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ORIGINAL RESEARCH PAPER

Urban solid waste characterization in the east part of Black Sea region

K.O. Demirarslan[1,*], B.Y. Çelik[2]

[1]Department of Environmental Engineering, The Faculty of Engineering, Artvin Çoruh University, Artvin, Turkey

[2]Republic of Turkey Ministry of Environment and Urbanization, Erzurum, Turkey

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ABSTRACT: In the current study, the solid waste characterisation that belongs to Artvin city centre, which is located in East Black Sea Region of Turkey, were searched. The study has the feature of being the first study for the country of Artvin in terms of study. The field of study is composed of 7 neighborhoods and those can be separated into 3 groups as low, middle and high level of income. In this study, 11 kind of waste were examined, which are organic, paper, plastic, glass, metal, ash, electronic, textile, garden waste, hazardous and others. The effect of seasons on the amount of waste was examined; also, the relationship between the amount of waste and the level of income was also examined by using the two-way ANOVA analysis. Furthermore, all ratios of wastes that are located in Artvin city centre were searched. According to that, the waste ratios, occurs in one year, of all neighborhoods in the Artvin city centre are found as 61.06% organic, 10.28% paper, 9% plastic, 3.20% glass, 2.29% metal, 3.87% ash, 0.037% electronic, 1.58% textile, 1.35% garden waste, 0.51 % hazardous and 7.23% others. Those obtained values were compared with other similar studies in the literature. Moreover, for collecting recyclable wastes for the city centre 3 different methods are proposed named as methods collection from households, collection from buildings and collection from neighborhoods. These methods have been studied economically and the collection from buildings method is the most appropriate among these three methods.

KEYWORDS: *ANOVA (Analysis of variance); Black Sea; Characterization; Solid waste;Urbanization.*

INTRODUCTION

Rapid urbanization and population growth together with technological developments and industrialization increases the pressure of human actions on environment rapidly in Turkey as in the entire world. Environment and human health are faced with serious threats since human needs are met at higher levels due to the development of technology, natural sources are destroyed and each product is finally turned to waste. One of the environmental problems that modern societies have difficulties about is urban waste. This problem is especially seen in the societies being in the developing process. As a result, the production of urban solid waste increases and the increase forces the local authorities to take enough precautions about the issue. However, many local authorities still cannot do solid waste characteristic. The formation of solid waste in cities is a complex process including the topography, season, kitchen habits, collection frequency, economic conditions, recycle culture and the ability to reuse and regional cultures (Azadi and Jashni, 2015; Delgado, *et al.,* 2015; Sun, *et al.,* 2015; Zhou, *et al.,* 2015; Khan, *et al.*, 2015). One of the most significant issues in protecting the environment and natural sources is waste management. Therefore, sorting of the solid wastes in the resource, collecting, transferring, processing, recycling and disposing of

*Corresponding Author Email: *onurdemirarslan@artvin.edu.tr*
Tel.: +90 0466 215 1040 Fax: +90 0466 215 1057

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the wastes are among the important environmental issues in today's world (Couto, *et al.,* 2015; Mir, *et al.,* 2016; Das, *et al.,* 2015). Waste management is a complex set of systems requiring the learning of a lot of information such as the source, amount and features. Another factor in this system is to know and guess the general conditions of the society (economic system, demography). The detection (recycle, regular storage etc.) of the methods to collect, remove and dispose of solid wastes could be done by obtaining all these information (Grazhdani, 2015). Methods like storage affect the gas emissions and the air, water seepage and the water and the soil negatively. Even though many countries take precautions with the purpose of decreasing the environmental effects, the practicality of these precautions becomes difficult because of the effects of geographic settlement, climate, demographic structure and socioeconomic factors on the structure and amounts of waste (Gomez, *et al*., 2009). Solid waste management is a problem in global scale which is handled with different methods in different parts of the world. The countries with developed economies apply a sustainable waste management system such as recycling and disposing methods appropriate for the standardization in the production, collection and removal of waste systems (Akıncı, *et al.,* 2012). The term of solid waste management can be defined as a discipline comprehending the stages of the control of the waste amount, collection, storage, removal-transfer, processing and last suspension by considering the production and consumption habits of the society related to human and environment health, economy, engineering, protection of the sources, esthetic and other environmental issues (Tchobanoglous, *et al.,* 1977). The cost and responsibility of all the services to be carried out in the process from the collection to the disposal of the solid waste which is an economic value getting lost as long as it could not be benefitted in the appropriate way and whose collection, transportation and disposal is a great burden in economic meaning as well as being significant in terms of the health of the society belong to the local managements. The term of solid waste management means the collection, storage, transfer-removal, processing, recycling and retrieval and last suspension of urban solid waste under the responsibility of local authorities which are domestic and derive from municipality functions, industrial institutions, houses, commercial and other institutions. The characterization of urban solid waste might be defined as the first step of solid waste management system to be applied. A solid waste characterization is a study of the measurements done with the weight and composition of waste components. In the light of the obtained data, the decision mechanism of waste management system and the selection of suitable technologies can be started. The formation rate and composition of urban solid waste are affected by many factors such as the geographical and climate features of the region, population and sociocultural features. Besides, the economic status of the country is especially effective in changing the waste amount and composition. Daily produced solid waste amount changes as 0.3~0.9 kg/person/day in the low income countries having income per capita under 5000 $ and as 1.4~2 kg/person/day in the high income countries. Besides, the ingredient of solid waste is complicated in developed countries (Al-Jarallah and Aleisa, 2014). The average municipality waste amount per person was determined as 1.12 kg/person/day according to "Municipality Waste Basic Indicators" announced by Turkish Statistical Institute (TSI, 2012) in Turkey. It has been seen that this amount becomes 1.4 kg/person/day in summers and 1.09 kg/person/day in winters. The By-Law on Solid Waste Control is the first step of the solid waste management in Turkey. Although it has some shortcomings in its implementation, the MSW management system has been improved based on new regulations and supported by studies, according to the Turkish Ministry of Environment and Urbanization. The amount of collected MSW in 2010 was 25 million tonnes, equivalent to 84 % of the total generated MSW. The share of MSW going to landfill was increased by 5 % in the years between 2001 and 2010. The number of sanitary landfill sites increased from 15 in 2003 to 68 in the 3rd quarter of 2012. According to 2010 TurkStat data, 54 % of the municipal waste is sent to sanitary landfills and 44 % is dumped into municipality dumpsites. 2 % of the MSW was reported as composted or disposed of by other methods. Municipal waste management is improving. The number of licensed recycling and recovery facilities has skyrocketed in the last decade. In 2003, there were 46 recycling and recovery facilities for different recyclable waste types, whereas by 2012 the number of licensed facilities increased to 956. However, these improvements in the waste management capacity have not yet been reflected in the reported data (Europan Environment Agency, 2013). In

the current study, the solid waste characterisation that belongs to Artvin city centre, which is located in the extreme east of the East Black Sea Region of Turkey, were searched so that it can be helpful in choosing the method of solid waste management that was being planned to build in Artvin city centre. Furthermore, this study has the feature of being the first for Artvin, which is rough in terms of topography, and town order, and also has a dispersed kind of settlement. In this study, 11 kind of waste were examined, which are organic, paper, plastic, glass, metal, ash, electronic, textile, garden, waste, hazardous and others. The difference between seasons in terms of the wastes was searched and also the relationship of the income levels of the neighborhoods was examined by using the two-way ANOVA (Analysis of variance). Moreover, for collecting recyclable wastes for the city center 3 different methods are proposed named as methods CFH, CFB and CFN. These methods are studied economically, socio-culturally and geographically. This study has been carried out in the city centre of Artvin province in 2015.

