Memo on Baseline emissions from MSW Management using SWEET
East Delhi & Coimbatore

Supported by
Climate & Clean Air Coalition-Municipal Solid Waste Initiative (CCAC MSWi)
Suggested format for citation

T E R I. 2017
Replace this line with the title of the report
New Delhi: The Energy and Resources Institute.
[Project Report No. Activity 1.5, 2016 MS 06]
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1 Assessment of Short lived climate pollutants (SLCP) from MSW management

1.1 Global warming

Global Warming (GW) occurs when greenhouse gasses collect in the atmosphere and absorb sunlight and solar radiation which have bounced off the earth’s surface. Radiatively active gases that absorb wavelengths longer than 4 micro meter are called greenhouse gases. This absorption heats the atmosphere, which in turn radiates energy back to the earth as well as outer space. These greenhouse gasses act as a thermal blanket around globe raising earth’s surface temperature. This is known as Greenhouse effect. Table 1 highlights the effects that global warming have along with a brief description.

<table>
<thead>
<tr>
<th>Effect</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher temperatures:</td>
<td>Earth’s temperatures in 2016 were the hottest ever recorded in the history, annual average global temperature was 0.99°C (Climate Change: Vital Signs of the planet: Global Temperature, 2017). Due to change in even 0.06°C, which may sound small, can upset the delicate balance of ecosystems, and affect plants and animals which inhabit them. (Climate Change Threats &amp; Solution</td>
</tr>
<tr>
<td>Changing Landscapes and Wildlife Habitat</td>
<td>As rising temperatures and changing patterns of precipitation are changing, encouraging the propagation of species which impact native ocean habitat. Experts predicted, one-fourth of the Earth’s species will be led for extinction by 2050 if the warming trend continues at its current rate. (Climate Change Threats &amp; Solution</td>
</tr>
<tr>
<td>Rising Seas</td>
<td>The rising seas threaten to submerge low-lying areas and islands, also threaten dense coastal populations, erode shorelines, damage property and destroy ecosystems such as wetlands and mangroves which protect coasts against storms. Rise in sea level could displace tens of millions of people in low-lying areas, especially in developing countries.</td>
</tr>
<tr>
<td>Health Risk</td>
<td>Due to melting of ice, there is emerging threat, new as well as old diseases spreading in places once thought safe. Melting permafrost may release &quot;zombie pathogens&quot;, which are frozen in ice for centuries. Majority of threats confined at higher latitudes. Like, in late July, 2016, Anthrax which outbreak in Siberia killing almost 2,000 people caused due to a reindeer carcass from 75 years ago (Pappas, 2016).</td>
</tr>
<tr>
<td>Increased Risk of Storms, Droughts, and Floods:</td>
<td>Draughts, storms and floods around the world are intensified due to climate change. Where nature has been destroyed by development, communities are at risk from these intensified climate patterns.</td>
</tr>
<tr>
<td>Economic Impact</td>
<td>It is hard to predict the true economic impact. But it can safe to say, many economic sectors, like fishing industries, tourism and recreation sectors which will be effected to changes in weather patterns as a disruption in global temperature due to global warming</td>
</tr>
</tbody>
</table>
1.2 Short Lived Climate Pollutants (SLCPs)

SLCPs are those pollutants which are causing global warming, but persist for a short period of time as compared to long lasting Greenhouse Gasses (GHG) such as Carbon Dioxide (CO2). Black Carbon (BC), which is a Short-Lived Climate Pollutant (SLCP) lasts about two weeks in atmosphere as compared to CO2 which lingers in the atmosphere for hundreds of years. The Four SLCP’s are Black Carbon, Methane, Hydrofluorocarbons and Tropospheric Ozone.

