A systematic analysis procedure incorporating the chip-tray incubation method for the hazard assessment of Acid Sulfate Soils in the Murray-Darling Basin

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Introduction

Acid Sulfate Soils (ASS) is the name given to those soils containing soil materials affected by iron sulfide minerals. These soils either contain sulfuric materials or have the potential to generate sulfuric materials in amounts that have an effect on soil pH. The Murray-Darling Basin (MDB) is currently experiencing the worst drought conditions in recent history. Declining water levels have caused non-acidic soils with previously accumulated sulfide minerals in wetlands, creeks, and lakes to be exposed to the atmosphere and undergo oxidation reactions, which generates sulfuric material and can turn these soil material acidic (pH < 4). Following their oxidation, ASS can cause detrimental impacts on the surrounding ecosystem in a variety of ways.

The MDB ASS Risk Assessment Project, initiated by the Murray-Darling Basin Authority (MDBA), aims to assess the spatial extent of, and risks posed by these hazards in wetlands of environmental significance, as well as those that could pose a risk to surrounding waters. These wetlands were subjected to a tiered assessment process, whereby wetlands were screened through a desktop assessment stage, followed by a rapid on-ground appraisal (RAP), and then detailed on-ground assessment if results of previous stages indicate an increased likelihood of occurrence of ASS. More than 19,000 wetlands underwent desktop assessment, and this identified approximately 1,450 wetlands considered to have a higher likelihood of ASS occurrence which required further assessment. The RAPs were performed by state and regional NRM agency staff.

During the RAP, wetland soil samples were collected from up to 3 different soil profiles within a wetland representing a toposequence. As part of the RAP these soil samples were then submitted for incubation analysis. pH incubation is a method whereby ASS are kept in a moist state and exposed to the atmosphere allowing them to undergo oxidation reactions in an attempt to simulate the natural acidification behaviour of the soil. If the soil in question is hypersulfidic the pH will reduce substantially during incubation to a pH < 4, as a result of sulphide oxidation and hence pose an acidity hazard (Sullivan *et al.* 2009a,b). The use of pH incubation for classification is often considered preferable to other methods, such as peroxide addition, because the result of the experiment is arguably more representative of what would be expected to occur in the field (Dent 1986).

A total of 1,329 wetlands from South Australia (SA), New South Wales (NSW), Victoria and Queensland (QLD) were assessed resulting in over 8,000 soil samples being submitted for pH incubation analysis. The large number of samples triggered the requirement for, and allowed the testing of, a new systematic analysis procedure.

Methods

The analysis procedure and associated pH incubation method using plastic chip-trays (Fitzpatrick *et al.* 2010) for the analyses of MDB soil samples is illustrated in the flow chart outlined in Figure 1. It illustrates the systematic order in which observations and analyses were conducted. Sections of the flow chart are examined further under subheadings below.

Sample collection and preparation

Soil was collected at up to 3 depths (0-5cm, 5-30cm, and >30cm) for up to three different profiles selected along a toposequence and placed into chip-trays (Fig. 2). The samples were then moistened to initiate incubation before posting to the laboratory. The construction of the chip-tray was found to be ideally suited to prevent excessive desiccation during the incubation period, whereby a slightly moistened sample was found to remain at or slightly below field capacity for periods up to 9 weeks without attention.

Basic morphology and moisture level

A simplified soil morphology description was collected for each sample. Descriptors included moisture status, colour, consistence, texture, and any other comments. Because a high sample throughput was essential for this project each morphology descriptor was refined to a limited number of choices. To further assist with sample throughput, a virtual tick sheet was created in Visual Basic for Applications (VBA), which allowed the user to rapidly input morphology data by simply clicking on the appropriate buttons. Albeit limited, the simplified soil morphology description and virtual tick sheet allowed the capture of key morphology information that otherwise would not have been collected.

XRD analyses of selected salt efflorescences

Salt efflorescences are often observed on the surface of chip-tray soil samples once they have dried at room temperature. Analysis of these efflorescences (usually sulfate containing) by XRD can be used to provide further information to help characterise the soil.

pH incubation

All soil samples, except for soil surface efflorescences, were submitted for pH incubation analysis. The soil sample was homogenised by mixing with a glass rod while deionised water was added until an approximate soil-to-solution ratio of 1:1 was achieved. These steps and the pH measurement take place in the chip-tray.

