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Industrial waste characterization and management in Arasanj industrial estate, Iran

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Abstract

The aim of this study was to survey the total waste generation and characterization as well as the related management activities in Arasanj industrial estate. A structured questionnaire was used to obtained data on the industrial processes, the types and quantities of products, waste generation and management and other general data. Then, 15 industries were selected and their wastes were sorted by hand and then weighed. In addition, detailed information about the waste in all industries was identified through interviews and observations. The results showed that the mean generation of solid waste in each industrial unit was 22.3 kg day^{-1}. Organic waste and metals constituted 64% of total waste generated and all other components were responsible for 36% of this amount. It was also indicated that the majority of industrial wastes come from food and beverage industries (46%), metallic industries (26.3%) and chemical industries (10.4%). Based on the results, total hazardous waste accounts for approximately 14.3% of total waste generated. The management of industrial waste in Arasanj industrial estate was weak and a variety of waste management problems were identified. For the best management, recycling and reuse of industrial wastes should be implemented as much as possible.

Keywords: Arasanj; hazardous waste; industrial estate; industrial waste; waste management.

1. Introduction

With rapid economic growth and industrial development, the characteristics of domestic economy in Iran have changed from agricultural to industrial (Li & Yu, 2011). This industrial development has resulted in the generation of a high amount of complex and hazardous industrial wastes (Salihoglu, 2010). The term industrial waste refers here to all wastes produced by industrial activities and manufacturing processes (Lei *et al.,* 2015). One of the main challenges of rapid industrial development is the negative impacts of these industrial wastes. Application of integrated waste management programs in compliance with environmental regulations is an ideal solution to minimize the negative impacts (Alkoot, 2014; Turskis *et al.,* 2012). Suitable management of industrial wastes is very important because they need to be treated and disposed of in a safe and economical manner (Duane, 2014; Roy *et al.,* 2015). However, in the absence of an integrated waste management scheme, this increase can result in severe environmental issues such as soil, water, and air pollution (Oluremi *et al.,* 2013; Usapein & Chavalparit, 2014). In addition, there is clear evidence that acute and chronic exposures to hazardous chemicals of industrial waste can cause adverse health effects in humans as well as aquatic flora and fauna (Lopez-Cima *et al.,* 2013).

In the past, generators of industrial wastes have managed their wastes by discharging them into the environment without any treatment (Wagland *et al.,* 2012). Today, industries are legally responsible for the management of their waste. Therefore, the manufacturers should manage the wastes themselves or contract qualified companies to collect and dispose of the wastes. In order to preserve the environment, waste minimization, separation and recycling processes should be developed and applied as much as possible (Wagland *et al.,* 2012). On the other hand, interest in industrial waste as an important source of energy and material has increased during recent years. Thus, most industries are in need of detailed analysis of their waste at all stages of management activities (Nasrullah

et al., 2014). The industries that have evaluated their own waste management system have found that there are large economic and environmental benefits, when appropriate waste management is implemented (Nasrullah *et al.,* 2014).

Many studies on hazardous and industrial waste from specific industries have been concentrated on waste characterization and identification of management activities (Curran & Williams, 2012; Das *et al.,* 2012; Maguyon *et al.,* 2012). Therefore, the first step for planning and developing a more adequate waste management system is to study the quantity, type, and composition of industrial waste. There is limited data on the generation of industrial waste in Iran and it has, until now, been only roughly estimated. To the best of our knowledge and based on literature review, there is no report on the characterization and analysis of waste in the Arasanj industrial complex. Thus, this research was carried out to survey the total waste generation, characterization and their related management activities.

2. Methodology

2.1. The situation

This descriptive study was conducted during the year 2014. There are many industrial areas in Iran, most of which are located in the outskirts of large cities. Qazvin with a population of 620,000 is one of the most important industrial cities in Iran. Arasanj industrial estate as one of the largest of these industrial estates is located in the vicinity of Qazvin. The survey identified 45 active industries including 3 electricity and electronic products industries, 1 medical and cosmetic products industry, 3 wood and cellulose products industries, 14 chemical products industries, 7 food and beverage products industries, 10 metallic products industries, 1 textile industry, 1 machinery and equipments industry, 2 non-metallic products industries, and 3 agricultural products industries in this industrial estate.

