ESTIMATION OF REDUCTION OF GREENHOUSE GASES EMISSION FROM A WASTE BANK ACTIVITY IN PRABUMULIH CITY, INDONESIA

University of Miyazaki, Student Member, ○ Pithan Chandra
University of Miyazaki, Member, Tomoo SEKITO and Yutaka DOTE
Gadjah Mada University, Deva FOSTERHAROLDAS

1. Introduction

Indonesia's government has committed to a 26% reduction in the total emissions of greenhouse gases (GHGs) in Indonesia by 2020, including the waste management sector. In 2000, the waste management sector was produced 11% of the GHGs emission in Indonesia [1]. One of the effective ways to reduce the emissions of GHGs would be to recycle solid waste, thereby reducing the amount of material in landfills.

The Waste Bank is one of the recycling systems. In this system, participants separate their valuable waste and bring it to the Waste Bank to save money on their Waste Bank account. However, the impact of reducing GHGs by means of the Waste Bank in Indonesia has never been studied. In this case study, the impact of the Prabumulih's Waste Bank activity, on the reduction of GHG emissions was estimated. The factors that affect the reduction of GHG emissions also are discussed.

2. Outline of The Prabumulih Waste Bank (PWB)

Prabumulih City in South Sumatra established its Waste Bank in 2014, and it is called the Prabumulih Waste Bank (PWB). Figure 1 shows the waste flow into PWB. The participants belong to PWB's main office or branch offices. In September 2016, there were 32 branches in PWB. The participants must separate their waste into 25 categories of waste resources. The waste resources from the main office member are collected and transported to the main office. The waste resources from the branch office members are collected by the PWB main office or branch offices and transported to the main office. Inorganic waste resources, such as plastics and metals, are sold to recycling companies. The compostable waste, such as food waste and yard waste, is composted at the PWB main office, and the product is sold directly to buyers who come to the PWB. The money obtained by selling the waste resources is allocated to the participants according to the amount and type of waste resources and used for operational costs at the main office and the branch offices such as fuel, electricity and to pay employees.

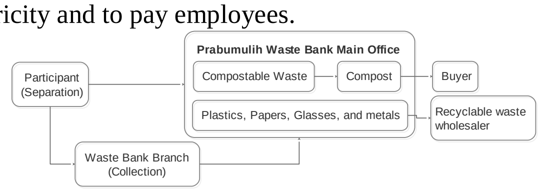


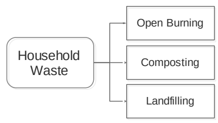
Figure 1. Flow of the waste resources of the PWB

3. Research Method

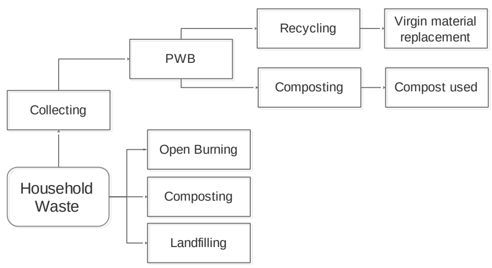
Figure 2 shows the system boundary of this study for estimating GHG emissions. Landfilling, open burning and composting were considered to be source of GHGs from traditional waste treatment. Regarding the GHG emissions from PWB, we considered fuel consumption, electricity consumption, the replacement of virgin material by recycled materials, and the replacement of inorganic fertilizer by compost.

The data concerning the amount and type of waste resources brought to the PWB office from January to September 2016 were obtained from the PWB's main office. In order to obtain the participants' fuel consumption and former waste treatment data, 216 participants were selected and asked about the type of vehicle used to bring the recycle material to PWB and about how they treated their waste before joining to the PWB. Fuel and energy consumption by the main office and the branch offices were also obtained.

