ASSAY

A NEWSLETTER ABOUT ACID SULFATE SOILS

No. 41 March 2007

Climate change and acid sulfate soils

Awareness of climate change has increased rapidly over the past year. Many people now believe that climate change is real and happening. There is a lot of interest in how we can halt or slow down the rate of climate change, which may include the reduction of greenhouse gas emissions. In this, as people involved with acid sulfate soils, we have a role to play.

Acid sulfate soils can be a source of greenhouse gases during three phases;

1) as acid sulfate soils are formed the oxidation of organic matter produces carbon dioxide,
2) if acid sulfate soils are oxidised large quantities of carbon dioxide are produced as well as significant quantities of sulfur dioxide, methane, nitrous oxide and nitrogen oxide, and
3) treatment of disturbed acid sulfate soils with lime can produce carbon dioxide.

The environment in which acid sulfate soils are commonly found, also has the potential to emit greenhouse gasses. Acid sulfate soils are commonly found in coastal wetlands, which are estimated to contain one third of all continental shelf carbon. Drainage of coastal wetlands results in the oxidisation of this carbon and its release to the atmosphere, eg the drainage of a tropical mangrove forest resulted in the emission of 150 tonnes of carbon dioxide per hectare.

There is an estimated 74,000km^2 of coastal acid sulfate soils located around Australia and with the knowledge that greenhouse gases can be released during the oxidisation and treatment of acid sulfate soils, avoidance becomes a critical objective for managing climate change.

Based on a discussion paper developed by Ian White and Rob Fitzpatrick for NatCASS.

In this edition

Greenhouse gas emissions: sugar cane soils and nitrogen fertiliser

A new collaborative project between CSIRO Land and Water, Australian National University, University of Wollongong and Qld Dept of Natural Resources and Water is seeking to identify whether sugar cane soils are a source of greenhouse gas emissions.

The project, funded by the Australian Greenhouse Gas Office will measure long-term emissions of greenhouse gasses from sugar cane soils.

Australian sugar cane soils are characterised by high soil moisture regimes, high soil temperatures, high levels of available carbon (if trash is retained) and high levels of soil nitrogen (from fertilisers). These conditions are conducive to the formation of methane and nitrous oxide and have a strong influence on carbon dioxide exchange and carbon sequestering.

Previous studies have shown that Australian sugar cane soils emit 10,000 tonnes of nitrous oxide a year, which is the equivalent to one third of all emissions from agricultural soils in the country.

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Sugar cane soils have been recorded as emitting 8,900 tonnes of methane a year and if the crop is burnt during harvest large losses of nitrous oxides can occur. Interestingly, emissions from acid sulfate sugar cane soils appear to be much larger than from other soils.

In this new project emissions have been measured using micrometeorological and chamber techniques for the whole of the 2005/2006 growing season on a ratoon crop growing on acid sulfate soil at Murwillumbah.

Emissions from acid sulfate sugar cane soils appear to be much larger than from other soils

Some notable outcomes of the Murwillumbah study:

Climatic conditions

- Rainfall for the period was 1879 mm.
- Over the 350 days of the study, evaporation from the cane averaged 3.1 mm per day for a total evaporation of 1089 mm.
- Meaning the soil was frequently wet.

Results

- Nitrous oxide emissions were very high, even in unfertilised soil. Emissions from the unfertilised soil amounted to 20 kg of nitrogen per hectare.
- Emissions of nitrous oxide from fields fertilised with 160 kg nitrogen per hectare as urea were large, totalling 41 kg nitrogen per hectare over the 350 days; they were greatly stimulated by high soil moisture content.
- Emissions from the fertiliser constituted 13% of the nitrogen applied. This contrasts with the figure of 1.25% commonly used in greenhouse gas inventories.
- Coated urea and urea with nitrification inhibitor both proved effective in reducing nitrous oxide emissions from fertiliser, the former by 16% and the latter by 26%.
- The net sequestering of CO_2 by the crop from the atmosphere was 110 tonne per hectare while the emission of nitrous oxide was equivalent to 20 tonne of CO_2.

