

## Investigation of Municipal Waste Characterization and Alternative Disposal Methods in Trabzon and Rize City Centres

Ayşe Kuleyin<sup>1\*</sup>, Muhammet Nalkıran<sup>2</sup>

<sup>1</sup> Ondokuz Mayıs University, Environmental Engineering Department, Samsun, Turkey

<sup>2</sup> Rize Municipality

E-Mail: akuleyin@omu.edu.tr, muhammet-nlkrn@hotmail.com

Received 07.01.2020; Accepted 02.04.2020

**Abstract:** The amount of waste produced is increasing day by day because of the enlargement of cities together with the growth in population and industry. It is imperative to make a feasible and sustainable waste management plan for these wastes produced. Otherwise, it will be much more difficult to protect the environment and human health. Therefore, it is very important for the ecological balance of the earth that every waste can be reused or discharge without damaging the environment. Disposal of urban wastes without harming nature has been the biggest requirement. As the energy resources in the world are gradually depleted, studies on obtaining energy from such wastes have increased.

In this study, the current waste management in two provinces of Turkey, Trabzon and Rize, was discussed and the system was explained in detail. In the context of integrated waste management, in order to decide on the most appropriate waste management option, provincial central waste characterization was carried out and seasonal variation in the waste composition was investigated. According to the results, approximately 65-75% of Rize municipal solid waste was found as organic waste and 35-25% as recyclable waste. Moisture content was determined as 68-70% on average annually. The lower calorific value was found between 3100 and 4800 kcal/kg on dry basis. Approximately 55-60% of Trabzon municipal solid waste was organic waste and 25-30% was recyclable waste. Annual average moisture content was found around 70%. The lower calorific value was determined between 3400-4500 kcal/kg on a dry basis. In addition, reuse, recycling, recovery and final storage systems of the municipal solid waste were discussed for the selection of the most appropriate methods within the scope of zero waste management of each province. Based on the characterization data, waste elimination from final disposal prolongs the lifetime of sanitary landfills.

**Keywords:** municipal solid waste management, characterization of solid waste, disposal.

### INTRODUCTION

As is known to all, that people have to reach and use some resources to meet their needs and maintain their lives. The remaining part after the consumption by people is considered as waste. At the same time, waste does not only mean used product. The products that have expired or have lost their purpose and quality are also classified as waste. On the other hand, the loss of usefulness of the substance and the fact that it has no financial value for its user is sufficient to qualify it as waste <sup>[1]</sup>.

According to the Waste Management Regulation <sup>[2]</sup>, the definition of waste is expressed as; "Any substance or material discharged or released into the environment by the manufacturer or person who actually owns it, or that must be disposed of."

For the development of solid waste management system, the current situation and waste characterization needs to be investigated should be examined.

Wastes were classified by Vaughn (2009) <sup>[3]</sup> as follows;

- Domestic waste,
- Industrial waste,
- Waste of electrical and electronic equipment
- Hazardous waste,
- Construction waste,(Building waste)
- Medical waste,
- Agricultural waste,

In our country, according to the Waste Management Regulation <sup>[2]</sup> of the Ministry of Environment and Urbanization, wastes are classified under 20 different groups. The wastes are separated according

\* Corresponding E-mail: akuleyin@omu.edu.tr

to the group it belongs and is included in the waste management plan according to the relevant waste group. In this way, it is aimed to reduce waste generation, reusable and recyclable wastes, natural resource consumption and provide waste management.

Waste management has a global importance as it will have negative effects on the environment when there is no integrated management. Rapid growth of cities, differentiation of human life, rapid increase in production and consumption increase the amount of waste. As the greenhouse gas emission values increase as a result of all these activities, the climate of the region is negatively affected. Many scientists have emphasized in the literature that environmental quality is rapidly deteriorated by not managing solid wastes properly [4,5].

