Extreme redox oscillations in fresh water re-flooded acid sulfate soil wetlands: Effects on Fe, S and trace metals speciation

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Fresh water re-flooding of former acid sulfate soil (ASS) wetlands is a remediation approach which generates alkalinity and leads to the reformation of various Fe(II) and reduced inorganic sulfur (RIS) species in surface soil layers. However in highly dynamic climate regimes, the newly formed RIS and Fe(II) species, are likely to be vulnerable to oxidation during dry periods, thereby generating substantial amount of acidity[1]. However, the kinetics and magnitude of acid generating reactions and competing acid neutralisation reactions during a dry episode are poorly constrained. In addition, the initial first flush of flooding following a dry period can mobilise a substantial amount of acidity and metals to the adjacent water bodies, prior to eventual re-establishment of reducing conditions. Effective management of these wetlands requires clear insights into the redox cycling of Fe, S and acidity within sediments and surface waters during wet-dry periods. In the first phase of the study, ten surface soil samples from two freshwater re-flooded ASS wetlands and subjected to oxidative incubation for 130 days. During the oxidative incubation, soil pH decreased rapidly by ~2–3 units, whilst titratable actual acidity increased. RIS species decreased over time whilst the reactive pool of Fe (III) minerals (e.g. schwertmannite) increased. Importantly, the highest rates of acidity generation occurred within the first 20 days, suggesting that surface soil layers in these remediated wetlands are prone to rapid acidification during future droughts. In the second phase of the experiment we re-flooded selected oxidised sediments from both wetlands under anaerobic conditions, for 84 days. During early stages of the re-flooding experiment (up to 7 days) we observed the initial pulse of acidity and metals, followed by quite rapid (4-6 weeks) reversion to anaerobic /sulfate-reducing conditions which ameliorates acidity and sequesters Fe / S and trace metals. Although management of these wetlands in a highly dynamic climate such as Australia will remain challenging over the long term, knowledge of the timing of redox oscillations and the associated changes in water geochemistry can be helpful to mitigate of risks to downstream estuarine water quality.

[1]Johnston, S.G., Burton, E.D., Aaso, T., Tuckerman, G., 2014. Sulfur, iron and carbon cycling following hydrological restoration of acidic freshwater wetlands. Chemical Geology, 371(0): 9-26.