

Hazardous and Industrial Wastes Management: a Case Study of Khazra Industrial Park, Kerman

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Background & Aims of the Study: Increasing hazardous industrial wastes and lack of necessary regulations for management of them have led to serious problems in some parts of Iran. The aim of this study was to evaluate the situation of collection, transportation, recycling, and disposal of hazardous industrial wastes in the Khazra Industrial Park of Kerman, Iran.

Materials & Methods: This study was a descriptive cross-sectional study that was done using questionnaires and local visits during year 2009. In this questionnaire, some information about the industrial wastes, production, storage on site, collection, transformation, sorting, recycling, and disposal were recorded.

Results: In the Khazra Industrial Park, 71,600 kg/day of different industrial waste is produced. The biggest proportion of waste includes metals, and construction and demolition waste which are about 16,500 tons a year. The smallest proportion is non-iron metal waste, which is produced at a rate of 8 tons per year. 88.7 percent of the active industries at the Khazra Industrial Park produce solid industrial waste. Most of the industrial units do not use a united and coordinated system for storing waste and have no specific place for temporary storage inside the industrial park. The majority of industrial waste collection, which is about 59.8%, is done by private contractors. The industrial units transfer their waste separately, and just 9 industrial units recycle their waste. Disposal of these wastes is mainly done by selling to trading agencies. Each day, 3 tons of hazardous industrial waste is produced in this park. The highest production belongs to the oil factory (Keyhan Motor).

Conclusions: According to the results, the Khazra Industrial Park needs a unified system for storing, transporting and collecting the sorted waste, and it also needs to have a transportation station with basic facilities. The wastes of most industrial units at the Khazra Industrial Park have the potential for recycling and re-usage in other industries. The best, most economic, and most environment-friendly waste management activity of the Khazra Industrial Park is prevention of production, increase in the potential of recycling, and reuse of material with emphasis on sorting at the production site, increase of mechanical sorting, and decrease in production of disposable waste.

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Background

The environmental effects of industries, especially the pollutants produced by their

activity require inevitable attention. One of the most important pollutants from industries is their waste. Industrial and hazardous waste includes all of the material produced excluding

the main desirable product (1,2). According to the previous studies, the sources of industrial waste produced in Iran, based on the variety of the materials produced in each group include: 1) chemical and medicinal industries, 82.14%, 2) oil and petroleum industry, 43.75%, 3) metal industries, 33.92%, 4) services industry, 19.64%, 5) electrical and electronic industry and household items, 16.07%, 6) textile and leather industry 15.17%, 7) non-metal organic industries, 11.6%, 8) cellulose machinery and automobile, 8.92%, and 9) food industry, 5.35%, (3,4). Waste management includes programming, organizing, maintenance, and executive activities related to production, collection, storing, transportation, recycling, processing and disposal of waste, and also educating and informing about waste (5,6). In addition to the 6 management steps regarding hazardous waste, two additional steps are added, including toxicity and risk reduction, and post disposal surveillance (7). Increasing the hazardous industrial wastes, on the one hand, and lack of necessary strategies and regulations for waste management, on the other hand has led to many serious problems worldwide (8). Regardless of the management of industrial and hazardous waste which is not performed satisfactorily, in most circumstances, the disposal of these waste is wrong and is managed in a way that causes environmental pollution and encounters the natural ecosystem and human health with serious harm. Pollution control cannot be done without a comprehensive and organized programming. Therefore, industrial towns need a comprehensive waste management project in order to control and decrease pollution (9,10). The regulations for solid waste has largely focused on decrease in waste volume, reuse of recyclable material, persuading towards using recycled material, clarifying the role of producers in waste management, and implementing persuasive policies for recycling industries (11). The history of industrial and hazardous waste control includes 1) legislation

making in America in 1965; 2) foundation and application of control and surveillance on industrial waste by the United States EPA in 1976; 3) approval of the legislation for refining and disposing hazardous and toxic material in 1980; 4) executing the approved legislations by the member countries of the European Joint Market in 1980; 5) creation and approval of the laws for export of industrial waste by the European development and economic organization in 1986; 6) creating the basics of toxic and hazardous waste management by the UN environmental program in 1987; 7) the Basel convention in Switzerland for transport of hazardous waste abroad and approving the legislation in 1989 (12,13).

