Benefit of composting application over landfill on municipal solid waste management in Phnom Penh, Cambodia

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Abstract

This paper presents an insight into benefits of organic waste recycling through composting over landfill on municipal solid waste management in Phnom Penh, in terms of greenhouse gases (GHGs) mitigation. Future waste generation from 2003 to 2020 was forecasted and four scenarios of organic waste recycling were carried out. Organic waste−food and garden waste−were used for composting and the remaining waste was landfilled. The recycling scenarios were set based on organic waste generated from difference sources; scenario 1: no recycling, scenario 2: household organic waste; scenario 3: market, restaurant, school and hotel organic waste, and scenario 4: all generated organic waste. The results showed that MSW generation in MPP increased significantly from about 0.24 million ton in 2003 to 0.41 million ton in 2010 and was projected to reach 1.02 million tons in 2020. Composting gave better benefit than landfill. It could reduce GHGs emission of 36.2%, 12.8% and 65.0% from scenario 2, scenario 3 and scenario 4 compared with scenario 1 (all generated waste is landfilled), respectively. These percentages reflect the amount of GHGs emission of 3.23, 1.14 and 5.79 million tons CO_2eq from the above respective scenarios. Hence, composting could be a potential GHGs mitigation option for MPP.
Keywords: composting, GHGs, GHG inventory, scenario analysis, solid waste management, Phnom Penh, Cambodia.

WIT Transactions on Ecology and The Environment, Vol 163, © 2012 WIT Press
www.witpress.com, ISSN 1743-3541 (on-line)
doi:10.2495/WM120061

1 Introduction

Cambodia is one of the least developed countries in Southeast Asia with a total population of about 13.39 million people and average gross domestic product (GDP) per capita of about USD 739 in 2008 [1]. In the context of climate change, Cambodia ratified the UN Framework Convention on Climate Change (UNFCCC) in 1995 and acceded to the Kyoto Protocol in 2002. Cambodia has committed to prepare its national greenhouse gases (GHGs) inventory and to identify the possibility of GHGs mitigation options.

In Cambodia, GHGs emission from waste was the third largest amongst the five components – energy, agriculture, land use change and forestry, waste, and industrial process. It was also reported to less significant change from 1994 to 2000; being 273 Gg CO_{2eq} in 1994 and 229 Gg CO_{2eq} in 2000 [2]. Although GHGs emission from waste was seen to decrease, the inventory procedure was conducted differently. It was hence not clear whether the net GHGs emission from waste decreased or increased. However, in conjunction with the creation of economic growth, vast population increase, urbanization, industrialization and excessive consumption of modern daily life, a large quantity of waste would be generated. It was consequently expected to increase in GHGs emission in the later years.

Municipality of Phnom Penh (MPP), capital city of Cambodia, produces a large quantity of municipal solid waste (MSW) which has increased rapidly from 0.136 million tons in 1995 to 0.409 million tons in 2010 [3, 4]. The generated waste has been mainly disposed of at landfill which has been operated in neither sanitary nor environmental sounds. It has been operated with no or irregular soil cover, no leachate treatment facility, no landfill gas capturing facility and hundreds of waste scavengers making their living on the disposal site [5]. MSW generated in MPP comprises a large portion of organic waste with high moisture content. This makes it inevitable to produce CH_4 and other gases which potentially contribute to climate change.

Composting of organic waste is one of the potential mitigation options to tackle climate change in Cambodia [6]. Generated waste in MPP contributed 80% to total urban waste generation [6] and its characteristics are suitable for composting. Hence, the aim of this study is to give an insight into benefit of organic waste recycling through composting, in terms of GHGs mitigation. Future waste generation by 2020 was forecasted and a set of scenario analysis on organic waste recycling were carried out.

2 Method

2.1 Study area

The study was conducted in MPP, the capital city of Cambodia. MPP has a total area of about 678.46 km^2 in 2010 [7]. The entire area is divided into 8 districts and 96 communes. The total population in 2008 was around 1.3 million people with an average population density of 4571 person km^{-2} and an average household size of 5.1 [1].

