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APPLICATION OF IWM2 SOFTWARE FOR ENVIRONMENTAL EFFICIENCY ASSESSMENT OF SOLID WASTE BURNING SCENARIOS IN HAI DUONG CITY

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Abstract

It is estimated in 2020 that there is about 1300 tons of domestic waste treated per day in Hai Duong city. Therefore, the treatment technique which enables energy recovery a priority for domestic solid waste management in order to reduce the burial rate according to the National Strategy for Integrated Management of Solid Waste until 2025, and Vision toward 2050 and the Decision 26/2020/QD-UBND of the People's Committee of Hai Duong province is urgent. It is in this context that the thermal method treatment of solid waste provides following advantages: minimizing the volume of disposable solid waste; reducing methane emissions; generating less leachate and occupying less land, etc. The most recent technologies used in the thermal treatment process including combustion and process for producing pellet fuels (or pallets) have shown their great potential for energy recovery. This study is carried out in order to make a comparative environmental analysis of selected solid waste treatment options using IWM-2 model. The results will not only serve as the basis for the selection of solid waste treatment technology for Hai Duong city, but also make a contribution to development of the suitable waste management system.

Keywords: Solid waste; Environmental management; LCA; Life cycle; Municipal solid waste; Hai Duong

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1. Introduction

Hai Duong city, the capital of Hai Duong province, is recognized as the economic, technical, educational, scientific, medical and service center of the province. The Government has issued Decree 88 / CP establishing Hai Duong city which is defined as a class-III urban area. By 2009, Hai Duong city was a city meeting class II urban standards in Hai Duong province, being an industrial - services center in the Northern Vietnam key economic region. Along with the speed of urbanization, waste disposal problems have become a pressing issue in Hai Duong city for many years. The population increase and the rise in the living standards are the main reasons which have led to an exponential increase in the volume of municipal solid waste (MSW) generated in terms of its composition and proportion. The total amount of daily solid waste generated in Hai Duong province averages 1300 tons per day and the amount collected is about 880 tons per day, accounting for about 68% [1].

In Hai Duong city, besides Soi Nam landfill operating before 2011, which was overloaded causing environmental pollution, all domestic solid waste in the city is collected by Urban Environment Co., Ltd and daily transported to the organic fertilizer manufacturing company. However, this amount of MSW has just accounted for a small proportion of the collected waste. In order to reach the target of hygienic collection and disposal rates in 2020 up to 95% of solid waste which would be collected and treated hygienically, the amount of treated domestic waste has been estimated at 1300 tons per day. One of the most important environmental issues of the whole city is the treatment of domestic solid waste which is both environmentally effective and does not occupy too much land. Hence, the method of treating solid waste by thermal method has been considered to show the potential for the local context by reducing the volume of solid waste to the lowest level, reducing methane emissions, generating less leachate, less land area occupied, etc. Hai Duong city is the economic, technical, educational, scientific, medical and service center of Hai Duong province, as well as an industrial and service center in the Northern key economic

region. Like other places in the country, in Hai Duong City, the process of urbanization is happening rapidly. This process has affected all sizes of settlements, so people's lives are gradually improved. Therefore, the demand for consumption and convenience in daily life also increases. As a result, increasing the amount of solid waste induces various problems in collection, transportation, and treatment. Currently, most of solid waste is collected and transported to Viet Hong's solid waste treatment facility [2]. The current waste treatment causes many negative impacts on the environment and human health. In order to develop solid waste management planning and strategies, solid waste treatment methods need to be considered in many aspects, not only in waste disposal costs, but also in terms of environmental pollution.

Hence, the object of the study is the treatment technology of solid waste generated from households in Hai Duong. This study was conducted to evaluate the solid waste treatment scenarios according to the Hai Duong city development scenario defined in Hai Duong City Master Plan to 2030 with a vision to 2050, which was approved by Hai Duong People's Committee on July 14, 2017. The entire study area, the planning area, of Hai Duong City will be expanded to 8 more communes including Minh Tan and Dong Lac communes (Nam Sach district), Ngoc Son commune (Tu Ky district), Tien Tien and Quyet Thang communes (Thanh Ha district); Gia Xuyen, Lien Hong and Thong Nhat communes (Gia Loc district), with an area of 13,070.78 hectares.