Aims of the study: The aim of this study was to assess the situation of collection, transportation, recycling, and disposal of industrial and hazardous wastes of the Khazra Industrial Park of Kerman city, Iran.

Materials & Methods

This study was a descriptive cross-sectional study based on field data and documents gathered through questionnaires and visits to the Khazra Industrial Park during one year (2009). The Khazra Industrial Park, with 564 hectares area (the first phase), is located at the latitude and longitude of 56°, 52' N and 30°, 12' E of the Kerman province. The aim of the questionnaire was to inquire information about the park's solid waste management, including the stages of production, storing on site, collecting in the park, transport, processing, recycling and disposal. In order to create a clear vision of the current situation of the industrial and hazardous waste at the Khazra Industrial Park, the following steps were done orderly:

1) Evaluation and analysis of the information and statistics related to the production of industrial hazardous waste (quantity and physical quality).

2) Evaluating the current way of storage of wastes, and recognizing the problems and shortcomings.

3) Evaluating the current methods of recycling and processing of industrial and hazardous waste and recognizing their problems and shortcomings.

4) Evaluating the current disposal system and identifying its problems and shortcomings.

Results

This industrial town has 278 industrial units that 97 of them are active and 50 are inactive. There are 8 zones -active industrial sites- which include the chemical, metal, non-metal, organic, textile, food, cellulose, and electronic zones. The location of industrial zones has been shown in Tables 1 and Figure.1. Industrial wastes are classified into 11 groups (Figure 2),

based on the content of waste, management of waste until disposal, and variety of produced waste. Quality and quantity of hazardous industrial waste vary depending on sources. It is influenced by number of active workers, number of active units, production rate, level of industrial owners, knowledge, management system, economic, and range of production. In Khazra Industrial Park, 71,600 kg/day of various industrial wastes is produced that reaches 26,141 tons/year.

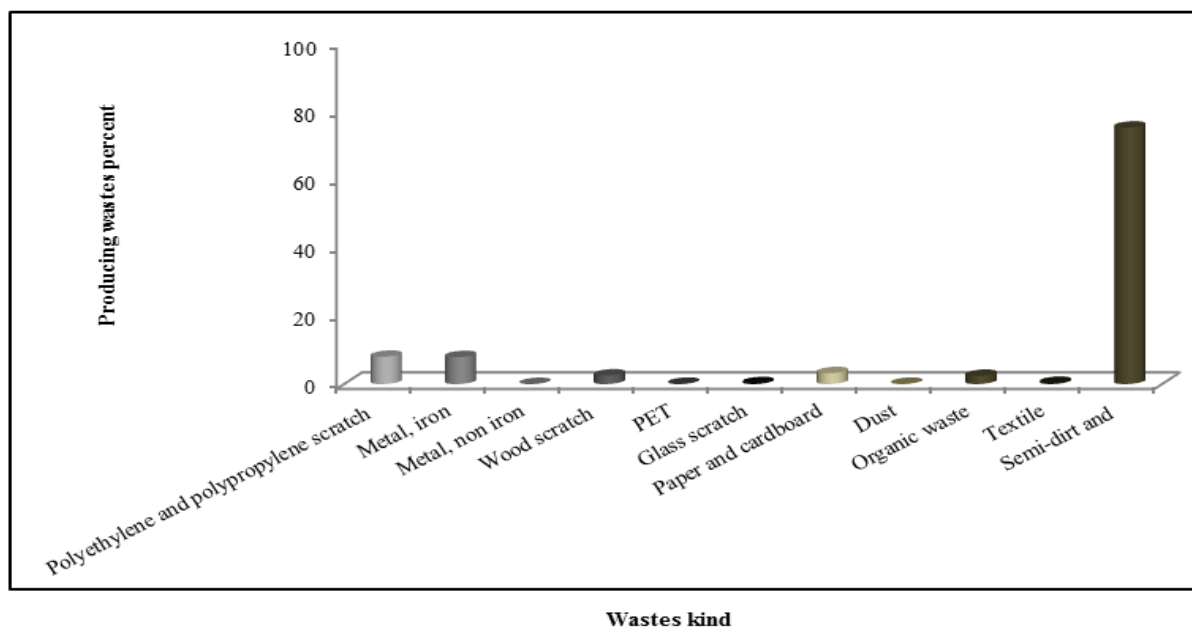
The maximum amount of the produced waste belongs to the metal zone and the group of dirt-like waste, and construction waste which is 16500 tons a year, and the reason for that is the high density of the disposed metals. The minimum amount of waste is 8 tons a year, which belongs to non-iron metal waste.



