

# Landfill Site Selection for Babol Using Fuzzy logic Method

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**ABSTRACT:** Landfill is one of the oldest and most widely used methods of waste management. Due to the special geographical and climatic condition of the northern province of Iran using this method is faced of many challenges. Several parameters are considered in determining the appropriate location for landfill. The goal of this study was to determine the best location for the landfill of Babol in north of Iran. The parameters that important in finding the location for landfill are such as: Groundwater level, distance from surface water sources, faults, slope, soil and rock type, distance from cities and aggregation centers, and distance from forest and roads. For understanding and finding knowledge about these parameters the topographic maps, geology, soil science and hydrology are used. In this study the range of effective parameters of this subject was determined, and analyzed with both Boolean and Fuzzy logic methods. This study indicates that Kardijkola has the most suitable conditions and the worst place for landfill is Ahangarkola and Kashikola. Indeed this study is based on the field that do not have any of condition for choosing are removed in first step (Initial selection) and afterwards between the remaining option, the option that have best condition according to weight was given is chosen as the final location of the landfill.

**Keywords:** Solid waste management, Site, Babol, Boolean logic Method, Kardijkola.

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## INTRODUCTION

In the present century, with growth in the population and urbanization, the one of environmental problems that always is compared to the human society is the solid waste production, increasing the generating the waste materials from one side and management of these waste materials with healthy methods is on the other side is forced the authorities to utilize the various decision making methods to locate the best place for landfill (Wanichpongpan and Gheewala, 2010). Although generation of solid waste materials in cities increased with growth and develop of population and economic (McNally, 2004).

Selection of suitable land for municipal landfill is the most important factor for municipal solid waste (MSW) management. Sanitary landfilling of MSW like all engineering projects requires the basic information and accurate planning. Doing the systematic management in beginning of project, site selection, preparation and operation have a great impact on successful project (Komilis et al., 2006).

In the process of selection of the best place for landfill there might be several options that can make it difficult to select the best option and decision making process. The increasing environmental pollution and rising costs, political and social situations, lack of available field and public health in the region affected by the landfill site selection (Baban and Flannagan, 2012).

Dumping and burying the MSW in as many years has been the most common method for the disposal of

municipal solid waste were used in different communities (Charnpratheeep et al., 2002). In the north cities of Iran especially Babol specific parameters such as geographical location high groundwater level, climate (especially high level of precipitation), soil fertility, high population density and lack of abandoned land and the current method of solid waste disposal in this city, that shows the need to plan for finding the suitable place for disposal of waste. About 200 tons of waste material daily are piled in open dumping in Babol for high slope of region (that led to the influx of leachate from waste and pollution of surface water and groundwater) and also the availability of the waste for animals and bird, stray dogs and harmful insects is inappropriate and can lead to the spread of parasitic and infectious diseases. However this problem has been present in the north for long time, but still continues (Mazandaran County, 2012).

City of Babol is located in the center of Mazandaran province; south of the Babolsar city, East of Qaemshahr, West of the Amal city and from north is bounded to the Tehran Province. Area of this city is around 1578 square kilometers and located between the 33 to 36 latitude and 41 to 45 longitudes and height of city from sea level is -2 to -5 m and height from Caspian Sea is 52 m. This city has 6 sections and 13 rural areas. In terms of plant that growth in this area, Babol is located in Caspian plant region. In the recent years resulted of converting the agricultural land to the citrus garden the landscape of the plain is changed. In overall perspective, we can divide the landscape to 2 parts of garden and agricultural land, in some places the area of the garden is

more than land and some place is vice versa. There are several rivers flow in the city area include Sejarood, Kelarood and Karyrood. Sejarood and baboolrood rivers are sourced from Alborz Mountains and Roodkola is sourced from Haraz River. All these rivers join together in near of Mohammad Hassan Khan Bridge and called Babolrood, it cross the Babol and flow in to the Caspian Sea in Babolsar. Climate of city is like other part of province of Mazandarn is hot and humidity in summers and mild in winters. Maximum rainfall is in the December and minimum is in month of July (Mazandaran County, 2012).

Nilchian in 2013 had a research for finding the location for collecting and separating center for waste materials in Tehran. In this research he identified the public services application in area such as municipal facilities, public utilities and parameter like land slope, architectural and historical significance sensitive natural ecology, property he used the separation component method and with removal the sensitive point, with using the weighting index for remaining option, identified the 14 place that have higher values. After that considering the slope, wind direction, the impact on the urban landscape and distance from the buried land, 14 options measuring and comparing, between the these option the 9 option is select as best choice that located on north highway of Tehran - Karaj around the Chitgar park (Nilchian, 2013).

In 2011, Mohammadi studied on selection of location for landfill in Nain. In this study screening methods was used for places. In initial screening, area that lack the minimum requirement were removed, and then with studied the region, 3 regions were selected as candidate for landfill. In next step with using the drastic method these 3 regions were weighted and scored. In this weighting of place, parameters such as depth of soil that suitable for covering the waste, natural covering of place from people view, probability of flood, density of well, depth of groundwater, privacy of place, privacy of city region and distance from the center of waste generating (Mohammadi, 2011).

