appropriate to site conditions and land filling practices; and (iii) cost-effective gas utilization schemes. In India, the labour-oriented solid waste management systems concentrate more on the collection and transportation stages. Disposal is mostly limited to uncontrolled filling of low-lying areas. As the solid waste contains a good proportion of degradable organic matter, and there is a growing energy demand in every sector of economy, there is good scope for controlled LFG generation, recovery and utilization.

A natural result of waste decaying in landfills is the production of byproduct gases. This occurs Because of the anaerobic degradation of biodegradable organic wastes. One of the byproducts of this decay process is the production of methane (CH_4). While there are several phases with unique characteristics, the most important is the methane production phase, which is generally the steady state. The methane production phase can be described by the following stabilization equation:

CHONS (proteins) + $H_2O \rightarrow H_2O + CO_2 + CH_4 + H_2 + NH_4 + HS$

Where the transition is driven by the presence of anaerobic bacteria. The average composition of this landfill gas is about 50% methane (CH_4), 45% carbon dioxide (CO_2), and 5% nitrogen (N_2) and other gases. However, the actual composition of gases depends upon the amount of organic matter feedstock, rain infiltration, the anaerobic environment, and the age of the landfill. As a result of increased environmental awareness, there has been an emergence of alternative and ‘‘add-on” features to land-filling such as energy recovery from LFG recovery, aero landfills, pre-composting of waste prior to landfilling and compost capping; all of which have various impacts on GHG emissions.

Landfills can be great C sinks owing to slow degradation of waste. The amount of C stored in a landfill is dependent on the deposited organic compounds (DOC) in form of and their rate constant, both of which can be obtain from the IPCC (2006).

Landfill Gas Migration

Landfill gas that is produced within the landfill mass will generally move away from the landfill. Landfill gasses can migrate through the soils or through ambient air (dispersion). The production of landfill gas results in pressure gradients (advection) and concentration gradients (diffusion) between the landfill and the surrounding environment. Landfill gas will migrate from the source area (landfill) along the path of least resistance due to pressure, density, and concentration gradients. Methane is lighter than air and carbon dioxide is heavier than air.

However, they will not separate by their individual density but rather move, as a mass in accordance with the density of the mixture and other gradients such as temperature and partial pressure (EPA, April 1992). This usually results in landfill gas moving upward through the landfill surface into the landfill gas collection system or through the surface soils into ambient air. However, the upward movement of landfill gas can be inhibited by compacted waste or landfill cover materials. This can result in landfill gas migrating horizontally through the waste mass into surrounding soils, utility conduits or structures if an adequate gas collection system is not designed and constructed.

Factors Affecting Landfill Gas Migration:

Landfill gas has been detected in soils at distances of up to 1,500 feet from the edge of waste at landfills. As with groundwater flow, highly porous materials, such as fine to coarse sands and gravels, will provide more passageways for landfill gases than fine-grained soils such as till, silts and clays. However, landfill gas migration differs from migrating contaminated groundwater in that gas flows within the soils along its own pressure and concentration gradient, which can cause gas migration in a direction opposite to groundwater flow or topography. Also, landfill gas flow in soils is impeded by soils that are saturated. For example, wetlands and other locations where exposed groundwater is situated, act as barriers to the migration of landfill gas. The water table (non-perched) is a barrier to landfill gas migration. Perched water table conditions, however, do not prevent landfill gas from migrating through soils located in between the perched water table interval and underlying water table. Landfill gasses can move through the landfill surface to the ambient air. Once in the air, landfill gasses can be carried off site to receptors by the wind. Odors are an indicator of gas moving in ambient air. The concentration of gases in ambient air, where people may be exposed, depends on many factors including, but not limited to: proximity to the landfill,

landfill gas production rates, landfill gas constituent concentrations within the landfill, and pressure gradients within the landfill, gas control systems, topography, weather and change in seasons (temperature inversions).

