Study of Solid Waste Landfill Suitability using Regional Screening Method and AHP in Rasht City

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***Abstract*—**The practice of burying the solid waste under the ground is one of the waste disposal methods and dumping is known as an ultimate method in the fastest-growing cities like Rasht city in Iran. Some municipalities select the solid waste landfills without feasibility studies, programming, design and management plans. Therefore, several social and environmental impacts are created by these sites. In this study, the suitability of solid waste landfill in Rasht city, capital of Gilan Province is reviewed using Regional Screening Method (RSM), Geographic Information System (GIS) and Analytical Hierarchy Process (AHP). The results indicated that according to the suitability maps, the value of study site is mid-suitable to suitable based on RSM and mid-suitable based on AHP.

***Keywords*—**Analytical Hierarchy Process (AHP), Geographic Information System (GIS), Rasht City, Regional Screening Method (RSM), Solid Waste Landfill

I. Introduction

ONE of the problems in environmental management in developing countries is inadequate disposal of municipal solid waste [1]. Solid waste landfill as an ultimate alternative of disposal has been always considered and selected by the solid waste management in the cities in spite of lower costs and easy operation [2]. But, the environmental pollutions and degradation of natural resources resulting from improper actions of the management of these sites have been one of the concerns of surrounding communities and distress of municipal authorities [3, 4].

Identification of the situation of urban solid waste landfills is required to prevent increasing the environmental problems [5, 6]. Therefore, a method should be used to reduce the different impacts of a solid waste landfill so that the local and regional conditions can be considered while overlapping with the standards and regulations [7]. In this method of study, the different parameters and factors including health, environmental, social, economic and land use are reviewed [8].

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So far, various patterns, methods, regulations and criteria have been developed by the national and international governmental organization and experts in this regard [9, 10].

II. Materials and Methods

A. Study Area

The solid waste landfill of Rasht city is located at 15 km from southwest of this city (Center of Gilan Province) on Tehran-Rasht road. The input solid waste to this site is 620 tons per day which are transferred from 14 towns, 12 villages, 11 organizations and governmental companies, 9 livestock companies, industrial estate, hospitals, health and treatment centers and buried with valley disposal method [11]. This site is located in the eastern latitude of 377845 and the northern latitude of 4103410 (Fig. 01).

