

Environmental impact assessment of Gonabad municipal waste landfill site using Leopold MatrixSeyed Ali Sajjadi¹, Zohreh Aliakbari², Mohammad Matlabi³, Hamed Biglari⁴, Seyedeh Samira Rasouli⁵

¹ Ph.D. of Environmental Health, Associate Professor, Department of Environmental Health Engineering, School of Public Health, Social Determinants of Health Research Centre, Gonabad University of Medical Sciences, Gonabad, Iran

² M.Sc. of Environmental Health, Department of Environmental Science, Faculty of Natural Resources, Tarbiat Maodares University, Tehran, Iran

³ Ph.D. of Health Education, Assistant Professor, Department of Health Education & Promotion, School of Public Health, Gonabad University of Medical Sciences, Gonabad, Iran

⁴ M.Sc. of Environmental Health, Senior Lecturer, Department of Environmental Health Engineering, School of Public Health, Social Development & Health Promotion Research Center, Gonabad University of Medical Sciences, Gonabad, Iran

⁵ M.Sc. of Environmental Health, Senior Lecturer, Department of Environmental Health Engineering, School of Public Health, Student Committee Research, Gonabad University of Medical Science, Gonabad, Iran

Type of article: Original

Abstract

Introduction: An environmental impact assessment (EIA) before embarking on any project is a useful tool to reduce the potential effects of each project, including landfill, if possible. The main objective of this study was to assess the environmental impact of the current municipal solid waste disposal site of Gonabad by using the Iranian Leopold matrix method.

Methods: This cross-sectional study was conducted to assess the environmental impacts of a landfill site in Gonabad in 2015 by an Iranian matrix (modified Leopold matrix). This study was conducted based on field visits of the landfill, and collected information from various sources and analyzing and comparing between five available options, including the continuation of the current disposal practices, construction of new sanitary landfills, recycling plans, composting, and incineration plants was examined. The best option was proposed to replace the existing landfill.

Results: The current approach has a score of 2.35, the construction of new sanitary landfill has a score of 1.59, a score of 1.57 for the compost plant, and recycling and incineration plant, respectively, have scores of 1.68 and 2.3.

Conclusion: Results showed that continuation of the current method of disposal, due to severe environmental damage and health problems, is rejected. A compost plant with the lowest negative score is the best option for the waste disposal site of Gonabad City and has priority over the other four options.

Keywords: Environmental impact assessment, Modified Leopold matrix, Iranian matrix, landfill, Gonabad

1. Introduction

Various methods have been devised and used to create balance and harmony between human activity and the environment (1-5). The purpose of using these methods is modification and minimization of the negative effects and consequences of human activities by using a set of protective and reform measures (6, 7). An environmental impact assessment (EIA) is one of the best ways to assess the impacts of sections or activities of a project on the components of the environment by identifying and understanding the importance of the environment; finally,

Corresponding author:

Seyedeh Samira Rasouli, Department of Environmental Health Engineering, School of Public Health, Student Committee Research, Gonabad University of Medical Science, Gonabad, Iran.

Tel: +98.5157225027 Fax: +98.5157223814, Email: srasouli6888@gmail.com

Received: June 10, 2016, Accepted: January 14, 2017, Published: February 2017

iThenticate screening: October 31, 2016, English editing: January 28, 2017, Quality control: February 06, 2017

