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Regional distribution trends and properties of acid sulfate soils during severe drought in wetlands along the lower River Murray, South Australia: Supporting hazard assessment

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ABSTRACT

Acid sulfate soil materials, if disturbed or influenced by lowering of water levels, can have serious environmental impacts, that include harm to ecosystems and leaching of acidity and metals into water bodies. Low river flows from 2007 to 2010 due to an unprecedented drought, resulted in 71 wetlands along 210 km of the River Murray below Lock 1 in South Australia becoming dry, exposing the normally subaqueous soils in wetlands and, in some instances, causing severe soil acidification. The aim of this study was to provide an understanding of the nature and distribution of acid sulfate soils for hazard assessment and to guide management. Substantial soil survey and acid sulfate soil data from multiple studies were consolidated, interpreted, and described in a regional and local context. Pedological, soil chemical and geomorphology data showed that acid sulfate soils with hypersulfidic (potential to acidify to pH ≤ 4) and sulfuric (pH < 4) materials with higher acidification hazard were more dominant in downstream wetlands. A trend observed in the chromium reducible sulfur data was likely linked to regional fluvial erosion and deposition processes because the transition coincides with the river landscape changing from a linear gorge valley upstream to downstream open floodplain areas.

1. Introduction

Acid sulfate soils occur naturally, and when left undisturbed do not typically cause harm. However, if disturbed or influenced by lowering of water levels the oxidised soils can then have a detrimental impact on the environment and infrastructure. Serious consequences relate to soil and water acidification (Dent and Pons, 1995), de-oxygenation of surface water (Sullivan et al., 2002), emission of foul-smelling gases (H_2S, organo-S compounds) (Lamontagne et al., 2004) and the release of heavy metals and metalloids that may be toxic (Shand et al., 2010).

Traditionally, acid sulfate soils have been identified and studied in some detail in coastal locations. Recently, significant areas of inland acid sulfate soils have been recognised, e.g. 157,000 km^2 of inland acid sulfate soils were estimated to occur in Australia, substantially greater than the 58,000 km^2 estimated on the coast (Fitzpatrick et al., 2008a).

The wetlands and floodplains of the Murray–Darling Basin were identified as one of the top 10 vulnerable ecosystems in Australia at risk to tipping points (Laurance et al., 2011). They are approaching environmental thresholds particularly when there are reduced water flows and levels (Colloff and Baldwin, 2010) with vulnerable habitats containing sulfidic soils (Laurance et al., 2011; Hall et al., 2006). In this region, inland acid sulfate soils are identified containing sulfidic, sulfuric and monosulfidic black ooze materials (Fitzpatrick et al., 2008a,b,c, 2009; Hall et al., 2006; Lamontagne et al., 2004).

The construction of barrages in the vicinity of the mouth of the River Murray was completed in the 1940s. They generally maintained water levels in the lower River Murray up to Lock 1 at a level that kept the wetland areas covered with water and since then has been the normal condition. This led to more continuous reducing conditions in wetlands caused by permanent inundation and a build up of sulfidic material in wetlands greater than during the 'natural' wetting-drying regime (Fitzpatrick et al., 2009).

A decade of drought (The Millennium Drought of SE Australia) resulted in significant decreases in river flows over Lock 1, particularly between 2006 and early 2010. This resulted in unprecedented lower river pool levels, from pre-drought of about +0.75 m AHD (Australian Height Datum) to below sea-level of between −0.5 and −0.8 m AHD inland to Lock 1, causing disconnections of water between floodplain wetlands and the river channel (Mosley et al., 2014a). From April 2010, river flow and pool levels began to return to normal.

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Wetlands with acid sulfate soils along a 210 kilometre length of the lower River Murray in South Australia from below Lock 1 near Blanchetown down to Wellington (Fig. 1) where the river enters the lower lakes were severely impacted by low water levels. Limited information was available on the distribution, characteristics and processes of acid sulfate soils throughout this region apart from the work carried out on 14 wetlands (Fitzpatrick et al., 2008b,c). Given the concerns identified in these early studies, combined with extensive drying of wetlands below Lock 1, a further 57 wetlands were surveyed to provide a comprehensive and standardised dataset for the wetland acid sulfate soil properties (Grealish et al., 2011). During the time of the lowest river levels, 68 of 71 wetlands studied along this length of the river were dry, exposing acid sulfate soil materials that would normally be covered with water.

