

Estimation of Greenhouse Gas Emissions from Municipal Solid Waste Disposal in China during the last decade

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Introduction

The latest IPCC sixth report shows that the average annual emissions of global GHG(greenhouse gas) from 2010 to 2019 are at the highest level in human history, rising by 12% from 52.5 to 59 billion tons, which means an average annual growth of 1.3%. The report warns that the window of opportunity for achieving climate resilient development in the world is shrinking rapidly, and pointed out the urgency of coping with climate change and the severity of the prospect of global 1.5 and 2°C temperature rise control.

China is facing severe pressure on GHG emission reduction. And in order to achieve the dual carbon goal, China must reduce carbon emissions from multiple perspectives. Among numerous human activities that cause GHG emission, MSW(municipal solid waste) sector accounts for 3%, ranking third in global non carbon dioxide GHG emission. With the average annual growth rate of 5.4% of China's MSW disposal, the GHG emission brought by it cannot be underestimated.

Objectives

- ① GHG emissions of MSW disposal units in China from 2010 to 2020. (including landfill, incineration and biological treatment)
- ② Trends and differences of GHG emissions from municipal solid waste from national, regional and provincial levels
- ③ Methane emission reduction potential of landfills
- ④ Recommendations of carbon emission reduction

Data resource

The National Statistical Yearbook.

Methods

① Landfill CH₄ emission

$$G_{CH_4}(t) = \sum_{i=1}^n MSW_{ti} * MSW_{fi} * L_{0i} (1 - e^{-k}) * e^{-k(n-i)} \quad (1)$$

$$L_0 = MCF * DOC * DOC_F * F * 16/12 \quad (2)$$

$$E_{CH_4}(t) = G_{CH_4}(t) * (1 - R) * (1 - OX) \quad (3)$$

② CO₂ and N₂O emissions from waste incineration

$$E_{CO_2} = MSW * \sum_j (WF_j * dm_j * CF_j * FCF_j * OF_j) * 44/1 \quad (4)$$

③ CH₄ and N₂O emissions from biochemical treatment

$$E_{CH_4} = \sum_i (M_i * EF_i) * 10^{-3} \quad (5)$$

④ Total GHG emissions from the MSW treatment sector

$$E_{Total} = E_{Landfill} + E_{Incineration} + E_{Biochemical} \quad (6)$$

The established GWP values for CH₄ and N₂O are 27 times and 273 times higher than CO₂, respectively.(IPCC 2021)

② Spatial and regional trends of GHG emissions every five years

(1) The proportion of GHG emission of North China and East China has decreased year by year, and the Northeast, Northwest and Central China regions have first increased and then decreased. In 2010, GHG emissions were: East China> South China> North China> Central China Southwest> Northeast > Northwest, and only the Southwest and North China regions exchanged sequentially in 2020.

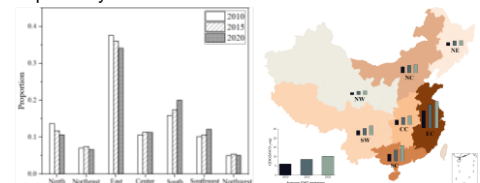


Figure 2 Proportion of GHG emissions in seven regions of China's waste sectors in 2010, 2015 and 2020

(2) On a provincial scale, the typical cities' GHG emission are ranked as:

2010: Guangdong>Shandong>Zhejiang>Jiangsu>Beijing>Sichuan>Hebei>Shaanxi

2020: Guangdong>Jiangsu>Shandong>Zhejiang>Sichuan>Hebei>Beijing>Shaanxi

In addition, the proportion of emissions from Shanghai, Jiangsu, Zhejiang and Shandong in the eastern coastal areas has decreased, while the proportion of emissions in Guangxi, Hainan in South China and Chongqing, Yunnan and Sichuan in the southwest has increased significantly.

Possible reasons: Rate of harmless waste treatment in the western and southern regions has increased significantly, but the amount of landfill still accounts for half of it. On the contrary, proportion of incineration in eastern coastal areas reached 80.8%, while landfill decreased to 14.1%.



Figure 2 GHG emissions from waste sectors in China's provinces in 2010, 2015 and 2020

Results & Discussions

① GHG emission trends in domestic waste treatment nationwide

Figure 1(a): The GHG emissions of MSW sector in China increased from 42.5MtCO₂-eq in 2010 to 76.3MtCO₂-eq in 2019, and then decreased to 72.1MtCO₂-eq in 2020.

Figure 1(b): CH₄ emissions in 2019 and before have been accounting for more than 50% of each emission source, but its proportion has decreased to 38.7%. And the proportion of incineration GHG emission has increased year by year, rising to 57.3% in 2020, becoming the main GHG source.

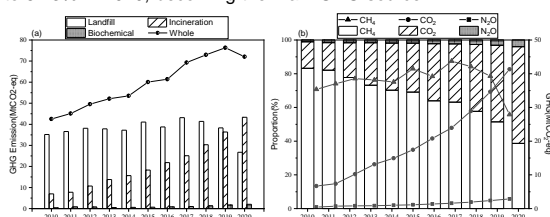


Figure 1 Trends of GHG emissions from multiple solid waste disposal in China from 2010 to 2020 (a), proportions of GHG emissions from three waste disposal methods and three greenhouse gas emissions trends (b)

Conclusions & Suggestions

① Since 2020, incineration has emitted more greenhouse gases than landfills for the first time, accounting for 60.1% of total GHG emissions.

② GHG emissions from municipal solid waste in China increased from 42.5MtCO₂-eq in 2010 to 75.3MtCO₂-eq in 2019, and then decreased to 72.1MtCO₂-eq in 2020.

③ In terms of spatial distribution, the GHG emissions of solid waste disposal units in East China have always been at the highest level in the country; The GHG emissions of municipal solid waste disposal in Guangdong, Jiangsu, Shandong and Zhejiang ranked among the top four in the country.

④ Improve the collection efficiency of landfill gas, so that methane can be better recovered and utilized;

⑤ Add functional materials or biochar to the landfill soil cover for better growth of methane oxidizing bacteria;

⑥ Adjust the structure of domestic waste disposal to realize the transformation from landfill to waste incineration;

⑦ The policy responds to the construction of zero-waste cities and the classification of domestic waste, so as to reduce the landfill of kitchen waste and increase the calorific value of incineration waste.