Land filling and Life Cycle Assessment:

Life Cycle Assessment (LCA) is used as the analytical tool to evaluate the environmental consequences of landfilling holistically. The generation of municipal solid waste (MSW) increases with socio-economic development. In an emerging economy such as India, rapid population growth has further added to the intensity of waste generation. As landfill is a low cost and easily manageable technology, it is a very popular mode of waste management. The inevitable consequences of the practice of solid waste disposal in landfill are gas and leachate (any liquid that, in passing through matter, extracts solutes, suspended solids or any other component of the material through which it has passed) generation due primarily to microbial decomposition, climatic conditions, refuse characteristics and landfilling operations. For small landfills, the methane can be collected and flared. However, for large landfills, the collected methane gas can be used to generate electricity and/or heat.

The Organization for Economic Co-operation and Development (OECD) is projected to decrease its landfill emissions by 31% in 2020 compared to 1990 levels, developing countries are expected to generate more waste and in the same period of time contribute to a 7% increase in total global landfill gas emissions reaching 817 $MtCO_2eq$ in 2020.

Landfill gas projects were among the first projects registered by the UNFCCC (UNFCCC, 2010) and many big dump-sites around the world have been ‘‘cleaned” thanks to the incentives created by the CDM. These are mainly based on revenues from methane destruction which make the projects financially very attractive.

Carbon balance of land filling:

It is important to carry out research on carbon sequestration for several reasons:

- A major tool for reducing carbon emissions from fossil fuels. However, much work remains to be done to understand the science and engineering aspects and potential of carbon sequestration options.
- Given the magnitude of carbon emission reductions needed to stabilize the atmospheric CO_2 concentration, multiple approaches to carbon management will be needed. Carbon sequestration should be researched in parallel with increased energy efficiency and decarbonization of fuel.
- Carbon sequestration is compatible with the continued large-scale use of fossil fuels, as well as greatly reduced emissions of CO_2 to the atmosphere. Current estimates of fossil fuel resources—including conventional oil and gas, coal, and unconventional fossil fuels such as heavy oil and tar sands imply sufficient

resources to supply a very large fraction of the world's energy sources through the next century.

- The natural carbon cycle is balanced over the long term but dynamic over the short term; historically, acceleration of natural processes that emit CO_2 is eventually balanced by an acceleration of processes that sequester carbon, and vice versa. The current increase in atmospheric carbon is the result of anthropogenic mining and burning of fossil carbon, resulting in carbon emissions into the atmosphere that are unopposed by anthropogenic sequestration.
- Determining which carbon compounds turn over faster in roots.
- Investigating the discrepancies between conventional and isotopic methods, and
- Using the tracer to track carbon in other tissues in the tree and into the soil organic matter itself.

"Sequestration," is important because it removes carbon from the natural carbon cycle indefinitely, reducing net emissions of greenhouse gases. Carbon is naturally removed from the atmosphere and stored in forests (and then in harvested wood products, e.g., paper, lumber, furniture), yard trimmings, and food scraps via photosynthesis. Once these materials are disposed of in a landfill, only a portion of them will decompose, while a portion will remain stored in the landfill indefinitely. Decomposition of the waste creates landfill gas, which is primarily composed of methane and carbon dioxide, as well as small amounts of volatile organic compounds. The proportion of the solid waste in landfills that decomposes depends on the type of waste, the amount of moisture, and other factors that affect the growth of microbes that break down the waste, and whether the landfill is operated to retard or enhance waste decomposition. The landfilling of harvested wood products, yard trimmings, and food scraps stores a significant amount of carbon that would otherwise decompose and release carbon to the atmosphere. Thus landfill carbon storage should be accounted for in greenhouse gas inventories. The Intergovernmental Panel on Climate Change recommends doing so by accounting for carbon storage associated with disposal of harvested wood products, yard trimmings, and food scraps in landfills.

Carbon Sequestration in Landfills

- Much of the disposed wood and paper products remain in the landfill for very long periods of time.
- Landfills mitigate carbon buildup in the atmosphere through carbon sequestration, offsetting methane emissions.

