2-6 Development of a Standardized Solid Waste Carbon Modeling for Promoting Adequate Landfill in Asian Countries

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ABSTRACT

From the beginning of 21st century, in developing Asian countries, solid waste has rapidly begun to increase owing to both industrial production activities and consumption behavior. Under high temperature and moist atmospheric conditions, vast of biodegradable solid waste is input into a lot of landfills which inadequately managed, and enormous greenhouse gases are emitted from such landfills. Influence of greenhouse gases from landfills on global climate system is not yet well understood. In this subject, we suggest the development of a schematic model which explains decomposition processes of solid waste carbon and quantitatively estimates methane (CH_4) gas emission.

1. Introduction

There are some growing concerns about insufficient landfill management in new developing countries in Asia. Pollutants and greenhouse gas (GHG), especially Methane (CH_4), is possibly emitted in large quantities from such landfills. For future adequate managements of landfills, acquisition of long-term background data is essential to understand ambient conditions of landfills. However, data acquisition is now limited, and data monitoring techniques are quite different at each site and not standardized based on a unified protocol.

Figure 1 shows change in total methane emission in Japan for recent two decades. About 70% is from agricultural field, and 20% is from landfills and wastewater. However, methane emission from the waste field is getting smaller year by year. Figure 2 shows change in GHG emission from waste field in Japan for recent two decades. Methane emission from landfills makes up from 16 to 30%. In Japan, however, total GHG emission from waste field is getting smaller, owing to adequate management of landfills.

Of course, GHG emission from landfills must be inhibited and collection of ambient condition data is need. Therefore, the goal of our program is set to suggest and develop of standardized monitoring and modeling of solid waste carbon.

