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Research Article

Characterisation study of solid wastes: A case of districts in Tekirdağ

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ABSTRACT

In this study, solid waste characterisation of high-income, middle-income, low-income regions and market areas in Tekirdağ Metropolitan Municipality was carried out in winter and summer, 2016. As a result, the amount of organic wastes (kitchen wastes, park and green wastes) and packaging waste (paper, cardboard, bulky cardboard, plastics, glass, metals and bulky metals) in Tekirdağ were determined as 41.02% and 32.4% respectively, by waste sampling. When waste characterisation was analysed based on the districts, it was seen that paper and plastic waste is mostly produced from the Çorlu district. The reason for this could be the high level of welfare of the citizens living in Çorlu and the high number of working people compared to other districts due to the high density of industrial facilities. It was also seen that the ash percentage of waste is high in the districts of Hayrabolu, Şarköy, Muratlı, Marmaraereğlisi, Malkara and Saray, which are the districts not covered by natural gas distribution grid. Waste samples were characterised in the Tubitak Energy Institute Laboratory to determine the moisture content, calorific value and glow loss. The results showed that there is a high moisture and organic matter in the wastes, which makes the incineration method not suitable for the treatment of solid wastes in Tekirdağ. The results of this study highlighted that there is a potential for introducing recycling schemes especially in high income regions in Tekirdağ. To initiate such programmes, collected municipal waste could be separated in two streams in place; organics and co-mingled dry-recyclables.

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INTRODUCTION

For the robust management of solid wastes, it is very important to properly characterise wastes and obtain accurate data about their composition. These data are used to determine the appropriate disposal methods, collection and separation systems for solid wastes [1].

As it is known, solid waste generation rises in parallel with increasing population, living standards and technological developments, especially in cities [2]. Similarly, an increase is observed in the amount and type of solid waste generated in Tekirdağ [3, 4]. The inadequacy of solid waste management in the province has led the local government to seek for new solutions [5].

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Characterisation studies guide the determination of alternative methods for the treatment and disposal of wastes. For instance, solid waste was characterised in Lagos, Nigeria for decision making and planning [6]. Similarly, it was determined that there is a high proportion of non-biodegradable wastes in Covenant University, Nigeria and requirements of alternative waste management solutions for a more sustainable and environmentally friendly waste management system were determined [7]. Importantly, it was reported that there is a high percentage of putrescible matters and plastics in the composition of the waste stream in Reunion Island, France and a life-cycle analysis identified the most favourable waste management option in the region as a multiple waste-treatment process [8]. Another characterisation study was also conducted to determine various physico-chemical parameters of the waste, which was dumped at Gazipur landfill site in Delhi, India and results showed a high fraction of degradable organic components in the waste [9]. It was also determined that the main waste components in Lagos, Nigeria, are food, metal and plastic and a high power potential could be obtained by adopting incineration [10]. In Tekirdağ, there has been no published study so far investigating particularly the characteristics of the municipal solid wastes produced from the province, which were collected by the district municipalities and brought to the transfer stations to be disposed of to the Demirli Landfill Site.

This study aims to produce a data set based on the characterisation of the solid wastes generated in the summer and winter periods in the districts of Tekirdağ to develop a technically and economically feasible solid waste management system. In this context, the solid waste characterisation analyses of Süleymanpaşa, Hayrabolu and Muratlı districts were carried out in Demirli Landfill Facility, which is the only landfill site in the province and the analyses for other districts (Malkara, Şarköy, Marmaraereğlisi, Çorlu, Çerkezköy, Kapaklı, Saray and Ergene) were carried out in the districts. The waste samples taken for the characterisation study were also sent to the Tubitak Energy Institute Laboratory to determine moisture content, calorific value and glow loss. Within the scope of this study, waste samples were taken from all districts to determine the composition of solid wastes generated in Tekirdağ. Considering the income level of the people living in the districts, four regions were defined as low, medium, high-income regions and market areas.

MATERIALS AND METHODS

The equipment used for the characterisation study is given in Figure 1. A scale was used to weigh the waste. The fixed volume container (1 m x 1 m x 0.5 m) was used to ensure that the waste streams to be characterised were equal. A plastic cover (5 m x 10 m) was also laid on the floor to prevent any loss from the waste samples. Component containers were used as discriminating containers on which the names of the waste groups (plastic, metal, glass, etc.) were noted. Shovels, rakes and brooms were also used for laying and filling waste. The sieve was used to shift waste piles.