Carbon Dioxide Sequestration

Carbon dioxide (CO_2), photo synthetically fixed, entering and remaining undecomposed ("sequestered") within landfills, should comprise roughly 500 million tonnes per year of CO_2 removed from the atmosphere. The net "greenhouse" benefit clearly depends on the basis for comparison (after all, conventional landfills sequester. as well). Still, such landfill sequestration of photosynthetically fixed carbon provides clear greenhouse benefit relative to common practices of aerobic composting, increasingly applied in developed countries, or to the open burning so common in developing countries. One such generalized diagram is shown on following Figure.1 depicting landfill carbon balance.

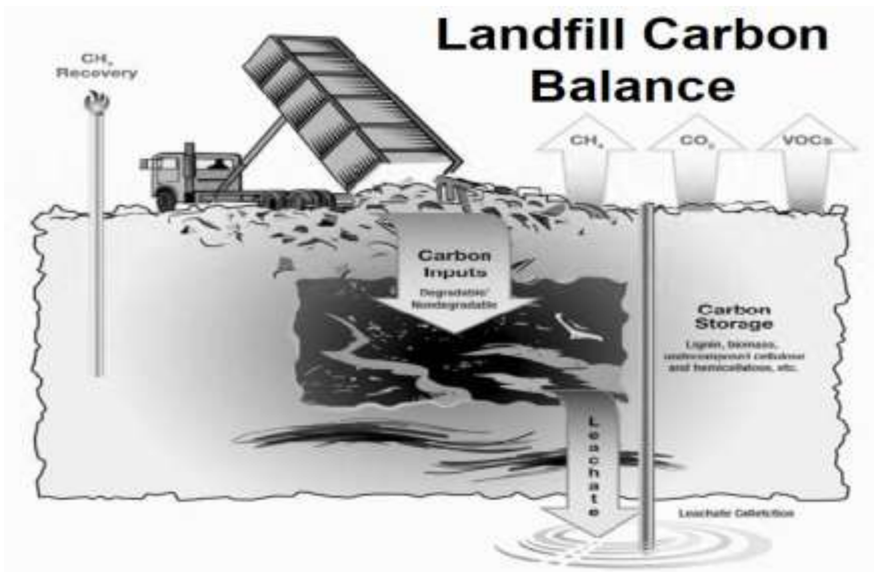

Figure.1 Generalized diagram case study on an integrated municipal waste processing complex at Ghazipur, Delhi

Unique Waste Processing Company (UWPC) is a 100% subsidiary of IL&FS Infrastructure Development Corporation Limited (IIDC) that has been incorporated for developing municipal waste management and processing projects through Public Private Partnership (PPP) framework in various parts of India. East Delhi Waste Processing Company Private Limited (EDWPC) is a special purpose vehicle, incorporated by UWPC for developing project for processing municipal waste using the technologies of processing municipal waste and also to produce as by-products, inter alia, refuse derived fuel, fluff, organic manure, and use such products for generating electricity at the Ghazipur site. EDWPC is working in close co-ordination with Municipal Corporation of Delhi (MCD) for developing a waste processing facility at the Ghazipur site to be developed on a build, operate and transfer basis to enable augmentation of the waste disposal capabilities of MCD.

The integrated municipal waste-processing complex includes a MSW processing plant at Ghazipur to produce Refuse Derived Fuel (RDF) along with a power plant of 10 MW capacities where the RDF derived from the waste will be used as fuel to produce renewable electricity. MSW processed will be on an average 1300 tons per day (TPD).

The components of the project are further listed below:

a) MSW processing plant on the lines of DST-TIFAC technology for RDF preparation. The plant shall be capable of processing 1300 tons per day of municipal solid waste.
b) Power Plant of 10 MW capacity.

In addition, the project activity will also address to some extent the acute energy crisis faced by northern India by producing 10MW of clean electricity that will be supplied to the local region which is being fed by Northern grid. Thus the project would achieve significant reduction in green house gas emission due to the following two components:

a) Avoidance of methane emission from dumping solid waste in the landfill (dump) sites.
b) Replacement of energy from carbon intensive northern regional grid of India by supply of renewable electricity.

