

Municipal Solid Waste Generation and Management in Kocaeli: 2023 Projections

*¹Özgür Kaplan, ²Mustafa Ogan Karabaş, ³Kadri Süleyman Yiğit
*^{1,2,3}Faculty of Engineering, Department of Mechanical Engineering, Kocaeli University, Turkey

Abstract

In this study, waste management practices for Municipal Solid Waste (MSW) in Kocaeli are summarized. Data of waste characterization and waste generation that gathered from Turkstat are presented and by using these data waste generation possibilities for 2023 are calculated. Waste reduction policies are also taken into consideration. With these assumptions, 2023 MSW generation projections are 785 thousand tons and for best case scenario 628 thousand tons. It is possible to produce of 24000 m³CH₄/day Methane in Kocaeli with utilizing OFMSW in 2012. 2023 projection of Methane generation was calculated as 28500 m³CH₄/day.

Key words: Municipal Solid Waste, Waste Generation, Biomethane Production

1. Introduction

Kocaeli is located on the north west of Turkey and it's a neighbor of İstanbul. Kocaeli is a heavily industrialized province. The industry based economy of Kocaeli accounts for 13% of Turkey's Industrial Production. Automotive factories Ford, Hyundai, Honda and Isuzu; tyre factories Goodyear, Pirelli, Lassa and Bridgestone; Turkey's largest enterprise, the Tüpraş Petroleum Refinery Plant and other 1900 industrial investments are located in Kocaeli (URL 1). Also Kocaeli is home to over 1.7 million people.

Waste is a byproduct of human life. Humans will always produce waste and it is available wherever human life takes place. When the population was relatively small comparing today, this was not a major issue. But the increase in the population and urbanization, generation of waste both increased and became a serious problem to deal with. Generation of OFMSW (Organic Fraction of Municipal Solid Waste) in cities is both a problem and an opportunity. If it can't be manage properly, it causes problems like contamination of water, soil and atmosphere and to a major impact on public health (Giusti, 2009). On the other hand OFMSW is a biomass source which every city in the world generates. OFMSW is available and accessible as a source of biomass in cities. MSW is collected, transported and disposal under the control of municipalities. There is no need to create a supply chain from scratch, it is already established but it might need re-organizing.

*Corresponding author: Address: ³Faculty of Engineering, Department of Mechanical Engineering, Kocaeli University, 41380, Kocaeli TURKEY. E-mail address: ozgurkaplan1@gmail.com, Phone: +902623033451

Management of Municipal Solid Waste (MSW) is accomplished by landfilling in Kocaeli. According to TurkStat data in 2012, 59,9 % of the waste generated in Turkey is disposed in sanitary landfills, 37,8 % of it is disposed in landfills and 2.3 % of it is disposed in other ways such as composting, recycling etc (URL 2). Management methods of MSW could be listed as Landfilling, Incineration, Composting, Recycling, Thermal, biological and mechanical treatment (Giusti, 2009; URL 2).

Landfilling of MSW causes spreading of bad odors, emitting of greenhouses gases - such as CO₂, CH₄, CO- to the atmosphere, polluting water and earth with badly managed landfill leachate. The sizes of the landfill sites are so big to control the landfill leachate and by that manner there is always a possibility of mixing the leachate with earth. In the developing cities, the distance between landfill sites and city is another problem. If it is too far, the transportation costs increase, if it is too close, aforementioned problems can be felt by residents (Giusti, 2009).

Incineration facilities pollute the air with SO₂, NO_x, N₂O, HCl, HF, CO, CO₂, dioxin and furan emissions (Giusti, 2009). In 2013, World health organization related cancer with outdoor air pollution and the outdoor air pollution is classified as carcinogenic to humans (group 1). Group 1 also includes asbestos, tobacco smoke, diesel engine exhaust and many other agents (Straif et. al., 2013). By that manner, it seems like incineration is not a favorable course of action in solid waste management. Recycling is can only be applied to paper, plastic, glass and metal wastes.