2.2 Data collection

The data describing the quantities of MSW, population and GDP cover from 1994 to 2010. The data of waste generation was collected from three available sources; the Ministry of Environment (MoE), Japan International Cooperation Agency (JICA), and a published paper [8]. The population data was collected from the National Institute of Statistics (NIS), Ministry of Planning (MoP) and GDP data was collected from both NIS and Asian Development Bank (ADB). The other related information, i.e., environmental law, and solid waste regulation and announcements, were collected from MoE and the Department of Environment of MPP, whereas the overall technical arrangement of MSW management (MSWM) was done through interview the key informants of CINTRI, private firm responsible for collection service, and Phnom Penh Waste Management (PPWM), the responsible authority of SWM in MPP.

2.3 Scenario set-up

Four scenarios of organic waste recycling via composting were set up based on sources of waste generation. Generated waste was classified into 9 categories; household, commercial (restaurants), commercial (other shops), market, school, hotel, office, street sweeping and other. The generated waste from every category was basically a mixed waste consisting of both compostable and non-compostable materials. In this study, kitchen and grass/wood waste was considered to be compostable, whereas metals, rubber/leather, textile, bottles/glass, soil/stone, papers and plastics were considered to be non-compostable. Hence, the scenarios were set as the following:

- Scenario 1 (S1) : All generated waste is landfilled (case: current situation).
- Scenario 2 (S2) : Household waste is used for composting while the remaining waste is landfilled (case: The biggest portion of organic waste generation source was recycled).
- Scenario 3 (S3) : Market, restaurant, school and hotel waste is used for composting while the remaining waste is landfilled (case: easy to request for cooperation from the business owners).
- Scenario 4 (S4) : All generated waste is used for composting (case: ideal condition).

2.4 MSW generation and its composition forecasting

The data of waste generation was collected from three available sources from 1994 to 2010. However, the data was neither consistent nor reliable which made it difficult to use for future waste generation forecasting. In this study, hence, the amount of future waste generation was forecasted based on number of generation sources, i.e., household (population), market (number of stalls), restaurant (number of restaurants), etc., and their individual discharge rate. The waste composition was forecasted based on economic growth. The detail of waste generation and its composition forecasts are given as the following:

2.4.1 Population

The population data from 2003 to 2008 was adopted from NIS of Cambodia [1] and from 2009 to 2020 was adopted from Statistics Bureau under Ministry of Internal Affairs and Communications, Japan [9]. The average annual growth rate from 2003 to 2008 was calculated based on the data of General Population Census of Cambodia (GPCC) in 1998, Cambodia Inter-censal Population Survey (CIPS) in 2004 and GPCC in 2008, whereas that from 2009 to 2020 was adopted from the data of a joint study on population projection in Cambodia from 2008 to 2030 of Statistics Bureau, Japan, and NIS, Cambodia.

2.4.2 Number of waste generation sources

Number of waste generation sources was forecasted to increase in proportion with the growth rate of GDP. The annual growth rate of GDP was adopted from ADB from 2003 to 2010 [10, 11]. The growth rate after 2010 was assumed to be same as the growth rate in 2010.

2.4.3 Waste discharge rate

Waste discharge rate prediction is practically difficult. It is affected by a number of factors such as business type and size, family income, people behavior, regulation and other factors. To simplify the complexity of effects from these factors, GDP was used as a sole parameter to estimate the discharge rate. The rate of every generation source, hence, was predicted to increase in proportion with the growth of GDP per capita. Based on Japanese statistics on waste generation and economic development from 1963 to 1970, the growth rate was adopted at 50% of GDP growth rate per capita [5] as the following – 2003-2005: 1.85% y^{-1}; 2006-2010: 2.30% y^{-1}; 2011-2020: 1.90% y^{-1}.

The above annual waste discharge rate will not apply to public cleansing services such as street sweeping and cleaning parks but their amount will be implicitly increased in accordance with the growth of the population and expansion of the city.

2.4.4 Waste composition forecast

The waste composition was forecasted based on two assumptions:

- Significant changes in dietary habit and living environment is not anticipated. Therefore, the discharge amount of kitchen waste, garden waste, textile, rubber/leather, soil and stone, and metals were assumed to remain the same.
- The discharge amount of waste for wrapping, i.e., paper, plastics, and bottle and glass were assumed to increase in accordance with economic growth.