The location detail of the project activity along with the map is given below in Figure.2

Location	**Latitude**	**Longitude**
Ghazipur, Delhi	28^{o} 37’	77^{o} 20’

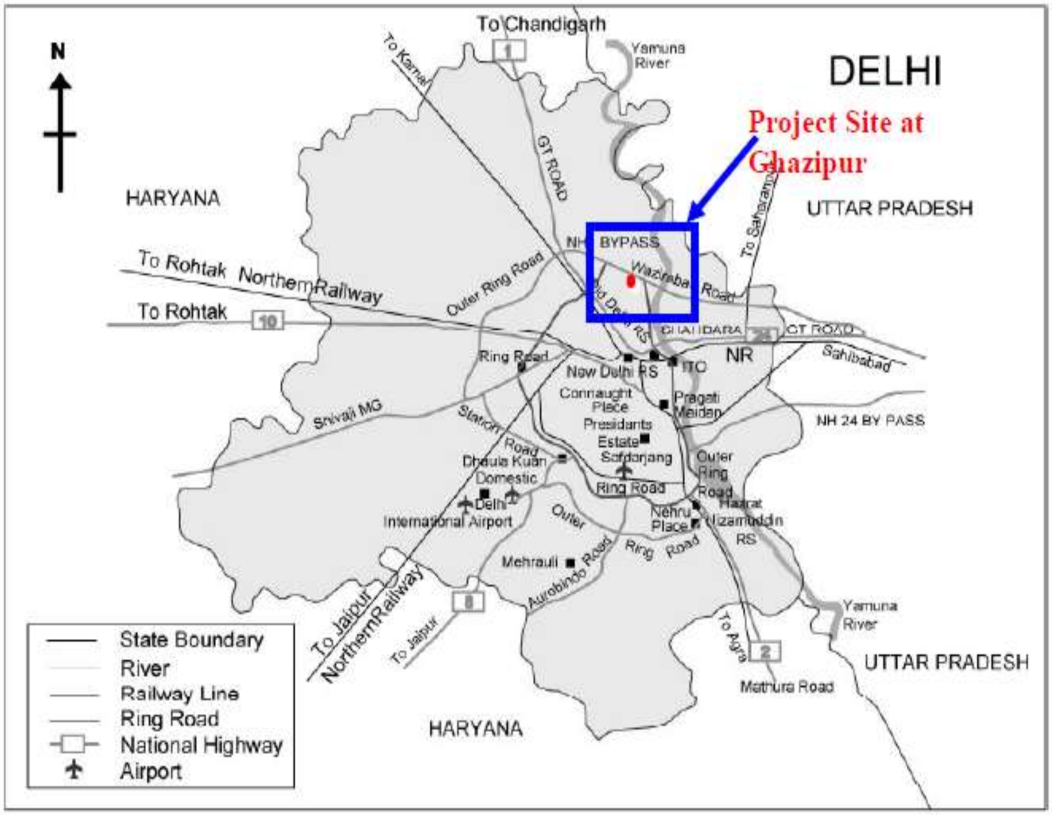

Figure.2 Land fill site at Ghazipur, Delhi

Emission reduction is estimated following the approved methodology AM0025.The estimation of project emission, baseline emission and leakage emission is described as below:

Project Emission

The project emissions in year y are:

$PE_y = PE_{elec, y} + PE_{fuel, on\text{-}site, y} + PE_{c, N2O, y} + PE_{c, CH4, y}$

Where:

PE_y	project emissions during the year y (tCO_2e)
$PE_{elec, y}$	emissions off-site from electricity consumption on-site in year y (tCO_2e)
$Re_{fuel, on\text{-}site, y}$	emissions on-site due to fuel consumption on-site in year y (tCO_2e)
$PE_{c, N2O, y}$	emissions during the composting process due to N_2O production in year y (tCO_2e)
$PE_{c, CH4, y}$	emissions during the composting process due to methane production through anaerobic conditions in year y (tCO_2e)

Emissions from electricity use:

The project activity will involve on-site electricity consumption. Electricity may be purchased from the grid or generated on-site. The CO_2 emissions from electricity generation are calculated as follows:

$PE_{elec, y} = kWh_{e, y} * CEF_{elec}$

Where:

$kWh_{e, y}$	is amount of electricity used for the composting process, measured using an electricity meter (MWh)
CEF_{elec}	carbon emissions factor for electricity (tCO_2/MWh). To account for emissions of electricity generation on site, project participants should use for Cep_{halic}, the default emission factor for a diesel generator with a capacity of more than 200 kW for small-scale project activities (0.8 tCO_2/MHz)

Emissions from fuel use on-site

Project participants shall account for CO_2 emissions from any on-site fuel combustion (apart from electricity generation, e.g. vehicles used on-site, heat generation, etc). Emissions are calculated from the quantity of fuel used and the specific CO_2-emisison factor of the fuel, as follows:

$PE_{fuel, on-site, y} = F_{cons, y} * NCV_{fuel} * EF_{fuel}$

Where:

$PE_{fuel, on-site, y}$	is CO_2 emissions due to on-site fuel combustion in year y (tCO_2)
$F_{cons, y}$	is fuel consumption on site in year y (l or kg)
NCV_{fuel}	is net calorific value of the fuel (MJ/l or MJ/kg)
EF_{fuel}	is CO_2 emissions factor of fuel (tCO_2/MJ)

Project participants may use IPCC default values for the net calorific values and CO_2 emission factors.

Emissions from composting

N_2O emissions: During storage of waste in collection containers, the composting process itself and when the compost is finished, N_2O emissions might be released. Based upon Schenk, a total loss of 42 mg N_2O-N per kg composted dry matter can be expected (from which 26.9 mg N_2O during the composting process). The dry matter content of compost is around 50% up to 65%. Based on these values, project participants should use a default emission factor of 0.043 kg N_2O per tonne of compost for $EF_{c,\ N2O}$ and calculate emissions as follows:

$$PE_{c,\ N2Oy} = M_{compost,\ y} * EF_{c,\ N2O} * GWP_{N2O}$$

Where:

$PE_{c,\ N2Oy}$	is N_2O emissions from composting in year y (tCO_2e)
$M_{compost,\ y}$	is total quantity of compost produced in year y (tonnes/a)
$EF_{c,N2O}$	is emission factor for N_2O emissions from the composting process (t N_2O / t compost)
GWP	is Global Warming Potential of nitrous oxide, (tCO_2/tN_2O)

CH_4 emissions: During the composting process, aerobic conditions are not completely reached in all areas and at all times. Pockets of anaerobic conditions – isolated areas in the composting heap where oxygen concentrations are so low that the biodegradation process turns anaerobic – may occur. The emission behaviour of such pockets is comparable with the anaerobic situation in the landfill, so anaerobia during the composting process is a potential emissions source for methane just like an unmanaged landfill is. Through predetermined sampling procedures the percentage of waste that degrades under anaerobic circumstances can be determined. Using this percentage, project methane emissions from composting are calculated as follows:

$$PE_{c,CH4} = MB_y * GWP_{CH4} * S_a$$

Where:

$PE_{c,\ CH4}$	is project methane emissions due to anaerobic circumstances in the composting process in year y (tCO_2e)
$S_{A,\ y}$	is share of the waste that degrades under anaerobic circumstances in the composting plant during year y (%)
MB_y	is quantity of methane that would be produced in the landfill in the absence of the project activity in year y (tCH_4)
GWP_{CH4}	is Global Warming Potential of methane (tCO_2e/tCH_4)

Now,

$$S_a = S_{OD} / S_{total}$$

Where:

S_{OD}	is number of samples per year with an oxygen deficiency (oxygen content below 10%)
S_{total}	is total number of samples taken per year, where S_{total} should be chosen in a manner that ensures estimation of S_a with 20% uncertainty at 95% confidence level.