In order to avoid or minimise the harmful effects of solid wastes proper solid waste disposal is required. For this purpose the elimination of solid waste by means of reuse, recycling and recovery is of crucial importance for economic benefits. If solid wastes are not stored and disposed of properly, they can create negative outcomes with respect to human and environmental health [6-8].

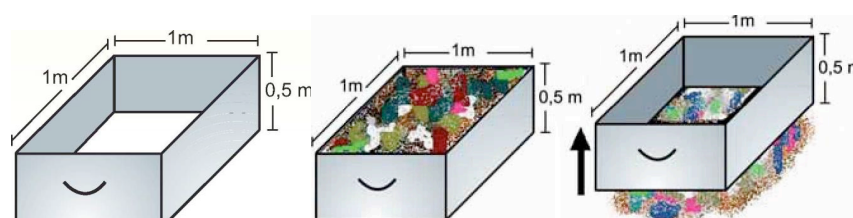
There are various technique for the disposal of solid wastes. For the selection of correct disposal technique solid waste characterization is of primary importance. Solid waste characterization is obtained by determining the waste composition and carrying out elemental analysis. [9-12]

In this study, the current municipal solid waste management in Rize and Trabzon provinces was explained. Within the scope of integrated waste management, to help decision makers choose the most appropriate waste management alternatives, the waste characterization of the provincial centres was determined and the seasonal variation related to waste characterization was investigated. Current alternatives regarding the solid waste management were evaluated with regard to the recyclable and recoverable fractions, environmental conditions and economic benefits. [13-16]

## **MATERIAL AND METHOD**

Since socioeconomic situation of each region showed variations, the characterization study was carried out by solid waste sampling at specific time intervals and locations. The analysis of samples were performed in accordance with Solid Waste Characterization Analysis Method of T.R. Ministry of Environment and Urbanization Characterization Method.[17] Sampling represented the seasons of summer, autumn, winter, and spring. During the sampling process, samples taken from regions of low, middle, and high income levels and the bazaar region have been separately mixed and homogenised. Sampling was carried out by taking minimum 20-30 kg of solid wastes from each region.

The standard volume container (Figure 1) (1m \* 1m \* 0.5 m) was completely filled by taking equal amounts of samples from the waste piles. This process was applied in the same way for each region. In this way, it is aimed to obtain a sample representing the region where the waste was taken.



**Figure 1.** Standard volume container

Biomass analysis and material group analyses including ash, volatile matter, fixed carbon, total sulphur, lower and upper calorific values were performed at TÜBİTAK Marmara Research Centre Energy Institute Laboratory. Before the samples were delivered for analyses dehumidification for 3 days at 60°C and size reduction with grinding was carried out. Within the scope of this study moisture analysis was also performed.

## **RESULTS AND DISCUSSION**

### **Information about Province of Rize and Trabzon**

Rize is a province located in north-eastern Turkey and the Black Sea coast. Neighbouring provinces are; Trabzon in the west, Artvin in the east, Bayburt in the southwest and Erzurum in the south. The

surface area of Rize is 3.920 km<sup>2</sup>. According to the data estimated by Turkish Statistics Institute, its population for 2019 is 343212. Province of Rize has 12 districts<sup>[18]</sup>.

Trabzon is one of the oldest commercial port cities of Anatolia. Neighbouring provinces are; Giresun in the west, Gümüşhane in the southwest, Bayburt in the southeast and Rize in the east. The surface area of Trabzon province is 4.685 km<sup>2</sup>. According to the data estimated by Turkish Statistics Institute, its population for year 2019 is 808974. Province of Trabzon has 18 districts<sup>[19]</sup>.

General map of province of Rize and Trabzon shown in Figure 2 (a) and (b).