© 2017 The Authors. This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

according to its results, it provides solutions to create greater consistency (8, 9). This action is a decision-making process in order to reduce the impact of human activities on the environment through changes in how the project is done or if it needs to prevent its construction (10). Among the assessment procedures followed in Iran, the matrix method is highly regarded and has shown effectiveness in many projects. This method presented by Leopold in the late 1960s in the global arena is a technic that considers all the environmental consequences of a project and is approved by the American National Environmental Law; this method was used in this study (11, 12). Many environmental problems are caused by increased production of municipal solid waste, which causes pollution of soil, surface, and groundwater and the air. Traditional views regarding the release and open dumping cause and exacerbate many problems and environmental effects (13, 15). Proper control and waste management play important roles in improving the quality of the environment and thereby promote public health and wildlife protection (16, 17). For this reason, according to paragraph A of Article 192 of the Fifth Development Plan of the Islamic Republic of Iran, landfills are projects for which an environmental impact assessment must be conducted. In recent years, many studies in Iran have been conducted to evaluate the environmental impact of projects; for example, Elahabadi et al. conducted a descriptive study on a compost plant in Sabzevar using the Leopold matrix in 2010. According to the results and comparing the positive and negative effects, the plant's design and its implementation in the intended site were possible and have a positive rating (18). Another study was conducted in the same way: proposed landfill options for special waste were evaluated in Khorasan Razavi. In that study, eight suggested sites were prioritized in the first phase of site selection studies in terms of environmental conditions; ultimately, three options were reported as the best options for construction of landfill (19). Municipal solid wastes of Gonabad have been disposed in traditional and improper methods in the current landfill at 15 kilometers north of the city for many years. The population of Gonabad was 36,367 people in 2011, and the daily production of waste, on average, is 45 tons. Any initial processing is not performed on waste. Waste is dumped into pits (depth of 3 meters) dug by machinery (tranche method). The lack of a proper drainage system to collect leachate and landfill gas is one of the current problems, thereby releasing offensive odors around the landfill and increased risk of explosion. There is no lining in the base of landfill, so leachate can easily infiltrate and pollute the soil. Also there is no suitable site for hazardous and hospital wastes that are collected separately. Because of improper enclosure of the disposal site, low weight wastes such as paper and plastic easily flow out of place with the wind. This problem can be intensified according to information received from the wind rose in the spring and summer, with southeast winds and southwest winds in autumn and winter. In addition, the transfer of smell through wind also can be increased. Part of the collection path is a dirt road, and movement of heavy waste collection vehicles causes the release of particulate matter into the air and reduces the air quality of the landfill. Another problem is noise pollution caused by the heavy machinery. Total noncompliance with environmental standards and regulations, lack of cooperation on source separation, the unsuitability of the landfill and disposal method in Gonabad's landfill are concerns that have caused many problems, especially in environmental and human health. Prior to this study, no study has been done to assess the environmental impact of this landfill. Due to the growing population in Gonabad and especially in the increase of immigration from surrounding towns, increasing the amount of waste generated in the city is inevitable, and, according to the current improper conditions in the landfill, there are threats to public health of citizens and ecologically, along with biological threats to flora and fauna populations. The main objective of this paper was to assess the environmental impacts of the current municipal solid waste landfill of Gonabad by using the Iranian Leopold matrix method (Iranian matrix) and reporting its negative environmental consequences.

2. Material and Methods

This cross-sectional study was carried out to assess the environmental impacts of Gonabad's landfill in 2015. This city is located in a warm and dry region in the southern province of Khorasan Razavi. Landfill soil is impermeable black kaolin, and underground waters in this area are in the high depth of the soil. In this study, the city's current landfill was evaluated with field visits to gather information from different sources. Gonabad's landfill is located in the 15 km of Gonabad-Mashhad road, latitude 34 degrees 54 minutes and longitude 50 degrees 52 minutes. This place is located 1 km from the road. The landfill area is intended for the 100 hectares; it was built and operated in 2010. The environmental impact assessment (EIA) was conducted to evaluate environmental effects of Gonabad's landfill. The most common methods of EIA in the world are the matrix, tables, network, maps overlay, and GIS modeling. Each of these methods has its strengths and weaknesses. Selection procedure for conducting EIA depends on various parameters such as type of project, environmental conditions, costs, timing, and available field and library information. In this paper, we evaluated the environmental impacts of landfill in Gonabad using the Iranian matrix. The matrix method, as a common method, with the overall judgment of average, has no particular separation of time and place in the evaluation. However, being standard and scientific, the reliability of evaluation criteria can be achieved by this method. This matrix contains 100 works on the horizontal axis (columns) and 88 environmental

factors on the vertical axis (rows), which formed a table or matrix with 8800 cells; any cell is an intersection of an activity from the horizontal axis and a parameter from the vertical axis. Matrixes has been formed for four environments (physical, biological, economic, and social) on the horizontal axis and activities that happened in various stages of the project on the vertical axis. In this method, the matrixes have been scored for each of the proposed options (current landfill, compost plant, recycling plant, incineration, sanitary landfill) in constructional and operational phases separately (20, 21). Table 1 shows the range and impact of environmental effects on each of environmental parameters. After scoring the matrix, the results were concluded in Excel software, and the combination of positive and negative effects on both phases of activities and final conclusion took place. The final calculated score is the base of decision-making. The final result is achieved as follows: if any of the options of the final score is less than -3, that option is rejected; if the final score of options is more than -3, that option is acceptable with corrective measures (22, 23).

