Optimal Management of Existing Alternatives in Municipal Solid Waste Recovery

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Tehran city is among the most populated capitals in the world. This city generates an approximate amount of 7,000 tons of municipal wastes per day that terminates in a total annual amount of 2.5 million tons. In this study available alternatives in municipal solid waste recovery in Tehran as a weighted representative for Iran are taken in to consideration. Through a cross-sectional study, feasible strategies concerning each alternative were classified, evaluated and ranked in order to provide an invaluable support for decision-makers. The analysis is run through SWOT (strengths, weaknesses, opportunities and threats) method. In order to make the comparison among different strategies possible, initially the strengths, weaknesses, opportunities and threats relating to optimization of municipal solid waste recovery are identified and then the priority of different proposed strategies are manifested for being used as a strong tool for decision-makers.

Key Words: Municipal solid waste, Recovery, Management, SWOT method.

INTRODUCTION

Regarding the shortage of natural resources, increasing rate of population growth as well as urbanization and industrialization and finally the augmented anthropogenic pollution imposed to the environment. The management of municipal solid waste (MSW) has become a global challenge during recent decades. The severity of such case is more observed in developing countries where inadequate financial resources, technical equipment and required infrastructure restrict the capability of municipalities and governmental and non-governmental authorities for approaching the integrated solid waste management horizons[1,2].

During last decades the nature of solid waste management policies that are strongly dependant on the solid waste problems have been remarkably changed[3,4]. Such distinct differences may be attributed to the decision-support systems that determine the priorities. For example the earliest goals in municipal solid waste management systems were limited to optimization of collection methods, transport routes and efficient landfilling. Next generation of municipal solid waste management policies was born when the municipalities faced the catastrophic conditions due to increasing rate of solid waste generation, lack of natural resources and deterioration of environment. Such conditions changed the priorities towards the policies emphasized on waste minimization, separation, material and energy recovery and landfill waste stream reduction[5,6].

Three models namely life cycle assessment, multi objective programming and multicriteria decision making have been extensively used in the process of municipal solid waste management decision making by different researchers all around the world[7-16].

Solid waste comprises a wide range of materials and come from a variety of sources[17]. Tehran city is among the most populated capitals in the world. This city generates an approximate amount of 7,000 tons of municipal wastes per day that terminates in a total annual amount of 2.5 million tons. Although some solid waste separation and consequently recovery policies are executed in the temporary stations within different districts of the city, amount of the generated waste is buried in Kahrizak (the exclusive landfill site of Tehran).

In this study available alternatives in municipal solid waste recovery in Tehran as a weighted representative for Iran are taken in to consideration. Through a cross-sectional study, feasible strategies concerning each alternative were classified, evaluated and ranked in order to provide an invaluable support for decision-makers.

EXPERIMENTAL

In this study the optimal alternatives in municipal solid waste recovery are analyzed through strengths, weaknesses, opportunities and threats (SWOT) method. This method and similar management models have been used in optimization of different environmental cases[18-20]. First of all internal factors

TABLE-1
RECIPROCAL IMPACTS OF SWOT RELATING TO OPTIMIZATION OF MUNICIPAL SOLID WASTE RECOVERY

Internal factors	Threats					Opportunities						
	External factors											
	Job-originated diseases	Impurities that make problems in the production process	Black market forming and cost instability	Lack of workers health control	Lack of expert workers in this field	Organizations acceptance of such achievement	Creating employment opportunities	Self-sustainability	Economizing in the cost of waste transfer and disposal	Workers financial support	Promoting national economy potential	Upgrading social hygienic level
Strengths												
Making profit and reuse of recovered wastes	×	×	×	×	×	×	×	×	×	×	×	×
Reduction in waste volume and weight and consequent shrunk cost of waste collection and transfer	−	−	−	×	×	×	×	−	×	×	×	×
Diminished cost in recovering water, soil and air pollution	−	−	−	×	×	×	×	−	×	×	×	×
Reduced cost of landfill processing	−	−	−	×	×	×	×	−	−	−	×	×
Prevention of excess raw materials import	−	−	−	−	−	×	−	×	−	−	−	−
Economizing energy and material use	−	−	−	−	−	×	−	×	×	−	×	×
Environment preservation	−	−	−	−	−	×	−	−	−	−	−	×
Weaknesses												
Low quality of recycled materials	×	×	−	×	×	−	−	−	−	−	−	−
Standard lack of recycled goods in comparison with non-recycled ones	×	×	−	×	×	−	−	−	−	−	−	−
Non-hygienic recycled products due to sanitary deficiencies in the process	×	×	−	×	×	−	−	−	−	−	−	−
Lack of required training in energy and material recovery	×	×	−	×	×	−	−	−	−	−	−	−