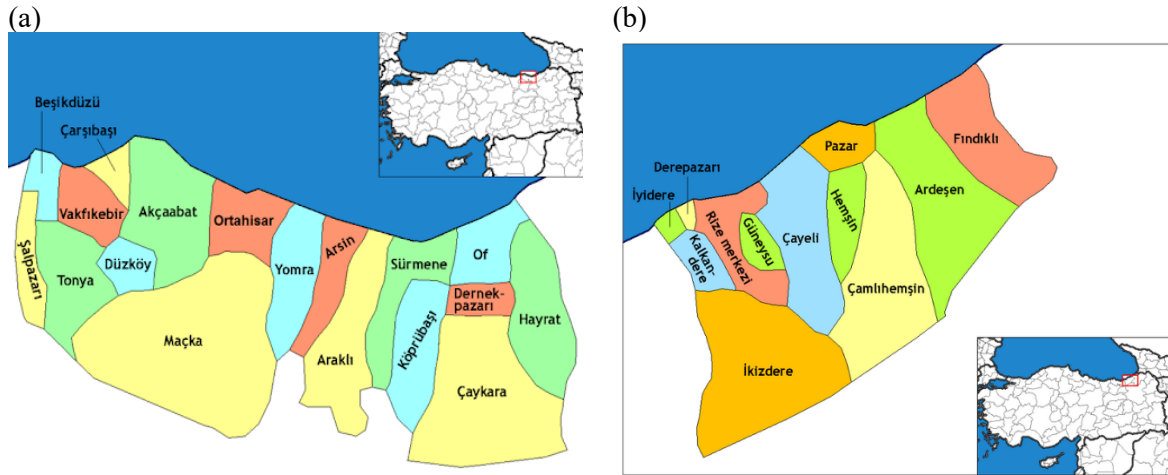


Figure 2. (a) Trabzon Province Map (b) Rize Province Map<sup>[18,19]</sup>

### Current Municipal Solid Waste Management in the Province of Trabzon

Municipal solid wastes in Trabzon Province are disposed in the sanitary landfill within the Trabzon-Rize Solid Waste Association (TRAB-Rİ-KAB) which is located in the district of Kutlular-Çamburnu-Sürmene in Trabzon. The storage area was built on 70,000 m<sup>2</sup> of land and consists of 4 lots. Municipal solid waste originating from Trabzon and Rize Provinces was stored in this area. Currently, 1.500.000 m<sup>3</sup> waste storage capacity has been approached. Approximately 230,000 tons of waste are disposed into the field each year. Since the sanitary landfill established in Trabzon province was almost filled completely, searches for new landfill areas have been initiated. Studies should be planned to reduce the amount of waste coming to the area by focusing on studies on waste reduction and recycling in the city.

There is a packaging waste recycling facility in Trabzon Province which has a licence and a Temporary Activity Certificate with a capacity of 99.911 tons/year and a packaging waste collection and separation facility which has a licence and a Temporary Activity Certificate with a capacity of 36.832 tons/year. The current capacity is capable for collection and separation of packaging waste that will be generated until 2023.

There is a licensed medical waste sterilization factory in the province of Trabzon. In this facility, medical wastes created by healthcare institutions not only in Trabzon but also in Rize province and its districts are sterilized and disposed in a regular storage area. The sterilization unit has a capacity of 4320 tons/year.

2 companies in Trabzon province have certificate for temporary storage of vegetable waste oil. Vegetable waste oils taken from Trabzon, Rize, Giresun, Ordu, Samsun, Erzurum, Gümüşhane, Kars, Erzincan provinces are also stored in these temporary storage areas. However, there is no waste oil recovery facility in the province. Waste engine oils originating from the enterprises in the province are collected by PET-DER, an institution authorized by the Environment and Urban Ministry.

There are 6 regional battery dealers in Trabzon Province meets the technical conditions within the scope of Article 12 of the Regulation on Control of Waste Batteries and Accumulators. There is no Transport Licenced Vehicle and Recovery Facility in the city. There is also no licenced recycling facility in the province within the scope of "Regulation on Control of Finished Tires".