Scope of Study and features of the study area

The study area, Artvin, is located in the border of Georgia in the northeast of Black Sea Region of Turkey and is between the 40° 34' 19.55"–41° 31' 29.62" north latitude and 41° 09' 25.41"-42° 35' 47.16" east longitude (Fig. 1). The settlement opportunities are very limited in the province which has different elevations in terms of the topography. In addition to these negativities in urbanization, services such as municipality may be limited compared to other provinces within opportunities (Demirarslan and Basak, 2017). The study tries to present the waste characterization of Artvin by making solid waste characterization in 7 neighborhoods in the center of Artvin. There are 7 neighborhoods in the city center being given solid waste service namely Balcıoğlu Neighborhood, Yeni Neighborhood, Orta Neighborhood, Çayağzı Neighborhood, Dere Neighborhood, Çarşı Neighborhood and Çamlık Neighborhood. The population of the city showed continuous increase between the years 1927 and 1980; the population has shown continuous decrease since then. The main reason is the internal migration due to economic reasons. The population of Artvin was 169334 including all the districts in 2013. The most crowded place is the Central district and the population of the district is 25192 according to 2013 Address Based Population Registration System. The contribution of the industry sector to the economy of Artvin is at a rather low level. The active enterprises in the industry sector have a structure mostly based on food, mine and forest products industry carried on towards evaluating the natural source potential of the city. The basic feature of these enterprises is that they are comprised of small scaled and medium-sized

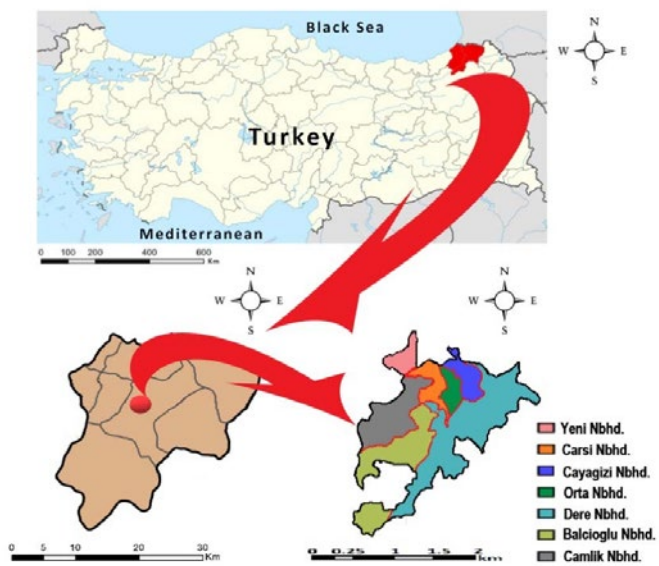

Fig. 1: Location of the study area

enterprises. There is not any Organized Industrial Site in Artvin. However, small industrial areas are existent (Central, Arhavi, Hopa districts). There is not another district and village that the central municipality give solid waste service to. It has been understood that daily collected solid waste amount in Artvin is approximately 20-22 tons. When compared to the population daily solid waste amount per person ranges between 0.79 kg and 0.87 kg. There is not any composition study for wastes done by municipality. Therefore, this study has the feature of being the first one for Artvin.

MATERIAL AND METHODS

Domestic solid waste management system in Artvin includes the stages of collection, removal and disposal of wastes and the relevant service has been done by Artvin Municipality. Wastes have been collected by "Directorate of Technical Works" of the municipality and disposed. As the collection method, plastic bags, litter baskets and garbage containers have been used and the wastes in the city center have been collected with 540 garbage containers of 400 lt. The hours of solid waste collection are between, 07:00 PM and 01:00 AM and throwing out garbage to containers is prohibited except for these hours. Solid wastes have been collected with 3 garbage vans of 4.5m^3 belonging to the municipality and there is approximately 1 garbage van for every two neighborhoods. Although collected solid wastes have been dumped as hazardous waste storage in the locality of Orta Neighbourhood which is in the boundaries of city center till January of the year 2015, solid wastes have been kept by making hazardous waste storage in the place of newly opened temporary store since then according to briefings of the Directorate of Technical Works. In the study, seven regions have been handled to represent different income groups of the central district in order to take samples to represent the city center of Artvin the best. In this study including one year, domestic solid wastes have been collected in mixed way from garbage containers in the determined routes in neighborhoods twice a month as at the beginning and end of each month. As a result of the mixed collection application, the average waste composition has been determined by considering the distribution of income group in Artvin. The data of 2015 explained by Turkish Statistical Institute have been used in the distribution of income group and accordingly this data the 57% of Artvin population comprises of high income level; 19% medium income level and 24% low income level. Solid wastes have been collected from the pilot points twice a month for one year and they have been weighed. Wastes that have been weighed have been thrown out. After taking all the data of these studies, total solid waste amount, daily, monthly, annual solid waste amount per person and weight, percentage weight of solid waste components have been evaluated. In the study of solid waste characterization, various materials were used like digital weighing device to use in weighing, colored plastic bags so that the wastes can be put separately, plastic firm (5 m x 4 m) in order to differentiate wastes on, mask for job security, gloves, boots etc. Three different scenarios called CFH, CFB, and CFN methods have been produced for economic recovery of the recyclable materials obtained as a result of the characterization work carried out in the study area. These methods have been economically examined and the best method has been proposed. In each of the three proposed methods, the wastes will be collected and then collected in an area in the province and once a month the wastes will be transported to the Hopa Port located on the Black Sea coast, which is 65 km away, and there will be marketed. In the economic review, income and expenditure for each method has been compared between the periods from collective to sale. Accordingly, for each method based on Eq. 1.

$$\sigma = \theta - \sum_{i=1}^{3} Bi \quad (1)$$

The Eq. has been improved. Here;