The aim of this study was to choose the best location for the sanitary landfill of municipal solid waste (MSW) of Babol city.

## MATERIALS AND METHODS

To locate a MSW landfill, in this study overlay methods was used. After the initial screening, the places that do not have any of parameters that mention below were eliminated; finally seven locations are selected as candidate for landfill of Babol city. The materials that were used as layer in this study are such as: topographic maps (prepared by the Geological Survey Scale 1/200000), soil Map, lithology map, fault map, groundwater depth and surface water map (include rivers and waterways, stream, dam and aqueduct), the way (include highways, roads paved, graveled, and a jeep road), forests, prevailing wind direction (Higgs, 2009; Kontos et al., 2009).

Two methods are used for operation on maps. First method is Boolean methods in this method only two cases consider. For instance, a characteristic such as slope of location is perfectly good or perfectly bad (binary

method). Second method is fuzzy logic, which applies more in this paper. In this method for suitability of each parameter, a coefficient was given to the parameters obtained by each region (Leao et al., 2005). It should be noted that due to the geographical situation of Babol using the Boolean methods is not suitable and cannot get useful results. This weighting is done based on fuzzy method. In Fuzzy method in this study, the layers above are members of the coefficients are arranged according to Table 1.

It should be mentioned that this factor is not absolute and for each region can be changed based on the own characteristics (Moeinaddini et al., 2012). In fact in this prioritize we try to consider the goal of study. These objectives are: minimizing the risk to public health, minimizing the impact on the social, cultural and natural environment and least economic cost (Ojha et al., 2011).

**Table 1.** Factors and coefficients of each of the factors in locating a landfill

Factor	Weight
Groundwater level	5
Distance from surface water sources	4
Soils and rocks	3
The range of slopes, faults and distance of them from the city	2
Distance from roads and population centers	1

Due to the high level of groundwater and high volume of surface water resources in the city of Babol, these 2 parameters have more coefficients. In this study, best kind of allocation of coefficients is mentioned below. Later with scoring the candidate areas (according to the characteristics of geology, topography, soil, geology, underground water depth, faults, and allowed distance) and act of factors, finally the option have the higher score is introduced as best place for landfill. In table 2 desirable and permissible values for each factor are listed (Salmanmahini and Gholamalifard, 2009; Siddiqui et al., 2003).

**Table 2.** Desirable and permissible limits for parameters influencing the selection of landfill

Criteria (map layers)	Allowance boundary
Distance from surface water	More than 400 meter (up to 600 meter)
Depth of groundwater	More than 16 meter (20 meter in some cases)
Allowance Slope	Between 8 to 16 percent
Distance from cities	Between 3 to 15 kilometer
Distance from population center	More than 500 meter
Distance from accessible roads	Between 80 m to 100 m.
Agrology	Permeable soils and etc
Geology (rocks properties)	Igneous & alteration rocks

## RESULTS AND DISCUSSION

In the terms like as topography, geology, hydrology (of surface water and groundwater) and finally, six locations were selected as the weighting option. It should be noted that many places were eliminated in the initial screening:

- Ahangarkola

- Daroonkola sharghi
- Kashkola
- Palangdareh
- Kardijkola
- Alamkola

In Tables 3 to 9, properties of each selected region and their values are calculated and shown.

**Table 3.** Characteristics of Ahangarcola region

Criteria (map layers)	Amount	Value (Without coefficient)	Coefficient	Value (with coefficient)
Distance from surface water	2 km from the Metalon river	5	4	20
Depth of groundwater level	6 m	3	5	15
Allowance Slope	1%	9	2	18
Fault	Relatively close to a possible fault	5	2	10
Geology (rocks properties)	Young alluvial	6	3	18
Agrology	Wet meadow soils	3	3	9
Distance from city	12 km	9	2	18

**Table 4.** Characteristics of Ahangarcola region

Criteria (map layers)	Amount	Value (Without coefficient)	Coefficient	Value (with coefficient)
Distance from surface water	2 km from the Babolrood river	6	4	24
Depth of groundwater level	12 m	5	5	25
Allowance Slope	1%	8	2	16
Fault	Relatively close to a possible fault	5	2	10
Geology (rocks properties)	Conglomerate, Marl	5	3	15
Agrology	Lytosel in the Brown forest soils area	3	3	9
Distance from city	17 km	8	2	16

In Table 9 the comparison of six proposed regions for municipal solid waste (MSW) landfill site selection project are shown. It indicates that Kardijkola has earned the most value according to the charts, tables and coefficients and the worst place for landfill is Ahangarkola and Kashikola. It also shows that the coefficient has an important role on site selection because ranking according to sum of values without coefficients is very different from the ranking according to sum of values with coefficients and the works of Şener and Vastava validates this study (Şener et al., 2010; Vastava, 2006).

