original article

Evaluation of new location of Isfahan's sanitary landfill site with Oleckno method

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ABSTRACT

Aims: The objective of present study was to evaluate the new location of Isfahan solid waste sanitary landfill using Geographical Information System (GIS) based on the Oleckno index method (OIM).

Materials and Methods: This study was on the field- and library-based data collection and surveys of relevant data. Assessment parameters included average annual rainfall, soil type and ground water beneath and adjucent to the landfill site. To analyze data, ArcGIS version 9.3 was used.

Results: In 2010 the total rainfall in the landfill location was less than 150 mm/year. The soil type was clay loam, and the average distance from the floor of the landfill to the groundwater level was 3-9 meters. As calculated results showed that, the Oleckno index (OI) score in the study area was 40.

Conclusion: The new Isfahan's sanitary solid waste landfill site had a good OI and the possibility of contamination of groundwater by leachate production based on this method also was low.

Key words: Groundwater table, Oleckno index method, rainfall, sanitary landfill, soil type

INTRODUCTION

The life cycle stages of municipal solid waste (MSW) commonly include generation, storage, collection, transfer and transport, processing, and disposal.[1] A sanitary landfill produces the decomposition products of wastes in three phases including solids (degraded waste), liquid (leachate) and produced gases namely carbon dioxide and methane. Sanitary landfill and the waste materials of their degradation have the potentiality to contaminate the environment by atmosphere (air), lithosphere (earth and soil) and hydrosphere.[2] Improper disposal of waste has adverse effect on all constituents of environment and human health. In most areas of the world, municipal solid waste management emphasizes on the collection of solid wastes, whereas collection only helps the transfer of waste materials of producers and collected wastes without any good cover have risk for environment and human health.[3]

Leachate landfill consists of substantial amounts of dissolved organics such as Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), inorganic salts, heavy metals, ammonia and xenobiotic organic compounds. More than 200 individual organic compounds are found in the leachates.[4] To avoid the risks of leachate in landfill sites, Oleckno introduces a method for selection of a good landfill site. In this method, soil type, rainfall and groundwater table

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levels from the bottom of landfill site are considered criteria.[5] In 2006, Pourahmad *et al*., studied the solid waste landfill site of Babolsar, north of Iran. They used different data such as the distance from the legal urban limit, distance from the road, land ability and so on. They incorporated these data into various models of information combination and maps being combined based on fuzzy logic model. Finally, in this study suitable sites were selected for solid waste landfill and were presented in different maps.[6] In a study conducted by Zamorano *et al*., they evaluated municipal solid waste landfill site in southern Spain with GIS-aided methodology and to achieve this goal used EVIAVE method. They investigated five environmental components including surface water, groundwater, atmosphere, soil, and human health. GIS was applied to produce spatial data in this research study. The EVIAVE is an innovative method presented by university of Granada for the assessment of landfill sites in accordance with European union legislation Granada.[7] In 2008, Chang *et al*., applied fuzzy multi-criteria decision analysis alongside with a geospatial analysis for the selection of landfill sites in urban regions by rapid growth in the south of Texas. Analyzes were including two stages. The first stage included use of the thematic maps in the GIS in conjunction with environmental, biophysical, ecological, and socio-economical variables that were applied as basis for the second stage of analyses for fuzzy multi-criteria decision-making.[8] In 2010, Sener *et al*., combined analytic hierarchy process (AHP) with GIS to landfill site selection for the Lake Beysehir catchment area (Konya, Turkey). To reach this objective, an AHP was combined with a GIS to study several criteria, such as geology/hydrogeology, surface waters, slope, land use, height, distance from settlements, roads, and protected areas.[3]

Geographical Information System (GIS) is a tool to aid in selecting the best possible site for sanitary landfills. During the last three decades, the advance in computer science has promoted the invention of GIS. The GIS will support the combination of spatial data including the maps, and satellite images with quality, quantity and descriptive databases. GIS could be an indispensable tool for better decision making.[7] The purpose of this study was evaluation of the new landfill location of Isfahan, an important historic city central of Iran, based on Oleckno index method.