Table 2: Short lived climate pollutants and their description

<table>
<thead>
<tr>
<th>S.No</th>
<th>SLCPs</th>
<th>Description</th>
</tr>
</thead>
</table>
| 1    | Black Carbon (BC):             | A major component of soot, which is produced by incomplete combustion of fossil fuel and biomass. Various sources of BC are trucks, forest fires, agricultural and waste open burning and industrial facilities. It’s warming impact on climate is about 460-1500 times (typically 900 times) more than CO2. It has a life span of about few days or weeks only. When it is deposited on ice and snow, BC causes both atmospheric warming and an increase melting of ice and snow. It also affects the formation of clouds and impacts regional circulation and rainfall patterns. It also impacts human health. It is also the primary component of Particulate Matter (PM) in air pollution, which is the major component of environmental cause of premature death globally. It also impacts human health. It is also the primary component of Particulate Matter (PM) in air pollution, which is the major component of environmental cause of premature death globally. It also makes up PM2.5 along with other co-pollutants which consist of particles 2.5 micro meters or are smaller in diameter, i.e. approx. 40 times smaller than the grain of salt. (Black Carbon | Climate and Clean Air Coalition, 2017)  
In India, emissions of BC were estimated at 483 Gg/yr in uncertainty range of 307–1035 Gg/y, based on emissions from fossil fuel and biomass combustion, and excluding open burning. India contributes to 10% of the total global BC emission. India is the second largest producer of BC, after China 1365 Gg/y which is almost 30% emission of BC. (Bond, et al., 2004) |
| 2    | Methane (CH4)                  | With a life span of about 12 years, Methane is produced naturally, through decomposition of organic matter, but it is also emitted by many man-made sources, like coal mines, landfills and oil systems. Approximately, 60% of CH4 is emitted from human activities (Methane | Climate and Clean Air Coalition, 2017). |
| 3    | Hydrofluorocarbons (HFCs):     | HFCs are used in air conditioning, solvents, foams, refrigeration, aerosols, and blowing agents. As a GHG its life span is about 15 years. They are only less than 1% of current total greenhouse gases, though they have a stronger warming impact and, if left unchecked, HFCs could account for nearly 20% of global climate pollution by 2050. (Hydrofluorocarbons-HFCs | Climate and Clean Air Coalition, 2017) Low-GWP (with zero ODP) or cleaner alternatives for HFCs are already available in the market, although with limited penetration due to a variety of reasons (Höglund-Isaksson, Winiwarter, & Purohit, 2013) |
1.3 Indian Scenario

India’s total GHG emission has grown in past from 8,17,023 Gg CO₂ eq.1994 (Ministry of Environment and Forests, 1994) to 15,23,777.44 Gg CO₂ eq in 2000 (Ministry of Environment and Forests, 2000) (CAGR 10.95%) and further increment to 21,36,841.24 Gg CO₂ equivalent by 2010 (Ministry of Environment, Forest and Climate Change, 2010). (CAGR 3.44%)

The waste sector contribution in GHG emission was initially 23,233 Gg CO₂ eq. in 1994 (Ministry of Environment and Forests, 1994), which grew to 52552.29 Gg CO₂ eq in the year 2000 (Ministry of Environment and Forests, 2000). The CAGR being 7.3%. Further increase was observed to 65,052.47 Gg CO₂ eq in 2010. (CAGR 2.16%). (Ministry of Environment, Forest and Climate Change, 2010)

Municipal solid waste disposal emitted about 12,222 Gg CO₂ eq. in the year 1994 (Ministry of Environment and Forests, 1994) and about 10,251.99 Gg CO₂ eq. (Ministry of Environment and Forests, 2000) for the year 2000 which has increased to 13,963.74 Gg CO₂ eq. in 2010 (Ministry of Environment, Forest and Climate Change, 2010)

1.4 Need for reduction of SLCPs

There is a strict need to reduce the GHG emissions from country’s activity, as the rate of near-term climate change needs to be bought down, it will reduce global warming impacts on those alive today. Gradually, biodiversity loss will reduce, increasing the time for adaptation to climate change, and reduce the risk of crossing the dangerous climate thresholds (e.g. the melting of permafrost which leads to the further emission of greenhouse gases). Reducing SLCPs have the additional benefits of reducing the disruption of rainfall patterns caused by particle pollution, and slowing the melting rate of ice in the artic and high elevation regions caused by deposition of BC particles. (Climate and Clean Air Coalition (CCAC), 2013)

Stringent, precise and accurate reductions of CO₂ and other long-lived GHGs are needed to avoid a substantial rise in sea level, SLCPs could reduce the cumulative rise in sea level by 22% at the end of the century relative to long-term uncontrolled SLCP emissions. (Climate and Clean Air Coalition, 2013)
1.5 Objective of this report

As a part of the strategy to reduce SLCPs from MSW sector, we have evaluated the emissions of greenhouse gasses from municipal solid waste activities in East Delhi Municipal Corporation area and Coimbatore municipal corporation area. This helped to estimate the baseline emissions using a CCAC tool –SWEET (Solid waste emissions estimation tool). This tool will help further in establishing the baseline emission and selection of alternatives to further formulate policies/action plans to reduce SLCPs for the city. On basis of data collection tool for urban solid waste management (Version 1.0) baseline data from the city was collected. This data collected was used to run SWEET for the two cities.
2 Baseline emissions from MSW Management