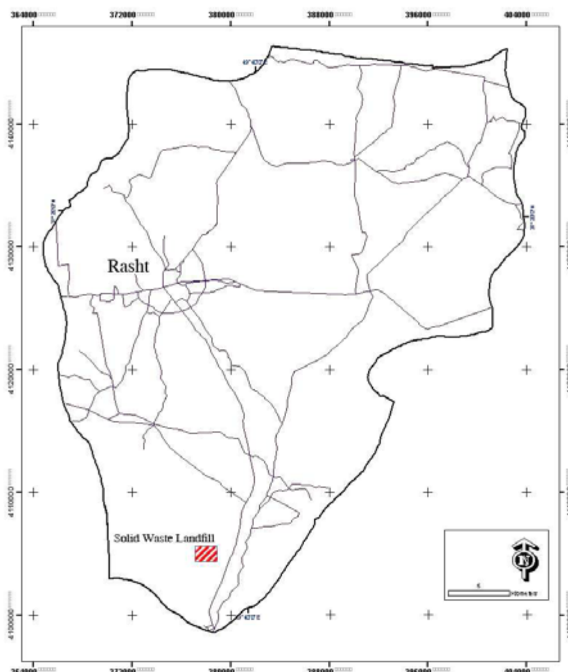

Fig. 1 Location of waste landfill in Rasht City

The population of Rasht city increased from 611946 people to 857606 people in 1986 to 2010 and will reach 1120740 people by 2021 with probable growth of 1.7% [12]. The average annual precipitation in a period of time from 1976-2010 is 1351.4 mm, the average annual temperature is 17.4°C, the evaporation is 777.5 mm, the frost days are 35.6 days and the sunny hours is 1556 hours/day [13].The solid waste landfill of Rasht city is located in the alluvial plain. Siahroud river at a distance of 3 km of this place flows into Anzali wetland after passing through Rasht city and connecting to Godarrood river in the name of Pir-Bazar river. Discharge of this river adjacent to the project area in Behdan village is 3.71 m^3/s. [14]. The underground water consists of a carbonate hardness flow which is originated from Neyzeh Sar highlands and flows towards Sefidrood river with a west-east flow. From seismicity view point, this region is located in moderate-to-severe destructive area. The height of landfill is 180 m a.s.l. [15]. The relevant landfill is placed in Sarvan forest lands. For the time being, the main community of this forest is Alder-parrotia persica and parrotia persica - carpinus betulus [16].

B. Methodology

In this study, the regional screening method is used to evaluate the municipal solid waste landfill of Rasht city. In this method, three main factors i.e. natural conditions, land use and economic factors are involved [2] which include:

a. Natural Conditions

1. The solid waste landfill should not be located in the ravines.
2. The solid waste landfill should not been located in surface water accumulation areas (minimum distance of 61 m should be observed).
3. The areas with high underground water levels are not suitable for construction of solid waste landfill unless the design is used as the hydraulic trap method.
4. The areas in which the supply of heavy clay fine-grained soil for creating and using the coating layers is difficult or impossible are not suitable for constructing waste landfill. This kind of soil should have a permeability coefficient of minimum 0-9 m/sl x 1. The layers of soil under the landfill should be of clay-silt type with permeability of 0-9 m/s1 x 1 and deep as far as possible (about 15 m and more).
5. The distance of landfill should be at least 61 meters away the faults.
6. The areas in which there is the slide risk as well as the areas containing sensitive clays are not suitable for construction of landfill.
7. The areas with high sensitive soils like limestone and/or the collapsible soils are not suitable for construction of landfill.

b. Land Use

1. Minimum distance of 150 m from the landfill is recommended for residential, commercial and educational applications and at least 80 m is recommended for industrial applications.
2. The minimum distance of 3 km from the airport should be respected.
3. The minimum distance of 300 meters of water wells should be observed.
4. The agricultural lands with suitable conditions can be suitable for solid waste landfill.

c. Economic Factors

The landfill should be located at a suitable distance form the main road (less than one kilometer is ideal). The classification pattern used in this method includes:

1. Distance from waterways, springs and kanats: less than 61 meters (unsuitable), 61 to 600 meters (mid-suitable) and more than 600 meters (suitable)].
2. Distance from water wells: Less than 300 m (unsuitable), 300 to 100 meters (mid-suitable) and more than 1000 m (suitable).
3. Distance from population centers and residential areas: Less than 150 meters (unsuitable), 150 to 300 m (mid-suitable) and more than 300 m (suitable).
4. Distance from industrial centers: less than 80 meters (unsuitable), 80 to 200 meters (mid-suitable) and more than 200 m (suitable).
5. Distance from roads: Less than one kilometer (suitable), 1 to 3 km (mid-suitable) and more than 3 km (unsuitable).
6. Distance from airport: Less than 3 km (unsuitable), 3 to 8 km (mid-suitable) and more than 8 km (suitable).
7. Distance from fault: Less than 61 m (unsuitable), 61 to 100 m (mid-suitable) and more than 100 meters (suitable)].
8. Geology: terrace reserves, old high level piedmonts (suitable), andesitic tuff, andesitic tuff and lavas, basalt tuff and lavas, lime shale and tuff, marl, limestone, sandstone, gypsies marl, marl, sandstone and conglomerate (mid-suitable) and terrace reserves, new low-level piedmonts, dacite volcanic, dark shale with tuff inter layers, andesitic-basalt lavas, andesitic lavas, dacite lavas (unsuitable).
9. Land use: agricultural lands – inferior (suitable) , range (mid-suitable) and residential areas and the other areas (unsuitable).
10. Soil texture: silt to clay-silty (suitable), clay and mixture (mid-suitable), gravel, sand and gravel and limestone (unsuitable).
11. Soil depth: 1500 cm and more (suitable), 100-500 cm (mid-suitable) and 0-25 and 25-100 cm (unsuitable).
12. Soil permeability: low permeability (suitable), semi-permeability (mid-suitable), high permeability (unsuitable).
13. Depth of underground water: less than 15 m (unsuitable), 15 to 60 m (mid-suitable) and more than 60 m (suitable).