Table 1. Range of effects on any of the environmental parameters

Value	Negative Effects	Value	Positive Effects
-5	Enormous Negative Effects	5	Enormous Positive Effects
-4	High Negative Effects	4	High Positive Effects
-3	Intermediate Negative Effects	3	Intermediate Positive Effects
-2	Low Negative Effects	2	Low Positive Effects
-1	Very Low Negative Effects	1	Very Low Positive Effects

3. Results

On average, 40 tons of municipal solid waste is produced daily in Gonabad. According to physical analysis, organic waste by 70% and plastic by 9% are the most common type of waste produced in Gonabad. Overall, about 90% of Gonabad’s waste, including organic waste, plastic, paper, metal and glass, are reusable (composting and recycling). Environmental impact assessment waste management options in Gonabad were conducted for constructional and operational phases of waste management options by using the Iranian Leopold matrix. In the process of scoring, in both construction and operation phases, positive and negative effects of all activities on the environment components were considered. The average of negative effects was a result of positive and negative effects of each option. A comparison of the final results of the environmental assessment of five options in this study by the Iranian Leopold matrix, in order to prioritize and identify the optimal choice for waste management in Gonabad, is presented in Table 2. The results showed that, despite the current open dumping option having no construction phase, the most negative effect is related to this option with a score of -2.35. Comparing the average negative environmental impacts of each option showed that a composting option has the least negative environmental impact. In total, in all options studied in the construction and operation phases, most negative effects on the physical, biological, socio-economic environments were related to noise pollution, air quality, land ecosystems, income and costs, and an increase in real estate prices, respectively; in the case of cultural environment, most negative effects were related to landscapes and social acceptance. In current open dumping of waste, soil characteristics in the physical environment, vectors in biological environment and health indicators and important diseases in operational phase have the greatest negative effects. In all, of the four proposed alternative options, social acceptance has less negative points than the current option.

Table 2. Iranian matrix results in both construction and operation levels

Options		Open Dumping	Sanitary Landfill	Composting Plant	Recycling Plant	Incineration
Construction level	Physical	-	-2.3	-1.4	-2.2	-2.37
	Biological	-	-1.49	-1.41	-1.66	-1.96
	Socio-Economic	-	-1.62	-1.71	-1.61	-1.8
	Cultural	-	-1.53	-1.69	-1.61	-1.75
Average		-	-1.71	-1.55	-1.77	-1.97
Operation Level	Physical	-3.03	-1.63	-1.73	-1.9	-2.78
	Biological	-2.36	-1.49	-1.63	-1.63	-2.64
	Socio-Economic	-1.63	-1.61	-1.71	-1.27	-2.93
	Cultural	-2.37	-1.15	-1.31	-1.58	-2.17
Average		-2.35	-1.47	-1.6	-1.59	-2.63
Final score of Leopold matrix		-2.35	-1.59	-1.57	-1.68	-2.3

4. Discussion

This study aimed to assess the environmental effects of waste management options, including sanitary landfill, current open dumping and recycling, composting and incineration plant by using the Iranian Leopold matrix in the city Gonabad. Summing up the results of the Iranian Leopold matrix showed that the first option (current open dumping), with a score of -2.35, has more negative impacts than other options; thus it was selected as the fifth priority for waste management in Gonabad. Environmental impact assessment has been done only for the operational phase in this option because this option does not need sanitary landfill facilities and advanced equipment. According to the final score of this option (-2.35), running this option has severe negative effects on environmental components (Table 2), and its implementation is rejected. This is mainly because of the nonconformity with environmental regulations and nonstandard nature of this method on waste management. Negative effects on the physical components mainly due to the exposure of soil and groundwater to wastes and leachate (3).

