Degradation Law of MSW Mixed with Sludge

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Keywords: Sludge, Municipal Solid Waste (MSW), Degradation, Mixing Ratio.

Abstract. The course, speed and duration of degradation of sludge-MSW mixture, which are major factors affecting settlement of landfill, have a direct impact on the stability and reuse of landfill. As today's quantitative study on refuse degradation focuses on municipal solid waste (MSW), this paper seeks to find out the degradation law of MSW supplemented with sludge to fill in the blank.

Introduction

As industrial wastewater and domestic sewage discharge and sludge production of wastewater treatment plants increase sharply, sludge treatment has become a serious environmental challenge to be addressed immediately; and landfilling has gradually become an increasingly popular sludge treatment practice in the world due to less CAMPEX, high capacity and quick result. Recent studies revealed that sludge-MSW landfilling accelerates the stabilization process of sludge and reduces adverse effect of sludge on the stability of landfill[1-7]. The practice of landfilling of sludge mixed with other wastes has been widely used in Hong Kong[8]. Landfilling of sludge mixed with MSW or soil is also employed by some foreign countries[5]. To promote the development and application of sludge-MSW landfilling in China, a number of key problems involving landfilling of mixture must be solved, where degradation is an important factor to be considered for the design, operation and management of landfill.

The course, speed and duration of degradation of sludge-MSW mixture, which are major factors affecting settlement of landfill, have a direct impact on the stability and reuse of landfill. Domestic and foreign scholars have performed extensive research on the degradation pattern of waste soil and achieved fruitful results, for example Jmaes Cs.[9] proposed to describe the degradation process of organic matter of waste soil with exponential decay model, Park and Lee[10] believed that settlement process caused by degradation of MSW may be expressed by functions of first-order kinetics. There are also degradation models of waste soil proposed by domestic scholars, including Logistic model proposed by Yun-fei Fang[11], Richards model proposed by Hu Yadong[12] and degradation model proposed by Liu Xiaodong[13]. Nevertheless, all of those models focus on MSW and there is rare quantitative study targeting on influence of mixed sludge on the degradation law of MSW at home and abroad. Therefore, this paper intends to perform a quantitative study on the degradation law of MSW mixed with sludge based on experiment.

Testing Program

Condition and Material

Tests were performed in a basement where temperature ranges from 12℃ to 18℃ and humidity ranges from 40% to 70%. The testing MSW is taken from Yancheng city of China, and the constituents and corresponding content is summarized in Table1. Water content of as-is sample is 73.43% (dry matter as denominator); water content of sludge is 79.05% (total matter as denominator) and specific gravity is 2.043; mixing ratio of sludge and waste is based on wet weight.

China bowl was used as container. Samples were dried at 70℃ when mass of dry matter was measured.

Tab. 1 Constituents of the Testing MSW (Dry Matter)

Constituents	Kitchen garbage	Paper	Wood	Plastics	Metals	Glass, soil, stone
Contents (%)	24.89	17.76	3.22	15.98	1.4	36.63

Schedule

The tests are carried out in 16 groups. Simultaneously, 50 samples are prepared for each group, and Sample preparation proportions and testing groups are shown in Table.2.

Tab. 2 Sample Moisture Content and Supplemented Ratio for Sludge

Moisture content/Supplemented ratio for sludge	0	0.05	0.1	0.15
0.95	A1	A2	A3	A4
1.07	B1	B2	B3	B4
1.18	C1	C2	C3	C4
1.30	D1	D2	D3	D4

Operation

All field samples were mixed evenly and cut into pieces, and a portion thereof was sorted to determine their constituents. Degradation rate, water content and other parameters were identified by observing the change of mass of dry matter.

The tests are carried out in 16 groups. Simultaneously, 50 samples are prepared for each group. Samples were covered with plastic wrap to create a relatively anaerobic environment and suppress evaporation. With the same initial conditions, samples of a single set were taken out one by one over a time interval to dry and determine the decrease of its dry matter and then find out its degradation rate.