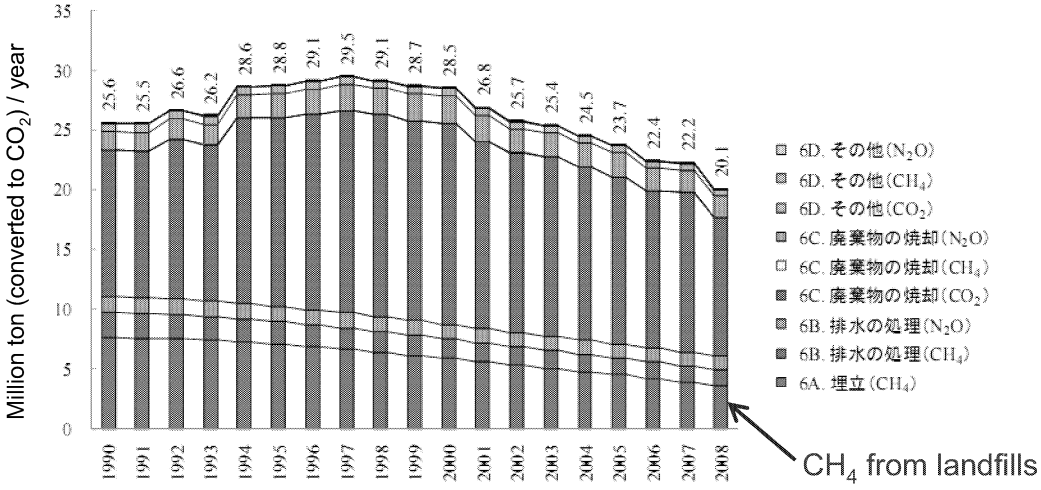

Fig.1 Change in total methane emission in Japan

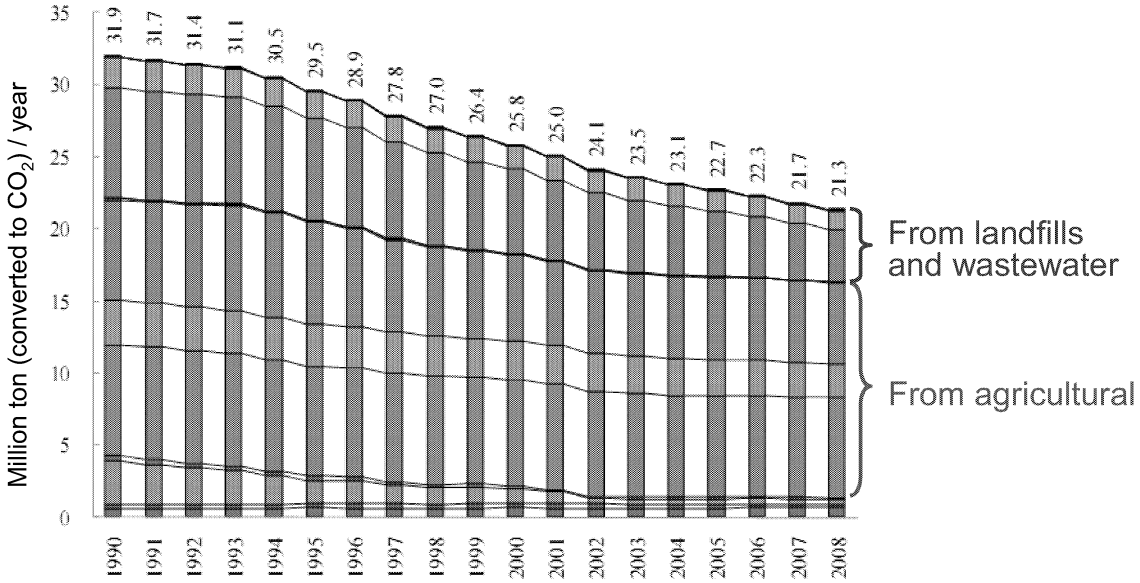

Fig.2 change in GHG emission from waste field in Japan

2. Methodology

What is need for effective estimation of gas emission from landfills? Once, solid waste is input into soils, after some weeks, month, or yeas passed, biodegradable carbon content in solid waste is decomposed. One part is eluted into water in soil or washed out by rain fall. And the other part is emitted as carbonic gas. Main components of emitted gas are CO_2, CO, methane, and non-methane hydro-carbon. More months or years later, biodegradable carbon content is decomposed furthermore.

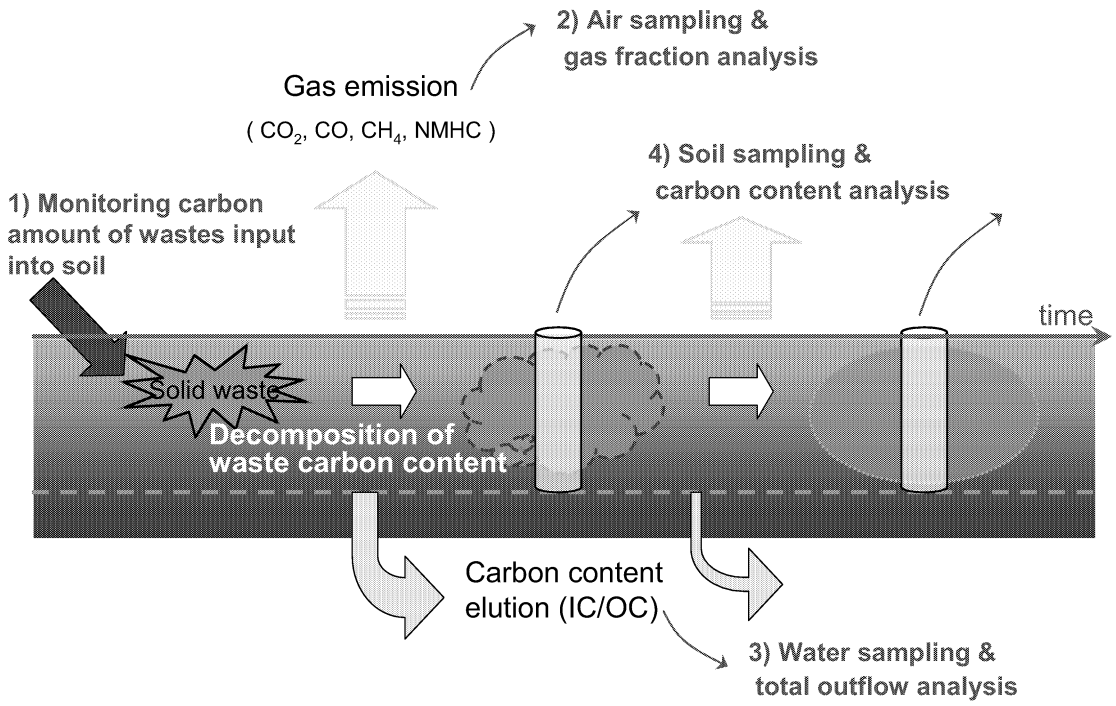

Fig.3 A schematic model of decomposition of waste landfill carbon and emission of CH_4 gas.