For those above reasons, the authors would like to outline proposals concerning the efficiency evaluation of the solid waste treatment using thermal methods in Hai Duong City. The results obtained from the research will partly serve as a basis for selecting solid waste treatment technology for Hai Duong City. It is interesting to note that at the same time the planning for both design and construction of a desirable management system can be carried out which is most suitable to the conditions of the area.

2. Methods and data used

2.1. LCA model in solid waste management and IWM2 software

LCA (Life Cycle Assessment) is an analysis technique to assess the environmental impacts associated with a product, process or activity by identifying and quantifying energy, materials used and waste released into the environment, thus identifying and assessing ways of improving its opportunities (according to Society for Environmental Toxicology and Chemistry). The LCA is also defined as a tool for systematic assessment of the environmental aspects of a product or service system through all stages of its life cycle [3].

A system boundary curve model of the LCA is the interface between the waste management system and the environment or other product systems. The life cycle begins when the material or product becomes waste, i.e. its owner removes it in the waste collection bin. Each collection method requires its own infrastructure, i.e. dedicated bins and collection facilities. Depending on the collection system of each country, solid waste can go directly to treatment plants such as incinerators, composting areas or sorted before treatment.

The LCA evaluates resource use and releases emissions into air, water, and soil and produces useful products. All inputs (resources and energy) and outputs (emissions and products) must be identified and quantified during the LCA's life cycle inventory (LCI) phase. The most important LCI components of each management phase are determined by stages of generation - collection - transportation - sorting and disposal.

An integrated waste management (IWM) system combines waste streams, collecting, treating and disposing of waste, in order to achieve environmental benefits, economic optimization and social acceptance. This will lead to a practical waste management system for any particular area [4].

IWM-2 is a software created to accurately predict the environmental and economic burden of a specific waste management system. This software is used by diverse groups of individuals including policy makers, waste managers, researchers, environmental groups or students who want to research and evaluate totally both the environmental impact and the economic cost of the waste management system. Models using this software will provide an optimization scenario to compare with other waste management scenarios.

This model does not require a large amount of data thanks to a default data set to provide to the user. However, the more data provided by the users, the more accurate the results of the research waste management system are. To run the model, it is necessary to have data on the number of people and households in the study area, the amount of waste generated per capita in a year, the discharge characteristics of the study area (Some countries are provided with default data). Data on energy needs, operating costs and performance are also required to describe each waste management process from collection through sorting, biological treatment, heat treatment and burying. One of the most important data to run the model is the electricity grid description. Different options for using the electric network will produce different results for the environment. Therefore, it is necessary to accurately describe the domestic grid of the study area to ensure the most accurate model calculation [4].

IWM-2 is used in the LCI phase to assess the life cycle of a specific waste management system. The stages assessed by this model include the emission phase, waste collection, sorting, biological treatment, heat treatment, landfill and generated energy. Secondary impacts (issues related to construction, decommissioning of facilities and waste management facilities) are not included in the model, although they should be included in the economic analysis.

In the IWM-2 model, inputs and outputs of each unit process (waste collection, central sorting, biological treatment, heat treatment and landfill) are all carried out on a volume basis, except heat treatment is carried out on mass and measurement basis. Emissions and leachate are distributed on the basis of each component (i.e., based on the composition of the material being buried); This approach takes into account the basic physical relationships between waste and gas and leachate as recommended by ISO 14041 [4].

2.2. Model input data

This study assessed the data of population derived from census data and forecasted data to 2030, the quantity of daily per capita waste generation, its composition and the current waste treatment methods. Waste treatment scenarios were designed based on the current state of solid waste treatment, following the National Strategy on Integrated Management of Solid Waste to 2025, with a vision to 2050 and the Decision 26/2020/QD-UBND of the Provincial People's Committee of Hai Duong province. In designing scenarios, recycling is prioritised over energy and useful materials recovery for waste that nevertheless arises in order to reduce the volume of waste sent to landfills and the environmental impacts.

The model input data is used according to the population projection data of 2030 according to the Hai Duong City Master Plan to 2030 with a vision to 2050. Specifically, the amount of solid waste generated in 2030 is 1,678 tons per day and night [2].