Testing Results and Analysis

Degradation Law

Testing results of sixteen sets of samples are shown in figures 1-4

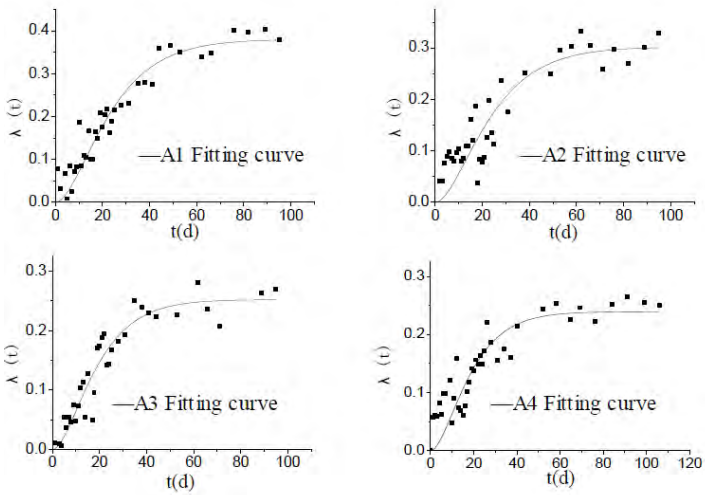

Fig. 1 Degradation Test Results for Moisture of 95%

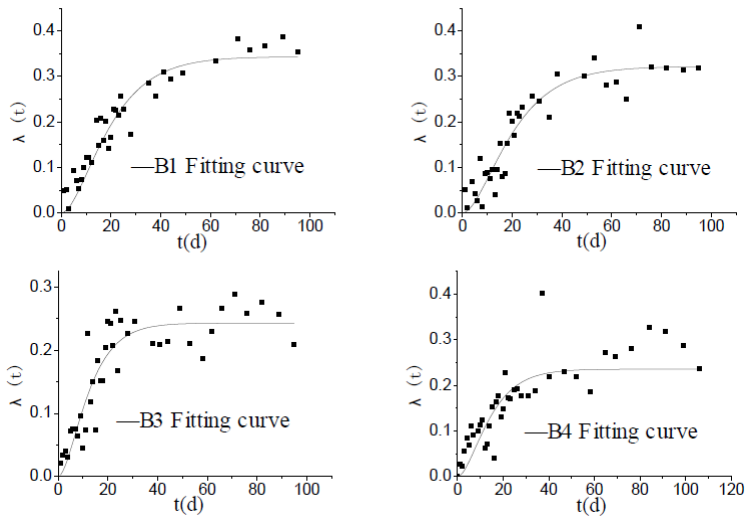

Fig. 2 Degradation Test Results for Moisture of 107%

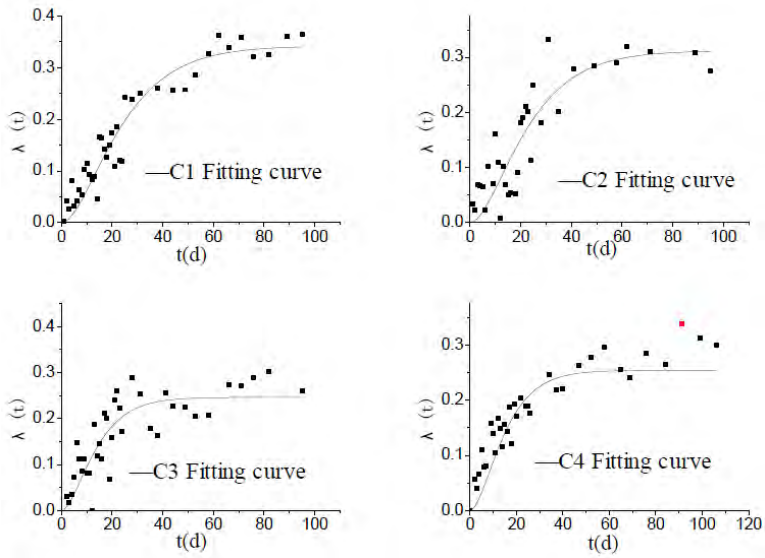

Fig. 3 Degradation Test Results for Moisture of 118%

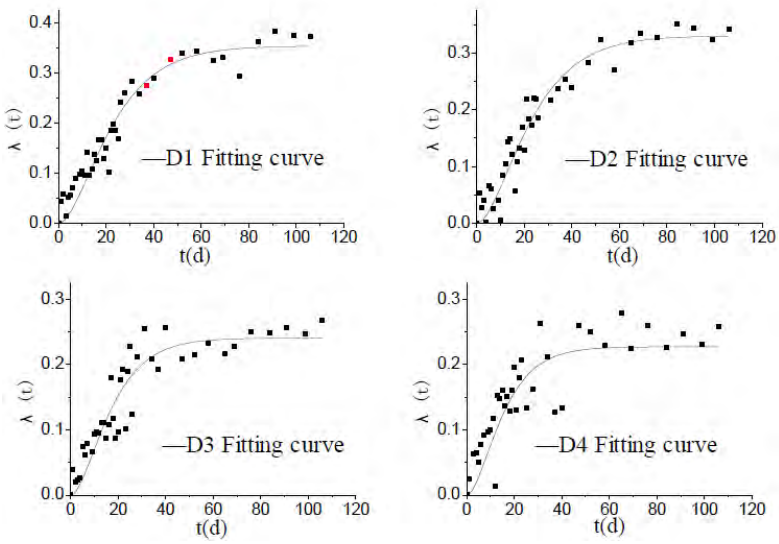

Fig. 4 Degradation Test Results for Moisture of 130%

According to figures 1-4, it is shown a similar slow-quick-slow degradation pattern on four sets of samples. At the initial stage, adjustment can be observed, and degradation is relatively slow; degradation rate reaches the maximum level quickly as degradation continues and then becomes stable. The curve declining with the increase of mixing ratio of sludge indicates that degradation rate of waste decreases with the increase of sludge mixed. The time taking by the curve to reach the turning point decreasing with the increase of mixing ratio of sludge indicates that time to achieve degradation stability shortens with the increase of sludge mixed. Testing results of four sets of samples show that mixing of sludge benefits the sedimentation stability of MSW.

Degradation Model

Testing results of sixteen sets of samples suggest a slow-quick-slow degradation pattern of MSW mixed sludge. Testing results fit well with the degradation model proposed by Liu Xiaodong[13].

The model is as follows:

$$\lambda(t) = ab[(-t/b)e^{-t/b} + (1-e^{-t/b})] \tag{1}$$