2.1 SWEET

Solid Waste Emissions Estimation Tool (SWEET) version 1 has been used to identify the emissions in baseline scenario from EDMC area. The municipal solid waste (MSW) sector is a significant source of short-lived climate pollutant (SLCP) emissions, especially methane and black carbon. The Climate and Clean Air Coalition Municipal Solid Waste Initiative (Waste Initiative) developed the Solid Waste Emissions Estimation Tool (SWEET) to assist stakeholders in estimating these emissions and comparing the emissions reduction benefits of different waste management scenarios. The tool can be used to inform MSW management decision-making and priority setting, and allows cities to benchmark and project their emissions over time. The tool assists users in determining first-order city-level estimates of annual emissions of methane, black carbon, and other pollutants (e.g., carbon dioxide) from various sources including:

a) Waste collection and transportation
b) Waste burning (including open burning and fires and landfills and open dumps)
c) Landfills and dumpsites
d) Organic waste management facilities (e.g., composting facilities)
e) Waste handling equipment (e.g., forklifts, bulldozers)
f) Waste combustion equipment (e.g., waste-to-energy facilities)

Except for landfills and open dumps, the tool generates annual emissions using annual activity data and process-specific emissions factors. For landfills and open dumps, the tool uses disposal site data to calculate annual methane emissions into the future (i.e., to 2050) using a methodology developed by the U.S. EPA for the Colombia Landfill Gas model.

Cities can use this information for multiple purposes, including establishing a city-level baseline, comparing city-level baseline scenarios to as many as four alternative scenarios, analysing specific projects for potential emissions reductions, estimating the contribution of activities in the waste sector to overall city emissions reduction goals, and tracking progress over time.

2.2 East Delhi Municipal Corporation Area- Baseline emissions

The emissions from all the sources in form of Carbon dioxide, Nitrous oxide, Black carbon, Organic carbon and methane have been estimated. The results of the baseline scenario predict the emissions of EDMC area as 328611 metric tonne CO₂ eq in 2021 and 259319 metric tonne CO₂ eq in 2025, 270516 metric tonne CO₂ eq in 2031, 472135 metric tonne CO₂ eq in 2041 and 933271 metric tonne CO₂ eq in 2051. The detailed results with sector wise contribution in Metric tonnes CO₂ eq are given in Annexure 1.
2.2.1 Overall Waste Sector Emissions

2.2.1.1 Black Carbon emission over time

Figure 1: Black carbon emissions over time
Black carbon emissions have gone up from 5859 MT CO\textsubscript{2} eq in year 2000 to 20158 MT CO\textsubscript{2} eq in year 2017 as waste generation and disposal along with burning has increased, increasing the diesel vehicles for waste collection in turn increasing the black carbon emission. The drop in emissions from 20158 MT CO\textsubscript{2} eq in 2017 to 8403 MT CO2 eq is expected to happen in the year 2018 due to closure of the Ghazipur dumpsite site by end of 2017. This would mean reduction in emissions from open burning. Though waste collection will increase in the future due to increase in the diesel vehicles / trips per vehicle to collect more waste that would be generated by an increased population. Emissions are expected to increase by a compound annual growth rate (CAGR) of 7.26% in the 2020-2050. Figure 1 highlights the trend of black carbon emissions from EDMC area over time.
2.2.1.2 Scenario Comparison of Methane Emissions over time

Figure 2: Baseline Methane emission over time from EDMC area
In the baseline emissions analysis, maximum methane gas is emitted from waste site a year after it has seized dumping. Hence, the emissions will peak in 2018 and is expected to come down sharply in the next 10 years to 67363 MT CO$_2$ eq in 2028 as no new waste is expected to be disposed in the Ghazipur dumpsite after 2017 and thereafter flatten as the half-life of waste is expected to be 10 years. Figure 2 describes the trend of methane emissions till 2050.

2.2.1.3 Scenario Comparison of Organic Carbon Emissions

Figure 3: Baseline Organic carbon emission from EDMC area over time
The cooling effect of organic carbon is higher than the direct warming effect, resulting in a negative global warming potential value. The cooling effect is due to negative radiative forcing. The Figure 3 depicts the reduced emissions due to organic carbon stored in waste. It has a negative global warming potential, hence the numbers portrayed are negative. The
organic carbon emissions sharply drop after 2017 as the dumpsite is expected to be closed and no organic carbon is assumed to be stored in form of waste organics. The emission will be -7853 MT CO\textsubscript{2} eq in 2017 and will increase to -206 MT CO\textsubscript{2} eq in 2018 and will gradually lower to -1942 MT Co2 eq by 2050.

