Removal of Orthophosphate from Aqueous Solution Using Water Plant Alum Sludge

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1. Introduction

Phosphorus(P) is an essential nutrient for terrestrial and aquatic plants. P presents usually in a low concentration in the natural surface water and is a growth-limiting factor for algae and other aquatic vegetation. Its introduction into environment has been an environmental concern it can cause the eutrophication of receiving water body.

Utilization of microorganism and addition of chemicals such as alum $[Al_2(SO_4) \cdot 14H_2O]$ and ferric chloride ($FeCl_2$) are generally used for the reduction of P concentration in the wastewater treatment process. However, the chemical treatment for reduction of P concentration is believed to be a high cost method. Low cost P adsorbents such as alum sludge, limestone, and metal-organic complex were tested (Galarneau and Gehr, 1997; Petrovic and Kastelan-Macan, 1996).

Historically water plant sludge has been discharged to the raw source stored in lagoons on-site, or discharged to the sewer in Korea. However, increasingly stringent regulatory environment is making it difficult for utilites to continue these practices. Landfill of the sludge has been adapted recently as a disposal method. However, it contributes a significant portion of the cost for tap water supply. Recycling alum sludge has attracted the interest of environmental scientist and engineer. We report the P removal from capacity of a water plant alum sludge at different solution pH.

2. Material and Method

An Alum sludge was collected from Chungju water clarification plant and air-dried for characterization and for P adsorbent. The air-dried sludge was analyzed for texture mineralogy, pH, cation exchange capacity, organic matter content, calcium carbonate equivalent, free iron oxide content, and reactive Al content. P adsorption capacity of the sluge was tested at various solution pH with a column study and a batch study. Solubility of Al and organic carbon during column study was also determined by analyzing leachates.

3. Results and Disscusion

The alum sludge contained 2.7% of reactive Al dominated by amorphous form and had 4.5% of calcium carbonate equivalent. The other properties of the sludge was similar with those of normal Korean soils. (Table 1.) It had 27,000 mg kg^{-1} of maximum P adsorption capacity. P removal capacity of the of the alum sludge decreased with increasing solution pH. (Fig. 1.) However, there was a side effect in the P removal process such as dissolution of Aluminum (Al) and organic matter especially at acidic (pH < 4) and alkaline (pH > 7). (Fig. 2.)

Table 1. Pysical, chemical, and mineralogical characteristics of the alum sludge.

Dispersion			pH		O.C.	CCE	Extract. Al			DCB-extract. Fe	CEC	Mineral.
Sand	Silt	Clay	water	0.01M KCl			Exch.	Organ.	Amor.			
----------%----------					%		----------mg kg-1----------				Cmolc/ kg	
82.1	5.6	12.3	7.3	7.1	6.4	4.2	7.6	6615	21105	54.6	8.1	Ka, Mi, Qt

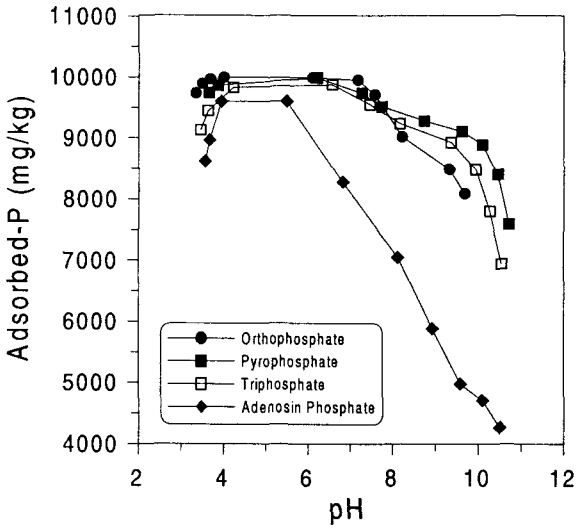

Fig. 1. Adsorption of P by the alum sludge at different solution pH.

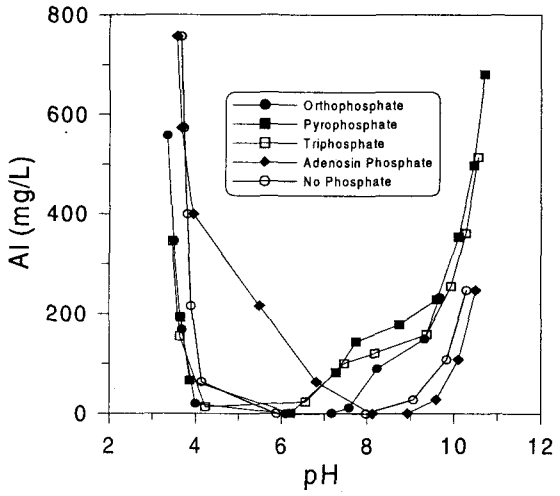

Fig. 2. Al solubility of the alum sludge at different solution pH.

Optimum solution pH for maximum P removal by the sludge with minimum side effect was 4. The sludge can treat 200 times of bed volume of pH 4 solution containing 30 mg l^{-1} P for reduction of P concentration to 1 mg l^{-1} at 15.6 cm an hour of flow rate. (Fig. 3.)

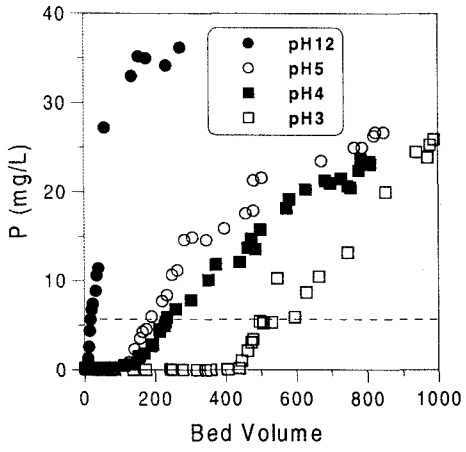

Fig. 3. P removal from aqueous solution by the alum sludge column (dashed line stands for P discharge limit).

5. References

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Key words: Alum sludge, column study, P removal rate, solution pH, pyrite.

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