The composition of solid waste used in the study is shown in Fig. 1.

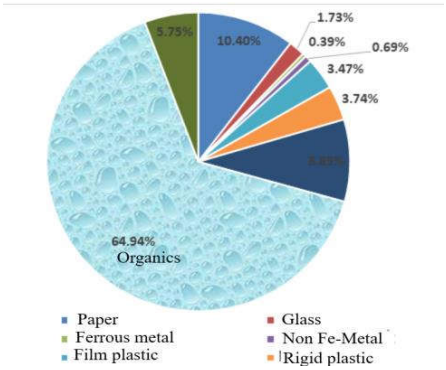


Figure 1: Results of solid waste composition analysis at landfills

3. Results and discussion

3.1. Proposed scenarios

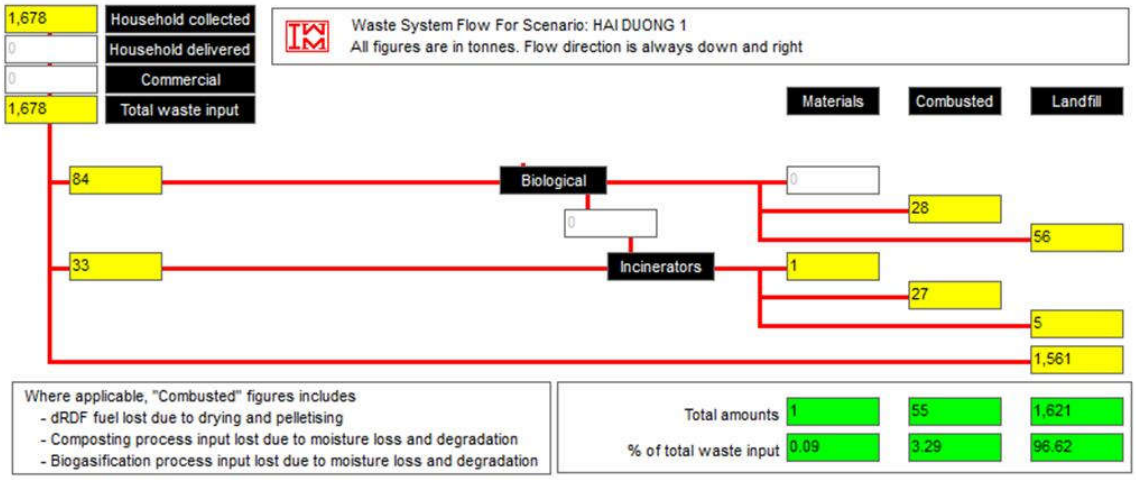
- *Scenario 1 (Baseline scenario)* is considered as the scenario used for reference, therefore, using the current technology, the collection rate of solid waste reaches 80%. Households carry out the classification and sorting of waste such as plastic lumps, metal, plastic bottles to sell to bottles

buyers. According to some previous studies, the rate of collection of recyclables in households is assumed to be 70% of the generated recyclable waste. After being collected, the waste is transported to Viet Hong solid waste treatment facility (Thanh Ha district, Hai Duong). Based on the data taken from the transportation process of solid waste to the factory, 45% of the waste is treated by microbiological methods while the rest is burned. However, by 2030, due to the estimated amount of solid waste generated according to the planning data, up to 612,470 tons per year will exceed the plant's capacity (64,000 tons per year), so the remaining amount of waste is assumed to be taken away for burying.

