Suppression of Dioxin Generation in the Garbage Incinerator, Using EM (Effective Microorganisms), EM-Z, and EM-Z Ceramics Powder

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Abstract: *Garbage incinerators pollute the atmosphere through the generation of ash and dioxin. The latter contributes to the degeneration of the atmosphere. Current technologies to mitigate this environmental problem are very expensive. Thus studies were initiated to evaluate the efficacy of EM formulations in overcoming the pollution problems of incinerators.*
Activated EM, when applied to the cooling chamber reduced dioxin contents of ash. Fortification of activated EM with EMz, and EMz ceramics powder enhanced the efficacy of reducing dioxin, thus removing the requirement further treatment.
The process of dioxin mitigation by EM products was examined. The results illustrate that EM products reduces the production of carbon monoxide, while promoting complete combustion. The studies revealed that EM reduced dioxin pollution to levels lower than that required in Japan. This clearly presented the benefits of using EM products for controlling dioxin pollution, using available facilities at very low cost and high efficiency.

Introduction

In recent years, environmental pollution by environmental hormones, or endocrine disruptors, is getting serious. Such pollution is also a serious problem in agriculture. Many popular agricultural chemicals have been reported to contain environmental hormones. The pollution by dioxins is a serious problem, and measures against it are said to require a huge amount of cost.

Dioxins are unintentionally produced during the combustion of some organic compounds and the synthesis of chlorinated organic compounds. These are structures of dioxins and related compounds, namely, polychlorinated-dibenzo-para-dioxin, polychlorinated-dibenzo-furan, and coplanar-PCB (Fig 1). Depending on the number and positions of chlorine atoms replacing hydrogen atoms on the benzene rings, they have 75, 135, and 13 isomers, respectively, and these isomers have different toxicity levels. Thus, the overall toxicity of dioxins and related compounds is usually expressed in terms of toxic equivalencies. In addition, Dioxins shows very strong toxicity even in extremely small amount, and are hard to decompose.

Thus, once released into the environment, dioxins exist there for a long time, are accumulated in our bodies through food chains, and cause various health problems.

To control dioxins, it is necessary to consider two aspects: the suppression of dioxin production and the decomposition of dioxins existing in the environment.

This study was conducted at a garbage incinerator, which burns 40 to 50 tons of garbage a day, to seek a solution to these problems. In addition, We also studied the possibility of EM as a method of bioremediation concerning the decomposition of dioxins.

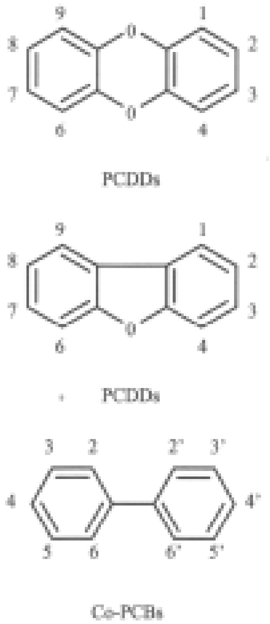

Fig 1. Structural Formulae of Dioxins and Related Compounds

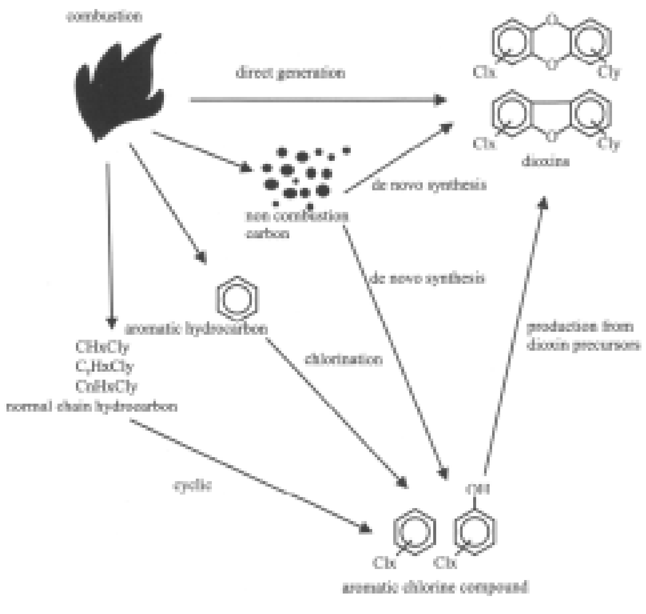

Fig 2. Main Sources of Dioxin Production through Combustion in Trash Incinerators

