Sustainable landfilling and mechanical biological treatment of MSW: a Japanese view

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Abstract

Landfills generate methane gas contributing global warming and infiltrated water passing through unstabilized waste results in polluted leachate generation which requires treatment. MBT processes do not produce final storage quality end-products. Therefore, MBT wastes should be landfilled and emissions should be monitored and controlled for decades or more. Nevertheless, MBT processing does not eliminate the necessity of in-situ technologies for acceleration of waste stabilization. More research for developing better landfilling technologies achieving faster stabilization of MSW or MBT wastes, in different regions of the world, is necessary. According to our findings with Japanese landfills, MBT landfills should be designed and operated as aerobic landfill bioreactors for at least a few years until the oxygen demand of the waste can be supplied by natural air diffusion into the waste mass.

Keywords

Sustainable landfill, pretreatment, landfill bioreactor, final storage quality, post-closure care

1 Introduction

Landfills generate methane gas contributing global warming and infiltrated water passing through unstabilized waste results in polluted leachate generation which requires treatment. Leachate treatment is quite costly and prediction of time period that it should be continued is difficult. Every extended year will increase the cost. On the other hand, liner facilities have a limited service life which can be maximum between 30 to 50 years, meaning that liners will deteriorate before the waste gets fully stabilized (Figure 1). Japanese legislation requires 2 year continued compliance with gas, leachate, temperature and settlement criteria for abandoning landfills, regardless the time passed after the closure. Moreover, many landfills have difficulties for meeting the current criteria of terminating the post-closure care. Some landfills, on the other hand, have stricter discharge limits than those set by the current regulation for treated leachate, as a result of agreement with local residents. This makes termination of post-closure care more difficult, if not impossible. Therefore, acceleration of stabilization is necessary for reducing the leachate treatment cost, shortening the post-closure care, elimination of long-term risk and for early after-use of the land.

Incineration and composting (MBT) are not alternatives but pre-cursors that remove some of the polluting components of the crude wastes. The residues still have to be landfilled. It is clear from the considerations above that in all three cases the polluting potential of the residues remain high, and none can be considered as being Final Storage Quality materials. The consequence of this is that landfills receiving these wastes should be designed and operated so the FSQ is reached within the landfill. In all three cases this will involve flushing with large volumes of water. In the case of MBT residues it will also mean managing the final part of the degradable organic content (KNOX, 2000). Precipitation in Japan is very high resulting in flushing (moderate) compared to landfills in other countries. However, flushing or washing waste before landfilling will not completely remove the pollutants (washing only does not produce FSQ, too).

