Journal of Environmental Sciences Studies (JESS)

Journal homepage : www.jess.ir

Prioritizing of Strategies for The Ecological Design of Urban Waste Transfer Stations Using SWOT Analysis

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Received: (December-29-2019)
Accepted: (January-27-2020)

Abstract

Comprehensive waste management represents a broad range of challenges that affect human health and the environment. Although the operation of urban waste transfer stations (WTS) has been successful in reducing transportation costs, the environmental impacts of them, impose a threat on public health and comfort. This research studies the environmental issues and pollutions produced by Darabad WTS, and presents priority assessed ecological design strategies to reduce and control the pollution discharged by the activities carried out at the station. Applied research methodology and descriptive-analytical approach are the methods utilized in this study. The descriptive approach relies on the surveys conducted in the field. In the analytical approach, the collected data on the environmental Weaknesses, Strengths, Opportunities, and Threats (SWOT) of the Darabad WTS are analyzed, and the design strategies are assessed based on the SWOT method. The results show that the total weight of the internal factors is 2.22, while the total sum of external factors is 3.02. Results imply the dominance of the external factors over the internal factors. Offensive strategies for station design are also a priority. The severity of the environmental impacts of the WTS can be reduced by applying the ecological criteria to the extent possible.

Keywords:
Ecological design; Solid waste; Strategic planning; SWOT; Transfer station

1. Introduction

Evaluation of the world's environmental status indicates that not only have human and environmental impacts not been mitigated, but more acute issues such as water and soil pollution, biodiversity depletion, ozone depletion, greenhouse effect, and global warming have occurred. One of the apparent effects of urban development on environmental, economic, and social issues is the waste generated in urban areas. Waste transportation and disposal directly linked to public health, soil, and air pollutioncreate global warming caused by methane pro duction, especially in landfills (Ferronato and Torretta, 2019). The city of Tehran, one of the world's largest cities, generates more than 8,000 tons of urban solid waste per day. A large amount of the generated waste, with high population growth rate, have increased the demand for an efficient, and effective waste management amount in the city in the recent decade (Minghua et al., 2009, Rupani et al., 2019a, Saraei et al., 2016). Prior to implementation of the new collection system, an approximate of 1,200 main and sub- waste facilities existed in the city, spread along the streets, and among the residential buildings and hospitals. These facilities were used as transfer stations. The collected waste was being discarded by laborers at these stations and transported to the final disposal site by truck. Implementation of the new collection system eliminated these facilities, and 11 transfer stations were constructed to replace these facilities. Waste transfer stations are constructed in case the landfill or other facilities within the waste management system are located distant from the gravity points of the waste generation. These transfer stations are designed t o avoid the transportation vehicles and machineriesinte rfering directly with the landfill or other facilities (Daryabeigi Zand, 2017). Evaluation and assessment of the waste collection process revealed the collection system has not succeeded in reducing the pollution in the waste disposal process in developing countries (Abdel-Shafy and Mansour, 2018, Firdaus and Ahmad, 2010). This pertains to the relatively low-performance efficiency of the collection system, mainly due to cultural complexity, urban tissue status, and lack of awareness and uncooperative community. However, the operation of the transfer stations despite the challenges in ownership status, lack of open spaces within the city, and the rising economic concerns has succeeded in reducing the waste transport costs (EPA, 2002). Even so, the improper foundation of the