Intergovernmental Panel on Climate Change (IPCC) formula [2], waste compositions, waste dry matter content and waste disposal method reported in the Prabumulih City Environmental Agency's activity report [3] and Japan International Cooperation Agency (JICA) survey at 2014 [4] were used to estimate the GHG emissions from each sector of the waste treatment. The emission factors of fuel and energy were 2.7 kg CO_2-eq per liter of diesel oil, 2.3 kg CO_2-eq per liter gasoline and 0.7 kg CO_2-eq per kWH of electricity [5]. As for virgin material replacement by recycled material, emission factors from Chen and Lin [6] were used. Waste generation in Prabumulih City was about 455 g per person per day [4], and the compositions of the wastes are shown in Table 1.



a) Traditional waste treatment



b) Waste treatment with PWB activities

Figure 2. Research system

Table 1. Prabumulih City waste composition

Type of Waste	Composition average, % [4]	Dry Matter Content, % [3) 4)]
Food waste	54.2	25
Yard and garden	17.5	57
Wood	0.2	85
Paper and Carton	5.1	83
Textile	1.3	88
Baby diapers	2.8	24
Rubber, leather	0.6	87
Plastic	12.8	60
Metal	1.2	91
Glass, ceramic	2.3	97
Others (organic)	0.1	56
Others (inorganic)	2.0	25

In this study, six scenarios were proposed to estimate GHG emissions reduction (Table 2). Scenario 1 was based on the conventional method without PWB. In scenario 2, household waste was treated by the current condition in Prabumulih City with PWB. In scenario 3, the percentage of the PWB active participants was set as 1.39%, which is equal to 50% of the total current PWB participants. For scenarios 4 and 5, the total number of PWB active participants was set as 16.5% and 16.4%. In scenario 6, the total of PWB active participants was set as 25% and the number of branches was set as 40.

Table 2. Research scenarios

Name of scenario	Conditions/Assumptions		
	Active participant* rate (%)	Number of branches	Participant ratio belonging to the main office (%)
Scenario 1	0	0	0
Scenario 2	0.92	32	60
Scenario 3	1.39	32	60
Scenario 4	16.5	32	71
Scenario 5	16.4	40	35
Scenario 6	25.0	40	35

* Active participant rate is the number of participants that brought waste resources to the waste bank in one year.

4. Results and Discussion

4.1. PWB actual ability in reducing GHGs

In total, 1,358 participants joined the waste bank in 2016, and the participation rate of households in Prabumulih City was 2.8%. Based on the record from PWB's main office, only 33% of the participants brought their waste resources to PWB in 2016 and the rest of participants did not bring any waste resources. A total 33 tons of waste resources was managed by PWB in 2016 (Paper 50%, Plastic 16%, organic waste 15%, Glass 11%, and metal 8%).

From the survey questionnaire, it was found that 40% of the respondents answered before joining the PWB, and their waste was collected and taken to the landfill site, 36% of respondents burned the waste in their backyard, 2% of respondents composted their waste, and the other 22% recycled, left the waste untreated, or used it as animal feed. It was assumed that the participants treated the residue waste, that was not accepted as waste resources, by the same methods used before joining the PWB.

The percentage of respondents belonging to the main office was 60%, and 75% of them use motorcycles to bring their waste resources to the main office. However, 94% of the respondents who were associated with the branch office brought their waste resources by foot because the locations of the branch offices were close to their houses.

It was found that 7.05 Gg CO_2 eq were generated from the conventional waste treatment (Scenario 1) in 2016 (Table 3). The dominant source was landfill with 5.59 Gg CO_2 eq or 79% of total GHGs generated by conventional treatment. Therefore, reduction of landfilling waste would be effective in reducing GHG emissions from the waste management sector.

