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An Urban Solid Waste Landfill Site Evaluation Process Incorporating GIS in Local Scale Environment: A Case of Ahvaz City, Iran

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ABSTRACT: Landfill is one of the primary methods for urban solid waste disposal. In order to reduce the environmental adverse effects and to protect the public health and human welfare, evaluating the landfill is utmost importance. In this research work evaluation procedure for the current condition of Ahvaz city urban solid waste landfill site with criteria of Local Screening Method (LSM) is outlined. In this method, with combining GIS technologies and site investigation the main criteria are physical conditions, economical factors, and land use. These 14 criteria were used into the overlaying technique to determine suitability conditions in the study region. The obtained results indicated that Ahvaz solid waste landfill should be graded on a scale of very weak condition in local scale and ranked in order of in appropriate. The main reasons for the occurrence of this condition was considered as land purchase ability, lack of landfill cover values of natural vegetation in public view, difficulty in sampling and high groundwater levels inside of the study site.

Key words: Screening method, Local scale, Evaluation of solid waste landfill, Ahvaz city

INTRODUCTION

Urban development, population growth and the changes in life style including consumption patterns have created numerous problems that dealing with are inevitable (ISWA, 1998). One of these problems is solid waste management, particularly landfill (Popov, 2005). Generally, solid waste landfills have inconsistent consequences in the condition of the lack of health-environmental considerations on their surroundings (Christensen and Hadix, 2004; Zamorano *et al.*, 2008; Sangari, 2010). Because of this, activities in this situation always face community concerns (Sumathi *et al.*, 2007; Ghanbari *et al.*, 2012). Managing the problems of landfilling is considered as a more complicated process due to some differences in its special environmental and geographical characteristics in Iran (Monavari, 2011).

In these geographical areas of special formations, climate, population, ecological and economic characteristics are different. Therefore, there are more problems to deal with regarding solid waste landfill. Landfills with environmental and health problems require scientific knowledge and attitudes to provide appropriate and reasonable options according to the most fundamental scientific and timely available capacities (Abessi and Saeedi, 2010; Ball, 2004). To locate optimized and sanitary solid waste landfill, there are several methods (Chang *et al.*, 2007). There are many variables and factors in each method to reduce negative environmental impacts (Monavari, 2012; Richard, 2009; Wang *et al.*, 2004). The first step to prevent likely pollution by landfills is to identify and analyze the location of the landfill region (Leao *et al.*, 2001).Considering the fact that site selection of urban landfill in Iran is mainly performed without primary investigations, it is important to evaluate its several conditions (Shin *et al.*, 2005; Wanichpongpan and Gheewala, 2007). In this study, appropriate level of solid waste landfill is determined in Ahvaz city using screening method in a local scale by preparing different layers in the GIS software. It could be used in any kind of planning to meet existing problems in the area of study.

MATERIALS & METHODS

Ahvaz city as capital of Khuzestan province is located in 48°, 20, E and 31°, 40, N (KPGO ,2012) (Fig. 1). The population of Ahvaz city during 35 years

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(1976 - 2011) increased from 334399 to 1115133, and with the possible growth of 2 percent, it will increase to 1829494 by 2031 (KPGO, 2011). The average annual precipitation at Ahvaz city station was 252 mm, and the average annual temperature was 25.4° C during 1976-2011 (MOKP, 2010). Ahvaz solid waste landfill has been located in 48°, 49, E and 31°, 17, N and 1236 meters away from the Transit Road north of Ahvaz – Mahshahr (Monavari *et al.*, 2011). Every day 1236 tons of solid wastes are transferred from five cities, many villages, organizations and governmental companies, hospitals, health and treatment centers, and are buried trenches (Davami and Monavari, 2010). This area is located in an alluvial plain, and Maleh stream which is the seasonal watercourse passes at a distance of one Km. It is about 80 Km far from Shadegan wetland. Landfill ground in the plain of roughness is relatively fine-grained silt-clay that is covered by sediments.

