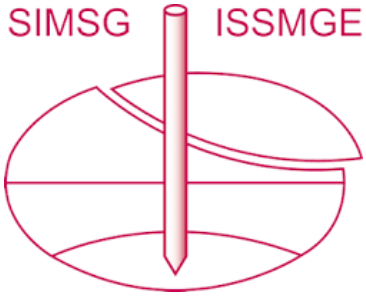
INTERNATIONAL SOCIETY FOR
SOIL MECHANICS AND
GEOTECHNICAL ENGINEERING



This paper was downloaded from the Online Library of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE). The library is available here:

https://www.issmge.org/publications/online-library

This is an open-access database that archives thousands of papers published under the Auspices of the ISSMGE and maintained by the Innovation and Development Committee of ISSMGE.

Decomposition of organic matter of MSW incineration ash by electrolytic method

Décomposition des matières organiques contenues dans les cendres d'incinération des DSM par la méthode électrolytique

K. Omine & T. Kobayashi
Faculty of Engineering, Kyushu University

ABSTRACT

In this study, in order to promote early stabilization of waste disposal landfill, electrolytic method for decomposition of persistent organic matter is applied to municipal solid waste (MSW) incineration bottom ash. First of all, effect of decomposition of persistent organic matter by the electrolytic method was investigated based on the test result. Secondly, stabilization effect of MSW incineration ash was confirmed by circular system of electrolytic water. The electrolytic method for decomposition of persistent organic matter was applied to MSW incineration ash. From the test results, it was clarified that stabilization of MSW incineration ash progresses by using circular system of electrolytic water.

RÉSUMÉ

Dans cette étude, pour promouvoir la stabilisation préliminaire des déchets stockés en décharge, la méthode électrolytique de décomposition des matières organiques persistantes a été appliquée à des cendres d'incinération provenant de déchets solides municipaux (DSM). Tout d'abord, l'effet de la méthode électrolytique sur la décomposition des matières organiques persistantes a été étudié sur la base d'essais. Deuxièmement, la stabilisation des cendres d'incinération des DSM en système circulaire d'eau électrolytique a été validée. La méthode électrolytique de décomposition des matières organiques persistantes a été appliquée à des cendres d'incinération des DSM. Les résultats des tests ont démontré que la stabilisation des cendres d'incinération des DSM est améliorée par l'emploi de système circulaire d'eau électrolytique.

Keywords : MSW incineration ash, persistent organic matter , decomposition, electrolytic water

1 INTRODUCTION

In recent years, it becomes diifficult to construct a new final landfill site and remaining landfill capacity is very small. Generally it takes a few decades for stabilization of final disposal site and requires maintaining leachate treatment for a long term. It is therefore expected to stabilize early the disposal site from viewpoint of both economical efficiency and reduction of environmental risk.

One of the reasons of delaying for closing and abolition of disposal site is an ingredient of organic matters. COD (chemical oxygen demand) or nitrogen compound in leachate is an indicator of the organic matters. It is considered that the source origin is persistent organic matter in landfill layer.

Electrolytic method for purification of waste water has been applied by some researchers. It enables to disintegrate persistent organic matter by electrolytic water. In this study, for the purpose of promoting early stabilization of waste disposal landfill, the electrolytic method for decomposition of persistent organic matter is applied to municipal solid waste (MSW) incineration bottom ash (Iwanaga et al., 2007, Omine et al., 2008). First of all, effect of decomposition of persistent organic matter by the electrolytic method is investigated based on the test result. Secondly, stabilization effect of MSW incineration ash is confirmed by circular system of electrolytic water.

2 ELECTROLYTIC OXIDATION METHOD

Advanced oxidation process to oxidize by ozone, hydrogen peroxide, ultraviolet rays and those combinations can decompose persistent organic matters which are difficult for biological treatment. Electrolytic oxidation method is one of them and to be expected for decomposing organic matter and ammonium-nitrogen into carbon dioxide CO_2 and nitrogen N_2 respectively.