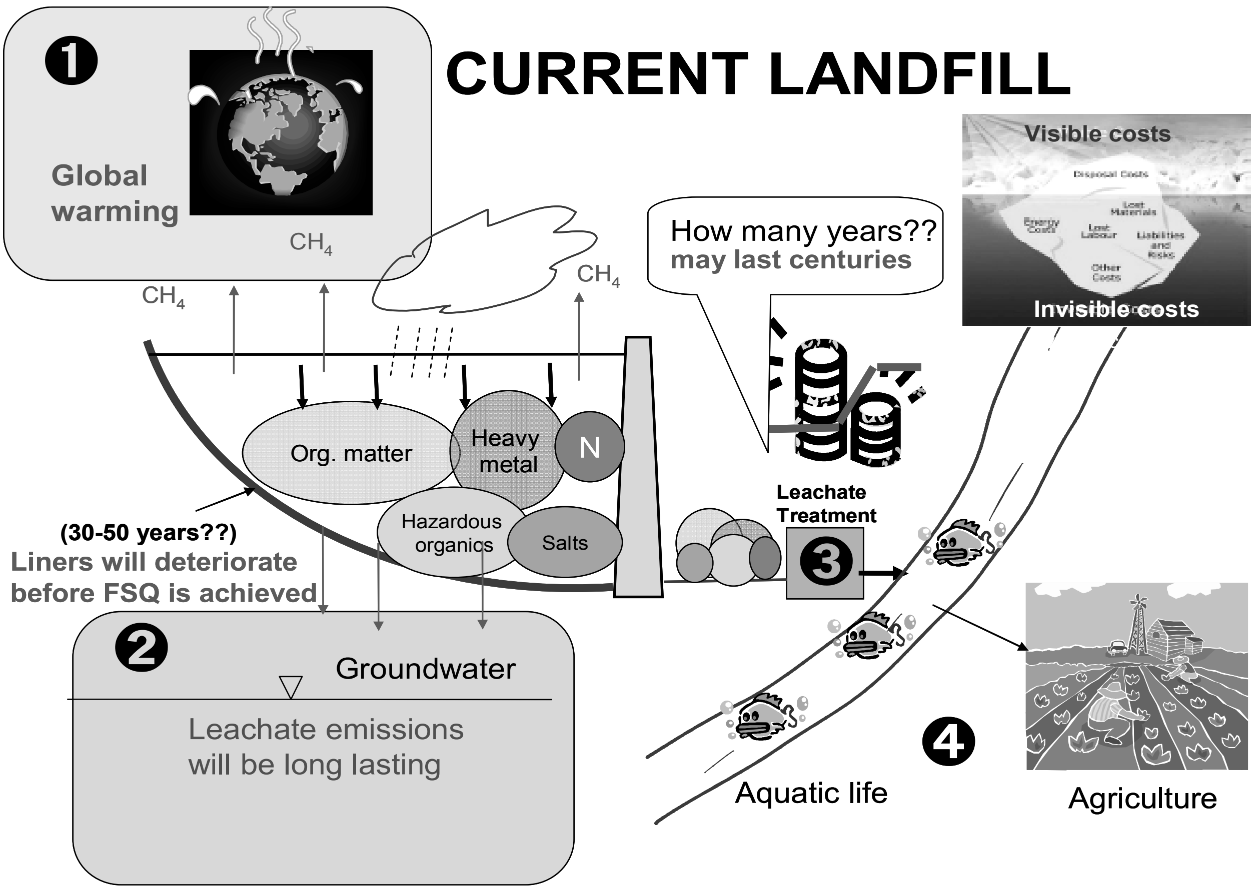

Figure 1 Risks and problems of the current landfills

2 Japanese waste management

In Japan, source separation of MSW is well practiced and organic rich kitchen waste is almost completely incinerated. Recyclable materials are also separated at houses and processed in recycling facilities. After recovery of valuable fractions, residues from collected recyclables are shredded and disposed at landfills. Types of current Japanese landfills are shown in Figure 2. These residues usually contain plastics, metals, wood, paper, glass etc. Although these residues have significantly lower organic content compared to MSW or conventional MBT waste, leachate emissions from the landfills require extensive treatment due to discharge limits usually set by mutual agreement with local residents and much stricter than state limits. Therefore, we have been conducting aerobic landfill bioreactor technology for Japanese landfills receiving significant amounts of shredded residues. Our results indicate great reduction of leachate emissions with aerobic bioreactor operation.

In most part of the world, waste separation at source is still not sufficient resulting in significant amounts of recylables and combustibles disposed at landfills together with organic rich kitchen waste. Mechanical step of MBT which separates and divert several recyclable wastes from landfilling is a significant contribution to sustainable landfilling. Residual organic rich fraction is biologically treated to reduce the emisssions from landfills. However, MBT treated organic fraction still contains significant amount of organic matter.