MATERIALS AND METHODS

Description of the study area

New solid waste landfill site of Isfahan city is located in the eastern of Isfahan province in Segzi region in 2 km of the south of Isfahan-Nain road (32°37'36" to 32°4' longitude and 52°1'36" to 52°4' latitude) [Figure 1]. Based on De Martonn method, climatological status of Segzi was dry.[9]

Compiling the data base for the Oleckno method

Data about the specifications and location of the new sanitary landfill of Isfahan city was completed via Isfahan municipal recycling office. The data of rainfall level of the studied region was collected from Isfahan meteorological department. The soil type data and its topographic map also were obtained from Isfahan department of natural resources. The data of groundwater table also was obtained from the Isfahan regional water company.

After obtaining the required data, entering data into ArcGIS 9.3 software, the data were classified and then scored based on Table 1. After that layers include of rainfall, soil type and groundwater table depth were prepared. Overlay method have been successfully used by ArcGIS 9.3 to calculate the total summation score of the layers. For this purpose the following equation was used:

Oleckno Index Method Score = rainfall (mm/year) + soil + ground water table (m).

RESULTS

In 2010, rainfall rate in total region of the Segzi in which landfill located was under iso-rain contour line of 150 mm/year. The maximum rainfall rate also was occurred in winter, and according to Table 1, a score of 21 belong to it. Figure 2 shows rainfall layer in the study area.

The soil type of Segzi region was mainly of loamy clay and in some regions there were few silt and sand with clay. But the soil type of studied sanitary landfill site was clay-loam type. Based on Oleckno method and Table 1, the 5 and 12 score were belonging to Segzi region and as it is shown in the Figure 3, in terms of Oleckno method, 12 belongs to this sanitary landfill site. Figure 3 shows soil type of the studied landfill site.

Groundwater table depth in the studied region to the bottom of the sanitary landfill site was mostly between 3 to 9 m. Based on OI, the 7 and 8 score were appropriate for it. Figure 4 indicates groundwater table depth from the bottom of the sanitary landfill site.

As it was mentioned, ranking of landfill site based on OI is achieved based on the sum of the scores of rainfall, soil

Table 1: The indices of rank determining in Oleckno method[5]

Rainfall (mm/year)	Score	Soil type	Score	Soil depth	Score	Oleckno method
<250	21	Clay silt or clay and sand	12	1.5-3	3	Good: 24-42
255-760	7	Silt and soft sand	5	3-6	7	Acceptable: 21-23
765-1780	6	Mud	4	6-9	8	Unacceptable: >20
-	-	Gravel and cobble	0	<9	9	-

Figure 1: New sanitary landfill site location of Isfahan

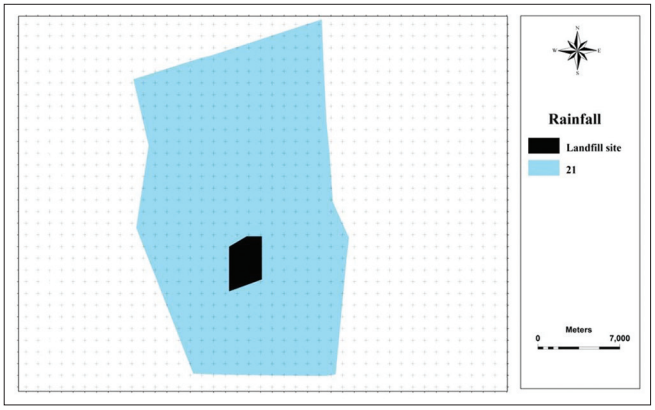

Figure 2: Rainfall rate in the new sanitary landfill sites of Isfahan

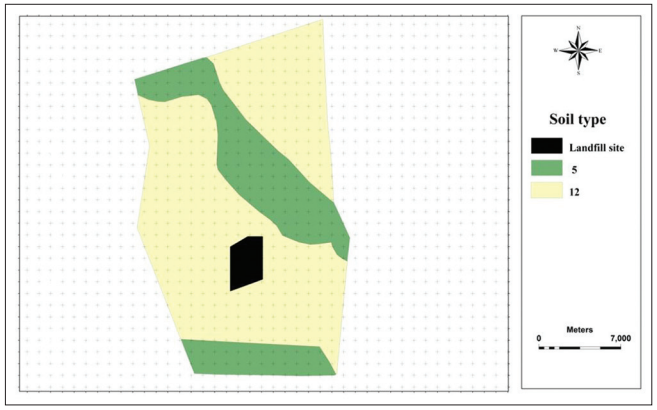

Figure 3: Soil type in the new sanitary landfill sites of Isfahan

type of the region and the distance of groundwater table depth from the bottom of new sanitary landfill site and is shown after layers overlay in Figure 5. After layers overlay in GIS and scoring to each of the layers, the ranks 33, 40 and in some regions 41 were achieved based on OI and solid waste sanitary landfill site with the score of 40 is established [Figure 5].