The oxidation processes are classified into two reactions which are direct and indirect oxidations (Ihara and Watanabe, 2004). Fundamental principle of the oxidation processes are shown in Figure 1. In direct oxidation reaction, decomposition of organic compound is promoted by hydroxy radical generating in a cathode. When a chloride ion is included in waste water, hypochlorous acid (HClO) is generated and acts as an oxidizer by indirect oxidation reaction. Hypochlorous acid contributes to processing of ammonium-nitrogen (NH4 -N) in addition to the oxidation treatment of an organic compound.

Chloride ions are necessary for the generation of hypochlorous acid by electrolytic method. When a certain amount of chloride ions is included in drainage, it can just take an advantage in the electrolytic method. Existence rate of the hypochlorous acid is shown in Figure 2 (http://www.jaie.gr.jp/z_hotta.pdf). A large amount of hypochlorous acid exists in mild acidity, so that electrolytic efficiency is considered to become high in mild acidity

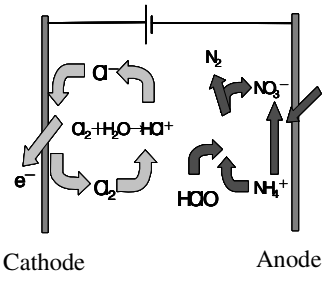


Figure 1. Fundamental principle of the oxidation processes.

© 2009 IOS Press.
doi:10.3233/978-1-60750-031-5-2308

condition. In addition, electrode material with high oxygen overpotential and durability is needed for generating chlorine effectively.

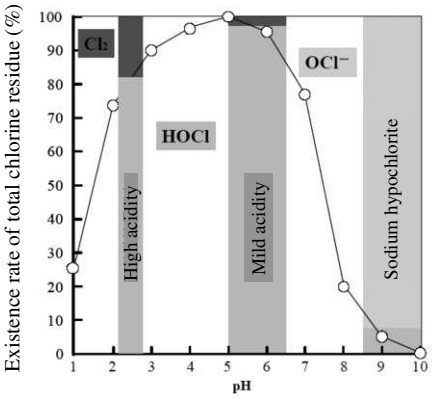


Figure 2. Existence rate of the hypochlorous acid.

3 APPLICATION OF ELECTROLYTIC METHOD TO LEACHATE FROM MSW INCINERATION ASH

Used leachate was obtained from MSW incineration ash at F city. Leaching condition in the column test was the mass ratio of 1 : 1 for MSW incineration ash and distilled water. The electrolytic method was applied to this leachate.

Schematic diagram of the electrolytic apparatus is shown in Figure 3. Cathode is a carbon board and anode is DSE (Dimensionally Stable Electrode). Size of these electrodes is 10 cm in width and 10 cm in height. Table 1 shows test conditions of the electrolytic method. Current in 0.5 ~ 1.5A was electrified for the leachate with 750 g during 6 h. Electrode distance is 1, 2 and 3cm in Case 1. In order to investigate an effect of hypochlorous acid, the electrolytic test under different pH conditions was also performed. The leachate was stirred using magnetic stirrer during the test. COD, total chlorine residue (free residual chlorine +combined residual chlorine), pH and ORP were measured for making clear the decomposition effect of persistent organic matters.

Change of COD against electrolytic time under the different electrode distances is shown in Figure 4. Although there are some data spread, these indicate same decreasing trend with time and the value of COD after 6 h is almost same. COD at initial condition is approximately 250 mg/l and it decreases less than 100 mg/l. On the other hand, as shown in Figure 5, the electric resistance becomes small as the electrode distance is short. From a viewpoint of energy consumption, it is said that the test condition of short electrode distance is efficient.

Figure 6 shows the relationship between concentration of total chlorine residue and electrolytic time. The concentration of total chlorine residue increases gradually with increase in the time. However, there is no clear trend for the electrode distance. It is considered that a large amount of chlorine residue has an important role to decompose the persistent organic matters.