Groundwater at the landfill is chlorinated and saline quality with depth of 1.5-2 meters. This area has the seismicity of low damage. Indeed, the site is located at an altitude of 100 meters above sea level (GOKP, 2010; ARO, 2013). Landfill and surrounding areas are covered by desert vegetation, and because of human activities, they do not have valuable habitats of animals and vegetations (WROKP, 2010).

Required materials and data for this study are as follows:

1) Underground water map and maps of the wells' distance

2) Topographic maps with the scale of 1:25000

3) SPOT satellite data (2008)

4) Geological map with the scale of 1:100000 including: slope classification, slope direction, slope elevation, fault, distance from main roads, transmission lines and surface waters are prepared using the existing topographic maps. Land use map was also prepared using SPOT satellite image in 2008. The software used in this study includes:

- Idrisi 15 software for normalization operations of the map,
- Autodesk map 2004 software for digitization and editing operations of the map, and
- Envi 4.3 software for image processing operations and land use mapping. Investigation of criteria

The Analysis Procedures:

The criteria in local screening method are classified into 3 main conditions including:

A. Natural conditions

1) Depth of appropriate soil for the landfill cover layers: areas with sandy, silt and clay soils are suitable to cover solid waste landfills and soils without these properties should be eliminated.

2) Available deep lands: deep lands created by people or by drilling, are suitable for landfill, but natural deep lands are not suitable.

3) Natural cover of landfill in public view: areas with natural cover for landfill (such as trees and natural embankment) are also appropriate.

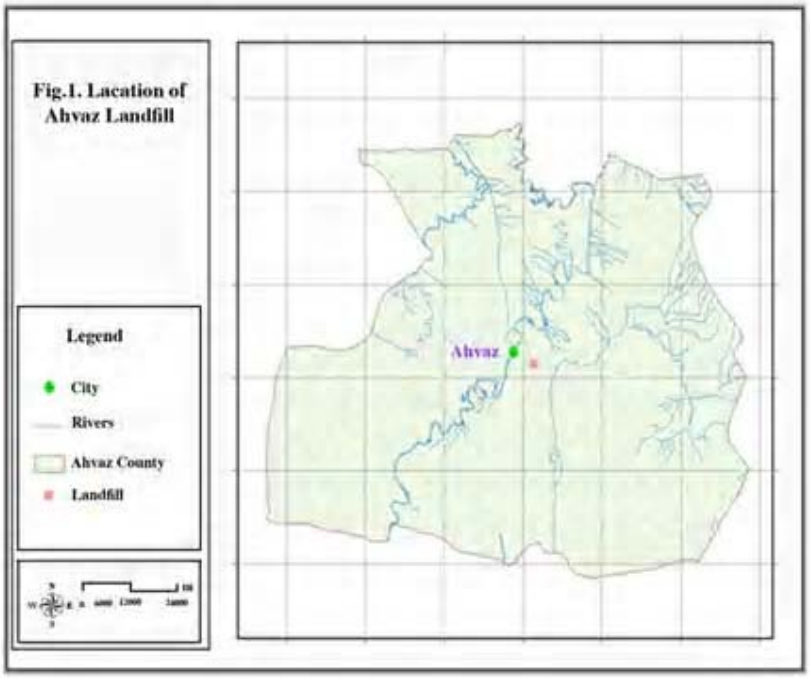

Fig. 1. Location map of Ahvaz county and solid waste landfill

4) Density of water wells: areas with lowest water wells are appropriate.
5) Easy sampling of groundwater: areas with complicated underground water regime, with difficult data preparation and interpretation of water quality control are not appropriate.
6) Slope of the ground: areas with slopes greater than 40% are not appropriate.
7) Landscape: areas that require more spending to create landscapes in the landfill are not suitable.
8) Depth of groundwater level: areas with low groundwater level and high depth of the half-saturation are suitable. Areas with high underground water levels are inappropriate, unless to be designed by a hydraulic trap.

