

# Municipal solid waste composition and assessment: a case study in Kocaeli, Turkey

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## Abstract

Composition of municipal wastes as well as projection of waste-generation and -disposal rates is need to plan and implement disposal and recycling activities. The primary objectives of the study are to characterize and evaluate the recycling potentials of the municipal solid waste. Waste sorts were conducted during the summer and winter of 2008 at the City of Kocaeli. A detailed physical sampling protocol was outlined. Weight fractions of 17 waste components were quantified from all geographic areas that contribute to the Kocaeli Sanitary Landfills. Each region was divided into four groups, i.e., low-income, middle-income, high-income and commercial district. Comparisons of solid waste generated between locations and seasons were conducted. The composition of the entire waste stream was organic wastes (38 – 41%), recyclable items (26 – 38%), combustible wastes (15 – 22%), hazardous wastes (1 – 2%), and others (3 – 12%).

## Keywords

Municipal solid wastes, solid waste composition, recycling

## 1 Introduction

Turkey covers an area of 780,580 km<sup>2</sup> with a population of 67.8 million according to the 2000 population survey. According to the recent survey conducted by the State Institute of Statistics (SIS), 28.5% of municipal solid waste (MSW) collected from municipalities was disposed in engineered sanitary landfills. While 63.4% of MSW was deposited in municipality dumps improperly constructed without bottom linings and leachate/gas collection systems, 5.9% was open dumped, 1.2% composted, and 1.0% was open burned (Sis, 2005). In 1991, there was no sanitary landfill; and the same institute reported that over 90% of MSW was disposed in non-engineered city dumps. Currently, there are more than 30 engineered sanitary landfills in Turkey. Kocaeli is located in the Marmara Region, between 29.960°E longitude, 40.790°N latitude, surrounded by Sakarya from its east and southeast, Bursa on the south, The Izmit gulf, Yalova and The Marmara Sea and Istanbul on the west, and the Black Sea on the north. It is located on an important crossroad binding Asia to Europe (Figure 1). Kocaeli with a population of 1.5 million is one of the largest commercial and industrial centres of Turkey. It is divided into 7 re-

gions and 44 sub-regions. Each region has its own municipality. Each sub-regional municipality is responsible for collection and transportation of solid wastes generated within its region. These sub-regional municipalities are working under the supervision of regional municipalities. Kocaeli has undergone a dense industrialization since the 1960s, which was followed by a rapid increase in population and an irregular urbanization. The city has a state-of-the-art sanitary landfill designed and constructed by German engineers in 2000.



Figure 1 Turkey's map and the location of the city of Kocaeli

Waste composition is critical in the planning, design, and operation of solid waste management systems. Waste composition should be carried out as a first step in solid waste management since management entails the handling, processing, and conversion of materials (SAVAGE AND DIAZ, 1997). In addition, any waste management plan must be related to a specific waste composition (HASSAN ET AL., 2000). MSW composition varies substantially from country to country and even region to region within a city due to the amount of community recycling activities, banned items, etc. Therefore, there is no substitute for a local analysis and a comprehensive MSW composition is necessary for every municipality. In the beginning of 2008, Turkish Ministry of Environment and Forestry has started a nationwide survey and asked to every municipality in Turkey to collect and compile data on their MSW characterization. This paper discusses the results of MSW composition data obtained in summer and winter of 2008 for the city of Kocaeli.

## 2 Methodology

Waste composition study has been carried out for 25 sub-regional municipalities (out of 44) having populations more than 5,000. The MSW samples are taken from four different regions within each sub-district, i.e., low income, middle income, high income and

commercial areas. Waste is sorted into 17 category namely kitchen wastes, paper, cardboard, cardboard boxes, plastics, glasses, metals, bulky metallic wastes, electronic wastes, hazardous wastes, yard wastes, other non-combustibles, other combustibles, other combustible bulky items, other non-combustible bulky items, and miscellaneous wastes. The constituents of each waste group are provided in Table 1.