Where, $\lambda(t)$ is degradation rate; t is the time for degradation; a and b are parameters related to basic conditions and characteristics of MSW in landfills.

Fitting results of model are shown by figures 1-4, where parameters are shown in tables 3 and.4.

Tab. 3 Parameter A

Moisture content/Supplemented ratio for sludge	0	0.05	0.1	0.15
0.95	0.03004	0.02418	0.02464	0.02397
1.07	0.03165	0.02982	0.03422	0.03329
1.18	0.0265	0.02545	0.03118	0.0326
1.3	0.02919	0.02684	0.02585	0.02713

Tab. 4 Parameter B

Moisture content/Supplemented ratio for sludge	0	0.05	0.1	0.15
0.95	12.66	12.48	10.24	9.98
1.07	10.84	10.78	7.1	7.04
1.18	12.9	12.25	7.89	7.8
1.3	12.34	12.33	9.31	8.37

According to fitting results shown in figures 1-4, the model proposed by Liu Xiaodong better describes the degradation pattern of sludge-MSW mixture.

Conclusions

1) Four sets of sludge-MSW mixture samples show a similar slow-quick-slow degradation pattern. Degradation rate of the mixture and time to achieve degradation stability reduce with the increase of mixing ratio of sludge, indicating that waste soil achieves degradation stability in a shorter time and reduce degradation rate after mixing with sludge.

2) Degradation test results of four sets of sludge-MSW samples indicate that fitting of

degradation pattern of sludge-MSW mixture with the model proposed by Liu Xiaodong demonstrates good fitting effect and larger correlation coefficient, implying the model better describes the degradation pattern of sludge-MSW mixture.

Acknowledgements

Funding was received from Social development project of Science and Technology Agency of Jiangshu Province which number is BE2011729.

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