Evaluation of the CDM project of the waste landfill in Asian countries -effect of GHGs emission reduction and its impact on the sustainable development (Abstract of the Final Report)

Contact person Masato Yamada
Senior Researcher, Research Center for Material Cycles and Waste Management
National Institute for Environmental Studies
Onogawa 16-2, Tsukuba, Ibaraki, 305-8506 Japan
Tel:+81-29-850-2837 Fax:+81-29-850-2016
E-mail: myamada@nies.go.jp

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1. Introduction

In Japan, the total amount of the emission of greenhouse effect gas (GHG) in 2000 increased 8.0 % of that in 1990. Although targeted reduction of GHGs in Japan during first commitment period (2008-2012) was decided as 6 % of reduction from the amount of GHGs emission in 1990, it could be almost impossible to achieve it only by the domestic actions. Therefore, it becomes to be indispensable for using flexibility mechanism adopted in the Kyoto Protocol to achieve the target reductions of GHGs emission reductions. Three flexibility mechanisms, namely Joint Implementation (JI), a Clean Development Mechanism (CDM) and Emissions Trading (ET), would assist Parties to meet their GHG emissions commitments. Avoidance of emission or collection and utilization of methane derived from waste landfills must be attractive target for CDM project, since large portion of organic waste is still directly disposed into waste landfill in developing countries.

Methane emission from waste landfill is now estimated using statistics on the population, and quality and quantity of waste. Uncertainty of this estimation and difference between estimates and real emission from landfill are always being problem, and validation and improvement of the accuracy of the emission estimation must be requisite. For instance, unless the fine emission estimation was not obtained, appropriate evaluation on baseline of emission and effect of CDM operation could be difficult; and unless the monitoring of the real emission was unsatisfactory carried out in each emission source (e.g. waste landfill), achieved reduction could be approved as the credit. Furthermore, CDM project must aim not only the reduction of GHGs emission, but also improvements of public health or regional environmental problem (secondary benefit) from the viewpoint of the sustainable development. Evaluation of landfill gas also contributes to assess the long-term change of characteristics of waste landfill, and it may lead the guideline of appropriate operation or maintenance of landfills from the viewpoint of the safety of environment and human health. The resolution of these subjects and accumulation of the acquaintance of the design and operation of CDM project on waste landfills should be urgent research topics for showing the guideline to achieve the target reduction of GHGs emission of Japan.

2. Research Objective

Objective of this study is to prepare the detailed guideline for appropriate planning and operation of CDM projects for developing countries in Asia. "Appropriate" means that the solid waste management in developing countries must be simultaneously improved by this activity, since inappropriate disposal of wastes causes serious problems on public health and regional environment. We will present a series of methodologies on estimation of the disposed organic waste from national and regional waste streams, acquisition of locally specific parameters for the landfill methane production, reduction of the landfill methane by enhancement of the methane oxidation in the cover soil, monitoring of the whole methane emission from landfill sites, and evaluation of the environmental sustainability of CDM projects in the solid waste management sector for design and operation of CDM projects in Asian developing countries.

3. Results and Discussion

(1) Establishment of method for estimation of National methane emission from waste landfills

The political priority of solid waste management is still low in developing counties in Asia, and it means that waste disposal sites will receive wastes with high organic contents and emit large amount of methane and polluted leachate in future. In this regards, CDM projects on solid waste and landfill management is important for improvement of management and prevention of global warming. In several waste streams in Asia, since the recovery of valuables from waste is progressed, the uncontrolled deposit and burning are still main streams as disposal options. Therefore, enlargement of collection area and population, recycling of organic waste and establishment of proper landfills are main issues on the solid waste management.

