# Improved accounting of carbon emissions from waste incineration confirmed by $^{14}C$ test of flue gas

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Waste-to-energy (WtE) is one of the most promising pathways to reduce greenhouse gas (GHG) emissions from municipal solid waste treatment, as WtE provide both electricity generation and an alternative to landfilling. However, as the waste composition and energy mix in China have changed over the years (Li et al., 2024), the carbon benefits of WtE are trending downwards (Ma et al., 2024a). Accurate accounting of carbon emissions from WtE plant is now widely scrutinized.

Existing methods for calculating carbon emissions from WtE plants commonly suffer from labor-intensive processes and data lag issues, highlighting the necessity to develop new accounting methods to improve accuracy and timeliness in assessing carbon emissions from WtE plants. Therefore, this study aims to construct a carbon emission accounting model for the WtE process based on a life cycle assessment approach (Ma et al., 2024b).

This study improved the method for calculating direct emission of WtE plants on the basis of the common method (Method I) and verifies them using the method of $^{14}C$ test for flue gas. The physical composition was adjusted by considering the co-incinerated waste (Method II) and the actual bottom ash yield (Method III). And the life cycle carbon emissions from WtE plants was accounted by combining the actual operation data of the MSWI plants. The $^{14}C$ test was used to obtain the FCF of different types of solid wastes that are more in line with the current Chinese waste characteristics. The fossil carbon contents of plastics, polyester textiles and mixed textiles, which play a major role in carbon emissions from WtE plants, showed significant deviations from the IPCC default values (Figure 1), which were 90.52 % ± 0.81%, 93.6% ± 0.02% and 62.4% ± 0.01%, respectively (Ma et al., 2024a). Under the 8 different incineration conditions, Method III obtained the fossil $CO_2$ emissions of 222−610 kg $CO_2$-eq/t waste, which is a reduction of 3.4−221 kg $CO_2$-eq/t waste compared to Method I. The flue gas was analyzed to verify the Method III. The fossil $CO_2$ emissions were 249−445 kg $CO_2$-eq/t waste before flue gas treatment (Method IV), and 233−405 kg $CO_2$-eq/ t waste after flue gas treatment (Method V). After fully considering the uncertainty of the calculation parameters, the result of improved method III is closer to the validation values than method I, and can further improve the accuracy of the calculation results of carbon emissions from WtE plants. Life cycle carbon emissions from MSWI plants accounting with operational data range from -33.2 to 483 kg $CO_2$-eq/t waste (Figure 2), and some WtE plants are currently able to achieve negative net carbon emissions, due to the lower proportion of fossil-source wastes and the higher local carbon emission factor for electricity.

The results of this study will contribute to the accurate accounting of carbon emissions from WtE and provide data and methodological support for GHG emission accounting for waste management. The data on the fossil carbon content of solid waste samples and WtE flue gases using $^{14}C$ tests will greatly enrich the database of waste management and the life cycle inventory of GHG emissions.

**References**

Li, X.J., Lü F., Liao, N.L., Zhang, H., Yang, N., He, P.J.. Greenhouse gas emissions of municipal solid waste in Shanghai over the past 30 years: Dependent on the dynamic waste characteristics and treatment technologies. Resources, Conservation & Recycling, 2024, 201, 107321.

Ma, Y.F., He, P.J., Lü F., Zhang H.. Improving the method for calculating carbon emissions from waste incineration: Confirmed by carbon-14 testing of flue gas. Carbon Research, 2024b, 3: 74.

Ma, Y.F., He, P.J., Lü F., Zhang H.. Greenhouse gas emissions and mitigation strategies across the life cycle of municipal solid waste incineration plants in China. ACS Sustainable Chemistry & Engineering, 2024a, 12(24): 9268–9278.