Wetland environments impact on the water quality of the River Murray. The river provides a number of ecosystem services including drinking water for Adelaide City (population about 1.2 million) and several regional towns, water for irrigation, recreation, and habitats for flora and fauna (e.g. rare fish species, waterbirds, frogs). The acid sulfate soil data from assessment studies (Grealish et al., 2011; Fitzpatrick et al., 2008b,c) were interpreted at that time to identify those wetlands that may pose a risk. The nature of the soil materials and their proportion in the wetland were evaluated and allocated to one of five hazard categories. A cursory observation of these results indicated that a higher hazard was more prominent in the wetlands at the down-stream (i.e. between Mannum and Wellington) end of the river section compared with those wetlands further up-stream (Grealish et al., 2012) as shown in Fig. 1.

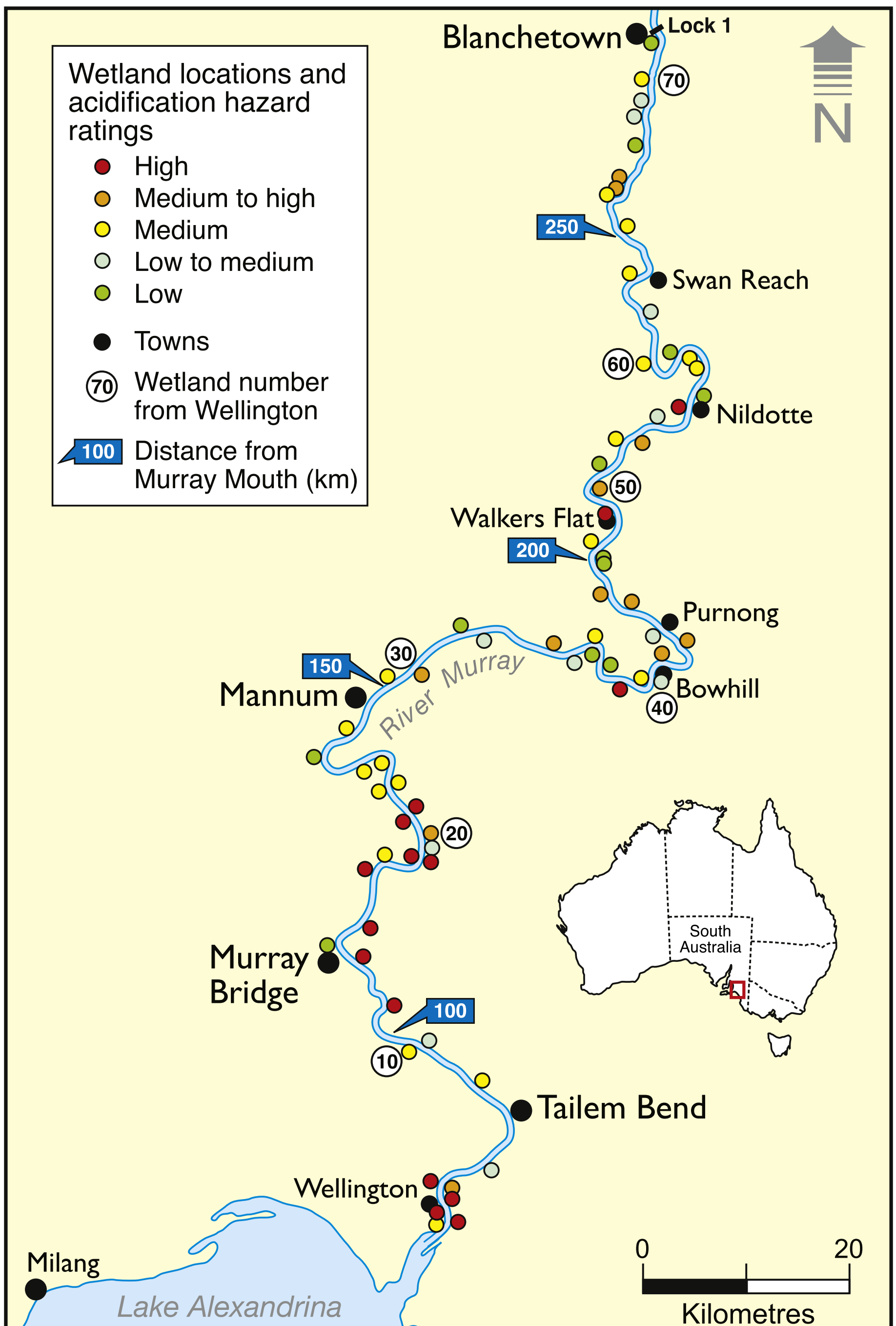

Fig. 1. Map showing wetland locations and their acidification hazard rating.