2.2. Data collection

In order to analyze the waste stream, the research was conducted in various steps. In the first step, all the industrial processes in the region, the types and quantities of products and other general data were identified. Next, the wastes generated by each industrial process were characterized. Three general methods were used to study the composition and management of industrial wastes generated: the questionnaire survey, observation & interviews, and sampling & analysis.

2.3. Questionnaire survey

On the basis of the studies carried out in other countries as well as in Iran, a structured questionnaire was prepared. The questionnaire included some general information on the items such as industrial group, number of employees, industrial processes, the types and quantities of products and other functional elements and organizational structure of the industry. It also contained some questions on generation of different fractions of the waste as well as management activities. This questionnaire was then sent to the company managers for completion.

2.4. Observation & interviews

Detailed information about the industry and the waste was obtained through interviews and observations. The whole business activity of manufacturing processes, waste generation and existing waste management system was observed and recorded. In addition, employees and managers were interviewed using interviewing techniques.

2.5. Sampling & analysis

Specific sampling and analysis were carried out in order to obtain sufficient information on the waste generation and its composition. Out of 45 industries, 15 were selected for sampling since they generate large amounts of waste. The containers of the selected industries were emptied and the waste were sorted by hand and then weighed. The procedures included detailed analysis of the contents of each waste container with regard to weight, volume and characteristics. Based on this information the total amount of waste generated per day was estimated. The waste was sorted into the following categories:

1- Organic wastes from restaurants and food sector industries as well as garden wastes.

2- Plastic including nylon, packaging materials and various other similar wastes.

3- Wood and wood products including sawdust and other residues from the wood sector activities.

4- Metals such as iron, steel, aluminum, lead, copper and brass.

5- Paper and cardboard.

6- Leather and Textiles, including clothing and upholstery industry wastes.

7- Waste oils and solvents including car oil, printing ink, paint and disinfectant.

8- Sludge.

9- Other components such as sand, gravel, ash, and other similar wastes.

3. Results and discussion

3.1. Waste quantity & composition

Despite the fact that the quantity of waste estimated was not purely industrial waste, all of these data were necessary for the estimation of the total waste quantity in the industrial estate. Thus, the information obtained provided an approximation of the quantity, characteristics and composition of wastes generated. Figure 1 shows the amount of industrial waste categories in all industries in Arasanj industrial estate. The results of our research showed that the total waste generation in Arasanj industrial estate was 365.9 tons year^{-1}. The amounts of industrial waste generated by various countries depend on the structure of their economies. For example, 18 million tons of industrial waste is produced every year in Taiwan (Mohamed *et al.,* 2008), while 3 million tons year^{-1} industrial wastes are produced by Chilean industries (Navia & Bezama, 2008).

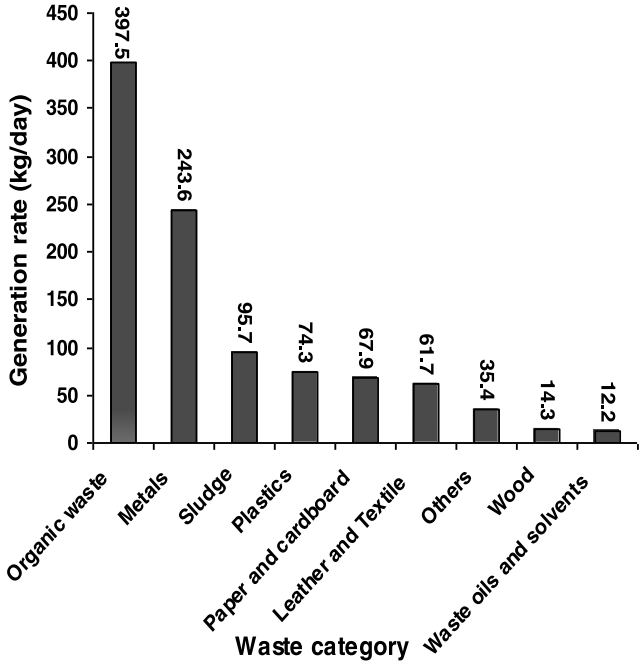

Fig. 1. Generation rate of various components of the total industrial waste in Arasanj industrial estate

Based on our results, metals and organic waste were the main components from standpoint of weight and volume. The characterization of wastes in industrial areas is largely dependent on the type of industrial processing activities (Salihoglu, 2010). 17 industries in Arasanj are based on metals and food processing products and generate metals and organic residues from their activities. For this reason, these two components constituted 64.0% of the total waste generated and all other components were responsible for only 36.0% of it (Figure 2).