### Current Municipal Solid Waste Management in the Province of Rize

ARRİKAB domestic solid waste administration, which was established in Rize in 2004, is not active currently and was terminated in 2016. KAÇKARBİR was established by the decision of the Council of

Ministers dated 24/09/2012 and numbered 2012/3755 and TRABRIKAB was established by the decision of the Council of Ministers dated 27/10/1997 and numbered 97/11182.

Waste collection and disposal processes are carried out by the municipalities in the province and the Special Provincial Administration and the municipalities in the villages. There is no sanitary landfill in the city. While municipal solid waste collected by member municipalities of KAÇKARBİR is disposed by the uncontrolled storage method, waste collected by member municipalities of TRABRIKAB is disposed in the sanitary landfill in Sürmene Çamburnu. For this purpose, member municipalities transport their waste to transfer stations located in the centre of Rize and Of-Eskipazar.

Medical wastes are disposed at Trabrikap Kutlular Sanitary Landfill with the vehicles belonging to the authorized company, not having compression mechanism and complying with the legislation.

Packaging wastes are collected by the authorized company with vehicles having 6 pieces of compression mechanism and capacity of 7 m<sup>3</sup>. 1800-1900 tons of packaging wastes are collected in a year in total. 937 pieces of packaging waste boxes are distributed to places such as institutions, schools, and workplaces for collection of packaging wastes.

Waste oils, approximately 450-500 tons in a year in total are collected by authorized company with one vehicle. 15 pieces of collection units have been placed at certain points of city for the collection of waste oils. Besides, in order to access the citizens easily, waste oil collection units are provided to all headman offices within the borders of Rize Municipality and collection process is performed.

Waste batteries are collected by Rize Municipality Cleaning Affairs Directorate with one vehicle and they are kept in a store. Following the accumulation process, they are taken by Portable Battery Producers and Importers Association (TAP) and they are recycled or disposed. In this way, 1000-1200 kg of waste batteries are collected in a year. At certain regions of the city, 100 pieces of waste battery collection units have been placed. Furthermore, by providing 80 pieces of waste battery collection units to certain institutions and associations in total, waste battery collection process is performed.

Average waste amount per capita and annual municipal solid waste amount for 2014, 2016 and 2018 in Trabzon and Rize provinces are shown in Table 1. Accordingly, the amount of waste per person across both Rize and Trabzon in Turkey in general and, as of year tend to increase.

Average waste amount per person and annual municipal solid waste amount for 2014, 2016 and 2018 in Trabzon and Rize provinces are shown in Table 1. As can be seen, the amount of waste per person have a tendency to increase by years in Rize and Trabzon as well as in Turkey.

**Table 1.** TÜİK 2014-2018 municipal solid waste statistics <sup>[20]</sup> (TÜİK, 2019)

	Waste generation per capita (kg/capita. day)			Municipal Solid Waste Generation (tons/year)		
	2014	2016	2018	2014	2016	2018
<b>Turkey</b>	1,08	1,17	1,16	28010721	31583553	32209222
<b>Trabzon</b>	0,678	0,79	0,81	186260	224454	237235
<b>Rize</b>	0,97	1.15	1,25	78516	97617	10015