- σ: Income
- θ: Sales Revenue
- $B_{1:}$ Waste collection cost in the study area
- $B_{2:}$ Intermediate storage cost
- $B_{3:}$ Cost of sales

Method and the process of characterization

Collected garbage have been removed to the plastic cover spread on the floor in the backyard of Artvin Çoruh University Engineering Faculty and all closed bags have been opened and cleaned out. Garbage have been spread over the area with the help of shovel and classification easily each waste component has been enabled. Wastes that have been classified according to their types and labeled have been put in plastic

Table 1: Solid waste components are examined in the study area

Components	Definition	Amount of sampling (kg/year)
Organic wastes	Leftovers, vegetables, fruit, etc.	16169.3
Paper	Newspapers, magazines, books, milk cartons, juice box, Tetrapak, cardboard boxes	2722.8
Plastics	All plastics (HDPE, LDPE, PP, PE, PS, PET)	2264.5
Glass	Bottles, glass, jar, etc.	848.1
Metal	Can, spoon, knife, other metals, etc.	608.3
Hazardous wastes	Batteries, paint, medicine boxes	135.9
Electronic wastes	Cable, miscellaneous electronic devices	10.0
Ash	Ash	1025.6
Textile	Fabric, bag, shoes, slipper, dress	419.6
Green wastes	Branches, tree leaves	358.7
Others	Diapers	1914.7

bags and weighed with scales. The scale calibrated in advance has been used in weighing. The classification has been realized by the people to eliminate wearing boots, gloves and mask for hygienic reasons. The characterization of 11 types of waste have been tried to be done for each neighborhood taken as sample for the study. The mentioned wastes have been given in Table 1.

There are 7 neighborhoods and 560 waste collection containers in the study area. Each neighborhood has about 80 containers. As an example, waste samples from 8 containers in each locality were collected every fifteen days. Wastes were collected from randomly selected 8 containers in each neighborhood and collected by large garbage bags mixed during the collection process. There is no industrial activity in the study area. For this reason, wastes come from houses, government institutions and schools. Produced wastes can be classified as urban waste.

RESULTS AND DISCUSSION

The differences in solid waste amount and composition occurs result from many factors such as physical, geographical, sociocultural, economic and political. Apart from these factors, seasonal factors should be take into consideration. The changes in solid waste amount and composition are affected from the consumptions of people showing difference depending on seasons. For example, the amount of waste decreases in winter and gains inorganic feature whereas waste amount and organic waste with beverage cans increase in summer along with the rising of the air temperature. Besides, increases are observed in garden wastes in spring, summer and autumn (Gallardo *et al*., 2014). Urban solid waste is a heterogeneous material and the rates of production and composition differ season by season. Especially in summer months, more waste is produced than winter months. There is an increase in the amount of waste in the spring. This can be explained by the increase in human activities in spring and the cleanliness that started with spring (Liu, 1997). The solid waste characterization of Artvin city center has been given in Fig. 2. Organic wastes constitute the largest percentage according to Fig. 2. It is followed by paper, plastic, textile, ash and other. Hazardous wastes separated in small amount include the packaging waste of paint materials and cleaning materials used in houses. The proportion of organic wastes in total waste has been detected as 61.06%. The biggest share belongs to paper wastes with 10%. Then, plastic wastes come with 9%, metal wastes with 2.29% and glass wastes with 3.20%.

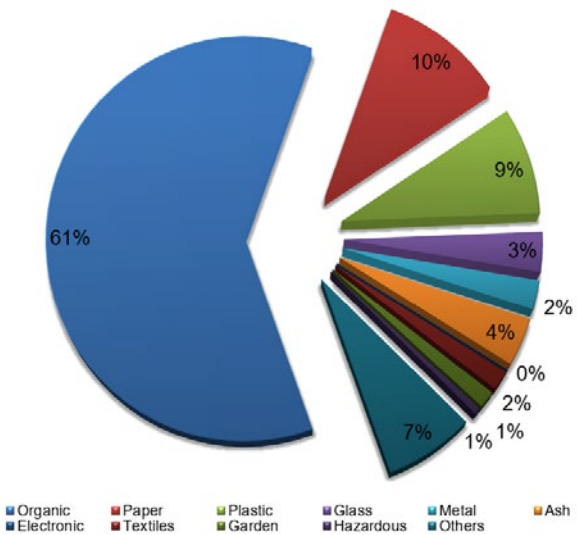

Fig. 2: Artvin general solid waste characterization in percent

It has been notified in previous studies comprehending the Eastern Black Sea Region that 2% of solid waste of Artvin is organic and 38% is recyclable. The solid waste composition values of other cities in Eastern Black Sea Region do not appear as the anticipated values. Therefore, it has been indicated that the process of identifying the solid waste composition which is a very important parameter to guess the reactions to occur in the storage area in the case of making the recycle and transformation analysis of domestic solid wastes, detecting the suitable suspension method and doing regular storage should be realized again with the cooperation with local authorities, relevant institutions and organizations-universities (Bayram and Serkan, 2007). Level of income of the neighborhoods in the field of study and seasonal percentages of waste components are given in the Table 2.

When Table 2 is examined, it is seen that organic waste is less, in every season; in the low-income level neighborhoods compared to the other neighborhoods even though there is difference between each of the waste. Apart from that, it is appeared that organic waste increases in each neighborhood in the autumn. Based on recycled paper, plastic, glass and metal wastes, it is determined that those wastes are at the ratio of 21.43% at low-income, 23.13% at middle-income, 18.68% at the high-income level of neighborhoods in winter. As for the springtime, the percentages of waste, which have the nature of recyclable in low, middle and high-income level neighborhoods, are, respectively, are calculated as 14.79%, 29.49% and 27.03%. Those ratios are calculated, respectively, 30.12%, 29.35%, 24.52% in the summer months while in the autumn it is determined as 22.9%, 22.95% and 24.09%. The ash, one of the warm-up based waste, is seen in winter more in addition to the spring and autumn when the air temperature is low in comparison with the winter. The ratio of ash is 18.35% in low-income, 11.82% in middle-income and 8.92% in the high-income level neighborhoods. When the electronic waste is examined, it is seen that at the ratio of 0.41% just in middle-income level neighborhoods. Textile waste is only seen in the winter months and just in the high-income level neighborhoods (2.07%) and it is appeared that that ratio increases with the summer months in the low-income level neighborhoods (4.94%). When garden waste is observed; its traces cannot be found in the winter and autumn months due to their seasonal features. However, garden waste reached its highest level in springtime, especially, in the low-income level neighborhoods (11.64%). On the other hand, garden waste was not found in summer months in the settlement of low-income level people. On the contrary, garden waste was found in middle and high-income level neighborhoods, respectively, at the ratio of 5% and 1%. As for hazardous waste, it was not seen any neighborhood in winter and summer. However, in autumn, hazardous waste was seen in the high-income level neighborhood (5.03%). When the other (remaining) waste is examined, in all seasons except spring, the ratio is higher in the low-income level neighborhood and the high-income level neighborhoods are ranked as the second for the remaining waste. Two-way ANOVA analysis was run in order to search that if there is a relationship between the kind and amount of the waste and the level of incomes. ANOVA is an, statistically-based, analysis