2.2.1.4 Total Emissions by Scenario including CO\textsubscript{2}, NOx, BC, CH\textsubscript{4}, Organic Carbon

Figure 4: Total Emissions from CO\textsubscript{2}, NOx, BC, CH\textsubscript{4}, Organic Carbon

Figure 4 depicts overall emissions from Carbon Di Oxide, Nitrogen Oxide, Black Carbon, Methane and Organic Carbon combined. The emissions are increasing at an increasing rate till 2017 from 1,16,264 MT CO\textsubscript{2} eq in 2000 to 4,81,589 MT CO\textsubscript{2} eq in 2017, followed by a sharp drop and a subsequent increase making a U curve, indicating a steady rise in emissions till 2050. It drops from 361511 MT CO\textsubscript{2} eq in 2020 to 2,61,959 MT CO\textsubscript{2} eq in 2030 and then increases to 4,42,266 MT CO\textsubscript{2} eq in 2040 to 8,70,804 MT CO\textsubscript{2} eq in 2050.
2.2.2 Baseline scenario sector specific emissions

2.2.2.1 Baseline Black Carbon Emissions by Source Over Time

Figure 5: Black Carbon Emissions by Source

Figure 5 shows that the baseline emissions due to waste burning will peak in 2017 at 12,324 MT CO₂ eq and will near zero in 2018 due to expected closure of dumpsite in end of 2017. We have assumed that 2% of waste is burnt at dumpsite by rag pickers and landfill fires. Waste collection and transportation steadily increases at an increasing rate, as 100% waste is being collected and waste generations is rises with a rise in the population served under the East Delhi Municipal Corporation area. Emissions from waste collection and transportation are calculated to increase from 1140 MT CO₂ eq in year 2000, to 5066 MT CO₂ eq in 2020 to 20,580 MT CO₂ eq in 2040 and peaking to 41479 MT CO₂ eq in 2050. Waste handling equipment fleet is also expected to expand as the amount of waste is increasing in the area. Emissions from waste handling equipment increase from 1297 MT CO₂ eq in 2000 to 4598 MT CO₂ eq to 37647 MT CO₂ eq in 2050.
2.2.2.2 Combustion Related Sulphur Dioxide Emissions by Scenario

Figure 6: Baseline SO\textsubscript{2} emissions from EDMC area
Sulphur oxides are released from Waste to Energy plant, which was commissioned in November 2016 in EDMC located right next to the Ghazipur dumpsite. The estimates depict these emissions shall increase at a steady rate 262 MT of SO\textsubscript{x} to 528 MT SO\textsubscript{x} to 1065 MT SO\textsubscript{x} in 2050. As the waste treated in the waste to energy plant increases simultaneously with increasing waste. Figure 6 depicts the trend of sulphur oxide emissions over time.

2.2.2.3 Baseline Transportation PM\textsubscript{10} Emissions by Source

Figure 7: Baseline Transportation PM\textsubscript{10} emissions from EDMC area
Figure 7 depicts emissions from waste burning increasing sharply from 57 MT CO\textsubscript{2} eq in 2000 to peaking at 206 MT CO\textsubscript{2} eq in 2017, till regular dumping at the Ghazipur dumpsite is continued. After 2017, it falls to zero as no open burning is expected on a closed dumpsite.
The emissions from waste handling equipment increases to 18 MT CO\textsubscript{2} eq in 2030, almost doubling to 37 MT CO\textsubscript{2} eq in 2040 and further doubling to 74 MT CO\textsubscript{2} eq in 2050.

### 2.2.2.4 Baseline All Climate Forcing Emissions by Source (CH\textsubscript{4}, Black Carbon, Organic. Carbon, NO\textsubscript{x}, CO\textsubscript{2})

![Figure 8 Baseline Climate Forcing Emissions by Source (CH\textsubscript{4}, Black Carbon, Organic. Carbon, NO\textsubscript{x}, CO\textsubscript{2})](image)

Waste collection and transportation increases at an increasing rate from 3390 MT CO\textsubscript{2} eq in 2000 almost doubling every decade to 7203 MT CO\textsubscript{2} eq in 2010, 15,065 MT CO\textsubscript{2} eq in 2020 to 30,362 MT CO\textsubscript{2} eq in 2030 to 61,195 MT CO\textsubscript{2} eq in 2040 and 1,23,337 MT CO\textsubscript{2} eq in 2050.

Since waste burning is completely contained post dumpsite closure, there are no emissions from that activity.

Emissions from landfill and landfill gas combustion reduce sharply from 2018 to 2028 (in 10 years) as no new waste is dumped at the site. Since methane emissions from the waste are maximum a year after being disposed, the emission peak in 2018 and drops thereafter. Post 2028 (marking its half-life), the emission follow a flat curve. Waste combustion increases as the entire quantity will be diverted to the waste to energy plant, where closed combustion shall happen. Hence, emissions from waste combustion are expected to rise sharply after closure of dumpsite, 61002 MT CO\textsubscript{2} eq in 2020 and reaching 574586 MT CO\textsubscript{2} eq in 2050.

