Orclever Proceedings of Research and Development
https://doi.org/10.56038/oprd.v5i1.561
OR CLEVER Science & Research Group

Conference Article

The Evaluation of Recycling Perception in the Plastic Waste Industry

Yunus Emre Arslan[1], Hande Çavuş Arslan[2]

[1] Halic University, Orcid ID: https://orcid.org/0009-0004-1736-8642, e-mail:yunusemrearsllan@gmail.com
[2] Halic University, Orcid ID: https://orcid.org/0000-0003-2340-8853, e-mail:handearslan@halic.edu.tr
* Correspondence: handearslan@halic.edu.tr, +905332463885

Received 24 October 2024
Received in revised form 25 December 2024
In final form 28 December 2024

4th International Conference on Design, Research and Development (RDCONF 2024)
December 19 - 20, 2024

Reference: rslan, Y. E., & Çavuş Arslan, H. (2024). The evaluation of recycling perception in the plastic waste industry. Orclever Proceedings of Research and Development, 5(1), 365-376.

Abstract

As the industry develops, plastic consumption continues to increase every year. Today, plastic pollution stands out as an important problem among environmental concerns. Plastic waste creates negative impacts on the environment, both on macro and micro levels, due to their types, size, and resistance to degradation. Recycling is of great importance its contributions to both nature and economy. The main purpose of this study is to determine the waste management, economic efficiency, sustainability and recycling awareness levels of companies operating in the plastic recycling industry using surveys and statistical tools. For this purpose, a survey was conducted with a total of 19 companies and 63 employees working in micro, small, medium and large companies that recycle different types of plastics. The data obtained from the surveys were evaluated using basic statistical methods. There are many studies in the literature that focused on consumers' perception of recycling. However, according to our knowledge, no study has been found on the recycling perception of recycling companies.

Keywords: *Plastic Waste, Recycling, Waste Management, Statistics, SPSS.*

https://doi.org/10.56038/oprd.v5i1.561

1. Introduction

The inability of plastics to biologically decompose is one of the leading environmental issues. With the rapid development of the industry, plastic consumption has also increased, which deepens the impact of plastic waste on the environment. Particularly, polyethylene (PE) and polypropylene (PP) types stand out in terms of production and consumption and play a significant role in recycling processes. The recycling of plastics holds critical environmental and economic importance [1-3].

Polypropylene, with its broad range of applications, is present in almost every aspect of our lives, and compared to other plastic types, it has a significant impact on the recycling sector. Recycled polypropylene can be reused across various industries, and to increase the recycling rate of plastic waste, government support, industry training, and raising public awareness are essential. Proper recycling of plastics helps conserve natural resources and prevents environmental pollution [4-6].

As the use of plastic rises, the development of new and advanced types of plastic has also accelerated. These plastic types are made more durable, particularly through their physical and mechanical properties and various additives (such as colorants, UV stabilizers, and antistatics). The growing expectations of consumer societies and the desire for a more comfortable life have led to the widespread use of plastics. However, alongside this increase, managing plastic waste and rendering it harmless has become crucial [7,8].

To prevent plastic waste from harming the environment, it is necessary to increase recycling rates and make the plastics used reusable. This process benefits both nature and the economy. Recycling plastic waste helps prevent environmental pollution and enables economic gains. Studies on reducing waste and improving recycling efficiency in the plastic sector contribute to both environmental and economic benefits [9-11].

As plastic usage increases, effective recycling and mindful consumption become even more critical. Proper recycling methods and conscious consumption will reduce the negative environmental impacts of plastics and contribute to the conservation of natural resources and economic development [12-14].

Based on this perspective, in this study, the amount of plastic types recycled by companies working in the plastic industry, where they prefer to obtain the raw waste to be recycled, the economic impact, sustainability and recycling perceptions of those working in this industry were examined through surveys and statistics. According to the

https://doi.org/10.56038/oprd.v5i1.561

results obtained, it was aimed to shed light on the difficulties experienced in the plastic industry and what kind of improvements can be made on recycling perceptions.

