1. Introduction

Unsuitable solid waste management practices from waste collection to final disposal lead to loss of energy, economic and human recourses and environmental pollution. Previous studies concerning optimization of MSW management are focused on one or more parts of SWM system. Selection of appropriate disposal method is a complex and multidisciplinary issue that should be considered with respect to multiple parameters including of: rate of waste generation, the combination of waste, local conditions, economic issues, social and technological factors, the governmental policies and so on. This paper focuses on selection of the best disposal method which has more compatibility with local conditions which is a controversial multidisciplinary problem; so, a combination of fuzzy set theory, Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and Analytical Hierarchy Process (AHP) were used to provide a multicriteria framework for decision making.

2. Case Study

Tehran as the capital of Iran has more than eight million inhabitants generating 7435 tons/day waste. The solid wastes of Tehran can be divided in 4 main groups: municipal (97%), clinical (1%), industrial (0.6%) and construction wastes(0.5%). While, there are considerable amounts of recycleable and compostable material in municipal solid wastes of Tehran, Most of the wastes are disposed in landfill and poor amounts are composted or recycled. Likewise, landfilling of large amount of solid waste has been resulted in air, water and soil pollution.

3. Material and methodology

This article has two main phases. The first one is weight calculation using AHP, disposal method selection applying fuzzy TOPSIS is the second one. Decision framework overview is illustrated in figure 1.

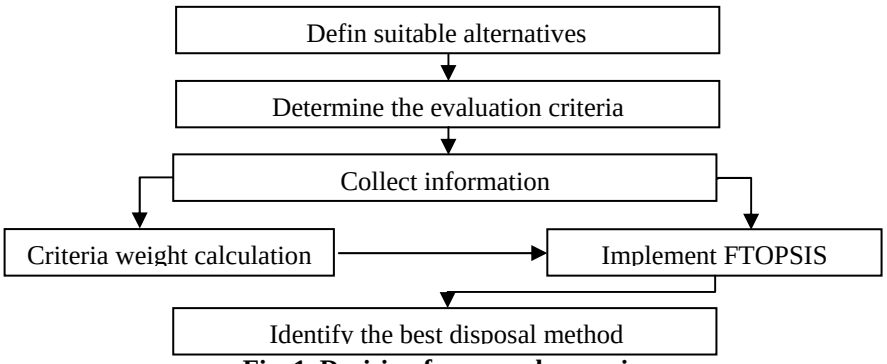

Fig. 1. Decision framework overview

3.1. AHP

Pair-wise comparison according to the expert's judgments is the basic concept of AHP process. Conclusive factors and elements in pairs are compared and the relative weights are computed with regards to the eigenvalue analysis. Lastly, the weighted final elements are aggregated to achieve overall rates for the alternatives.

3.2. TOPSIS & Fuzzy TOPSIS

Calculation of distances of alternatives from positive and negative ideal solutions is the basic principal of TOPSIS. Moreover, the alternatives are ranked by the values of the closeness coefficient. The chosen alternative is defined as the alternative that has shortest distance from the positive (PIS) and the furthest from the negative ideal solution (NIS) Interestingly, in this

method crisp values are used for rating the alternatives with respect to criteria and the priority values and weights are finally normalized. Reaching more realistic and accurate decisions could be achieved by application of fuzzy numbers and assigning the relative importance of characteristics using lingual terms rather than crisp numbers.

$$d\left(\tilde{a},\tilde{b}\right)=\sqrt{\frac{1}{3}\left[\left(l_1-l_2\right)^2+\left(m_1-m_2\right)^2+\left(u_1-u_2\right)^2\right]}$$

where $\tilde{a}=\left(l_1,m_1,u_1\right)$ and $\tilde{b}=\left(l_2,m_2,u_2\right)$.
Closeness coefficient is calculated for each alternative as

$$CC_j^*=\frac{D_j^-}{D_j^*+D_j^-}\ ,\ \ j=1,2,...,m$$

4. Results

Five alternatives were selected namely landfilling, traditional incineration, recycling with landfilling, RDF combustion and composting. 4 main categories including of environmental impacts, economical issues, social aspects and technological demands were picked up. To employ more real and detailed views, some sub-criteria were chosen for each main criterion. Detailed structure of criteria and their weight (calculated applying AHP) is shown in table 1.

table 1. Hierarchy of criteria

Main criteria	Subcriteria- stage 1	Subcriteria- stage 2	Weigh
environmental impacts (0.424)	Direct (0.540)	pollutions of soil, water and air (0.240)	0/302
	indirect (0.163)	vehicle emissions (0.020)	0/008
		life cycle pollutant production (0.092)	0/035
	compensatory impacts (0.297)	material recovery (0.020)	0/014
		energy recovery (0.017)	0/012
economical issues (0.227)		initial investment (0.100)	0/125
		current costs (0.052)	0/065
		maintenance expenses (0.043)	0/054
social aspects (0.227)		social acceptability (0.044)	0/055
		occupation opportunities (0.017)	0/021
		human health (0.085)	0/106
technological demands (0.122)		Technological availability (0.108)	0/072
		compatibility with the waste combination (0.017)	0/114
		operator experience demands (0.028)	0/019

Ranking of five proposed disposal methods was carried out using fuzzy TOPSIS decision making technique. The linguistic values are given in Table 2.

table. 2. Linguistic terms and corresponding triangular fuzzy numbers

Linguistic values	Fuzzy numbers
Very low (VL)	(0,0,0.2)
Low (L)	(0,0.2,0.4)

Medium (M)	(0.2,0.4,0.6)
High (H)	(0.4,0.6,0.8)
Very high (VH)	(0.6,0.8,1)
Excellent (E)	(0.8,1,1)

In this study, two positive and negative ideal solutions are assumed as $(1,1,1)$ and $(0,0,0)$, respectively. The distances of alternatives from the two ideal points calculated and illustrated in Table 3.

Table 3. Final D^- and D^* values

Alternatives	Final D-	Final D*
Landfill	0.524	0.970
Incineration	0.399	0.970
Recycle with landfill	0.636	0.938
RDf	0.556	0.906
Compost	0.570	0.906

With respect to the alternatives' distances from negative and positive ideal solutions, the closeness coefficients calculated. The CC_j and also the normalized ones are shown in Table 4.

Table 4. Closeness coefficients' values

Alternatives	CCj	normalized
Landfill	0.351	0.194
Incineration	0.291	0.161
Recycle with landfill	0.404	0.223
RDf	0.380	0.210
Compost	0.386	0.213

As can be seen, the recycling with landfilling of residues stands as the proper disposal method.

4. Conclusion

Waste composition, relatively low involved expenses, less environmental pollution, remarkable compensating effects and benefits of recycling, filling up landfill, lack of technology for complete recycling and so on, are reliable reasons that approve efficiency of selected alternative for Tehran.

Application of an integrated method of fuzzy TOPSIS and AHP is an appropriate approach for modeling and problem solving in selection of a proper disposal method for municipal solid waste. Using MCDM techniques besides fuzzy sets theory dispel the complexity of multidisciplinary problems and covers vagueness and the lack of human knowledge. Using the linguistic comparison makes modeling very flexible and approximates it to the human way of thinking. Additionally, applying of sub-criteria makes the problem structure more detailed. Hence, impression of each influencing factor can be investigated vividly and more acceptable results can be achieved.

For further research, developing a group decision making system, using the Delphi techniques, combining with meta-heuristics or using mathematical modeling for more viewpoints' varieties and accurate modeling are suggested.