Figure 1) The location of industrial zones in Khazra Industrial Park and its development project

Table 1) The situation of the active industrial units in different areas of the Khazra Industrial Park

The industry	The position of zones								
The industry	Number of units	Chemical	Metal	Food	Non metal	Electrical	Textile	Cellulose	Services
Chemical	34	10	8	1	9	2	4	0	0
Metal	19	2	14	1	2	0	0	0	0
Food	15	0	0	12	2	1	0	0	0
Non metal organic	13	1	2	0	10	0	0	0	0
Electrical and electronics	7	0	2	0	0	3	2	0	0
Textile	5	0	4	0	0	0	1	0	0
Cellulose	3	0	0	0	1	0	0	2	0
Services	1	1	0	0	0	0	0	0	0
Total	97	14	30	14	24	6	7	2	0

**Figure 2) The percent of wastes produced at the Khazra Industrial Park**

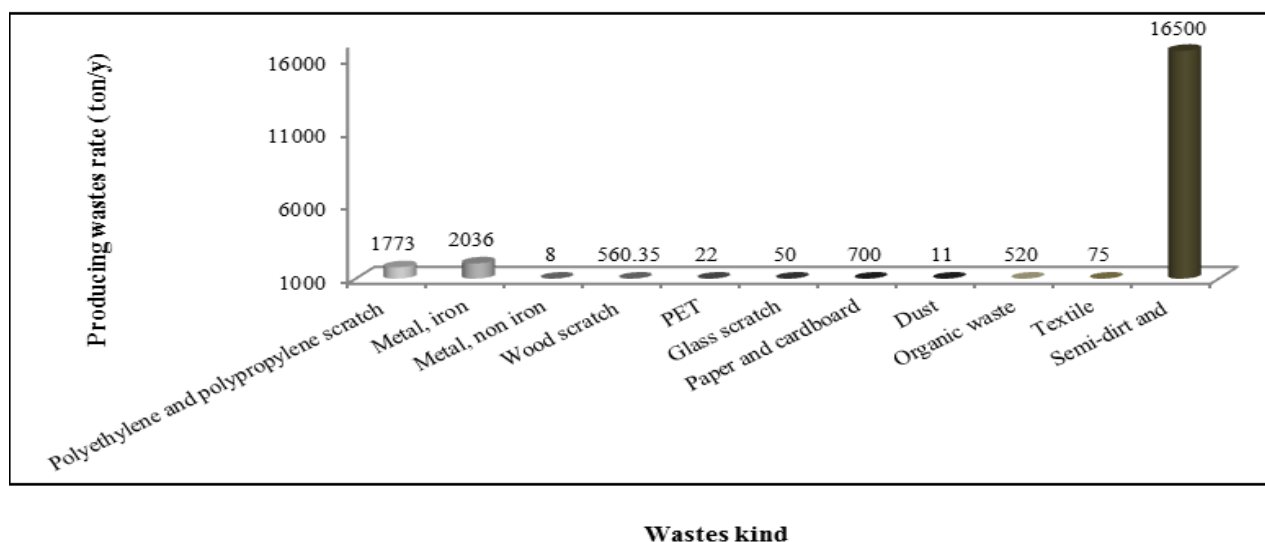


Figure 3) The amount of waste (ton per year) produced at the Khazra Industrial Park

Discussion

The produced waste of this park can be classified into 6 groups based on content: 1) non-organic waste, 2) organic and degradable waste, 3) organic and non-degradable waste, 4) fatty waste, 5) high volume and low danger waste, 6) miscellaneous waste. Based on the content, from 97 industrial units in this park, 86 units produce solid waste, 4 units produce semi-solid waste, and 7 units does not produce any kind of industrial waste. Therefore, 88.7% of the active industries at the Khazra Industrial Park produce solid industrial waste.

