

Phosphorus Removal from Wastewater

PHOSPHORUS CHEMISTRY

BIOLOGICAL PHOSPHORUS REMOVAL. The chemistry behind biological phosphorus removal is complicated, not completely understood, and is therefore not shown.

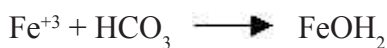
The principal science is the need for an anaerobic state sufficient to create volatile fatty acids (VFAs) such as acetic and propionic in advance of an aerobic (mixed liquor) zone. During anaerobic treatment some of the phosphorus is released into the wastestream, but during the subsequent aerobic treatment the released phosphorus and much more is taken up by PAOs, “phosphate-accumulating organisms” (bacteria).

CHEMICAL PHOSPHORUS REMOVAL. Chemical phosphorus removal processes are better understood and are shown in the equations that follow.

Iron salts. Iron is commercially available in three forms: ferric chloride (FeCl_3), ferrous chloride (FeCl_2), and ferrous sulfate (FeSO_4). All are corrosive and therefore must be carefully handled.

Theoretically, 1.8 pounds of iron is required to remove one pound of phosphorus (as P). However, to achieve low phosphorus concentrations, much more is required. Approximately 1 mg/L of alkalinity is consumed for each mg/L of iron added; as a result, the wastewater pH drops approximately 0.1 per 10 mg/L of iron added. Iron works over a wide pH range. Iron salt solutions contain some trace metals: up to 75-100 mg/L depending on the product.

Ferric chloride (FeCl_3)



@ 34.5% ferric chloride solution = 1.38 pounds of iron per gallon

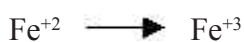
@ 40% ferric chloride solution = 1.62 pounds of iron per gallon

Ferrous chloride (FeCl_2)



@ 25% ferrous chloride solution = 1.18 pounds of iron per gallon

Ferrous sulfate (FeSO_4)



@ 16.3% FeSO_4 solution = 0.59 pounds of iron per gallon

@ 46.7% (Fe_2SO_4)₃ solution = 1.74 pounds of iron per gallon

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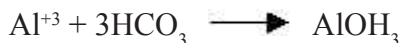
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Aluminum salts. Aluminum is commercially available in five forms: aluminum sulfate (alum) ($\text{Al}_2(\text{SO}_4)_3$), poly-aluminum chloride (PAC), aluminum chloride (AlCl_3), aluminum chlorohydrate, and sodium aluminate ($\text{Na}_2\text{Al}_2\text{O}_4$).

A simplified chemical equation illustrating aluminum precipitation of phosphorus is given below.

Theoretically, 0.87 pounds of aluminum removes one pound of phosphorus (as P). But, as with iron, much more will be required to meet low phosphorus limits.

The different aluminum forms consume differing amounts of alkalinity. Alum uses approximately 0.5 mg/L of alkalinity for each mg/L of aluminum added. Aluminum chloride uses 1 mg/l. PAC uses almost no alkalinity. The optimum pH is 6.5.



@ 48.6% $\text{Al}_2(\text{SO}_4)_3$ solution = 0.49 pounds of aluminum per gallon

@ 28% AlCl_3 solution = 0.59 pounds of aluminum per gallon

@ 50% PAC solution = 0.54 pounds of aluminum per gallon

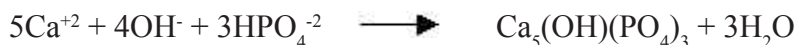
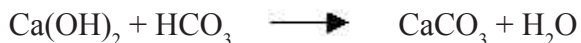
@ 70% PAC solution = 0.56 pounds of aluminum per gallon

@ 82% Aluminum chlorohydrate solution = 1.39 pounds of aluminum per gallon

@ 39% $\text{Na}_2\text{Al}_2\text{O}_4$ solution = 1.30 pounds of aluminum per gallon

Lime. The chemical equations for lime removal of phosphorus are given below. Lime dosage is more influenced by alkalinity than phosphorus concentration; the pH must be raised to 10.5 for phosphorus removal to occur. The amount of lime required is approximately 1.5 times the alkalinity concentration in mg/L.

Simplified stoichiometric equations are provided below.



Acknowledgement:

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