Tharefore, we need four operations of measurement and analysis to develop the model. Firstly, monitoring of waste carbon amount input into soil. Secondly, air sampling and gas fraction analysis of CH_4 will be done. Thirdly, water sampling and total outflow analysis of inorganic carbon and organic carbon are planned. And finally, soil sampling and carbon content analysis. When we do these four operations, and obtained some, CH_4 gas emission can be estimated by the following equation,

$$F_{CH_4} = \frac{\chi_{CH_4}\left(C_{soil}(t_0) - C_{soil}(t_1) - \sum_t C_{water} \right)}{t_1 - t_0} \qquad \text{.....(1)}$$

First term in the bracket is amount of carbon content in soil at initial time Second term in the bracket is amount at following time. And, third term means total carbon content eluted into water between initial stage and following stage. χ_{CH4} means methane gas fraction to total carbonic gases defined as,

$$\chi_{CH_4} = \frac{C_{CH_4}}{C_{CO_2} + C_{CO} + C_{CH_4} + C_{NMHC}}$$

However, the third term in equation (1) is most difficult to measure or estimate. Actually, CH_4 emission flux in Japan is calculated by this equation according to IPCC guideline (2006).

$$F_{CH_4} = \sum_i c_i \cdot g_i \cdot \chi_i \cdot \left[W_i(t_0) - W_i(t_0) \cdot e^{-\frac{\ln(2)}{H_i}} \right] \qquad \text{....(2)}$$

C_i : carbon content ratio of waste i

G_i : gasification coefficient of waste i (= 0.5 in Japan)

C_i : CH_4 gas fraction to total carbonic gases of waste i (= 0.5 in Japan)

W_i : amount of waste i in soil

H_i : half-decay period of waste i

As for G_i and C_i, 0.5 is used as practical value for estimate. These values are very rough and not applicable for other Asian countries.

Table 1 is summary of carbon content ratio (C_i) in some solid waste species applied in Japan. Only these values seem to be applicable as common values. Total amount of biodegradable solid waste (W_i) is essential parameter for estimation of waste carbon content. Fortunately, in Japan, these amounts are getting smaller year by year most recent value is one-tenth smaller than 20 years ago (shown in Table 2).

Table 1 Summary of carbon content ratio (C_i) in some solid waste species applied in Japan.

Kitchen waste（食物くず）	43.4
Paper（紙くず）	40.9
Wood（木くず）	45.2
natural fabric（天然繊維くず）	45.0
water purifying sludge（浄水汚泥）	6.0
Polluted sludge（汚泥）	30.0~45.0
Manure from livestock（家畜ふん尿）	40.0

Table 2 Change in total amount of biodegradable solid waste in Japan.

unit : kt(dry)/yr	1990	1995	2000	2005	2006	2007	2008
Kitchen waste（食物くず）	501	483	297	110	98	50	52
Paper（紙くず）	1,179	868	611	290	247	82	71
natural fabric（天然繊維くず）	59	48	31	20	13	7	5
Wood（木くず）	652	476	221	152	142	76	39
Polluted sludge（汚泥）	697	441	260	148	105	80	77
water purifying sludge（浄水汚泥）	199	166	146	66	62	67	67
Manure from livestock（家畜ふん尿）	12	12	11	11	11	11	12
total	**3,299**	**2,494**	**1,577**	**797**	**678**	**373**	**323**

3. Summary

Gas emission is quite site-specific parameter and direct measurement by micrometeorological technique is unrealistic as a standardized method. It is not easy to measure and estimate total outflow of carbon eluted into water. However, current calculation to estimate CH_4 emission is rough and not so precise, and some coefficients are not applicable for moist and high-temperature Asian countries.