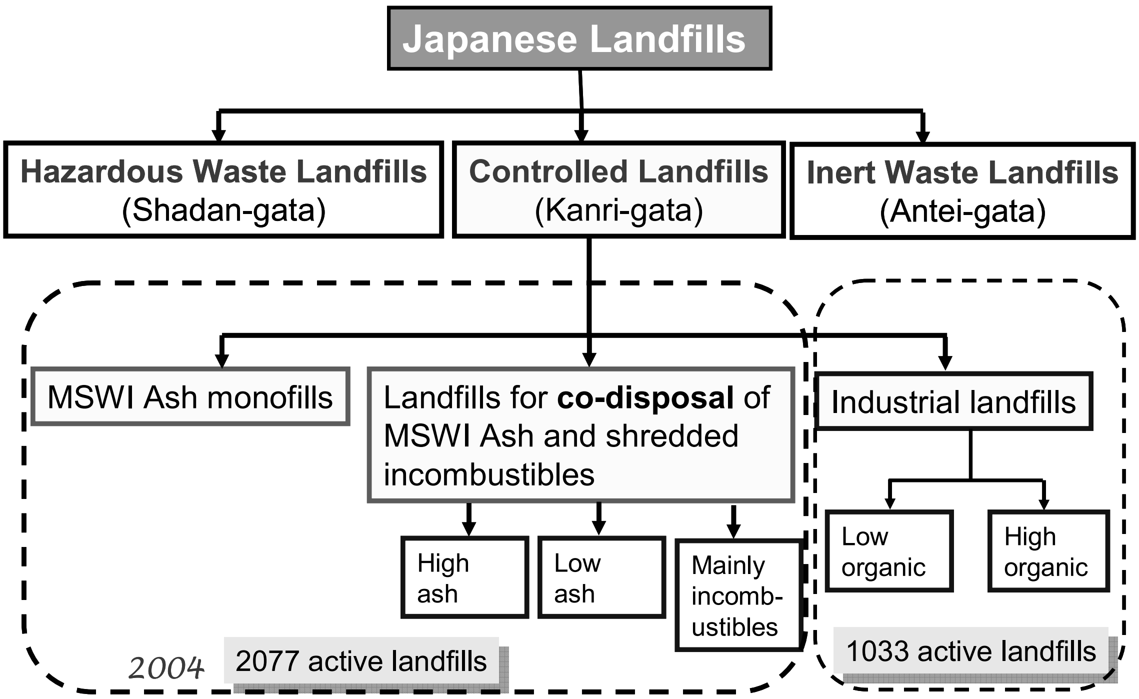

Figure 2 Types of current Japanese landfills

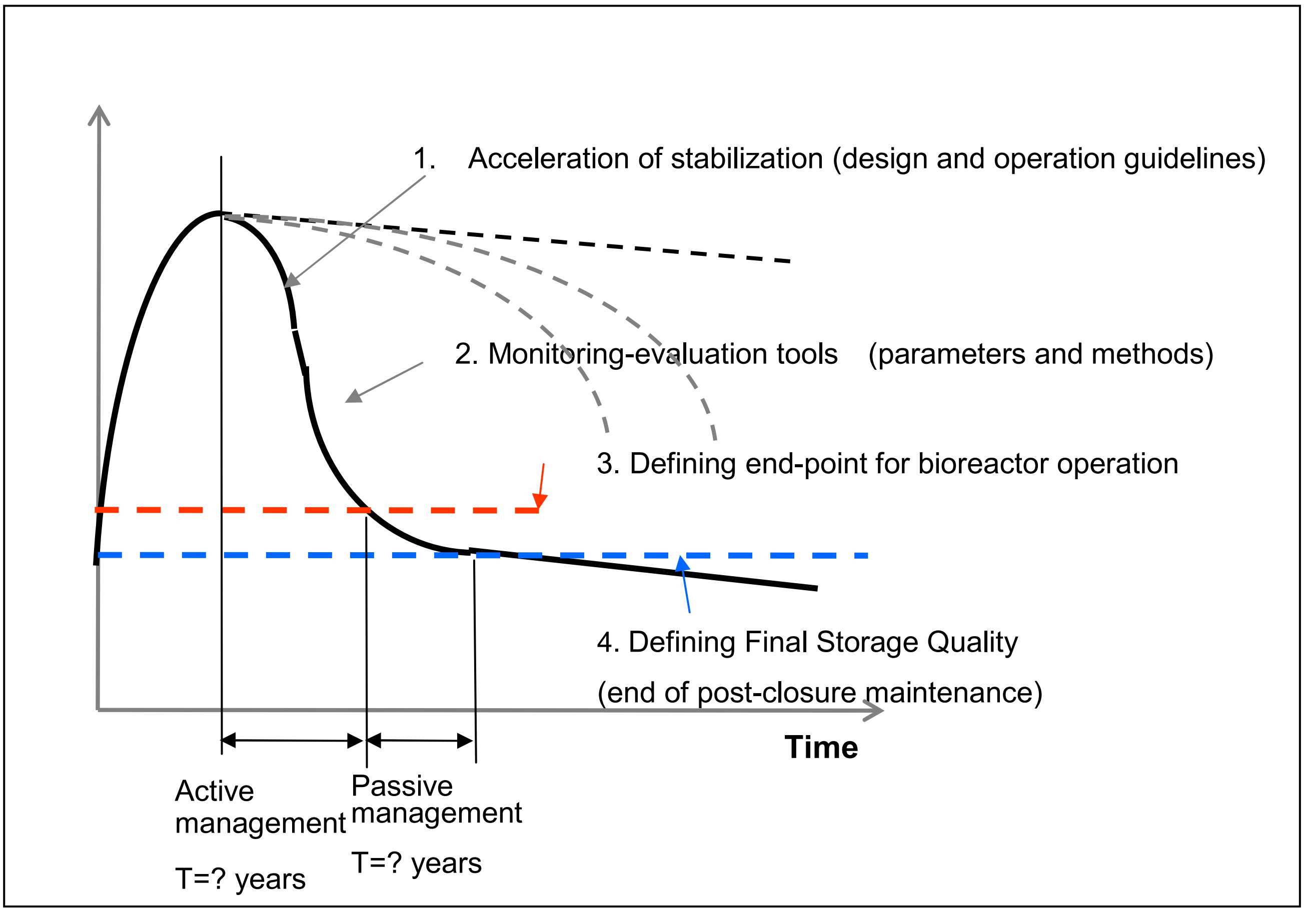

Figure 3

3 Landfilling of MBT wastes

MBT processes do not produce final storage quality end-products. Therefore, MBT wastes should be landfilled and emissions should be monitored and controlled for decades or more. Some issues related to landfilling of MBT wastes are discussed below.

3.1 Necessity of aerobic landfill

Semiaerobic landfills do not provide enough oxygen required by decomposition processes in the landfills resulting in anaerobic conditions. Anaerobic processes which are slower than aerobic processes delay the complete stabilization (final storage quality) of the landfilled wastes. Compared to low organic recycling residues in Japan to MBT wastes in Europe, it seems that cessation of methane generation and complete stabilization of organic matter will be much longer for landfills of MBT waste. MBT experiments by REDON ET AL. (2005) indicated an obvious decrease of biological activity of pretreated wastes. However, the threshold values required by German and Austrian regulations were difficult to reach with a low cost MBT process. They concluded that long duration of treatment as long as 25 weeks would be necessary and the economic viability of MBT appears difficult. Incomplete treatment will result in increased amounts of biodegradable organic matter. Considering the sustainable landfill concept “each generation should manage its own waste” and “one generation is 30 to 50 years”, aerobic bioreactor operation for MBT waste landfills is required. On the other hand, decreased air and leachate permeability is a big handicap for bioreactor operation. Installing horizontal and lateral drainage pipes in the MBT landfills is recommended (STEGMANN R, 2004). Considering the similar structure of Japanese semi aerobic landfills, uneven stabilization-washout