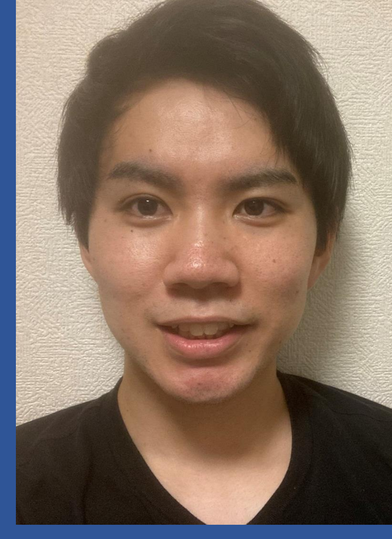
Stabilization of lead in municipal solid waste incineration fly ash using a combined treatment of hydroxyapatite from fishbone and a chelating agent



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Background：

In Japan, 2.92 million tons of incineration residues are discharged annually. Fly ash, one of the incineration residues, is required to be stabilized because it contains harmful heavy metals such as lead. However, the existing methods have various problems such as high treatment cost. And the current situation in Japan is that a large amount of fish sludge is generated every year. In addition, hydroxyapatite (HAP) contained in fish bones reacts with lead as follows to form insoluble phosphates.

$$Ca_5(PO_4)_3(OH) + H_2O \rightarrow 5Ca^{2+}(aq) + 3PO_4{}^{3-}(aq) + 2OH^-(aq)$$
$$5Pb^{2+}(aq) + 3PO_4{}^{3-}(aq) + 2OH^-(aq) \rightarrow Pb_5(PO_4)_3(OH) + H_2O$$

Objective：

To clarify the effect on insolubilization when fish bones and chelating agents are used together to stabilize heavy metals in fly ash. Three treatments, fish bone only, chelating agent only, and the combination of fish bone and chelating agent, were conducted to compare their effects on insolubilization.

Materials：

Fly ash | Fly ash taken from 4 cleanup sites in N, H, R and J cities

Fish bones | Mixing of fish species such as kanpachi, tobiko, eso, and aji

Killing agent | Pipelagin killing agent

Figure1 : Fish bone

Figure2 : N-city fly ash

Methods：

(1)Fish bone treatment

Fly ash(g)	Fish bone(g)	L/S	Setting time	
10	1	1.5	6,12,24(h)	3,7,14,28(d)

▼ After setting

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(2)Chelating treatment

Fly ash(g)	Chelate addition rate (%)	Pure water(ml)
10	0.5、 1、 1.5、 2、 2.5	3

▼ After 1h of setting (with lid open)

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(3)Combined treatment

▲ After 1h of setting (with lid open)

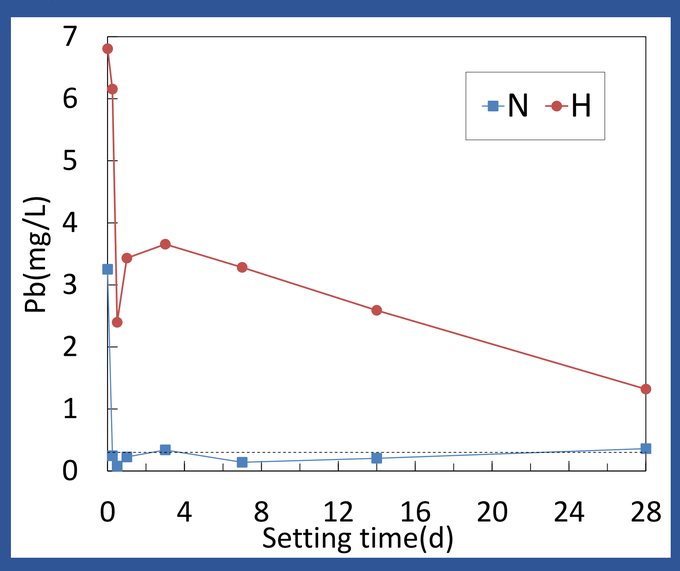
Chelate addition rate(%) | 0.5、 1、 1.5、 2、 2.5

▲ After 6h of setting (with lid close)

