

Industrial waste generation and characterization in Iran: a circular economy approach

E. Valiasil¹, M.H Sarrafzadeh^{1*}, O.Tavakoli², S.B. Ghaffari¹

¹ UNESCO Chair on Water Reuse, School of Chemical Engineering, College of Engineering, University of Tehran, Tehran, Tehran, Iran

² School of Chemical Engineering, College of Engineering, University of Tehran(UT), Tehran, Tehran, Iran

*Corresponding author:

email: sarrafzdh@ut.ac.ir

Address: Unit 8, No. 11, Farre Danesh Alley, Qods St. Enghelab St. Tehran, Iran

Phone: +98 21 8897 0375

Fax: + 98 21 8897 4639

Abstract:

Industrial solid waste management is one of the most pressing environmental issues facing Iran. The characteristics, composition, and types of industrial waste must be understood in order to manage them effectively. There have been scattered and various case studies conducted about the production of industrial wastes in Iran. However, there has been no comprehensive study of the amount and characteristics of industrial waste, nor its potential for reuse. The purpose of this study was to investigate Iranian industrial waste generation, characteristics, and potential reuse and recovery. This research was conducted in the major international and Iranian national databases. According to the results, the total amounts of industrial waste generated are 1,180,930 tons per year, with the highest quantities coming from Shams Abad industrial park and the lowest coming from Birjand industrial park. Non-metallic industries generate the largest amount of waste. Several solutions are given for improving the conditions for the reuse and recycling of industrial waste.

Keywords: industrial waste, circular economy, waste characterization, reuse

1- Introduction:

Industrial waste can cause environmental pollution. Various forms of industrial waste contain highly toxic organic and inorganic pollutants, which can be harmful to living organisms. Consequently, such hazardous wastes need to be appropriately managed to protect the environment and public health[1]. Industrial waste can generally be classified into two categories, namely non-hazardous and hazardous waste. Non-hazardous industrial waste is any waste generated by an industry that does not pose a health or environmental risk. Examples of nonhazardous industrial waste include cardboard, plastic, metal, glass, rock, and organic waste. Contrary to this, hazardous

waste consists of materials resulting from industrial activities that can harm public health or the environment, such as flammable, corrosive, active, or toxic substances [2].

The global industrial waste generation in 2011 was approximately 9.2 billion tons, and the global industrial waste generation per capita is about 1.74 tons. The majority of industrial waste is generated in Asia and the Pacific. In developing countries, industrial waste generation is forecast to grow rapidly in the future, while industrial waste generation in developed countries will probably remain stable or continue to decline. Compared with developed countries, many developing countries still have lower collection and recycling rates. Additionally, toxic waste poses a greater threat to developing countries[3].

Material consumption is linked to prosperity and human development. Waste will always be generated because of the entropic nature of production and because of the obsolescence of products[4]. In response to the rapid increase in the population, manufacturing industries have been challenged to meet consumer demand and technological advancements. Due to this development of a new product, a different category of waste is generated, which poses social and environmental challenges as a result of its disposal and mismanagement. A decided and articulate action is necessary to effectively manage waste that may later be recycled and reused as a valuable resource. The food, agriculture, and oil industries contribute significantly to waste generation [5]. The United Nations has declared that one indicator of sustainable development is the requirement to substantially reduce waste generation by 2030 as a result of prevention, reduction, recycling, and reuse[6].

To move toward sustainable patterns of production and consumption, the circular economy is vital. Contrary to the linear "take, make, dispose of" model, the circular economy replaces its use with "take, make, reuse." This model minimizes primary raw material consumption, volumes of processed and disposed waste, as well as landfill area[7]. The Circular Economy has been conceptualized as a system that is restorative by design with a core strategic focus on reframing and reorganizing material, information, and energy flow to achieve greater resource efficiency through the reuse, remanufacture, and recycling of materials. Its fundamental premise is that waste minimization can act as a new source of value for the business[8]. Also, A circular economy system aims to eliminate waste and pollution, keep products and materials in use, and regenerate natural systems[9].