Figure 1. Equipment used for waste characterisation.

The steps for the characterisation process are summarised below;

1 Each waste bag was emptied and levelled with a shovel and rake.

2 The fixed volume container was filled with the waste samples taken from different points of the waste pile,

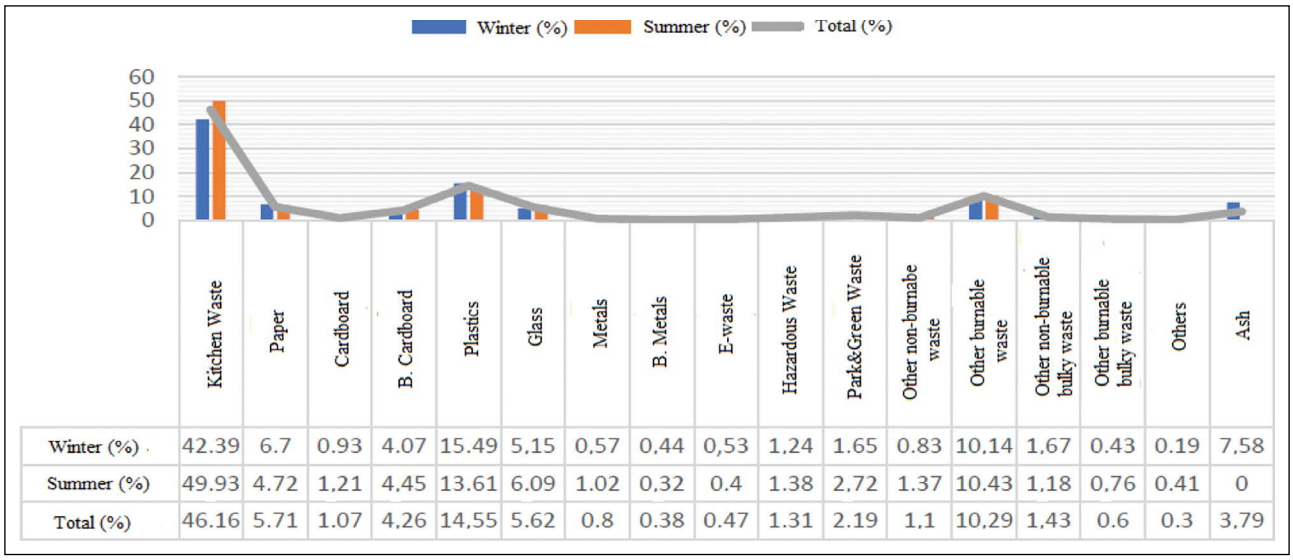
3 After the fixed volume container was filled and then emptied on the plastic cover, the waste was separated and filled into component containers,

4 The waste containers were tared and absolute weight of the waste was recorded.

5 In the sieving step of the waste characterisation in winter, it was observed that the amount of ash contaminated and adhered to other wastes was negligibly low. For this reason, after each category was determined, the waste pile remaining on the ground was sieved through a 1 cm sieve. The part remaining under the sieve was defined as ash. Although there is no specific definition for size distribution of ash in municipal waste stream, it is known that it refers to remaining incombustible residues. Ash is a biologically inert material that can be managed in a more environmentally sound way [11]. The use of bottom ash in municipal solid waste incinerators, for example, could be used as a part of cement raw material or road base [12, 13].