Fly ash(g)	Fish bone(g)	Pure water(ml)
10	1	15

Results & Discussion：

(1)Fish bone treatment



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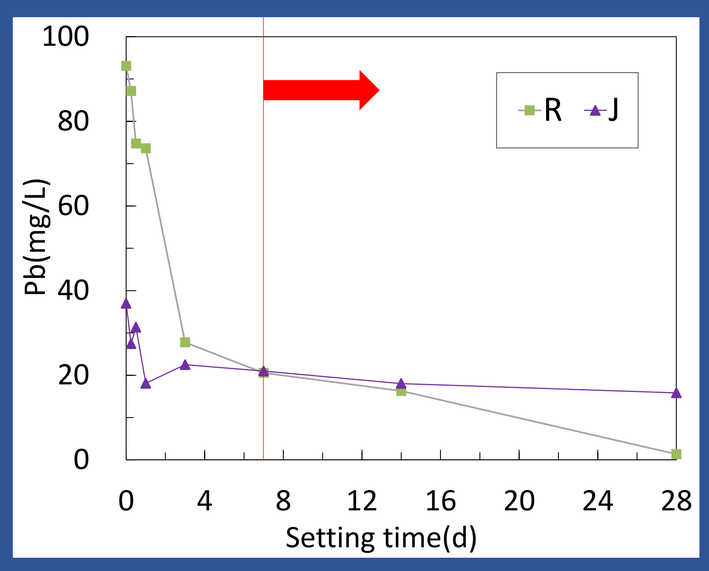
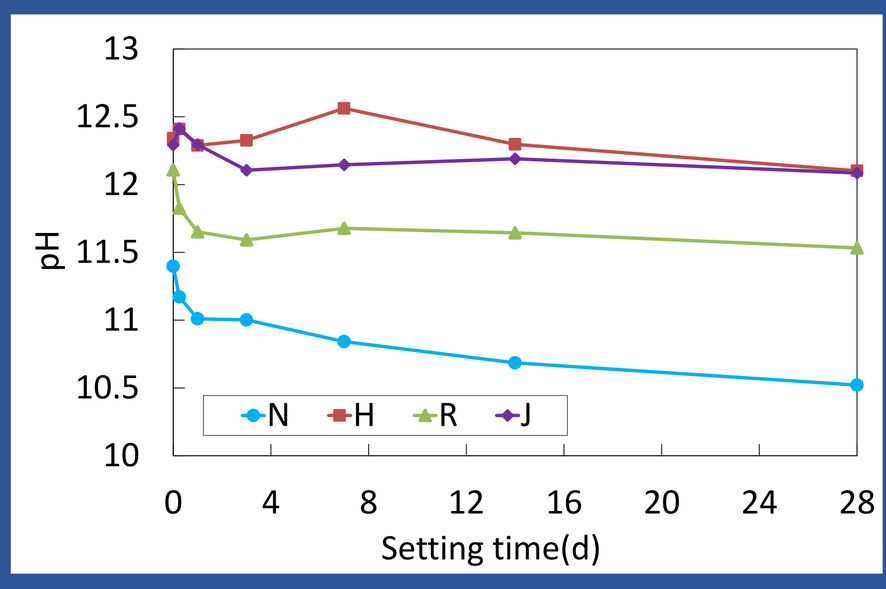


Figure3,4 : Relationship between setting time and lead concentration (left : N,H right : R,J)

- N city fly ash with the lowest initial Pb concentration of 3.25 (mg/L)
  →Satisfied the landfill standard value of 0.3 (mg/L) for Pb in 6h
- The leaching concentration of all fly ashes tends to decrease with time.
- After 7d, the concentration of R city fly ash became smaller than that of J city fly ash.
  →The ease of reaction may differ depending on the elemental composition of the fly ash.

▼ Focus on pH change and mass fraction of Cao



Mass fraction of Cao (XRF analysis)

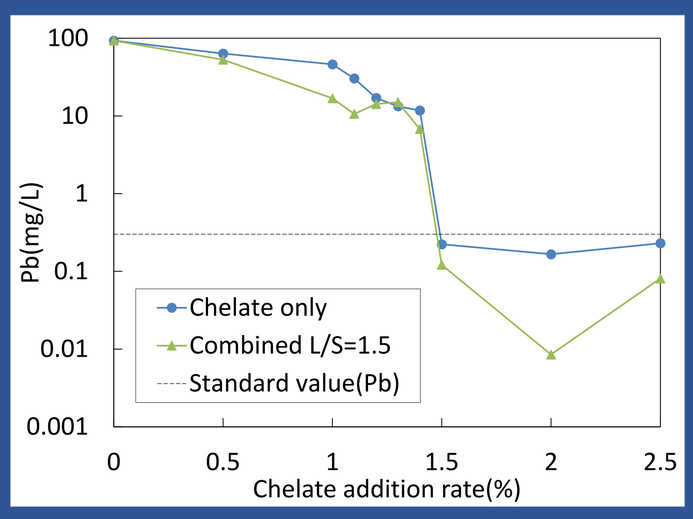
H > J > R > N

Figure5 : Relationship between setting time and pH

- Cao is hydrolyzed to CaOH, a strong base.
  →The smaller the mass fraction of Cao, the easier it is to lower the pH.

▶ Based on the results of N,H fish bone treatment, pH adjustment may promote stabilization within 1d(≦11.5).

(2) (3) Treatment with chelating agent



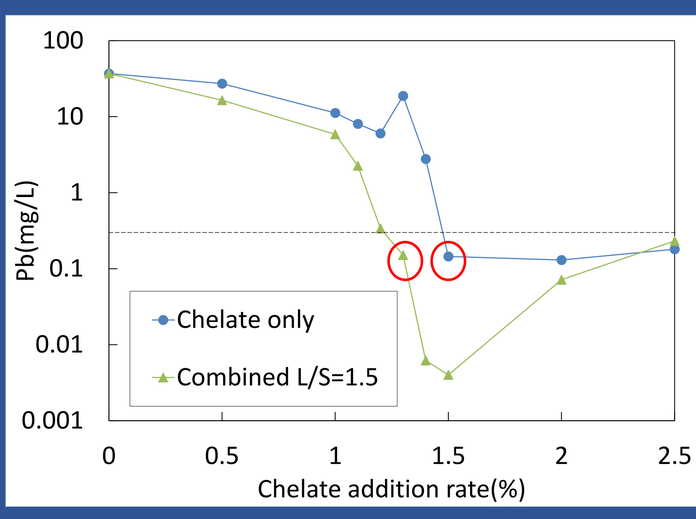


Figure6,7 : Relationship between chelate addition rate and lead concentration (left : R right : J)

- R-city fly ash | Removal rate difference of 30% when chelate addition rate is 1%.
- J-city fly ash |
  Chelating treatment alone → The standard value is satisfied at an addition rate of 1.5%.
  Combined treatment → The standard value is satisfied with an addition rate of 1.3%.

Conclusions：

- For fly ash with a low Pb leaching concentration of 3.25 (mg/L), fish bone treatment satisfied the standard value.
- It was suggested that the stabilization within 1d was accelerated by pH adjustment.
- Combined treatment was up to 30% more effective in insolubilizing than chelation alone.