Table 3. GHGs generated by traditional waste treatment

Sources	GHGs Generated (Gg CO_2 eq/ year)	GHGs Generated per waste amount (Gg CO_2 eq / Gg of waste/ year)
Landfill	5.59	0.44
Composting	0.22	0.18
Open burning	1.25	0.28

Table 4. GHGs produced from PWB's activities

Sources	GHGs Generated (Mt CO_2 eq/year)
Fuel Consumption	0.26
Electricity used	1.11
Virgin material replacement	(-19.5)
Inorganic fertilizer replacement	(-0.13)

Table 4 shows the GHG emissions from PWB activities in scenario 2. The GHG emission reduction from the replacement of virgin material was -19 Mt CO_2 eq/ year. In total, PWB's activities generated -18 Mt CO_2 eq/ year.

GHGs reduction rates of scenarios 2 to 6 from scenario 1 are shown in Figure 3. A significant reduction of GHGs was produced in the recycling sector by replacement of virgin material. GHGs emissions from landfill and open burning also were reduced by 0.14% and 0.06%, respectively. PWB activities produced GHGs, and the level was increased by 0.03%. Scenario 6 shows that total 14% of GHGs could be reduced from conventional waste management.

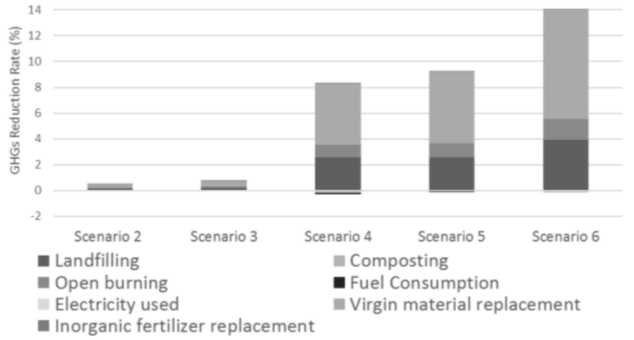


Figure 3. Reduction of GHGs emission by various scenarios on PWB

4.2. Factors that influence the reduction of GHGs

Given the current conditions, PWB contributed to only a 0.45% reduction in GHG emissions. The reduction percentage of scenario 5 was greater than of scenario 4, because of the shorter transportation distance by participants who were associated with the branch offices. Scenario 6 showed the highest reduction because of the higher active participation rate. Assuming that there is a linear correlation between the active participant rate and GHG reduction rate, a 48% active participant rate would be required to achieve a 26% reduction in GHG emissions which is Indonesia's target value.

5. Conclusions and Recommendations

The Current GHG reduction rate by PWB activities in 2016 was significantly small (0.45%). In order to increase the reduction rate, the participation rate must be increased significantly. Expansion of storage facilities for waste resources at the main office and increasing the number of branch offices would be required to achieve this goal.

References

1) Environmental Ministry of Indonesia. *Indonesia Second National Communication Under the United Nations Framework Convention on Climate Change (UNFCCC)*. Ministry of Environment, Republic of Indonesia; 2010.

2) KLH. *Pedoman Penyelenggaraan Inventarisasi Gas Rumah Kaca Nasional: Buku II Volume 4 Metodologi Penghitungan Tingkat Emisi Gas Rumah Kaca Pengelolaan Limbah*. Jakarta: Kementerian Lingkungan Hidup Republik Indonesia; 2012.

3) BLH. *Laporan Monitoring, Reporting dan Evaluasi Emisi Gas Rumah Kaca (GRK) di Kota Prabumulih 2016*. Badan Lingkungan Hidup Kota Prabumulih; 2016.

4) Ueda H, Matsuoka N. Importance of Accurate GHG Estimation for the Effective Promotion of Mitigation Policies. In: Kaneko S, Kawanishi M, editors. *Climate Change Policies and Challenges in Indonesia*. Japan: Springer; 2016.

5) Eisted R, Larsen AW, Christensen TH. Collection, transfer and transport of waste: accounting of greenhouse gases and global warming contribution. *Waste Manag Res*. 2009;27:738–745.

6) Chen T-C, Lin C-F. Greenhouse gases emissions from waste management practices using Life Cycle Inventory model. *Journal of Hazardous Materials*. 2008 30;155:23–31.