IRON TRANSPORT AND REMOVAL DYNAMICS IN THE OXIDATIVE UNITS OF A PASSIVE TREATMENT SYSTEM: A FIVE-YEAR PERFORMANCE EVALUATION[1]

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Abstract: Performance evaluation of the preliminary oxidative units of the Mayer Ranch Passive Treatment System (Tar Creek Superfund Site, Commerce OK) reveals an average removal of 17.5 g $m^{-2}day^{-1}$ iron oxyhydroxides within Cell 1 (73% removal efficiency; 26,905 kg/year), 95% (33,547 kg/year) for the three oxidative units, and 99% (33,696 kg/year) for the system over five years of operation (2009-2013). Performance nearly meets design expectations of 20 g $m^{-2}day^{-1}$ iron for Cell 1, and the average iron export of 0.51±0.43 mg/L from Cell 6 is satisfactorily below the 1 mg/L guideline for iron loading of surface waters. However, the oxidative unit demonstrates variability in removal efficiency based on seasonality and storm events which impact iron oxidation and sedimentation mechanisms. Cell 1 demonstrates attenuated removal efficiency in December through February with an average water temp = 6.5°C, yet removal inefficiency is mitigated by the surface flow wetlands (cells 2N/2S) in design series. Storm events transport a significant amount of iron oxides in excess of standard operational baseline values ($p = 0.05$; t test), yet the amount transported does not correlate to rainfall intensity. Any rainstorm with an intensity greater than 0.25 cm/hr mobilizes iron oxides for transport due to disruption to the settling of iron flocs rather than the resuspension of sequestered materials. The high frequency of low intensity rain events (0.25-0.99 cm/hr; 6 per month on average) has the largest contribution to iron mass loadings due to storm-induced transport dynamics in comparison to the total mass transport induced by moderate (1.00-2.99 cm/hr; 1 per month), high (2.00-2.99 cm/hr; 1 per month), and extreme (>3.00 cm/hr; 2 per month) events combined. Iron accumulation within the oxidative unit was found to lack bathymetric uniformity as removal and deposition of material has been measured in the initial section of the cell rather than being distributed uniformly. Accumulation and characterization of the physical properties of iron oxyhydroxides from discrete core samples yield bulk phase properties for goethite, with low crystallinity (<20% in Cell 1, <70% Cells 2N/2S), low organic matter (<4%), and average particle size of 11-19 microns (hydrated via laser diffraction). A reduction in the design hydraulic retention time of Cell 1 was confirmed (7.7 days design; 5.4 days in 2015) via rhodamine tracer study.

Additional Key Words: iron oxidation, solids transport and accumulation, Tar Creek

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