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Determination of oxygen consumption rate for variety of waste and its correlation with waste characteristics

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1. INTRODUCTION

Since many decades, Japan opted for the incineration technique as main option for managing the huge waste generated. However the amount of the dumped waste still remains an enormous "problem" considering the availability of landfill sites (e.g. in 1997, 45 million tons were generated, 78% of it was incinerated, and the total amount landfilled waste was about 12 million tons (Japan Solid Waste 2000)). Waste substances that are disposed at landfill sites consist mainly of incombustibles and incineration residue.

Due to the hopeless gain from anaerobic gas production and the early stabilization under aerobic conditions, The application of Semi-aerobic landfill site showed to be effective for the Japanese conditions (Hanashima, 2000).

The aim of this study is to give efficient design and allocation of gas collection pipe to promote stabilization of waste in Semi-aerobic landfill sites.

Oxygen consumption rate and air permeability/diffusion are the major parameters for the design.

For the current work we try to find out the oxygen consumption rate for different kind of waste basing on various analysis and correlation between the tests results.

2. METHODOLOGY

Series of experiments were carried out on solid waste brought form different processing facilities in Sapporo City. Samples consist of shredded bulky waste, non-combustible waste, and incineration residue ash.

A rough description is shown in Table 1.

Due to the enormous heterogeneity of the samples (especially for the shredded bulky waste and the non-combustible waste), three sub-samples of each sample were analyzed.

Table 1. Analyzed material

Sample	Description
A	From "H" shredding facility, consists of incombustible residue of shredded bulky waste
B	From "H" incineration facility, consists of incineration ash residue
C	From "S"] shredding facility, consists of incombustible residue material
D	From "I" shredding facility, consists of incombustible residue material

2.1. Tests and parameters

The different parameters were selected for characterizing the waste samples according to the object of the work and based on the literature.

2.1.1. Eluateparameters

Consist of the TOC, COD (Chrome oxidation), BOD_7 and the UV absorbency at 260nm (E-260). Tests were carried out with leached sample in distilled water.

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2.1.2. Putrescible matter (Pm)

It consists of hydrolysis in NaOH (1%) under 100 degree. TOC of the soluble fraction correspond to the putrescible matter (Kim, et al., 1995). It has been reported by Bowen, et al. (1968), that Pm test seeks to identify a part of the organics, especially the fermentable fraction.

2.1.3. Ignition Loss (IL)

Determined after igniting the sample at 600 ° C in a muffle furnace for 3 hours.

2.1.4. Fermentable volatile solids (Vsf)

The Fermentable Volatile Solids represent the amount of organic matter available for microbial degradation in a short period. It is based on extraction by means of ethanol and Chloridric acid. From an analytical point of view, the Vsf are defined as the part of volatile solids soluble in ethanol and in concentrated Chloridric acid in Soxlet apparatus (method setup by Adani, 1998).

2.1.5. Respiratory activity (RI)

Assesses the microbial activity of the sample, i.e. its momentary oxygen (O_2) consumption under aerobic condition ([mg O_2/gTS]). The oxygen consumption could also be represented as respiratory intensity [mg O_2/gTS*h] (Heyer, et al.1997).

Test method: Oxygen consumption was determined by measuring the change of O_2 concentrations in the headspace of sealed 1000 ml flasks containing 20 ~ 40 g of wet sample and connected to a manometric apparatus under a constant temperature of 30 ° C.

The flasks were flushed with a pumped atmosphere air for about 2 minutes to obtain fixed O_2 concentration (~21 %). A solution of sodium hydroxide is put in the flasks to absorb the CO_2 produced by sample's respiration. Gas samples were taken from the flask and analyzed with a GC-TCD (Shimadzu) to determine the change in the air fraction concentration inside the bottles. The flasks are flushed regularly to avoid any risk of being under oxygen limiting condition.

2.1.6 Physical fraction analysis

Consist of sieving about 700 g of dried sample with 2mm and 5.6mm sieves. The fraction above 5.6mm is separated manually into different categories of materials, when the fraction under 5.6mm is characterized using the procedure developed by Sekito, et al. (1997).

3. RESULTS AND DISCUSSION

The different analysis results are listed in the Table. 2

The Respiration Index is presented for 7 days (RI_7), 10days (RI_{10}) and for the maximum daily consumption registered (RI_{max}) and referred to Total Solids. The BOD is reported for the BOD_7

Table 2. Results for tested material

Parameters	Sample A	Sample B	Sample C	Sample D
COD_{Cr} (mgO_2/gTS)	7.17	3.91	6.17	4.22
BOD_7(mgO_2/gTS)	2.35	1.19	2.73	1.5
TOC (mg/gTS)	3.14	2.63	3.08	1.86
Pm (mg/gTS)	61.65	42.7	52.83	50.1
E-260	3.09	0.99	2.86	0.85
I.L (mg/gTS)	686	88.5	324	51
Vsf (mg/gTS)	169.49	37.42	10.2	2.86
BOD/COD	0.33	0.30	0.44	0.36
RI_7 (mgO_2/g TS 168h)	15.1	1.3	8.7	1.3
RI_{10} (mgO_2/g TS 240h)	21.6	1.6	11	2.1
R_{max} (mgO_2/g TS day)	4	0.22	2.5	0.36

The respiration activity tests were done for different levels of moisture content, but only data for the moisture corresponding to the Field Capacity® of the samples are shown (Figure 1 and 2).