stations, disregarding the environmental hazards, and not taking the health risks to the station's workforce into consideration, the operation poses not only a negative impact but also a great threat to the neighboring environment. The ecological design is a design approach in the quest to plan asafeandgentleintegration with the environment consid ering the environmental impacts in the design process. Hence, ecological design is founded on the basis of the local environmental features. The first step in ecological design is to prevent environmental deterioration and to attempt to stabilize and restore the environment to p re disturbance conditions (Zemanek et al., 2011, EPA, 2002). Urban areas adhering to the ecological design principles encompass features like weather, geographical and environmental factors such as sunlight and wind optimization, high-quality water and decent urban water management, quiet and cleanenvironments with good climate, low or no carbo n dioxide emissions and exploitation of renewable ener gy resources, with a closed loop recycling, reproductio n, and fertilizerproduction (Marianov and Serra, 2003). Environmental pollution is a major drawback of waste transfer stations. The environmental impacts of these transfer stations are identified the emanated unpleasant odor from the waste, the noise pollution produced by transportation vehicles andthe activities in the station, leachate dispersions in t he surroundings, accumulation of noxious insects and vermin at the stations, visual pollution of the landscape, and posing health risks and threats to the public health. A recent research study has identified the natural environment and green spaces to significantly contribute to improving the physical strength and the mental health of the inhabitants of cities. The major environmental problem in cities is the noise pollution caused by machines and transportation. Studies have indicated that exposure to noise pollution for extended periods of time disrupts the body's physiological system causing hyper tension conditions, impairment of attention and memor y, change in social behaviors, and sleep disorder (Bluh m et al., 2007, Organization, 2017). Green spaces respond to the ecological, biological, functional, and aesthetic needs of industrial sites. In the case of ecological and biological needs, the green spaces reduce the pollutants, and the adverse environmental conditions to preserve the regional ecos ystem and prevent environmental degradation. Besides , constructing facilities such as sports complex, and service spaces provide the desired environment for the employees to relax. The green space is also useful in creating functional spaces for recreational activities, and enclosure space, reduce the wind speed, and the light intensity. The rigid form of the industrial spaces signifies the use of vegetation in these spaces to improve the landscape quality and balance the hard tissue of the space (Farzamfar et al., 2014). Trees are known as an important reduction factor of urban pollution. The efficacy of the trees as noise barriers in blocking the noise and noise pollution reduction varies by the tree species. The level of noise reduction additionally depends on the height, density, and location of the trees, and the climatic conditions. Trees also contribute to the reduction of noise health effects, indirectly by improving the weather conditions. Plants impact the sound through sound absorption, sound reflection, and sound deviation (Fan et al., 2010). In the study of (Omrani et al., 2012), the environmental and hygienic aspects of the waste transfer stations concerning the amount of leachate present in the station area, and the odor and pollutant emissions were investigated during the station operation in residential areas in Tehran. The results show that 90% of the stations lack proper sanitation, adequate worker accommodation, and personal protective equipment, the appropriate appearance of the waste disposal system, and available solutions toregulatethe station's condition. For leachate contamin ation control and odor emission and environmental tox icity prevention, management principles are presented. In a study, the evaluation of optimal approaches in urban services with the focus on urban waste, based on the SWOT analysis method was studied. The research findings suggest the decisions and prioritiesofcitizens in Mashhad and a sustainable envir onment with a strategic perspective(Mafietal.,2013). In another study, SWOT model was applied in developin g management strategies to improve waste managemen t in Ardabil in a study aiming at providing solutions to sustainable development, environmental protection, and urban health promotion. Results showed that the current waste management in Ardabil to be poor in internal factors while the external factorsarerelatively acceptable in terms of opportunitie s and threats(Abdollah,2016). The supporting strategie s in waste management promotion by engaging the sta keholders was studied in Shenzhen, China, and present ed seven key strategies to improve the waste managem ent in the city of Shenzhen(Yuan,2013). (Omranietal.,2 002) Studied the environmental aspects of the waste tr ansfer stations using sampling andmeasurement metho ds considering the odor emission, noise dispersion, and leachate contamination status, during the operation of the stations in residential areas. Analyzing the question naire surveying the residents indicated that 80% of the residents suffer from noise pollution during midnight activities at the stations, and 85% of the residents suffer from the waste odor. Since the leachate collection system use wells to collect leac hate from the landfill, the improper flooring at these st ations caused the leachate contamination to enter the s oil or underground and surface water (Omranietal.,200 2). In view of the significance of plants in reducing the various environmental pollutions including air, water and soil pollutions, the present study aims to provide prioritized strategies for the ecological design principles of the urban waste transfer stations using the practical impacts of the plant species on improving the

environment by creating optimal visual corridors, and reducing the destructive effects of the environment. Tehran had 23 waste transfer stations in the 1990s. Lack of attention to locating criteria, failure to observe health, and the lack of environmental laws in most of these stations, leads to the closure of some of these centers. Currently, the city of Tehran has 11 waste transfer stations, which collect and transfer daily over 8000 tons of municipal wastes to the Aradkouh final disposal site (Daryabeigi Zand et al., 2019, Rupani et al., 2019b).

2. Materials and Methods

This work presents an applied research study conducted using the descriptive-analytical research methodology. The descriptive section was carried out using field surveying and investigating the criteria for locating the municipal waste transfer stations. In the analytical section, based on the collected data, strengths, weaknesses, opportunities, and threats of the environment in Darabad solid transfer station were investigated. SWOT model is used for analyzing data, and formulating the optimal strategies. The current study has been carried out in Tehran in 2019.