2. Materials and Methods

A survey was conducted to 19 companies with a total of 63 employees working in micro, small, medium and large companies that recycle different types of plastics. In this survey, 7 questions were prepared regarding variables related to demographic characteristics. These variables are; gender, age, education, how many years have they worked in this sector, in which industry they have worked, the size of the company they work for and their position in the company. In the second part of the survey, questions were prepared under four headings on waste management, economic impact, sustainability and recycling perception. The questions prepared on recycling perception were in 5-point Likert type and Cronbach Alpha reliability coefficient was calculated as 0.857.

The data obtained in the study were analyzed using IBM SPSS 26.0 software. Frequency (n) and percentage (%) were used as descriptive statistical measures. For the questions prepared in nominal and ordinal scales in the study, significance analysis was performed with chi-square analysis. Normality test was applied to the data set obtained with Likert scale and it was determined that the data were suitable for normal distribution. Since the data were suitable for normal distribution, parametric tests (independent t-test, one-way analysis of variance (ANOVA)) were applied. The cut-off value for the analyses to be considered statistically significant was accepted as $p < 0.05$.

3. Result

Demographic characteristics of the companies and employees are given in Table 1 and 2, respectively. As can be seen from Table 1, the participation rates of small, medium, and large companies are relatively close to each other, while only one medium-sized company participated. When the field of these companies is examined, it is observed that 57.9% of the participants are from the plastic industry, while data has also been collected from companies operating in various fields such as automotive, electronics, and white goods.

Table 1: Demographic characteristics of companies

Demographic characteristics		Frequency	Percentage (%)
What is the Size of Your Company?	Micro Companies (1-10 employees)	8	42.1
	Small Companies (10-50 employees)	5	26.3
	Medium Companies (50-250 employees)	1	5.3

https://doi.org/10.56038/oprd.v5i1.561

	Large Companies (250+ employees)	5	26.3
Which industry do you work in?	Plastics Industry	11	57.9
	Automotive Industry	1	5.3
	Electronics and White Goods Industry	1	5.3
	Construction Industry	2	10.5
	Health Industry	1	5.3
	Agricultural Industry	1	5.3
	Textile Industry	2	10.5

When the demographic characteristics of the employees are examined (Table 2), it is seen that the majority of the participants work in micro companies and the plastic industry, with a higher percentage of middle-level managers and experts.

Table 2: Demographic characteristics of employees

Demographic characteristics		Frequency	Percentage (%)
Age	18-24	15	23.8
	25-34	25	39.7
	35-44	9	14.3
	45-54	9	14.3
	55 and above	5	7.9
Gender	Female	19	30.2
	Male	44	69.8
Education Level	Primary School	5	7.9
	Middle School	5	7.9
	High School	12	19.0
	Bachelor's Degree	34	54.0
	Master's Degree and above	7	11.1
Years of Work in the Industry?	1-3 years	20	30.2
	3-5 years	8	12.7
	5-10 years	12	19.0
	10-20 years	8	12.7
	20 years and above	15	23.8
Which industry do you work in?	Plastics Industry	33	50.8
	Automotive Industry	4	6.3
	Electronics and White Goods Industry	8	12.7
	Construction Industry	7	11.1
	Health Industry	6	9.5
	Agricultural Industry	3	4.8
	Textile Industry	2	3.2
What is the size of Your Company?	Micro Companies (1-10 employees)	31	49.2
	Small Companies (10-50 employees)	13	20.6
	Medium Companies (50-250 employees)	6	9.5
	Large Companies (250+ employees)	13	20.6

https://doi.org/10.56038/oprd.v5i1.561

What is Your Position in the Company?	Manager (CEO, etc.)	11	17.5
	Mid-level Manager (Department Head, Team Leader, etc.)	17	27.0
	Specialist (Financial Analyst, Marketing Specialist, Engineer, etc.)	17	27.0
	Sales Personnel	3	4.8
	Production Staff	8	12.7
	Administrative Personnel (Secretary, Office Manager, etc.)	5	7.9
	Other (Please Specify)	2	3.2

In order to examine their waste management characteristics, companies were asked to answer questions about which products they recycle and where they obtain the waste raw materials they will recycle, with the ability to mark more than one option, and the results are presented in Table 3 below.

