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Development of the Economy-Ecology Balanced Municipal Solid Waste Management Model by WRAP (Waste Resources Allocation Program) and Screened LCA (Life Cycle Assessment) for Taejon Metropolitan City

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I. Introduction

As the WTO (World Trade Organization) and the ISO 14000 are highlighted as international hot issues, governments and consumers are responding sensitively to environmental problems. Many business companies, governments, and local governments are striving for the realization of ESSD (Environmentally Sound and Sustainable Development) to become more environmentally friendly and more economically efficient ones through the "Economy and Ecology Balance" strategies.

There are many studies on applications and methodologies of LCA[1)-10)], but few study has been conducted so far in which the balance of economy and ecology is considered.

Therefore in this study a practical method of the "Economy and Ecology Balance" is suggested through 4 steps; (1) generation of feasible waste management systems, (2) performance of screened LCA, (3) estimation of the optimal cost for the alternatives, and (4) selection of eco-efficient options by considering both economy and ecology simultaneously.

II. Generation of waste management alternatives

In this study, we suggest 7 alternatives for Taejon City via a survey on municipal waste generation in Taejon City in 1995 as shown in Table 1.

III. Screened LCA (=s-LCA) for waste management system[11)]

We carried out s-LCA by 4 steps (4-I's) for the 7 alternatives previously shown; (1) initiation (goal and scope definition), (2) inventory analysis, (3) impact assessment, and (4) interpretation.

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Table 1. Seven alternatives for municipal solid waste management system in Taejon City

No.	Alternatives
Alt-1	landfilling of all waste **[LF]**
Alt-2	composting of all compostable wastes and landfilling of the rest **[CMP]**
Alt-3	composting of some compostable wastes from vegetable market and obligatory commercial stores and landfilling of the rest **[CP+LF]**
Alt-4	incineration of all the waste and landfill of the ash after incineration **[INC]**
Alt-5	incineration of only the combustible wastes, and landfilling of the rest **[IC+LF]**
Alt-6	composting of all the compostable wastes, incineration of only the combustible waste, and landfilling of the rest **[CMP+IC+LF]**
Alt-7	composting of all the compostable waste, incineration of the rest, and landfilling of the ash after incineration **[CMP+INC]**
Index ;	LF : Landfilling of all waste CMP : Composting of all the compostable wastes CP : Composting of some compostable wastes from Vegetable market and obligatory Commercial stores INC : incineration of all the waste IC : incineration of only the Combustible wastes

Input of the system was total mass of the municipal solid waste generated in Taejon for 1 year. The required data for input and emissions of incineration, landfill, and transportation were obtained from several researches[12)13)], and data for recycling and energy were from White(1996)[7)].

We used the characterization factors of CML (Centre of Environmental Science), and normalized each environmental effect by dividing the characterized effects by corresponding total pollution mass generated in Taejon[14)]. Weighting factors for each environmental effect were calculated by the global assumed target value estimated Guinee using 1.5% ratio of Korea GNP to Global GNP, and 2.9% ratio of Taejon's population to Korean population[15)].

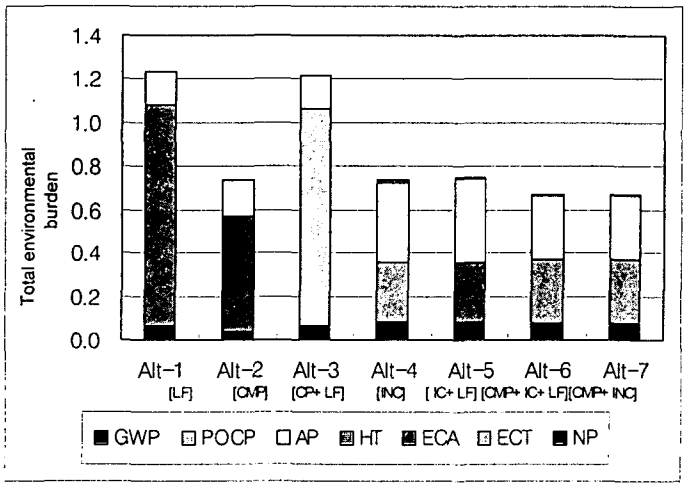

Fig.1. Total environmental burdens of each alternative.

As shown in Fig. 1, lower environmental effect is depicted in alternatives No.6 (which is composting of all the compostable wastes, incineration of only the combustible waste, and landfilling of the rest) and No.7 (which is composting of all the compostable waste, incineration of the rest, and landfilling of the ash after incineration). Generally, composting all food stuffs without incineration is known as more environmentally friendly.