Since there is no specific disposal and management mechanism for organics, there will be no emissions from organics management.

Figure 8 depicts the trend of emissions from various sectors.
2.2.3 Landfill and Dumpsite Emissions Summary

2.2.3.1 Landfills and Dumpsites Emissions

Figure 9 Baseline Dumpsite Emissions from Ghazipur in EDMC area

Figure 9 Baseline Dumpsite Emissions from Ghazipur in EDMC area depicts the present scenario, i.e. population increasing, with an increase in the waste generated under EDMC’s jurisdiction, dumpsite closing in 2017, waste burning happening at 2% approximately and waste to energy plant functioning at an increased capacity after 2019 (as per the expansion plans) and no LFG being captured. The emissions will increase at an increasing rate till 2018 (reaching 3,62,418 MT CO₂ eq) one year after expected closure of dumpsite and sharply declining to 6037 MT CO₂ eq by 2050. The major component of landfill gas is methane and the curve, though shows all gases combined, is majorly skewed along emissions from methane gas.
2.2.4 Baseline Transportation and collection emissions summary

Since a huge amount of emissions happen during waste transportation and management, the CO$_2$ (Figure 10), sulphur oxide (Figure 11), Nitrogen oxide (Figure 12), and PM$_{10}$ (Figure 13) emissions keep increasing at an increasing rate with a rise in population and waste generation.

2.2.4.1 CO$_2$ Emissions

![CO$_2$ Emissions Graph](image)

**Figure 10 CO$_2$ Emissions**

Figure 10 CO$_2$ Emissions depicts the carbon di oxide emissions increase from 2501 MT CO$_2$ eq in 2000 to 11116 MT CO$_2$ eq in 2020 to 91011 MT CO$_2$ eq in 2050.

2.2.4.2 NOx Emissions

![NOx Emissions Graph](image)

**Figure 11 NOx Emissions**

Figure 11 NOx Emissions shows the increase of NOx emissions from 8 MT NOx in 2000 to 37 MT NOx in 2020 to 307 MT NOx in 2050.
2.2.4.3 SOx Emissions

Figure 12 SOx Emissions
Figure 12 SOx Emissions shows the expected increase in SOx emissions till 2050. It rises from 1 in 2020 to 5 in 2050.

2.2.4.4 PM$_{10}$ Emissions

Figure 13 PM$_{10}$ Emissions
Figure 13 PM$_{10}$ Emissions 2017 onwards. From 2 MT PM$_{10}$ in 2017 it increases to 5 MT PM$_{10}$ in 2030 and further to 18 MT PM$_{10}$ in 2050.
2.2.5 Waste burning emissions summaries - Baseline

2.2.5.1 Total Climate Forcing from Waste Burning Emissions

![Graph showing total climate forcing from waste burning emissions]

Figure 14 Total Climate Forcing from Waste Burning Emissions
Waste burning (on the dumpsite) is expected to reduce to zero since dumpsite is expected to be closed in 2017. Figure 14 Total Climate Forcing from Waste Burning Emissionsshow that the burning emissions peak to 35,610 MT CO₂ eq in 2017.

2.2.5.2 Climate Forcing from Open Burning Emissions

![Graph showing climate forcing from open burning emissions]

Figure 15 Climate Forcing from Open Burning Emissions
Figure 15 shows that since 100% of the waste generated is being collected by the municipal corporation using diesel trucks fleet, there is no open burning (outside houses, road sides, streets etc.)
Hence the emissions from open burning remains zero throughout. Open burning is banned as per the prevailing norms and regulations.
2.2.5.3 Climate Forcing from Landfill/Dumpsite Fire Emissions

![Graph showing CO₂e emissions from Landfill/Dumpsite Fire Emissions](image)

**Figure 16 Climate Forcing from Landfill/Dumpsite Fire Emissions**
Dumpsite fires burning about 2% of the waste due to surface and sub-surface fires and rag pickers have been generating emissions that will peak in 2017 to 35,610 MT CO₂ eq and are expected to drop sharply to zero immediately after the expected closure of dumpsite as shown in Figure 16.

2.2.5.4 PM₁₀ Emissions from Waste Burning Emissions

![Graph showing PM₁₀ emissions from Waste Burning Emissions](image)

**Figure 17 PM₁₀ Emissions from Waste Burning Emissions**
PM$_{10}$ emissions from burning of waste in the dumpsite increases from 70 MT PM$_{10}$ in 2000 to 251 MT PM$_{10}$ in 2017, and drops to zero in 2018 after the expected closure of the dumpsite as shown in Figure 17.