4-1. Current storage condition of industrial waste at the Khazra Industrial Park

The methods of industrial waste storage are in direct connection with the production source and the quantity and quality of waste and include a broad range of waste containers. Studying and recognizing the methods of industrial waste storage, in addition to its positive effect on the functional effectiveness of waste management system, has an effective role in programming a waste collection and transportation system and also has positive hygienic and aesthetic effects. IAAt the Khazra Industrial Park, most of the producers keep

their waste in the open space (14). Actually, among 97 units, 53 units (54.6%) keep their waste in the open environment, 16 units (16.5%) store their waste in a barn, and the rest (28.9%) use methods, such as storing the waste in a hole in the ground, closed containers and barrels. Another problem of storing waste in a temporary way is storage at the same production site or at a special site. Most of the industrial units keep their industrial waste at the working site. Only 7 units have a special place for keeping the waste outside their industrial unit. It is seen that most of the industrial units do not use a united and coordinated system for storing waste, and have no determined place for temporary waste storage in the Khazra Industrial Park. This has led to the distribution of waste and interaction with executing the waste management program in this park. In order to manage this section, industrial units proportional to their industrial waste production should determine a place for temporary storage of their industrial waste (15). Currently, most of the units have such a place, but it lacks sufficient equipment and facilities for waste storage. In order to perform this, it is necessary to keep these places confined to prevent the dissemination of waste into the environment. Also, these places should be established in a

place in the industrial park territory, so that the health safety and environmental inspectors and the people in charge of waste transport have easy access to them.

4-2. Current situation of waste collection at the Khazra Industrial Park

There are many different methods for industrial waste collection at the Khazra Industrial Park, that each of these methods includes key parts and criteria, such as the method of waste storage and determination of path collection. At the Khazra Industrial Park, industrial waste collection is done in three ways: the industrial workshops, the private sector, and the park municipality trucks. Among 97 active units in this park, 58 units have handed their wasted collection to the private sector, 26 units collect their waste themselves, and 13 units have no

Table 2) Management of industrial waste at the Khazra Industrial Park

Collecting vehicle	Number of units	Percent
Private sector	58	59.8
The producing industrial unit	26	26.8
Not clear	13	13.4

In order to collect the industrial waste of this park, it is necessary to establish a unified collection system, in which industrial waste is collected from the door of industrial units. In order to perform this industrial collection system, four standard vehicles are needed. Since these amount of produced waste dose not require daily collection, we propose that for waste collection, initially the amount of waste production in the whole park should be determined and then, a sorted collection system should be introduced in a specific time frame. This means that collection should be performed according to the industrial classification (16). The important point is collection of construction and demolition, which is produced in the non-metal zones. We suggest that collection of these wastes, which are part of the

clear situation and do no produce waste. Thus, the majority of industrial waste collection (59.8%) is done by private contractors (Table 2). These private contractors do not have the expert workforce needed for industrial waste collection and generally do not use the appropriate safety equipment. Most of the industrial park's waste is transported by mini trucks, and 37 industrial units use mini trucks for transport of waste. In second place, the vehicle for waste transfer in the Khazra Industrial Park is trucks, which are used by 23 industrial units. Transport in 12 units is unclear and other units use vehicles such as tankers, tractors, lift trucks, and carriages. It is necessary to mention that only 3 industrial units use special vehicles for transport of industrial waste (Table 3).

Table 3) The situation of the waste collecting vehicles at the Khazra Industrial Park

Transport vehicle	Number of units	Percent
Mini truck	37	49.3
Truck	23	30.6
Special waste transfer vehicle	3	4
Others	12	16

industrial waste, are harmless, and comprise the majority of waste, should be transferred separately by covered trucks, and the waste should be evacuated from the park zone for disposal or recycling at the appropriate site, under the supervision of the Baghein Municipality and the Stone Carvers Corporation, and according to the regulations of the Environmental Protection Agency (5).