Baseline emissions

To calculate the baseline emissions project participants shall use the following equation:

$BE_y = (MB_y - MD_{reg,\,y}) * GWP_{CH4}$

Where:

$BE_{,\,y}$	is baseline emissions in year y (tCO_2e)
$MB_{,\,y}$	is methane produced in the landfill in the absence of the project activity in year y (tCH_4)
$MD_{reg,\,y}$	is methane that would be destroyed in the absence of the project activity in year y (tCH_4)
GWP_{CH4}	is Global Warming Potential of methane (tCO_2e/tCH_4)

In cases where regulatory or contractual requirements do not specify $MD_{reg,\,y}$, an Adjustment Factor (AF) shall be used and justified, taking into account the project context. In doing so, the project participant should take into account that some of the methane generated by the landfill may be captured and destroyed to comply with other relevant regulations or contractual requirements, or to address safety and odor concerns.

$MD_{reg,\,y} = MB_y * AF$

Where:

AF is Adjustment Factor for MB_y (%). AF is defined as the ratio of the destruction efficiency of the collection and destruction system mandated by regulatory or contractual requirement to that of the collection and destruction system in the project activity.

The 'Adjustment Factor' shall be revised at the start of each new crediting period taking into account the amount of GHG flaring that occurs as part of common industry practice at that point in the future.

Methane generation from the landfill in the absence of the project activity:

The amount of methane that is generated each year (MB_y) is calculated for each year with a multi-phase model. The model is based on a first order decay equation. It differentiates between the different types of waste j with respectively different decay rates k_j (fast, moderate, slow) and fraction of degradable organic carbon (DOC_j). The model calculates the methane generation based on the actual waste streams $A_{j,\,x}$ disposed in the most recent year (y) and all previous years since the project start (x=1 to x=y). The amount of methane produced in the year y (MB_y) is calculated as follows:

$$MB_y = \varphi . \frac{16}{12} . DOC_f . MCF . \sum_{x=1}^{y}\sum_{j=A}^{D} Aj,x . DOC_j . 1\text{-}e^{-k_j} . e^{-k_{j(y-x)}}$$

Where:

$MB,_y$	is methane produced in the landfill in the absence of the project activity in year y (tCH_4)
φ	is model correction factor (default 0.9) to correct for the model-uncertainties
F	is fraction of methane in the landfill gas
DOC_j	is per cent of degradable organic carbon (by weight) in the waste type *j*
DOC_f	is fraction of DOC dissimilated to landfill gas
MCF	is Methane Correction Factor (fraction)
$A_{j, x}$	is amount of organic waste type j prevented from disposal in the year x (tonnes/year)
k_j	is decay rate for the waste stream type j
j	is waste type distinguished into the waste categories (from A to D)
x	is year during the crediting period: x runs from the first year of the first crediting period (x=1) to the year for which emissions are calculated (x=y)
y	is year for which LFG emissions are calculated

Model Correction Factor (φ): The relative error of multi-phase models assessed to be 18%. Methane correction factor (MCF): The methane correction factor (MCF) accounts for the fact that unmanaged landfills produce less methane from a given amount of waste than managed landfills, because a larger fraction of waste decomposes aerobically in the top-layers of unmanaged landfills. The proposed default values for MCF are listed as below in following Table.1 and Waste stream decay rates (k_j) and associated IPCC default values for DOC_j given in Table.2.

Table.1: Solid Waste Disposal Site (SWDS) Classification and Methane Correction Factors

Type of site	**MCF default values**
Managed site	1.0
Unmanaged site – deep (> 5 m waste)	0.8
Unmanaged site – shallow (< 5 m waste)	0.4
Note: Managed SWDS must have controlled placement of waste (i.e. waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include some of the following: cover material, mechanical compacting or leveling of waste.	

Table.1: Source: Table 5.1 in the 2000 IPCC Good Practice Guidance

Table.2: Waste stream decay rates (k_j) and associated IPCC default values for DOC_j

Waste stream A to E	Per cent DOCj (by weight)	Decay-rate (kj)
A. Paper and textiles	40	0.023
B. Garden and park waste and other (non-food) putrescibles.	17	0.023
C. Food waste	15	0.231
D. Wood and straw waste[1)]	30	0.023
E. Inert material	0	0

[1)] Excluding lignin-C

Fraction of degradable organic carbon dissimilated (DOC_f): The revised IPCC Guidelines propose a default value of 0.77 for DOC_f. A lower value of 0.5 should be used if lignin-C is included in the estimated amount of degradable organic carbon.