2.1. Study area

Darabad solid waste transfer station selected for the present study, which is situated in District 1 of Municipality of Tehran. Darabad neighborhood is located in the northeast of the Tehran metropolitan, which is one of the largest cities in West Asia and is the 21st largest city in the world, with a population of 13,267,637 in 2016. It is located at 35.5044°N latitude and 51.2935 °E longitude (Figure 1). Darabad waste transfer station with the capacity of 1200 Tons waste handling with the area of 1.6 hectares was established in 2005 to reduce environmen tal issues related to waste transfer stations. The station is 56 kilometers from the Aradkouh final disposal site. The daily average of loading and unloading of waste in this station is 550 tons/day. Unfortunately, due to soil pollution, vegetation is not significant on this station.

Figure 1. Location of Darabad solid waste transfer station in Tehran

2.2. SWOT Analysis

The word SWOT is made up of the first four letters of the word Strengths, Weaknesses, Opportuniti es and Threats (SWOT). SWOT analysis consists of a s trategic method for planning and assessing the internal and external factors (Bas, 2013, Solangi et al., 2019). The SWOT technique is an important tool in developing strategy through data comparison (Hom Haacke, 2001, Kamran et al., 2020, Srdjevic et al., 2012). In the present study, the environmental factors for both internal and external environments of the Darabad transfer station were identified by forming a working group from the management experts and administrators working on the site and the related management working in the District 1 of Municipality of Tehran, and reviewing the existing reports and documents. Through identifying the environmental factors, in the next step, a list of strengths, weaknesses, opportunities, threats are prepared. The Internal Factor Evaluation (IFE) and External Factor Evaluation (EFE) matrices were used to evaluate the internal and external factors. The internal factors are performed to interoperate and highlight the strengths and weaknesses of any sort of strategic planning, whereas external factors are conducted to explore the associated opportunities and threats (Alptekin, 2013, Paliwal, 2006, Terrados et al., 2007). The final score of each matrix at this stage represents the status of the station's performance in accordance with the internal and external factors. In the IFE matrix, the internal factors corresponding to the strengths and weaknesses of the station are listed, and to assign importance to the factors in a group, a weight coefficient in the range of 0-1 was determined for each factor, with 0 representing the lowest importance and 1, representing the highest importance in the group. The factors are then scored in the scale of 1-4. The score 1 indicates a major weakness, and score 2 indicates a minor weakness, while the score 3 indicates a strength, and score 4 indicates a very high strength for the factor under the evaluation. To determine the final score of each factor, the weight coefficient of the factor is multiplied by its score. The sum of final scores of each factor determines the total score. These steps are repeated for the EFE matrix to evaluate the factors corresponding to the opportunities and threats at the transfer station. A final score greater than 2.5, in the IFE matrix indicates the strengths are greater than the weaknesses, and in the EFE matrix indicates the opportunities are greater than the threats, while a final score of less than 2.5 is interpretedoppositely(omranietal.,2010). The next step involves producing the SWOT table based on the list of strengths, weaknesses, opportunities and threats in Darabad solid waste transfer station. Comparing the internal strengths and e xternal opportunities, strategies are determined in four different categories (Pourahmadet al., 2013). These categories are the aggressive strategies (SO): Their focus is on the internal strengths and external opportunities. The conservative strategies (ST) focus on the internal strengths and the external threats. Competitive strategies (WO) focus on the internal weaknesses, with an attempt to exploit the external opportunities in order to overcome the internal weaknesses. Defensive the final score in each section determines the overall design status of the design strategies for Darabad transfer station. Each division

holds a factor that keeps a total score of the weighted score of the individual factor. Connecting the points of each section on their correspondingaxes draws a shape that is the indicator of the status of the design strategies as if more inclined and stretched towards a specific side. It should be noted that in identifying the internal and external environmental factors, the strategies determined in the SWOT table, and assigning the score values opinions of the experts in different sectors of thewastemanagementsuch as environmental engineering and environmental health engineering andenvironmentalmanagementwere considered. Based on this method, it is appropriate to minimize strengths and opportunities to maximize the weaknesses and threats. Strategies (WT): which are offered to address internal weaknesses and external threats (Sevkli et al., 2012).