B. Land use

1) Privacy of landfill: areas in which additional spending is required for landfill are inappropriate.
2) Land use after closing landfill: it is recommended not to use landfill final cover layer for its healthy status and to leave as open space. Sometimes it is recommended to create park or green space.
3) Urban areas privacy: areas within urban environment with regulatory barriers are not suitable landfill.
4) Areas with limited road traffic rules: roads in landfill areas should be controlled in terms of machineries that carry wastes. Traffic limitations also should be investigated. Road areas with traffic limitations are not suitable.
5) Areas with environmental protection: landfill should not be located in areas with environmental protection importance.
6) Landfill impacts on traffic: landfill impacts on traffic should be investigated.

C .Economical factors

1) Ability to purchase land: some selected areas of local scale may be subject to sales and they will be eliminated automatically.
2) Distance from the center of solid waste generation sources: a waste transportation cost is about 50 percent of waste management total costs including construction costs. So, areas where the cost of solid waste transporting is high are not suitable.

Among the conditions listed as criteria of landfill area and its status, the following three options should be omitted:
Important environmental areas (sensitive habitats).
Regions with high gradients (more than 40 percent).
Areas of historical and religious importance.

At this stage of study, weight and score methods will be used. Table 1 indicates the weight of each parameter. In this stage, higher scores indicate better place for landfill. Scores of each parameter is presented in Tables 2 to 15.

Table 1. Studied parameters in local scale and their weight

PARAMETER	WEIGHT
A – Natural conditions	
Depth of appropriate soil for the landfill cover layers	4
Available deep lands	1
Natural vegetation burial in public view	2
Density of water wells	5
Easy sampling of groundwater	5
Landscape of landfill	2
Depth of groundwater level	5
B - Land use	
Landfill privacy	2
Using landfill after its closing	1
Privacy of urban areas	1
Areas with limited road traffic	3
Landfill impacts on traffic	4
C - Economical factors	
Distance from the waste generation centers	4
Ability to purchase land	3

Table 2. Scores range of appropriate soil depth for landfill cover layers

Limitation of soils depth	Scores
Soils with a depth of 6 to 10 meters	6-10
Soils with a depth of 10 to 15 meters and more	3-6
Soil level is low and extra soils should be provided from other areas.	1-3
Soil is not available, geosynthetic materials should be used.	0-1

Table 3. The scores range of available deep lands

Volume percent that deep land creates for the landfill and proportional the total required volume	Scores range from
Available deep land creates more than 25 percent of the required volume.	**5-10**
Available deep land creates more than 10 percent of the required volume.	**3-5**
Available deep land creates more than 5 percent of the required volume	**1-3**
Deep land contained more than 2 percent of the required volume	**0-1**

Table 4. Scores ranges of natural coverage of the landfill in terms of public view

Natural cover landfill percent	Scores ranges
Natural coverage can cover more than 25 percent of the landfill	**5-10**
Natural coverage can cover more than 10 percent of the landfill	**3-5**
Natural coverage can cover more than 5 percent of the landfill	**1-3**
Natural coverage can cover more than 2 percent of the landfill	**0-1**

Table 5. Scores ranges of water wells density

Number of wells within 8 km of the landfill	Scores anges
Less than 5 wells	8-10
Less than 10 wells	6-8
Less than 15 wells	4-6
More than 20 wells	0-4

Table 6. Scores range of easy sampling of groundwater

How to take samples of water	Scores anges
Sampling is with no problem.	**5-10**
Hydrogeological situation is complicated because of the sampling.	**2-5**
It is complicated due to pollutants in water samples.	**0-2**

Table 7. Score ranges of landfill landscape

Type of the impact of landscape of landfill on surrounding natural environment	Scores range from
Landfill does not have any effect on the natural environment.	**7-10**
The effects of waste landscape on the natural environment in the basic local scale	**4-7**
The effects of waste landscape on the natural environment in the basic regional scale	**3-4**
The effects of waste landscape on the natural environment in the basic country scale.	**0-2**