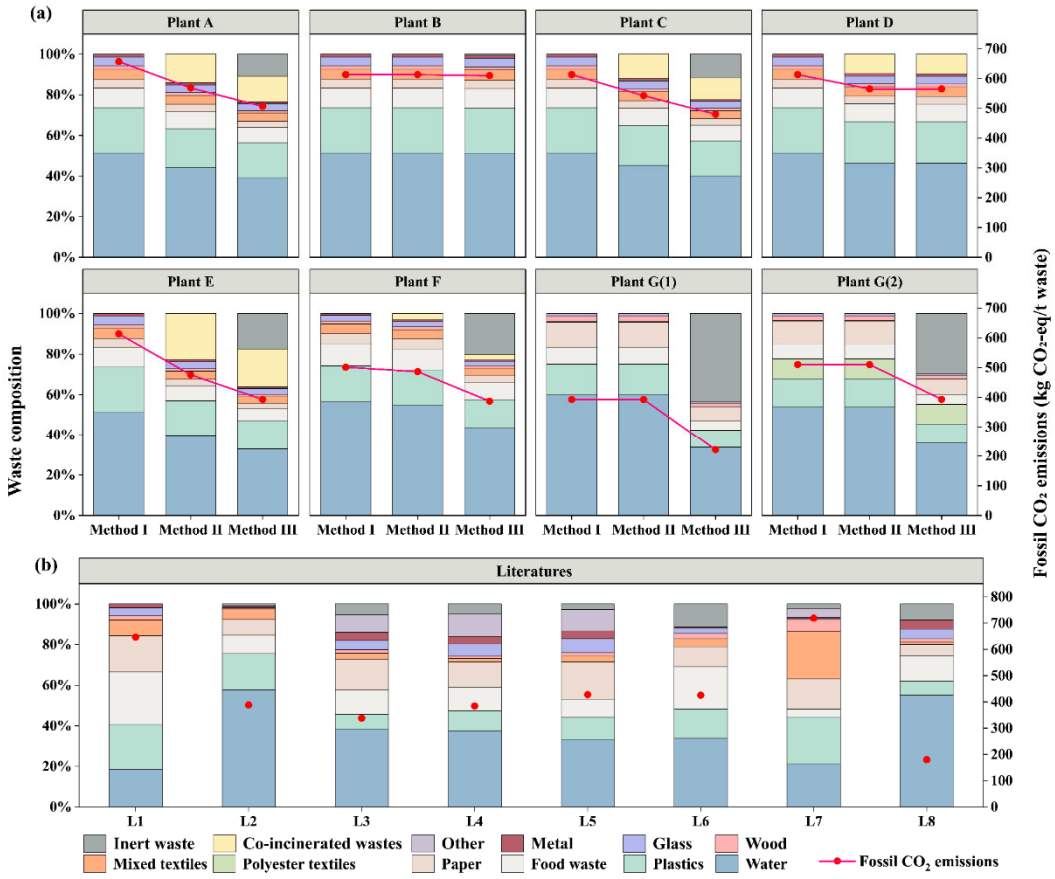


**Figure 1 Results of physical composition of incinerated waste and fossil $CO_2$ emissions under different accounting methods (a) and in various literature reports (b)**

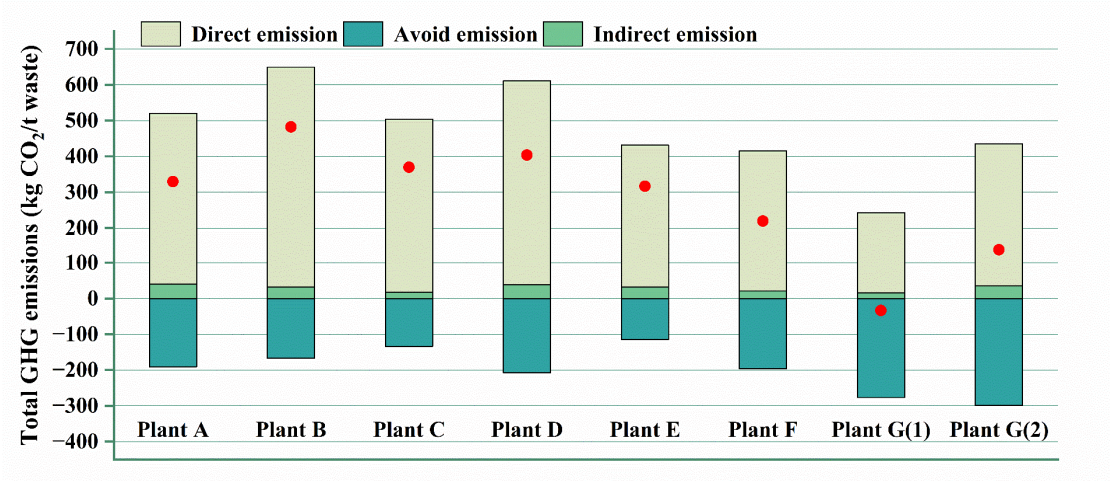


**Figure 2 Total GHG emissions from WtE plants by the improved method**