3. Results & Discussion

To prioritize the design strategies for Darabad transfer station, the SWOT model is used for strategic analysis. Tables 1 and 2 list the internal and external factors of the Darabad transferstation,thefactors were evaluated and weighed in these tables. According to tables 1 and 2, the weighting the environmental factors of the transfer station, the weight coefficient of 0.05 is assigned to the most important strengths and the pollution of the air, soil, surface water and groundwater as the most significant weaknesses are weighted with the coefficient of 0.08. In addition, the use of leachate treatment system for reusing the water on site in irrigating the green spaces of the station with the weight coefficientof0.09 is considered to be the most important opportunity, while the increased probability of disease being transferred from animals and insects on the site with the weight coefficient of 0.07 has been evaluated as the most important threat of the Darabad station.Inthe score column, the score of the factors in scale of 1 to 4, as discussed earlier, is presented. In the last column, the results of multiplicationoftheweightcoefficients by the scores of the factors are presented. The total sum of internal factors is equal to 2.22 while the total sum of external factorsequals3.02. The results signify the dominance of the external factors over the internal factors. In Figure 2, the executive strategies and priorities are mapped to the design of the Darabad transfer station establishment, and marked on their corresponding axes as the weight identified for the strengths, weaknesses, opportunities and threats on their corresponding axes, and connected to draw a geometric shape, indicating the status of the design strategies. The results verified that the strategies of the Darabad transfer station are close to aggressive strategies, and the authorities are recommended to take the advantages of the strengths and opportunities in developing the strategies.

Table 1: Internal Factor Evaluation Matrix (IFE) of Darabad Waste Transfer Station

Parameter	No.	Internal factors	weight	score	Weight coefficient
Strengths(S)					
Environmental, Biological	S1	Proper slope	0.05	4	0.2
	S2	The area has natural elevations	0.02	3	0.06
	S3	Darabad River	0.03	3	0.09
Physically	S4	Several main access to the site from multiple locations	0.03	4	0.12
	S5	High green space around the site	0.04	4	0.16
	S6	Collection and transportation of municipal waste by the municipality regularly and daily	0.02	3	0.06
Landscape	S7	The view of the mountains and the presence of the green spaces on the West Side	0.02	3	0.06
	S8	In the Western perspective, there is a visual pattern of continuity of vision	0.03	4	0.12
Economically	S9	Reducing the costs of waste transportation to the final disposal center through the establishment of the station	0.05	4	0.2
Social-cultural	S10	Existence of young population	0.04	3	0.12
	S11	Relatively high literacy rate	0.04	4	0.16
		Sum of the strength weight coefficients			1.35
Weaknesses (W)					
Environmental, Biological	W1	Air, soil, surface water, and groundwater pollution	0.08	1	0.08
	W2	Many groundwater resources around the area	0.03	1	0.03
	W3	Animals and insects carry pollution and disease from the station	0.05	2	0.1
	W4	High rainfall in this area	0.03	2	0.06
Physically	W5	Low site distance to water resources, residential areas	0.05	1	0.05
	W6	Illegal construction on land around the site	0.04	1	0.04
	W7	Lack of proper fencing and security to prevent people from accessing the site	0.02	2	0.04
	W8	Lack of recreational spaces for the station's staff	0.03	2	0.06
	W9	Lack of proper leachate collection system on station	0.04	1	0.04

	W10	Station's wastewater discharge into the municipal sewer system	0.05	1	0.05
Landscape	W11	Disrupt the visual rhythm and landscape due to the establishment of waste transfer facilities in the outdoor station	0.02	2	0.04
	W12	Unpleasant odor caused by waste storage in WTS	0.03	2	0.06
	W13	Undesirable visibility from outside the station into the site	0.01	2	0.02
Economically	W14	Lack of the municipality's ability to raise funds to improve contaminated WTS	0.02	2	0.04
	W15	Increasing construction around the site due to increasing land value and loss of green spaces in the region	0.01	2	0.02
Social-cultural	W16	High population growth rates, especially between 1996 and 2006	0.02	2	0.04
	W17	The low level of women's participation in society	0.03	1	0.03
	W18	Inappropriate health conditions for residents and staff	0.04	1	0.04
	W19	Lack of necessary expertise among station staff	0.03	1	0.03
		Sum of the weaknesses weight coefficients			0.87
		The sum of all internal factors			2.22

