Section4 Study on Optimal Design of Solid Waste Management System and its Facility Planning Process in Vientiane Capital, Laos

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1. Introduction

Waste is an unavoidable by-product of human activities. Economic and population growth cause the solid waste problems to many countries. Lao PDR also has the same problems especially Vientiane Capital which covers a land area about 3920 square kilometers and has population around 698318 (National statistic center, 2005). The population growth rate is 2.99%. Vientiane capital consists of nine districts. However, the solid waste management service is mainly available in 4 urban districts: Chanthaboury, Sikhottabong, Sisattanak and Xaysettha districts. Vientiane people generate waste around 220-250 ton/day (UDAA, 2005), but municipal solid waste service can collect approximately 120 ton/day, the rest is uncollected. Municipal solid waste service lacks capacity, planning and fund to handle with these problems. To cope with these problems, the government needs the proper plan for improving solid waste management system and its facilities.

Therefore, the objectives of this research focus on:

- Proposing optimal solid waste management to solve the solid waste problems for environmental safety society.
- Assessing the solid waste models and apply the model application to a case study, aiming to minimize the cost of the facility construction and find out the optimum short term and long term planning in Vientiane.

2. Proposed Solid Waste Management System Planning

The aims of solid waste management planning are to increase the awareness of environmental problems from garbage, encourage public participation and stimulate public partnerships from various sectors such as municipality, private sectors, NGO, CBO (community base organization) and informal sectors. Furthermore, Law and regulation are also necessary to enforce the plan to implement and prevent an inequality in the society.

There are two major problems from the existing solid waste management in Vientiane. Those are nearly haft of the waste that generates every day in the city is not collected, and the collected waste does not separate from the household level. To tackle with these problems the municipal solid waste management has to improve its capacity and encourages people to sort and reduce the waste from their households. Waste prevention and separation strategies are proposed in this study. For instance, the municipality should enhance the people to purchase durable-long lasting goods, use less packaging, use products that are free of toxic substance and reuse the material. Furthermore, the municipality should create an incentive to encourage the people separate waste into three main categories: organic waste, none organic waste and hazardous waste (Figure 1) in order to make it easy to compost, recycle and burn the waste. The result from this process, the amount of waste in land fill is reduced and some material in waste stream can reproduce and transform into the other value material such as fertilizer and recycling product.

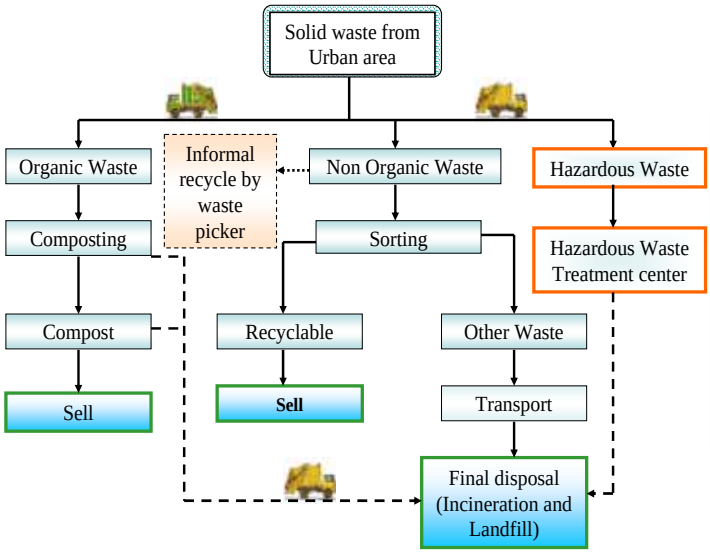

Figure 1: Proposed optimal solid waste management

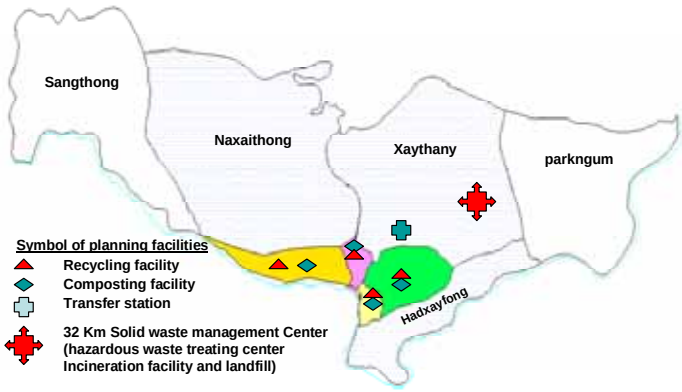

Figure 2: Location of planning facilities

3. Optimal Solid Waste Facility Planning

For improving the capacity of municipal solid waste service, the facility construction planning is an important stage that we have to consider. The location and the number of facilities should conform to demand of the population and the

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financial situation. The solid waste facilities which need to be improved and constructed include: recycling facility (material recovery facility), composting facility, transfer station, hazardous waste treating facility and incineration facility (future alternative).

