

Greenhouse Gas Emissions and Energy Consumption through Solid Waste Disposal Scenarios Using LCA, Case study: Siri Island

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Introduction

LCA has been successfully utilized in the field of solid waste management to select the practical disposal methods for an area; using database existed in literature for other areas, to improve the present waste management system and to compare the present methods in an area. Kirkeby (2005) showed that despite the general expectancy concerning increase in emissions by going down from source reduction to landfilling through waste management hierarchy, the environmental impacts may be affected mainly by storage, collection and transportation stages. Blengini (2008) confirmed the above mentioned findings by conducting a research on a composting facility in Italy, concluding that the source separation of wastes had diverse effects on environmental impacts in his case study. In another study the main source responsible for GHGs emissions in current MSW management options in Taipei Island, Taiwan, was realized as recycling the kitchen wastes for swine feed, regarding the use of heavy fuels needed to cook and sterilize these wastes. The present study focuses on the assessment of environmental performance of alternative MSW disposal scenarios defined for Siri Island located at south of Iran. The environmental impacts of GHGs emissions and energy consumptions are studied in this research, and it is desired to find out the effects of waste paper and plastic source reduction activities on the above mentioned impacts.

Methodology

The data for LCA was gathered from actual applications in Siri and literature as well. The GHGs emissions from incineration and landfilling can be calculated through Eq.2 and 3, respectively.

$$E_{ci} = G_{ci} - U_{ci} - R_{cm} \quad (\text{Eq.2})$$

$$E_{Li} = G_{Li} - N_{csi} + T_i \quad (\text{Eq.3})$$

Where (all units are in metric ton of carbon equivalent (MTCE) per ton of waste):

E_{ci} and E_{Li} : net GHGs emissions from material i combusted or land filled, respectively;

G_{ci} and G_{Li} : gross GHGs emissions per ton of material i combusted or land filled;

U_{ci} : avoided utility CO_2 per ton of material i combusted;

R_{cm} : avoided CO_2 emissions per ton combusted due to material recovery;

N_{csi} : avoided CO_2 emissions per ton of material i land filled due to carbon sequestration;

T_i : CO_2 produced during landfill operation and waste transportation;

The parameters discussed in Eq.1 and 2, were gathered from literature

Results and discussion

The waste composition generated in Siri Island is illustrated in Table 1. The scenarios investigated in this paper are shown in Fig. 1 and 2, in which the system boundaries and input/output streams are depicted. Also, the comparative information including GHGs emissions and energy consumptions, considering the average daily waste generation rate as the functional unit (i.e. 1 588.2 kg/day) is illustrated in Table 2.

Results show that the incineration scenario is superior to land filling without LFG collection. However, by LFG collection and energy recovery the related GHGs emissions and energy consumptions for land filling scenario will decrease notably.

Plastic source reduction as illustrated in Fig. 3 has a positive effect on decreasing the GHGs emissions on scenario 1, while there is no considerable effect on the other scenarios. In contrast, by diverting paper wastes from overall waste stream (Fig. 4), the GHGs emissions from scenario 1 will be increased for about 0.12 kg CO₂ eq. /day per any 1% source reduction applied.

Table 1: Physical properties of MSWs generated in Siri Island

Source component	Kitchen & Restaurant	Semi- MSW	Offshore platforms
Paper and Cardboard	61.91	63.58	22.22
Plastics	124.22	109.46	27.73
Metals	29.64	10.03	2.98
Glass	23.60	42.58	2.15
Food waste	710.10	100.39	23.43
Wood	0.00	116.81	0.00
Other	25.53	82.15	9.69
Total	975.00	525.00	88.20

Note: all the units are in kg/day;

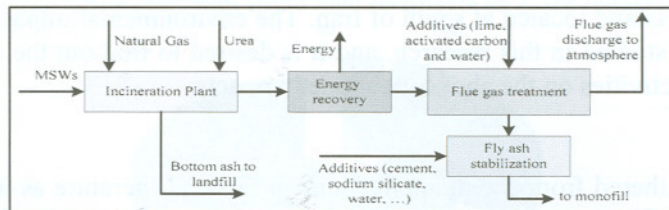


Fig. 1: Components of scenario 1: Incineration

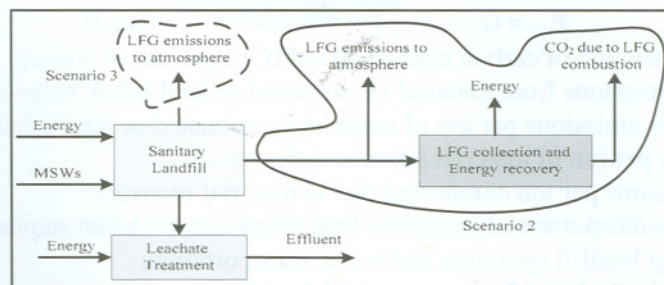


Fig. 2: Components of scenarios 2 and 3: Land filling with/without LFG collection and energy recovery

Conclusion

A LCA of three MSW disposal scenarios, i.e. 1) incineration with energy recovery and land filling of ashes, 2) land filling and collecting LFGs towards energy recovery, and 3) land filling without LFG collection, was performed in order to select the environmentally sound and practical method to deal with MSWs generated in Siri Island, Iran.

Results show that the land filling scenario by LFG collection and energy recovery is superior in comparison with the other scenarios. However, due to physical limitations in the studied area and its weather conditions and considering the compulsions related to international environmental conventions, the incineration

scenario is recommended as a sound disposal method for this island. Applying source reduction strategies for this scenario will result in a 4.25% reduction in GHGs emissions per 1% diverted plastics from waste stream.

Table 2: Comparison of the studied scenarios

Scenario No.	1	2	3
Impact			
GHGs emissions (kg CO ₂ eq./day)	28.94	-25.30	305.46
Energy consumption (MJ/day)	-3,786.27	-423.41	53.05

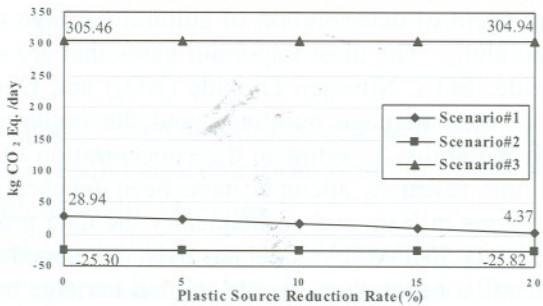


Fig. 3: Sensitivity analyses of waste plastic source reduction

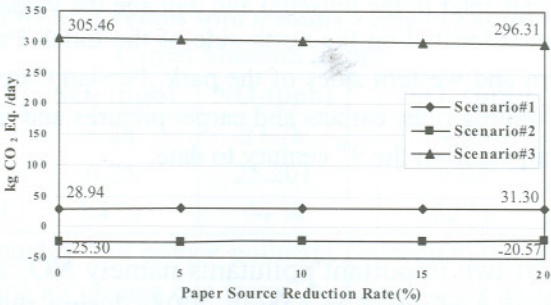


Fig.4: Sensitivity analyses of waste paper source reduction

Key words

Solid waste, Disposal, Greenhouse Gas, Energy, Lifecycle Assessment