Proximate and Chemical analysis of Segregated Municipal Solid Waste

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1. Introduction

Management of solid urban waste is evolving in parallel with municipal and industrial expansions. Recently, more efforts are driven toward reducing the amount and volume of municipal solid waste (MSW) being disposed of on landfills via some treatments and processing of these wastes. However, it was reported that waste treatment and landfilling result in emissions of greenhouse gases (GHGs) such as carbon-dioxide and methane, which contribute to global climate change as shown in Figure 1. According to UNEP 2004, the most significant GHG gas produced from waste is methane, which is released during the degradation of organic matter in landfills as illustrated in Figure 2. Hence, this study investigated the chemical composition of some segregated wastes from Japan and possible trace elements in these waste materials. The proximate analysis including moisture content and volatile matter by percent weight were evaluated while the chemical analysis of these wastes was examined using the ion chromatography. In addition, for the chemical analysis, water chemistry of ignited segregated wastes at 550ºc was estimated.

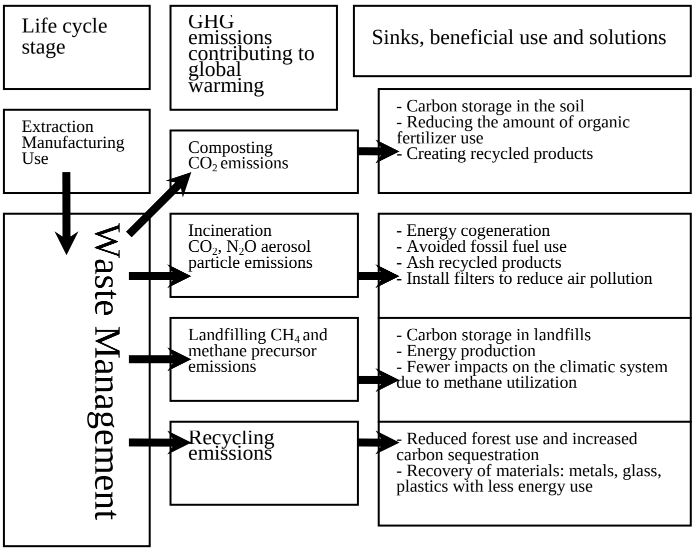

Figure 1: Contribution from waste to climate change
Source: UNEP 2004

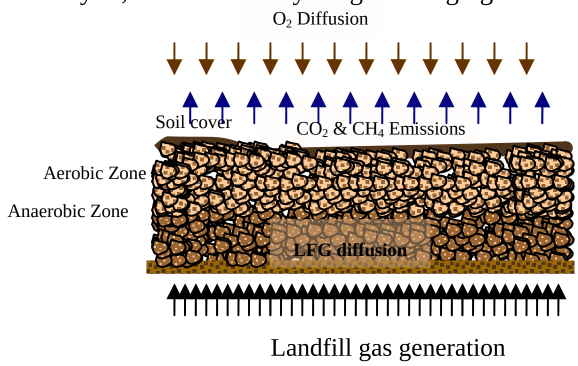

Figure 2: Schematic mechanism of MSW degradation within a soil cover

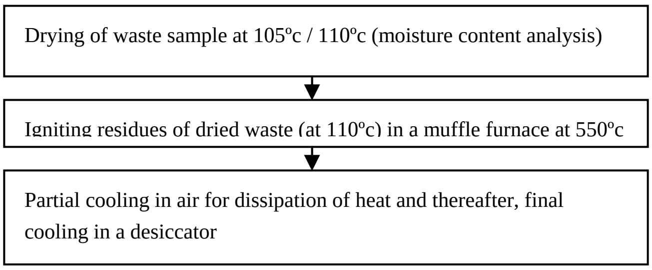

Figure 3: Flow diagram of experimental procedure for estimation of volatile matter/solids

2. Experimental methods

2.1 Materials

In this study, municipal solid waste (MSW) of residential and institutional origin from Japan were segregated at the point of collection into three main categories namely paper products, plastics and organic. The paper products include newsprints, magazines, printed and non-printed papers, and carton packages. Polyethylene terephthalate (PET) and fruit waste were considered under the waste category of plastic and organic respectively.

2.2 Proximate analysis

Proximate analysis includes moisture content by percent weight, volatile matter, fixed carbon and non-combustible in an open crucible. This study estimated both moisture content and volatile matter by percent weight using the American Public Health Association (APHA) standard methods for the examination of water and wastewater, a joint publication by the American Water Works Association (AWWA) and Water Environment Federation (WEF). The APHA promotes public health.

2.2.1 Moisture content

The moisture content of segregated MSW from Japan including paper products, plastics (PET) and organic (fruit waste) were expressed as a percentage of the wet weight of the waste materials. Initial weight of each waste sample was measured, and dried separately at a temperature of 110ºc (Japanese oven's temperature timing) in a drying oven for 18 h. The dried waste sample was allowed to cool in the desiccator after which final measurement was taken.