The developing technology and science gave us the ability to manage the waste more properly. In the recent years organic wastes are considered to be a valuable source of renewable energy and biogas production via anaerobic fermentation is the most promising process for that manner (Khalid et. al., 2011). Biogas could be used directly as a fuel in internal combustion engines and gas turbines to generate electricity and it could also be used as biomethane for home and industrial usage. (Alves et. al., 2013; Galvagno et. al., 2013; Molino et. al. 2013).

2. Waste Management in Kocaeli

Curbside collection is used in collection of municipal solid wastes (MSW) in Kocaeli. Source separation is not mandatory but there are special trash bins available for packaging waste (or recyclables), battery waste and oil waste (MARKA, 2013). MSW is collected with trucks and sent to landfills for final disposal. In Solaklar Landfill, landfill gas (LFG) is utilized to produce electricity which total capacity of the facility is 5,093 MW (URL 3).

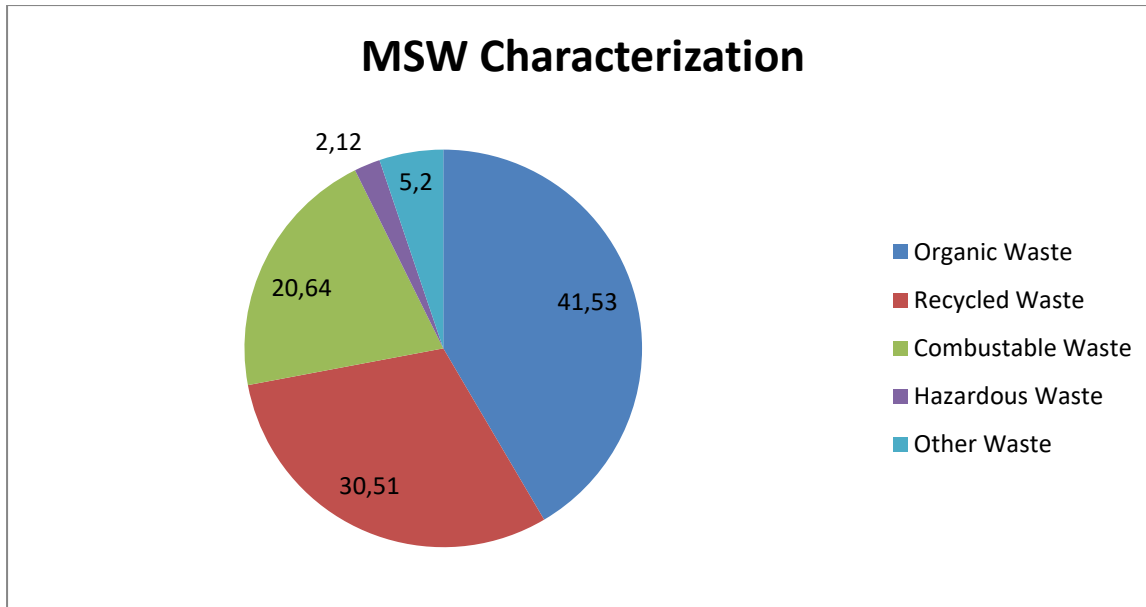


Fig. 1 MSW characterization of Kocaeli (Yenice et al., 2011)

Waste composition is studied by Yenice et al., (2011) in Fig. 1. and it was found out as 41.53% organic wastes, 30.51% recycled wastes, 20.64% combustible wastes, 2.12% hazardous wastes and 5.20% other wastes.