should be expected due to preferential water pathways. Therefore, MBT waste landfills should be designed and operated as aerobic landfill bioreactors. Forced air injection should be done for a few years until the oxygen demand of the waste can be supplied by natural air diffusion into the waste mass. This will prevent also methane emissions from MBT waste landfills. Otherwise, produced methane, which is less than economically feasible quantities for electricity generation, has to be vented to the atmosphere, though some portion might be eliminated via biological oxidation in the cover soil.

3.2 Precipitation-infiltration-surface capping

MBT waste can be compacted to a high density (1 t/m3 dry waste) and has a very low hydraulic conductivity ($5.0x10^{-7}$ – 10^{-10}) (MULLER AND BULSON, 2003). This results in delayed biostabilization of residual biodegradable organic matter and washout of inorganic pollutants.

Some researchers speculate on the benefits of reducing leachate generation from MBT landfills by installing barrier caps such as capillary barrier. However, this approach is very similar “DRY TOMB” concept of USEPA Subtitle D. Surface capping or capillary barriers should be considered only after achieving very low emissions (after achieving FSQ).

3.3 Ash co-disposal

On the other hand, diverting the MSW from landfills to MBT and incineration will bring the fact that MBT waste and MSWI ashes will be disposed together in co-disposal landfills. New conditions, such as, pH, ORP, salt concentration, heavy metals etc. will create completely different decomposition and emission behavior of the landfills. Japan is already experiencing these type of landfills. Figure 4 and 5 shows the development of pH in aerobic and anaerobic test cells of co-disposed bottom ash and low-organic residues (INANC ET AL., 2004). The actual pH behavior will depend on the ratio of ash to residues.