Note: Cited from Journal of Combustion Society, 112, 25-34 (1998), written by M. Takeuchi

Materials and Methods

The Suppression of Dioxins

The main source of dioxin production through combustion is considered to be trash incinerators and the possible processes of dioxin production during the combustion of waste materials which produced in the furnace and in the processes of gas cooling and dust collection is shown in is shown in Fig 2. They are formed in an imperfect combustion range of 300 to 700 °C through the chlorination of dioxin precursors, such as chlorinated phenol and chlorinated benzene, and through de novo synthesis by catalysis of metals such as copper and cobalt in the dust collector.

In addition, incinerators are operated in different operation methods. In the continuous operation, an incinerator is operated for 24 hours a day, and in the intermittent operation an incinerator is operated only for certain hours a day. In the intermittent incinerators, imperfect combustion tends to occur because of large temperature changes when the operation is started and ended, and thus they are said to produce more dioxins.

In this experiment, a slurry containing an extended EM (Effective Microorganisms) solution, EM-Z which is an extract of antioxidant substances produced by EM and EM-Z ceramics powder, which is made by mixing EM-Z in ceramics materials, was sprayed into the garbage pit, and an extended EM solution was mixed in the cooling water which was then injected into the gas cooling chamber (Fig 3). Fly ash and residual ash obtained from the incinerator were analyzed for their dioxin contents.

These are the treatments done at the Gushikawa incinerator (Table 1). The control is before EM was used, and the EM treatments were set for different places of injection, amounts, and their combinations. For sampling, fly ash was taken from the dust collector, and residual ash from the furnace during stable operation, when the combustion temperature was stable.