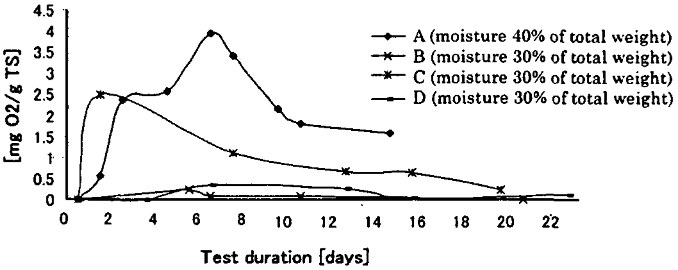

Figure 1. Daily Oxygen consumption for different tested materials

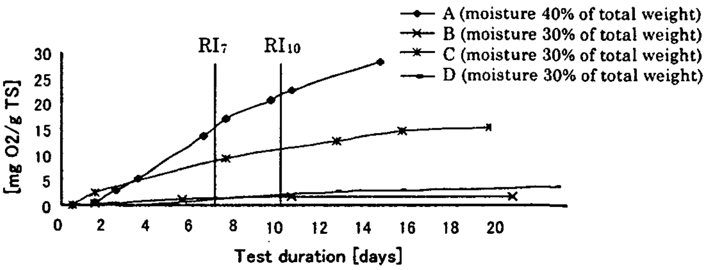

Figure 2. Respiration activity for different tested materials

The tests showed low oxygen consumption. These results were expected regarding the physical composition of the samples (Figure 3). Samples C and D are both classified as incombustible waste, but they showed different RI. These results are explained by the difference of the organic component, indicated by TOC and BOD values.

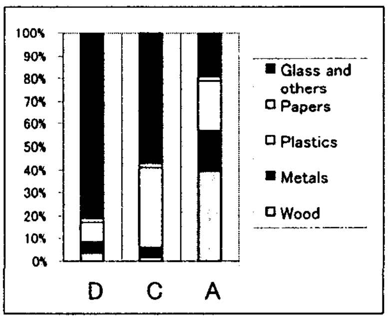

Figure 3. Physical fraction analysis

® Data for the Field Capacity determination not shown

In the Table 3, respiration activity values from the literature are illustrated. RI for Sample A and C are comparable with value for old landfilled waste.

Table 3. RI values for different kind of waste (from literature)

Sample characteristics	Respiration Index
28 years old landfilled waste (Heyer, et al., 1997)	RI_4 : 7.1 mg O_2/ gTS*96h
Composted organic waste (treatment duration 3 months) (Cossu, et al., 1999)	RI_7 : 67.3 mg O_2/ gTS*168h
Mechanical Biological Pretreated wastes (treatment duration 3 weeks) (Binner, et al.,1999)	RI_7 : 73 mg O_2/ gTS*168h

Correlation for respiration activity with different parameters revealed some interesting result. The correlation between the respiration activity and COD_{cr} (Figure 4) and respiration activity and IL (Figure 5) show high value for the correlation coefficient R^2 (0.9518 and 0.9917, respectively).

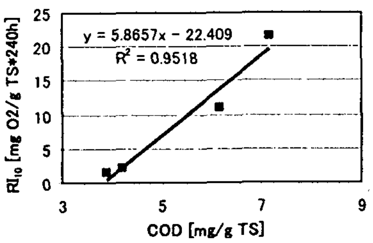

Figure 4. Correlation between RI_{10} and COD

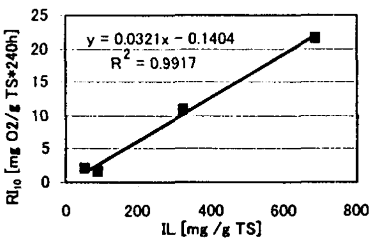

Figure 5. Correlation between RI_{10} and IL

Lower value (but still interesting) for R^2 of the respiration activity correlated with E-260 (Figure 6) and Pm (Figure 7), respectively.

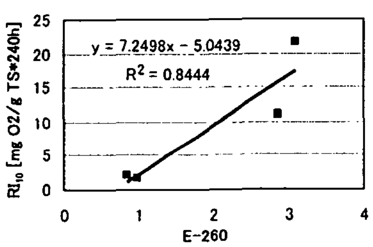

Figure 6. Correlation between RI_{10} and E-260

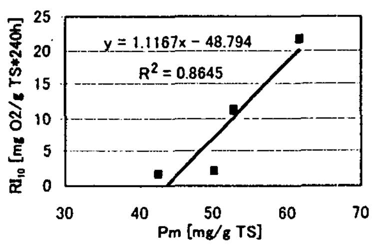

Figure 7. Correlation between RI_{10} and Pm

Adani, et al. (1998) and Cossu, et al. (1999) showed an eventual correlation between the Vsf and the Respiration index whereas the current Vsf tests didn't show any interesting result. In fact the values are very low, thus they are extremely sensitive to the sampling heterogeneity and manipulation errors. This parameter is not suitable for characterizing Japanese landfilled wastes.

4. CONCLUSION AND PERSPECTIVES

Waste destined to disposal in landfill showed a low oxygen consumption rate.
There is a very high correlation for RI correlating to IL and RI correlating to COD.

The venting pipes are supposed to be planted after the closure of the site, assuring first the release of the gases generated during the anaerobic phase, and then the aeration of the site. Results for the oxygen consumption rate in this study will be used in a further step for simulating the oxygen flow rate, and estimating the radius of influence of pipes for the oxygen supply, yet much more data (i.e. old landfilled wastes and mixture of samples) are needed for an accurate assumption.

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