Precipitation and Fluidized Bed Reactors

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Precipitation (or "chemical dosing") is a basic method of dissolved phosphorus (phosphate) removal, and the main commercially-employed method for treating various types of wastewater (de-Bashan and Bashan, 2004). In this process soluble iron, aluminum, or calcium salts such as ferric chloride, aluminum sulphate, or calcium hydroxide are added to wastewater resulting in the release of metal cations that react with soluble phosphorus to form an insoluble precipitate (Pratt et al., 2011).

Yi et al. (2005) and Yi and Lo (2003) found phosphate could be effectively removed from a high-phosphate greenhouse wastewater using sodium hydroxide (NaOH) dosing, which increased pH and caused precipitation of calcium phosphate minerals. Generally, 90% removal of incoming phosphate could be achieved by dosing NaOH to achieve a pH>8. One concern with the precipitation method is the chemical cost. Hydrated lime (CaOH) may provide a cheaper alternative to NaOH, and our current research at the University of Guelph suggests it is highly effective and affordable. However, the main challenge with the precipitation method is that the precipitate formed is typically fine and difficult to separate from wastewater (Pratt et al., 2011). Ideally, if this material can be separated from wastewater via settling, filtration, and drying (Vanotti et al., 2007; Fernandez et al., 2012), it can be re-used as a fertilizer. If it is not separated, and is released back into the environment, it may again become soluble.

The phosphate crystallization method has been developed to remove this separation issue and create a more desirable (and easily handled) fertilizer product. Phosphate crystallization occurs in what are often called "fluidized bed reactors". In these reactors, water pH is increased and calcium or magnesium ions are added via chemical dosing (of NaOH, CaOH, etc.), to encourage formation of calcium or phosphate precipitates. To reduce the formation of fine precipitate, "seeding materials" such as sand or limestone are added to the reactor, which encourage the formation and growth of calcium or magnesium phosphate crystals on the seeding material surface. The contents of the filter, including the seeding material (the "fluidized bed"), is continuously mixed. Often, conditions in the reactor (pH, temperature, etc.) must be closely maintained to ensure crystal growth on the seeding material is maximized, and formation of fine precipitates minimized (Valsami-Jones, 2001).

These reactors typically achieve phosphate removal efficiency of around 80-95% (Seckler et al., 1996; de Bashan and Bashan, 2004; Le Corre et al., 2009) and often produce a useful fertilizer product. However, reactors available on the market (such as Crystalactor® and Ostara Pearl®) are typically expensive and highly controlled, and as such likely only economically viable for municipal and industrial plants treating very large volumes of water. Nurseries and greenhouses tend to produce comparatively small amounts of wastewater.

Despite the challenges with both, the similar concepts employed by phosphate precipitation methods and fluidized bed reactors will likely be useful for phosphate removal from greenhouse and nursery wastewater. Particularly, these methods may be useful for facilities where phosphate concentration in wastewater is >>20ppm, as at these high concentrations other treatment technology such as reactive media filters or constructed wetlands may not be able to effectively remove phosphate. Our lab at the University of Guelph is currently conducting more research on phosphate removal and the results will be available for growers shortly.

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