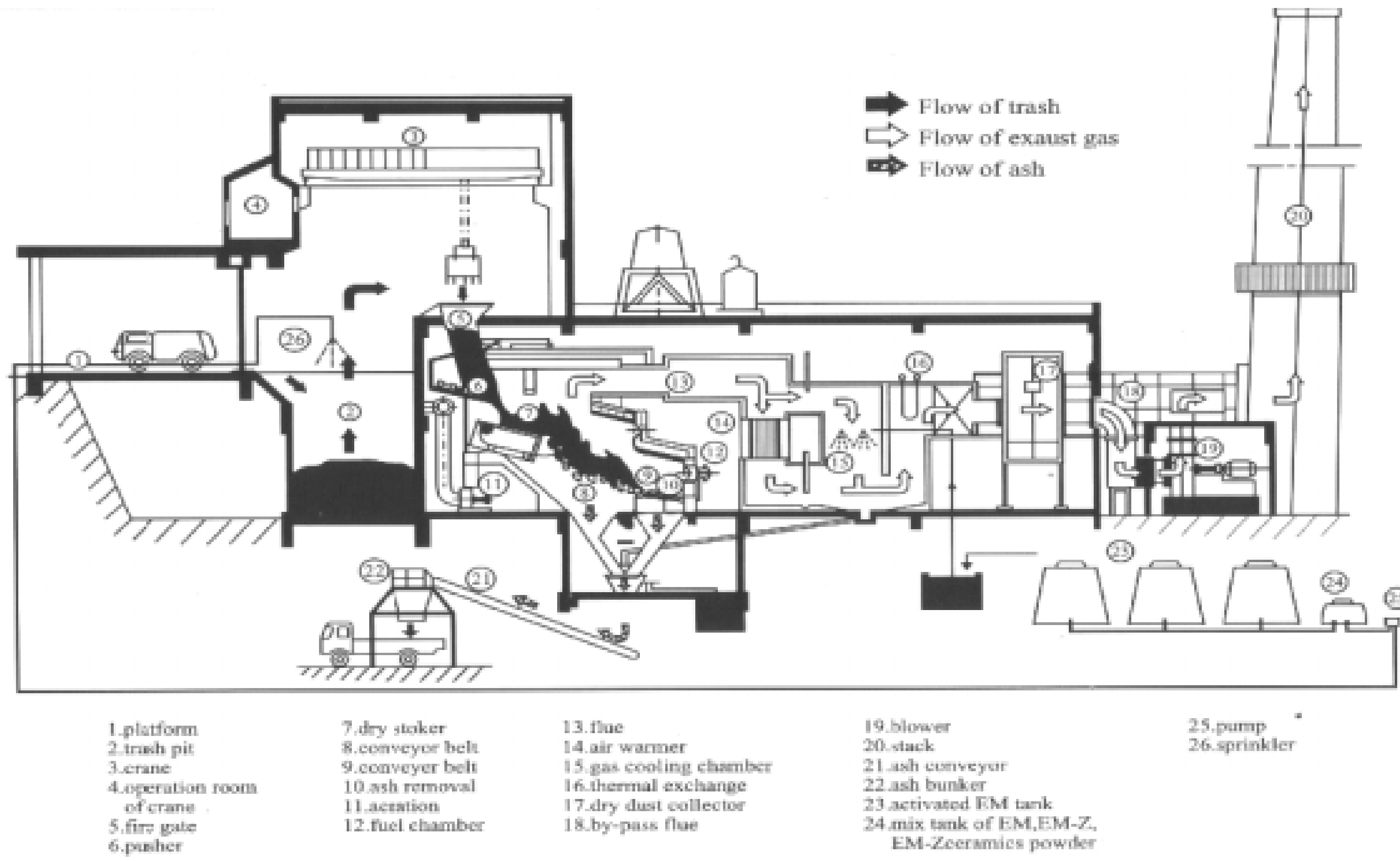

Fig 3. Flow Diagram of the Gushikawa Municipal Incinerator

Table 1. Details of each Treatments

Treatments	Sampling Date	Cooling Chamber	Trash pit		
		Extended EM[z]	Extended EM[z]	EM-Z	EM-Z ceramics
Control	Jul.22,1998	-	-	-	-
Treatment 1	Jul.23,1998	0.26%	-	-	-
Treatment 2	Jul.30,1998	0.26%	18 / t	-	-
Treatment 3	Aug.3,1998	0.5%[y]	18 / t[y]	-	-
Treatment 4	Aug.4,1998	0.5%[y]	18 / t[y]	25 /t	1 kg/t
Treatment 5	Aug.13,1998	0.5%[y]	30 / t[y]	-	0.25kg/t
Treatment 6	Aug.14,1998	0.5%[y]	30 / t[y]	-	0.125kg/t
Treatment 7	Sep.4,1998	0.5%[y]	30 / t[y]	25 /t	1 kg/t

[Z] (% dilution in water)
[Y] Addition of mineral salts as 1 % of substrate for EM extension

The Decomposition of Dioxins

We examined the possibility of EM as a method of bioremediation on dioxins.

Bioremediation is a method of recovering the environment using microorganisms, and is drawing attention in recent years. It has been reported that dioxins are decomposed by wood-decaying fungi. Wood-decaying fungi belong to the group of *Eumycota*, which also includes molds and mushrooms, and they are known to decompose lignin, a hard-to-decompose substance, in the soil. Other lignin-decomposing enzymes are lignin peroxidase, manganese peroxidase, and laccase. In the decomposition of dioxin by wood-decaying fungi, it is known that lignin peroxidase removes chlorine atoms on the benzene rings, which are the basic structure of dioxin, breaks the ring structure by oxygenation, and eventually decomposes dioxin into carbon dioxide. Therefore, we examined the possibility of dioxin decomposition by measuring the effect of EM treatment on the activity of lignin-decomposing enzymes.

(1) We mixed Shimajiri subsoil with chopped and sterilized rice straw in vinyl pots in the laboratory. We then supplied EM bokashi and an extended EM solution to the plot of EM treatment and tap water to the control, and kept the pots at 28 °C. We measured the activity of lignin-decomposing enzymes of the control and the EM plots. The lignin-decomposing enzymes we measured are lignin peroxidase and laccase.

(2) We also measured the population of fluorescent *Pseudomonases*. Fluorescent *Pseudomonases* are bacteria, and are known to decompose dioxins, like wood-rotting fungi.