4-3. Current situation of waste transfer of the Khazra Industrial Park

Nowadays, because of the establishment of industrial parks and their distance from the burial sites, the costs of transfer have increased dramatically. Thus, it is necessary to use some effective vehicles and correct of the available systems in order to save expenses and increase production. By organizing and transmission of

industrial wastes in a logical way, we can prevent huge unhygienic collection of waste in the industrial park environment and its surroundings (17). In the industrial park, there is no specific depot for waste produced in the park that leads to transfer waste separately for each industrial site. This situation leads to increase in the expenses of storage, collection, and transfer. According to the current situation, it is likely that the Khazra Industrial Park needs a unified system for sorted waste storage, collection, and transfer. There also seems to be a necessity for a station which sorts, transfers waste and is equipped with primary processing systems. This station according to the classification of the park's waste (excluding construction and demolition waste) is divided into 10 sections, proportional to the amount of waste produced, and each waste is sent to its own section. This facilitates the dividing, processing, and transferring of the usable waste to the industrial units for recycling.

4-4. Current situation of processing and recycling of industrial waste at the Khazra Industrial Park

Processing is referred to any method, technique, or system in which the physical, chemical or biological appearance of solid waste is changed (18). According to the current conditions at the Khazra Industrial Park, practically no activity is done for the processing of industrial waste and generally the produced waste is disposed as it is produced. It is worth mentioning that the waste from most of the industrial units at the Khazra Industrial Park can be recycled and can be used by the other industries; however, this material is collected by sectors outside the industrial park, which are the private sector or the waste collectors, and generally it creates a lot of hygienic and environmental problems (19). Most of the industrial units in this industrial park sell their recyclable waste, but the method of selling is without considering the basics of hygiene, safety and environmental protection. Currently, at the Khazra Industrial Park, from the 11 elements of industrial waste production,

9 units are recyclable, which are the wastes of polyethylene, polypropylene and foam, iron metals, non-iron metals, wood wastes, PET, glass wastes, paper and cardboard waste, organic waste, and construction and demolition wastes. The two other parts are dust and textile fibers, which are not recyclable. Considering the industries working in this park, recycling can be done for two groups of waste, which are the Kerman Paper and Cardboard Company and the Mahboob Plastic Company. After collection, the plastic material, paper and cardboard can be separately given as raw material to these two units. Iron waste is also reused. When they accumulate to a transferrable amount, they are sent to one of the iron melting companies and are sold as scrap iron.

In Iran, recycling industries have been founded and can recycle most of the industrial and municipal wastes. However, there are some factors related to their development and success, which are as follows: The macroeconomic policies about industrial waste, the related regulations, guidelines and approved instructions, estimating the engineering potential of the recycling industry in Iran, the amount of support from related organizations and ministries, the knowledge and awareness of the industrial unit managers, economic factors and financial support for industrial units (20,21). The recycling of industrial waste has its own economic and environmental benefits. One of the economic pros of recycling is saving energy and decreased use of raw material. Some of the environmental benefits of recycling are reusing of non-degradable and destructive waste (such as plastic, rubber, and metals), reducing the mass of waste, and reducing the land needed for disposal of the waste (22,23).

4-5. Current situation of waste disposal at the Khazra Industrial Park

The last step in the process of industrial waste management is the disposal of non-reusable and remaining waste from waste processing. In Iran,

most of the solid waste is disposed by landfill practice according to the basis and standards of hygiene and environmental sciences. Currently, other methods of waste disposal, such as burning solid waste are under scrutiny and possible evaluation (4). At the Khazra Industrial Park, the disposal of industrial waste is mainly through sale to the purchaser agencies. Only 12 industrial units evacuate their waste from the park for burial and the other units handle their waste through the recycling process. The Table 4 shows the classification of different industrial disposal methods at the Khazra Industrial Park.

Table 4) Classification of different disposal methods in the Khazra Industrial Park

Disposal Method	Number of industrial units
Temporary storage, selling by auction	4
Selling	61
Burial, outside the park	12
Recycling	2
Burning	1
Unspecified	3

4-6. Current situation of the hazardous waste management at the Khazra Industrial Park

The management of hazardous industrial wastes is one of the most important parts of environmental protection, which has been considered by waste management specialists in the recent years. The consequences of mismanagement of these wastes in the recent years, has encountered human with many disasters (7,24,25). At the Khazra Industrial Park, there are 7 units which produce hazardous industrial waste. The situation of the hazardous waste produced at the Khazra Industrial Park, based on type, characteristics, amount, and management method has been shown in Table 5. According to this Table, each day 3 tons of hazardous industrial waste is produced at this park, and the highest amount belongs to the Kayhan Motor Oil factory. This waste is mainly toxic and corrosive, and sound management is not performed for its disposal.