Table 1 Main waste classification

Waste class	Waste components	Waste constituents
Organic	Kitchen wastes Yard wastes	Food wastes, bread, fruits, vegetables Yard trimmings, leaves, grass, crop residues
Recyclable	Paper Cardboard Cardboard boxes Plastics Glasses Metals Bulky metallic wastes	Newspaper, magazines, office paper Milk boxes, juice boxes Various types of cardboard boxes HDPE, PET, PVC, Film plastic Clear bottles, colored bottles, flat glass Ferrous metals, aluminium cans Metal cabinets, metal tables
Combustible	Other combustibles Other combustible bulky items	Textiles, wood, diapers, shoes, rugs Furniture, wooden cupboard
Hazardous	Electronic wastes Hazardous wastes	Computers, radios, phones Batteries, detergent boxes, medicine bottles
Others	Other non-combustibles Other non-combustible bulky items Miscellaneous Ash (only in winter)	Rock, concrete, soil, dirt, brick, ceramics Refrigerators, washing machines Remainder/composite Ash from coal burning

The sampling is repeated in summer and winter of 2008. Approximately 1 m<sup>3</sup> of samples are taken from the collection vehicles at disposal sites. To carry out the analysis, the wastes in the samples are sorted according to the 17 categories listed in Table 1. In the sorting process, each type of waste is placed in its appropriate container (see Figure 2). At the completion of the sorting, each container and its contents are weighed (gross weight). Gross and tare (empty container) weights are recorded. The difference be-

tween the two weights is the net weight of the individual type of wastes. In winter, the amount of ash resulted from household coal burning is separately determined. The ash amount is determined with the use of manually manipulated screens. The screens have square openings of 1 cm<sup>2</sup>. After bulky wastes are sorted, composite waste is placed on the screen. The screen is shaken until particles of refuse no longer pass through the openings. Material remaining on the screen (oversize) is collected and re-sorted. The material that has passed through the screen (undersize) is considered as ash.

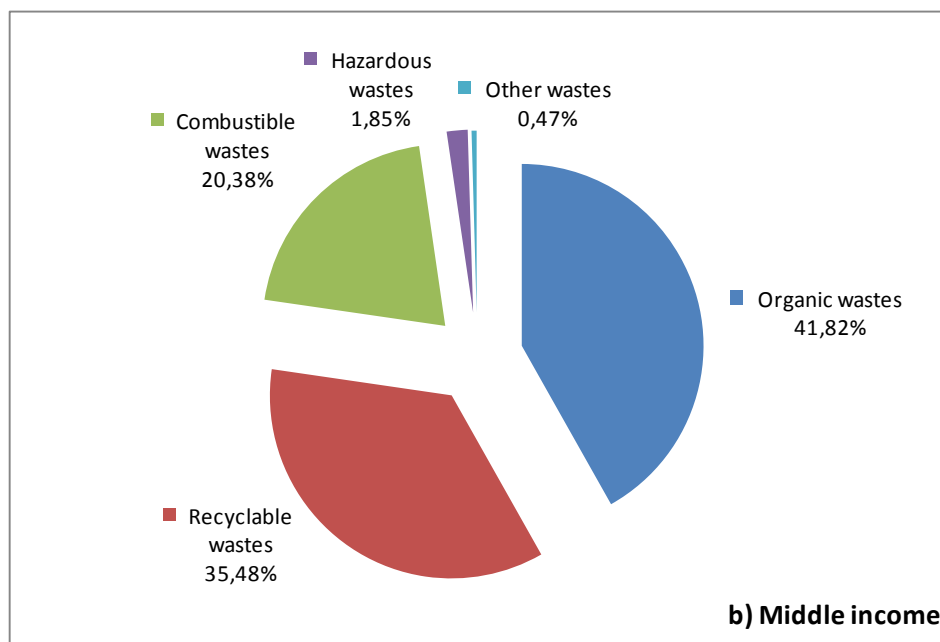
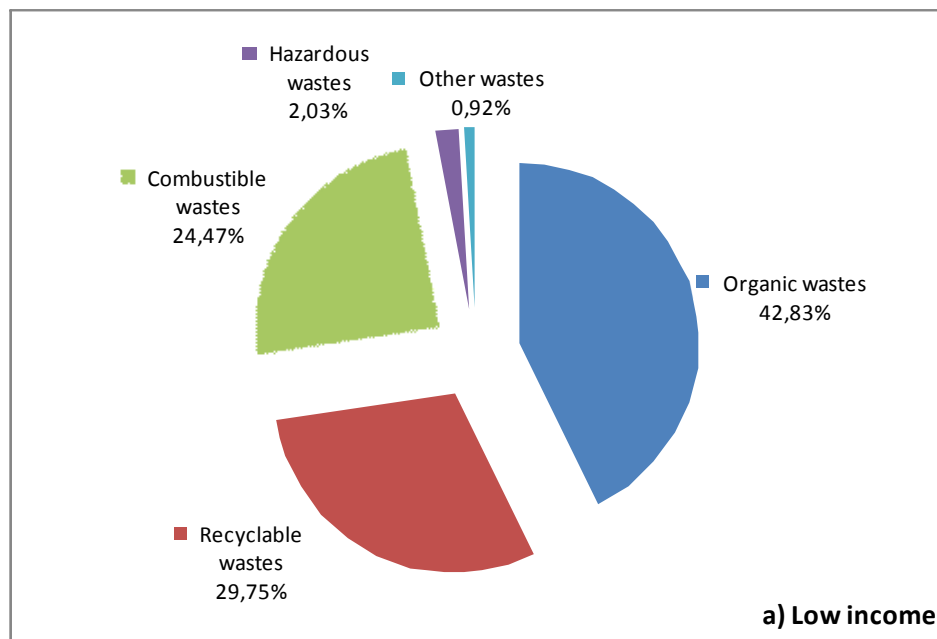