Table 8. Scores ranges of ground water depth

Underground water resources and its depth	Scores anges
There are no underground water sources and the landfill in 800 meters away.	**8-10**
There are no underground water supplies beneath the landfill.	**6-8**
Groundwater level is deeper than 25 meters.	**4-6**
The depth of underground water level is over 15 meters.	**0-4**

Table 9. Scores range of landfill privacy

Landfill privacy	Scores range
Privacy in all areas around the landfill is over 46 meters.	**9-10**
There is a privacy area of more than 33 meters in all areas around the landfill.	**8-9**
There is a privacy area of more than 33 meters in more than 50 percent in all areas around the landfill	**5-7**
There is a privacy area of more than 33 meters in more than 25 percent in all areas around the landfill	**4-5**
Features more than 33 meters from the landfill, there are around 25 percent.	**3-4**
There is a privacy area of more than 33 meters in less than 25 percent in all areas around the landfill	**0-3**

Table 10. Scores range of using landfill after its closing

Conditions after its closing	Scores range
The use of the landfill after its closure will be required locally.	**7-10**
The use of landfill is added to the existing facilities and is compatible with them.	**3-6**
Use of landfill is incompatible with the environment.	**0-3**

Table 11. Scores range of urban areas

Location of landfill compared to urban privacy	Scores range
Landfill is located in the city	**8-10**
Landfill is located within the area controlled by the city.	**5-7**
Landfill outside the city area is under control of city and human control is strong.	**3-4**
Landfill outside the city is under control of city and human control is weak in that area.	**0-2**

Table 12. Scores ranges of limited traffic

Type of road traffic restriction	Scores range
There is no limit to the landfill.	**9-10**
In order to access to 50% of routes leading to the landfill, there is no little restrictions.	**8-9**
Little limiting factors are available in all directions	**7-8**
In order to access to 50% of routes leading to the landfill, there is little restrictions	**4-6**
To access the landfill from all directions, there are serious limitations.	**0-3**

Table 13. Scores range of the impact of landfill on road traffic

Type of impact of landfill on road traffic	Scores range
There is no traffic impact.	**8-10**
There is a limited traffic impact in area near the landfill.	**6-8**
There is limited impact on all routes leading to the landfill.	**4-5**
There is moderate traffic impact in local areas.	**2-4**
There are serious traffic impacts in local areas.	**0-2**

Table 14. Scores range of distance from the solid waste generation center

Distance from the center of solid waste generation	Scores range
Landfill is located at a distance of 16 kilometers from the center of solid waste generation.	**8-10**
Landfill is located 32 km away.	**6-8**
Landfill is located 48 kilometers away.	**5-6**
Landfill is located at a distance of 64 kilometers.	**3-4**
Landfill is located at a distance of 80 kilometers.	**1-2**
Landfill is located at a distance of more than 80 kilometers.	**0-1**

Table 15. Scores range of the ability to buy land

Possibility of land purchase	Scores range
Purchase possibility is high	**8-10**
There is the possibility of purchase.	**5-7**
Purchase possibility is low.	**2-4**
There is no purchase possibility	**0-1**

According to the given weights and scores, total score of the related location will be calculated in a local scale that will be compared with Table 16.

S A = W 1 R 1 + W 2 R 2 +.....

S A = A final total score for place A

W 1 = Weight of the first parameter (Table 1)

R 1 = First parameter score (Table 2 to 15)

Table 16. Parameters of total score

314 -420	Appropriate
214 -314	Moderate
182 -214	Weak
0-182	Very weak

In order to prepare the final suitability map, the maps classified based on suitable, mid-suitable and unsuitable values, are placed on each other two by two and classified in ARC GIS9.2 software and using Raster Calculator command (Monavari, 1999). Consequently, the final map will be prepared based on the above values.

RESULTS & DISCUSSIONS

Among criteria for selection of landfill in local scale, characteristics of areas that should be excluded in Ahvaz city include:

1) Important environmental areas (sensitive habitat): Shadegan International Wetland Protected Area is a sensitive habitat in the study area. Shadegan Wetland is environmentally important and landfill is 80 km far from this area.