2.3 Coimbatore Area Baseline Emissions

2.3.1 Overall emissions summary figures 2000 to 2050 emissions

![Graph showing emissions from 2000 to 2050](image)

Figure 18: Baseline Black carbon emissions from Coimbatore
The Figure 18 shows the emissions of Black carbon in Coimbatore city for the years 2000 to 2050. For the period 2000 to 2010, there were no emissions. As the landfill started operating from 2011, there was a steep increase to 9,721 MT CO$_2$ eq in the year 2011 which continued to rise to 12,413 MT CO$_2$ eq in 2016. This value is expected to increase to 26,314 MT CO$_2$ eq by the year 2030. However, a decline in emissions is supposed to 22,795 MT CO$_2$ eq by the year 2030. It is presumed that emissions would finally rise and reach up to 59,892 MT CO$_2$ eq in 2050.
Figure 19: Baseline methane emission over time
The Figure 19 shows the emissions of Methane in Coimbatore city for the years 2000 to 2050. For the years 2000 to 2010, methane emissions were zero. The emissions rose sharply from 1,061MT CO₂ eq in 2011 to 80,880MT CO₂ eq in 2015. A slight increase in emissions is estimated to 88,912MT CO₂ eq by 2020 which are further expected to raise up to 1, 47,173 MT CO₂ eq in 2032. Thereafter, since the landfill is expected to close in 2031, by 2050 the emissions are expected to decline to 63,358MT CO₂ eq following a concave up decreasing trend.

Figure 20: Baseline organic carbon emission from Coimbatore
Figure 20 depicts the reduced emissions due to organic carbon stored in waste. It has a negative global warming potential, due to negative radiative forcing and its cooling impact is higher than overall warming effect. The organic carbon emissions were initially zero from 2000 to 2010. In 2011, -4,244 MT CO₂ eq emissions from Organic carbon was recorded, which is expected to decline to -12,541 MT CO₂ eq in 2031. Emissions are assumed to increase to -9,192 MT CO₂ eq by 2032 which would finally reduce to -24,151 MT CO₂ eq by 2050. This is possibly due to composting practised even after landfill stops receiving waste.
2.3.2 Baseline scenario Sector specific emissions

Figure 22: Baseline black carbon emissions by source over time from Coimbatore

Figure 22 shows that the baseline emissions due to waste burning were zero from 2000 to 2010 which increased to 9,359 MT CO₂ eq in 2017. An increase in emissions is presumed to 19,840 MT CO₂ eq by 2031, which will again reduce due to closure of landfill to 14,433 MT CO₂ eq by 2032. After 2032, emissions will again raise to 37,921 MT CO₂ eq in 2050.
Emissions due to waste handling equipment during waste collection and transport, were 1,296 MT CO₂ eq in 2011 when the landfill started operating which are estimated to increase to 1,330 MT CO₂ eq in 2017. Similar increase is expected to occur to 4,839 MT CO₂ eq by the year 2030, 8,277 MT CO₂ eq in 2040 and finally to 14,156 MT CO₂ eq by 2050.

Emissions due to waste collection & transport were zero from 2000 to 2010, which increased to 1,725 MT CO₂ eq in 2011 and 2,409 MT CO₂ eq in 2017. A further increase in emission values are expected to occur to 4,839 MT CO₂ eq in 2030. By the year 2050, increase in the emissions to 14,156 MT CO₂ eq emissions is expected.

Figure 23: Baseline SO₂ emissions from Coimbatore area

The Figure 23 depicts the baseline emissions of SO₂ were zero from 2000 to 2010 which increased to 8 MT SO₂ in 2017. It is assumed that emissions would increase up to 17 MT SO₂ in 2030 and drop to 11 MT SO₂ in the next two years i.e. 2032. By the year 2050, increase in the emissions to 28 MT SO₂ emissions is expected to be recorded. This sudden increase of SO₂ emissions are due to landfill getting operational in 2011 and closed in 2031.

Figure 24: Baseline Transportation PM10 emissions by source from Coimbatore area

Figure 24 shows that the baseline emissions of PM₁₀ due to waste burning were zero from 2000 to 2010, which increased to 112 MT CO₂ eq in 2011 and 157 MT CO₂ eq in 2017. A further increase in emission values are expected to occur to 332 MT CO₂ eq till 2031 after which
there would be a drop to 242 MT CO\textsubscript{2} eq in the following year i.e. 2032. This is attributed to landfill getting operational in 2011 and closed in 2031 with estimated 2% waste burning at the landfill site. By the year 2050, increase in the emissions to 635 MT CO\textsubscript{2} eq emissions is expected. PM\textsubscript{10} emissions from waste handling equipment are expected to rise from zero in 2011 only to 14 MT PM\textsubscript{10} by 2050.

