

Investigating reaction mechanism of the solubilization of P from runoff sediments using low molecular weight organic acids

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Ensuring that there is a continuous supply of phosphorus (P) is critical for continued food security into the later decades of the twenty-first century. P, which is currently a mined and nonrenewable resource, is used in agriculture to boost crop yields. The recovery of P from agricultural runoff sediment is currently seen as a potential new source for P for reuse in agriculture. Therefore, we propose the development of a phosphate solubilizing fungi (PSF)-mediated bioextraction process to recover P from agricultural runoff sediments. Aiding in the development of the proposed process, this study determined the solubilization kinetics and speciation dynamics of the solubilization of P from runoff sediments using low molecular weight organic acids (LMWOAs). The LMWOAs used in this study, which were acids of interests determined by a previous study¹, were 60 mM citrate and a 60 mM mixture of oxalate and citrate in a 2:1 molar ratio. Sediment from Woods Lake in Kalamazoo, Michigan was used due to the lakes known eutrophic qualities. Kinetic and dynamic properties of the solubilization process were measured at five time points (0, 30, 60, 90, and 120 minutes) using a sequential sacrificial sampling scheme and using previously determined optimal process conditions¹; initial pH of 3.45 and 12.5% sediment loading. Solubilization kinetics and speciation dynamic results from this study will be used to gain a better understanding of prevailing system mechanisms.

Kinetic results show that the citrate reagent and the citrate and oxalate mixture reagent were able to solubilize P from sediment comparably; solubilizing approximately 1800 and 1700 mg P per kg of sediment respectively. However, they showed different kinetic results in the changes of solution pH and organic acid concentration in solution. The differences between the two extraction processes is also reflected in the studies dynamic results. The 2:1 oxalate citrate reagent mixture primarily solubilized P from the inorganic sediment bound P, specifically the Fe-bound P. The citrate reagent solubilized P also from primarily the inorganic P but solubilized inorganic P species in similar proportions, resulting in the distribution of sediment inorganic P species remaining similar throughout the solubilization process. These findings are contradictory to many studies that found that citrate is primarily successful at liberating P from metal oxides such as Fe-bound P, and is less successful at releasing P from species such as Ca-bound P. These differences in kinetic and dynamic results suggest that different mechanisms of P solubilization took place in each system to achieve the similar extent of P solubilization. Runge Kutta analysis is being used to determine theoretical reaction rate constants for each of the solubilization processes in order to determine which mechanism of P solubilization are playing a dominant role in each P extraction process. In the future the findings of this study will aid in the development of the proposed (PSF)-mediated bioextraction process by allowing the development

of system models and process simulations.

Mondala, A., Sheilds, S., Gaviglio, K., & Kaczmarek, S. (2017). Influence of Fungal Low Molecular Weight Organic Acids on Extraction and Speciation of Runoff Particulate-Associated Phosphorus: Implication for Nonpoint Phosphorus Recovery and Beneficial Reuse. *Environmental Progress & Sustainable Energy*, 36(6), 1810-1816.