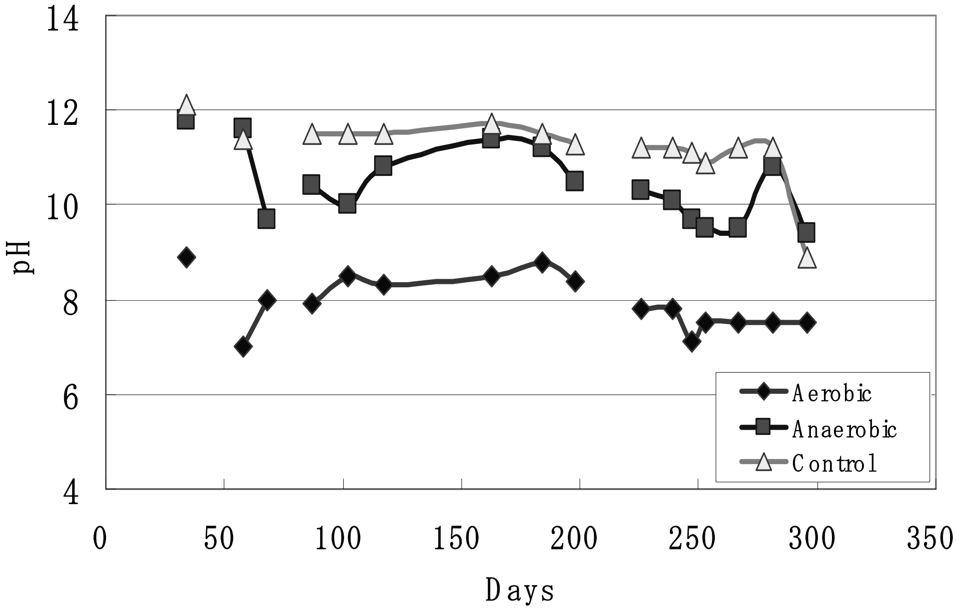

Figure 4 pH development in the leachate of test cells for co-disposed bottom ash and shredded low organic residues (INANC ET AL., 2004)

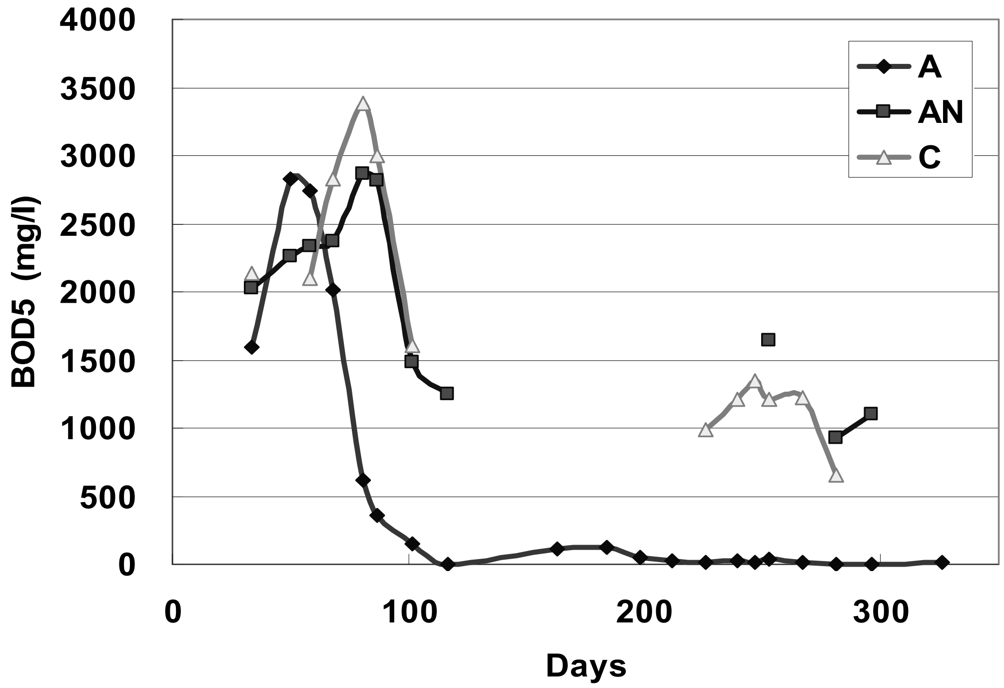

Figure 5 Behavior of BOD_5 in the leachate of test cells for co-disposed bottom ash and shredded low organic residues (INANC ET AL., 2004)

4 Conclusions

MSW landfills generate gas and leachate emissions in long term. Time period for these emissions could be between decades to centuries. In this context, MBT, as an intermediate processing technology, provides a temporary solution to the problem. MBT waste in landfill will further undergo decomposition and create gas and leachate emissions which require costly long-term monitoring and control, due to stricter emission limits anticipated in the future. Nevertheless, MBT processing does not eliminate the necessity of in-situ technologies for acceleration of waste stabilization. More research for developing better landfilling technologies achieving faster stabilization of MSW or MBT wastes, in different regions of the world, is necessary. According to our findings with Japanese landfills, MBT landfills should be designed and operated as aerobic landfill bioreactors for at least a few years until the oxygen demand of the waste can be supplied by natural air diffusion into the waste mass.

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