### **Characterization of Municipal Solid Wastes in the Province of Rize and Trabzon**

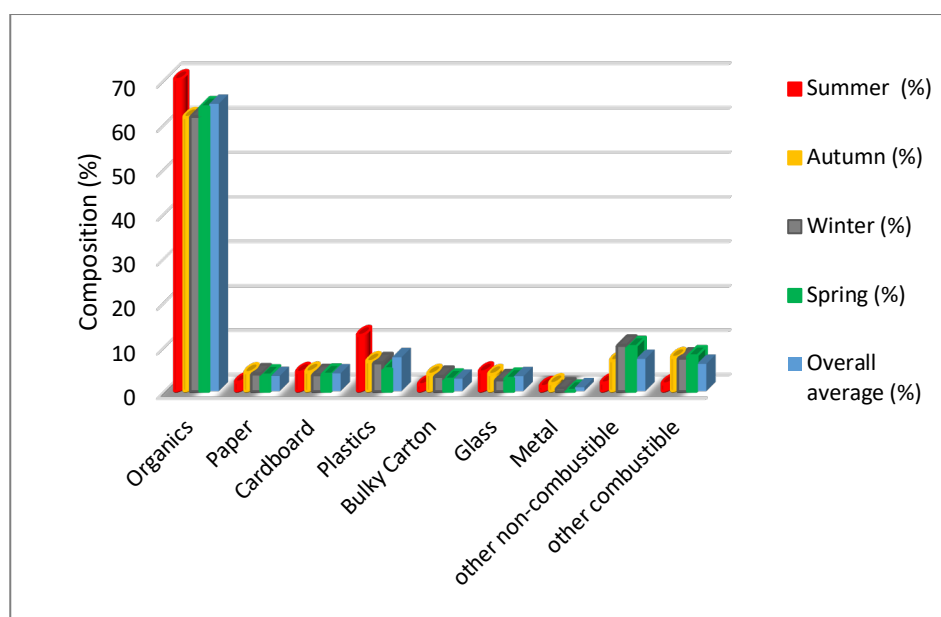
Establishment of solid waste disposal facilities is essential in overcoming solid waste management problems, protecting environmental health and preventing environmental pollution. In order to determine the disposal methods, knowing the amount and characteristics of domestic wastes is the basic principle <sup>[8,9]</sup>. In this context, characterization of solid waste is a basic unit where these principles are determined in the field where waste management system will be established. The most common method used in determination of the contents of domestic solid wastes is “Solid Waste Characterization” and material group analysis. During determination of solid waste characterization in Trabzon and Rize provinces, seasonal changes were taken into consideration and analysis was carried out 4 times in a year in the region to represent each season. Analysis results are given in Tables 2 and 3. Annual averages are presented in Figures 3 and 4.

**Table 2.** Municipal Solid Waste Characterization for Rize Province

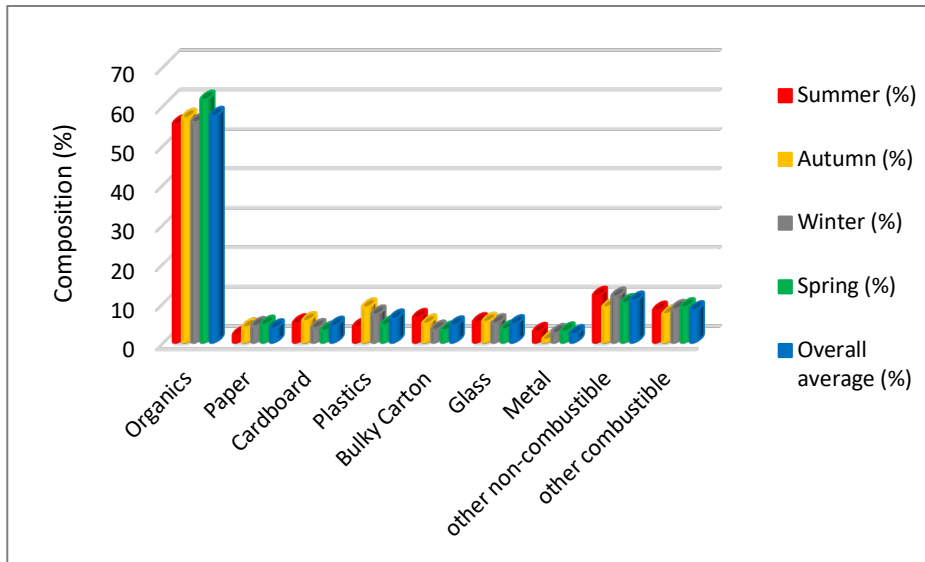
Waste Types	Summer Period (%)	Autumn Period (%)	Winter Period (%)	Spring Period (%)	Overall average (%)
<b>Organics</b>	71,20	61,48	61,77	63,9	<b>64,58</b>
<b>Paper</b>	2,00	4,12	3,87	3,60	<b>3,40</b>
<b>Cardboard</b>	4,20	4,28	3,70	3,80	<b>4,00</b>
<b>Plastics</b>	12,50	6,60	6,37	5,03	<b>7,63</b>
<b>Bulky Carton</b>	1,40	3,75	3,32	2,68	<b>2,78</b>
<b>Glass</b>	4,30	3,72	2,55	2,87	<b>3,36</b>
<b>Metal</b>	1,00	1,67	0,68	0,17	<b>0,88</b>
<b>other non-combustible</b>	1,80	6,83	10,30	10,02	<b>7,24</b>
<b>other combustible</b>	1,60	7,55	7,42	7,93	<b>6,13</b>

