

Analysis on moisture content of mixed MSW considering distribution characteristic of physical composition

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Abstract:

In South Korea, as energy content in municipal solid waste (MSW) is getting higher, the interest to produce SRF is increased. However, there are some operational problems for MBT facilities because of poor separation efficiency and SRF production. Thus, operational data for physical composition of 40 incineration facilities and moisture content of mixed MSW was evaluated by Monte Carlo simulation in this study. The results of simulation were 19.9~44.4% (31.9% as mean) at 95% confidence level and the result of sensitive analysis was that moisture content in papers was the biggest factor among variables.

Keywords: Moisture content; Physical composition; Municipal solid waste; Goodness of fit; Uncertainty

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1. Introduction

In physical properties of waste, some characteristics are included such as bulk density, particle size and moisture content. Among them, moisture content has a serious impact to waste treatment/disposal facility. In the case of landfill, moisture content can influence to the rates of MSW decomposition related to gas production (Burton et al., 2004). In the case of incineration, MSW that contains too much water makes it difficult to combust in incinerator and recovery thermal energy (Saito et al., 2001). For these reasons, valid estimation of moisture content is important. Nevertheless, variability and uncertainty of moisture content make it difficult to estimate the result.

In South Korea, as diverse policies like volume-rate garbage disposal system and separate collection system of food waste have begun, moisture content in MSW is getting lower and heating value of that becomes higher (Komilis et al., 2014). This becomes the reason that the mechanical-biological treatment (MBT) has been introduced to produce solid recovered fuel (SRF) from MSW. However, there are some operational problems including poor separation efficiency and SRF yield (Lee, 2012). It is regarded that moisture content of MSW is underestimated by insufficient consideration for heterogeneity of waste composition (variability of organic and moisture content) at the design stage of MBT facilities (Jo et al., 2012).

Uncertainty analysis can be used to quantify the uncertainty and variability of moisture content in MSW. Uncertainty means that parameter associated with the result of measurement that characterized the dispersion of the values that could reasonably be attributed to the measured (Woo, 2000). The uncertainty of measured value is evaluated by mathematical model of measurement and the law of propagation of that. For uncertainty analysis, there are many methods such as Delta method, Monte-Carlo simulation, Loop analysis, Interval analysis (Hayes, 2011). Monte Carlo simulation is only adopted tool to estimate global sensitive, variability and uncertainty simultaneously. And it enables to calculate the complex measurement system including components that cannot be analyzed readily by conventional analytical methods (Lorenzo, 2011; Marta, 2001).

In this study, distributions of each physical component of MSW were identified by goodness of fit. The range of moisture content of mixed MSW was evaluated by MCS considering variability and uncertainty.

2. Material and method

2.1 Data source

Operational data including physical composition of incoming MSW into 40 incineration facilities reported every month from 2007 to 2012 and research data for moisture content of each component were applied in this study (Resource recovery facility operation committee, 2007-2012; Bae et al., 2011).

2.2. Goodness of fit

Distributions of each physical composition were fitted using Chi-square which is one of the representative methods that compare the similarity between population and specimen.

2.3. Estimation of moisture content in MSW

Moisture content of mixed MSW was evaluated by using uncertainty which is utilized when true value does not exist or non-representative sample was analyzed. To analyze the uncertainty of moisture content of mixed MSW, MCS was used which is the representative way to analyze uncertainty. The principle of Monte-Carlo simulation was that selected random value for each sensor was combined according to the measurement algorithms. And it was repeated many times (Basil, 1999). In this study, it is performed for 30 times and 1,000,000 runs at each time to reduce the uncertainty and variability of measured value.

2.4. Sensitive analysis

Sensitive analysis was implemented to identify major factors that affect estimating the moisture content of mixed MSW.

3. Result and discussion

3.1. Goodness of fit

The results of fitting distributions of physical composition and moisture content were shown in Table.1. All of physical compositions indicated lognormal distribution that expected value is biased toward one side. These were similar to the result from Nabegu et al. (2013). Moisture contents of each physical component showed normal distribution except plastic which indicated logistic distribution.