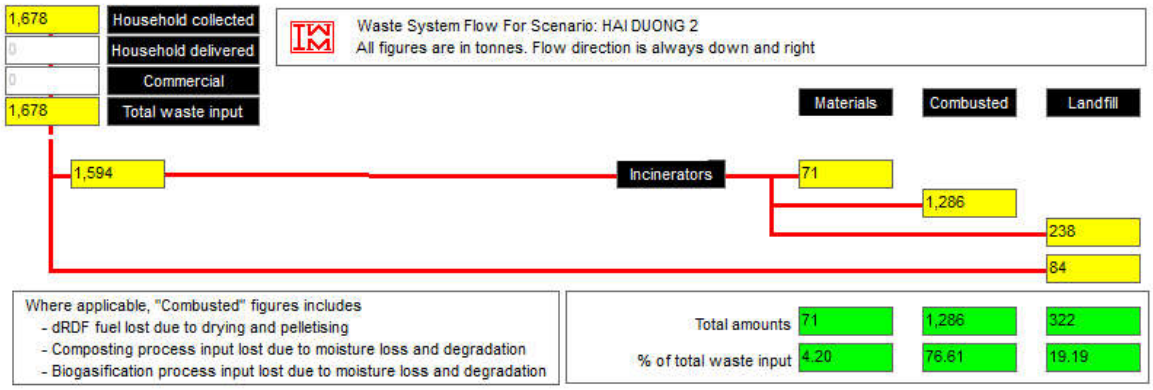
- *Scenario 2:* The amount of waste collected and transported to the treatment area is similar to scenario 1, but it is assumed that all collected solid waste will be burned. This scenario was designed due to the state of Viet Hong waste treatment plant, in which the produced compost cannot be sold, so the combustion technology has received more attention from managers.

- *Scenario 3:* The amount collected and transported to the treatment area is similar to the scenario 1, assuming that the treatment technology consists of the waste-to-energy system in Viet Hong waste treatment plant with improvement and investment in the fuel pellet processing system, namely RDF (Refuse-derived fuel).

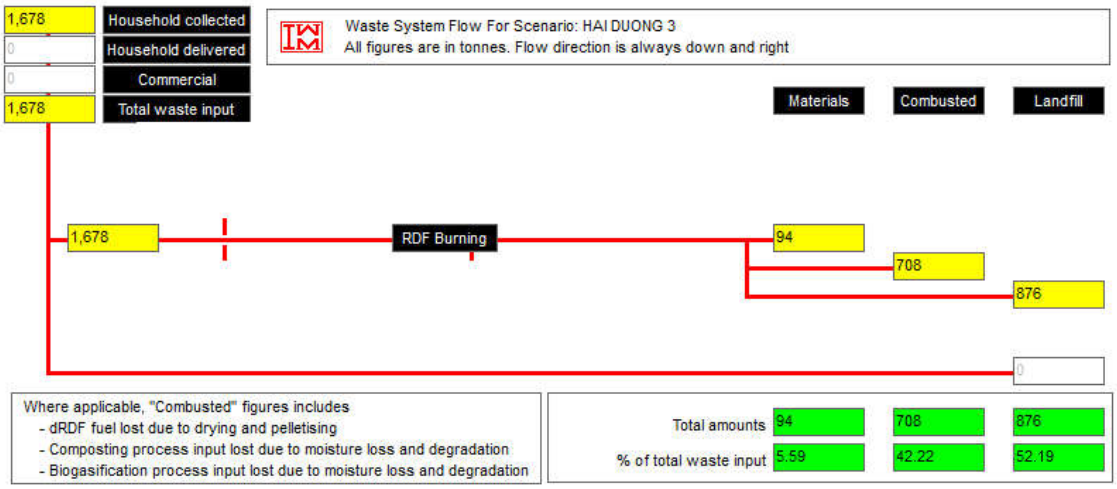
The material circulation flows according to the above scenarios are shown in Figure 2.



a. Scenario 1



b. Scenario 2



c. Scenario 3

Figure 2: Solid waste circulating stream by three scenarios

(Note: Unit in circulating stream is ton per day and night)

3.2. Evaluation of environmental effectiveness of options

IWM2 software was used to calculate and compare the scenarios according to the following parameters:

- Exhaust gases: CO_2, CH_4, NOx, HCl, SO_2
- Leachate: COD in water
- The remaining solid waste is put into landfill

Calculation results are shown in Table 1 and Figure 3

Table 1. Assessment results calculated by IWM2 of three scenarios

	Scenario 1	**Scenario 2**	**Scenario 3**
CO_2 (kg/year)	302,786	1,243,299	-18,713
CH_4 (kg/year)	122,614	5,925	66,313
NO_x (kg/year)	1	-79	-264
HCl (kg/year)	21	13	15
SO_2 (kg/year)	6	26	-457
COD (kg/year)	592	32	324
Final solid waste (kg/year)	1,620	235	736