**Table 3.** Municipal Solid Waste Characterization for Trabzon Province

Waste Types	Summer Period (%)	Autumn Period (%)	Winter Period (%)	Spring Period (%)	Overall average (%)
<b>Organics</b>	55,23	56,77	55,67	61,4	<b>57,27</b>
<b>Paper</b>	1,68	3,60	3,97	4,33	<b>3,40</b>
<b>Cardboard</b>	4,67	5,23	3,47	2,83	<b>4,05</b>
<b>Plastics</b>	3,73	8,70	6,90	4,24	<b>5,88</b>
<b>Bulky Carton</b>	6,03	4,57	3,07	2,90	<b>4,14</b>
<b>Glass</b>	4,97	5,00	4,70	3,13	<b>4,45</b>
<b>Metal</b>	2,49	0,46	2,20	2,60	<b>1,94</b>
<b>other non-combustible</b>	11,70	8,70	11,47	9,80	<b>10,42</b>
<b>other combustible</b>	7,90	6,97	8,30	8,77	<b>7,98</b>



**Figure 3.** Rize Province Seasonal Municipal Solid Waste Characterization



**Figure 4.** Trabzon Province Seasonal Municipal Solid Waste Characterization

When the results of solid waste characterization was evaluated, it was observed that organic wastes and recyclable wastes showed reduction in winter season, while they showed increase in summer period. The reason of this can be explained that amounts of fruit and vegetables consumed increase in summer months. Besides, the increase in the amount of recyclable materials such as glass bottles, plastic boxes, tin boxes, and metal in the summer months can be linked to the increase in human population in the region in the summer season.

Non-combustible materials are expected to be high for both cities during the winter period. Disposal of wastes such as coal and solid fuels used in the winter season to the garbage containers increases waste amount. Another reason is the decrease in consumption of fresh vegetables and fruits in the region during the winter season.

#### Municipal Solid Waste Moisture Values of Rize and Trabzon

Moisture content of the municipal solid wastes of Rize and Trabzon Province was determined in the laboratory of Ondokuz Mayıs University Environmental Engineering Department. Seasonal changes and annual averages are presented in Table 4. When the annual averages are evaluated, the moisture values in solid wastes of Rize province was determined as 68.96%, was determined as 70,85% for Trabzon province. Due to the high amount of precipitation in the region, the moisture in both provinces was high. In addition, the habits of the people of the region are another factors that affect this.

**Table 4.** Moisture values of Rize and Trabzon municipal solid wastes according to seasons

	Summer Period (%)	Autumn Period (%)	Winter Period (%)	Spring Period (%)	Annual Average (%)
<b>Rize</b>	70,56	67,46	65,47	72,36	<b>68,96</b>
<b>Trabzon</b>	70,91	75,83	64,23	72,41	<b>70,85</b>

#### Energy and Biomass Values of Rize and Trabzon Municipal Solid Wastes

The calorific value and biomass analyses of the municipal solid wastes of Rize and Trabzon Province were carried out by TÜBİTAK and are presented in Table 5.