Table 2: External Factor Evaluation Matrix (EFE) of Darabad Waste Transfer Station

	No.	External Factor	weight	score	Weight coefficient
Opportunities (O)					
Environmental , Biological	O1	Use the slope of the ground to direct and collect leachate toward the treatment	0.08	4	0.32
Physically	O2	Short distance from the station to residential areas reduces waste collection and transportation costs	0.06	4	0.24
	O3	Converting WTS into a multipurpose space to attract public participation	0.08	4	0.32
Landscape	O4	Visibility of the mountain landscape from within the site	0.02	3	0.06
	O5	Improvement WTS landscape with proper design	0.06	4	0.24
Economically	O6	Using Renewable energy such as the sun to reduce electricity costs	0.04	3	0.12
	O7	Use of leachate treatment system for reuse of water for washing and car washing and irrigation of green spaces in WTS	0.09	4	0.36
	O8	Waste separation at WTS	0.07	4	0.28
Social-cultural	O9	The growing trend of NGOs	0.06	4	0.24
	O10	The growing trend of women's participation in society	0.07	4	0.28
		Sum of the opportunities weight coefficients			2.46
Threats (T)					
Environmental , Biological	T1	The possibility of transferring the disease from animals and insects in WTS	0.07	1	0.07
	T2	Risk of flooding in spring and winter	0.03	2	0.06
	T3	Heavy rainfall increases the volume of leachate and flowing	0.06	2	0.12
Physically	T4	The high density of residential tissue around the site and an increase in density in future developments and consequently an increase in the volume of waste generation	0.03	2	0.06
Landscape	T5	Environmental contamination causes the animals to be attracted to the site and area, creating an undesirable landscape for the area.	0.06	1	0.06
Economically	T6	Increasing the level of income and consequently increasing the ability to buy and consumption	0.03	2	0.06
Social-cultural	T7	Increasing the culture of consumption and generation more waste among people	0.04	2	0.08
	T8	reducing municipal services due to population growth	0.05	1	0.05
		Sum of the threats weight coefficients			0.56
		The sum of all external factors			3.02

In the next step, the SWOT Strategic Factor Analysis t able for executive strategies is presented in four different categories; aggressive, competitive, conservat ive and defensive (Table 3).The significance of the effects of the internal and external environmental factors of the Darabad station, implies the importance of an ecological approach to avoid the environmental deterioration and to promote access to practical benefits of the favorable plant species to reduce the adverse environm ental effects and improve the environment, and in addition develop the desired visual corridors in the

environment. The SWOT strategic analysis provides four different categories of strategies. The results of S WOT analysis identified the priority of aggressive strat egies over the three other strategies. Corresponding to t he benefits achieved by developing appropriate aggres sive strategies that can be planned using the present strengths, opportunities, and exploitation. A number of strategies were developed, which include:

1.The impact of environmental factors (wind, sun radiation, topography and...) in the design on controlling the emission of pollutants.

2.The site design based on the land slope to direct and collect the waste leachate.

3.Training and educating the public especially women, to in separating the waste from the origin to reduce the waste generation.

4.Establishing green spaces inside the station to reduce the effects of the visual pollution of the transfer platform at the station.

5.The orientation of the transfer platform in accordance with the direction of the wind and radiation to control and reduce the pollution.

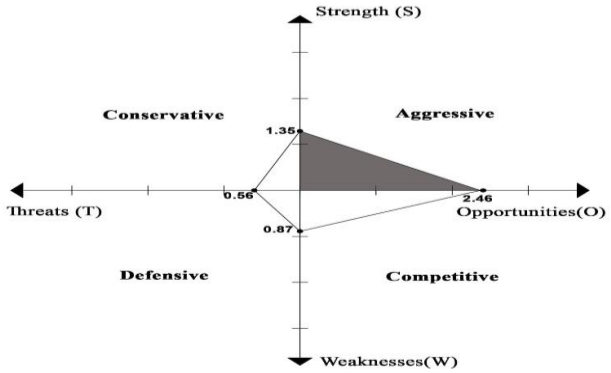

Figure 1. Diagram of Implementation Strategies and Priorities in the Design of Darabad Waste Transfer Station