2.5 Greenhouse gases emission

2.5.1 Composting

The GHGs – CO_2, CH_4, N_2O – emission from composting process was estimated based on mass balance of C and N in the process cycle [12]. CO_2 and CH_4 can be estimated based on either percent carbon lost or carbon input. In this study, CO_2 was estimated based on percent carbon input while CH_4 was estimated based on percent degraded carbon. The emission of the two gases is expressed as the following:

$$CO_{2,release} = C_{input}.C_{CO_2\%}.\frac{44}{12} \tag{1}$$

$$CH_{4,release} = C_{input}.C_{degraded\%}.C_{CH_4\%}.\frac{16}{12} \tag{2}$$

where C_{input} is total carbon content in raw waste (kg), $C_{CO2\%}$ is percent of C converting to CO_2 (%), $C_{CH4\%}$ is percent of C converting to CH_4 (%), $C_{degraded\%}$ is percent of C_{input} degraded (%).

N_2O was calculated based on the total nitrogen input as:

$$N_2O_{release} = N_{input}.N_{N_2O\%}.\frac{44}{28} \tag{3}$$

where N_{input} is total nitrogen content in raw waste (kg), $N_{N2O\%}$ is percent of N converting to N_2O (%).

2.5.2 Landfill

The emission from landfill consists of various gases which are potentially contributed to the amount of global GHGs, in particular CH_4. CH_4 was estimated by applying IPCC Waste Model [13]. The model was developed based on first order decay method with the main input of degradable organic carbon (DOC). CH_4 generation, in this model, can be simulated by two ways depending on input data; bulk waste or waste by composition. In this study, waste by composition option was chosen and CH_4 generation can be simulated as:

$$CH_4\ generated_T = \sum_x DDOC_{x,ma_{T-1}}\left(1-e^{-k_x}\right)\times F \times \frac{16}{12} \tag{4}$$

Part of the CH_4 generated is oxidized in the cover of the landfill, or can be recovered for energy or flaring. The CH_4 actually emitted from the landfill will hence be smaller than the amount generated.

$$CH_4\ \text{emission}_T = \left(\sum_x CH_4\ generation_{x,T} - R_T\right)\times\left(1-OX_T\right) \tag{5}$$

where T is inventory year, x is waste component, F is fraction of CH_4 in generated landfill gas (volume fraction), k is reaction constant (y^{-1}), $DDOC_{ma_{T-1}}$ is mass of decomposable DOC accumulated in the landfill at the end of year T-1 (Gg), R_T is recovery CH_4 in year T (Gg), OX_T is oxidation factor in year T (fraction), $CH_4\ generated_T$ is amount of CH_4 generated in year T (Gg), $CH_4\ emission_T$ is amount of CH_4 emitted to the atmosphere in year T (Gg).

3 Results and discussion

3.1 MSW generation and its composition

Generated MSW in MPP was basically a mixed waste which is generated from 9 difference sources. The basic information of population, GDP and waste generation from 1994 to 2010 are presented in Table 1 and the distribution of generated waste from the 9 sources is presented in Fig. 1.

Table 1: Population, GDP and amount of disposal waste from 1994 to 2010.

Year	Population[a] [million]		GDP[b] (Current price)		Amount of waste [tons y^{-1}]		
	Cambodia	MPP	US\$ $Capita^{-1}$	Growth rate [%]	c	d	e
1994	9.752	0.812	247	8.2	-	14,500	-
1995	10.148	0.855	297	20.3	136,388	14,548	-
1996	10.560	0.901	295	-1.0	143,103	15,264	-
1997	10.990	0.949	281	-4.7	142,536	15,203	-
1998	11.436	1.000	253	-9.8	169,111	18,038	-
1999	11.656	1.007	282	11.4	191,625	20,440	-
2000	11.881	1.014	288	2.2	219,000	20,702	-
2001	12.110	1.022	308	7.0	-	21,050	-
2002	12.344	1.029	326	5.9	-	21,367	-
2003	12.581	1.037	345	5.6	-	240,859	253,569
2004	12.824	1.044	389	12.8	-	227,910	261,457
2005	12.963	1.108	454	15.7	-	266,781	283,076
2006	13.103	1.177	513	13.0	-	324,159	328,902
2007	13.245	1.249	575	12.0	-	343,657	343,742
2008	13.389	1.326	739	19.8	-	361,344	355,561
2009	-	-	765	0.0	-	393,141	-
2010	-	-	830	9.8	-	409,335	-