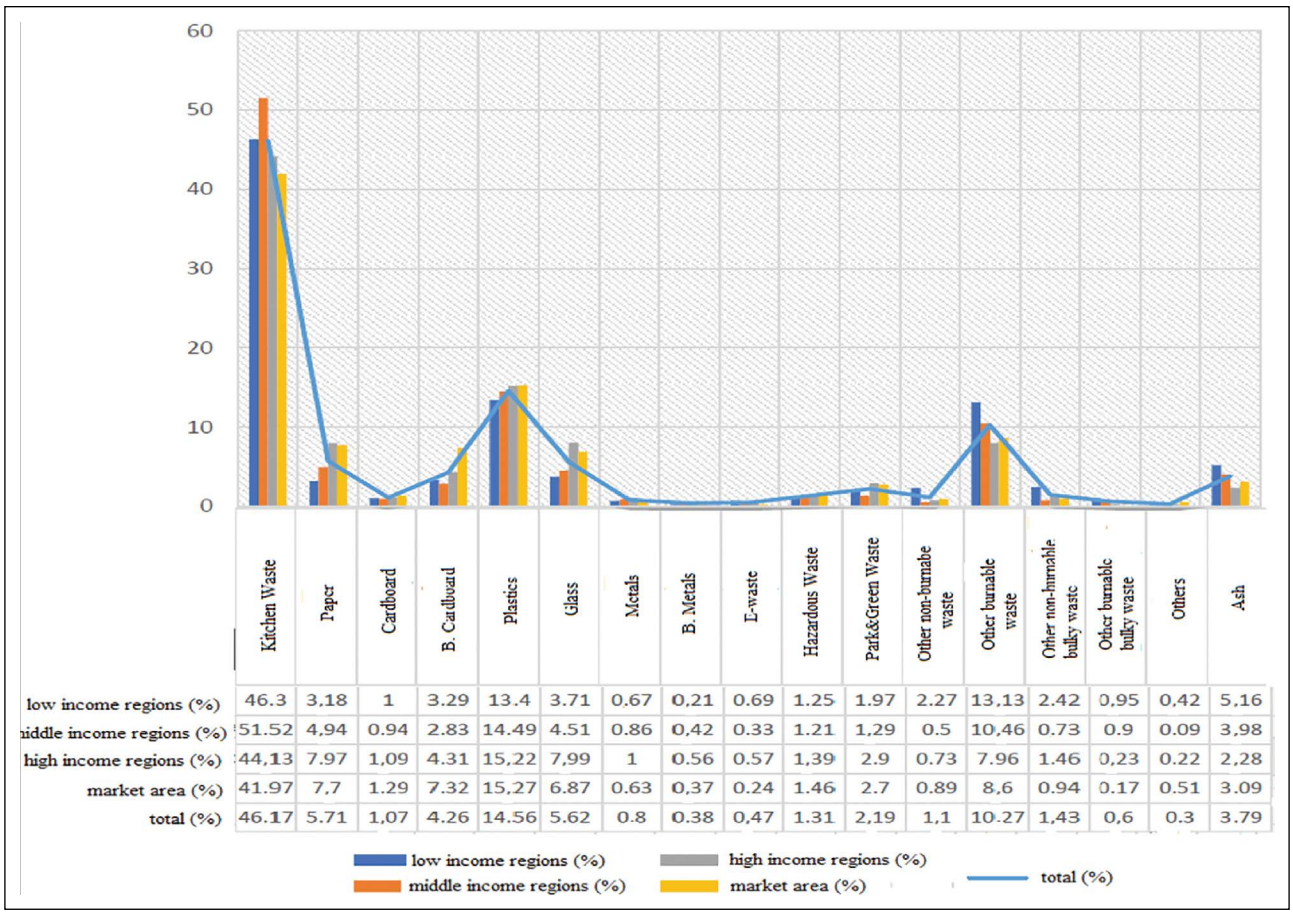
6 2 kg solid waste samples were taken from each district and sent to the Tubitak Marmara Research Centre-Energy Institute Laboratory to determine moisture content, calorific value and glow loss.

For moisture determination, the samples were dried in an oven at 105°C for 24 hours and their water content was measured. The dried samples were processed by coarse and fine grinders in series. The product from the grinders was



	Kitchen Waste	Paper	Cardboard	B. Cardboard	Plastics	Glass	Metals	B. Metals	E-waste	Hazardous Waste	Park&Green Waste	Other non-burnabe waste	Other burnable waste	Other non-burnable bulky waste	Other burnable bulky waste	Others	Ash
Winter (%)	42.39	6.7	0.93	4.07	15.49	5,15	0,57	0,44	0,53	1,24	1.65	0.83	10,14	1,67	0.43	0.19	7,58
Summer (%)	49.93	4.72	1,21	4,45	13.61	6.09	1.02	0,32	0.4	1.38	2,72	1.37	10.43	1,18	0,76	0.41	0
Total (%)	46.16	5.71	1.07	4,26	14,55	5.62	0.8	0.38	0.47	1.31	2.19	1,1	10,29	1,43	0.6	0.3	3,79

Figure 2. Seasonal characterisation of solid wastes in the districts of Tekirdağ.