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Welcome to edition No 41

With growing awareness of climate change, I thought it would be interesting to highlight a link with acid sulfate soils. Our two cover articles describe how acid sulfate soils and floodplain agriculture can both contribute to climate change, through the production of greenhouse gases.

In this edition we continue to showcase the positive work being done in Western Australia to manage acid sulfate soils. It's well worth checking out WA's new contaminated lands legislation and how it will potentially relate to acid sulfate soils, very interesting!

This edition also contains a range of articles on how acid sulfate soils are being managed on agricultural lands in NSW. Included is a research paper describing why landowners have responded to acid sulfate soils and how policy can be developed to better support this interest.

Till next time

Chrisy

Thank you from Del Fanning

As the 'American connection' for the development of the highly successful acid sulfate soils symposium, field tour, and associated activities at the 2006 World Congress of Soil Science, I would like to thank all of the Australians who helped to organise the acid sulfate soil events and who participated in them.
Leigh Sullivan of Southern Cross University, Chair of the International Acid Sulfate Soil Working Group since the international acid sulfate soil conference in Tweed Heads, NSW, in 2002, was very instrumental in organising all of the events that took place and encouraging his colleagues, students and others to come to the USA and participate. Out of the 13 countries that had representatives on the field tour, after the U.S. there were more from Australia than from any other country. Without the Australian support there may well not have been a tour, so thanks again to all of you Aussies who came to the US for the Congress.

(Left) Leigh Sullivan walking a path through *Phragmites australis* reeds at the last stop of the tour, where we saw an active acid sulfate soil in dredged materials in Baltimore, Maryland, with monosulfidic black ooze in its deeper horizons. One of the items of discussion on the tour was the idea/proposal for a 'Phriends of Phragmites Society' to promote the understanding, use, and control of Phragmites in the use and reclamation of acid sulfate and other soils.

(Below) Three of the Australian contingent, from the left -- Rob Fitzpatrick, Richard Bush and Leigh Sullivan examining weathering sulfidic materials exposed by shore erosion on the east bank of the Potomac River in Charles County, Maryland.

To view other photos from the tour visit the Mid-Atlantic Association of Professional Soil Scientist web site, http://sawgal.umd.edu/mapss/ .
The guidebook for the tour, slightly updated from the printed version that was given to tour participants, is also on the web site.

Once again, thank you Australia and Australian acid sulfate soil folks for all the good things that you do.

CLAMs will help manage coastal lakes and lagoons

A new computer based model will allow stakeholders to assess the impacts of development and other changes to sensitive coastal lakes and lagoons. The model, known as the Coastal Lake Assessment and Management (CLAM) tool, can assess the social, economic and environmental trade-offs associated with development, remediation and other use options for coastal lakes and estuaries.

The tool consists of a software package which relies on a Bayesian Network approach to model the complex interactions that occur in coastal lake systems. The model provides simple representation of complex systems and the processes that occur within them. The potential impacts of any change in management are presented as probabilities outcomes for a set of defined indicators including acid sulfate soils. Other aspects of the model are its ability to incorporate both quantitative and qualitative data and the identification of tradeoffs for different management scenarios.

The CLAM tool will be particularly useful in making planning decisions to maintain and where possible enhance the health of coastal lakes and lagoons. The model may also alert planning staff to potential issues they may have not considered previously.

The CLAM tool has its origins from the Healthy Rivers Commission's 'independent inquiry into coastal lakes'. After the inquiry a comprehensive assessment of eight coastal lakes was conducted by Australian National University's Integrated Catchment Assessment Management team (ICAM) on behalf of Department of Natural Resources. During the project assessment methods were developed and trialled, these became the foundation for developing the CLAM tool. Further funding from the Northern Rivers Catchment Management Authority will see the development of 16 CLAMs for important coastal systems along the North Coast.

For further information contact Wendy Merritt on (02) 6125 7762 or wendy.merritt@anu.edu.au

A partnership to manage natural resources

Establishing stakeholder committees is common place in natural resource management. However one group has taken this a step further, formalising their committee as a 'partnership'.