Figure 2 MSW Sorting process

### 3 Results and discussion

The waste components sorted are further grouped under 5 different main categories depending on their physical, chemical and biological properties. These are organic wastes, recyclable wastes, combustible wastes, hazardous wastes and other wastes (Table 1). The break-down of the main waste classes and their average percentage distribution for different socio-economic categories in 25 sub-districts of Kocaeli are given in Figures 3 and 4. Solid waste compositions in summer and winter have been found to be relatively stable. Organic wastes always comprise the highest portion, followed by recyclable wastes and combustible wastes. In Kocaeli, organic wastes account for about 42 – 49 % of the total waste streams in summer and 34 – 44 % in winter. Maximum rates of organic waste discard occurred in summer due to greater availability of fruits and vegetables. On the other hand, recyclable wastes account for 30 – 40 % in summer and 21 – 36 % in winter. Although the comparison of national waste statistics

may not be a simple task, due to the difference in compositional classifications and the manner in which the data were collected, solid waste composition in Kocaeli has been found to be quite similar to that in other major metropolitan cities of Turkey, e.g., Istanbul, Izmir, Bursa, Adana (METIN ET AL., 2003; BERKUN ET AL., 2005), and those in major cities in the developing countries, but very different from those in cities of the developed countries in the world (UNEP, 2005). The organic wastes in Kocaeli almost doubled the percentage in the major cities of developed countries. The amounts of other wastes are substantially increased in winter due mainly to high rates of ash production from coal use for space heating.