Iran's economy transformed from agricultural to industrial due to industry development and rapid economic growth. These industrial developments have resulted in the generation of several complex and hazardous industrial wastes[10]. Iran faces numerous environmental issues due to its expanding urban population, and industrial solid waste management is one of the most pressing ones[11]. The amount of industrial waste production in Iran is 32 million tons per year. It is estimated that the growth rate of production of this industrial waste is 6.8% per year (Reported by the Department of environmental of Iran, 2020). To manage industrial waste effectively, it is essential to understand the characteristics, composition, and types of industrial waste (food,

chemical industry, etc.). There have been scattered and various case studies conducted about the production of industrial wastes in Iran. However, there has been no comprehensive study of the amount and characteristics of industrial waste, nor its potential for reuse.

This study investigated the generation, characteristics, and reuse potential of industrial waste generated in Iran. Iranian industry generates a great deal of industrial waste. Thus a reusing and recycling program is recommended as a beneficial solution. For instance, materials, including plastic, PET, glass, metals, paper, and cardboard, can be recycled and reused. This research was conducted in the major international and Iranian national databases, including Science Direct, Scopus, PubMed, Google Scholar, SID, Civilica, and Magiran, using appropriate keywords in order to identify the articles that have been published on the topic at hand.

2-Methodology

2-1- The current situation in Iran:

The world has seen the development of comprehensive programs to manage industrial and municipal waste. However, little progress has been made in Iran regarding the management of industrial waste. Iranian industries have experienced rapid growth, resulting in an increase in the production of industrial waste, yet no basic steps have been taken to classify or identify the compounds. There is no clear structure or process for describing the current state of affairs in the studies completed today, and case studies and the data they contain are fragmented.

Due to improper transportation and industrial waste disposal, Iran has witnessed one of the most devastating consequences of industrial development over the last few decades. In addition, environmental damage results from this, and its destructive effects on emerging crises are pretty evident. Despite this, however, industrial waste management continues to grow worldwide.

There are currently no comprehensive waste management systems for the industries in Iran. When developing a waste management system, it is necessary to identify the compounds and classify the waste. According to studies, a small percentage of industrial waste produced in Iran is recycled or reused. The cost of landfilling is low compared to recycling, so many industries don't recycle their waste.

In Iran, there is a lack of accurate statistics and information regarding the generation, quality, and classification of industrial waste, which have been neglected. Under the waste management law, companies and industries are responsible for managing production waste, so there are no strict rules and regulations in this area.

2-2- Data collection

There are three general methods presently used to analyze the generation, type, and composition of industrial waste [12]:

- an empirical approach using available industry information;
- a questionnaire survey;

- use of control/monitoring data from a waste management system.

The studies used for this research have used two methods of observation and questionnaires. Survey questionnaires were prepared according to Iran's Department of Environmental Protection standards. These questionnaires collect data on waste generation, composition, industry type, waste management methods, and recycling and reusing. Surveys are given to companies and industries, which they fill out, and then the data is extracted.

2-3- Search strategy

In order to identify relevant articles for our study, we used keywords such as "waste", "industrial waste", "industrial", "waste management", "reuse", "and" recycling. We then checked the abstracts and keywords of each article for relevance to our study, and after filtering and excluding irrelevant papers, we extracted useful and applicant data.

3-Result and discussion

3-1- Classification of industrial activities

There are different classifications of industrial waste depending on the type of industry that generated it. In Iran, there are 2400 companies with more than 100 employees and 48038 small industrial units in more than 832 industrial parks. Figure1, based on the Industrial Parks Organization classification, shows the chemical and metal industries have the largest share of industrial parks, with 22 and 26 percent, respectively (Iran Small Industries and Industrial Parks Organization, The Central Bank of Iran).

Articles that have been examined during this study have been classified according to the standard of the Environmental Protection Organization of Iran. The following industries are included in this classification: 1) food and beverages industry, 2) non-metallic mineral industry, 3) cellulosic(wood, paper), 4) metal industry, 5) Textile industry, 6) chemical industry, 7) electronic industry, and 8) machinery and equipment industry.