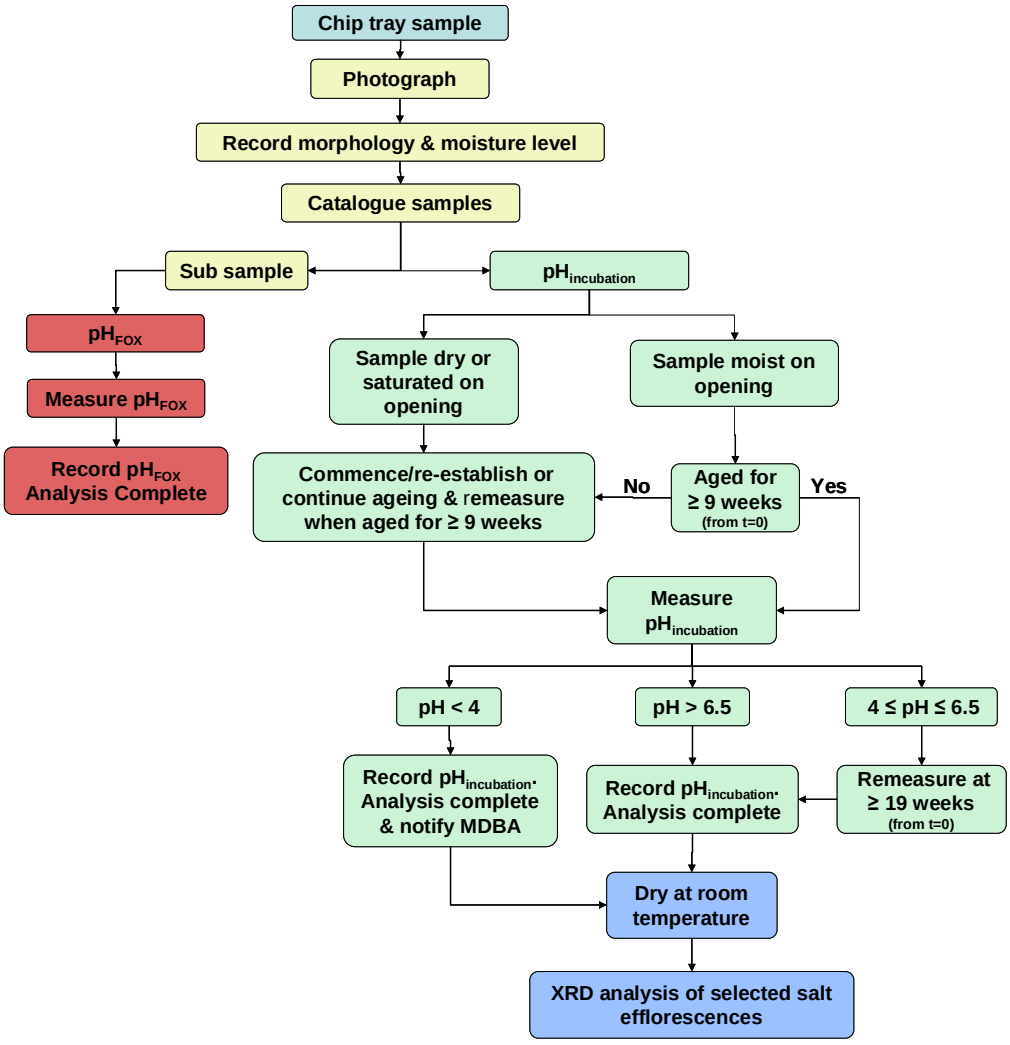

Fig. 1. Flow chart of the analysis procedure and pH incubation method of chip-tray samples