including strengths and weaknesses of this proposal followed by external factors including opportunities and threats are thoroughly analyzed. Considering all above aspects, some strategies are proposed for better implementation of the main target (waste recovery). Obviously, the strategy which has more strength and opportunities and simultaneously less weaknesses and threats will be prior to others. Consequently, the group of proposed strategies will be analyzed in a quantitative strategic planning matrix (QSPM) for better understanding. In this matrix the sorting of strategies is defined in following steps; (1) First of all, internal factors including strengths and opportunities as well as external factors including weaknesses and threats are taken in to consideration. (2) Each factor is classified by contributing the grade 1, 2, 3 or 4 in accordance with its effect on the considered strategy; grade 1 and grade 4 show the lowest and highest level of impact by the factor, respectively. (3) Different strategies are inserted in the matrix and a weight followed by a score is defined for each strategy. (4) The weight of each strategy in accordance with different internal and external factors varied between zero showing the lowest relationship and one showing the highest relationship. Finally, the sum of different weights relating to one strategy must equal one. (5) The score of each strategy in accordance with different factors is gained by the result of each factors grade multiplied by its weight. (6) Finally, the total score of each strategy is computed and the final categorization would be applied according to the final scores. In other words, the

strategy which has gained the most score will be proposed as the first option and so on.

RESULTS AND DISCUSSION

In order to compare possible strategies, initially the strengths, weaknesses, opportunities and threats relating to optimization of municipal solid waste recovery are identified as follows:

Strengths: (i) Making profit and reuse of recovered wastes. (ii) Reduction in waste volume and weight and consequent reduced cost of waste collection and transfer. (iii) Diminished cost in recovering water, soil and air pollution. (iv) Reduced cost of landfill processing. (v) Prevention of excess raw materials import. (vi) Economizing energy and material use. Environment preservation.

Weaknesses: (i) Low quality of recycled materials. (ii) Standard lack of recycled goods in comparison with non-recycled ones. (iii) Non-hygienic recycled products due to sanitary deficiencies in the process. (iv) Lack of required training in energy and material recovery.

Opportunities: (i) Organizations acceptance of such achievement. (ii) Creating employment opportunities. (iii) Self-sustainability. (iv) Economizing in the cost of waste transfer and disposal. (v) Workers financial support. (vi) Promoting national economy potential. (vii) Upgrading social hygienic level.

TABLE-2
QSPM FOR DETERMINATION OF TOTAL STRATEGIES SCORES (CONTINUED)