	Kitchen Waste	Paper	Cardboard	B. Cardboard	Plastics	Glass	Metals	B. Metals	E-waste	Hazardous Waste	Park&Green Waste	Other non-burnabe waste	Other burnable waste	Other non-burnable bulky waste	Other burnable bulky waste	Others	Ash
low income regions (%)	46.3	3,18	1	3.29	13.4	3.71	0.67	0,21	0.69	1.25	1.97	2.27	13,13	2.42	0,95	0,42	5,16
middle income regions (%)	51.52	4,94	0.94	2.83	14.49	4.51	0.86	0,42	0.33	1.21	1,29	0.5	10,46	0.73	0.9	0.09	3,98
high income regions (%)	44,13	7.97	1,09	4.31	15,22	7,99	1	0.56	0.57	1,39	2.9	0.73	7.96	1.46	0,23	0.22	2,28
market area (%)	41.97	7,7	1.29	7.32	15,27	6.87	0.63	0,37	0.24	1.46	2.7	0.89	8,6	0.94	0.17	0.51	3.09
total (%)	46.17	5.71	1,07	4.26	14.56	5.62	0.8	0.38	0,47	1.31	2,19	1,1	10.27	1,43	0,6	0.3	3.79

Figure 3. Solid waste characterisation by income level in districts of Tekirdağ.

sent for analyses. The calorific value of the wastes was determined based on the principle of calculating the mass of the substances released as gas by burning the dry waste sample at 550°C for at least 60 minutes [14].

RESULTS AND DISCUSSION

General Evaluation of Solid Waste Characterisation

The results of the characterisation study based on the

districts are given in Table 1. It is seen that the highest percentage of kitchen waste was produced in Çorlu, Çerkezköy and Süleymanpaşa districts. It is estimated that due to a large number of industrial facilities in Çorlu and Çerkezköy and the cooking activities taking place in the cafeterias located there, the kitchen waste component (53.59% in Çorlu and 48.67% in Çerkezköy) was comparatively high.

It is also seen that the highest (7.585%) and lowest percentage (3.365%) of the paper waste is produced in Çorlu, and Hayrabolu, respectively. The high income citizens living in Çorlu and number of working people compared to other districts, because of industrial activities in the district, may have resulted in Çorlu having the highest share of the paper waste.

When the generation rate of plastic wastes is investigated, it is seen that this rate is higher in Marmaraereğlisi, Şarköy and Çerkezköy with 19.175%, 17.85% and 17.19%, respectively. It is also seen that the highest percentage of ash waste comes from these districts, which are located out of natural gas distribution grid. Therefore, the use of coal continues and the ash component of the waste is significant.

Table 2 shows the moisture content, calorific value and glow loss of solid wastes generated in the districts of Tekirdağ. According to the results of the analysis conducted in Tubitak, the waste with the highest percentage of humidity is collected from in Malkara, Hayrabolu and Şarköy districts, respectively (Table 2). It is also seen that the district with the highest percentage of dry matter is Çerkezköy, while the district with the lowest percentage is Malkara.

In addition, the highest glow loss at 550°C was detected in waste produced from Marmaraereğlisi, Çorlu and Şarköy. It is estimated that this is due to contamination related to waste fractions. As it is known, flexographic inks, adhesives, wires, staples in papers and types of polymers in plastics could cause loss of heat depending on humid weather conditions and cross contamination of waste. The glow loss, which is an indicator of the percentage of volatile organic substances in the waste, was measured as 80.3% in Tekirdağ. It is advantageous if the waste has a high glow loss in terms of both thermal and biological methods.

It is seen that the district with the highest upper calorific value and the lowest calorific value is Marmaraereğlisi. The lower calorific value is an important indicator in terms of deciding whether thermal methods are efficient. For the treatment of wastes in incineration technology without using external additional fuel, a calorific value of waste must be at the level of a minimum of 1,500–1,600 kcal/kg waste [15, 16]. The low calorific value of combustible components and the high moisture value of the waste have a negative effect on combustion efficiency.

Seasonal Variation in Waste Characterisation in Tekirdağ

The seasonal variation of different waste categories is shown in Figure 2. It is seen that, kitchen waste has the largest percentage regardless of the season. It is also seen that kitchen and park -green waste increase relatively in summer. The main reason for this is the increase in consumption of thick-skinned fruits and vegetables such as melons and watermelons in summer.