In order to prepare the final suitability map, the maps classified based on suitable, mid-suitable and unsuitable values (According to the presented model), are placed on each other two by two and classified in ARC GIS9.2 software and using Raster Calculator command. Consequently, the final map was prepared based on the above-said values.

III. Software

In this study, basic information was extracted using GIS software including Micro station and ARC GIS9.2. ERDAS9.1 software was also used for processing and interpreting the satellite images. Then in ARC GIS9.2 software, the relevant landfill was determined within a 30 km area (transportation area of municipal waste) using Buffer function .Then in the same software, all the digital files are extracted using Clip function. After preparing the basic maps of the area, these maps were classified in ARC GIS9.2 software according to the presented model and final maps based on three values: suitable, mid-suitable and unsuitable were prepared.

The different maps which are prepared regarding the criteria of the used model are as follows:

Digital topographic maps: By digital information of Iranian National Geography Organization (NGO) and Iranian National Cartographic Center (NCC) with the scale of 1:25000 and 1:50000, information layers of surface waters (waterway, spring and kanat), wells, population centers and residential area, industrial centers, roads and situation of airport to Ipgntk'slhkn.

- Land slope map (%): using topographic maps contour with 1:25000 scale with 20 m antral in Arc GIS software.

- Faults and geological map: digital maps at the scale: 1:100000, Iranian Geological Organization.

- Land use map: Digital maps at the scale 1:25000 and satellite images of ETM + Landsat 7 in 2002.

- Soil science map: This map is prepared based on the maps at the scale 1:250000 of Water and Soil Researches Institute. But in view of precision in work, the topographic map at the scale 1:25000 was prepared again using the satellite images and field inspection. All the maps were initially drawn on paper and these paper maps were converted to digital forms using digital geographic information so that the maps can be ready for combination with the other information. Furthermore, regarding the soil classification map, profile drawing and the existing information such as soil texture, depth and gradation, the other information and maps like soil texture and soil depth and soil permeability maps were prepared.

- Underground water depth map: The statistic of observation wells in the alluvial formation which is obtained by Gilan Regional Water Organization shows that there are 823 observation wells in the alluvial formation of the relevant area. By interpolating between the data points from depth view point in geographic information system, the underground water depth map was prepared.

- Sensitive habitats map: The sensitive habitats are the areas which are managed by Environmental Protection Organization, water lands and the other areas which are identified and introduced as the sensitive areas due to unique natural factors [17]. Deylaman Dorfak which is a hunting ban area is a sensitive habitat in the study area.

After preparing the basic maps, in order to prepare the final suitability map which shows the suitability of the landfill according to the criteria of Regional Screening Method, a pattern has been prepared for classification of the criteria by studying the different resources. The low level of this classification is in accordance with the screening method. Then the prepared maps were classified in 3 categories: suitable, mid-suitable and unsuitable values. Accordingly, the point and linear features such as road, waterway, kanat, faults, industrial centers, residential centers, wells, springs and airport are spaced in ARC GIS9.2 software using partial analysis function and distance alternative and classified according to the presented model. The polygon features such as geology, soil, land use and permeability were also classified based on the presented model.

Since the weights of all the used criteria were not the same, and some of the criteria act as a key factor [18], therefore, for ranking the importance of the decision-making criteria about identification of landfill, the factors have been weighed [19]. Therefore, the Analytical Hierarchy Process (AHP), which is the common method in decision-making analysis in the field of environment modeling, is used. [10, 21]. Accordingly, by interview with 10 environmental experts, the suitable value of each criterion was determined using this method and then the layers with different values have been placed on each other and the value of landfill is determined.

