Biogeochemical Processes for Treating Oil and Gas Produced Waters Using Hybrid Constructed Wetland Treatment Systems

Castle, James [1]; Rodgers, John H.[2]; Alley, Bethany [2]; Spacil, Michael [2]; Beebe, Alex [1]; Pardue, Michael [1]; Song, Yun [1] (1) Environmental Engineering & Earth Sciences, Clemson University, Clemson, SC. (2) Forestry & Natural Resources, Clemson University, Clemson, SC.

Waters involved in oil and gas drilling and production may require renovation prior to discharge or reuse. Produced waters investigated in this study include waters from shale gas, coalbed methane, tight gas (sands), and conventional oil and gas. Constituents that may be present in produced waters include oil and grease, metals, metalloids (e.g. selenium and arsenic), and chemicals used in drilling and completion fluids. Preferred biogeochemical pathways for treatment were selected based on biogeochemical theory, previous studies, and specific constituents identified in each type of produced water. Pilot-scale constructed wetland systems were designed and constructed with unique combinations of sediments, plants, size, and other design parameters to produce conditions that promote preferred biogeochemical treatment pathways (e.g. oxidation, reduction, sorption). Explanatory parameters (e.g. pH, redox potential, temperature, plant density) were measured to assess treatment readiness of each system and were monitored during the experiments. Treatment performance data indicate that pilot-scale systems are effective in achieving targeted concentrations of oil and grease, metals, and metalloids. Factors such as excessive temperature, salts (e.g. chlorides, boron), and very high oil and grease concentration can require “hybrid” constructed wetland treatment systems to achieve the treatment performance goals. These “hybrid” systems involve additional steps or pathways to treat constituents that are deleterious to sustained performance of constructed wetlands or cannot be reliably treated in constructed wetlands. Data from the pilot-scale systems demonstrate that removal rates and extents for targeted constituents in simulated produced waters are achievable by constructed wetland treatment systems designed based on specific biogeochemical treatment pathways. Results indicate that a variety of organic and inorganic constituents in produced waters can be treated to meet performance criteria for discharge or reuse in many situations.