There is a considerable increase in packaging waste such as glass and metals in summer (Fig. 2). It is expected that the reason for this is the high consumption of beverages in summer because of the hot and humid weather. It is also seen that the ash is produced relatively high in districts without natural gas (Hayrabolu, Şarköy, Muratlı, Marmaraereğlisi, Malkara and Saray). This is caused by the burning of charcoal for heating in the districts not covered by natural gas distribution grid, and as a result, the ash produced from the houses is mixed with municipal waste.

Waste Characterisation by Income Levels in the Districts

Solid waste characterisation by income levels in the districts is shown in Figure 3. It is seen that kitchen waste has by far the largest share in all of the income levels. Figure 3 also shows that kitchen waste production rate is the highest (51.52%) in middle-income regions. However, as stated in the section above, there are a large number of industrial facilities in Çorlu and Çerkezköy and cooking activities take place in the cafeterias located in Süleymanpaşa. The tendency to consume more packaged materials in these districts causes high proportion of kitchen and packaging waste to occur at the same time from high-income regions. This is reflected to Figure 3 which shows a higher proportion of packaging waste (38.14%), such as paper (7.97%), cardboard (1.09% and 4.31% for bulky cardboard), glass (7.99%), metals (1% and 0.56 for bulky metals) and plastics (15.22%), are produced in high-income regions compared to middle-income regions where packaging waste is only 28.99% [paper (4.94%), cardboard (0.94% and 2.83% for bulky cardboard), glass (4.51%), metals (0.86% and 0.42 for bulky metals) and plastics (14.49%)].

It is seen in Figure 3 that the category of paper-cardboard waste production is low in low-income regions in comparison to the other regions. In general, it is estimated that the consumption of packaged food, and so the production of packaging waste (such as paper and cardboard waste), is higher in high-income regions. However, there is no significant difference in the percentage of plastic wastes among high, medium, low income regions and market areas.

The other combustible materials category in Figure 3 includes diapers. The use of diapers seems to be widespread for every income group. This rate is higher in low-income regions than in other regions. This could be due to higher birth rates in low-income areas. The percentage of ash waste is also high in low-income regions where the use of natural gas is not widespread.

Table 1. Characterisation of solid wastes based on districts in Tekirdağ (%)

Waste categories	Districts waste composition (%)											
	Muratlı	Malkara	Hayrabolu	Şarköy	M.ereğlisi	S.paşa	Çorlu	Ç.köy	Kapaklı	Saray	Ergene	Tekirdağ
Kitchen waste	35.3	43.1	39.845	35.59	32.815	46.37	53.59	48.67	45.28	39.35	38.7	46.16
Paper	6.1	5.1	3.365	4.36	5.765	6.81	7.585	4.335	4.86	4.43	3.83	5.71
Cardboard	1.5	2.4	1.505	2.665	2.11	0.675	0.89	0.99	0.935	1.35	0.675	1.07
Bulky cardboard	4.7	3.3	3.855	3.855	3.855	3.855	3.855	3.855	3.855	3.855	3.855	3.855
Plastics	16.3	15.6	14.46	17.85	19.175	15.92	11.97	17.19	14.015	10.22	14.665	14.55
Glass	4.7	6.5	4.12	5.775	5.65	6.945	5.995	4.46	3.845	4.975	5.87	5.62
Metal	1.9	1.9	0.87	2.27	2.57	0.79	0.56	0.43	0.46	0.665	0.545	0.795
Bulky metals	0.4	0.3	0.06	0.13	0	0.4	0.48	0.295	0.585	0.38	0.6	0.38
E-waste	0.8	0.6	0.47	0.86	0.855	0.81	0.325	0.195	0.205	0.54	0.415	0.465
Hazardous waste	2.0	1.2	1.41	2.115	1.975	1.445	1.145	1.11	1.08	1.67	1.345	1.31
Park and green waste	4.5	1.2	3.28	2.75	3.645	1.575	1.18	1.58	2.03	2.955	7.135	2.185
Other non-burnable waste	0.8	0.5	2.96	0.615	0.975	0.36	1.175	0.465	1.4	2.635	3.175	1.1
Other burnable waste	14.6	9.1	11.02	8.28	10.575	7.27	7.15	16.605	14.35	12.23	9.81	10.285
Other burnable bulky waste	0.6	0	1.37	0.38	0.115	2.99	1.45	0.735	1.705	0.71	1.765	1.425
Other non-burnable waste												
Bulky waste	0	0	0.77	0	0.255	0.18	0.195	0.17	0.355	3.66	3.26	0.595
Others	0	0	0	0	0.11	0.01	0.22	0.43	0.465	1.78	0.565	0.3
Ash	5.7	9.1	10.655	11.575	6.96	2.415	1.465	0.86	5.07	5.48	3.56	3.79
Total	100	100	100	100	100	100	100	100	100	100	100	100