Table 3: Waste Management Characteristics of Companies

Waste Management		Frequency	Percentage (%)
Which products do you recycle or sell? (You can choose more than one option)	Polyethylene (PE)	12	34.3
	Polypropylene (PP)	11	31.4
	Polyvinylchloride (PVC)	3	8.6
	Polyethylene terephthalate(PET)	3	8.6
	Acrylonitrile butadiene styrene (ABS)	3	8.6
	Polyamide (PA)	3	8.6
How do you access raw materials? (You can choose more than one)	From individual consumers	1	2.5
	From municipalities	8	20.0
	From industrial establishments	6	15.0
	From commercial enterprises	7	17.5
	From scrap dealers	9	22.5
	From other recycling companies	8	20.0
	From international suppliers	1	2.5

So as to obtain information about the economic efficiency characteristics of recycling, questions were asked to the employees about the incentives provided to the waste sector and the difficulties encountered. The frequency and percentage distribution results of the economic characteristics are given in Table 4.

Table 4: Economic Efficiency Characteristics

Economic Efficiency		Frequency	Percentage (%)
Have you benefited from government or private	Tax reductions	13	16.7
	Credit and financial support	15	19.2

https://doi.org/10.56038/oprd.v5i1.561

incentives in your activities? If yes, which options?	R&D incentives	12	15.4
	Other	2	2.6
	No	36	46.2
What are the challenges you face when taking advantage of incentives?	Bureaucratic hurdles	16	25.4
	Insufficient information	36	57.2
	Timing issues	10	15.9
	Too many paperwork requests	1	1.6
What is the biggest challenge you face in recycling plastic waste? (You can choose more than one option)	Lack of education and awareness	15	17.9
	Transportation to recycling facilities	22	26.2
	Costs	28	33.3
	Lack of adequate recycling infrastructure	19	22.6

To examine the perspectives of those working in the field of recycling on sustainability in their companies, questions were asked about whether they had activities in this context. The frequency and percentage distribution results of sustainability features are given in Table 5.

Table 5: Sustainability Characteristics

Sustainability		Frequency	Percentage (%)
What kind of activity have you done to save energy? (You can choose more than one option)	Using energy efficient machinery	45	38.8
	Using recycled energy	12	10.3
	Switching to less energy consuming production processes	28	24.1
	Investing in renewable energy sources (e.g. solar, wind)	16	13.8
	Heat recovery systems	15	12.9
Do you have any activity to reduce environmental damage? (You can choose more than one option)	Reducing water use	35	21.1
	Using energy efficient equipment	23	13.9
	Zero waste target	26	15.7
	Minimizing waste generated during recycling	30	18.1
	Methods to reduce carbon emissions	17	10.2
	Reducing the use of harmful chemicals	19	11.4
	Using renewable energy	16	9.6

It was examined whether there was a significant difference between the types of plastic waste produced by the companies and their sizes. Since there was only one medium-sized company, a frequency distribution table was prepared by combining medium and large-sized companies (Table 6).

https://doi.org/10.56038/oprd.v5i1.561

Table 6: Distribution of Plastic Waste Types by Company Size

		What is the size of your company?		
		Micro Companies (10 or less employees)	Small Companies (10-50 employees)	Medium and Large Companies (50+ employees)
What products do you recycle or sell? (You can choose more than one option)	Polyethylene (PE)	5	4	3
	Polypropylene (PP)	4	4	3
	Polyvinylchloride (PVC)	3	0	0
	Polyethylene terephthalate(PET)	1	1	1
	Acrylonitrile butadiene styrene (ABS)	2	0	1
	Polyamide (PA)	1	0	2

Data examining the relationship between the average monthly amounts of waste recycled by companies and the types of plastics recycled are presented in Table 7.