Strategies	Grade	S1		S2		S3		S4		S5		S6		S7	
		W	S	W	S	W	W	W	S	W	S	W	S	W	S
Strengths															
Making profit and reuse of recovered wastes	3	0	0	0	0	0.1	0.3	0.05	0.15	0	0	0	0	0.1	0.3
Reduction in waste volume and weight and consequent shrunk cost of waste collection and transfer	3	.2	0.6	0	0	0.1	0.3	0.05	0.15	0	0	0	0	0	0
Diminished cost in recovering water, soil and air pollution	3	0.2	0.6	0	0	0.1	0.3	0.05	0.15	0	0	0	0	0	0
Reduced cost of landfill processing	3	0.1	0.3	0	0	0.1	0.3	0.05	0.15	0	0	0	0	0	0
Prevention of excess raw materials import	2	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.2
Economizing energy and material use	3	0	0	0	0	0.05	0.15	0	0	0	0	0	0	0	0
Environment preservation	3	0.15	0.45	0	0	0.1	0.3	0.05	0.15	0	0	0.1	0.3	0	0
Weaknesses															
Low quality of recycled materials	1	0	0	0	0	0	0	0.05	0.050	0	0	0	0	0	0
Standard lack of recycled goods in comparison with non-recycled ones	1	0	0	0	0	0	0	0.05	0.050	0	0	0	0	0	0
Non-hygienic recycled products due to sanitary deficiencies in the process	1	0	0	0	0	0	0	0.05	0.05	0	0	0	0	0	0
Lack of required training in energy and material recovery	2	0	0	0.3	0.6	0	0	0	0	0	0	0.3	0.6	0	0
Opportunities															
Organizations acceptance of such achievement	4	0.2	0.8	0.3	1.2	0.1	0.4	0.1	0.4	0.25	1	0.3	1.2	0.3	1.2
Creating employment opportunities	3	0.05	0.15	0	0	0.1	0.3	0.1	0.3	0.2	0.6	0.1	0.3	0.1	0.3
Self-sustainability	3	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.3
Economizing in the cost of waste transfer and disposal	3	0	0	0.2	0.6	0.1	0.3	0.05	0.15	0	0	0	0	0	0
Workers financial support	4	0.05	0.2	0.05	0.2	0.05	0.2	0.1	0.4	0.15	0.6	0.1	0.4	0	0
Promoting national economy potential	3	0	0	0.05	0.15	0.05	0.15	0.05	0.15	0.05	0.15	0.1	0.3	0	0
Upgrading social hygienic level	4	0.05	0.2	0.1	0.4	0.05	0.2	0.05	0.2	0.15	0.6	0	0	0.3	1.2
Threats															
Job-originated diseases	1	0	0	0	0	0	0	0.05	0.05	0	0	0	0	0	0
Impurities that make problems in the production process	2	0	0	0	0	0	0	0.05	0.1	0	0	0	0	0	0
Black market forming and cost instability	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lack of workers health control	1	0	0	0	0	0	0	0.05	0.05	0	0	0	0	0	0
Lack of expert workers in this field	2	0	0	0	0	0	0	0	0	0.2	0.4	0	0	0	0
Total score	–	1	3.3	1	3.15	1	3.2	1	2.7	1	3.35	1	3.1	1	3.5
Ranking	–	–	8	–	11	–	9	–	14	–	5	–	12	–	2

TABLE-3
QSPM FOR DETERMINATION OF TOTAL STRATEGIES SCORES

Strategies	Grade	S8		S9		S10		S11		S12		S13		S14	
		W	S	W	S	W	W	W	S	W	S	W	S	W	S
Strengths															
Making profit and reuse of recovered wastes	3	0.05	0.15	0.05	0.15	0.05	0.15	0.05	0.15	0.05	0.15	0	0	0	0
Reduction in waste volume and weight and consequent shrunk cost of waste collection and transfer	3	0	0	0	0	0	0	0.1	0.3	0.05	0.15	0	0	0	0
Diminished cost in recovering water, soil and air pollution	3	0.05	0.15	0.05	0.15	0.05	0.15	0.05	0.15	0.05	0.15	0	0	0.1	0.3
Reduced cost of landfill processing	3	0	0	0	0	0	0	0.1	0.3	0.05	0.15	0	0	0.1	0.3
Prevention of excess raw materials import	2	0	0	0.2	0.4	0	0	0.05	0.1	0.05	0.1	0	0	0.1	0.2
Economizing energy and material use	3	0.1	0.3	0	0	0.05	0.15	0.05	0.15	0.05	0.15	0	0	0.05	0.15
Environment preservation	3	0	0	0.1	0.3	0.15	0.45	0.1	0.3	0.1	0.3	0.08	0.24	0.05	0.15
Weaknesses															
Low quality of recycled materials	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Standard lack of recycled goods in comparison with non-recycled ones	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-hygienic recycled products due to sanitary deficiencies in the process	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lack of required training in energy and material recovery	2	0	0	0	0	0	0	0	0	0	0	0.12	0.24	0	0
Opportunities															
Organizations acceptance of such achievement	4	0.3	1.2	0.1	0.4	0.2	0.8	0.2	0.8	0.23	0.92	0.25	1	0.12	0.48
Creating employment opportunities	3	0.1	0.3	0.05	0.15	0.2	0.6	0.05	0.15	0.12	0.36	0.15	0.45	0.08	0.24
Self-sustainability	3	0.05	0.15	0.2	0.6	0	0	0	0	0.05	0.15	0	0	0.1	0.3
Economizing in the cost of waste transfer and disposal	3	0.05	0.15	0.05	0.15	0	0	0	0	0.05	0.15	0.05	0.15	0.1	0.3
Workers financial support	4	0.1	0.4	0.05	0.2	0.05	0.2	0.2	0.8	0.1	0.4	0.15	0.6	0.1	0.4
Promoting national economy potential	3	0	0	0	0	0.08	0.24	0.1	0.3	0.05	0.15	0	0	0.05	0.15
Upgrading social hygienic level	4	0.2	0.8	0.1	0.4	0.12	0.48	0	0	0	0	0.15	0.6	0.05	0.2
Threats															
Job-originated diseases	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Impurities that make problems in the production process	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Black market forming and cost instability	2	0	0	0.05	0.1	0	0	0	0	0	0	0	0	0	0
Lack of workers health control	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lack of expert workers in this field	2	0	0	0	0	0.05	0.1	0	0	0	0	0.05	0.1	0	0
Total score	–	1	3.6	1	3	1	3.32	1	3.35	1	3.28	1	3.38	1	3.17
Ranking	–	–	1	–	13	–	7	–	4	–	6	–	3	–	10