Table 2: Level of income of the neighborhoods in the field of study and seasonal percentages of waste components

Solid waste components (%)	Winter season			Spring season			Summer season			Fall season		
	Income levels											
	Low	Mid.	High	Low	Mid.	High	Low	Mid.	High	Low	Mid.	High
Organic	46.02	60.81	60.72	57.48	66.52	56.80	58.35	60.97	67.95	62.98	69.77	67.07
Paper	14.31	7.65	9.67	3.69	8.26	14.84	17.15	8.58	10.28	4.95	7.51	10.11
Plastic	3.28	11.40	7.71	8.87	8.97	7.47	10.27	7.05	11.67	7.27	11.25	8.99
Glass	1.15	2.45	0.84	0.64	8.07	3.24	1.06	9.79	2.34	4.38	0.36	3.22
Metal	2.69	1.63	0.46	1.59	4.19	1.48	1.64	3.93	0.23	6.30	3.83	1.77
Ash	18.35	11.82	8.92	2.38	0	0.46	0	0	0	8.61	0	0
Electronic	0	0	0	0	0.41	0	0	0	0	0	0	0
Textile	0	0	2.07	2.84	0	2.61	4.94	1.46	0.53	0.13	3.71	0.60
Garden waste	0	0	0	11.64	0.69	0	0	5.00	1.00	0	0	0
Hazardous	0	0	0	0.17	0	0	0	0	0	0	0	5.03
Others	14.20	4.23	9.60	10.71	2.89	13.10	6.60	3.22	6.01	5.39	3.57	3.21
Total	100	100	100	100	100	100	100	100	100	100	100	100

method that can reveal and define the relationships between 3 or more variables that are to be analyzed (Gumus, *et al.,* 2016; Bilga, *et al.*, 2016). Two-way ANOVA analysis is used for comparing the effects between more than one variable to each other. In this study, significance level is determined as 0.05. This level is commonly used in similar statistical analyses (Zhang, 2012; Zhou, *et al*., 2014). The obtained values are given in the Table 3. According to this analysis, p-value is obtained as 0.397 for whole waste and the level of income. Since our p-value is not higher than our significance level 0.05, there cannot be found any significant difference, in the meaning level of 95%, between the levels of income. When the level of income and the amount of recyclable waste (paper, plastic, glass, can) were examined with the ANOVA analysis, it was seen that p-value is under the 0.192. In conclusion, there cannot be found a significant difference between the level of income and those wastes. Similarly, when the ANOVA analysis was run for the organic and garden waste, it was seen that p-value is under 0.326. According to that, there cannot be found a significant difference again in the analyzed level of incomes in the meaning level of 95%. Hence, in the field of study, there cannot be found any trace of the relationship between the level of income and the wastes. When the solid wastes collected in the study area have been examined according to types, the following data have been obtained.

Table 3: The relationship between income and waste- P-value from ANOVA Test

Solid waste components	P-value from ANOVA test
All wastes	0.397
Recyclable waste	0.192
Organic and garden wastes	0.326

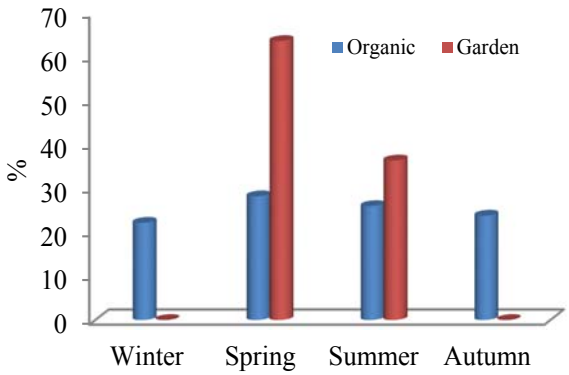

Fig. 3: According to season percentage of organic and garden wastes

According to Fig. 3, organic wastes have shown increase in spring month and decrease in winter month. The reason why organic wastes have shown increase in spring is that fruits and vegetables have been consumed more with the rising temperatures. In the city of Artvin attracting the attention with more green areas, garden wastes have an important place in spring and summer when bundles and garden cleanings are intense.

When the graphics of recyclable wastes such as paper, plastic, glass and metal have been examined in Fig. 4, it draws the attention that paper wastes increase in summer considerably. The reason is that beverage consumption increases in summer with rising temperatures. The possible reason for the low percentage of paper waste in other periods is that they are used for heating. If the seasonal changes of plastic and metal wastes which are one of the important recyclable wastes are to be examined, general percentages of these wastes are high in all seasons. It is thought that the increase in spring and summer might result from the increase in beverage consumption with the rising temperatures as it is seen in the increase of waste paper in winter months. It is thought to result from the increase in population with the coming university students to the study area in winter and autumn periods. When looked at the seasonal changes of glass wastes, it has been seen that the most important increase occurs in spring period. The reason might be the increase in glass wastes because of the opening of construction season and alterations in work places. Technical, institutional, economic and social limitations in the developing countries cause to the problems such as irregular

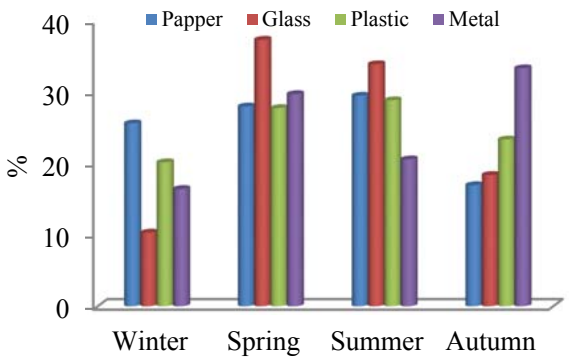

Fig. 4: According to season percentage of paper, glass, plastic and metal wastes

storage, illegal recycling processes and uncontrolled burning in the management of the solid waste. The solid waste composition is also affected by the economic conditions. While the amount of the recyclable wastes such as paper, plastic, glass and metal are more in the developed economies, the amount of the deformable organic materials is high in the developing countries (Akıncı, *et al*., 2012).

According to Fig. 5, the amount of ash is high in the city of Artvin due to the usage of wood and coal in winter because of the inexistence of natural gas usage. An increase has been observed in the waste group classified as "Other" in winter and spring. The diapers and disposable underpads are in majority among these wastes. When the textile wastes are taken into consideration, they are lower in terms of percentage when compared to other wastes. It is thought that the reason for this lowness in percentage in winter when compared to other seasons is also the burning of such kinds of wastes for heating purposes by the people.