Table 2. Moisture content, calorific value and glow loss of solid wastes in Tekirdağ

Waste properties	Districts waste composition (%)											
	Muratlı	Malkara	Hayrabolu	Şarköy	M.ereğlisi	S.paşa	Çorlu	Ç.köy	Kapaklı	Saray	Ergene	Tekirdağ
Moisture content (%)	73.37	87.04	82.45	81.53	58.02	74.19	79.7	72.9	75.25	77.59	73.03	75.1
Dry matter (%)	26.63	12.96	17.55	18.47	21.98	25.81	20.3	28.36	24.75	22.41	26.97	24.9
Glow loss (%)	83.14	82.66	83.19	85.41	88.67	82.7	87.25	76.21	77.57	68.71	67.89	80.3
Upper calorific value (cal/g)	3643.75	3881.3	4118.25	3600.3	4193.13	3246.13	3935.1	3616.8	3757.7	3851.6	3076	3691
Lower calorific value (cal/g)	541.12	-6.17	240.42	188.02	1420.86	403.81	332.59	553.67	489.82	409.25	402.24	479.72

Waste characterisation provides useful information to city authorities in terms of planning to reduce waste, set up recycling programmes and hence, to protect resources. In this way, landfill diversion could also be maximised and recyclable waste could be captured and beneficially reused. The results of this study highlight that there is a potential for introducing recycling schemes especially in high income regions in Tekirdağ. To initiate such programmes, municipal waste could be separated in two streams, organics and co-mingled dry-recyclables at homes. Dry recyclables could further be segregated and reproduced as a secondary product by any proposed materials recycling facility in the province [17].

CONCLUSION

In this study, solid waste characterisation based on different income levels (low, middle, high-income regions and market area) in the districts of Tekirdağ was conducted in the summer and winter periods and moisture content, glow loss and lower-upper calorific value of the waste were determined.

As a result of this characterisation study, the rate of organic wastes (kitchen wastes, park and green wastes) and packaging waste (paper, cardboard, bulky cardboard, plastics, glass, metal and bulky metal) were determined as 42.02% and 32.4% in Tekirdağ, respectively. This shows similarity with the study conducted in Çorlu, which resulted that 170 tonnes of domestic waste are generated daily and 30% of this waste is recyclable materials [18]. In another study, it was found that almost 70% household waste in Eskisehir was food waste, while 20% of it was recycling waste including paper–cardboard, metals, glass and plastics [19]. It was also noted that the effects of socio-economical changes on waste composition plays a crucial role. High content of recyclables in waste stream was found significant in terms of pioneering on-site recycling schemes for residents. For instance, it was found that more than 65% of municipal wastes in the Campus Mexicali, Mexica are recyclable or potentially recyclable. This highlighted the feasibility of waste segregation and recycling in the campus and attracted recycling companies which could absorb all of these wastes [20].

It was also determined that the district with the highest production of kitchen and paper waste is Çorlu, because of the high level of welfare of the citizens living in the district and the high number of working people compared to other districts depending on the density of industrial facilities. It was also observed that the ash percentage is high in the districts of Hayrabolu, Şarköy, Muratlı, Marmaraereğlisi, Malkara and Saray, which are the districts not covered by natural gas distribution grid.

As a result of the analysis conducted in Tubitak, the humidity and dry matter was obtained as 75.1%, 24.9% in Tekirdağ, respectively. The glow loss at 550°C was measured as 80.3%. Upper and lower calorific values were determined as 3691 cal/g. and 479.72 cal/g. This shows similarity with the outcomes of the study which presents that approximately 54% of domestic waste was organic in nature and average moisture content of samples was 62.41% in İstanbul [21]. These results indicate that incineration is not a suitable method for the solid wastes produced in Tekirdağ.

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DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

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