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Using ground-based geophysics to rapidly and accurately map sub-surface acidity

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Globally, large areas of coastal and estuarine floodplains are underlain by sulfidic sediments and acid sulfate soils (ASS). These soils can be environmentally hazardous due to their high acidity and large pool of potentially mobile metals. The floodplains are characterised by high spatial and temporal heterogeneity. On coastal floodplains, ASS are of moderate to high salinity, with salts derived mainly from either connate marine sources or oxidation of biogenic sulfides and the subsequent increases in soluble ions (e.g. SO42-) and acidity that follow oxidation. Enhanced acidity also increases the mobilisation of pH-sensitive trace metals such as Fe, Al, Mn, Zn and Ni and contributes to increasing apparent salinity.

Ground-based geophysics using electromagnetic (EM) induction techniques have been used successfully and extensively to rapidly map soils for salinity management and precision agriculture. EM induction techniques measure apparent soil electrical conductivity (ECa), which is a function of salinity, clay content, water content, soil mineralogy and temperature to determine the spatial distribution of sub-surface conductivity. In this study, we used ECa as a proxy to map the surface and sub-surface spatial distribution of ASS and associated acidic groundwater. Three EM instruments were used, EM38, DUALEM-421 and EM34, which focus on different depth layers, in a survey of a coastal floodplain in eastern Australia. The EM surveys were calibrated with limited soil sampling and analysis (pH, EC, soluble and exchangeable salts and metals, particle size and titratable actual acidity (TAA)).

Using fuzzy k-means clustering analysis, the EM38 and elevation data, from a digital elevation model, clearly identified three classes in the near-surface (0-2m) layers: i) levee soils, ii) fluvial sediment capping and iii) ASS (Fig. 4). Increasing the number of classes did not alter the classes identified. Joint inversion of the DUALEM-421 and EM34 data also identified sulfuric and sulfidic layers (oxidised and reduced ASS), acidic shallow groundwater, and features of the infilled palaeovalley (Triantafilis et al. 2012).

Accurate soil maps with high spatial resolution are required to develop appropriate management strategies for ASS and other soil types associated with low-lying coastal floodplains. The classes identified in this study form sensible soil management zones across the study area related to defined geomorphic units. EM data can then be used to build below-ground 3D models to inform practical targeted management strategies on coastal floodplains to improve land and water quality outcomes.

References

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