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Phosphorus Leached from Incinerated Sludge of a Biological Excess Phosphorus Removal process

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INTRODUCTION

Removal of phosphorus can be accomplished by chemical, biological, and physical methods. Chemical precipitation using iron or aluminum salts or lime has commonly been employed for phosphorus removal. Biological processes has also been developed in recent years as alternatives to chemical precipitation. However, from any process, waste sludge containing phosphorus needs to be disposed. Since the nutrients regulation for wide areas such as Tokyo Bay were in force in 1992, treatment and disposal of waste sludge have become as important as removal of nutrients from wastewater. A study was carried out to investigate the leaching of phosphorus from incinerated sludge of a laboratory biological excess phosphorus removal (BEPR) process.

MATERIALS AND METHODS

The sludge was obtained from a laboratory BEPR process. Phosphorus was completely removed and the sludge phosphorus content was 7 to 9%. The sludge was first dried by a boiling water bath then incinerated by an electric muffle furnace for two hours.
For the test of investigating the effect of temperature during leaching and pH on leached phosphorus, the temperature of the furnace was fixed at 670°C. The temperature was controlled at 400°C, 670°C, 850°C, or 1000°C to examine its influence on leached phosphorus.
The ash was cooled to the room temperature, ground into fine particles by using mortars and pestles and mixed with deionized water. The concentration of ash mixture was about 1000 mg/L and total phosphorus was 150 to 320 mg/L. A magnetic stirrer was only provided in the experiment in which the temperature during leaching was varied.
The filtrate of sampled mixtures with a 0.22 micrometer filter was analyzed for both orthophosphate and total phosphorus (sum of polyphosphate and orthophosphate). Persulfate digestion method was used to convert phosphorus compounds to dissolved orthophosphate. Orthophosphate was determined by the stannous chloride method.

RESULTS

Effect of temperature during leaching

The effect of temperature during leaching was investigated by maintaining the mixture at 35°C and 80°C. In following description, orthophosphate and total phosphorus are presented as PO^{3-}_4-P and T-P. The results at 35°C and at 80°C are shown in Fig. 1 and Fig. 2.

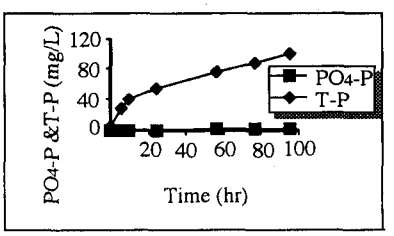

Fig. 1 Leached phosphorus at 35°C
(T-P in ash was 322 mg/L)

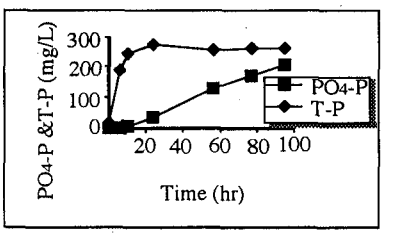

Fig. 2 Leached phosphorus at 80°C
(T-P in ash was 322 mg/L)

Leached T-P increased positively while leached PO^{3-}_4-P was only 1 to 2% of leached T-P at 35°C. This means that most of the leached phosphorus was in the form of polyphosphorus. About 31% of phosphorus in ash was leached at the end of the test. At 80°C, Leached T-P rapidly increased to higher than 280 mg/L within 20 hours while PO^{3-}_4-P was leached gradually. 82% of phosphorus in the ash was leached and 80% of the leached phosphorus was in the form of PO^{3-}_4-P as the final results. The results indicate that the difference of temperature resulted in two types of leaching;the ratio of leached PO^{3-}_4-P and T-P was much bigger in leaching at 80°C .

Effect of pH

To examine the effect of pH on phosphorus leaching, the starting pH was adjusted at 1, 7, or 11. The results are shown in Fig. 3.
Under both acidic and alkaline conditions, leached T-P reached over 90% of phosphorus in ash. However, increase in leached PO^{3-}_4-P was strongly dependent on pH. PO^{3-}_4-P/T-P reached 62% under acidic condition while it was only 8% under alkaline condition. Both PO^{3-}_4-P and T-P were leached least at pH of 7. About 33% of phosphorus in ash was leached and 6% of it was in the form of PO^{3-}_4-P. The results suggest that both extremely acidic and alkaline conditions may bring more chance for phosphorus leaching.

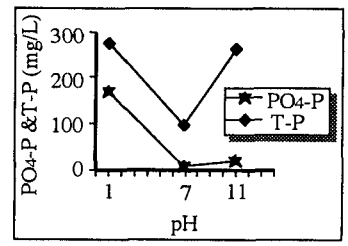

Fig. 3 Leached P with various pH
(T-P in ash was 286, 293, and 265 mg/L respectively with pH of 1, 7, and 11)

Effect of incineration temperature

Experimental results for ash with various incineration temperature are shown in Fig. 4. The highest leached T-P was observed with the ash incineratied at 400°C, probably due to incomplete incineration. The results also indicated that, the ratio of leached T-P to phosphorus in the ash increased with incineration temperature when it was higher than 670°C. In any case, leached PO^{3-}_4-P was less than 4% of leached T-P.

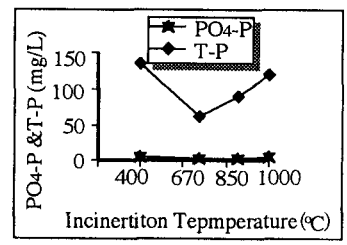

Fig. 4 Leached P with various incineration temperature
(T-P in ash was 153, 258, 226, and 249mg/L respectively with incineration temperature of 400°C, 670°C, 850°C, and 1000°C)

CONCLUSION

(1) The phosphorus leached directly from ash produced by incinerating BEPR sludge was mostly in the form of non orthophosphate, probably polyphosphate.
(2) The conversion of the non orthophosphate compounds to orthophosphate was very slow under abiotic mild conditions.
(3) The rates of the leaching and the conversion strongly depended on the conditions such as temperature and pH as well as on the temperature at which the sludge was incinerated.
Since the polyphosphate was reported to be hardly precipitated by aluminum, iron or calcium, the results of this study suggest that phosphorus by the BEPR ash disposal would run off directly into aquatic environments without being immobilized in soil.