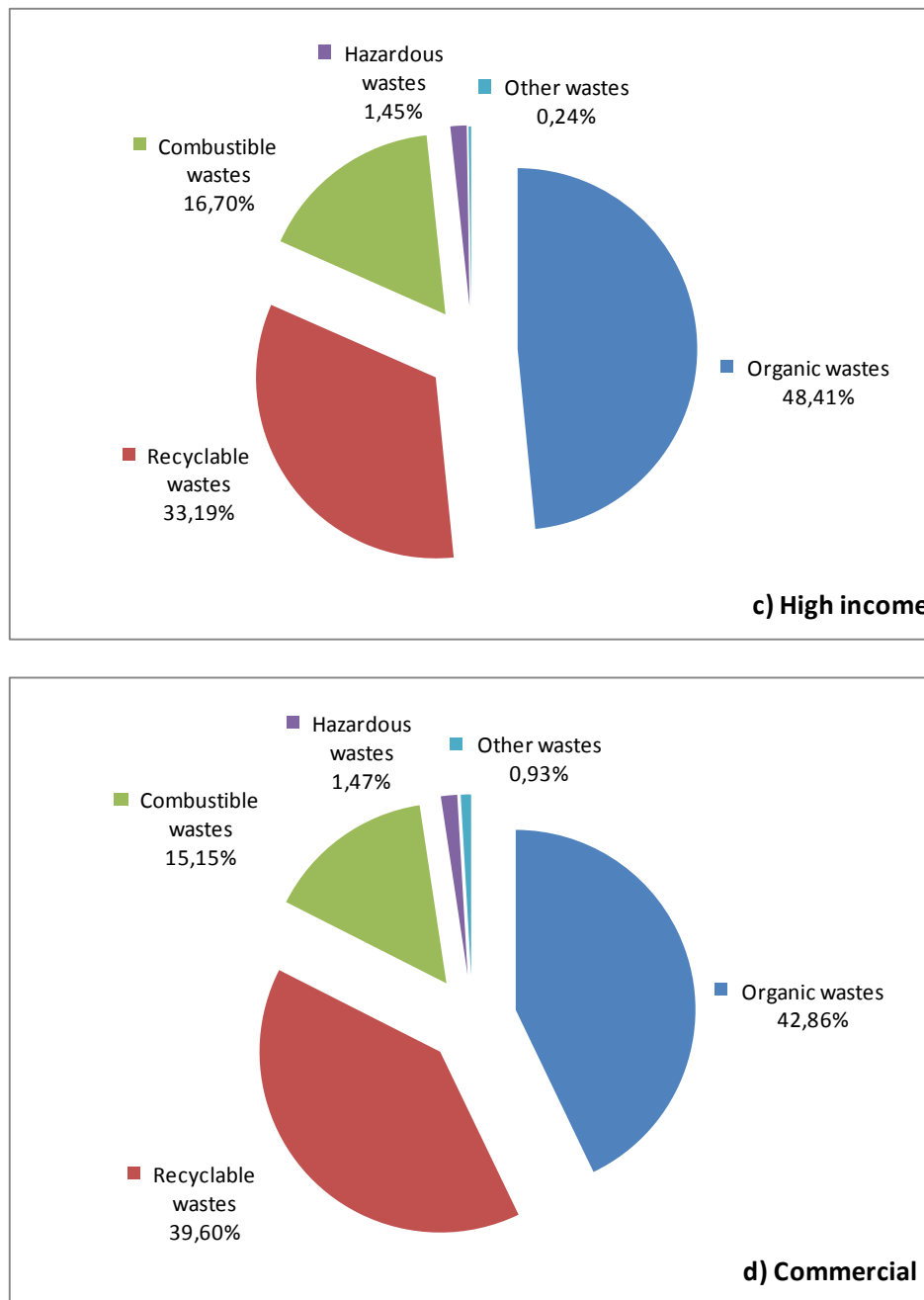
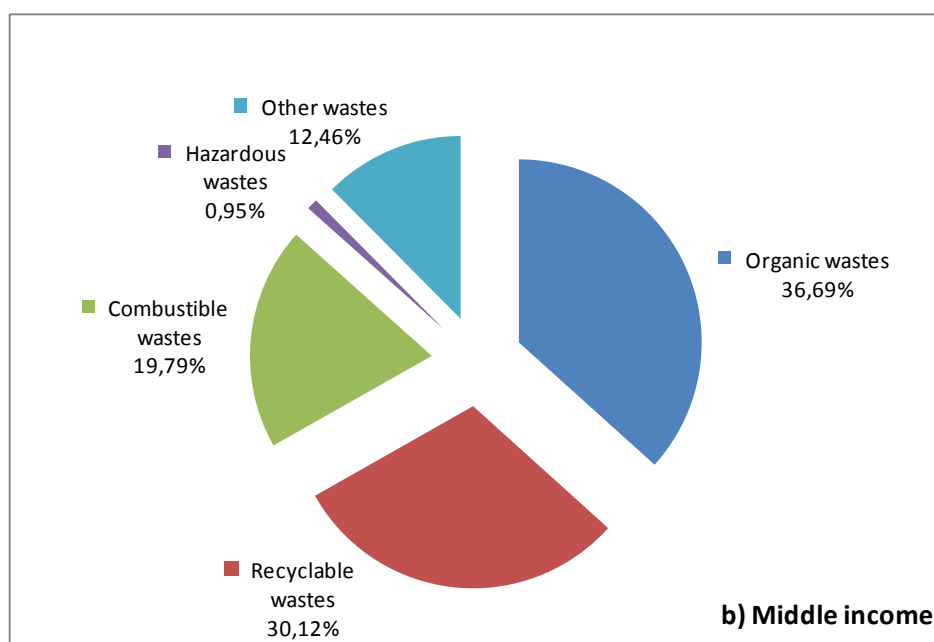
