Influence of Biological Pre-treatment of Municipal Solid Waste on Landfill behaviour in Sri Lanka

Egodaha Gedara Wasana Gunawardana (47-56883)

1. Introduction

1.1.*Background and Problem Identification*

Sri Lanka is a tropical island in the Indian Ocean with an area about 65,610 km^2. The population of the country is 20.2 in 2006.

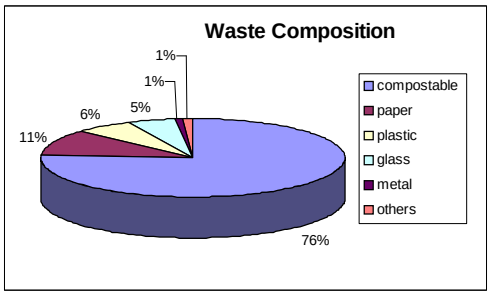

Figure 1: *Composition of the MSW.*

Hazardous disposal of Municipal Solid Waste (MSW) is an immense concern particularly in the most urbanized areas of Sri Lanka. The best estimation of MSW generation in the country is around 6,400 tonnes/day. MSW is mainly organic in nature. Fig. 1 illustrates the composition of the MSW in the country. Open dumping is the prevalent system of final waste disposal, creating considerable environmental and health hazards. Most of the open dumpsites are in riverbanks and wetlands. Waste dumpsites are exposed to scavengers, insects, and also susceptible to open burning. However, the prevailing technology does not facilitate any waste pre-treatment techniques before final disposal. As a consequence, there is an immense pressure to improve the waste disposal practices in the country.

1.2. *Purpose of the study*: Under the above circumstances, a simple and effective pre-treatment method for MSW is very important. Biological pre-treatment of MSW by composting is a practicable method for Sri Lanka. Therefore, this study is an attempt to examine the influence of biological pre-treatment of MSW on landfill behaviour in Sri Lanka.

2. Materials and Method of Study

2.1 *Experiment*:

The data for this study was based on the field scale lysimeter/test cells studies on biological pre-treatment of MSW, which have been conducting at the University of Peradeniya, Sri Lanka. The construction details of the lysimeters are given in Fig.2.

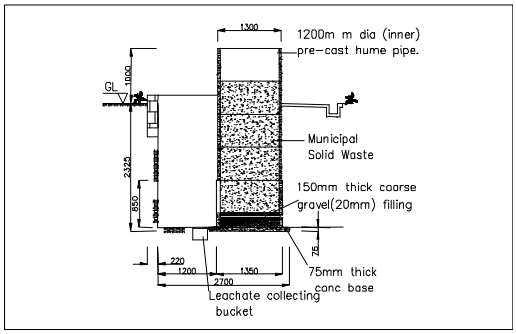

Figure 2: *Construction details of the lysimeters.*

There were two constructed lysimeters with known weight of manually sorted untreated and biologically pre-treated MSW. After filled the wastes, the samples were analyzed for various important parameters (leachate quantity and leachate quality, settlements, waste decomposition, ambient parameters) that represent the processes inside the landfills.

2.2. *Data Simulation*: In the study, the data

fitting was done on the settlements, organic waste degradation, and biomass concentration.

2.2.1. ***One dimensional consolidation model for settlement in landfills***

- $S_{(t)} = H_0 C\alpha_1 log\ (t / t_{initial})\ t_{initial} < t < t_2$
- $S_{(t)} = H_0 C\alpha_2\ log\ (t / t_2)\ t_2 < t < t_{final})$

Where,

$C\alpha_1$ = coefficient of intermediate secondary compression

$C\alpha_2$ = coefficient of long-term secondary compression

$t_{initial}$ = end of initial settlement period

t_{final} = end of field experiment observations

t_2 = time at which the slop of tress-strain curve changes (day)

2.2.2. ***Developed Monod Kinetic model for organic waste degradation***

- **Model for Microbial Concentration**

$(C_B)_{n+1} - (C_B)_n / dt = \{[\mu_B (Cs)_n / K_B + (Cs)_n] - K_{dB}\} (C_B)_n$

- **Model for Substrate Concentration**

$(Cs)_{n+1} - (Cs)_n / dt = - 1 / Ys \{\mu_B (Cs)_n / K_B + (Cs)_n\} (C_B)_n$

Where,

C_B =Carbon concentration of biomass (g/l)

C_S =Substrate carbon concentration (g/l)

K_{dB} =Biomass death rate constant (day^{-1})

μ_B =Biomass growth rate constant (day^{-1})

K_B =Half saturation constant (g/l)

3. Result and Discussion

Leachate quality and quantity are considered as the factors for environmental risk and represents a key consideration on design of landfills. Therefore, evaluation on leachate is very important. As in Fig. 3, the effect of rainfall incident on pre-treated waste was fairly less than that on untreated waste.