These test results are obtained for small amount of leachate. It is therefore considered that this electrolytic method will be applied to a larger quantity of leachate by using larger currency and electrodes.

In order to investigate the effect of pH on the decomposition of organic matter, the electrolytic method was performed on the leachate under different pH conditions. Figure 7 shows the relationship between COD concentration ratio C/C_0 and elapsed time, where C and subscript of 0 represent COD concentration and initial value respectively. The leachate with C_0 of 235~250 mg/L was used and the current in 1.0 A was applied. The value of C/C0 decreases with increase in the time. Although the rate of decrease in the case of CO2 addition is higher than that of other pH conditions, it becomes almost same value after 6 h. The relationship between total chlorine residue and elapsed time is shown in Figure 8. The concentration of total chlorine residue increases rapidly with the time in each case. A large amount of total chlorine residue is caused by chlorine containing MSW incineration ash. These results mean that the effect of pH condition on the decomposition of organic matter is relatively small. It may be said that the effect of direct oxidation in the cathode is prominent in comparison with the indirect oxidation by hypochlorous acid generating effectively in mild acidity. In other words, it is considered that the electrolytic method is effective in high alkaline condition such as MSW incineration ash.

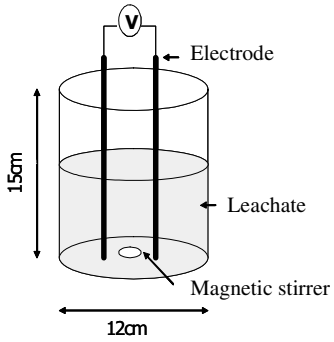


Figure 3. Schematic diagram of the electrolytic apparatus.

Table 1. Test conditions of the electrolytic method.

	Electrode distance (cm)	pH adjustment	Current (A)
Case 1	1, 2, 3	-	1.0
Case 2	2	HCl, CO_2	1.0
Case 3	2	-	0.5, 1.0, 1.5

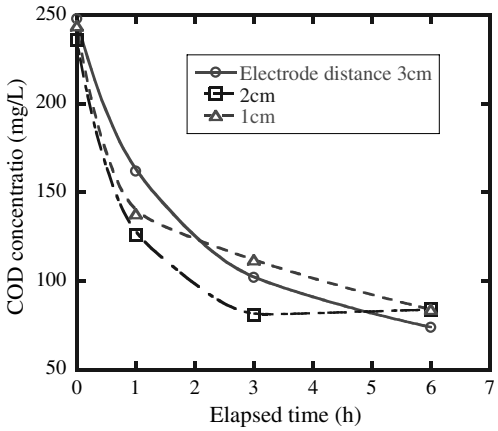


Figure 4. Relationship between COD concentration and elapsed time.

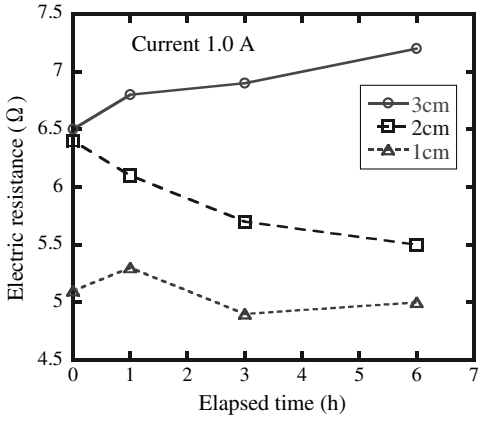


Figure 5. Relationship between electric resistance and elapsed time.