Threats: (i) Job-originated diseases. (ii) Impurities that make problems in the production process. (iii) Formation of black market and cost instability. (iv) Lack of workers health control. (V) Lack of expert workers in the field of solid waste.

Different strengths, weaknesses, opportunities and threats of the proposed option as well as different configurative steps of QSPM are shown in Tables 1-3, respectively.

Following strategies are proposed in accordance with the optimization of existing alternatives in municipal solid waste recovery.

(A) Environmental strategies considering the use of strengths for reducing threats: (i) Making facilities in order to implement waste minimization plans. (ii) Training people and upgrading their knowledge in waste generation patterns. (iii) Constructing well-equipped recovery stations in each district under hygienic control. (iv) Sanitary control of separated recyclables. (v) Encouraging people in order to organize recovery process.

(B) Environmental strategies considering the use of opportunities for reinforcing the strengths: (i) Promoting people knowledge through nation-wide educational programs. (ii) Encouraging authorities to fund projects relating to waste recovery. (iii) Provision of required infrastructure to give key roles to private section. (iv) Developing appropriate marketing

for hygienic recycled products in order to insure their sale. (V) Establishing an organization for exclusive performance of waste recovery.

(C) Environmental strategies considering minimization of disadvantages caused by threats and weaknesses: (i) Hygienic surveillance of responsible organization during the whole process. (ii) Use of appropriate technology, expert technicians and well-equipped instruments in the whole process.

(D) Environmental strategies considering the use of opportunities for removing weaknesses: (i) Defining relevant researches in all aspects of waste recovery. (ii) Establishing production centers that use recycled materials as raw materials.

Conclusion

According to the results achieved from Tables 2 and 3 the priority of 14 suggested strategies is determined as follows: (i) Making required infrastructure to give key roles to private section (S8). (ii) Encouraging authorities to fund projects relating to waste recovery (S7). (iii) Defining relevant researches in all aspects of waste recovery (S13). (iv) Hygienic surveillance of responsible organization during the whole process (S11). (v) Encouraging people in order to organize recovery process (S5). (vi) Use of appropriate technology, expert technicians and well-equipped instruments in the whole process (S12). (vii) Establishing an organization for exclusive performance of waste recovery (S10). (viii) Making facilities in order to implement waste minimization plans (S1). (ix) Constructing well-equipped recovery stations in each district under hygienic control (S3). (x) Establishing production centers that use recycled materials as raw materials (S14). (xi) Training people and upgrading their knowledge in waste generation patterns (S2). (xii) Promoting people knowledge through nation-wide educational programs (S6). (xiii) Developing

appropriate marketing for hygienic recycled products in order to insure their sale (S9). (xiv) Sanitary control of separated recyclables (S4).

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