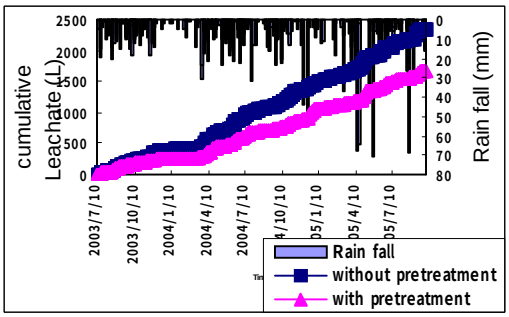

Figure 3: *Cumulative leachate generation.*

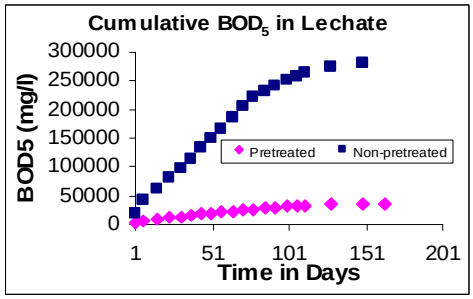

Figure 4: *Organic pollutant load in leachate.*

According to the Fig. 4, pre-treated waste was resulted the lower organic pollutant load in leachate. It was seven times less than that of untreated MSW. Volatile Solids and Total Solids content also were less in leachate of pre-treated waste.

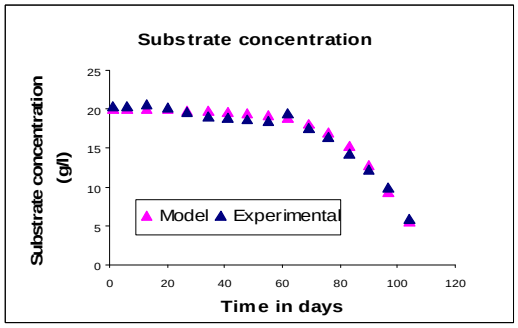

Figure 5: *Change of substrate concentration.*

During the waste decomposition, microorganisms take organic matter as nutrient for their growth and reproduction. Therefore, with the time pass, microorganisms degrade the

organic matter in MSW and result the reduction of organic pollutant load as in Fig.5.

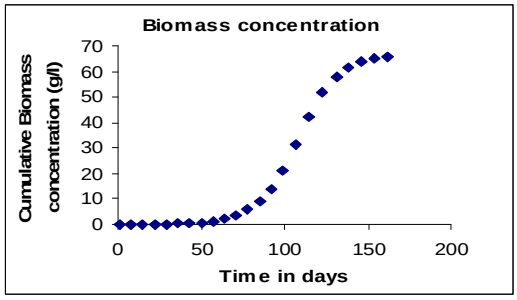

Figure 6: *Biomass concenrattion in leachate.*

Fig. 6 shows the simulated data on bacteria concentration of the leachate of untreated waste.

The understanding of long-term uneven settlements of landfills is very important for landfill design and its ultimate reuse [1]

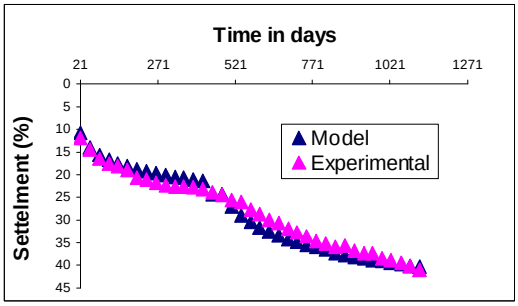

Figure 7: *Settlement of the untreated MSW.*

The greater microbial decomposition in the lysimeter with untreated waste caused higher secondary settlement as of Fig. 7. The settlement of pre-treated MSW (Fig. 8) was very low compared with the untreated MSW.

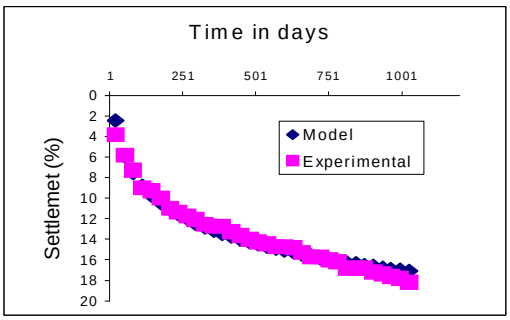

Figure 8: *Settlement in pre-treated MSW.*

The data fitting on settlement was well consistent with experimental results.