Improper disposal of municipal solid waste can cause a large entrance of hazardous pollutants to the environment. In this option, there are fewer negative effects on economic components because it has less investment and operation costs and requires simpler equipment than other options. The second option (sanitary landfill), with a final score of -1.59, has weak negative consequences on the environment components. The negative effects of the implementation of this option are mainly related to socio-economic components and costs of digging the trenches and use of multilayer coatings (15). According to the final score of the option (-1.59), its implementation was the second priority among waste management options. Iranian Leopold matrix results indicated that the third option (compost plant) with a final score of -1.57, has the lowest negative effects in five studied options and was selected as the first priority in waste management in Gonabad. According to Table 2, the negative impact of this option was the less than the other options; however, this option also will have weak negative consequences on the environment components. The highest negative rates are related to high costs of implementing this option in its construction phase; but since about 70% of the city's waste composition consists of biodegradable organic matters, the proceeds from the sale of compost, the project will be justified economically. Other advantages of this option are creation of job opportunities and the return of consumable materials and reducing the use of resources.

The fourth option (recycling), with a final score of -1.68, was designated as the third priority for waste management in Gonabad. Because only about 22% of the waste in Gonabad are recyclable components, and, due to the need for sophisticated equipment to separate and recycling sites and construction costs, the desirability of implementing this option in Gonabad has been less than composting and sanitary landfill options. The fifth option (incineration) because of deficiencies such as high initial investment and maintenance costs, air pollution, odor and smoke problems and need to dispose of residual ash from the combustion process, with a final score of -2.3, was selected as the fourth priority among the five options. At present, unsanitary disposal of waste is being done in Gonabad, which has high negative effects, and it is expected to continue this trend, which will cause irreversible effects on environmental components. Environmental assessment of five different options for waste management in Gonabad demonstrated that a compost plant with a final score of -1.57 has the least negative impacts. In a similar study done in Birjand, the results were similar to those in the present study, and composting options were the first priority in waste management (23). Also, in another study in which the environmental impacts of solid waste landfill in Shahrekord (3) were evaluated, consolidated compost-recycling option was introduced as the first priority of waste management. The similarities and differences from recent studies and the present study were mainly because of the different composition of waste and weather conditions in studied areas.

5. Conclusions

The results of this study showed that the current option (open dumping), due to severe environmental damage and health problems, has been rejected and will not be responsible for waste management over the years. Compost plant options with the lowest negative score (-1.57) was the best option for waste management in Gonabad.

Acknowledgments:

The authors gratefully acknowledge the Student Research Committee (Deputy of Research and Technology, Gonabad University of Medical Sciences) for financial support and also the respectable personnel of the Gonabad Municipality and Environmental Protection Organization.

Conflict of Interest:

There is no conflict of interest to be declared.

Authors' contributions:

All authors contributed to this project and article equally. All authors read and approved the final manuscript.

References:

- 1) Amini SM, Gilaki M, Karchani M. Safety of Nanotechnology in Food Industries. *Electron Physician*. 2014; 6(4): 962-8. doi: 10.14661/2014.962-968. PMID: 25763176, PMCID: PMC4324265.
- 2) Vatankhah S, Mokarami H, Karchani M, Hosseini Z, Izadi B, Moradi F. Effect of executive programs of infection control committees on the prevalence of nosocomial infections in Kermanshah's Hospitals (2010-2011). *Electronic Physician*. 2014; 6(1): 768-70. doi: 10.14661/2014.768-70. PMID: 25763143, PMCID: PMC4324287.
- 3) Najafi TF, Bahri N, Ebrahimipour H, Najari AV, Taleghani YM. Risk Assessment of Using Entonox for the Relief of Labor Pain: A Healthcare Failure Modes and Effects Analysis Approach. *Electron physician*. 2016; 8(3): 2150-9. doi: 10.19082/2150. PMID: 27123224, PMCID: PMC4844482.
- 4) Mohammadfam I, Soltanzadeh A, Moghimbeigi A, Savareh BA. Analysis and Modeling of Threatening Factors of Workforce's Health in Large-Scale Workplaces: Comparison of Four-Fitting Methods to select optimum technique. *Electron physician*. 2016; 8(2): 1918-26. doi: 10.19082/1918. PMID: 27053999, PMCID: PMC4821305.
- 5) Asefzadeh S, Varyani AS, Gholami S. Disaster Risk Assessment in Educational Hospitals of Qazvin Based on WHO Pattern in 2015. *Electron physician*. 2016; 8(1): 1770-5. doi: 10.19082/1770. PMID: 26955448, PMCID: PMC4768927.
- 6) Taghavi SM, Momenpour M, Azarian M, Ahmadian M, Souri F, Taghavi SA, et al. Effects of Nanoparticles on the Environment and Outdoor Workplaces. *Electron Physician*. 2013; 5(4): 706-12. doi: 10.14661/2013.706-712. PMID: 26120406, PMCID: PMC4477780.
- 7) Sharif MR, Soltani B, Moravveji A, Erami M, Soltani N. Prevalence and Risk Factors associated with Extended Spectrum Beta Lactamase Producing *Escherichia coli* and *Klebsiella pneumoniae* Isolates in Hospitalized Patients in Kashan (Iran). *Electron Physician*. 2016; 8(3): 2081-7. doi: 10.19082/2081. PMID: 27123215, PMCID: PMC4844472.
- 8) Canter L. Environmental impact assessment. second editor: McGraw Hill.
- 9) Glasson J, Therivel R, Chadwick A. Introduction to environmental impact assessment: Routledge; 2013.
- 10) Gholamalifard M, Mirzaei M, Hatamimanesh M, Riyahi Bakhtiari A, Sadeghi M. Application of rapid environmental impacts assessment matrix and Iranian matrix in environmental impact assessment of solid waste landfill of Shahrekord. *Journal of Shahrekord University of Medical Sciences*. 2014; 16(1): 31-46.
- 11) Makhdum M. Four Notes in assessing the developing impact. *J Environ Develop*. 2009; 2(3): 9-12.
- 12) Monavari M. Dams' Environmental Impact Assessment Guide, Strengthening basic environmental impact in Iran: Iran Environmental Protection Agency and UNDP; 2001.
- 13) Lohani B, Evans J, Ludwig H, Everitt RR, Carpenter R, Tu SL. Environmental Impact Assessment for Developing Countries in Asia. Asian Development Bank. 1997; 1: 356.
- 14) Lorber M, Pinsky P, Gehring P, Braverman C, Winters D, Sovocool W. Relationships between dioxins in soil, air, ash, and emissions from a municipal solid waste incinerator emitting large amounts of dioxins. *Chemosphere*. 1998; 37(9): 2173-97. doi: 10.1016/S0045-6535(98)00279-3. PMID: 9828336.
- 15) Yenigül NB, Elfeki AM, Gehrels JC, Van den Akker C, Hensbergen AT, Dekking FM. Reliability assessment of groundwater monitoring networks at landfill sites. *Journal of Hydrology*. 2005; 308(1): 1-17. doi: 10.1016/j.jhydrol.2004.10.017.
- 16) Hurst C, Longhurst P, Pollard S, Smith R, Jefferson B, Gronow J. Assessment of municipal waste compost as a daily cover material for odour control at landfill sites. *Environ Pollut*. 2005; 1(135): 171-77. doi: 10.1016/j.envpol.2004.09.004. PMID: 15701404.
- 17) Ridgway B. Environmental management system provides tools for delivering on environmental impact assessment commitments. *J Impact Assess and Proj Apprais*. 2005; 4(23): 325-31. doi: 10.3152/147154605781765373.
- 18) Elahabadi A, Rahmani A, Behroozikhah M. Environmental Impact Assessment of Compost Plant in Sabzevar, Iran. *Journal of Sabzevar University of Medical Sciences*. 2010; 17(4): 281-86.
- 19) Moghadas NH, Hajizade H, editors. Environmental impact assessment of the proposed special waste landfill options in Khorasan Razavi. *Geology and Environmental pollutants*; 2008.
- 20) Glasson J, Therivel R, Chadwick A. Introduction to environmental impact assessment. 4th Edition. Routledge; 2012.

- 21) Monavari M. Environmental impact assessment guideline for municipal solid waste landfills. Tehran Municipality of Tehran organization of waste-material recycling and composting deputy of education and research; 2002: 16-7.
- 22) Soumare M, Tack F, Verloo M. Characterization of Malian and Belgian solid waste composts with respect to fertility and suitability for land application. *Waste Management*. 2003; 23(6): 517-22. doi: 10.1016/S0956-053X(03)00067-9. PMID: 12909092.
- 23) Valizadeh S, Shekari Z. Evaluation of Iranian Leopold Matrix application in the Environmental Impact Assessment (EIA) of waste management options in birjand city. *Iran J Health and Environ*. 2015; 8(2): 249-262.