Figure 25: Baseline Climate Forcing Emissions by Source (CH\textsubscript{4}, Black Carbon, Organic Carbon, NO\textsubscript{x}, CO\textsubscript{2}) from Coimbatore area

In Figure 25 emissions from landfills & LFG Combustion were zero from 2000 to 2011. In 2015, the emissions increased to about 72,541 MT CO\textsubscript{2} eq and are expected to rise to 123,074 MT CO\textsubscript{2} eq by 2032. By 2050, emission values are expected to decline to zero.

Emissions due to waste burning from 2000 to 2010 were nil which increased to 19,361 MT CO\textsubscript{2} eq the following year. In 2017, the emissions reached to 27,043 MT CO2 eq and are estimated to rise to 57,326 MT CO\textsubscript{2} eq by 2031. A decline in emission values will be recorded to 41,703 MT CO\textsubscript{2} eq in 2032. By 2050, 109,571 MT CO\textsubscript{2} eq emissions are expected.

Emissions due to organics management were zero from 2000-2014. In 2015, 7,008 MT CO\textsubscript{2} eq are estimated and this value is expected to rise to 57,313 MT CO\textsubscript{2} eq by 2050. This is due to 300 TPD organic waste management (composting facility) becoming operational in Coimbatore.
2.3.3 Landfill and Dumpsite emission summary

The baseline emissions from landfill and dumpsite in Vellore from 2000 to 2050 are shown in Figure 26. The emission values during 2000-2011 were nil. In 2015, the emissions increased to about 4,048,051 MT CO₂ eq. It is expected that by 2020, emissions would rise to 4,225,211 MT CO₂ eq and finally to 6,867,966 MT CO₂ eq in 2032. From 2033 to 2050, the emissions are assumed to decline continuously due to closure of landfill in 2031 and reach to about 2,176 MT CO₂ eq in 2050.

2.3.4 Baseline transportation and collection emission summary

Figure 27: CO₂ emission in baseline scenario from Coimbatore area

Figure 27 shows emission of CO₂ amount from transportation sector in metric ton(MT) from 2000 to 2050. CO₂ emission from transportation is zero from 2000 to 2010 and increased to 2536 MT in 2011 at very high constant rate. In 2012 emission was increases by 148 MT and total emission was 2684 MT. In 2016 emission was 3357MT and continuously increasing. It is
expected that emission in 2020, 2030, 2040, and 2050 would be 4160 MT, 7116 MT, 12170 MT, 20184 MT respectively.

![Figure 28: NOx emission from Coimbatore area in baseline scenario](image)

Figure 28 shows emission of NOx amount from transportation sector in metric ton (MT) from 2000 to 2050. NOx emission from transportation is zero from 2000 to 2010 and increases to 11 MT in 2011. In 2012 emissions increased by 1 MT and total emissions were 12 MT. In 2016 emissions were 15 MT and continuously increased. It is expected that emissions in 2050 would be 94 MT.

![Figure 29: SOx emissions from Coimbatore area in baseline scenario](image)

Figure 29 shows emission of SOx amount from transportation and collection sector in metric ton (MT) SOx from 2000 to 2050 year wise. SOx emission from transportation is zero from 2000 to 2010 and increases to 0.2 MT SOx in year 2011. It is expected that emissions in 2050 would be 1.4 MT SOx following a concave up, increasing trend.
Figure 30: Baseline scenario PM10 emissions from transportation and collection sector- Coimbatore area

Figure 30 shows the emission of PM$_{10}$ amount from transportation and collection sector in metric ton (MT) from 2000 to 2050 year wise. Emission of PM$_{10}$ was zero till 2013 and in 2015, it was more than 1.0 MT PM$_{10}$. It is expected that emission till 2050 will follow a concave up increasing curve and would be more than 7 MT PM$_{10}$ in 2050.