We prepared in Wagner pots a soil polluted with dioxins by mixing Shimajiri subsoil and fly ash obtained from a trash incinerator. Next we set up 6 different plots: a control plot, which was supplied with tap water; two EM plots, which were supplied with activated EM solutions of different dilutions; an EM and EM bokashi plot, in which EM bokashi was mixed and an activated EM solution was supplied; an organic matter plot, in which bokashi materials were mixed without EM; and an EM-Z ceramics plot, in which EM-Z ceramics was mixed. Changes in the activity of lignin decomposition enzymes and the population of fluorescent *Pseudomonases* of the samples were measured.

Results **The suppression of Dioxins**

The data of fly ash and residual ash is given in Table 2. For treatment 1, which is the treatment of only cooling water, the dioxin concentration of fly ash is reduced by about 73 percent, compared with the control, and the suppression rate is about 81 percent for treatment 2, which is the treatment of cooling water and the trash pit. The suppression rate increases further when EM-Z and EM-Z ceramics powder is also used. As for residual ash, the data is mixed, and there are higher values than the control for some treatments. For treatments 4 to 7, where ceramics powder is used, the dioxin concentration tends to decrease as the amount of ceramics powder increases.

Table 2. Reduction of Dioxins (PCDD/PCDF) Emission by EM Materials at the Gushikawa Municipal Waste Incinerator

	Dioxin Concentration			
	Fly ash		Residual ash	
Treatments	Concentration^z	Reduction	Concentration^z	Reduction
Control	75.5	-	0.0234	-
T1	20.5	72.848	-	-
T2	14	81.457	0.5385	-2201.3
T3	7.769	89.710	0.005	74.632
T4	6.582	91.282	0.0055	76.496
T5	3.178	95.791	0.0915	-291.03
T6	1.024	98.644	0.088	-276.07
T7	0.010	99.987	0.006	74.539

^{z} ng-TEQ/g

Note: T1, T2, etc.:Treatment1, Treatment2, etc.

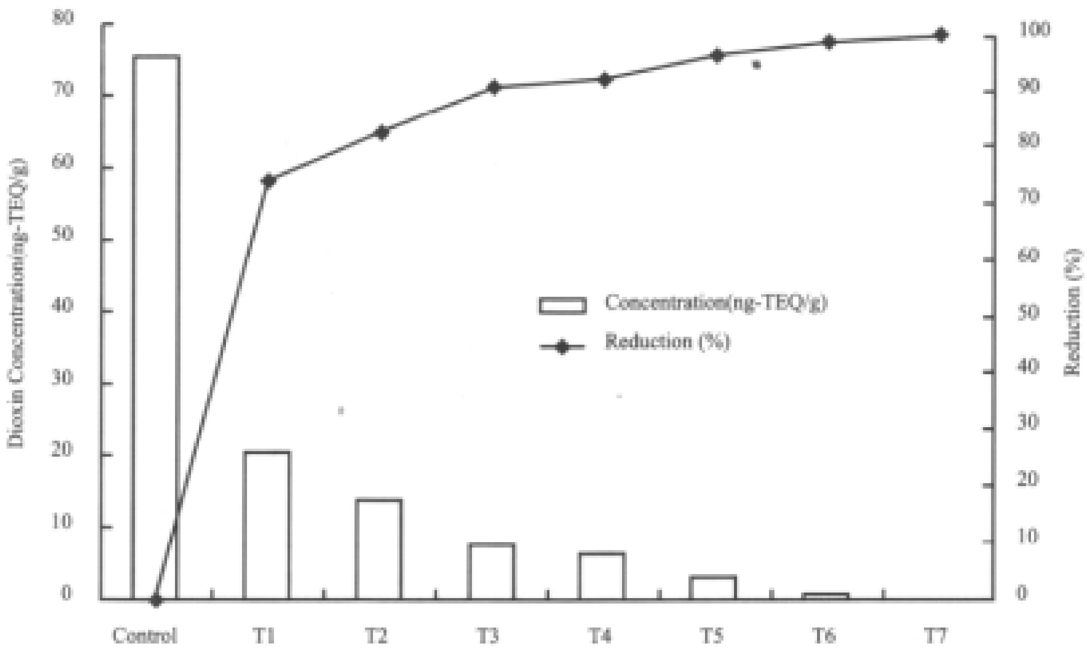

Fig 4. Reduction of Dioxins (PCDD/PCDF) Emission by EM Materials at the Gushikawa Municipal Waste Incinerator

Note: T1 T2 etc.: Treatment 1, Treatment 2 etc.