The amount of organic waste type *j* ($A_{j,x}$) is calculated based on the total amount of waste collected in the year x (A_x) and the fraction of the waste type in the samples ($p_{n,j,x}$), as follows:

$$A_{j,x} = A_x \frac{\sum_{n=1}^{z} p_{n,j,x}}{z}$$

Where:

$A_{j,x}$ is amount of organic waste type j prevented from disposal in the year x (tonnes/year).

A_x is amount of total organic waste collected during the year x (tonnes/year).

$Pn_{,j,x}$ is fraction of the waste type j in the sample n collected during the year x

Z is number of samples taken during the year x

Calculation of F:

The project participant shall determine *F* with the following preferences**:**

1. Measure *F* on an annual basis as a monitoring parameter, at a landfill in the proximity of the composting plant, receiving comparable waste as the composting plant receives.

2. Measure *F* once prior to the start of the project activity at a landfill in the proximity of the composting plant, receiving comparable waste as the composting plant will receive.
3. In case there is no access to a landfill, the project participants should apply the conservative default value of 0.5, being the lower end of IPCC range of 0.5 – 0.6.

Leakage emission :

The only source of leakage considered in the methodology is CO_2 emissions from off-site transportation of waste materials. The composting project may result in a change in transport emissions. This would occur when the waste is transported from waste collecting points in the collection area to the composting facility, instead of to existing landfills. When it is likely that the transport emissions will increase significantly, such emissions should be incorporated as leakage. In this case, project participants shall document the following data in the CDM-PDD: an overview of collection points from where the waste will be collected, their approximate distance (in km) to the composting facility, existing landfills and their approximate distance (in km) to the nearest end-user.

For calculations of the emissions, IPCC default values for fuel consumption and emission factors may be used. The CO_2 emissions are calculated from the quantity of fuel used and the specific CO_2-emission factor of the fuel for vehicles i to n, as follows:

$$L_y = \sum_{i}^{n} NO_{vehicles,i,y} * km_{i,y} * VF_{cons,i} * CV_{fuel} * D_{fuel} * EF_{fuel}$$

Where:

$NO_{vehicles,i,y}$	is number of vehicles for transport with similar loading capacity.
$Km_{i,y}$	is average additional distance travelled by vehicle type i compared to baseline in year y
VF_{cons}	is vehicle fuel consumption in litres per kilometer of vehicle type i (l/km)
CV_{fuel}	is Calorific value of fuel (MJ/Kg)
D_{fuel}	is density of fuel (kg/l)
EF_{fuel}	is Emission factor of fuel (tCO_2/MJ)

Emission Reductions:

To calculate the emission reductions, the following equation is used:
$ER_y = BE_y – PE_y – L_y$

Where:

ER_y	is emissions reductions in year y (t CO_2e)
BE_y	is emissions in the baseline scenario in year y (t CO_2e)
PE_y	is emissions in the project scenario in year y (t CO_2e)
L_y	is leakage in year y (t CO_2e)

If the sum of PE_y and L_y is smaller than 1% of BE_y in the first full operation year of a crediting period, the project participant may assume a fixed percentage of 1% for PE_y and L_y combined for the remaining years of the crediting period.

Using the above emission formulae for the GHAZIPUR LANDFILL, the estimated amount of emission reductions over the fixed ten year crediting period are shown in following Table.3, Figure 3 depicts the assessing project potential of the site and Table.4 shows the net emissions as per the UNFCCC for Ghazipur area.