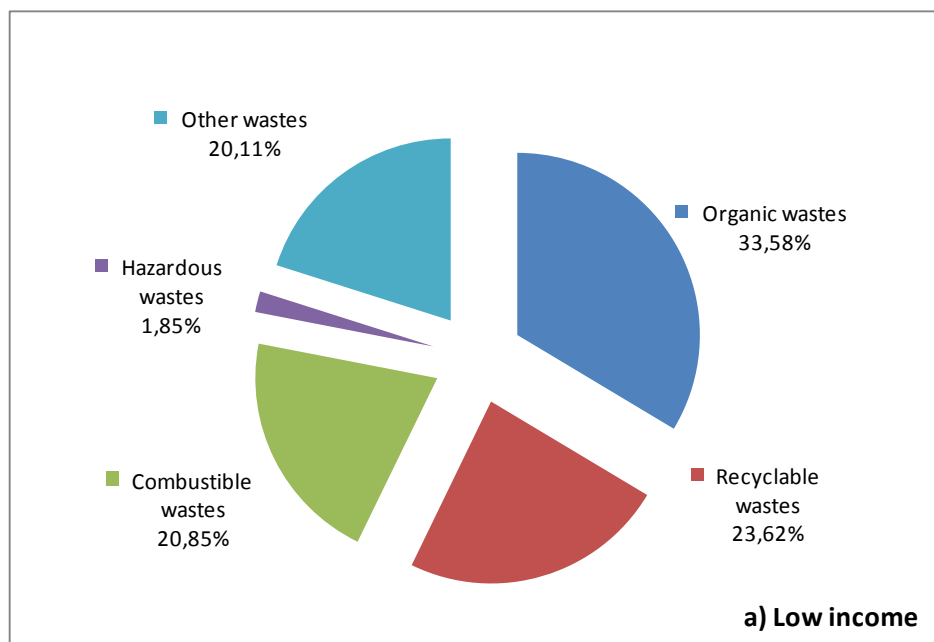


