Comparison of lime and caustic addition for pH control on activated sludge settleability and plant performance – implications for the field


ABSTRACT

The performance of bioflocculation and settling of activated sludges is a common problem for many treatment systems. According to divalent cation bridging theory, research has shown that cations are important in floc formation and subsequent settling and dewatering properties. Specifically, divalent cations (such as Ca\(^{2+}\) and Mg\(^{2+}\)) have a positive impact on bioflocculation while monovalent cations (such as Na\(^{+}\)) can negatively impact bioflocculation. Therefore, the choice of chemicals used for pH control can significantly impact subsequent settling and effluent quality. The objectives of this research were to compare the impact of using either lime, Ca(OH)\(_2\), or caustic soda, NaOH, for pH control, and determine their effect on settling and plant performance of an activated sludge nitrification/denitrification system. The lime would control pH and also add Ca\(^{2+}\) which should benefit settling, while caustic addition would add Na\(^{+}\) to the solution which could potentially degrade floc properties according to the divalent cation bridging theory. Three laboratory scale reactors were constructed to mimic the five-stage, full scale Blue Plains wastewater treatment plant in Washington DC. Each reactor was fed effluent from the secondary treatment process and methanol was added as an external carbon source for denitrification. To maintain the pH, one reactor was fed lime (Ca(OH)\(_2\)), one reactor fed caustic (NaOH), and one reactor was used as a control with no base addition. The reactors were operated for three solids retention times and monitored for effluent quality and treatment performance as well as floc and settling characteristics. In addition, microbial communities were analyzed using molecular techniques to compare the microbial communities in the lab and full-scale systems. The reactor fed with Ca(OH)\(_2\) generally had better floc characteristics as well as effluent quality in terms of soluble COD, effluent total nitrogen, and supernatant turbidity, and had greater stability. The microbial communities were compared using polymerase chain reaction – denaturing gradient gel electrophoresis (PCR-DGGE) targeting on both universal bacteria and ammonia oxidizing bacteria (AOB). The results showed that the lime addition reactor had the most diverse bacterial community followed by caustic addition and the control. The control reactor also had a much less diverse population of AOBs which can contribute to stability problems. Interestingly, results from the full-scale system showed that greater AOB community diversity was generally associated with better plant performance and stability. The results from this research support the divalent cation bridging theory, in that Ca\(^{2+}\) addition generally provided improved treatment performance compared to the control with no cation addition, and the Na\(^{+}\) addition reactor. Therefore, the use of Ca(OH)\(_2\) for pH control would be the recommended choice for achieving better settleability, treatment performance, and
plant stability compared to NaOH addition. The results have significant implications for full-scale treatment plants that are considering potential chemicals to add to their treatment processes, in that divalent cation based alternatives are a better choice when they are available.