Preserving the biological conditions of the area, paying attention to the material and energy recovery cycle, promoting the general health status of employees and neighboring residents, improving the visual landscape quality, cultivating to enhance the public participation and improving the economy of the community at the local scale, protecting the ecosystem, preventing the ecological disruption, and ultimately controlling and reducing the environmental pollution applying bio-methods is essential for a desired ecological design to reduce the environmental impacts of the site. waste dump and the odor emission from the waste, the leachate flow and penetrating of the pollutants in the land, leachate contamination of the soil and water, are the contributing factors in the environmental destruction and the visual disturbances in the landscape. when a destruction factor is identified, subsequently it has to be controlled or removed making use of the strengths of the site, for instance the desired natural physical conditions such as the slope and green landscape surroundings, to reconstruct the destructions, by which and the environment will return to the pre-disruption conditions and regain its initial properties in accordance with the main objective. For instance, in the case of waste collection, they should be collected as far as possible and returned to pre-disturbance status, which can improve the landscape. It also used a suitable planting design to control the visual and the noise pollution. Since the separation of origin is effective in reducing the amount of the waste generation, it is crucial to educate people on the matter.

Table 1: Table 3: SWOT Strategic Factor Analysis

Internal factors **External Factor**	**Strengths(S)**	**Weaknesses (W)**
Opportunities (O)	Aggressive Strategies (SO) 1. Use of environmental factors (wind, sun radiation, topography, etc.) in the design to control emissions 2. Design of the station based on the slope of the ground to direct and collect leachate correctly 3. Training people, espe cially women, in the separation of waste from the origin in order to reduce the volume of waste generation 4. Using green vegetation inside the station to reduce the adverse effects of visual the station structure. 5. The orientation of the transfer platform according to the direction of radiation and wind to control and reduce pollution	Competitive Strategies (WO) 1. Locate and plant proper tree species around the site to control noise and odor and improve the landscape 2. Considering leisure spaces for employees to increase their level of mental health in order to work hard. 3. Using proper fencing around the site to prevent the spreading of paper and waste around the station. 4. Use of suitable vegetation and tree species and resistant to pollution to reduce the harmful effects of environmental pollutants
Threats (T)	Conservative Strategies (ST) 1. Create a green buffer zone around the station 2. Considering the place for training courses which mainly increase the efficiency and awareness of experts. 3. Establishment of the main building in the direction to reduce the prevailing winds inside the building and to disperse the waste.	Competitive Strategies (WT) 1. washing and disinfection of the station's vehicles 2. green space around the station to reduce wind speed and waste dispersion 3. Equipping the waste transfer stations with leachate treatment and disposal facilities such as septic tanks and absorbent wells to prevent leachate infiltration 4. Creating incentiv es for people who s eparate their SW at home

Omrani et al. (2012) suggests pollution in 90% of stations including leachate, noise, sanitation problems

which coincided with the results in Table 1 and 2. Also, Mafi et al. (2013) emphasized the priority of the needs of citizens in Mashhad, based on the third category of the strategies, the aggressive strategy, for instance, training and cultivating, the public, and particularly women in separating of waste from the origin to reduce the amount of waste generation. It also coincides the results reported by Yuan (2013) in which they studied the effects of engaging the stakeholders (communities and authorities) on waste management status of the city of Shenzhen.

4. Conclusion

In general, the construction of waste transfer stations in Iran has brought advantages such as economic efficiency, reducing the traffic of the trucks to the community by integrating smaller loads of trucks into the larger vehicles, etc. However, the disadvantag es such as the noise pollution, odor emission, and increase in social, environmental, and economical costs has introduced challenges. The presence of birds and rodents, the dispersing of waste into the outer space of the station, and air pollution will be among other problems with the improper design of the stations. Accurate evaluation and precise site selection, on target design and effective management of the operations, can control and reduce the potential negative impacts of the transfer stations. Concerns and needs of neighboring residents should be considered as legal stakeholders in the process of decision-making. In an ecological design, it is important for the designer to recognize that it is impossible to provide a plan to be entirely in line with the ecological design goals. Therefore, the best way is to make the design to adopt the most ecological design considerations for the system designed and the local ecology that the system is designed to have the least negative effects on, during their life span, and bring the most benefit to nature. The current solid waste transfer station in the city of Tehran, are causing environmental damages in a number different aspects of the environment. However ,the severity of these damages can be minimized by applying the criteria consistent with the ecological principles and restoring the polluted areas.

Acknowledgements

The authors would like to thank the University of Tehran and also Tehran Waste Management Organizati on for their support during this research.

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