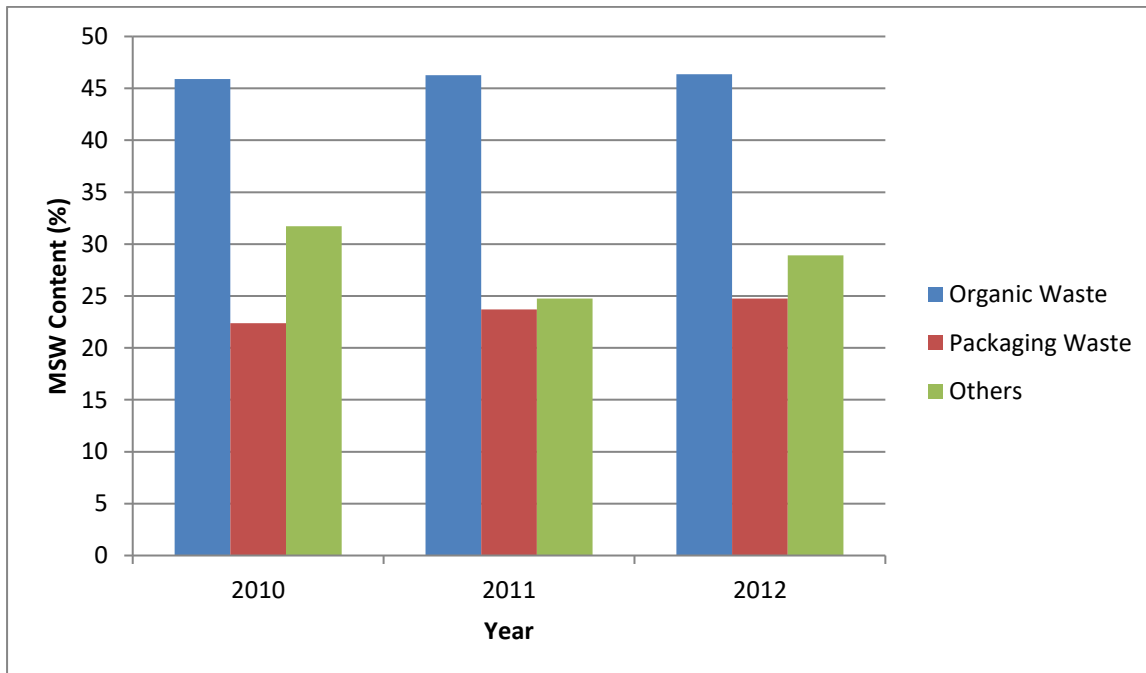


Fig. 2 MSW characterization over years in Kocaeli (MARKA, 2013)

Waste characterization over years can be seen on Fig. 2 which indicates percentage of the organic waste in MSW nearly stays constant. In the both of the studies, percentage of the organic waste in

MSW is above 40% which makes organic fraction of municipal solid waste (OFMSW) an important source of biomass for Kocaeli. It also indicates that a proper method have to be adopted to manage organic waste.