Fig 4 shows the measured dioxin concentrations of fly ash of the Gushikawa incinerator. The toxicity equivalency and the suppression rate are plotted on the ordinate, and the treatments on the abscissa. The EM treatments shows high suppression rates of dioxins, and thus the EM materials are found to be effective in dioxin control.

The Decomposition of Dioxins

Fig 5 shows changes in the activity of lignin peroxidase. The EM plot shows a higher activity than the control, especially on the third day.

Fig 6 shows changes in the laccase activity. Again, the EM plot shows a higher activity.

Fig 7 shows the laccase activity in the soil after 2 months. The 0.2 percent EM and EM bokashi plot shows the highest laccase activity. The 2 percent EM plot is the second highest, and the 0.2 percent EM plot comes next.

Table 3 shows the population of fluorescent *Pseudomonases* in each plot. We could not measure the population in the 0.2 percent EM and EM bokashi plot because of contamination. Fluorescent *Pseudomonases* were observed only in the EM plots.

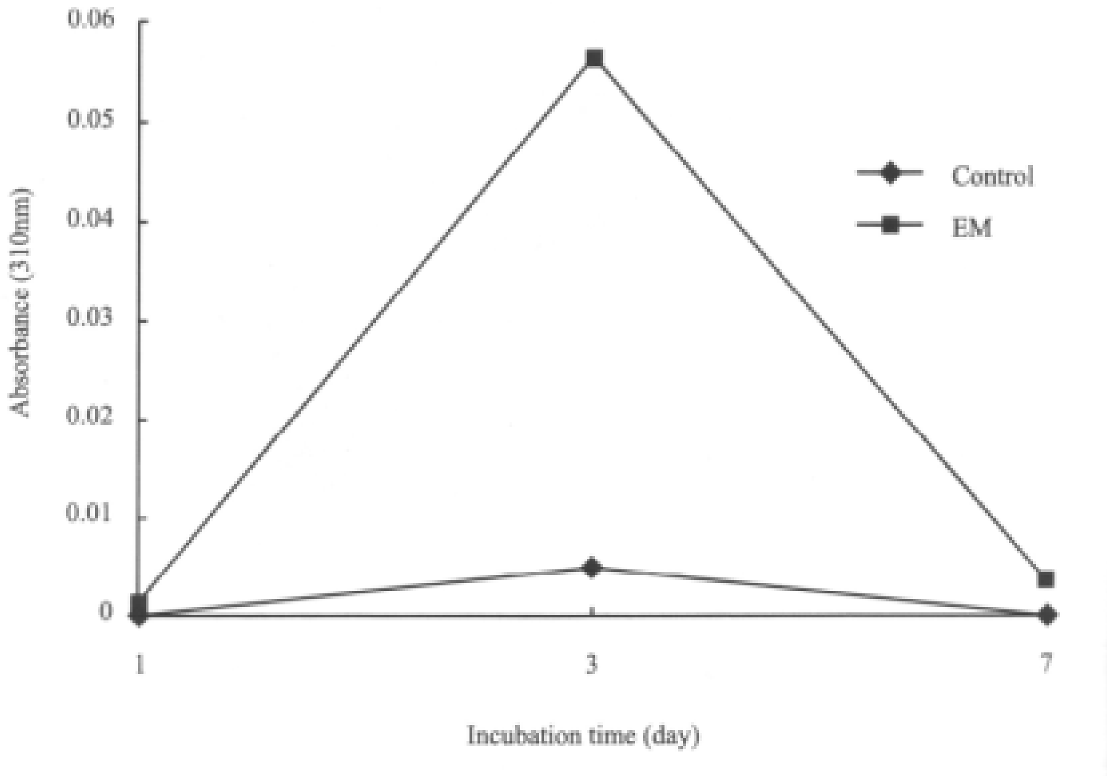

Fig 5. Change in the Activity of Lignin Peroxidase Using EM

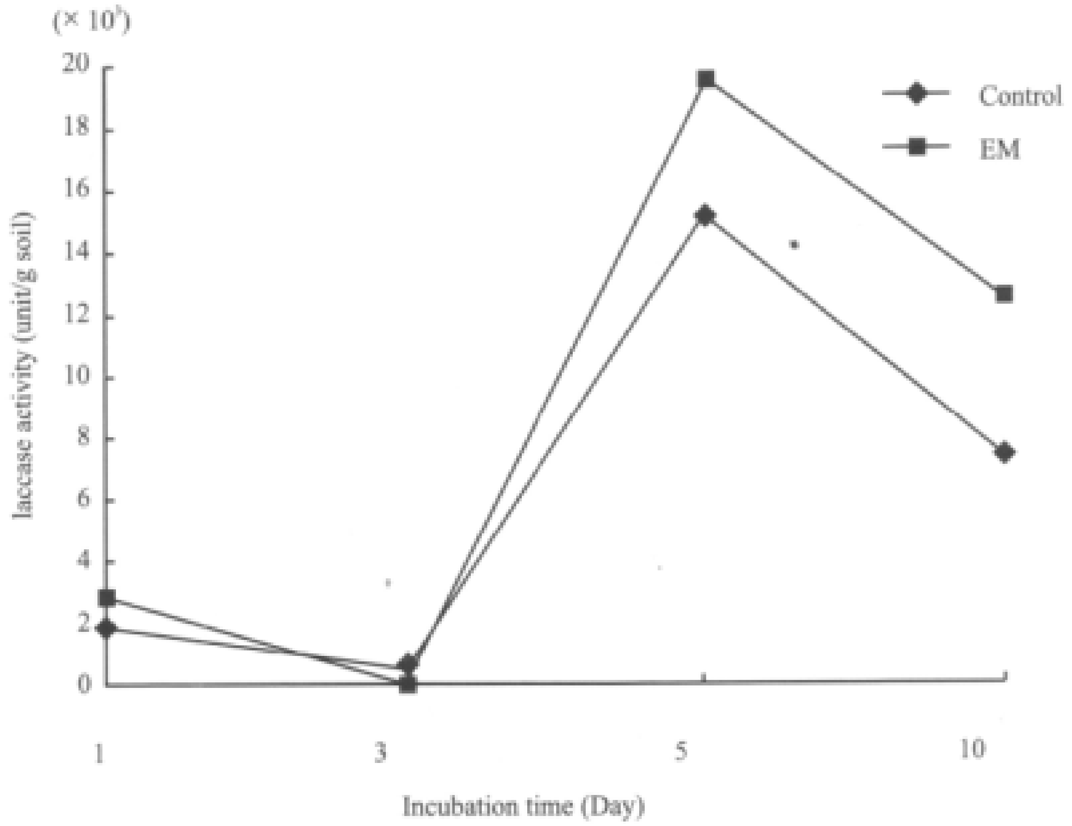

Fig 6. Change in the Activity of Laccase Using EM

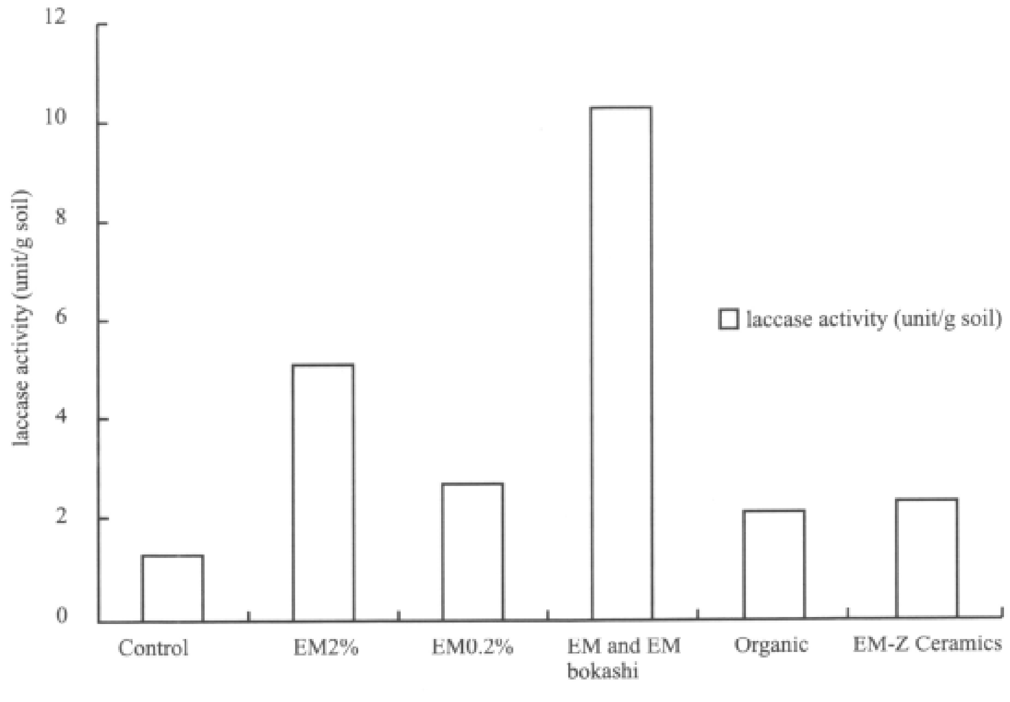

Fig 7. Laccase Activity in the Soil

Note: EM 2%: Inoculated with 2% Extended EM, EM 0.2%: Inoculated with 0.2% Extended EM, EM and EM bokashi: Mixed the EM bokashi and inoculated with 0.2% Extended EM, Organic: Mixed the material of EM bokashi without EM, EM-Z Ceramics: Mixed the EM-Z Ceramics powder

Table 3. Population of Fluorescent *Pseudomonases* in each Plot