IV. Results

For evaluating the site suitability of Rasht solid waste landfill, the standard maps obtained from the previous stages, were classified using GIS for integrating the standardized layers. The relevant factors are classified into two general criteria: 1) physical and 2) economic-social, for weighing.

1) Physical Criteria

The physical criteria include surface water, springs, depth of ground water, water wells, geology and faults, depth of soil, soil permeability and soil texture.

a) Surface Water

These criteria are important from an environmental and economic view point due to probability of pollution and its consumptions. The distance of landfill from waterways and springs is more than 800 m. There is no kanat in this area.

b) Ground Water

Unsuitable solid waste disposal particularly in the areas that the elevation of groundwater is high can endanger the consumer's health due to the pollution of materials and penetration of these materials to ground water. The distance of landfill from the water wells is more than 1720 m. Depth of ground water is also less than 15 m which increases possibility of pollution.

c) Geology and Faults

Faults as one of the geological features are considered in the site selection of landfills (Gemitzi et al., 2007). The geology of the study area consists of thick and moderate layers of dark-grey lime in piedmonts. The distance of the nearest fault to the landfill is more than 1300 m.

d) Social Permeability

By increasing soil permeability factor, more leachate penetrates into the ground water and consequently, the pollution of water will increase. The soil of landfill and the surrounding area is mainly clay which has a moderate permeability.

e) Soil Texture

The soil texture of the area is moderate since it is clay.

f) Soil Depth

The depth of soil in the landfill is 80 to 90 cm.

2) Social- Economic Criteria

In this study, the social economic criteria include residential areas and population centers, industrial centers, access roads, airport and land use.

a) Population Centers and Residential Area

The problems resulting from air pollution, odor and noise in population centers and residential areas are considered as unsuitable aspects of landfill. The long distance between these centers and landfill will minimize the above-said problems. The distance between the study landfill and residential areas and population centers is 2300 m.

b) Industrial Centers

The nearest industrial center to the study solid waste landfill is Rasht industrial city (with a distance of 8 km).

c) Access Roads

Rasht-Tehran road is located at 2 km away from the study landfill and the access is made through a sub-road.

d) Airport

A wide variety of different birds in the study area can cause problems in airplane flights and to increase the safety risk. The distance between Rasht International Airport and the solid waste landfill is 26 km.

e) Land Use

The study landfill is located in Saravan forest lands with intensive forests. These lands are being demolished since they are used as a landfill for several years and more trees and shrubs are being removed.

The results of comparison of the existing conditions in Rasht solid waste landfill are presented in the relevant tables. These criteria are weighed according to AHP (Analytical Hierarchy Process).

V. Conclusion

According to the results obtained using the Regional Screening and AHP methods and comparison of them, review of the factors used in the Regional Screening shows (TABLE I) that the solid waste landfill in Rasht city is classified in "suitable" category (64.3%) (Fig. 02).

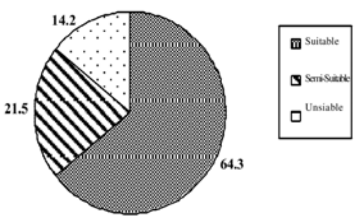

Fig. 2 Values of Rasht solid waste landfill criteria with Regional Screening Method (%)

Distance from waterways, depth and permeability of soil have mid-suitable value and water table and land use are of unsuitable values (Fig. 03).