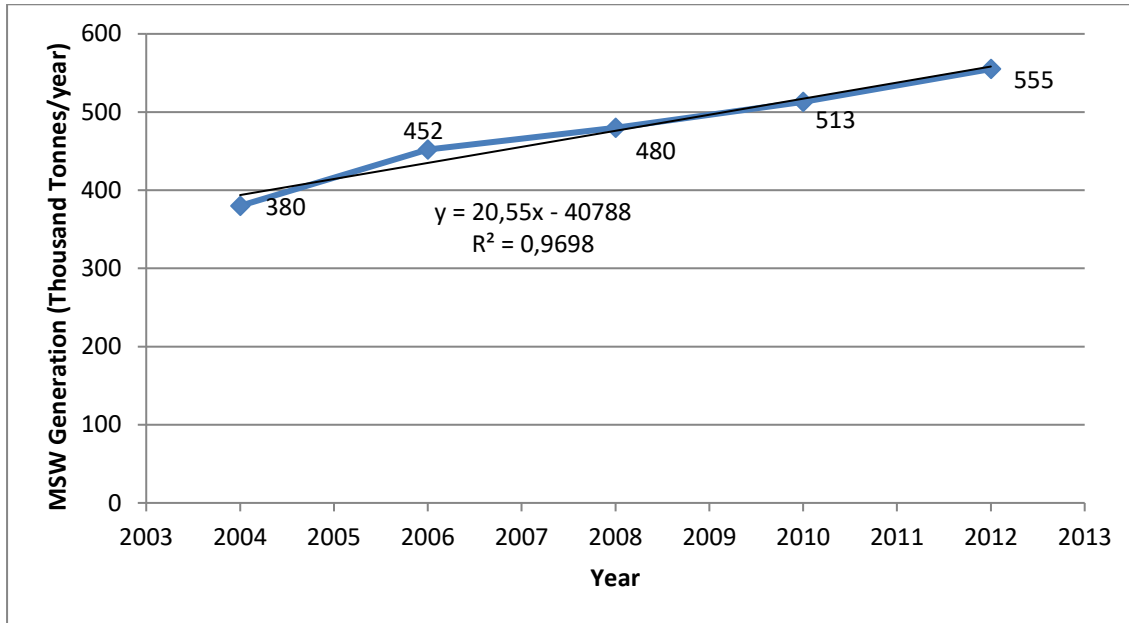


Fig. 3 MSW generation in Kocaeli (Tuik, 2013)

Collected amount of waste in Kocaeli is increasing between years 2004-2012 in Fig. 3. Although MSW generation per capita is fluctuating over years in Fig. 4, general trend of MSW generation per capita is increasing.

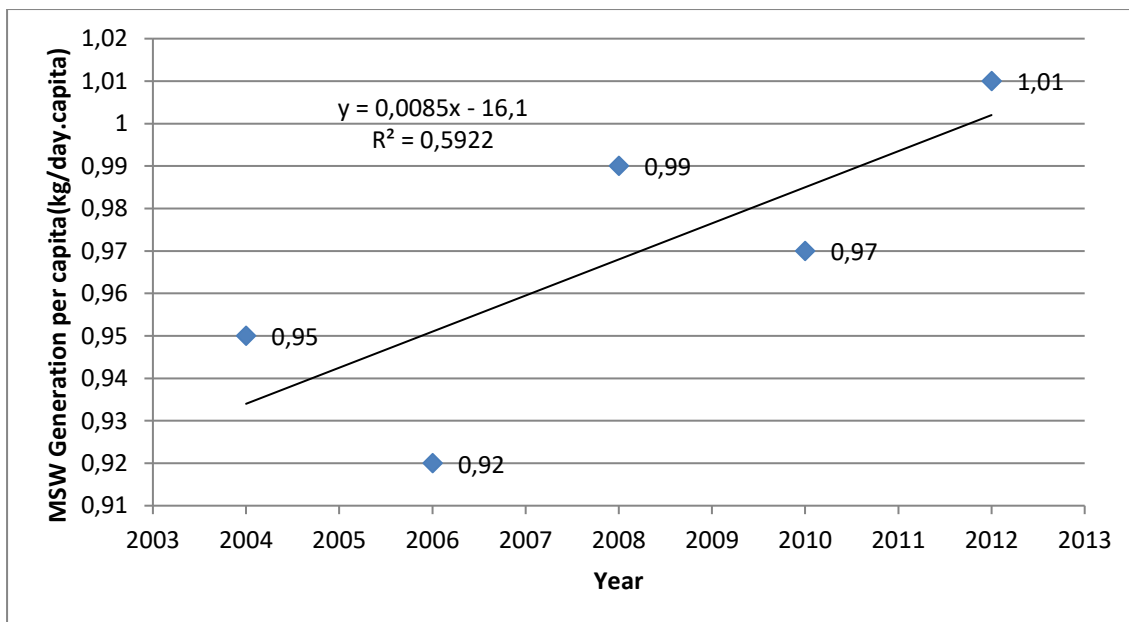


Fig. 4 MSW generation per capita (Tuik, 2013)

The rate of population that gets waste collection service is 100 % in the years 2004, 2006 and 2010 and it is 99 % in the years 2008 and 2012 (Tuik, 2013).