Treatment	Fluorescent *Pseudomonases* sp. ($X10^3$)
Control	0
EM 2%	1.826
EM 0.2%	1.768
EM and EM bokashi	*[Z]
Organic	0
EM-Z Ceramics	0

[Z] This plot could not measure the population because of contamination

Note: EM 2%: Inoculated with 2% Extended EM, EM 0.2%: Inoculated with 0.2% Extended EM, EM and EM bokashi: Mixed the EM bokashi and inoculated with 0.2% Extended EM, Organic: Mixed the material of EM bokashi without EM, EM-Z Ceramics: Mixed the EM-Z Ceramics powder

Conclusion

In this study, we examined the effect of EM; EM-Z, and EM-Z ceramics powder, in suppressing dioxin production at municipal trash incinerators, one of the largest source of dioxin production. We also studied the possibility of EM as a method of bioremediation concerning the decomposition of dioxins.

The following results were obtained:-

- The injection of extended EM alone into the gas cooling chamber and the garbage pit was highly effective in reducing the dioxin content of fly ash. Furthermore, using EM-Z and EM-Z ceramics powder in addition to extended EM, the dioxin content of fly ash was reduced by more than 99.9 percent, and that of residual ash by more than 74 percent. Their actual dioxin contents were 10 pg/g and 6 pg/g, respectively. These values indicate that they can be recycled without any further processing, such as melting and solidification.

- The suppression of dioxin generation by EM-Z and EM-Z ceramics was initially thought to be brought by the combining of chlorine with minerals contained in the EM materials, whereas dioxin generation was highly suppressed when only extended EM, which does not contain minerals, was used.