A percentage that catches the attention only in the spring term has been determined in the electronic wastes seen in Fig. 6. They are the basic electronic wastes such as cable and chargers occurring as a result of the spring cleaning made in the houses. As seen in Fig. 7, hazardous waste amount has only occurred in the autumn term. The reason for this is thought to be the paint and detergent wastes used due to the preparation in the houses for winter.

The reason for the fact that the amount of garbage collected in winter months is higher than that collected in summer months in the city of Artvin arises from the ash and clinker based on the fuels burnt in winter months for heating purposes. The other studies that were made in Turkey and the world were examined and the examples, which establish academic resources, were determined. In Table 4, the comparison of the fields of studies and the waste ratios of some of the countries, geographical regions in Turkey, where the waste characterization study was made were given. When Table 4 is examined, it can be seen that in every part of Turkey, waste composition in urban areas are 50% organic, 13% paper, 10% plastic, 4% metal, 4% glass, 0.5% domestic hazardous waste and 13% ash (Öztürk, *et al*., 2015). It was determined that the ratio of the organic waste in the field of study is 10% more than general organic waste of Turkey while the ratio of the recyclable waste (paper, plastic, glass, can) is more than the field of the study with 31%. In the ash waste, the field of study still stays under of the general ratio of Turkey. The domestic hazardous waste is determined to be the same with the general ratio of Turkey. The country of Gümüşhane, which is at the same geographical region with the field of study, was compared with the ratio of waste and it was

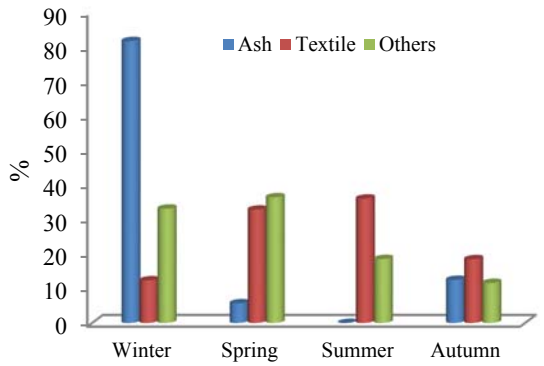

Fig. 5: According to season percentage of ash, textile and other wastes

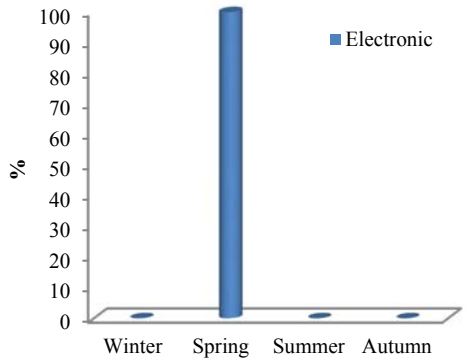

Fig. 6: According to season percentage of electronic wastes

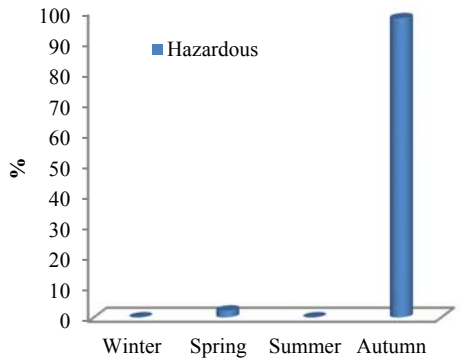

Fig. 7: According to season percentage of hazardous wastes

seen that organic waste was 31.2% higher. The ratios of recyclable waste like paper, plastic, glass and metal were close to each other and also higher than the field of study with 1.82%. Percentage of the ash is 21.83% higher than the field of study. The ratios of the textile waste were close to each other and the other waste was 10.27% more in the country of Gümüşhane. Another country Trabzon, which is at the same geographical region with the field of study, was compared with the field of study in terms of the waste ratios and it was seen that in the field of study, the ratio of the organic waste is 3.66% higher. When ratios of the recyclable waste were examined, it was concluded that that ratio is 16.02% higher in the Artvin city center. Even though there were not much difference with the textile waste, ratios of the country Trabzon is 20.87% more in the other wastes. When the percentages of the wastes in the field of study were compared with the other countries in the other regions, Adana > Mersin > **Artvin** > İzmir > Denizli > İstanbul > Sakarya > Kocaeli gradation occurred for the organic waste. In the ratios of the recyclable waste İstanbul > Denizli > İzmir > Mersin > Sakarya > Adana > **Artvin** > Kocaeli gradation can be seen. In the purpose of comparison of the conclusions obtained in this study with other studies in different countries, similar researches were searched and the examples that establish academic resources were determined. Among those examples, comparisons were made with those which resemble with the study in Artvin city center; Zagreb (Croatia) from Europe continent, Kuwait from Middle East, Tulsipur (Nepal), Beijing (China), Abuja (Nigeria) from Africa continent and Kampala (Uganda). The obtained data are given in Table 5. When the organic waste was taken, the following gradation was seen: Kampala > Abuja >**Artvin**> Beijing >Tulsipur> Kuwait > Zagreb. When the recyclable waste was taken, the following gradation was seen: Zagreb > Beijing >Tulsipur> Kuwait >**Artvin**> Abuja > Kampala. When the textile waste was examined, the following gradation was seen: Zagreb > Beijing > Abuja >**Artvin**>Tulsipur> Kampala. In the other waste, gradation became the following form: Tulsipur> Abuja >**Artvin**> Zagreb > Kampala.

Table 4: The waste percentages of the field of study and the comparison of those percentages with some countries in Turkey (Nas and Bayram, 2008; Ağdağ, 2009; Erses Yay, 2015; Yenice *et al.,* 2011; Öztürk *et al.,* 2015)

Solid waste components (%)	Turkey general	East Black Sea Region		Marmara Region			Aegean Region		Mediterranean Region		Study area
		Gümüşhane	Trabzon	İstanbul	Kocaeli	Sakarya	Denizli	İzmir	Adana	Mersin	
Organic	50	29.8	57.4	43	38.69	42.4	43.66	46	64.4	63	61.06
Paper	13	9.8	6.1	7.8	5.45	10.5	10.33	12	14.8	18.42	10.28
Plastic	10	7.8	0.9	14.2	13.69	13.4	15.83	12	5.92	6.69	9.00
Glass	4	3.3	0.8	6.2	3.14	3.6	3.5	4	3.08	3.08	3.20
Metal	4	1.6	0.5	5.8	1.84	0.8	1.83	3	1.4	1.25	2.29
Ash	13	25.7	4.9	-	3.19	11.3	1	-	-	-	3.87
Electronic	-	-	-	-	0.52	0.3	-	-	-	-	0.037
Textile	-	1.4	1.3	-	-	-	-	-	-	-	1.58
Garden waste	-	-	-	-	2.84	2.3	-	-	-	-	1.35
Hazardous	0.5	-	-	-	1.61	0.6	-	-	-	-	0.51
Others	-	18	28.1	-	0	1.4	-	23	11.4	7.6	7.23
Population	78741053	53074	312060	14657434	1780055	953181	554424	4168415	2183167	1745221	25192