According to the proposed solid waste management (Figure 1), Organic waste is collected and transfers to the composting facility. While Non-Organic waste is collected from curbside and then transported to materials recovery facility to separate some recyclable products, and non recyclable products can be carried directly to landfill. Hazardous waste facility will treat the dangerous substances and dispose them by the proper methodology. Incineration is the alternative that we have to consider when the land area of landfill is expensive because incineration facility can reduce the volume of the waste about 95-96%. Landfill will be used for dispose the ashes from incinerating facilities and materials that can not be burned. These facilities are planned to construct in 5 zones in planning area (Figure 2) which have population approximately 334966 people.

4. Mathematical Analysis

Objective Function

Min V(T)= C (Costs) – M (income)

Status function

$$P(t) = p(t) + P(t-1)$$

$$V(t) = v(t) + V(t-1)$$

Plan variable

$$\$(t) = \{s_1(t), s_2(t), \cdots s_j(t), \cdots s_n(t)\}$$

Where

i: type of general waste, j: type of processing facilities, , P(t): amount of waste to landfill until period t, $\$(t)$ vector showing 1= facility exists 0= does not exists

The objective function of solid waste facility investment model is to minimize the total cost of the construction facilities during a certain planned period, which is 'T' in this case. The determination will be done when the process of the household waste starts at the disposal of the waste. It is assumed during a period 'T', and it should be considered: the type of processing facilities, the time, the scale of the facility and the administration during this period 'T.'

Besides, it was considered the reduction of cost for facilities as an objective function considering the economical conditions as a priority to waste management and it can be realized that not all the facilities will be constructed because of the income that municipalities have. However, it can be considered as the future alternative.

This type of problems can be handled as a control mathematics problem of the discrete variables in the dispersal time. This is the formularization regarding the objective function, project variable, the state space and each boundary condition. The formularization of model is shown in the above box.

5. Result

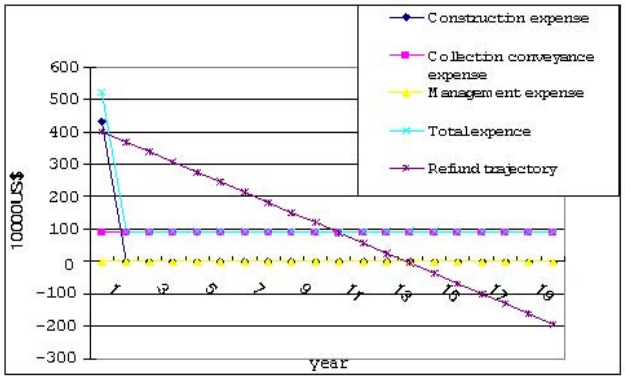

Figure 3: investment expense for 20 years planning

After the data were input to the mathematical model, the output of the computing program was shown in Figure3. The brief detail of output from the mathematical model is described as follow:

The financial investment planning of solid waste facility for the next 20 years is computerized. In order to show the profitability of a system, it can be analyzed from the refund graph (refund = total cost – revenue). The results of the analysis are shown into figures of investment expenses which include graphs for: Construction expense, Conveyance (transport) expense, Management expense, Refund trajectory. The investment for this plan is high at the beginning 5.2 million dollars. However, municipality can manage the facility without doing any investment and expect to be recovered in refund since the 13th years.

6. Conclusions

In Vientiane, solid waste problems seem to increase significantly in each year because of the expansion of urban area, so it is important to find the optimal way to manage the waste. This research tries to propose the optimal solid waste management such as improving the solid waste collection system, using the waste prevention and separation strategies, and educating the waste awareness in order to attract the participation of people. Furthermore, How to find the optimal fund to allocate to improve the capacity of municipal solid waste service is the key study of this research because Lao government has a limited fund. From the mathematical analysis show that the municipalities have to invest 5.2 million dollar at the beginning for constructing the facilities and they can recover in refund in the 13th years.

Reference

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