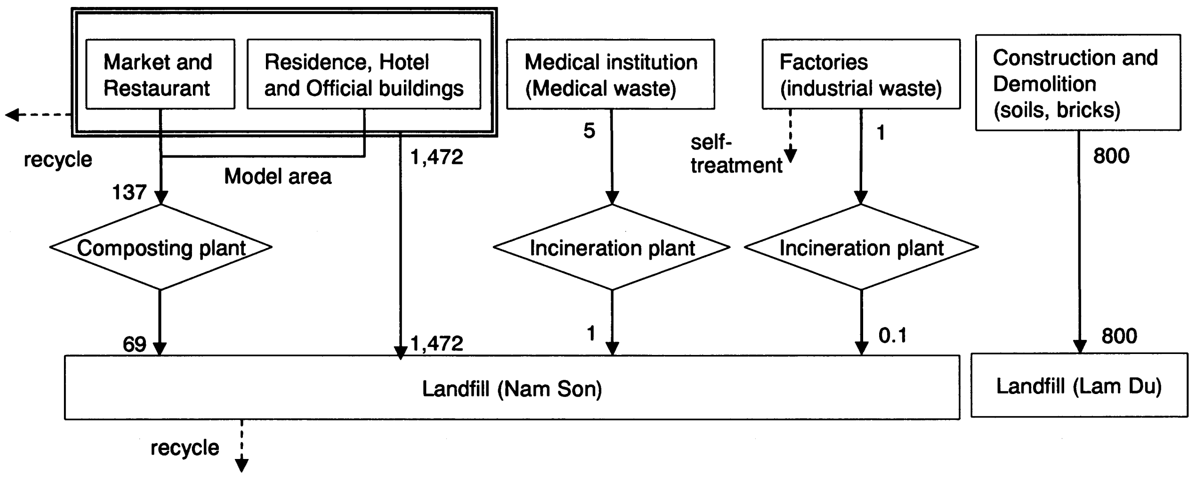


Figure 1. Waste stream managed by URENCO in Hanoi urban area (2002)

In the Hanoi and the Ho Chi Minh City, Vietnam as case studies, the methodology for estimation of the organic waste flow in streams to landfill sites was presented based on the survey of documents and statistics and the field investigation **(Fig.1)**. For this estimation, not only statistics on waste generation and management, but also investigation of waste component in all waste streams to land disposal including streams of direct disposal, resource recovery, composting and so on, was identified as an important procedure.

Engineering for enhancement of methane oxidation in cover soil was presented as simple, low cost and applicable technology for Southeast Asia. In experiments using the column filled with cover soil materials, 17% of methane reduction was achieved by the sand mixed with the wood waste, which can be locally procured as an agricultural waste, at 10% of moisture **(Fig.2)**. This cover soil material can maintain higher methane reduction capacity at wider moisture contents. Methane oxidation in cover soil columns was active at 30 cm depth. For Southeast Asian countries, which have dry and rainy seasons under tropical climate condition, the cover soil mixed with wood waste would be applicable for on site methane reduction at landfill sites. It also revealed when a certain mass (10^7 of pmoA gene number) of the methanotroph will exist in the cover soil, main factors affected to the methane oxidation are physical properties of the cover soil material, such as the air permeability.

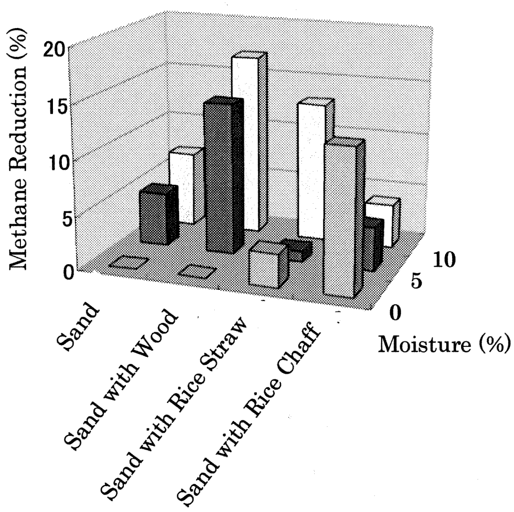


Figure 2. Methane reduction capacity of several cover materials

(2) Development of the method of measurement of methane emission from waste landfill

Changes of GHGs from landfill sites and composition in landfilled waste were observed at landfills in Vietnam and Thailand, and rate constants for the emission estimation models were obtained. Field surveys on methane emission from different aged landfills (0.5, 2, and 8 years) in Hanoi were conducted and the methane emission were estimated at 76, 21, 1.15 ml/min/m^2, respectively **(Table 1)**. The first-order reaction rate of methane generation was obtained as 0.74. Methane emission from waste landfill was calculated using the statistical data under the first-order reaction model. The estimates of methane emission were well accorded with results of filed survey. These showed that the landfill methane emission can be exactly estimated using data on the amount and composition of landfilled waste, as studied in section (1), and methane production rate constants obtained under local and specific situation. These filed estimates of landfill methane emission and its rate constants should also be rare and valuable information on landfills in Southeast Asia.