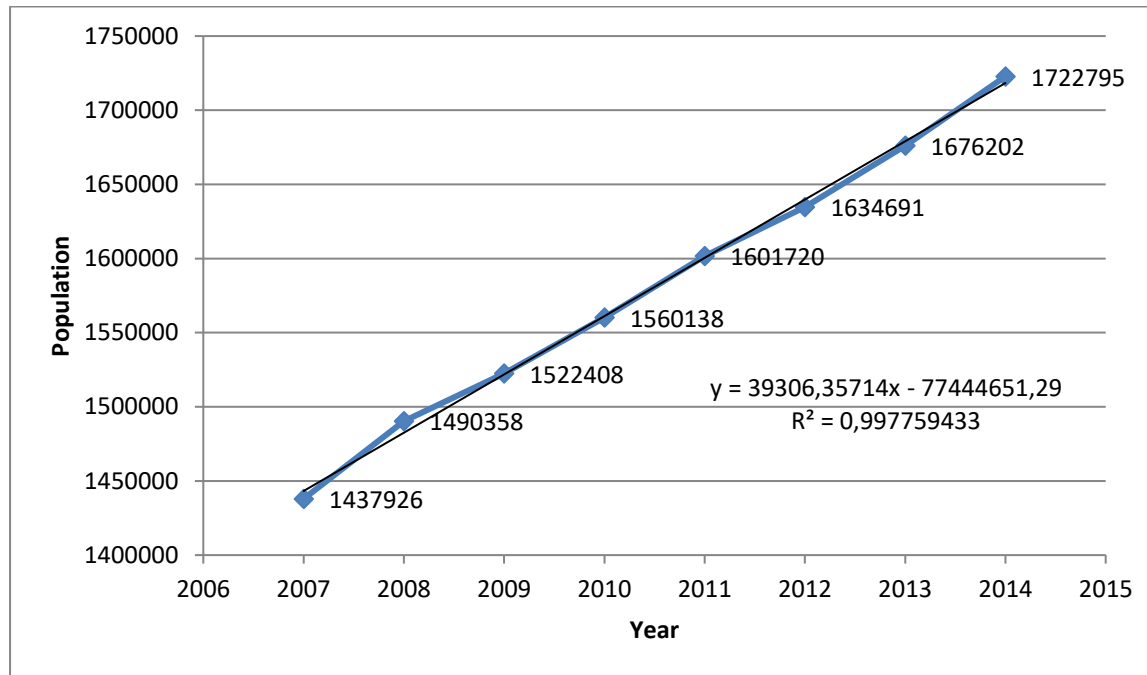


Fig. 5 Population of Kocaeli (URL 4)

It should be taken into account that waste is generated by people and it can be expected that the increase in the population would be resulted with increase in the MSW generation. In Fig. 5 it can be observed that population of the Kocaeli is increasing over years.

3. Results

First degree curves are fitted to the graphs given in Fig. 3, Fig. 4, Fig. 5 which is also summarized in Table 1.

Coefficient of determination (R^2) value is over 0,9 for collected MSW and population curves which can be useable in the projection calculations. It is predicted that MSW generation would be 785 thousand tons in 2023 which indicates a 42 % increase and the population of the Kocaeli would be 2.072.109 that also defines a 20 % increase.

Coefficient of determination (R^2) value of MSW generation per capita is relatively low (0,59) and the projected value for this item is 1,09 kg/capita.day for 2023.

MSW generation per capita.day can be calculated with Equation (1) (Tuik, 2009).

$$MSW_{capita.day} = (MSW_{collected} / (Population \times k_{service}))/365 \quad (1)$$

$MSW_{capita.day}$ is MSW generation per capita.day (kg/capita.day), $MSW_{collected}$ is the MSW collected per year (kg/year), Population (capita) is the population of the city and $k_{service}$ is the rate of population that gets waste collection service which can be assumed as 100 %. With using Equation (1), MSW generation per capita.day for 2023 can be calculated as 1,03 and the difference between the projected values of MSW generation per capita.day is 5 % which indicates that this date can be usable. MSW generation per capita also states that MSW generation is increasing towards 2023.