[a][1] ; [b][1–7] ; [c][8] ; [d][3, 4] ; [e][15]

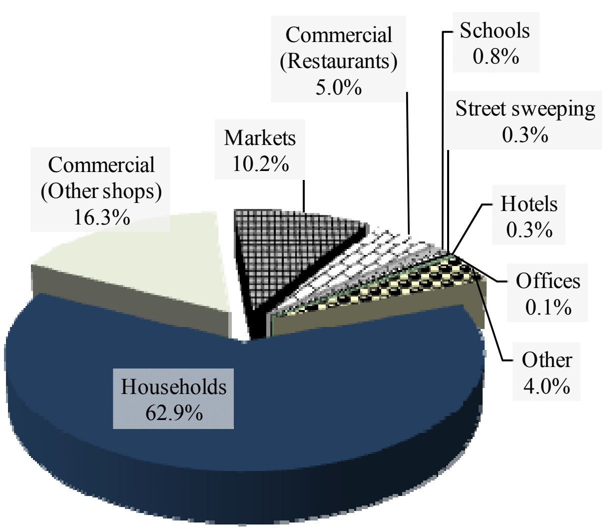

Figure 1: Distribution of MSW in MPP.

Future MSW generation was predicted based on the available data of the base year 2003.The total amount of forecasted waste generation from 2003 to 2020 is presented in Table 2. The amount of waste generation was predicted to increase significantly from 811.2 tons d^{-1} in 2003 to 2783.9 tons d^{-1} in 2020. Overall, the predicted results showed higher values than actual data from 2003 to 2010. It was hard to calibrate the predicted results because the available data was the amount of waste collected for disposal, not the amount of generated waste. Basically, the amount of generated waste is bigger than that of disposal waste and their difference depends on collection efficiency. In 2009, around 82.1% of generated MSW was collected for disposal [14]. This means that the total amount of generated waste should be around 1311.9 tons d^{-1}

Table 2: Forecasted number of waste generation source, waste generation rate, and total waste generation amount 2003–2020.

Sources	Unit	2003	2006	2009	2012	2015	2018	2020
Number of waste generation sources								
Household waste	person (million)	1.037	1.177	1.439	1.637	1.835	2.018	2.127
Commercial waste (restaurant)	Table	27808	38492	45222	54013	64513	77053	86741
Commercial waste (Other shops)	Shop	33524	46404	54518	65116	77773	92892	104570
Market waste	Stall	51766	71655	84184	100548	120094	143439	161472
School waste	Student	385013	532936	626122	747834	893205	1066835	1200959
Hotel waste	Room	13385	18528	21767	25998	31052	37089	41751
Office waste	Office	368	509	598	715	854	1020	1148
Street sweeping waste	km	56	56	56	56	56	56	56
Waste generation rate								
Household waste	g $person^{-1}d^{-1}$	487	517	553	588	622	658	683
Commercial waste (restaurant)	g $table^{-1}d^{-1}$	1664	1766	1891	2008	2125	2248	2335
Commercial waste (Other shops)	g $shop^{-1}d^{-1}$	4502	4777	5114	5433	5748	6082	6315
Market waste	g $stall^{-1}d^{-1}$	1823	1934	2071	2199	2327	2462	2557
School waste	g $student^{-1}d^{-1}$	20	21	22	24	25	26	27
Street sweeping waste	g $km^{-1}d^{-1}$	53373	53373	53373	53373	53373	53373	53373
Hotel waste	g $room^{-1}d^{-1}$	231	245	262	279	295	312	324
Office waste	g $office^{-1}d^{-1}$	3560	3778	4045	4296	4546	4810	4995
Waste generation amount								
Household waste	Tons d^{-1}	504.8	608.1	796.1	962.4	1141.2	1328.0	1453.0
Commercial waste (restaurant)	Tons d^{-1}	46.3	68.0	85.5	108.5	137.1	173.2	202.5
Commercial waste (Other shops)	Tons d^{-1}	150.9	221.7	278.8	353.7	447.1	565.0	660.4
Market waste	Tons d^{-1}	94.3	138.6	174.3	221.2	279.5	353.2	412.9
School waste	Tons d^{-1}	7.5	11.0	13.9	17.6	22.2	28.1	32.9
Hotel waste	Tons d^{-1}	3.1	4.5	5.7	7.2	9.2	11.6	13.5
Office waste	Tons d^{-1}	1.3	1.9	2.4	3.1	3.9	4.9	5.7
Street sweeping waste	Tons d^{-1}	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Total	Tons d^{-1}	811.2	1056.8	1359.7	1676.7	2043.1	2467.0	2783.9