Table 1. Summary of field investigation of methane flux on the landfill surface at landfills in Hanoi

	Number of				Range of flux ml/min/m^2	Average, coefficient of variance	Total emission
	measured points	Positive flux	Negative flux	undetected			
Tay Mo	13	3	4	6	-2.8～29	4.38 ml/min/m^2 ±277%	1.15 ml/min/m^2
Nam Son (phase 1)	14	10	2	2	-0.89～150	22.5 ml/min/m^2 ±186%	21 ml/min/m^2
Nam Son (cell4)	18	11	7	0	-5.6～770	120 ml/min/m^2 ±171%	76 ml/min/m^2

As a simple and rapid observation method for the methane flux from the landfill surface, a combination of the closed chamber and the laser methane detector, i.e. the LMD-chamber method was developed and compared with the conventional closed chamber method at landfills in Japan and Thailand. Contributing rates of correlation between observed surface methane flux by LMD-chamber and conventional method were 0.33, 0.82 and 0.79, and slopes of regression line were 0.50, 1.07 and 0.77 at -0.31 to 1.11, -0.07 to 274 and 0.78 to 2,700 g-CH_4/m^2/day of surface methane flux, respectively (**Fig. 3**). The LMD-chamber method can be replaced with the conventional method at sites with 10^0 to 10^2 g-CH_4/m^2/day of surface flux with 5 to 15 min of measurement and 0.2 m diameter and 1 m height of chamber. Further considerations need on enhancement of detection limit of the LMD for lower flux measurement and volume of the chamber and duration of measurement for higher flux measurement. Observation of whole methane flux from landfill sites was also carried out using an open path FTIR and 3D anemometer.

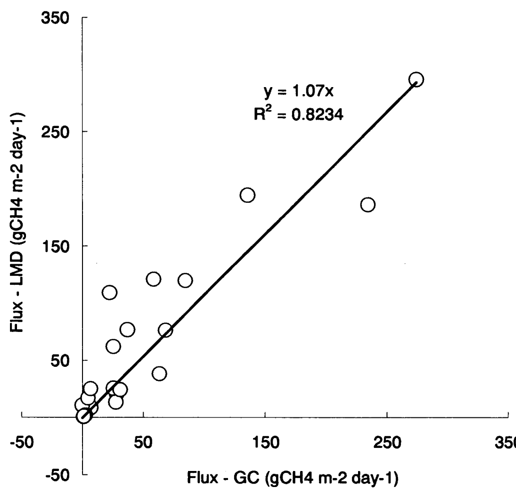
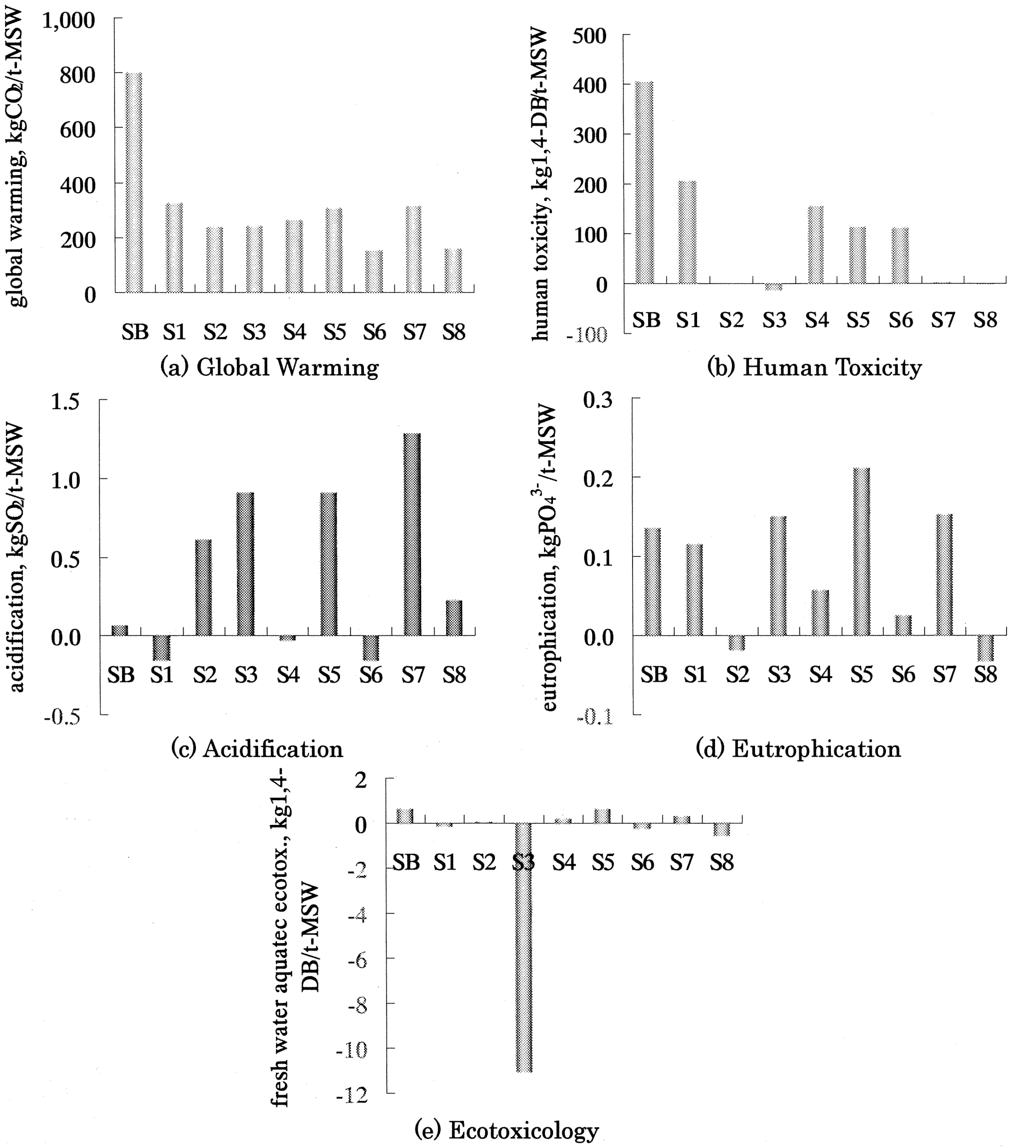