Table 7: Relationship between type of plastic recycled and monthly amount of recycled waste

		The amount of waste you recycle in a month	
		0-500 kg	500 kg and more
Which products do you recycle or sell? (You can choose more than one option)	Polyethylene (PE)	0	12
	Polypropylene (PP)	0	11
	Polyvinylchloride (PVC)	1	2
	Polyethylene terephthalate(PET)	3	0
	Acrylonitrile butadiene styrene (ABS)	1	2
	Polyamide (PA)	1	2

The distribution of preferred methods for accessing raw materials according to company size is presented in Table 8.

Table 8: Preferred Methods for Accessing Raw Materials by Company Size

	What is the size of your company?	
	Micro and small companies	Medium and large companies

https://doi.org/10.56038/oprd.v5i1.561

How do you access raw materials? (You can choose more than one)	From individual consumers	4	4
	From municipalities	1	0
	From industrial establishments	4	2
	From commercial enterprises	5	3
	From scrap dealers	7	2
	From other recycling companies	7	1
	From international suppliers	0	3

The effects of the size of the companies they work for on the recycling perception of employees were examined with t-test analyses and the results obtained are given in Tables 9.

Table 9: T test results for the relationship between recycling perception and company size

	What is the size of the company you work for?	N	Mean	Standard Deviation	p
How important do you think recycling is?	micro and small companies	44	4.3409	1.14004	**0.004**
	medium and large companies	19	4.8947	0.31530	
How much do you know about plastic waste management and recycling in your company?	micro and small companies	44	3.8409	1.14004	0.486
	medium and large companies	19	3.6316	0.95513	
How active do you think your company is in recycling?	micro and small companies	44	2.9773	0.92733	0.588
	medium and large companies	19	3.1053	0.65784	
Are you aware of the environmental impact of recycling plastics in your company?	micro and small companies	44	4.0909	0.98402	0.613
	medium and large companies	19	3.9474	1.12909	
How do you evaluate the environmental impact of products obtained by recycling plastic waste?	micro and small companies	44	4.1818	0.97104	0.908
	medium and large companies	19	4.2105	0.71328	
How much importance do you give to environmentally friendly products when shopping?	micro and small companies	44	3.9091	1.05253	0.596
	medium and large companies	19	4.0526	0.77986	
How does the fact that environmentally friendly products are more expensive than other products affect your purchasing decision?	micro and small companies	44	3.5000	1.19105	0.576
	medium and large companies	19	3.6842	1.20428	
Should the government require manufacturers to use recyclable materials in their packaging?	micro and small companies	44	4.0455	1.01052	0.104
	medium and large companies	19	4.4737	0.77233	
	micro and small companies	44	3.7045	1.06922	0.753

https://doi.org/10.56038/oprd.v5i1.561

Do you find recycling easily applicable in our daily lives?	medium and large companies	19	3.7895	0.71328	
Do you separate your waste using recycling bins?	micro and small companies	44	3.8409	0.98697	0.243
	medium and large companies	19	3.8409	1.14004	

The effect of the training they receive on recycling on the recycling perception of employees were examined with t-test analyses while the effect of positions of the employees on their perception of recycling was examined using ANOVA analysis. Only the significant results obtained are given in Tables 10 and 11, respectively.