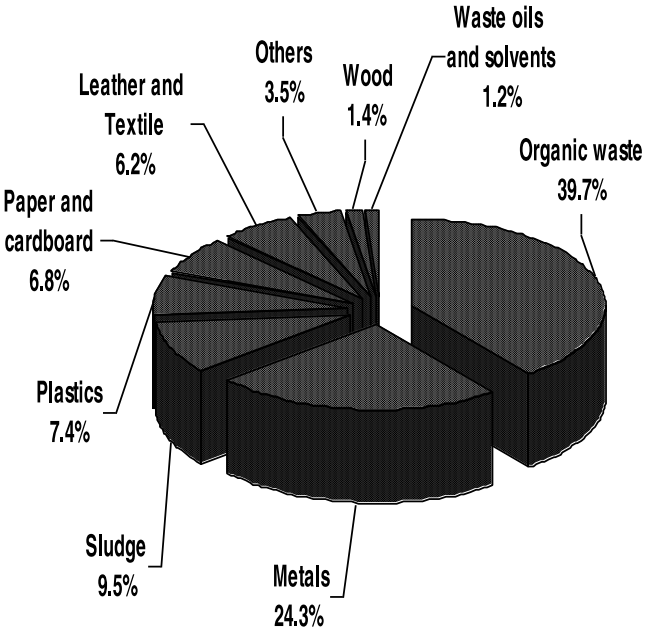

Fig. 2. Composition of the total waste generated in Arasanj industrial estate

Breaking down by industrial type (Figure 3), it can be seen that the majority of industrial wastes come from food and beverage industries (46%) metallic industries (26.3%), and chemical industries (10.4%). The reason is that these three industries constitute the majority of all active industries in Arasanj industrial estate. Electricity industries, non-metallic industries, agriculture industries, medical and cosmetic industries, machinery industries, Textile industries, and wood and cellulose industries are responsible for 5.3%, 4.1%, 2%, 1.7%, 1.7%, 1.4%, and 1.1% of the total waste generated, respectively.

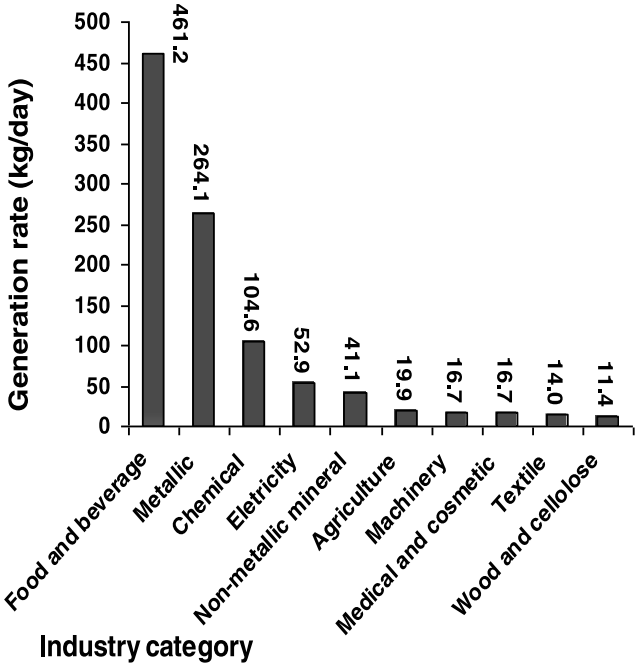

Fig. 3. Generation rate of total waste in each industry category in Arasanj industrial estate

Table 1. Composition of waste generated in Arasanj's food and beverage industries

Waste category	Generation rate (Kg day^{-1})	Percentage
Organic waste	265.78	57.63
Metals	5.79	1.26
Paper and cardboard	31.12	6.75
Leather and textile	46.91	10.17
Wood	1.14	0.25
Plastic	51.37	11.14
Waste oil and solvents	10.44	2.26
Sludge	35.51	7.70
Others	13.14	2.85
Sum	461.20	100.00

Generation rate and percentage of each waste category in these three industries are shown in Tables 1 to 3. It was obvious from the tables that the waste composition is largely dependent on the type of the industrial activity. Accordingly, the highest percentages of metals and organic wastes are observed in metallic industries and food processing industries, respectively.