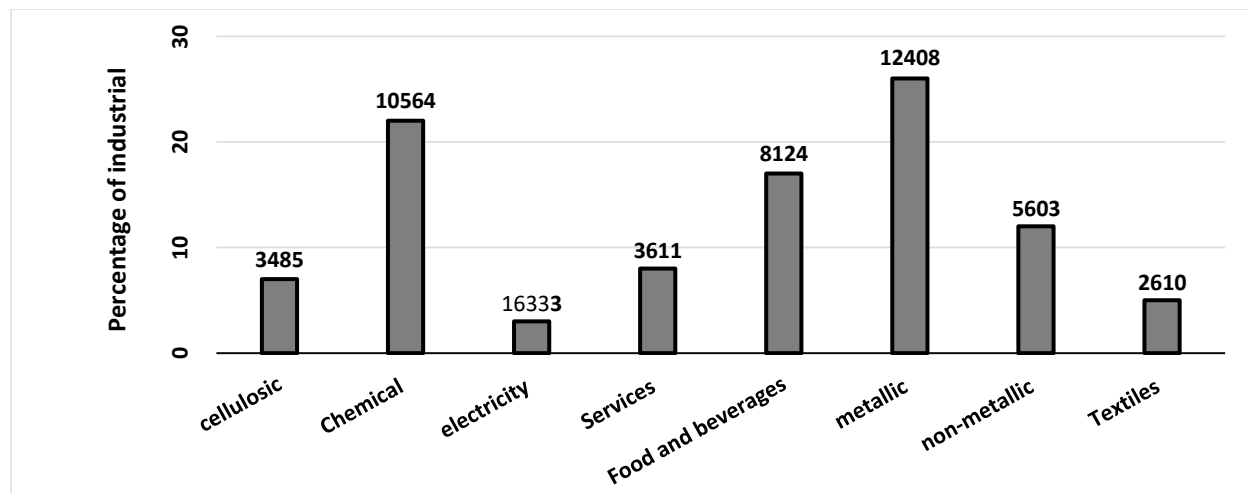


Fig.1 Classification of active companies in industrial parks in Iran

Review articles indicate that the total amount of industrial waste produced is 1,180,930 tons per year. As shown in the table, the highest amount of waste produced is from Shams Abad industrial park, and the lowest amount is from Birjand industrial park. The table also indicates that the largest amount of waste is generated by the Non-Metallic industries.

Many large factories and industries, such as chemical and metal industries in Iran, operate outside industrial parks where the amount and classification of their waste have not been carefully studied. It can be well estimated that such industries generate considerable amounts of waste. In particular, heavy metals and chemicals produce large quantities of hazardous waste.

Zearei et al. conducted a study on the waste of the Shiraz refinery. Their study found that 188 tons of industrial waste are generated each year, most of it hazardous. As well, recycling and reusing were recommended as the most effective options for managing waste[13]. In a study on waste management at Pardis Petrochemical Company, Namdari et al. discovered that about 50% of the wastes identified were hazardous[14]. Approximately 265 tons of industrial waste are produced annually by Kavian Petrochemical Company; 108 tons (41%) of that are classified as hazardous waste[15].

Waste production and classification studies have typically focused on determining the best ways to manage waste. Even though about 50% of industrial waste is recyclable and reusable, these studies show that only a small percentage is recycled.

From an environmental perspective, Farzadkia et al. investigate the waste characteristics and waste management practices in Savojbolagh. Their study covered 54 industries and analyzed all the industrial processes, types, and quantities of products, industrial waste generation per capita, physical analysis, and management activities pertaining to waste minimization, storage, processing, recycling, and disposal. According to the study, approximately 22,000 tons of industrial waste are generated annually. The Food and Beverage, Metal, and Chemicals/Plastic industries generated the most waste[16].

Masandaranizadeh et al. carried out a study on the generation and characterization of wastes in Arasanj industrial park. In the study, solid waste was generated by each industrial unit at a mean rate of 22.3 kg day⁻¹. Metals and organic waste accounted for 64% of total waste generated. Moreover, food and beverage industries generate the majority of industrial wastes (46%), followed by metallic sectors (26%) and chemical industries (10.4%). Arasanj industrial park's waste management system was weak, and several problems were identified. To optimize industrial waste management, recycling and reuse should be implemented as much as possible[10].