Table 1. 2023 projections

Projected Item	Fitted Curve	Coefficient of Determination (R^2)	2012 Data	Projected Data for 2023	Increase (%)
Collected MSW (Thousands tonnes/year)	$y = 20,55x - 40788$	0,96	555	785	41
MSW generation (kg/capita.day)	$y = 0,0085x - 16,1$	0,59	1,01	1,09	8
Population (capita)	$y = 39306,35714x - 77444651,29$	0,99	1.722.795	2.072.109	20

4. Discussion

The increased value of collected MSW indicates that OFMSW can be accepted as a sustainable source of biomass for Kocaeli. It is also projected that population of the Kocaeli will increase over time. These projections are made under current legislations. In the recent years, a few countries changed their policies on the waste management and started to reduce the collected amount of MSW (Fischer, 2013 and URL 5).

Despite waste management methods can vary between countries or regions, some of them can be defined as waste hierarchy, extended producer responsibility (EPR) and polluter pays principle. Waste hierarchy which can be seen on Fig. 7 indicates that waste should be treated according to its characteristics. Prevention, reuse and recycle are at the top of the pyramid which indicates these methods should be applied where available (Reddy, 2011).

Extended producer responsibility is widely applied in packaging industry in EU member states (URL 6). Polluter pays principle makes polluter responsible for the impact caused to the environment (Reddy, 2011). South Korea government applied a volume-based waste fee system and they managed to reduce waste generation from 1,33 kg/day.capita in 1994 to 1,03 kg/day.capita in 2009 that indicates a 23% reduction on the generation of MSW (URL 5).

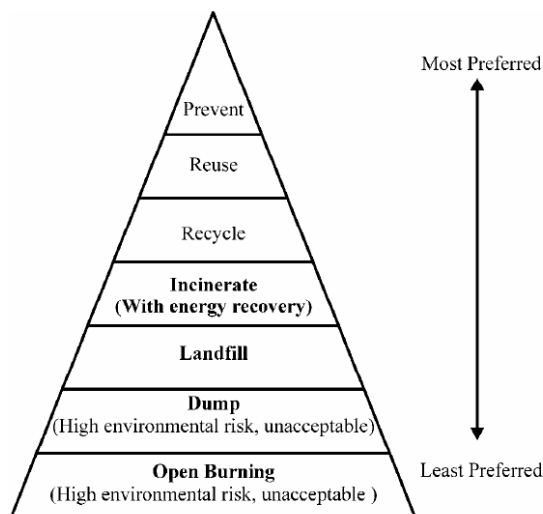


Fig. 7 Waste hierarchies (Reddy, 2011)

If Turkish Government passes a bill that promotes waste reduction like South Korea, MSW generation could be reduced. A 23 % decrease in MSW generation per capita, just like South Korea, would result with 0,83 kg/capita.day and MSW generation would be 628 thousand tons for 2023. In this case, despite the increasing population, MSW generation would only increase 13 % which is below half of the projected data for 2023.

Conclusions

Kocaeli MSW generation projections for 2023 are studied in this work. Data of waste characterization and waste generation that gathered from Turkstat are presented and by using these data waste generation possibilities for 2023 are calculated. Waste reduction policies are also taken into consideration. With these assumptions, 2023 MSW generation projections are 785 thousand tons and for best case scenario 628 thousand tons.

In 2012, 555 thousand tonnes MSW was collected in Kocaeli (Turkstat, 2013). 1500 tonnes /day MSW generation can be used in the calculations. Characterization of the MSW can be found in Fig. 1 and fig. 2 and 41.53 % organic fraction can be assumed (Yenice et. al., 2011). Total solids (TS, % wet weight) and total volatile solids (TVS, TS%) of OFMSW can be assumed between 27-47%, 55-91%, respectively (Bolzonella et. al., 2006). Considering the aforementioned data, it could be assumed that 200 tonTVS/day organic solid waste can be generated in Kocaeli. Bolzonella et al. (2006) stated that with using dry anaerobic digestion a methane generation rate of between 0.13 – 0.4 m³CH₄/kgTVS (m³ methane per kg of Total volatile solid) could be accomplished if the feedstock is selected as organic fraction of municipal solid waste. It is possible to produce of 24000 m³CH₄/day methane in Kocaeli with utilizing OFMSW in 2012. 2023 projection of Methane Generation was calculated as 28500 m³CH₄/day.

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