Field visit can verify the research findings. Kardijkola is located in south of Babol and in an area where the ground water level is too low and groundwater contamination caused by construction of landfill sites is reduced because of low groundwater levels. Other important factors in choosing this location are such as:

The direction of the prevailing wind is not blowing into town, distance from population centers and future expansions, low permeability soil, Access to cover soil for daily cover, Access the roads, Lack of tourist area, this land is not suitable for agricultural purposes.

**Table 5.** Characteristics of Ahangarcola region

Criteria (map layers)	Amount	Value (Without coefficient)	Coefficient	Value (with coefficient)
Distance from surface water	1.5 km from the Kelarood river	4	4	16
Depth of groundwater level	16 m	6	5	30
Allowance Slope	%10	8	2	16
Fault	Relatively close to a possible fault	4	2	8
Geology (rocks properties)	Conglomerate and Marl	5	3	15
Agrology	Lytosel in the Brown forest soils area	3	3	9
Distance from city	2 km	7	2	14

**Table 6.** Characteristics of Ahangarcola region

Criteria (map layers)	Amount	Value (Without coefficient)	Coefficient	Value (with coefficient)
Distance from surface water	1.5 km from the Khosh river	3	4	12
Depth of groundwater level	17 m	7	5	35
Allowance Slope	%15	7	2	14
Fault	Relatively far from a main fault	7	2	14
Geology (rocks properties)	Conglomerate and Marl	5	3	15
Agrology	Wet meadow soils	3	3	9
Distance from city	24.5 km	7	2	14

**Table 7.** Characteristics of Ahangarcola region

Criteria (map layers)	Amount	Value (Without coefficient)	Coefficient	Value (with coefficient)
Distance from surface water	2 km from the Babolrood river	5	4	20
Depth of groundwater level	28m	10	5	50
Allowance Slope	%30	4	2	8
Fault	Relatively close to a possible fault	5	2	10
Geology (rocks properties)	Conglomerate and Marl	5	3	15
Agrology	Lytosel in the Brown forest soils area	3	3	9
Distance from city	26 km	7	2	14

**Table 8.** Characteristics of Ahangarkola region

Criteria (map layers)	Amount	Value (Without coefficient)	Coefficient	Value (with coefficient)
Distance from surface water	2 km from the Babolrood river	5	4	20
Depth of groundwater level	32 m	10	5	50
Allowance Slope	35%	3	2	6
Fault	Relatively close to a possible fault	5	2	10
Geology (rocks properties)	Limestone and Marl	4	3	12
Agrology	Lytosel in the Brown forest soils area	3	3	9
Distance from city	32.5 m	6	2	12

**Table 9.** Comparison of proposed regions for municipal solid waste landfill site

Name of area	Sum of Values (Without coefficient)	Sum of Values (with coefficient)
Ahangarkola	40	108
Daroonkola Sharghi	40	115
Kashikola	37	108
Palangdareh	39	113
Kardijkola	39	126
Alamkola	36	119

While in Ahangarkola and Kashikola regions, the volume of rainfall in the area is high so groundwater elevation will increase and it causes the groundwater contamination. Also, these regions are in prevailing wind direction which causes the odor to release into the city. Other factors that led to the place of burial are not appropriate are such as:

Tourist area, high soil permeability zone, the land is fertile and suitable for agriculture is, lack of a cover soil for daily cover, proximity to residential areas and industrial.

## CONCLUSIONS

One of the main reasons that important to choose a suitable place for disposal of municipal solid waste (MSW) is that Babol is located near the Babolrood. Babolrood is provides the water for agriculture of Babol, Babolsar and Bahnamir. High level of precipitation in northern regions of Iran, increases leachate production that is a serious threat to the environment (especially water resource).

It will protect the rivers of Babol as the main source of surface water in this area. There are numerous forests in most parts of the city as one of the limitations that we face in locating landfills. As well as the constraints that we face during this study, is the lack of access to all layers (as desired scale maps). Finally, according to the ratings assigned to each area, the overall results were achieved and the region "Kardikola" was selected as the most suitable place for municipal solid

waste (MSW) landfill for the city of Babol and the worst place for landfill is Ahangarkola and Kashikola.

Although different methods have been used for finding the location for landfill around the world, but for each region for its different properties these methods must be different. For instance in this study the depth of groundwater and surface water is highly valued (for its critical condition that has been mentioned). It should be mentioned that local elections for municipal solid waste landfill is very important. However, the use of coatings to protect it and to prevent leakage of leachate and other possible consequences is very necessary. Also due the vicinity of urban and rural area in the northern regions of Iran, necessity for the comprehensive planning for disposal of municipal solid waste (MSW) with local and regional decision making will be strongly needed.

Some recommendations for further research are such as: because of the lack of standards and guidelines for locating waste disposal sites, it is proposed to set criteria and guidelines for locating the landfill in accordance with the conditions of this region. It is suggested that the combination of fuzzy methods and GIS be used. Additional indicators proposed to be used for initial screening points. Due to the lack of suitable land for landfill, high groundwater levels and fertile land for agriculture, it is highly recommended to choose a central burial place rather than several places.

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