Table 1 The generation rate and classification of industrial waste

reference	Study location	Industry activity										Total		
		Chemical	Food And Beverages	Metallic	Non-Metallic	Cellucis	electricity	Machinery	Textile					
[31]	Nasir Abad I.P	395	520	170	-	170	420	-	-	-	-	-	-	1405
[30]	Ore and Shoja abad I.P	-	-	-	-	-	-	-	-	-	-	-	-	228350
[29]	Bo Ali I.P	1342	665	106	1303	138	33	-	-	37	-	-	-	3625
[28]	Isfahan I.P	467	984	21464	160	-	-	-	-	410	-	-	-	23485
[27]	Neyshabur I.P	-	-	-	-	-	-	-	-	-	-	-	-	15121
[26]	Razi(Isfahan) I.P	1456	16	8846	84	400	-	-	-	13	-	-	-	10815
[25]	Qazvin I.P	172560	12552	53820	15466	738	-	-	-	516	-	-	-	255652
[24]	Rasht (food industry waste)	-	91	-	-	-	-	-	-	-	-	-	-	91
[23]	Rasht I.P	216	204	264	228	96	108	84	144	-	-	-	-	1344
[22]	Rafsanjan I.P	-	-	-	-	-	-	-	-	-	-	-	-	2139
[21]	Tehran municipality` s 9th zone	-	-	-	-	-	-	-	-	-	-	-	-	4851
[20]	industries Located between Tehran and Karaj Zone	-	-	-	-	-	-	-	-	-	-	-	-	45060
[19]	Gilan Province (plastic industries)	-	-	-	-	-	-	-	-	-	-	-	-	207
[18]	Ghadir iron & steel company	-	-	-	-	-	-	-	-	-	-	-	-	39307
[17]	Caspian I.P	147	350	413	-	49	103	86	121	-	-	-	-	1269

Table 1. continued

reference	Study location	Industry activity										Total	
		Chemical	Food And Beverages	Metal	Non-Metallic	Cellucis	Electronic	Machinery	Textile				
[40]	a petrochemical company in west	-	-	-	-	-	-	-	-	-	-	-	353
[39]	Kavir Steel Complex	-	-	99	-	-	-	-	-	-	-	-	99
[13]	Shiraz Oil Refinery Company	348	-	-	-	-	-	-	-	-	-	-	348
[38]	Nazar Abad I.P	-	-	-	-	-	-	-	-	-	-	-	806
[15]	Kavian Petrochemical Company	265	-	-	-	-	-	-	-	-	-	-	265
[37]	Semnan I.P	-	-	-	-	-	-	-	-	-	-	-	5440
[36]	Abas Abad I.P	5281	5817	47232	70	231	-	-	-	-	-	-	59441
[35]	Shams Abad I.P	-	-	7212	426048	-	-	-	-	-	-	-	433260
[34]	Shokohie I.P	911	-	666	640	31	20	2	220	-	-	-	2490
[33]	Birjand I.P	-	-	-	-	-	-	-	-	-	-	-	126
[32]	Yazd I.P	5524	3487	2147	2523	1543	-	5211	1432	-	-	-	21867
[16]	Savojbolagh I.P	4472	5396	5493	1393	1418	1389	3346	477	-	-	-	23384
[10]	Arasanj I.P	36	157	90	14	4	18	6	5	-	-	-	330
	Total	188766	28840	142026	446522	5495	1358	6132	6927	-	-	-	1,180,930

*I.P: Industrial Park

4-conclusion

The purpose of this article is to investigate the classification and generation of industrial waste in Iran using a circular economy approach. As a developing country, Iran produces more industrial waste than other countries based on the data and results obtained. There are significant amounts of these wastes that can be recycled or reused; however, due to an inadequate waste management system, only a small percentage of them are. To improve the existing conditions for the reuse and recycling of industrial waste, the following solutions are recommended:

- Scientific training for industries or consulting with experts in this field.
- Implementing an integrated waste management system.
- Establishing a database that includes information about industrial waste generation, classification, and composition.
- Sorting hazardous and nonhazardous wastes at the source.
- Optimizing equipment and production processes.
- Supporting and creating various incentives for waste management in industries.

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