In 2004, the then participating organisations of the Clarence Floodplain Project steering committee and other stakeholders working on floodplain and estuary issues came together with the desire to formalise their partnership in managing the natural environment of the Clarence River floodplain and estuary. Eighteen different stakeholder organisations signed a formal agreement, which would become known as the Clarence Floodplain and Estuary Partnership. Partner organisations included local government, state agencies, researchers from regional universities and industry bodies such as NSW Farmers, Clarence Cane Growers and Clarence Fishermen's Co-op. Local aboriginal land councils and conservation groups were also included. The Partnership provides a means of bringing together all those parties involved in natural resource management on the Clarence Floodplain.

Whilst the agreement is not a commitment by signatories to contribute any funds, it communicates a spirit of cooperation, mutual goals and joint priorities with regard to natural resource management. Members build consensus as to the key issues, priorities and solutions and work together in managing collective resources and delivering priority management actions.

Partners work together on projects, tackling issues such as acid sulfate soils, wetland management, natural vegetation and improving fish passage.

A close working relationship has been established with the Northern Rivers Catchment Management Authority, who see the Clarence Floodplain and Estuary Partnership as a leading example for the future direction of the management of our natural environment.

For further information contact Peter Wilson on (02) 6641 7350 or peter.r.wilson@clarence.nsw.gov.au

NSW update

Understanding the value of wet pasture systems

Further investigations are occurring on the value of wet pasture species.

Establishing wet pasture systems on drained acid sulfate soils has become popular with North Coast beef graziers. Reducing drainage and allowing surface water to pond on these areas not only improves downstream water quality but may also provide a boost to productivity. Reduced drainage and containment of shallow surface water reduces acid discharge into downstream waterways, as well as providing favourable conditions for native wetland species such as water couch (Paspalum distichum) and soft rush (Eleocharis sp.) to establish.

In 2004, Carol Rose, Extension Agronomist for NSW Department of Primary Industries, quantified the nutritional quality of water couch. For two years, the quality and quantity of water couch growing at Clybucca on the Macleay Floodplain was recorded. The results indicated that water couch is a highly nutritious pasture species that grows well in shallow ponded areas. This data has since been very influential in encouraging landowners to reduce drainage of low lying areas.

A new project will further Carol's work by continuing the monitoring at Clybucca as well as establishing a second site near Tucabia on the Clarence floodplain. The new sampling program will expand the number of species analysed to also include soft rush and mud grass (Pseudoraphis sp). The Northern Rivers Catchment Management Authority has keenly supported this work, allocating $20,000 to help further understand the quality of low lying pasture species.

For further information contact Carol Rose on (02) 6562 6244 or carol.rose@dpi.nsw.gov.au or Phil Hirst on (02) 6640 1673 or phillip.hirst@dpi.nsw.gov.au

WA update

Framework for Managing Acid Sulfate Soils in Western Australia

The Department of Environment and Conservation is in its final consultation phase in preparation for implementing the 'Framework for Managing Acid Sulfate Soils in Western Australia'. A coordinated whole-of-government approach in dealing with acid sulfate soil disturbance has resulted in a very productive and thorough consultation phase and timely implementation of the Framework.

A Western Australian Acid Sulfate Soil Management Advisory Committee (WAASSMAC) will be formed during 2007 to facilitate the implementation of the Framework's recommendations. The WAASSMAC will review the pressing acid sulfate soil issues raised by land developers, industries and community and will provide a forum to enable continuing improvements for managing disturbed and undisturbed acid sulfate soil landscapes and assist in prioritising investigation, mitigation and rehabilitation. A key component of the Framework is to raise awareness of acid sulfate soil issues and encourage community networking with natural resource management groups.