Table 5: The waste percentages of the field of study and the comparison of those percentages with other studies in the world (Al-Jarallah and Aleisa, 2014; Dangi, *et al.,* 2013; Ogwueleka, 2013; Komakech *et al.,* 2014; Wang and Nie, 2001; Ribic, *et al.,* 2016)

Solid waste components (%)	Kuwait	Tulsipur (Nepal)	Abuja (Nigeria)	Kampala (Uganda)	Beijing (China)	Zagreb (Republic of Croatia)	Study area
Organic	44.6	46	63.6	92.12	56.01	26.5	61.06
Paper	6.76	6	9.7	1.32	11.76	27.2	10.28
Plastic	7.16	10	8.7	2.39	12.60	26.3	8.55
Glass	6.24	7	2.6	0.56	3.84	3.6	3.20
Metal	4.33	5	3.2	0.14	1.69	1.1	2.29
Ash	-	-	-	-	2.79	0.7	3.87
Electronic	-	-	-	-	-	-	0.037
Textile	-	1	1.6	0.46	2.75	3.4	1.58
Garden waste	-	-	-	-	-	4.1	1.35
Hazardous	-	1	-	-	-	-	0.51
Others	-	46	10.6	0.62	-	6.1	7.23
Population	3250496	21234	1235880	1659600	21700000	792875	25192

- No Data

The amount and features of the solid wastes change depending on the countries and it could also change from region to region in the same country and even from town to town in the same city. This change is dependent on the socio-economic structure of the people, income level, consumption and usage habits. There is a permanent increase in the amount of the solid waste produced per person due to the reasons such as the consumption tendencies in parallel with the rapid urbanization and the changes in the living conditions. The solid wastes are heterogeneous structure. The materials in the garbage such as the foodstuff, paper, carton, glass, plastic, ash, clinker, metal, dust, soil, wood, ceramic etc. shows difference from city to city and season to season. In addition; the composition of the solid waste changes depending on many socio-economic and physical parameters. This change makes the management of the solid wastes hard, because knowing the composition of the solid wastes helps us detect the disposal method. This solid waste characterization study conducted in the city of Artvin is the first study in terms of the assignment of the disposal method that is appropriate according to the content and amounts of the solid wastes and the formation of a resource in the planning of the regular storage area to be established.

Method advice

Improvement of the current waste management system which is applicable in the area of study has significant importance primarily in terms of environmental aspect and then in economical and social aspect. Necessary processes for waste management system have been initiated in city center but it has not been improved due to economical and geographical conditions. However, prior to that, analysis for waste compound has not been conducted. In the meetings with the municipality, it has been acknowledged that there isn't any execution on recycling in the city center and there is only one unauthorized company which is gathering cardboards especially from markets and selling them as raw material. According to the information from the municipality, waste management in the city center is summarized in Fig. 8.

According to the information from the Artvin Governorship, in total there are 4841 buildings and 13964 households in 7 districts. In the districts in the area of study there are 560 waste containers. Every day between 6 pm and 21 pm wastes in the city center are being collected by 3 trucks in total, one 12 m^3 and two 8 m^3 capacity, that belong to municipality. Wastes that are collected are transferred to the 52 m^3 waste transfer vehicle and then carried to uncontrolled disposal area. It can be said that approachment to waste management in municipalities is the sum of the approachment by the municipalities to social, legal, economic and environmental issues. Thus the complexity of a more suitable waste management system requires an interdisciplinary effort. This collective effort can be affected by the number of districts, buildings, households, residents and level of education and socioeconomic development of residents and more factors as such. Consequently, in order to design a suitable waste management system for the area of study it is required that the system should be economically viable and for that purpose gain/loss

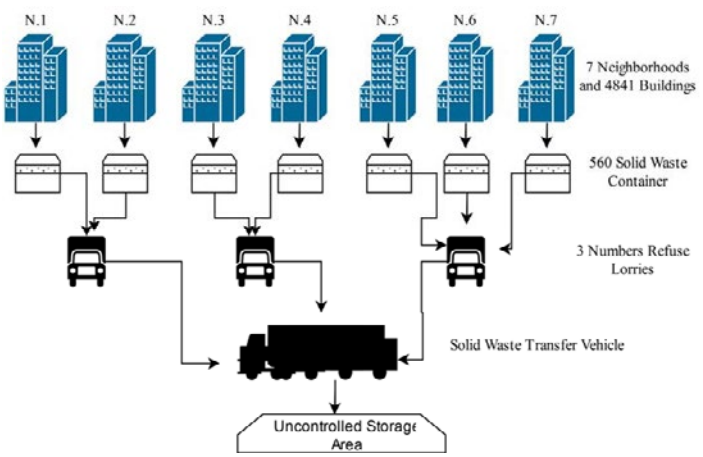

Fig. 8: Available waste management system's flow chart

analysis should be done on the system. However, when the public interest is the subject of concern, municipality should be in agreement with the CSO's (civil society organizations) in the matter of how much loss can be tolerated. In the currently working process (Fig. 8), expenditures are categorized in two units. These are monthly expenditures for the workers in the waste gathering processes and expenditures for the maintenance and fuels of the vehicles used in waste collecting process. The summation of all these expenditures for the area of study yields a total number of 39721 €/month for solid waste gathering, when proportioned to the population it yields 1.57 € per month and it yields 0.051 €/kilograms per day when proportioned to daily production amount of waste. For regaining of the recyclable materials acquired by the characterization study in the area of study back to the economy three different scenarios are put out and best scenario is proposed after studying them economically. In each of three advised method, after wastes are collected they will be gathered in an area in the city and once in a month they will be carried to Hopa Port which is located on the shore of Black Sea 65 km away by loading them in the trucks and will be marketed there. The map showing all of this route is presented in Fig. 9.

In the Method CFH, wastes are going to be collected by the waste bags that are distributed to 13964 households in 4841 buildings in city center. For collecting paper, metal, plastic, glass and organic wastes each household will be supplied by 5 waste bags. These wastes will be collected each week on a specified day and firstly they will be carried to waste gathering area and then to Hopa Port. Monthly waste bag need for the working area will be approximately 280000. Expenditures in this method will be firstly to collect waste with the waste bags from the households and then vehicle and fuel expenditures in the process of carrying them to Hopa Port. Flowchart of the method is presented in Fig. 10.