Table 2. Composition of waste generated in Arasanj's metallic industries

Waste category	Generation rate (Kg day^{-1})	Percentage
Organic waste	52.57	19.91
Metals	177.43	67.19
Paper and cardboard	2.69	1.02
Leather and textile	2.47	0.94
Wood	0.10	0.04
Plastic	3.31	1.25
Waste oil and solvents	0.17	0.06
Sludge	21.11	7.99
Others	4.23	1.60
Sum	264.09	100.00

Table 3. Composition of waste generated in Arasanj's chemical industries

Waste category	Generation rate (Kg day^{-1})	Percentage
Organic waste	34.06	32.56
Metals	21.00	20.07
Paper and cardboard	15.12	14.45
Leather and textile	0.41	0.39
Wood	3.30	3.15
Plastic	5.34	5.10
Waste oil and solvents	0.43	0.41
Sludge	22.10	21.12
Others	2.87	2.74

Table 4 shows the percentages of hazardous waste generated in each industry category. According to the table, 48.4% of the total waste from non-metallic mineral industries was hazardous. In this regard, non-metallic mineral industries have the highest hazardous portion of the total waste. Waste from chemical industries and medical and cosmetic industries are the second most hazardous component-bearing waste with 24.3% and 24.2%, respectively. The lowest hazardous portion of waste was observed in wood and cellulose industries and electricity industries. Based on our results, the total

hazardous waste in all industries amounted to nearly 143.3 kg day^{-1}. This quantity accounts for nearly 14.3% of total waste generated. Malaysian industries generated more than 363,000 tons of hazardous waste in 2002 (Mohamed *et al.,* 2008). Industries in Spain produce nearly 2 million tons year^{-1} hazardous waste, which accounts for nearly 8.0% of the total waste generated by the manufacturing industries (Salihoglu, 2010). In China the reported generation of hazardous waste was 11.6 million tons in 2005, which accounted for 1.1% of total industrial waste (Duana *et al.,* 2008).

The amount of hazardous wastes generated by the top four manufacturing industry categories, which are food and beverage industries (41.3%), metallic industries (17.8%), chemical industries (17.7%), and Non-metallic minerals (13.9%), accounted for 90.7% of the hazardous waste generated. The amount of hazardous waste generated by industries in Turkey were basic metals (27.4%), chemicals and chemical products (24.2%), food and beverages (21.9%), coke and refined petroleum (9.5%), and motor vehicles and trailers (6.0%) in 2004 (Salihoglu, 2010).

Table 4. The amount and percentage of hazardous waste generated in Arasanj industrial estate

Industry category	Generation rate (Kg day^{-1})		Percentage	
	Non-Hazardous waste	Hazardous waste	Non-Hazardous waste	Hazardous waste
Electricity	48.76	4.18	92.11	7.89
Medical and cosmetic	12.67	4.03	75.85	25.15
Wood and cellulose	11.23	0.18	98.44	1.56
Chemical	79.22	25.40	75.72	24.28
Food and beverage	402.11	59.09	87.19	12.81
Metallic	238.58	25.51	90.34	9.66
Machinery	15.14	1.51	90.93	9.07
Textile	12.31	1.67	88.08	11.92
Agriculture	18.07	1.84	90.76	9.24
Non-metallic minerals	21.21	19.86	51.64	48.36
Sum	59.30	143.25	85.71	14.29

The largest contributor to the hazardous waste from Spanish industry was reported to be basic metals together with non-metallic products manufacture (57.0%), and chemical and plastic industries (27.0%) in 2006 (Salihoglu, 2010). 38.0% of the hazardous waste generated by Chinese industry was from raw chemical materials and chemical products industry (Duana *et al.,* 2008). The programs for hazardous waste management should be focused on these plants.

3.2. Management

The analysis of the current waste management of the industrial estate provides the basis for the planning of the future management system. A variety of waste management problems in the area under study were identified. The handling of waste in Arasanj industrial estate is based on the collection of waste in containers placed in different locations. There are some bins and containers of various sizes and shapes available for the collection of co-mingled waste. These containers are emptied twice a week by a company, which has been contracted for this purpose. Two trucks are responsible for the collection and transportation of waste to the landfill. Our study showed that some of the wastes are left outside the containers on the street because the number and volume of containers are insufficient. Most of the industrial wastes are transported to municipal landfill without sorting and prior treatment. Therefore, certain wastes that could be used in recycling processes are instead dumped in landfills, or burnt. Much of the waste may often be illegally dumped in neighboring areas not designated for this purpose. Moreover, one of the primary

problems arising along with industrial activities in Arasanj industrial estate is illegal dumping and uncontrolled incineration of waste. Another problem is the mixing of the hazardous industrial waste with non-hazardous municipal solid waste. Unfortunately, companies in Arasanj exhibit a weak recovery of all the waste materials that they generate. There are not any private companies that collect hazardous wastes such as oils and other liquids. As well, there are not other specialized companies for the recovery of valuable recycling materials, such as paper and cardboard, metals, and plastic. Therefore, companies in Arasanj industrial estate have not found economic uses for any wastes that they generate.