Figure 3. Surface CH_4 flux measured by LMD- and conventional chamber methods at Hua Hin landfill

(3) Design of the model for evaluation on environmental sustainability of GHG reduction measures in waste management



Scenarios

B: Commingled MSW is disposed in landfill site. LFG recovery and leachate treatment are not occurred.

1: Commingled MSW is disposed in current landfill site. 50% of generated LFG is used for electricity generation and surplus electricity is exported to national grid.

2: Commingled MSW is incinerated in waste incinerator, and its residues are disposed at current landfill site. Surplus electricity produced from waste heat in incinerator is exported to national grid.

3: Commingled MSW is carbonized (low temperature pyrolysis) and char (product) replaces coal.

4: Commingled MSW undergoes MBP process and all residues from MBP process are disposed at current landfill site. Surplus electricity generated from biogas is exported to national grid.

5: Organics separated from the sources fraction are composted, and others are disposed in current landfill site. Produced compost replaces chemical fertilizer.

6: Organics separated from the sources are treated by anaerobic digestion process, and others are disposed in current landfill site. Surplus electricity produced from biogas of anaerobic digestion is exported to national grid, and produced compost replaces chemical fertilizer

7: Organics separated from the sources are composted, and others are incinerated in waste incinerator. Incineration residues are disposed in current landfill site. Surplus electricity produced from waste heat of incineration is exported to national grid, and produced compost replaces the chemical fertilizer.

8: Organics separated from the sources are treated by anaerobic digestion, and others are incinerated in waste incinerator. Incineration residues are disposed in current landfill site. Surplus electricity produced from biogas and waste heat is exported to national grid, and produced compost replaces chemical fertilizer

Figure 4. Environmental impact of each scenario in Hanoi

The life cycle assessment (LCA) was applied to evaluate GHG reduction and environmental sustainability of CDM projects on waste measurement. In Seoul as one case study, change on environmental impacts of organic waste management between 1997 and 2005, when the land disposal of food waste was banned, was analyzed. Decrease of land disposal waste reflected to 30% reduction of the global warming impact and 70% reduction of the human toxicity impact. The environmental impact of the feedstuff production was lesser than that of the composting. In Hanoi as another case study (**Fig 4**), the scenario on introducing the landfill gas recovery to their solid waste management showed lower energy consumption but higher landfill volume consumption, higher environmental impact and lower GHG reduction than other scenarios. The scenario on the biological treatment showed GHG reduction of 140 to 300 kg and lower environmental impacts and landfill volume consumption than the scenario on the landfill gas recovery. Since the anaerobic treatment can recover energy from the organic waste, this should have more advantage than the aerobic treatment. These results suggested that a tradeoff between GHG reduction and other environmental impact would be often found in CDM projects.