4. Assessment of the environmental and economic advantages

The organic load in leachate can be reduced by the waste pre-treatment. Therefore, the environmental risks, health risks, and also post closure leachate treatment cost can be reduced.

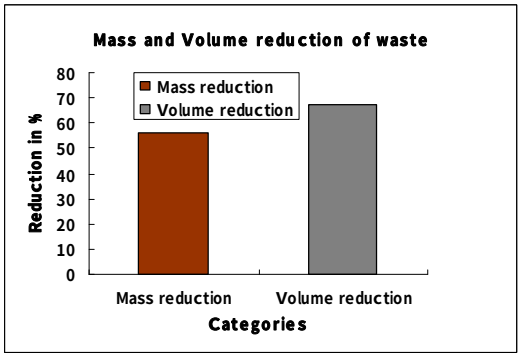

Figure 9: *Volume and mass reduction during pre-treatment.*

As in Fig. 9, the noticeable reduction of volume (67%) and mass (56%) of waste can be reached by the pre-treatment. Considering the waste generation in City of Kandy, the amount of money that can be saved by the means of mass reduction is 211,220 Rs/day (1889.6 USD USD). Note: 1 Sri Lanka Rupee = 0.008944 USD.

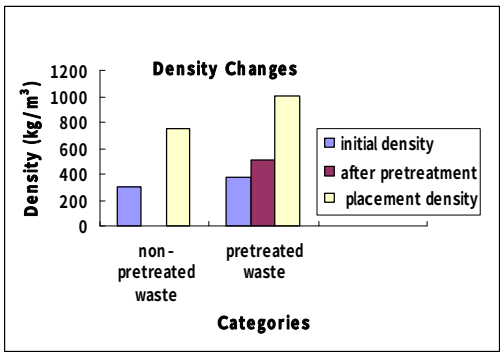

Figure 10: *Density change of waste.*

Due to homogeneity and smaller particle size, of pre-treated wastes, a higher landfill density can be achieved compared with untreated waste (Fig. 10). Considering landfill site (100m*100m*1m) in the City of Kandy, it can be saved the area of 7.7 hectare/year (by volume 25 %). Therefore, the additional volume reduction can be reached and the lifetime of the landfill can be prolonged.

Recently, pre-treated residue is widely used as a daily cover material of landfills. [2]. However, if it is used the separately collected organic waste (vegetables, garden refuse, and kitchen waste), it can be produced good quality compost as a fertilizer.

5. Conclusion

The primary investigation undertaken in this study highlighted the following considerations in landfill design and management.

(1) The pattern of rainfall has profound impact on the leachate quantity and its characteristics. Therefore, the pattern of rainfall, temperature, and evaporation should be considered when design a leachate collection and treatment systems.

(2) The organic load of leachate of biologically pre-treated waste was seven times less than that of in untreated MSW, which is beneficial in terms of reduced the costs of leachate treatment.

(3) Due to volume reduction, the lifetime of the landfill can be prolonged. It is very important for Sri Lanka, as the finding of final waste disposal sites is very difficult due to scarcity of land.

(4) The process also promotes the high waste stabilization resulting low settlements, which is beneficial in reuse the landfill site in short period of time.

(5) Fly and odour problems are less in pre-treated waste due to less of readily degradable organic waste. Therefore, the health risk and nuisance are reduced.

(6) Finally, it can be concluded that the biological pre-treatment of MSW by composting prior to final disposal is very effective method to pre-treat MSW in Sri Lanka. In addition, it is very important to draft new policies and regulations and also to provide incentives for enhancing material recovery, recycling, waste separation, and reuse, while promoting composting to develop the final waste disposal sites in Sri Lanka.

Recommendations for future researches:

As the future research it is very important to evaluate the possibility to re-circulate the excess leachate of rainy seasons during the prolonged dry seasons to enhance the waste stabilization and to mange the excess leachate.

References:

[1].El–Fadel, M., Shazbak, S., Saliby, E., and Leckie, J. (1999): Comparative assessment of settlement models for MSW landfill applications. Waste Management. & Research, 17, 347-368.

[2].Claire Hurst., Philip Longhurst., Simon Pollard., Richard Smith., Bruce Jefferson. and Jan Gronow. (2005): Assessment of municipal waste compost as a daily cover material for odour control at landfill sites. Environmental pollution, 135, 1, 171-177.