Table 10: T test results of the relationship between recycling perception and receiving training about recycling

	Have you received any training regarding recycling?	N	Mean	Standard Deviation	p
How much do you know about plastic waste management and recycling in your company?	Yes	33	4.0909	1.04174	**0.015**
	No	30	3.4333	1.04000	
How active do you think your company is in recycling?	Yes	33	3.2727	0.80128	**0.011**
	No	30	2.7333	0.82768	
Are you aware of the environmental impact of recycling plastics in your company?	Yes	33	4.4242	0.61392	**0.002**
	No	30	3.6333	1.21721	

Table 11: ANOVA test results of the relationship between recycling perception and employees' positions

	What is your position at your company?						P
	Manager (n=11)	Mid-level manager (n=17)	Expert (n=17)	Sales personnel (n=5)	Production worker (n=8)	Administrative staff (n=5)	
How much importance do you give to environmentally friendly products when shopping?	4.3636 ± 0.67420	3.2941 ± 1.21268	4.0000 ± 0.86603	4.6000 ± 0.54772	4.2500 ± 0.70711	4.0000 ± 0.70711	**0.020**

The results of the examination conducted to determine whether there is a relationship between the type of products allocated for recycling among employees in the plastics industry and those in other industries are given in Table 12.

https://doi.org/10.56038/oprd.v5i1.561

Table 12: The type of product that is preferred to be separated for recycling depending on the field of industry

		The field of industry	
		Plastic Industry	Other Industries
Which of the following products do you recycle in your daily life? (You can choose more than one option)	Metal	15	18
	Glass	13	20
	Textile	8	14
	Plastic	28	20
	Batteries and electronics	16	15

4. Discussion and Conclusion

It is known that PP is the most recycled plastic type in the world. In this study, it was determined, in line with the literature, that PE and PP are the two most commonly recycled plastic types. (Table 3). When the company size is taken into account, it is also seen that PE and PP are the most recycled waste types among all companies (Table 6). Similarly, when the monthly average recycling amounts are examined, it is revealed that PE and PP are recycled at higher rates than other plastic types, while PVC and PET are recycled at lower rates (Table 7). The lower recycling rates of PVC and PET can be explained by the fact that the recycling processes of these types of plastics are more difficult and expensive [15].

It is seen that companies mostly use scrap dealers and municipalities to provide the raw material to be recycled (Table 3). Although this preference varies according to the size of the company, municipalities and commercial institutions are the frequently preferred sources for both micro and small and medium and large companies. However, as the company size decreases, the need for scrap dealers and other recycling companies increases (Table 8).

More than half of the participating companies stated that they did not receive any incentives. Insufficient information was shown as the biggest challenge for companies seeking incentives. It is thought that if more information is provided about incentives, the application rates of the companies for incentives will increase. In addition, it was stated that bureaucratic obstacles are also an important problem in incentive applications. The biggest challenge in recycling plastic waste is shown as costs and logistics of raw materials (Table 4).

https://doi.org/10.56038/oprd.v5i1.561

It is observed that recycling companies also work on sustainability and environmental awareness. The majority of the participants use energy-saving machines and attach importance to issues such as zero waste, reducing the amount of waste and saving water. Renewable energy investments are generally made by large companies (Table 5).

In the surveys conducted to examine the recycling perception of company employees, a statistically significant difference was found between the question "How important do you think recycling is?" and the company size. Accordingly, employees in medium and large-sized companies stated that the importance of recycling is higher than employees in micro and small companies, $p<0.05$ (Table 9). It was also statistically calculated that those who received training on recycling were more conscious about plastic waste management recycled in their own companies, $p<0.05$ (Table 10). When the effect of the positions of the employees on their preference for environmentally friendly products while shopping was examined, a statistically significant difference was found. Hence, it was seen that the sales personnel preferred environmentally friendly products the most while shopping, while it was calculated that the middle-level managers had the lowest score, $p<0.05$.

When the perception of products separated for recycling was evaluated by considering whether the employees worked in the plastic industry or not, it was found that employees in other industries separated waste such as metal, glass, textile, battery for recycling more than those working in the plastic industry, and that employees in the plastic industry gave more importance to plastic recycling than employees in other industries, $p<0.05$ (Table 12).