- As a result of EM application a rapid increase of the diversity of microorganisms in the soil was observed. This was accompanied by a marked increase in the population of fluorescent *Pseudomonas*, which promotes the decomposition of dioxins. Furthermore, it was confirmed that the activity of lignin decomposing enzymes (lignin peroxidase and laccase), which decompose dioxins, increased largely.

- The use of EM materials greatly improved sanitary conditions: a sharp reduction of foul odors and harmful insects, such as flies and cockroaches. It also had a secondary effect of preventing machine rusting and reduced machine failures, resulting in a large reduction of maintenance cost and labor.

The use of EM materials for dioxin control is a unique technology, which is totally different from the existing dioxin control technologies. We have found that this technology is highly effective in suppressing dioxin production at trash incinerators, and that it can be used at low cost without modifying the operation of the incinerators. In addition, the use of EM not only reduces foul odors and controls flies and cockroaches in the trash pit, but also enables to recycle fly ash and residual ash and prevents rusting of machines. The use of EM at terminal waste dumping sites is expected to purify the wastes and to prolong the life of the sites by accelerating the decomposition of organic wastes.

We have also found that the use of EM and EM bokashi increases the activity of lignin-decomposing enzymes in the soil and the population of soil microorganisms, including fluorescent *Pseudomonases*, and diversifies the soil microflora. This fact indicates that EM can be used as an effective method of bioremediation of the soil environment.