Figure 3 Average MSW compositions for Kocaeli in summer

Recycling may sometimes be far more costly than originally anticipated. Collection and handling costs have always formed a large component for material recycling, and the quality of waste materials separated for recycling has frequently been inadequate for direct resale (BAI ET AL., 2002). Although there is no comprehensive recycling program carried out by the central municipality in Kocaeli, there are several success stories achieved by few sub-regional municipalities in the past. In general, recyclable materials are collected mainly by individuals (scavengers) under non-hygienic conditions and sold to private companies. At present, the key players are scavengers, middlemen and traders. Currently, an integrated solid waste management strategy is under preparation for

the central municipality. This anticipated strategy has a state-of-the-art recovery plant and a MSW baling and packing plant.

Since paper, plastics, glass and metals have been the most commonly separated waste materials for recycling purposes, the average percentage distribution of these individual components in recyclable wastes are provided in Table 2. It can be noted that the percentage of plastics in the recyclable wastes is relatively high. This is due to fact that plastics rather than paper is widely used in packaging in Turkey. The increase in the amount of plastics in summer can be explained by the fact that it is very common using drinking water in disposable plastic bottles.



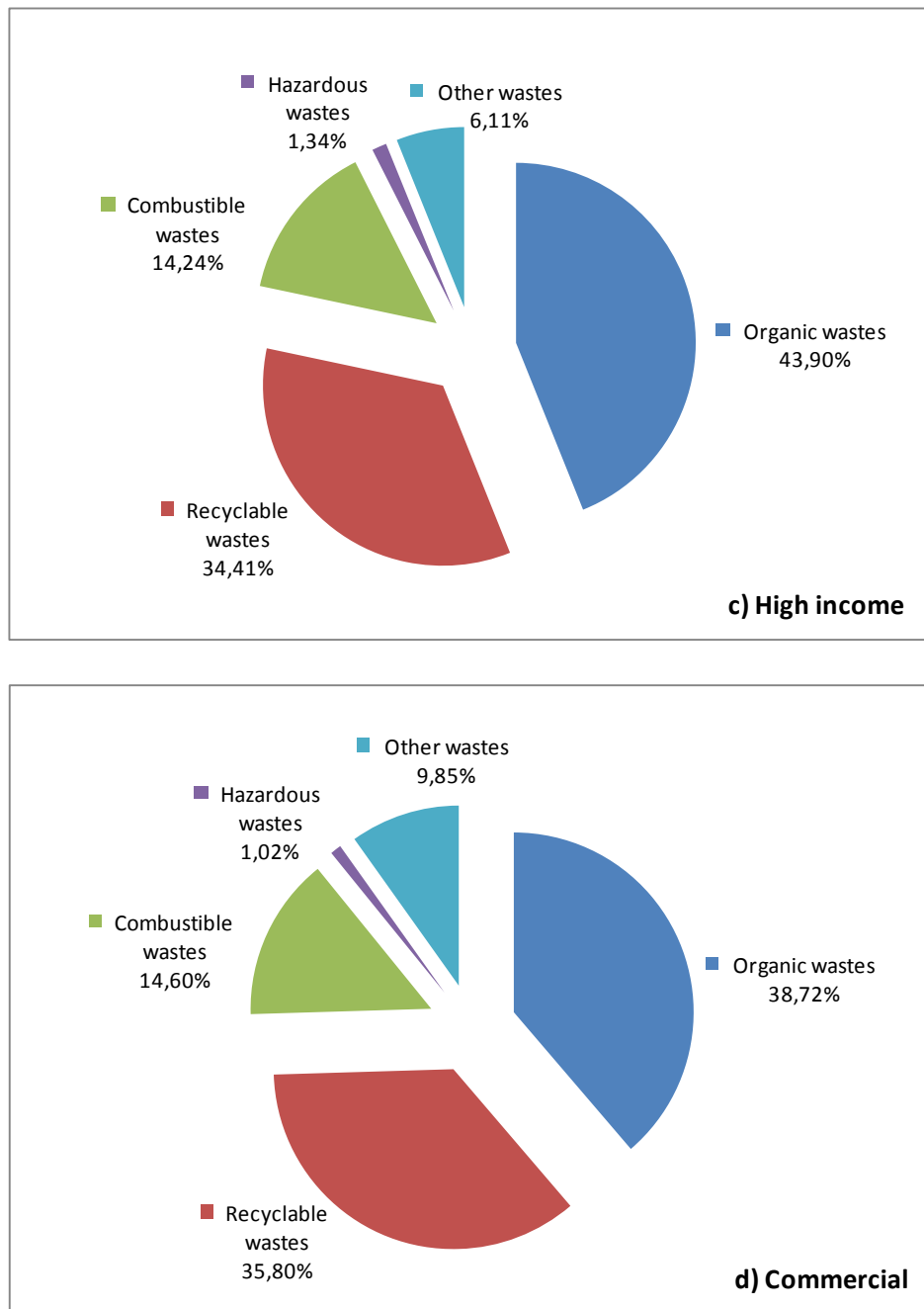


Figure 4 Average MSW compositions for Kocaeli in winter

The average per capita MSW generation in Turkey is assumed to be 0.95 kg/person-day (Metin et al., 2003). Therefore, Kocaeli's daily MSW production amounts to 1425 metric tonnes (0.5 million metric tonnes per year). The average amounts of paper including cardboard and cardboard boxes, plastics, glass, metals including bulk metallic wastes are 61550, 75650, 18100, 7550 tonnes per year, respectively. The average buying prices at source for paper including cardboard and cardboard boxes, plastics, glass, metals including bulk metallic wastes are determined as about € 60, 115, 25, 100<sup>-1</sup>, respectively (METIN ET AL., 2003).



Table 2 Average recyclable waste components

Recyclable waste components	Percent by weight		
	Summer	Winter	Average
Paper	5.88	4.33	5.11
Cardboard	2.61	2.75	2.68
Cardboard boxes	4.65	4.38	4.52
Plastics	16.11	14.15	15.13
Glasses	3.81	3.43	3.62
Metals	1.30	1.65	1.48
Bulky metallic wastes	0.01	0.04	0.03

Thus, the total potential economic value for separating recyclable materials from the waste stream at source in Kocaeli is about € 3.7, 8.7, 0.5, 0.8 million  $y^{-1}$ . Due to technical, economic and management constraints, no country is able to recycle 100% of their recyclable wastes. If it is assumed that 75% of the recyclable wastes could be recycled, the estimated total revenue from selling recyclable wastes at source is about € 2.8, 6.5, 0.4, 0.6 million  $y^{-1}$ . At this 75% level, the estimated potential revenue from recyclable wastes is about € 10.3 million  $y^{-1}$ .

#### 4. Conclusions

For the protection of conservation of natural sources in Kocaeli, MSW recycling must be provided. In addition, the above-mentioned estimates clearly indicate the economic potential for recycling of wastes in Kocaeli. Separation of MSW components at the source of generation is the most effective way to achieve the recovery and reuse of recyclable materials. Kocaeli should have its own MSW management strategy since the differences in solid waste composition have a great impact on the system of solid waste management. Recyclable waste collection centres should be created to encourage recycling. A price, even in a small amount, paid especially for used papers, glasses and metal products can motivate the delivery of these materials to the collection centres.

#### 5. Acknowledgements

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