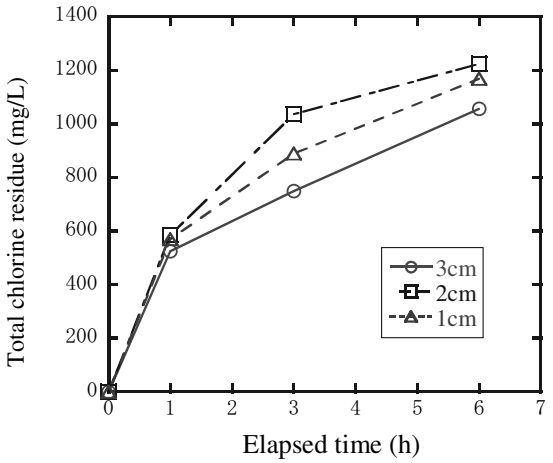


Figure 6. Relationship between total chlorine residue and elapsed time.

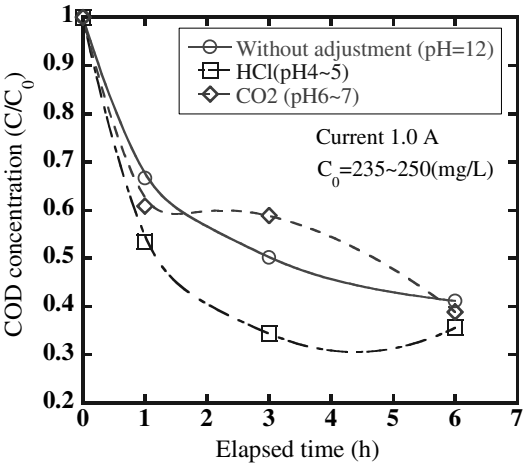


Figure 7. Relationship between COD concentration and elapsed time.

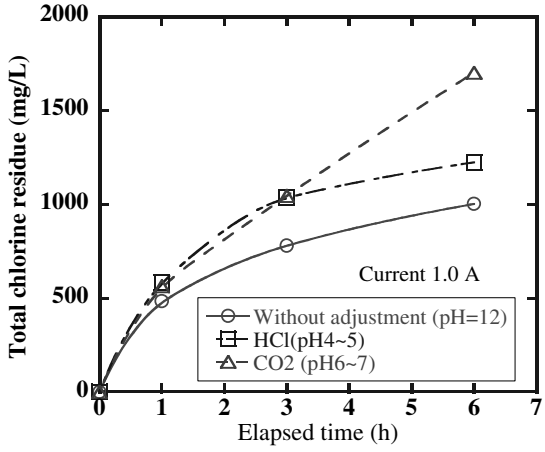


Figure 8. Relationship between total chlorine residue and elapsed time.

Next, from the viewpoint of energy efficiency, the electrolytic tests with different current conditions were performed on the same leachate. The relationship between COD concentration ratio and elapsed time is shown in Figure 11. The COD concentration ratio depends on the current intensity significantly. Concentration of COD can be reduced rapidly using relatively high current intensity of 1.5 A. It is also considered that higher current intensity will be required for decomposition of high concentration of COD. Consideration of electric power consumption is one of important issues. Figure 10 shows COD concentration ratio against electric power consumption in the condition of 1.0 and 1.5 A. As shown in this figure, when higher current is electrified, the decomposition of organic matter can be accelerated in smaller electric power.

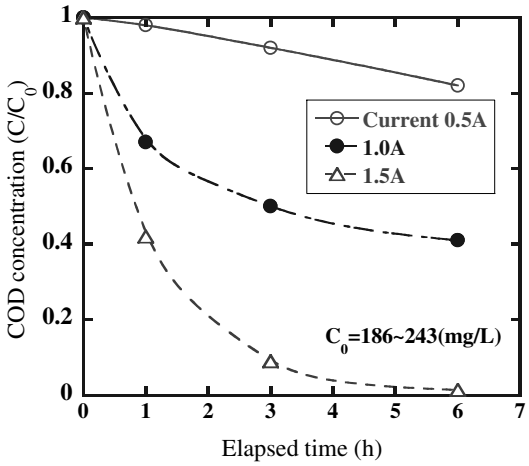


Figure 9. Relationship between COD concentration and elapsed time.