Table.3: Annual estimation of emission reductions in tones of CO_2e

Year	Annual estimation of emission reductions In tonnes of CO_2e
2010-11	32632
2011-12	60822
2012-13	86877
2013-14	110964
2014-15	104099
2015-16	120118
2016-17	134935
2017-18	148642
2018-19	161327
2019-20	173067
Total	**1133482**

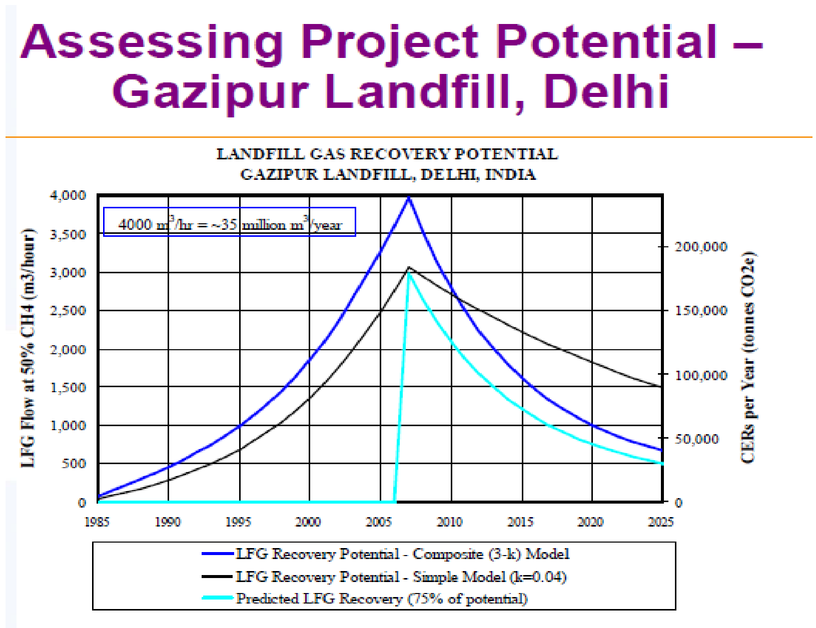

Figure.3 Assessing project potential-Gazipur landfill, Delhi

Table.4: Total net emissions as per the UNFCCC for Ghazipur area

Year	Avoidance of Methane Emission	Compliance (%)	BAU (%)	Compliance adjusted	Project emission	Leakage	Net emissions	Emissions due to export of power	Total net emissions
2010-11	33895	10	90	30505	34612.5	53	-4160	35393	31233
2011-12	65217	10	90	58695	34612.5	53	24030	35393	59432
2012-13	94168	10	90	84751	34612.5	53	50085	35393	85478
2013-14	120930	10	90	108837	34612.5	53	74172	35393	109565
2014-15	145675	30	70	101973	34612.5	53	67307	35393	102700
2015-16	168559	30	70	117992	34612.5	53	83326	35393	118719
2016-17	189726	30	70	132808	34612.5	53	98143	35393	133536
2017-18	209309	30	70	146516	34612.5	53	111851	35393	147244
2018-19	227430	30	70	159201	34612.5	53	124535	35393	159928
2019-20	244201	30	70	170941	34612.5	53	136275	35393	171668
Total				1112219	346125	530	765563	353930	1119492

Fixed crediting period: 1/11/2010
Duration: 10 years
Expected operational lifetime: 25 years

This baseline emission estimation if certified is called as certified emission reduction (CER) and is used to issue the Carbon credit. The CER will be issued based upon the emission reduction achieved by the project activity. The annual average over the fixed ten year crediting period is 113348 tones of CO_2e.

Conclusions

The feasibility analysis using CDM potential in the integrated municipal waste processing complex in Ghazipur landfill area was done considering the UNFCCC project design document form (CDM PDD) Version 05 and a relation between the CDM projects and the baseline emission is drawn. This baseline emission estimation if certified is called as certified emission reduction (CER) and is used to issue the carbon credit. The CER will be issued based upon the emission reduction achieved by the project activity.

The annual average over the fixed ten year crediting period is found out to be 1, 13,348 tones of CO_2e.By any measure, the CDM is a work in progress. Since its inception it has experienced an almost exponential growth in project numbers. In particular India has recognized the benefits of CDM program and hosted a number of projects. The past few years have demonstrated that the CDM has the potential to be a major avenue for international cooperation in GHG emissions reductions. The carbon credit is of high value so as to attract more investment in renewable energy projects and hence, a measure to mitigate the GHG’s to some extent and has a better environment to live in.

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