In order to establish integrated waste management system and effective use of resources, promotion of recycling and reuse of industrial wastes should be regarded (Memon, 2010). Waste prevention or minimization should be focused as the priority principle in waste management system (Ghinea *et al.,* 2012). Manufacturers should reduce generation of hazardous substances and increase the use of recycled materials (Koolivand *et al.,* 2015). If a source separation system is to be implemented, containers of different sizes and shapes or colours (one for each category of waste) can be placed at suitable locations. For successful management of industrial wastes, an integrated regulatory framework as well as technical assistance, management and operation improvement and economic incentives are needed (Bain *et al.,* 2010; Shi *et al.,* 2010; Park, 2014). For implementation of these programs, it is very important to increase motivation for waste management activities among employees and managers. This can be done through an educational program for material sorting and information about the importance of source separation as well as an active tax policy for waste management and mismanagement.

4. Conclusion

It was concluded from the study that waste composition of each industry depended on the type of industry and its processes. Also, the main components of the waste included organic and metallic wastes. The majority of industrial wastes came from food and beverage industries, metallic industries, and chemical industries because the waste from these three industries constituted more than 60% of all active industries. Non-metallic mineral industries, chemical industries, and medical and cosmetic industries had the highest generation of hazardous waste. On the other hand, the lowest generation of hazardous waste was observed in wood and cellulose industries and electricity industries.

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References

Alkoot, F.M. (2014). Multimodal biometric authentication using adaptive decision boundaries. The Kuwait Journal of Science, **41**(3):103-127.

Bain, A., Shenoy, M., Ashton, W. & Chertow, M. (2010). Industrial symbiosis and waste recovery in an Indian industrial area. Resources, Conservation and Recycling, **54**(12):1278-1287.

Curran, T. & Williams, I.D. (2012). A zero waste vision for industrial networks in Europe. Journal of Hazardous Materials, **207-208**:3-7.

Das, A., Gupta, A.K. & Mazumder, T.N. (2012). Vulnerability assessment using hazard potency for regions generating industrial hazardous waste. Journal of Hazardous Materials, **209-210**:308-317.

Duana, H., Huangb, Q., Wang, Q., Zhou, B. & Li, J. (2008). Hazardous waste generation and management in China: A review. Journal of Hazardous Materials, **158**(2):221-227.

Duane M.J. (2014). 19th century lignite mining (Germany): Hazards from non-ideal waste sequestration. The Kuwait Journal of Science, **41**(3):191-202.

Ghinea, C., Petraru, M., Bressers, H.T.A. & Gavrilescu. M. (2012). Environmental evaluation of waste management scenarios-significance of the boundaries. Journal of Environmental Engineering and Landscape Management, **20**(1):76-85.

Koolivand, A., Gholami Borujeni, F. & Nourmoradi, H. (2015). Investigation on the characteristics and management of dental waste in Urmia. Iran. Journal of Material Cycles and Waste Management, **17**(3):553-55.

Lei, L., Wang, S., Lin, Y., Liu, W. Chi, T. (2015). A covering model application on Chinese industrial hazardous wastemanagement based on integer program method. Ecological Indicators, **51**:237-243.

Li, J. & Yu, K. (2011). A study on legislative and policy tools for promoting the circular economic model for waste management in China. Journal of Material Cycles and Waste Management, **13**(2):103-112.

Lopez-Cima, M.F., Garcia-Perez, J., Perez-Gomez, B., Aragones, N., Lpez-Abente, G., *et al.* (2013). Lung cancer risk associated with residential proximity to industrial installations: a spatial analysis. International Journal of Environmental Science and Technology, **10**(5):891-902.

Maguyon, M.C.C., Alfafara, C.G., Migo, V.P., Movillon, J.L. & Rebancos, C.M. (2012). Recovery of Copper from spent solid printed-circuit-board (PCB) wastes of a PCB manufacturing facility by two-step sequential acid extraction and electrochemical deposition. Journal of Environmental Science and Management, **15**(1):17-27.

