Characterization of organic matter in municipal solid waste incineration residues from a landfill site

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1. Introduction

Incineration can reduce the volume and mass of municipal solid waste to a fraction of its original size (generally, 85–90% by volume). However, during the incineration process, the organic components can`t be completely mineralized and some may remain in the bottom ash.

During the landfill process of the municipal solid waste incineration (MSWI) residues, degradable organic matter is gone with time, and most of the remaining organic matter exists in the form of humic substances (HS), which are very stable and thereby degradable only in long term. It has been known that humic substances have a large influence on the leachability of heavy metals and dioxins[1,2], which are very harmful to the environment and human being.

In this study, to identify the transformation of organic matter in MSWI residues, HS were extracted from MSWI residues and characterization of HS was conducted. JLT 46 leaching test was performed to analysis the characters of the disposed MSWI residues in different landfill depth.

2. Materials and methods

2.1. Sampling

The bottom ash (BA) samples were taken from a MSW incinerator in Japan collected after a water quench tank. Boring samples were taken from the landfill site affixed to the incineration plant and named 0-1m, 1-2m, 2-3m, 3-4m, 4-5m corresponding the landfill depth. There were two layers in the landfill site. The samples in the upper layer from 0 to 3 meters are about 3 years old and the samples in the lower layer from 3 to 5 meters are about 9 years old. The coarse particles, larger than about 50 mm in diameter, were removed from the samples by hand to homogenize them. The samples were air dried after brought to the laboratory.

2.2 Extraction of humic substances

Extraction of HS from the MSWI residues was performed by acid-base treatment method[3].

Step 1. The sample (100 g) screened by 2.0 mm sieve was dissolved in 1 M HCl, when pH is between 1 and 2. Then shake the suspension for 1 hour and then separate the supernatant 1 from the suspension by centrifugation at low speed.

Step 2. 1 M NaOH solution was added to the No.1 residue, when pH was back to 7. Continue to add about 0.1 M NaOH solution and pH is 13. Then shaked for 4 h and settled down for 12 h. Again, separate the supernatant from the suspension by centrifugation. The separated supernatant was assumed as No.2 one. The residue is again acidified down to pH 1 with 6 M HCl. The humic acid (precipitation) was separated with fulvic acid (supernatant 2) fractions by centrifugation. The humic acid (HA) was then redissolved with 0.1 M NaOH.

Step 3. No.1 supernatant and No.2 supernatant were introduced into a column containing XAD 8 resin. The solution collected at the bottom of the column represented the nonhumified fraction (NHF). The elution with 0.1M NaOH of the column made it possible to obtain the fulvic acid solution.

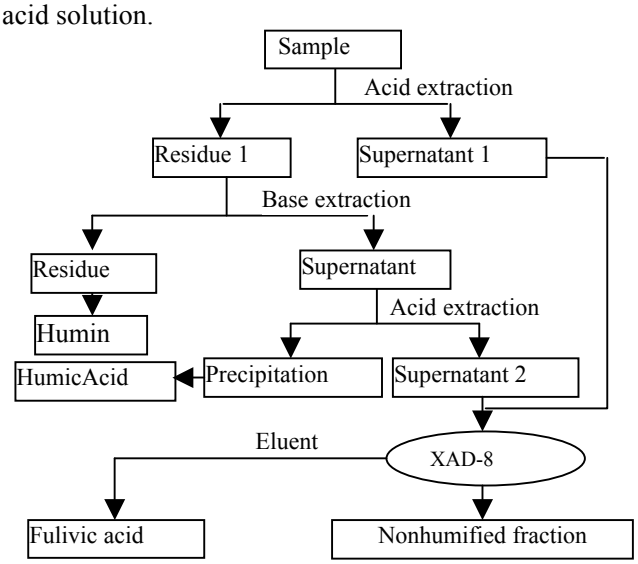

Fig. 1. Schematic diagram of extraction HS procedure

2.3 Characterization of the materials

Water content and loss on ignition of MSWI residues were measured. By JLT46 (Japan Leaching Test No. 46), MSWI residues were conducted in L/S ratio 10 ($g \cdot g^{-1}$) and stirring at 200 rmp for 6 h. The supernatant was used for analysis of TOC using a Shimadza ASI-V total carbon analyzer. The results were listed in Table 1. The supernatant also used for measurement of pH values and oxidation-reduction potential (ORP).

Table 1 The basic characters of MSWI residues

Sample	Age (years)	W.C. (%)	LOI (%)	TOC (mg/kg)
BA	0	17.10	6.48	564.30
0-1m	3	27.08	8.56	216.61
1-2m	3	25.46	9.79	179.25
2-3m	3	30.57	9.06	197.8
3-4m	9	30.29	11.34	78.47
4-5m	9	23.13	7.03	50.66

2.4. UV spectroscopy

Ultraviolet (UV) absorbance was measured with a Shimadzu UV-1230 spectrometer at 260nm using a quartz cell with 1 cm path length. Milli-Q water was used as a blank sample.