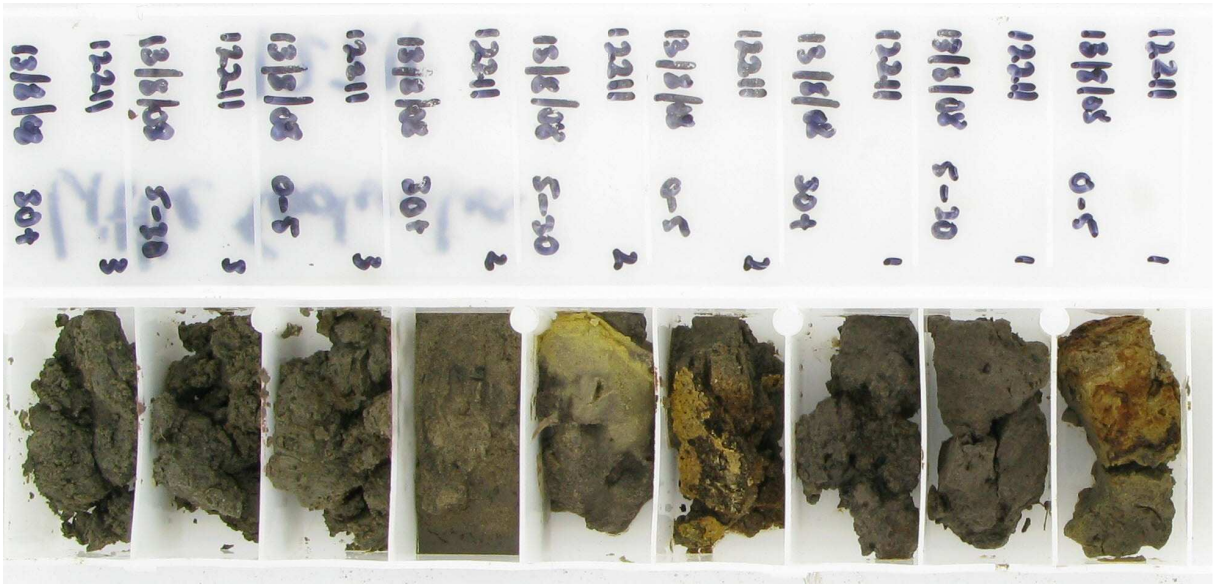

Fig. 2. Photograph of plastic chip-tray filled with soil from a wetland in South Australia.

If a sample was found to be moist on receipt it was stored and allowed to undergo incubation for ≥ 9 weeks starting from the date of collection. If a sample was found to be dry or the appropriate amount of water was added or subtracted before incubating the sample for ≥ 9 weeks starting from that days date. If a soil sample was found to acidify to a pH < 4 after an incubation period of 9 weeks or more, that sample was classified as hypersulfidic material and analysis for that sample was considered complete. Additionally, if a soil sample did not acidify over the same period to a pH below 6.5 analysis was also considered complete. In the case that the pH of a sample lies between a pH of 4 and 6.5 ($4 \leq pH \leq 6.5$) incubation is continued for a further ≥ 10 week period (i.e. total incubation period ≥19 weeks) before pH re-measurement. For these samples, analysis was considered complete after this second incubation period. Samples were discriminated this way because it was reasoned that if after ≥ 9 weeks of incubation the pH of a sample did not drop below a pH of 6.5 the sample will not age to a pH < 4 given more time. This assumption was based on the fact that if a sample has a pH of > 6.5 it still contains an amount of acid neutralising capacity (ANC) and, hence, has ability to buffer acidity and resist changes in pH.

Ideally sample analysis would continue until a stable pH was obtained as suggested in recent literature (Sullivan *et al.* 2009b). However, when the scope of the project does not allow for this it is suggested that this method of sample discrimination is adopted as a suitable alternative.

Conclusion

The use of the chip-tray pH incubation method like other incubation methods is considered favourable over other methods for classification of hypersulfidic materials because it is a direct measurement and produces a more realistic result for testing of hypersulfidic soil materials in ASS by allowing the soil to "speak for itself" (Dent 1986). However, incubation methods are also very time exhaustive in that in some instances it can require > 19 weeks to give a conclusive determination and that soil samples must be periodically monitored for moisture status during the incubation. The systematic analysis procedure presented here provides a tested means that streamlines data acquisition, assures correct hazard identification, and is able to handle these and other problems even with very large sample numbers.

References

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