2.3.5 Waste burning emissions summary-Baseline

Figure 31: Total climate forcing from waste burning emission from Coimbatore area

In Figure 31 the baseline emissions from waste burning in Coimbatore from 2000 to 2050 are shown. The emissions during 2000-2010 were nil. In 2011, the emissions increased to about 19,362 MT CO$_{2}$ eq. It is expected that by 2020, emissions would rise to 31,767 MT CO$_{2}$ eq and finally to 57,326 MT CO$_{2}$ eq in 2031. However, a decline in emissions is expected to 41,703 MT CO$_{2}$ eq in 2032. By the year 2050, again an increase in the emissions to 109,571 MT CO$_{2}$ eq emissions is expected.
Memo on Baseline emissions from MSW Management using SWEET-East Delhi & Coimbatore

Figure 32: Climate forcing from open burning emissions from Coimbatore area
Figure 32 shows the baseline emissions from open burning in Coimbatore from 2000 to 2050. The emissions during 2000-2010 were nil. In 2011, the emissions increased to about 13,348 MT CO$_2$ eq. It is expected that by 2020, emissions would rise to 21,902 MT CO$_2$ eq and to 37,459 MT CO$_2$ eq in 2050. By the year 2050, 109,571 MT CO$_2$ eq emissions are expected.

Figure 33: Climate forcing from landfill/dumpsite fire emissions from Coimbatore area
Figure 33 shows the emissions from Landfill/dumpsite fire in Coimbatore from 2000 to 2050. The emissions during 2000-2010 were nil. In 2011, due to landfill becoming operational the emissions increased to about 6,012 MT CO$_2$ eq. It is expected that by 2020, emissions would rise to 9,865 MT CO$_2$ eq and finally to 17,802 MT CO$_2$ eq in 2031. Thereafter, due to expected closure of landfill in 2031, the emissions are assumed to decline sharply and reach to zero by 2050.
Figure 34: PM$_{10}$ emissions from waste burning in baseline scenario from Coimbatore area

Figure 34 shows emission of PM10 amount from waste burning in metric ton (MT) from 2000 to 2050 year wise. Emission of PM10 was zero from 2000 to 2010 and suddenly increased to 136 MT in 2011. In year 2017 emission is 190 MT PM$_{10}$. Emission is continuously increasing and it is expected that emission would be 224 MT in 2020 and increases up to 382 MT in 2030. A small peak shown in graph during year 2031 due to emission of amount 404MT. During year 2032 it is expected a sudden reduction in emission by the value 110 MT, total emission in 2032 would be 294 MT and after year 2032 emission continuously increase and in year 2050 emission would be 771 MT.
2.4 Observations on SWEET:

1. The landfill at EDMC is expected to close in end of 2017 and waste is expected to be diverted to waste to energy (with increased capacity to handle waste). The SWEET tool is calculating emissions from waste handling equipment’s since 2016, (Figure 7-SWEET) these equipment’s are operating at landfill site and are not expected to be operating at waste to energy plant. We could not find an option to eliminate this error.

2. The CO₂ Eq emissions of methane from landfill are different in graph in comparison to the excel output sheet (Summary emissions sheet column L).

3. SWEET tab – general information (cell: C44) The waste coming to composting unit is expected to be comprised of only wood, food and green waste. This is not the case in India. The MSW waste bought to the composting plant (centralized) is screened and segregated and thereafter the rejects (based on size) are either sent back to landfill or co-processing units. SWEET is not giving an option to feed such data.

4. Figure 7 Fault: The graph shows zero emissions from waste handling equipment before 2017, which cannot be the case as motorized diesel fueled equipment are still used on the dumpsite and for proper disposal and management of waste.

5. 

6. 

7. Figure 9 Fault: The numbers shown in the graph are different and of much higher value as compared to the table. Further, a part of landfill (5 acre) is capturing and producing electricity (30 KW capacity) since 2013, which is not captured by the model.

8. Figure 13 Fault: Transport emissions have been happening since the waste was started to be collected. The diesel fleet has been proportionate with growing waste. Hence, they cannot be zero.
The Energy and Resources Institute (TERI) has created an Indian Cities Network under the auspices of the Climate and Clean Air Coalition (CCAC) Municipal Solid Waste Initiative (MSWI). The CCAC MSWI unites national and local governments, intergovernmental organizations, and leading organizations to reduce emissions of short-lived climate pollutants (SLCPs), such as methane and black carbon, across the solid waste sector. The MSWI brings together experts and practitioners through cooperative peer-to-peer networks, and helps cities and governments identify and analyze opportunities to improve solid waste management and reduce SLCP emissions, self-fund or obtain sustainable financing for capital projects, and scale up actions to reduce emissions through multilateral cooperation within countries and across borders.

Objectives of the CCAC MSWI Indian Cities Network

- To develop a focused city network in India to foster outreach to municipalities and harness the demand for improved waste management technologies and approaches to mitigate SLCPs
- To improve the waste management in the selected cities through an exchange of best practices internationally and learn from mentors in other countries
- To assist Coimbatore and East Delhi in developing CCAC work plans to improve solid waste management with specific activities that can be implemented after the present phase of the project;