Table 5) Characteristics and conditions of hazardous industrial waste produced at the Khazra Industrial Park.

Industrial Unit	Hazardous waste produced	Characteristic	Amount of production (kg/day)	Storage method	Collection and transfer method	Hazard control	Processing and recycling method	Disposal method
Pooya distilled water	Hydrochloric acid	Corrosive	1	Storage in septic tank	Wastewater transport vehicle	No activity is done in order to eliminate or reduce the danger of the waste	Sold mixed with other wastes for recycling	Is evacuated from the park by tankers
Baran publishing	Film and Zinc	toxic	Not clear	Storage inside the factory limits	Mini truck	"	"	Is sold to the private sector
Sahar Khooshe dye industry	Tin containing chemicals	toxic	5.5	Storage inside the factory limits	Mini truck	"	"	Is sold with the other waste
Kayhan Motor Oil	Acidic slug and dirt contaminated with slug and fatty solutions	Corrosive	2266	Storage inside the factory limits	Not yet collected or transported from the factory	"	"	Is mixed with soil and lime , and after it dries, is disposed in the environment
Almas Kavir Carpets	Dye and lint	Corrosive and toxic	6	In a silo inside the industrial unit	Mini truck	"	"	No management
Paper & Cardboard	Cardboard contaminated with toxins	toxic	8.2	Storage inside the factory limits	Mini truck	"	"	Toxic cardboard boxes are burned
Oxygen gas	Motor oil and saturated perlite	toxic	810	Outdoors, in metal barrels	truck	"	Is offered to the Kayhan Motor factory for recycling	Recycled to Motor oil
Total			3096.7					

4-7. Improving the industrial wastes management system at the Khazra Industrial park

The general advantages of implementing a comprehensive plan for industrial waste management at the Khazra industrial zone is presented in Figure 4.