2) Historical and religious centers: Landfill is not near any historical or religious centers, and its distance from the nearest site is about 6.5 km.

3) Slope range of the study area: The slope of the lands is different in various parts and varies from 0.4 to 0.6 per thousand.

Results of other local criteria based on field observations of landfill site visits, interviews with experts and officials and using prepared maps are as follows:

1- Natural plant cover of landfill in public view: Landfill has no natural plant cover.

2- Density of water wells: In order to evaluate this parameter, 5 km radius of the landfill was considered. There were 13 operating wells in this area.

3- Depth of appropriate soil for the landfill cover layers: Landfill soil depth is low and needs to be prepared from other areas.

4- Deep lands: The location of the landfill does not have natural depth.

5- Depth of groundwater level: Depth of ground water is less than 2 meters.

6- Urban areas privacy: Ahvaz landfill is located outside the city privacy.

7- Easy sampling of groundwater: Depth of groundwater level is high in this area. However, it is rather complicated due to sampling.

8- Areas with limited road traffic rules: There is no limit to the availability of landfill.

9- Landscape: Landfill affects natural environment in local scale.

10- Distance from the center of solid waste generation: This area is located within 6 km from the solid waste generation centers.

11- Privacy of landfill: There is a privacy area of more than 33 meters in less than 25 percent in all areas around the landfill.

Table 17. Parameters studied in the local scale and their scores in Ahvaz landfill

Parameter	score
A – natural conditions	
Depth of appropriate soil for the landfill cover layers	**12**
Available deep land	**0**
Natural cover of landfill in public view	**2**
Density of water wells	**25**
Easy sampling of groundwater	**5**
Landscape of landfill	**10**
Depth of groundwater level	**0**
B - Land use	
Landfill privacy	**6**
Using landfill after its closing	**7**
Privacy of urban areas	**6**
Areas with limited road traffic	**27**
Landfill impacts on traffic	**32**
C - Economical factors	
Distance from the solid waste generation centers	**32**
Ability to purchase land	**0**

12- Landfill impacts on traffic: Due to Ahvaz-Mahshahr, highway transit in the 1.2 km from the landfill, there is no traffic impact.
13- Using of the landfill after closure: After completion of landfill operations, creating of sport space will be required locally.
14- Ability to purchase land: Landfill is not in a purchased land, and there is no purchase possibility due to National Iranian Oil Company.

CONCLUSION

Ahvaz city has been rapidly growing in the last 35 years because of increasing population, urban and industrial development, and connections between rural and urban areas. Population growth in Ahvaz caused more solid waste production. This phenomenon due to lack of recycling process performance causes various economic, social, environmental and health problems. Considering 1264 tons of landfilling per day in Ahvaz city, based on local screening method, it is possible to rank this location as 174 that show its very weak values. The main reasons for the occurrence of this condition may be considered as land purchase ability, lack of landfill cover soil, natural vegetation in public view, difficulty in sampling and high groundwater levels. This condition reveals that solid waste landfill of Ahvaz city is in undesirable situation. According to the findings of this study, we can recommend the following results:
1 – Considering the increasing population of Ahvaz city in the coming years, completing of existing landfill capacity and the absence of favorable conditions, it is essential to find other options for disposing of solid wastes.
2 – Ahvaz is in the urban industrial development process, and it will develop closer to the existing landfill. In this situation, future concerns resulting from various infections, especially air pollution increases. Moreover, other small and large populated centers such as the villages of Koreit Boroomi, Damgheh and Davoohiyeh will face adverse conditions because of their proximity to the existing landfill.
3 - It is essential to perform solid waste recycling in Ahvaz city, and separation and reduction programs of hazardous waste such as hospital and industrial wastes and preventing them from being discharged in the landfill seems necessary.
4- Preventing of leachate to groundwater with the implementation of engineering and health measures is one of the priorities for reconstruction and reducing adverse and negative effects of present landfill that will be possible with environmental management.

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