(waste disposal = 1077.1 tons d^{-1}) which compares to the predicted value of 1359.7 tons d^{-1}. The forecasted waste generation was hence acceptable and used for further analysis in scenario studies.

The forecasted results revealed that household waste has always made up the biggest portion (>52.2%), followed by commercial waste (other shops) (>18.6%), market waste (>11.6%) and commercial waste (restaurant) (>5.7%). The remaining sources including school, hotel, office and street sweeping waste have accounted for less than 1.2%.

Waste composition was categorized into 10 components including paper, rubber/leather, kitchen waste, textile, plastics, grass/wood, metals, bottle/glass, soil/stone and other. In 2003, waste generated from household, market, commercial (other shops), commercial (restaurant), hotel and office contained the biggest portion of kitchen waste (>35.3%), followed by either plastics (>9.9%) or paper (>5.2%), whereas the other components were less significant. On the other hand, school waste contained the biggest portion of plastics (26.5%) and paper (25.0%), and street sweeping waste contained the biggest portion of soil/stone (58.3%). The proportion of waste composition in future generated waste from each source kept the same order. However, the portion of plastic, paper and bottle/glass increased gradually in the future while that of other components decreased slightly. The waste composition forecast, household waste is as a sample, is presented in Table 3.

Table 3: Forecasted household waste composition from 2003 to 2020.

Composition	2003	2006	2009	2012	2015	2018	2020
Paper	5.23	5.47	5.75	6.01	6.26	6.51	6.69
Rubber /Leather	0.14	0.13	0.13	0.13	0.13	0.13	0.12
Kitchen Waste	61.45	60.56	59.51	58.56	57.64	56.70	56.06
Textile	2.57	2.53	2.49	2.45	2.41	2.37	2.35
Plastic	17.83	18.65	19.62	20.51	21.36	22.23	22.82
Grass /Wood	8.46	8.34	8.20	8.06	7.94	7.81	7.72
Metals	0.67	0.66	0.65	0.64	0.63	0.62	0.61
Bottles /Glass	0.81	0.85	0.89	0.93	0.97	1.01	1.04
Soil /Stone	1.04	1.03	1.01	0.99	0.98	0.96	0.95
Others	1.80	1.77	1.74	1.71	1.69	1.66	1.64
Total	100	100	100	100	100	100	100

3.2 Green house gases emission

The GHGs emission from both composting and landfill were estimated. The GHGs emission from composting was attributed to two gases; CH_4 and nitrous oxide (N_2O), whereas only CH_4 was considered to contribute to GHGs emission from landfill. CO_2 emitted from both composting and landfill was not accounted for net GHGs emission as a result of its biogenic origin [13]. To compare the quantitative GHGs emission, all gas components were converted to CO_2 equivalent (CO_2eq); CH_4 is 21 times higher than CO_2 and N_2O is 310 times higher than CO_2.

In composting system, the percent of carbon converted to CO_2 was reported to be in the range 50–60% of input carbon [12]. The percent of total carbon degraded was assumed to be in the range 66-84% based on hemicelluloses and fiber degradation rate during composting period [16]. The percent of carbon converted to CH_4 was in the range 0.8–2.5% of degraded carbon [17]. Based on the above criteria, GHGs emission from each scenario is presented in Table 4.

Table 4: Green house gases emission from composting 2003–2020.