In the Method CFB, it will be ensured that wastes are going to be collected in the waste collecting bags which will be located in the suitable places of the 4841 buildings in the working area. To collect paper, metal, plastic, glass and organic wastes separately 5

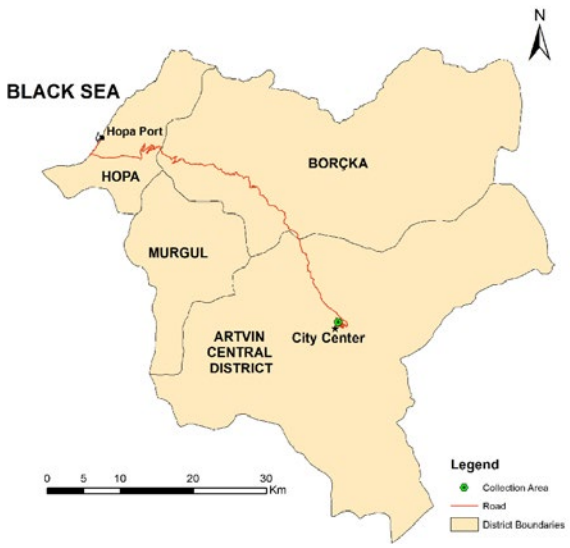

Fig. 9: Transport route

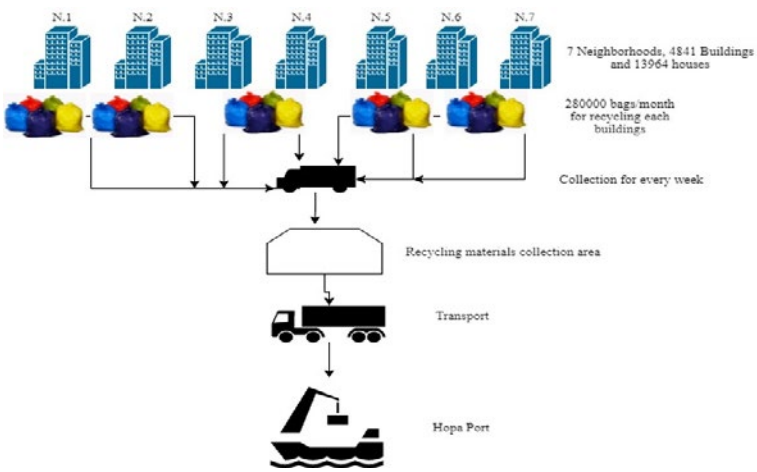

Fig. 10: Method CFH flow chart

waste bags will be supplied to each building and once in a week they will be collected by the use of vehicles. The rest of the process is the same with Method CFH. Again in this method expenditures will be to collect the waste from households with the bags and vehicle and fuel expenditures in the process of carrying them to Hopa Port. Flowchart of the method is presented in Fig. 11.

In the Method CFN, it is proposed that recycle bins from which recyclable wastes can be collected are going to be located near the 560 waste container positioned in specific areas in the districts. Wastes that are collected in these bins will be again collected by the use of waste collecting vehicles and then the same processes that are applied in the first two methods will be applied here too. Expenditures in this method will only be resulting from the vehicles used in the process of collecting waste and carrying them to Hopa Port. The collecting bins will not be operating costs because they will be taken only once. Flowchart of the method is presented in Fig. 12.

As the economic profiles of these methods are designed, waste kilogram prices of the recyclable wastes (glass, metal, plastic, paper) in Turkey are determined by conducting market research. Then monthly changing economic values of recyclable wastes are determined. Expenditures of each of three methods are calculated and compared with the amount of value that will be available with the sales of these wastes and these values are presented in the graphic in the Fig. 13.

When Fig. 13 is examined, it can be seen that Method CFH has the highest cost. It is determined that there is 50% more expense than income that can be