2.2.2 Volatile matter

Residues of segregated wastes (from Japan) produced from the analysis of moisture content were weighed and ignited

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in a muffle furnace to constant weight at a temperature of 550^{o}C for about 40mins. The dish containing the samples was allowed to cool partially in air until most of the heat has been dissipated and was later transferred to a desiccator for final cooling. Figure 3 illustrates the flow diagram of experimental procedure for the estimation of volatile matter. After then, the samples were weighed to determine the dry weight of ash and volatile solids were calculated from equation 1:

$$\text{VS} = \frac{d - A_w}{d} 100 \qquad (1)$$

where VS = volatile solids/matter (%), d = dry weight of sample (kg), A_w = weight of ash (kg)

Figure 4: Ash obtained from ignition of newsprint

2.3 Chemical analysis

Water chemistry of ignited segregated wastes (from Japan) at 550ºc (ash) was analyzed using the Japanese leaching test method (JLT-46). Ash shown in Figure 4, obtained from newsprints, magazines, printed and non-printed papers, carton packages and fruit waste were each placed in separate graduated flasks and mixed with distilled water of about 500mL. Each flask was set on a double shaker NR-150 apparatus and number of rotations was set to 200rpm while breadth of shaking was kept at 50mm for 6 h. After 6 h of shaking, centrifugal separation was carried out for 20mins at 3000rpm. Thereafter, clear liquid was filtered with 0.45µm membrane filter. Furthermore, the resulting solution was analyzed using ion chromatography.

3. Results and discussion

In Table 1, moisture contents of each segregated waste category tested at different times varied simply due to changes in relative humidity. Moreover, loss of organic matter by volatilization was very minimal due to the marginal temperature at which absorbed water was removed. Organic (fruit waste) had the highest moisture content of 76% followed by newsprint and carton packages with 6.4 and 6.1%, while plastic (PET) had the lowest moisture content of 1.5%. In addition, volatile matter by percent weight remained approximately constant when tested at diverse times with plastic (PET) having the highest volatile matter of 100% followed by non-printed and printed papers with 94.3 and 93.6% respectively, whereas magazine had the lowest volatile matter of 70.6%. Besides, the weight loss on ignition, called the volatile solids/matter was not confined to organic matter but also included losses due to decomposition or volatilization of some mineral salts.

Table 1: Proximate analysis of segregated waste samples

Segregated waste category (from Japan)	Moisture content at 110^{o}C (%)			Volatile matter at 550^{o}C (%)		
	Sample 1	Sample 2	Average	Sample 1	Sample 2	Average
Paper products Newsprint	7.8	4.9	6.4	86.9	89.6	88.3
Magazine	4.3	3.0	3.7	70.2	70.9	70.6
Printed papers	7.2	4.6	5.9	93.7	93.5	93.6
Non-printed papers	6.2	5.0	5.6	94.1	94.5	94.3
Carton packages	6.7	5.5	6.1	88.3	88.0	88.2
Plastics (PET)	2.6	0.4	1.5	100.0	100.0	100.0
Organic (fruit waste)	78.0	74.0	76.0	96.0	96.5	96.3

Table 2 shows the chemical analysis of cations in the segregated wastes from Japan ignited at 550ºc. Organic (fruit waste) had the highest value of potassium, K, and magnesium, Mg of 126.6 and 14.9 mg/L respectively. White printed paper had the highest value of 3.8mg/L sodium, Na, while brown printed paper had both the lowest potassium and calcium, Ca, of 2.0 and 26.2mg/L respectively. Moreover, magazine had the highest calcium value of 75.5mg/L with newsprint having the lowest value of magnesium of 0.8mg/L whereas, ammonium, NH_4, was scarcely present in the waste materials.

Table 2: Chemical analysis of cations in segregated waste materials

Segregated waste category (from Japan)	Na (mg/L)	NH_4 (mg/L)	K (mg/L)	Mg (mg/L)	Ca (mg/L)
Brown non-printed paper	0.8	0.1	2.3	1.2	36.0
White non-printed paper	0.7	0.1	2.9	1.3	35.0
Brown printed paper	0.4	0.1	2.0	1.9	26.2
White printed paper	3.8	0.0	2.5	1.0	32.3
Carton packages	1.7	0.1	2.7	1.7	61.9
Magazine	0.4	0.1	2.8	1.2	75.5
Newsprint	0.6	0.0	2.7	0.8	27.3
Organic (Fruit waste)	2.9	0.0	126.6	14.9	52.5

4. Conclusion

The chemical composition of some segregated wastes from Japan including trace elements in these waste materials were investigated considering the water chemistry analysis of these wastes. It was observed that volatile solids/matter was not confined to organic matter but also included losses due to decomposition or volatilization of some mineral salts. Furthermore, the cations in the segregated municipal solid waste materials may represent few possible trace elements in a typical landfill leachate composition if these wastes were disposed of in un-segregated manner.

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