**Table 5.** Average biomass and energy values of Rize and Trabzon municipal solid waste

	<b>Rize</b>	<b>Trabzon</b>
<b>Total Phosphorus (%)</b>	0.24	0.24
<b>Carbon (%)</b>	46.01	46,85
<b>Hydrogen (%)</b>	6.00	5,86
<b>Nitrogen (%)</b>	2.36	2,21
<b>Sulphur (%)</b>	0,20	0,16
<b>Ash (%)</b>	12.60	7,47
<b>Lower calorific value (cal/g)</b>	3780	3932
<b>Higher calorific value (cal/g)</b>	4118	4223

For composting, it is necessary to know the Carbon, Nitrogen and Phosphorus content in the waste. Average values for both cities are given in Table 5. The C/N ratio should be 25-30/1 for the good operation of compost plant [21]. When we estimate the ratio of the values given in Table 5, the C/N ratio was found as 21/1 for Trabzon and 19,5/1 for Rize. These values are suitable for composting even if the amount of nitrogen is high. The high amount of organic matter indicates that the biodegradability of the waste is high. In this case, different compost systems can be installed to produce fertilizer for soil improvement and energy recovery by bio-methanization.

Lower calorific value was determined between 3700 and 4000 cal/g on pre-treated samples. According to the analysis results, due to the high moisture and organic substance content, incineration method was not considered to be appropriate. Due to the reason that the investment costs of combusting compared to disposal method is high, incineration facility will not be economical for the city. Additional drying processes will be needed in order to reduce moisture content.

## CONCLUSION

Alternative disposal methods were evaluated by considering solid waste characterization and other parameters. It was considered that incineration method was not appropriate due to high moisture content of solid waste, drying requirement of wastes, and probable emissions that may occur.

As a result of the evaluation of current solid wastes disposal status in Rize and Trabzon Provinces, an integrated waste management system should be established for both provinces. This system initially requires the separation of recyclable wastes at the source. For this purposes, licensed waste collection and separation facilities should be established in both provinces. Organic wastes should be composted as much as possible. In particular, by adding elements such as nitrogen, sulfur and potassium into the compost, it can be turned into a perfect fertilizer for tea growing in Rize province.

It will also be appropriate to dispose of remaining part of wastes in a sanitary landfill. Although sanitary landfill process has very low costs, it is not considered to be an appropriate method due to the geographical conditions of province of Rize, land structure, and lack of enough area that can be used for regular storage. Furthermore, as leachate being formed in landfill can reach to very high levels in Rize, this situation would cause for big problems. For these reasons, it will be more appropriate to dispose wastes in a landfill together with Trabzon province as now.

There is the sanitary landfill in the province of Trabzon. However, the storage area will expire in a few years. For this reason, an integrated waste management system that will eliminate the amount wastes in the provinces should be established. And, as soon as possible, the separation and recovery works at the source should be performed and the amount of waste sent to the disposal area should be reduced. Otherwise, the new storage area will be filled before planned time. Since the current solid waste landfill area in Trabzon Province was almost filled, the construction of a new solid waste landfill site should be carried out quickly.

It is clear that none of the methods that known and used in solid waste management today will solve the waste problem alone. Integrated waste management system should be developed for both Rize and Trabzon provinces, and recyclable wastes should be separated at source and gained into economy. All disposal options described above could be applied only after the source separation system is installed in the city.