Memon, M.A. (2010). Integrated solid waste management based on the 3R approach. Journal of Material Cycles and Waste Management, **12**(1):30-40.

Mohamed, A.F., Wang, M.A., Hassan, M.N. & Jaafar, A.B. (2008). Ecosystem approach for sustainable industrial hazardous waste management in Malaysia. Environmental Research Journal, **2**(6):306-310.

Nasrullah, M., Vainikka, P., Hannula, J., Hurme, M. & Kärki, J. (2014). Mass, energy and material balances of SRF production process

Part 1: SRF produced from commercial and industrial waste. Waste Management, **34**(8):1398-1407.

Navia, R. & Bezama, A. (2008). Hazardous waste management in Chilean main industry: an overview. Journal of Hazardous Materials, **158**(1):177-184.

Oluremi, J.R., Coker, A.O., Sridhar, M.K.C., & Olaoye, R.A. (2013). Solid waste management in a leprosarium in Southwestern Nigeria. Civil and Environmental Research, **3**(10):98-106.

Park, J.Y. (2014). Assessing determinants of industrial waste reuse: The case of coal ashin the United States. Resources, Conservation and Recycling, **92**:116-127.

Roy, W.Y., Asem, S.O. & Al-Burais, M. (2015). Crude oil contamination on the Sabkha facies of Kuwait. The Kuwait Journal of Science, **42**(3):191-209.

Salihoglu, G. (2010). Industrial hazardous waste management in Turkey: Current state of the field and primary challenges. Journal of Hazardous Materials, **177**(1-3):42-56.

Shi, H., Chertow, C. & Song, Y. (2010) Developing country experience with eco-industrial parks: a case study of the Tianjin Economic: Technological Development Area in China. Journal of Cleaner Production, **18**(3):191-199.

Turskis, Z., Lazauskas, M. & Zavadskas, E.K. (2012). Fuzzy multiple criteria assessment of construction site alternatives for non-hazardous waste incineration plant in vilnius city, applying ARAS-F and AHP methods. Journal of Environmental Engineering and Landscape Management, **20**(2):110-120.

Usapein, P. & Chavalparit, O. (2014). Options for sustainable industrial waste management toward zero landfill waste in a high-density polyethylene (HDPE) factory in Thailand. Journal of Material Cycles and Waste Management, **16**(2):373-383.

Wagland, S.T., Veltre, F. & Longhurst, P.J. (2012). Development of an image-based analysis method to determine the physical composition of a mixed waste material. Waste Management, **32**(2):245-248.

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توصيف وإدارة النفايات الصناعية في منطقة أراسانج الصناعية، إيران

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ملخص

كان الهدف من هذا البحث هو دراسة إجمالي إنتاج النفايات وتوصيفها بالإضافة إلى أنشطة إدارتها في منطقة أراسانج الصناعية. وتم استخدام استبيان للحصول على بيانات عن العمليات الصناعية، وأنواع وكميات المنتجات، وإنتاج النفايات وإدارتها وغيرها من البيانات العامة. وبعد ذلك، تم اختيار 15 صناعة وتم فرز نفاياتها باليد ومن ثم وزنها. وبالإضافة إلى ذلك، تم تحديد معلومات تفصيلية عن النفايات في جميع الصناعات من خلال إجراء المقابلات وتدوين الملاحظات. وأظهرت النتائج أن متوسط توليد النفايات الصلبة في كل وحدة صناعية بلغ 22.3 كيلوغراما في اليوم. وشكلت النفايات العضوية والمعادن 64% من مجموع النفايات المتولدة وكانت جميع المكونات الأخرى مسؤولة عن 36% من هذه الكمية. وأظهرت النتائج أن غالبية النفايات الصناعية تأتي من صناعات الأغذية والمشروبات (46%)، والصناعات المعدنية (26.3%) والصناعات الكيمائية (10.4%). واستناداً إلى النتائج، يمثل مجموع النفايات الخطرة حوالي 14.3% من مجموع النفايات المتولدة. وكانت إدارة النفايات الصناعية في منطقة أراسانج الصناعية ضعيفة وتم تحديد مجموعة متنوعة من مشاكل إدارة النفايات. ولتحقيق أفضل إدارة، ينبغي إعادة تدوير النفايات الصناعية وإعادة استخدامها إلى أقصى حد ممكن.