Scenarios	2003	2006	2009	2012	2015	2018	2020
CO_2 emission rate [Ton d^{-1}]							
Scenario 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scenario 2	155.45	181.90	229.96	269.13	309.20	348.16	372.37
Scenario 3	41.10	58.49	70.84	86.78	106.02	129.36	147.61
Scenario 4	255.33	324.89	404.39	484.28	573.71	673.04	744.74
CH_4 emission rate [Ton d^{-1}]							
Scenario 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scenario 2	1.21	1.41	1.78	2.09	2.40	2.70	2.89
Scenario 3	0.32	0.45	0.55	0.67	0.82	1.00	1.15
Scenario 4	1.98	2.52	3.14	3.76	4.45	5.22	5.78
N_2O emission rate [Ton d^{-1}]							
Scenario 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scenario 2	0.02	0.03	0.04	0.04	0.05	0.05	0.06
Scenario 3	0.01	0.01	0.01	0.02	0.02	0.02	0.03
Scenario 4	0.04	0.05	0.06	0.08	0.09	0.11	0.12
GHG emission rate* (CH_4 x 21 + N_2O x 310) [Ton CO_2eq d^{-1}]							
Scenario 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scenario 2	32.81	38.39	48.53	56.80	65.26	73.48	78.59
Scenario 3	9.02	12.84	15.55	19.05	23.27	28.39	32.40
Scenario 4	54.23	69.05	85.94	102.93	121.96	143.12	158.41
GHG emission per year [Ton CO_2eq]							
Scenario 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scenario 2	11974.95	14012.45	17714.71	20732.82	23819.01	26820.78	28685.53
Scenario 3	3292.80	4685.92	5674.53	6952.04	8492.80	10362.59	11824.57
Scenario 4	19793.77	25204.66	31367.02	37569.26	44517.16	52239.58	57817.90
Cumulative GHG emission [Ton CO_2eq]							
Scenario 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scenario 2	11974.95	51212.64	100711.32	159884.69	228251.91	305752.39	362208.83
Scenario 3	3292.80	15829.94	32334.88	51868.02	75739.20	104877.09	127771.89
Scenario 4	19793.77	88917.37	178029.94	284415.47	410842.66	559669.00	672471.80

*The conversion of CH_4 and N_2O to CO_2 equivalent is based on the global warming potential of each gas, e.g. CH_4 is 21 times and N_2O is 310 times higher than CO_2.

GHGs emission from landfill was estimated by IPCC Waste Model. The model was run with the default values of DOC of each waste component and with the default values of reaction constant in Moist and Wet Tropical condition. The detail input parameter's values for the model are presented in Table 5. The total CH_4 emission was estimated and accumulated until 60 years after the closure of the landfill. The cumulative GHGs emission from each scenario is presented in Fig. 2.

Table 5: Input parameter values for IPCC Waste Model.

Parameter	Symbol	Unit	Value	Remark
Degradable Organic Carbon	*DOC*			Fraction of DOC in waste composition (Wet basis)
Food waste		-	0.15	-
Garden		-	0.2	-
Paper		-	0.4	-
Wood and Straw		-	0.43	-
Textiles		-	0.24	-
Methane Generation Rate Constant	*k*			Moist and Wet Tropical
Food waste		y^{-1}	0.4	-
Garden		y^{-1}	0.17	-
Paper		y^{-1}	0.07	-
Wood and Straw		y^{-1}	0.035	-
Textiles		y^{-1}	0.07	-
Fraction of DOC	DOC_f	-	0.5	Fraction of DOC that can decompose
Fraction of Methane	*F*	-	0.5	50% by volume of CH_4 in the generated landfill gas
Methane Correction Factor	*MCF*	-	0.8	Unmanaged-deep(>5m waste) and/or high water table
Oxidation Factor	*OX*	-	0	Managed, unmanaged and uncategorized landfill
CH_4 Recovery	*R*	-	0	No gas collection, No flaring
Delay Time	-	months	6	CH_4 start to produce after 6 months of waste deposition