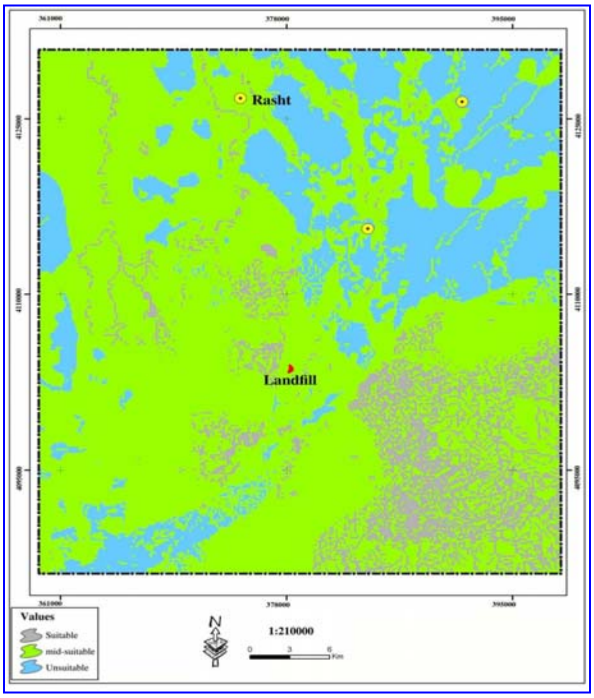

Fig. 3 Final classification of study area based on the regional screening criteria

TABLE I
Suitability of Solid Waste Landfills in Rasht City Based on Regional Screening Method

Criteria in Regional Scale	The Suitability Valve of Landfill
distance from waterways	mid-suitable
distance from springs	suitable
distance from wells	suitable
distance from population and residential centers	suitable
distance from industrial centers	suitable
distance from access roads	suitable
distance from airport	suitable
distance from faults	suitable
Geology	suitable
Land use	unsuitable
soil depth	mid-suitable
soil permeability	mid-suitable
soil texture	suitable
Underground water depth	unsuitable

Using AHP, and after weighting 14 criteria used in the regional screening method, it is determined that distance from waterways, underground water depth and population and residential centers and land use have the top priority. According to weight of the factors (Fig. 04), the under-review landfill is within an area with mid-suitable valve .The comparison of the above-said findings show that the application of the criteria in various methods is different based on the location conditions and do not have equal capability in analyzing the conditions. Therefore, the decision-making power of the decision-makers will increase using AHP and regarding the wide range of classification so that they can take appropriate actions for reducing the economic and environmental costs with an optimal environmental management in solid waste landfills.

TABLE II
FINAL WEIGHT OF CRITERIA BASED ON AHP

Criteria	Weight
Distance From Waterways	0.1967
Underground Water Depth	0.1512
Distance From Population And Residential Centers	0.1353
Land Use	0.1124
Soil Texture	0.0649
Soil Permeability	0.0587
Soil Depth	0.0501
Distance From Springs	0.0351
Distance From Well	0.0284
Geology	0.0233
Distance From Faults	0.0213
Distance From Population Centers	0.018
Distance From Access Roads	0.0142
Distance From Airport	0.0122

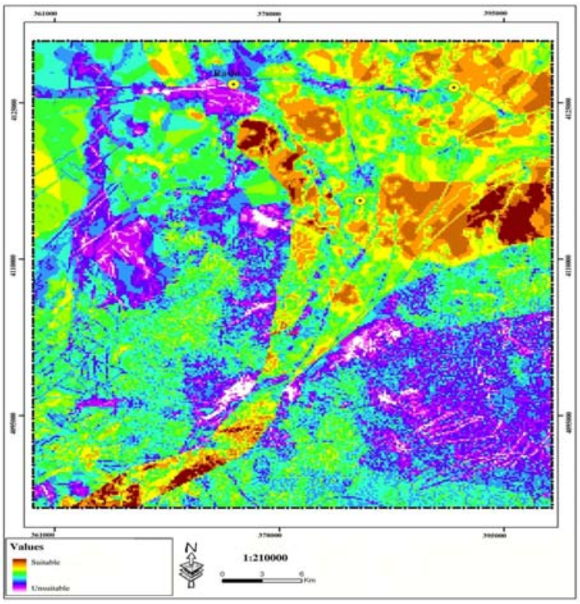

Fig. 4 Final classification of study area based on AHP

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