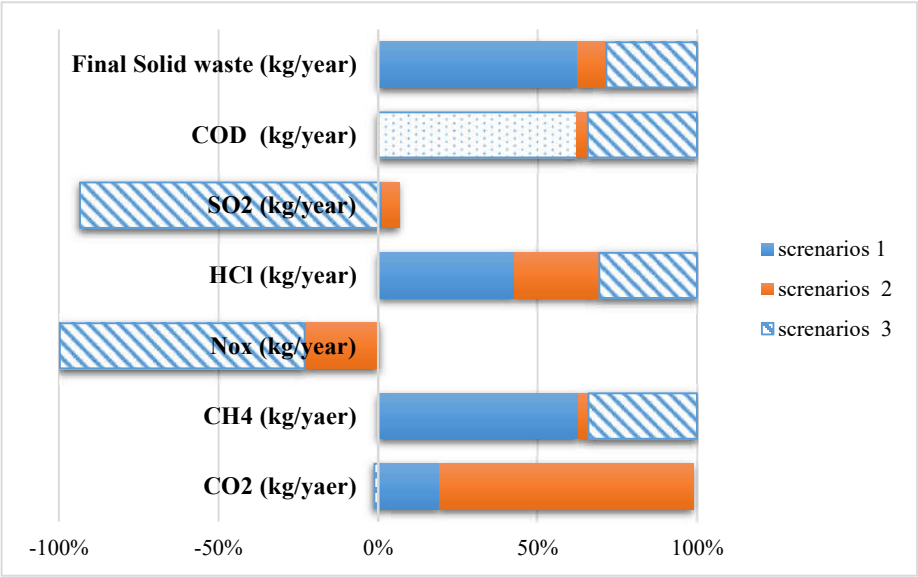


Figure 3: Comparison of scenarios based on environmental parameters

After using IWM-2 model in three scenarios developed in case of Hai Duong city, the results are presented as follows:

- *Scenario 1:* When the current treatment facilities are taken into account, Hai Duong's government needs to invest in building a new waste landfill site with a capacity of 1620 tons per day. Such a large amount of solid waste is put into landfills, which also increases the pollutants in leachate and exhaust gases. Moreover, the burial of solid waste occupies a large area of land and can easily cause more conflicts with households living in the vicinity of the landfill site.

- *Scenario 2:* By putting all domestic solid waste into incineration, this method generates the waste residual, mainly ash, accounting for the smallest amount of the three scenarios. However, the amount of CO_2 released into the environment is still the largest, which is a prominent disadvantage when we need to consider the treatment plan in terms of reducing environmental pollution. To implement this scenario, Hai Duong city needs to invest in building 9 more incinerators with the same capacity as the current incinerator, which is also a major drawback of this scenario.

- *Scenario 3:* In this scenario, the remaining solid waste is three times higher than scenario 2 but only accounts for 45% compared to scenario 1. In scenario 3, the local government should invest in additional technologies, including compression, cutting and forming processes to produce fuel pellets. The numbers of incinerators that need additional investment is three. They can directly use fuel pellets to burn power generation (Figure 4 results calculated by the software are 683,617kWh of electricity/year) and reduce the moisture content of waste. In addition, this scenario also reduces the amount of NO_x and SO_x acids due to the change of not burning waste directly but indirectly burning through fuel pellets.

Results

Scenario **HAI DUONG 3**

Costs | Fuels | Final Solid Waste | Air Emissions | Water Emissions | Emissions Guide

	Units	Collection	Sorting	Biological	Thermal	Landfill	Recycling	Total
Elec-recycling	kWh	n/a	n/a	n/a	n/a	n/a	-683,617	-683,617

Figure 4: The amount of electricity recovered from the treatment process

4. Conclusion

Through the development of solid waste treatment scenarios for Hai Duong city, the optimal urban solid waste treatment scenario for Hai Duong city is proposed as follows: After being collected, the waste is transported to a waste treatment plant. The amount of 612,470 tons solid waste per year was treated at the facility using the method of processing pellets of fuel (RDF) and burning on site to generate electricity. According to this scenario, the local government needs to invest more in the fuel pellet production system with 4 incinerators designed with the same capacity to the current capacity. The estimated amount of electricity generated is 683,617kWh which is capable of serving the plant itself or joining the national grid. This is also a source of funding to offset the cost of solid waste treatment.

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