Table 1 Fitting distribution result of physical composition and moisture content

Component	Physical composition			Moisture content		
	Mean. \pm S.D. (%)	C.V. (%)	distribution type	Mean. \pm S.D. (%)	C.V. (%)	distribution type
Paper	35.9 \pm 12.1	31.6	Lognormal	31.9 \pm 13.3	41.7	Normal
Textile/Leather	7.6 \pm 4.0	53.2	Lognormal	24.7 \pm 10.4	42.3	Normal
Food	15.5 \pm 8.7	56.3	Lognormal	71.5 \pm 9.9	13.9	Normal
Plastic	25.6 \pm 7.1	27.7	Lognormal	18.2 \pm 9.9	54.5	logistic
Misc. organics	8.2 \pm 6.9	84.8	Lognormal	41.8 \pm 14.3	34.3	Normal
Wood	8.1 \pm 6.6	80.8	Lognormal	27.8 \pm 9.0	32.3	Normal
Inert	7.2 \pm 3.8	52.9	Lognormal	N/A	N/A	N/A

S.D.: standard deviation; C.V.: coefficient of variation

3.2. Moisture content of mixed MSW

Moisture contents of mixed MSW were shown in Fig. 1 and Table 2. At 95% confidence interval, range of those was from 19.9% to 44.4% (Mean 31.9%) with 19.5% of standard uncertainty. Because of the characteristics that were always changed, repetitive times of simulation have to be performed to reduce the variability of measured value and to search the convergence band (Ata, 2007). As shown in Table 3, there was no difference between the values of estimated result. From

this one, estimated values were valid as representative value. It is regarded that the C.V of each value were 0.1% below.

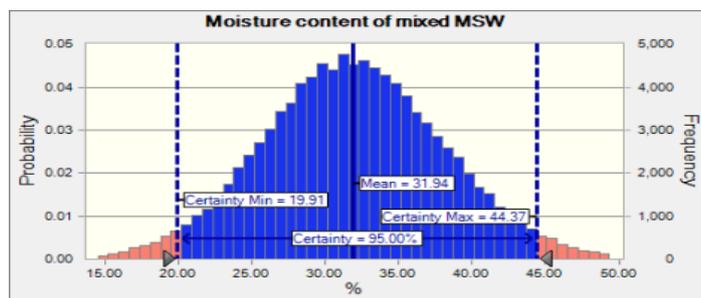


Fig. 1 Distribution of moisture contents of mixed MSW

Table 2 Result of MCS

	Value
Mean	31.9
Standard deviation	6.2
standard uncertainty	19.5
Max	44.4
Min	19.9

MCS : Monte Carlo simulation

Table 3 Variability of moisture contents of mixed MSW

	Mean	Max	Min
Mean ¹	31.96	44.41	19.96
Max ²	31.97	44.44	20.01
Min ³	31.94	44.37	19.91
Standard deviation	0.01	0.02	0.02
Coefficient of variation	0.02	0.05	0.10

Mean : mean of value for 30 runs , ² Max : maximum of value for 30 runs, ³ Min : minimum of value for 30 runs

3.3. Result of sensitivity analysis

From sensitivity analysis (Table 4), moisture content of paper (51.9%) was the most influential factor determining moisture content of mixed MSW, followed by physical composition of food (27.7%) and moisture content of food (5.6%).

Table 4 Result of sensitive analysis for moisture content of mixed MSW

Component	Sensitivity (%)	Component	Sensitivity (%)
Physical composition of paper	0.0	Moisture content of paper	51.9
Physical composition of textile	-0.2	Moisture content of textile	1.6
Physical composition of plastics	-2.3	Moisture content of plastics	1.7
Physical composition of food	27.7	Moisture content of food	5.6
Physical composition of wood	-0.1	Moisture content of wood	1.3
Physical composition of misc. organics	0.9	Moisture content of misc. organics	3.3
Physical composition of inert	-3.4	Moisture content of inert	0.0

Silvennoinen et al (2013) (silvennoinen, 2013) reported that hygroscopic material such as paper and wood has the ability to soak up humidity from air to its molecules. Bartlett (1983) also reported that the density of paper was increased by adding moisture content contrary to aluminum and plastics. It is regarded that paper made in pulp absorbed a lot of moisture in food. In contrast, physical compositions of inert and plastic were negative factor for determining moisture content of mixed MSW.

4. Conclusion

For MBT facilities, high moisture content of MSW can result in operational problems involving poor separation efficiency and SRF yield. In this study, moisture content of MSW were evaluated by MCS using operational data of 40 incinerations and research data for physical composition and its moisture content. It could be concluded that moisture content of mixed MSW was variable with range of 19.9~44.4% and 19.5% of standard uncertainty at 95% confidence interval. It means that moisture content of mixed MSW could be existed on the wide range. To confirm the valid result,

repetitive run was performed. It was identified that estimated moisture content of mixed MSW was reasonable because C.V value of the result were 0.1% below. Furthermore it was confirmed that moisture content of paper and physical composition of food influenced significantly determination of moisture content of mixed MSW. For these reasons, high variability of moisture content of mixed MSW should be considered and physical composition of paper need to be carefully considered at the design stage of facility.

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6. Reference

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