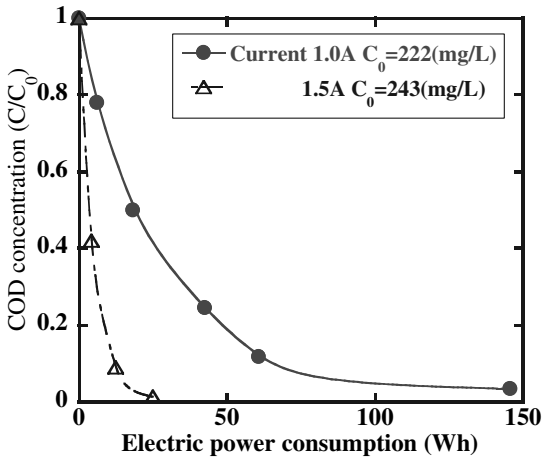


Figure 10. Relationship between COD concentration and electric power consumption.

4 EFFECT OF STABILIZATION OF MSW INCINERATION ASH BY CIRCURATION OF ELECTROLYTIC WATER

Same MSW incineration ash as described in former chapter is used. Schematic diagram on the circulation apparatus of electrolytic water is shown in Figure 11. The incineration ash in mass of 1000 g was filled in the acrylic column and distilled water in 1340 mg was rotated using pump. Then, the leachate from the column was electrolyzed in 1.5 A and electrode distance with 3 cm. In addition, column test in the condition of water circulation without electrolysis was also performed. The leachate from the column was loatated during 24 h. COD, total chlorine residue, pH and ORP were measured on the leachate before forwarding electrolysis tank.

The relationship between COD concentration and elapsed time is shown in Figure 12. In the case of circulation without the electrolysis, COD concentration increases gradually until 13 h and decreases after that. On the other hand, when the electrolytic water is rotated, the concentration of COD decreases with the elapsed time and becomes less than the waste water standard after 8 h. Furthermore, the reduction rate of COD becomes approximately 98% after 24 h. It is considered

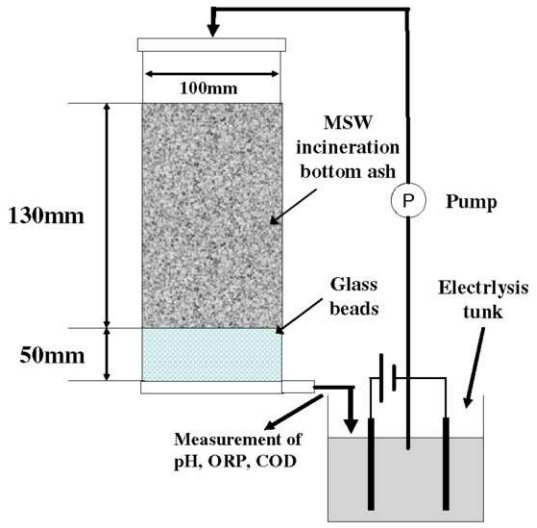


Figure 11. Schematic diagram on the circulation apparatus of electrolytic water.

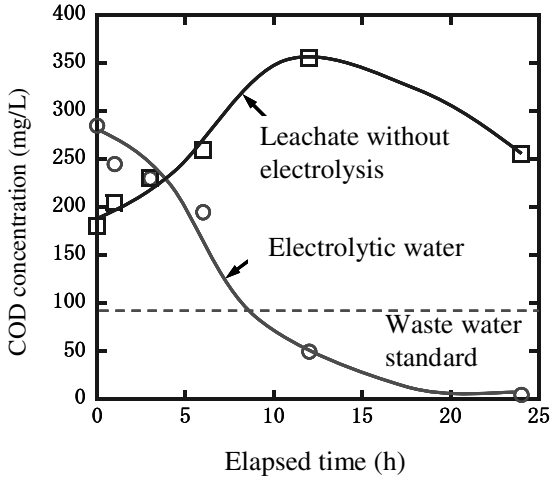


Figure 12. Relationship between COD concentration and elapsed time.