In conclusion, this study examined the practices of companies in Turkey regarding plastic recycling, the difficulties they face, and the perception of recycling. It is seen that PE and PP are the most recycled plastic types, but cost and logistics problems are important obstacles in recycling processes. In order to overcome these problems, strengthening incentive mechanisms, investing in recycling facilities, and improving logistics infrastructure will greatly contribute to the recycling industry. It has also been observed that one of the factors preventing recycling is lack of knowledge. Supporting employees with regular training on recycling and encouraging their participation in recycling practices will play a key role in helping companies achieve their recycling goals.

https://doi.org/10.56038/oprd.v5i1.561

5. Acknowledge

The authors would like to thank Dr. Çağrı Özgün Kibiroğlu for her contributions and ideas throughout the study process.

References

[1] J. Hopewell, R. Dvorak, and E. Kosior, "Plastics recycling: challenges and opportunities," Philosophical Transactions of the Royal Society B: Biological Sciences, vol. 364, no. 1526, pp. 2115-2126, 2009.
[2] S. V. Kalias, "Applications and Processing of Polymers," Indian Institute of Science, Dept. of Mechanical Engineering, Bangalore, pp. 1-2, 2012.
[3] K. O. Ç. Adil and S. A. Korun, "Polietilen plastik atıkların kimyasal bozundurma metodu ile faydalı ürünlere dönüştürülmesi," Ankara Üniversitesi Çevrebilimleri Dergisi, vol. 8, no. 1, pp. 19-26, 2021.
[4] X. Hua, Y. Guo, L. Chen, X. Wang, and Y. Li, "A novel polymeric intumescent flame retardant: Synthesis, thermal degradation mechanism and application in ABS copolymer," Polymer Degradation and Stability, vol. 97, pp. 1772-1778, 2012.
[5] M. A. Suleiman, I. A. Huin, and M. C. Williams, "Rheological investigation of the influence of short chain branching and Mw of LDPE on the melt miscibility of LDPE/PP blends," The Open Macromolecules Journal, vol. 5, pp. 13-19, 2011.
[6] A. J. Peacock, Handbook of Polyethylene: Structures, Properties, and Applications, Marcel Dekker, New York, 2000.
[7] M. R. Nofar, K. Majithiya, and C. B. Park, "The foamability of low-melt-strength linear polypropylene with nanoclay and coupling agent," Journal of Cellular Plastics, vol. 48, no. 3, pp. 271-287, 2012.
[8] H. Çetinel, "Polietilen ve polipropilenin mekanik özelliklerinin incelemesi," Dokuz Eylül Üniversitesi Mühendislik Fakültesi Fen ve Mühendislik Dergisi, vol. 2, no. 3, pp. 79-87, 2000.
[9] J. M. Encinar and J. F. González, "Pyrolysis of synthetic polymers and plastic wastes. Kinetic study," Fuel Processing Technology, vol. 89, pp. 678-686, 2008.
[10] G. Akovali, "Polimerik ileri malzemeler," Metalurji Mühendisleri Odası Yayını, vol. 20, p. 32, 1996.
[11] A. Okatan, "Plastikler nasıl geri dönüştürülür?," Tübitak Bilim Genç Dergisi, Aug. 30, 2022.
[12] M. Mehrabzadeh and F. Farahmand, "Recycling of commingled plastics waste containing polypropylene, polyethylene, and paper," J. Appl. Polym. Sci., vol. 80, pp. 2573-2577, 2001.
[13] A. Eröztürk, "Türkiye'de ambalaj atıklarının geri kazanımı," M.S. thesis, Fen Bilimleri Enstitüsü, İstanbul Teknik Üniversitesi, İstanbul, 1997.
[14] H. Öznalbant, "Çevre sorunları açısından geri dönüşüm sanayi," M.S. thesis, Marmara Üniversitesi, 1998.
[15] K. E. Hanbay, "Küresel iklim değişikliğinin olumlu ve olumsuz dışsallıkları üzerine bir değerlendirme," Sayıştay Dergisi, no. 118, pp. 101-131, 2020.