## REFERENCES

- [1] Uzunoğlu, H., 2014, Çevremizi Kirleten Atıklar ve Atık Yönetiminin Önemi, Ar&Ge Bülten, p.2 ([http://www.izmir.org.tr/portals/0/argebulten/at%C4%B1klarveat%C4%B1ky%C3%B6netimi\\_handeuzunoglu.pdf](http://www.izmir.org.tr/portals/0/argebulten/at%C4%B1klarveat%C4%B1ky%C3%B6netimi_handeuzunoglu.pdf))
- [2] Waste Management Regulation, 2015, Environment and Urban Ministry, Official Gazette issue: 29314
- [3] Vaughn, J., 2009, Waste Management A Reference Handbook. *ABC-Clío*. doi:1598841505, 9781598841503
- [4] Das, S., Lee, S.H, Kumar, P., Kim, K-H., Lee, S.S., Bhattacharya, S.S., 2019, Solid waste management: Scope and the challenge of sustainability, *Journal of Cleaner Production*, 228, 658-678.
- [5] Pereira, T.S. and Fernandino, G., 2019, Evaluation of solid waste management sustainability of a coastal municipality from northeastern Brazil, *Ocean and Coastal Management*, 179, 104839.
- [6] Adenirana, A.E., Nubib, A.T., Adelopo, A.O., 2017, Solid waste generation and characterization in the University of Lagos for a sustainable waste management, *Waste Management*, 67, 3–10.
- [7] Ayelerua O.O., Okontab, F.N., Ntuli F., 2018, Municipal solid waste generation and characterization in the City of Johannesburg: A pathway for the implementation of zero waste, *Waste Management*, 79, 87–97
- [8] AbdAlqader, A., Hamad, Jehad., 2012. Municipal Solid Waste Composition Determination Supporting the Integrated Solid Waste Management in Gaza Strip. *International Journal of Environmental Science and Development* 3, 172–176
- [9] Villalba, L., Donaliso, R.S., Basualdo, N.E.C., Noriega, R.B., 2020, Household solid waste characterization in Tandil (Argentina): Socioeconomic, institutional, temporal and cultural aspects influencing waste quantity and composition, *Resources, Conservation & Recycling* 152, 104530
- [10] Sauve, G., Van Acker, K., 2020, The environmental impacts of municipal solid waste landfills in Europe: A life cycle assessment of proper reference cases to support decision making *Journal of Environmental Management* 261, 110216
- [11] Istratea, I.R., Iribarrena, D., Galvez-Martosa, J.L., Dufour, J., 2020, Review of life-cycle environmental consequences of waste-to-energy solutions on the municipal solid waste management system *Resources, Conservation & Recycling* 157 104778
- [12] Yadava, V., Karmakar, S., 2020, Sustainable collection and transportation of municipal solid waste in urban centers, *Sustainable Cities and Society* 53. 101937
- [13] Bartolaccia, F., Gobbob, R., Paolinia, A., Soverchia, M., 2019, Efficiency in waste management companies: A proposal to assess scale economies, *Resources, Conservation & Recycling*, 148, 124–131.
- [14] Minelgaitė, A. and Liobikienė, G., 2019, Waste problem in European Union and its influence on waste management behaviours, *Science of the Total Environment*, 667, 86–93.
- [15] Kayakutlu, G., Daim, T., Kunt, M., Altay, A., Suharto, Y., 2017, Scenarios for regional waste management, *Renewable and Sustainable Energy Reviews*, 74, 1323–1335.
- [16] Bozkurt, S., 2012, Eysel Nitelikli Katı Atıkların Geri Dönüşüm Olasılıkları ve Bertaraf Yöntemlerinin Araştırılması. Çukurova Üniversitesi, Fen Bilimleri Enstitüsü, Çevre Mühendisliği A.B.D. Doktora Tezi. Adana.
- [17] Solid Waste Characterization Analysis Method, 2018, Environment and Urban Ministry
- [18] Anonymous, 2019, [https://www.wikiwand.com/tr/Rize%27nin\\_il%C3%A7eleri](https://www.wikiwand.com/tr/Rize%27nin_il%C3%A7eleri),
- [19] Anonymous, 2019, <http://www.mmsrn.com/trabzonun-ilcelerinin-isimleri-ve-haritasi/>
- [20] TUIK, 2019, <https://biruni.tuik.gov.tr/medas/?kn=119&locale=tr>
- [21] Kazemi, K., Zhang, B., Lye, L.M., Cai, Q., Cao, T., 2016, Design of experiment (DOE) based screening of factors affecting municipal solid waste (MSW) composting, *Waste Management*, 58, 107-117.