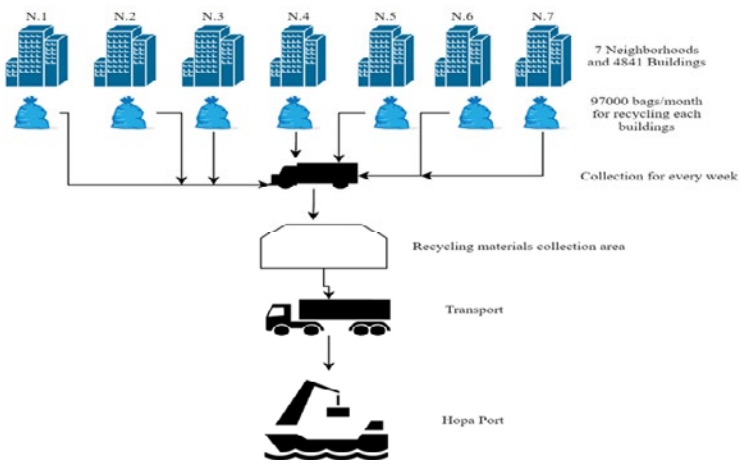

Fig. 11: Method CFB flow chart

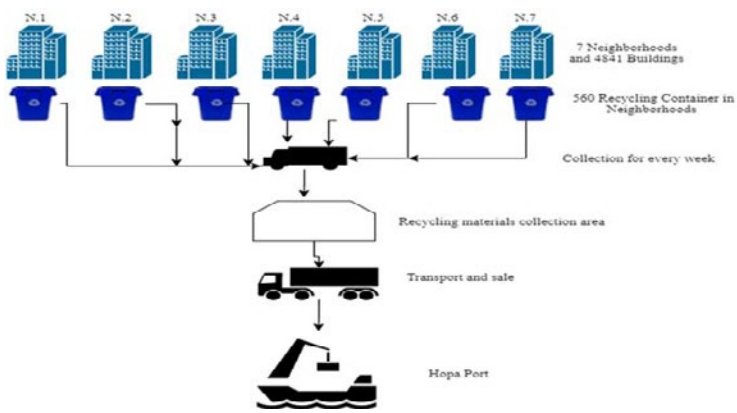

Fig. 12: Method CFN flow chart

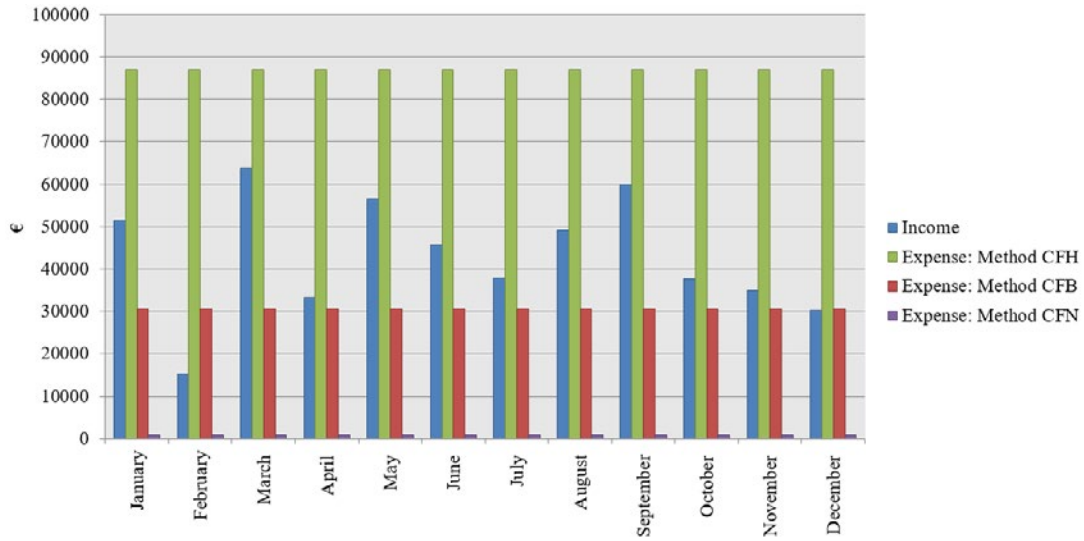

Fig. 13: Method comparison chart

acquired by the sales of recyclable wastes. The main reason for that is the waste bags that are going to be distributed for collecting 5 separate waste category to each household. When Method CFB is examined it is determined that only in February and December income is less than expenses but on the other months an average of 140% income will be acquired. When the last method is examined economically, it is clearly seen that Method CFH >Method CFB >Method CFN. These three methods are examined according to waste management and people's habits in Turkey is likely to be more functional method of CFN. Recycle bins which are going to be located near the domestic waste collecting bins are not going to be used and adopted by the public that is residing in the working area due to lack of knowledge, culture and such habits. In addition to that, since streets are narrow, topographically slope is high and there are not much parking space for individual vehicles in the city, locating additional waste bins will not be welcomed by the public and that will cause intense pressure by the public to remove them. Although Method CFH is the most expensive one in the economic aspect, it will be to the point to examine it socio-culturally. Waste bags that are going to be distributed to each household will initiate a mission awareness starting from the kids and this awareness of kids which initially started as a game will result in the awareness on all of the household members with the psychology of being a role model in adults for the kids. However, this method has its own disadvantages. Shortcomings such as delays in the delivery of the waste bags to the staff, not being able to make this discipline adopted by everyone, not being able to make everyone volunteered to collect these wastes in their house will make this method useless. When Method CFB which is going to be conducted by distributing 5 waste bags to buildings is examined it is seen that this method is the best method for both gathering the wastes and collecting them by the municipality. Besides that public will not have any objection to gather their wastes in waste bags that are going to be located in a suitable place of their apartments. The disadvantage of this method is the liquid leakage and smell which can be caused by the packing wastes. This can be prevented by using durable waste bags and placing them in the areas which are not commonly used such as garage, warehouse and garden. However, in order to apply this method public should be educated and the culture of waste recycling should be imposed too.

Solid waste characterization is an important step in order to create waste management system. When this is taken into consideration, it was determined that 61.06% of the total wastes in the city are organic, 10.28% are paper, 9% are plastic, 3.2% are glass, 2.29% are metal, 3.87% are ash, 0.037% are electronic, 1.58% are textile, 1.35% are garden, 0.51% are dangerous waste and 7.23% are other wastes in a study conducted so as to help creating a waste management application for Artvin city center. Also the relation

between the type and amount of wastes with income level was researched by two-way ANOVA test in the city but no relation could be found. For collecting recyclable wastes for the city center 3 different methods are proposed. These methods are studied economically, socio-culturally and geographically. In each of these 3 methods firstly it is aimed to gather all of the collected recyclable wastes in a specified area in the city and then it is aimed to carry them to Black Sea Hopa Port which is 65 km away once in a month. When the methods are examined economically it is determined that Method CFH >Method CFB >Method CFN. When 3 proposed methods are examined it can be said that Method CFN is the least useful one. Although Method CFH is the economically most expensive method it can be said that this method is the most useful one on making public adopt recycling habits and on collecting all of the recyclable wastes. However, it is seen that this method has disadvantages too. Shortcomings such as delays in the delivery of the waste bags to the staff, not being able to make this discipline adopted by everyone, not being able to make everyone volunteered to collect these wastes in their house will make this method useless. When Method CFB is examined it can be seen that this is the most suitable method for both gathering the wastes and collecting the wastes by the municipality. For the area of study, as a result of the carried out assessments it is realized that Method CFB is the most suitable one both socio-culturally and economically. However this system requires a developed waste, recycling and environmental sensitivity culture. Unfortunately this culture is not prevalent in the study area just like majority of Turkey. In order to make this culture prevalent it should be promoted and educated by people who will be assigned voluntarily in social areas like schools, cinema, theatres and sanctuaries, in public institutions, hospitals, shopping malls by teachers, non-governmental organization employees, mayor and municipality officials by taking the age groups of the community into consideration. In these meetings to be held, promotions like discount in municipality, real estate and environmental cleaning taxes as well as public transportation coupons will may be suitable. Recyclable wastes can be collected and redounded to economy and a portion of the income to be obtained can be used in financing aforementioned education meetings. Apart from this, compost can be obtained under suitable conditions from the organic wastes that are collected and this compost can be sent to tea gardens (which exist all around Artvin city in general) free of charge so as to be used as soil conditioner and accordingly redounded to economy as added value.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interests regarding the publication of this manuscript.

ABBREVIATIONS

$	Dollar
€	Euro
%	Percentage
AM	Post Meridiem
ANOVA	Analysis of Variance
CFB	Collection from Buildings
CFH	Collection from Households
CFN	Collection from Neighborhoods
CSO	Civil Society Organizations
Eq.	Equation
etc	et cetera
HDPE	High Density Polyethylene
Kg	Kilograms
LDPE	Low-Density Polyethylene
lt	Liter
m^3	Cubic meters
Mid.	Middle
MSW	Municipal solid waste
NBHD	Neighborhoods
PE	Polyethylene
PET	Polietilen tereftalat
PM	Ante Meridiem
PP	Polypropylene
PS	Polystyrene
P-value	Probability-value

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AUTHOR (S) BIOSKETCHES

Demirarslan, K.O., Ph.D., Assistant Professor, Department of Environmental Engineering, The Faculty of Engineering, Artvin Çoruh University, Artvin, Turkey. Email: *onurdemirarslan@artvin.edu.tr*

Çelik, B.Y., Ph.D., Republic of Turkey Ministry of Environment and Urbanization, Erzurum, Turkey. Email: *besteyalcn@hotmail.com*

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