3. Results and discussion

3.1 leaching test results

TOC of JLT46 leaching solution decreased with the samples landfill depth increasing (Table 1). It meant dissolved organic matter in water becomes less and less with increasing the age of landfill MSWI residues. ORP is a property describing the redox condition of the solution, which was determined with a platinum electrode and calculated to standard electrode potential (Eh) according to the formula: Eh=ORP+210(mV). The Eh of JLT46 leaching solution was plotted versus pH in Fig. 2. For MSWI residues, with the landfill depth increasing, Eh became higher. This was a result of degradation of organic matter and generation of acid matter.

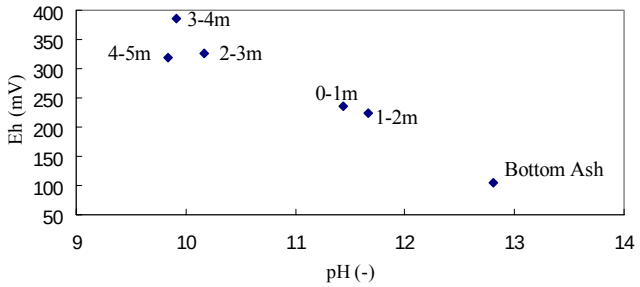

Fig. 2. Eh vs pH for landfilled MSWI residues

3.2 HS and NHF distribution in MSWI residues

The TOC of HA, FA and NHF from the humic substances extraction process was measured and showed in Fig. 3.

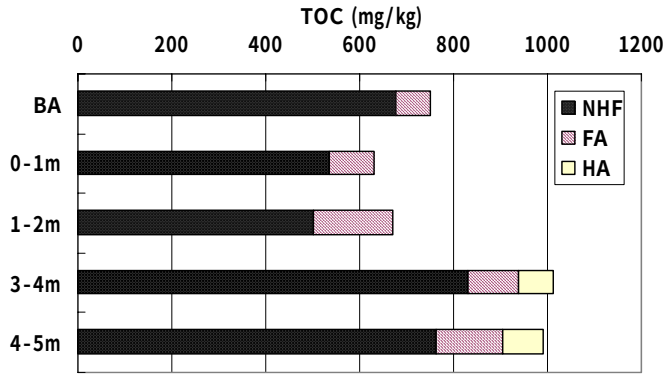

Fig. 3. Dissolved organic matter (DOM) fraction of MSWI residues sample from the landfill site. NHF, nonhumified fraction; FA, Fulvic acid; HA, humic acid.

The sum TOC of sample 0-1m and 1-2m in the upper layer is the lowest, while the TOC of sample 3-4m and 4-5m in the lower layer is highest, which is inverse with the TOC in distilled water (Table 1). There is no humic acid in bottom ash and in the upper layer samples, only existing in the lower layer samples. The humic substances content of MSWI residues increases with landfill depth i.e. age.

This indicates that 1) Dissolved Organic matter will move downwards in the landfill with rainwater and 2) Organic matter can`t be mineralized in a short time, most of them are evolved into more stable organic matter, such as hunmic substances[2)].

3.3 UV absorbance to TOC ration of HS

Fig. 4 indicates the UV/TOC ratio of fulvic acid and humic acid. UV/TOC of HA and FA, exhibited a distinctive pattern depending on the landfill ages. Generally, UV/TOC shows a high value in advanced humus. The bottom ash and upper layer samples have lower value of UV/TOC, which indicated that UV/TOC could be used to judge the humification degree of landfilled MSWI residues.

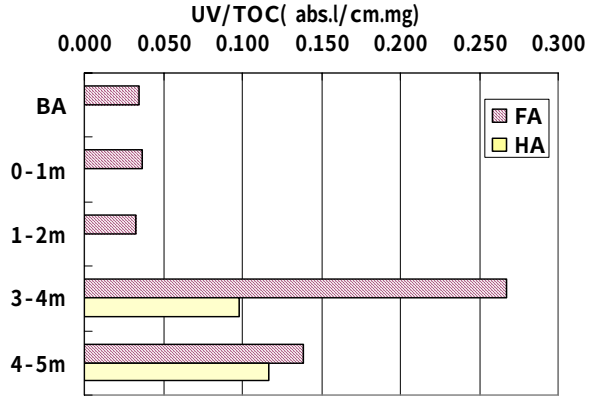

Fig. 4. UV/TOC ratios of humic acid and Fulvic acid

4. Conclusion

Organic matter in landfill site could`t be mineralized in a short time, most of them only evolved into refractory organic acids such as humic substances because of degradation of organic matter resulting in pH value decrease and Eh increase. The results of extraction and investigation on humic substances showed that more and advanced humic substances were generated with the landfilled age increasing, and UV/DOC ratio can be used to estimate the humification of MSWI residues. It was suggested that organic matter moved downwards with rainwater.

References

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