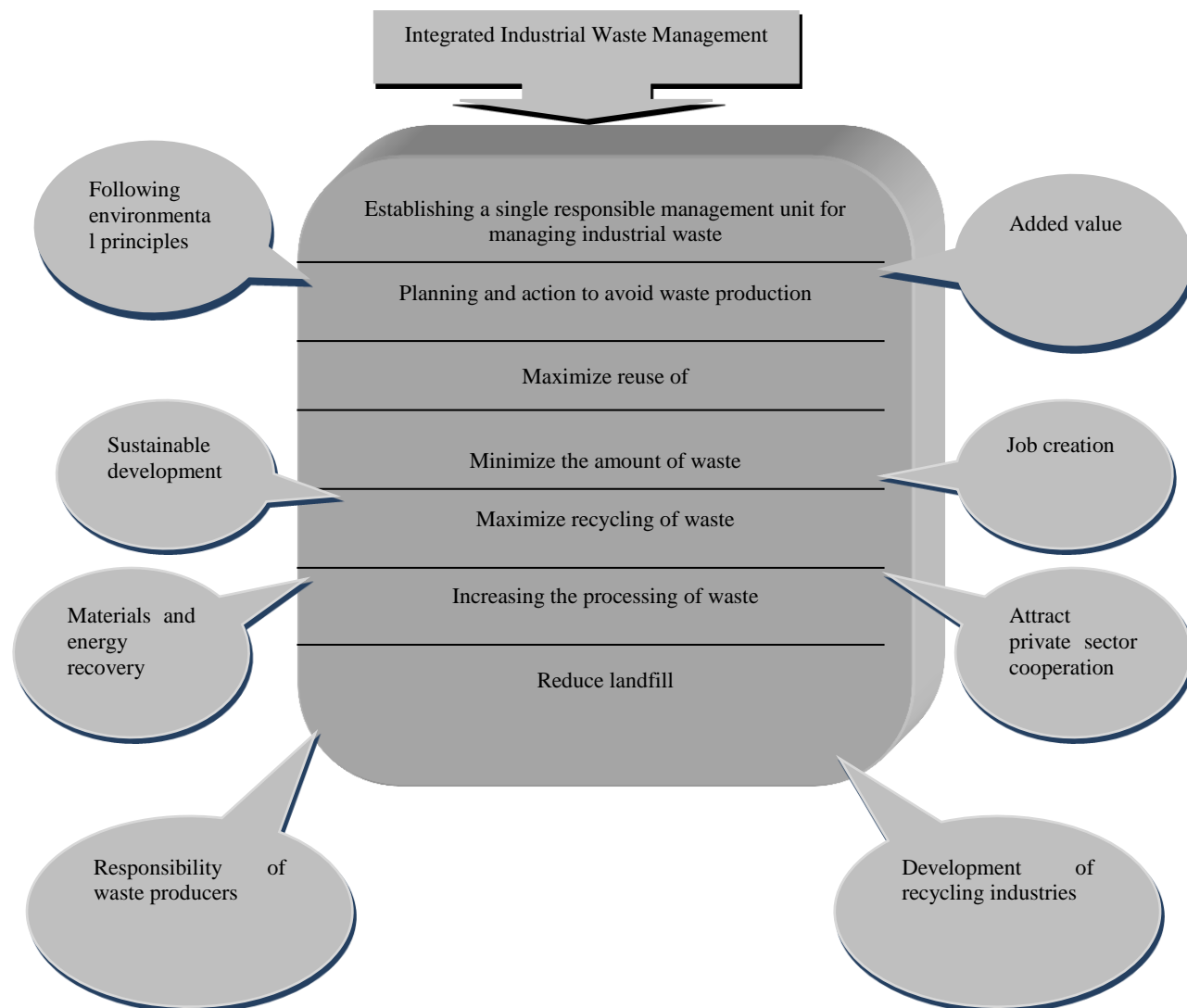


Figure 4) Qualitative achievements of Khazra Industrial Waste Management Implementation Plan

In order to improve the waste management system at the Khazra Industrial Park, the following instructions are suggested, which if applied, will result in successful waste management:

A- Creating systems for storing hazardous industrial waste are proposed as follows: Using standard plastic bags for storing waste which is storable in bags; using standard wheeled and galvanized containers in appropriate volumes, with monthly production of each waste at the

industrial units for temporary storage of the waste; using standard containers with inserting the characteristic of each produced industrial waste, separately.

B- Collection and transfer of hazardous industrial waste are proposed as follows: Using machinery for processing and condensing industrial waste; sorting the hazardous and industrial wastes collection system according to a timeframe

C- Transport of the hazardous industrial waste is proposed as follows: Foundation of a waste station for separating each waste type in its own zone (for hazardous, industrial waste); equipping the transport stations with devices and mechanical compactors; using specialized contractors for the transport of the waste, according to the hygienic and protection regulations and using equipped and safe transport; obeying the practical regulations for road transport of hazardous waste, approved at the Iranian cabinet on March 17, 2001; completely obeying the available guidelines and surveillance on the proper management, according to international rules and regulations for management of hazardous industrial waste.

D- Processing and disposal of hazardous industrial waste are proposed as follows: Creating a cooperative at the Khazra Industrial Park for managing hazardous industrial waste, especially in case of processing and selling wastes. The members can be from the owners of the industry, other stakeholders, and banks. In this situation, the benefits of the industry owners will be reimbursed from waste recycling; Creating new processing potential by the private sector; Inquiring from the Environmental Protection Agency for introducing an appropriate place for burying the industrial parks' waste and using this site for disposal of non-reusable waste; Signing a contract for selling semi-dirt and rubble (stone cutting rubbish), according to the usage of the suggested collaboration.

Conclusion

At the Khazra Industrial Park, there are 8 zones or active industrial units, and the total amount of waste produced in the park is 26,141 tons a year and 21,912 tons of it are industrial waste and the rest is 4,229 tons, which are among the special wastes. According to the surveillance done at the Khazra Industrial Park, the mean amount of waste production for each production unit is 48 kg (0.048 tons). Considering the current situation and problems for proper

hazardous and industrial waste management at the Khazra Industrial Park and the regulations and guidelines for waste management, the following initiatives can be suggested as follows: Applying the steps and obeying the regulations for united and proper management of hazardous and industrial waste at the Khazra Industrial Park; Satisfying and incorporating the industrial owners and stakeholders of the industrial park; Improving the methods of waste management; Creating the legal, judiciary, and executive infrastructure for waste management at the Khazra Industrial Park; Education of the industrial owners about their role in the management of the Khazra Industrial Park's waste.

Footnotes

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Conflict of Interest:

The authors declare no conflict of interest.

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