Ⅳ. Economic efficiency assessment of alternatives[16)~19)]

WRAP (Waste Resources Allocation Program) has been applied for optimal cost estimation of trade-off between treatment cost and transportation cost in Taejon City. Construction, operation, and management costs are utilized for the estimation of treatment cost, and the transportation costs in Taejon City are obtained for the previous study[19]. The result is shown in Fig. 2.

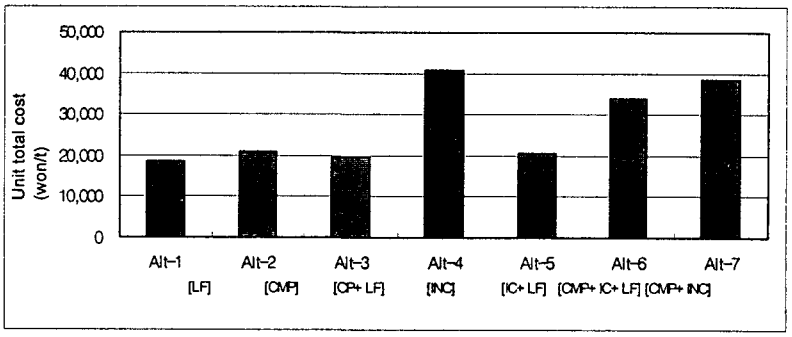

Fig. 2. Unit total costs of each alternative in Taejon City.

Because of lower cost in landfill, the more we use landfill, the cheaper is the cost. While alternative No.1 (which is landfilling of all waste) shows the lowest cost, alternative No.4 (which is incineration of all the waste and landfill of the ash after incineration) is the most expensive.

Ⅴ. Economy-Ecology Balance in alternatives selection

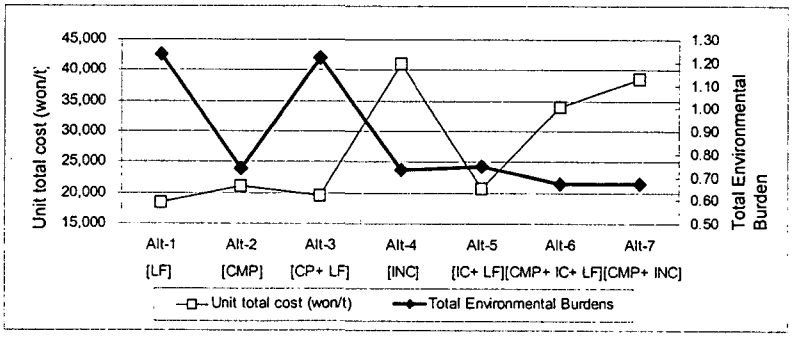

Fig. 3. Treatment tonage costs and environmental burden of each alternative.

As shown in Fig. 3, considering cost per ton and environmental effect, that is, considering economy and ecology, the alternatives No.2 (which is composting of all compostable wastes and landfilling of the rest) and No.5 (which is incineration of only the combustible wastes, and landfilling of the rest) luckily turn out to be proper ones.

Several methods exist for the simultaneous consideration of economy and ecology, e.g., EPS (Environmental Priority Strategy) that can calculate environmental loss into cost, and MCE (Multi-Criteria Evaluation). They utilize a willingness to pay concept in estimating weighting factors for environmental impacts. For this kind of multi criteria decision making (including public acceptance, e.g., NIMBY syndrome), a fuzzy set concept that is one of combing method can be suggested. Thus so-called a vector LCA is possible.

Ⅵ. Conclusion

In this research, we assess ecology by the screened-LCA and economy by the WRAP for seven alternatives of municipal solid waste management systems in Taejon City. The findings are:

1. More environmental burdens are produced in the process of treatment process rather than transportation one. For full LCA of waste management it is necessary to perform, more detail investigation of treatment processes.
2. The composting option is environmentally better than the incineration or landfilling, though its limitation to the waste type of foods and vegetables. Furthermore the keen consideration of odor is required.
3. Alternatives No.6 **[CMP+IC+LF]** and No.7 **[CMP+INC]** are environmentally sound, and alternative No.1 **[LF]** is economically superior.
4. The economy-ecology balanced alternatives are No.2 **[CMP]** and No.5 **[IC+LF]**.
5. POCP by CH_4 from landfill is major environmental effect. Thus CH_4 recovery is crucial. Also land pollution(soil and ground water pollution) data are required.

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