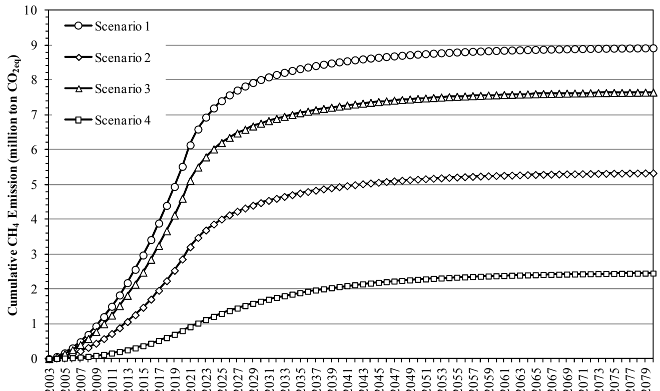

Figure 2: Cumulative CH_4 emission from landfill (waste disposal by 2020).

The total GHGs emission from landfill (from 2003 to 2080; landfill received waste until 2020) and composting (from 2003 to 2020) is presented in Fig 3. The results revealed that, based on current MSW management, total GHGs emission from generated waste from 2003 to 2020 would be 8.92 million ton CO_{2eq}. However, this amount could be reduced significantly by recycling organic waste through composting. Recycling organic waste from household waste alone (S2) could reduce 36.2% of GHGs emission to the atmosphere, whereas around 12.8% and 65.0% can be reduced if organic waste was recycled in accordance with S3 and S4 compared with S1, respectively. These percent reductions reflect the amount of GHGs reduction of 3.23, 1.14 and 5.79 million tons CO_2eq from the respective S2, S3 and S4.

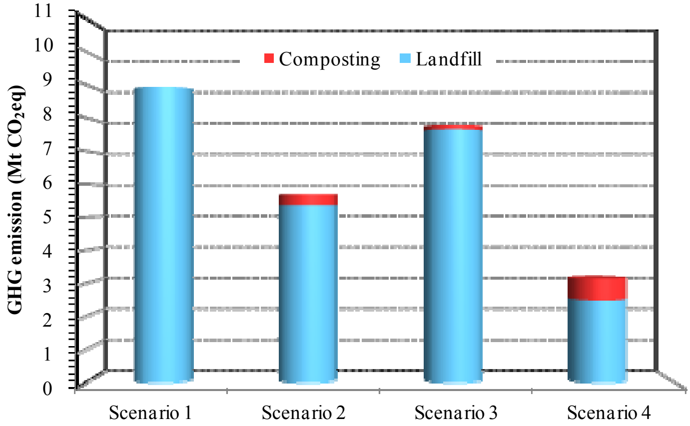

Figure 3: Total GHGs emission from each scenario.

Organic waste recycling gave better benefit than landfill. However, it is important to carefully consider the difficulties in its implementation. In MPP, although organic fraction in generated waste was the largest portion, the nuisance materials (plastics) made composting difficult. Plastics, hence, need removing from the raw waste before composting. Plastics separation can be carried out before waste discharge (source separation) or after waste discharge (separation before composting). The most efficient, easy and economical ways to separate plastic waste is source separation. Therefore, it is strongly recommended that simple separation activities should be introduced to the residents in MPP. The simplest way is to separate organic, plastic and unburnable waste. Organic waste can be used as resource for composting, plastic waste can be used for RDF production, or direct incineration for energy recovery, and unburnable waste is disposed of at landfill. It is also important to make sure that collection and transport of the separated waste can be performed by the current private firm.

4 Conclusion

The study was conducted in MPP, capital city of Cambodia, to gain an insight into benefit of composting over landfill on MSWM. In this study, future waste generation was forecasted from 2003 to 2020 and 4 scenarios of organic waste recycling via composting were carried out, with the main focus on GHGs mitigation. MSW generation in MPP increased significantly from about 0.24 million ton in 2003 to 0.41 million ton in 2010 and was projected to reach 1.02 million tons in 2020. Organic waste recycling via composting could significantly contribute to the solution of improper waste management and environmental impacts. Composting could minimize the GHGs emission of about 36.2, 12.8 and 65.0% compared with landfill when organic waste was recycled in accordance with scenario S2, S3 and S4, respectively. Hence, it is strongly recommended that MPP should start to prepare a strategic recycling plan along with modification of discharge and collection regulations.

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