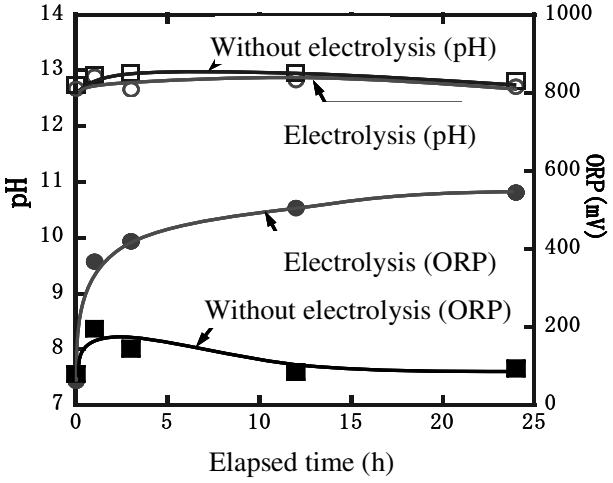


Figure 13. Relationship among pH, ORP and elapsed time.

Table 2. Test result of the electrolytic method.

	Initial	After circulation
COD (mg/L)	48	4
Ignition loss (%)	10.1	9.3

that the organic matter containing the leachate is decomposed in the electrolysis tank and the circulation water with available chlorine accelerates the decomposition of the organic matter in the incineration ash.

Figure 13 shows the values of pH and ORP during the circulation of the leachate in the case of the electrolysis or not. The circulation water indicates high alkalinity independent of electrolysis condition. Although the circulation water without electrolysis indicates a low value of ORP, the electrolytic water reveals an aerobic condition with high value of ORP. This is considered to be due to the oxidation reaction for decomposing the organic matter.

Table 2 shows the test result of the electrolytic method. COD was measured for the solution of batch test in mass-liquid ratio of 1:10 and ignition loss of the sample was also measured. It is found that these values decrease after the test.

Thus, the concentration of COD can be reduced in a short time by the circulation of electrolytic water through the MSW incineration ash. It is also suggested that this electrolytic method may become early stabilization technique of the incineration ash.

5 CONCLUSIONS

Electrolytic method for decomposition of persistent organic matter is applied to MSW incineration bottom ash. The following conclusions were obtained from this study:

1) For the leachate from MSW incineration ash, COD as an indicator concerning persistent organic matter can be reduced by the electrolytic method.

2) Reduction effect of COD is much higher when electric current increases.

3) When interval between electrodes is short, electric resistance becomes small and efficiency of decomposition is improved.

4) By circular system of electrolytic water through MSW incineration ash, it is possible to reduce COD effectively.

ACKNOWLEDGEMENT

The authors are grateful to Mr. S. Iwanage and Y. Kobayashi for their cooperation.

REFERENCES

Ihara, I. and Watanabe, T. 2004. Development of a wastewater treatment system with electrochemical reactions and magnetic separation, Environmental Conservation Engineering, Vol.33, No.8, pp.577-580 (in Japanese).

Iwanaga, S., Ochiai, H., Omine, K. and Kobayashi, Y. 2007. The effect of short-time stabilization and decomposition of organic matter for municipal solid waste incineration ash by circular system of electrolytic water, Proc. of the 7th Symposium on Geo-environmental Engineering, pp.211-214 (in Japanese).

Omine, K., Yasufuku, N., Kobayashi, T., Ochiai, H., Iwanaga, S. and Kobayashi, Y. 2008. Application of electrolytic method for decomposition of organic matter and early stabilization of MSW incineration ash, Proc. of Geo-environmental of Engineering, pp. 193-198.