DISCUSSION

The new sanitary landfill site of Isfahan is located in the eastern of the city and in the Segzi region. Sanitary solid waste landfill sites have high potential in contaminating environment. Therefore, their risk management and assessment has been useful tool to protect environment and human being health against the adverse effect of landfill sites. Sanitary landfill is one of the common methods of municipal solid waste disposal and leachate of these sites works as a strong wastewater. This liquid causes acute and chronic toxicity in the environment. On the other hand due to being mixed with surface water and penetrating to groundwater makes water, and soil resources polluted,[10] so it has high potentiality in contamination of groundwater. In fact leachate generation rates are mainly dependent on the amount of liquid the waste originally contained, quantity of rainfall that enters the landfill through the cover or falls directly on the waste, and surface water and groundwater entering the land filled waste, where leachate enters surface waters or groundwater impact on water quality. Clay improved soil texture of landfill because small colloidal size and high specific surface area make them highly reactive and strong physical and chemical interactions with fluids and dissolved species. The most important characteristic of clay is the presence of negative surface charges, which permits clay to adsorb different kind of molecules such as organic

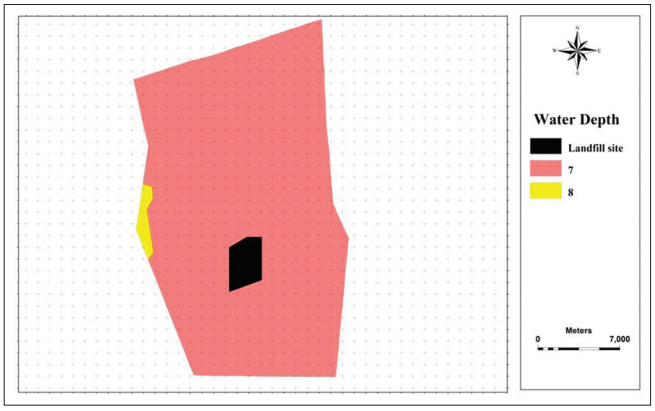

Figure 4: Groundwater table depth from the bottom in the new sanitary landfill sites of Isfahan

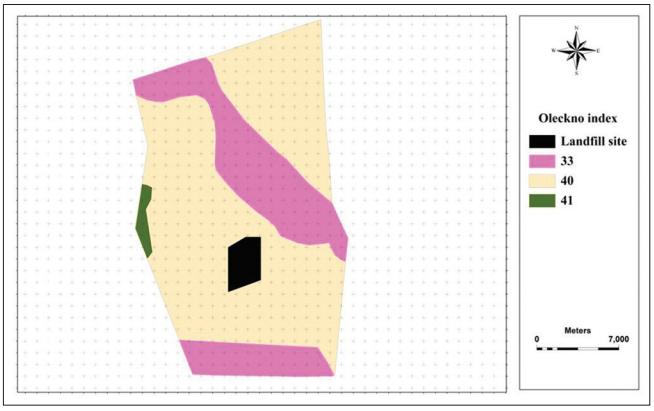

Figure 5: Oleckno method of the new sanitary landfill sites of Isfahan

and inorganic cations. According to Figure 5, the condition of this landfill is good.[11] Pourahmad *et al*., found that the current location of Babolsar landfill has an inappropriate environmental situation. This landfill site show tangible kind of poor urban and regional management which risk the sustainable development of the area.[6] Zamorano *et al*., reported suitable locations for the sanitary landfill. The environmental values revealed the suitability of this landfill site in addition to its nominal negative impacts on the environment.[7] Chang *et al*., establish that fuzzy multi-criteria decision making in GIS helps decision makers for the selection or rejection of solid waste landfill site, so that by this method the best place for waste landfill was selected in the south of Texas.[8] Sener *et al*., found that 73.70% of proposed sites were determined to be completely inappropriate for a landfill site.[3]

As it has already been mentioned, Oleckno index is a method for evaluation of sanitary municipal solid waste landfills. In this method, parameters such as rainfall, soil characteristics, and groundwater table depth are considered in order to the dangers of leachate and underground water pollution. The integration of Oleckno methods with GIS provides a mechanism to explore problems and immediate feedback for decision makers.

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