For further information contact Stephen Wong on (08) 6364 7089 or stephen.wong@environment.wa.gov.au

Contaminated Sites Act (2003)

The Contaminated Sites Act (2003) recently came into effect in Western Australia. Land, where disturbance of acid sulfate soil has resulted in concentrations of contaminants and/or a level of acidity within soils, sediments and waters that are above background concentrations may come under the Act. These areas by definition will present, or have the potential to present, a risk of harm to human health, the environment or any environmental value. The Act will not apply to undisturbed naturally occurring acid sulfate soils.

Where groundwater has been impacted, the Department of Environment and Conservation may classify the site as 'contaminated–restricted use', with advice that groundwater should not be abstracted for any purpose without testing to determine its suitability for intended use. This classification requires a memorial to be placed on the Certificate of Title, and requires owners to disclose the contamination to any potential purchaser, mortgagee or lessee of the property.

The Department of Environment and Conservation has published a series of fact sheets and administrative and technical guidelines to assist with the assessment, management and remediation of contaminated sites in Western Australia; these are available from www.dec.wa.gov.au/contaminatedsites.

Management of nutrient release and acid sulfate soil

Location: south west of Western Australia
Funded: $770,000 (NHT RCC Round 3)

Western Australia has large areas of acid sulfate soils as well as one of the earliest recorded instances of acid sulfate soils in Australia (1917); though presently there is little awareness of acid sulfate soil in the state.

In response to this, a joint project by the Department of Agriculture and Food, Department of Environment and Conservation, Department of Water, Chemistry Centre (WA), South West Catchments Council and South Coast Regional Initiative Planning Team was developed to manage nutrient release and acid sulfate soils. One of the main aims of the project, managed by the Department of Agriculture and Food, is to raise awareness of acid sulfate soils and develop the skills in natural resource management groups, government agencies and local government to manage the issue. To do this, brochures are being developed and educational workshops are being run in major centres.

A new project will investigate whether ASS contribute nutrients to waterways.

Contaminants such as acid and metals from disturbed acid sulfate soils are well documented. Overseas experience also suggests that disturbed acid sulfate soils could be large contributors of nutrients such as phosphorous and nitrogen to waterways. A component of the project will look at the possible role acid sulfate soils have in contributing nutrients to the environment and if they are contributing extra nutrients, managing the impact.

While there has been a lot of work done on managing acid sulfate soils in New South Wales and Queensland, due to Western Australia's different soils and climate, these techniques will need to be trialled and adapted for local conditions. The project will set up demonstration sites in different catchments across the south west of Western Australia trialling different remediation techniques.

For further information contact Adam Lillicrap on (08) 9892 8518 or alillicrap@agric.wa.gov.au

Developing policy that supports change

Woodhead A., Legg W. & Packham R. (2004) *Developing policy for communities managing diffuse source pollution: a case study from subtropical catchments of NSW Australia* International Journal of Agricultural Sustainability Vol 2 (1):43-54

Landowners in the Tuckean Swamp working together to remediate an acid sulfate soil scald.

Landowners' roles are changing. Managing agricultural land is no longer solely about the production of commodities such as beef or sugar. Landowners are now expected to take into consideration the community's environmental and social concerns. Such is the case for landowners who own areas of acid sulfate soil. Often the management options suggested to reduce acidic runoff present little on-farm benefit, with most of the beneficiaries located downstream of the farm.
The results of a benchmarking survey conducted in NSW also indicated that landowners frequently did not identify with government visions and were unaware of the regulations. However a large number of landowners were thinking about or had changed some management practices. So why did these landowners change? Farmers who had altered their management practices shared the following characteristics:

- the belief that acid sulfate soils are a problem,
- the belief that the changes wouldn't adversely affect their property,
- perception of some net benefit from changing,
- they could see a financial benefit in changing,
- they could foresee the consequences of not changing, or
- generally had a high level of knowledge about the issue.

Largely the survey identified that the above characteristics were a result of educational/ extension activities conducted by local facilitators or coordinators. Successful facilitators had followed a similar process in engaging local landowners:

- build a trusting relationship with the landowners,
- negotiate an agreed plan on how to address the issue,
- develop or promote practical best management practices,
- acquire funding for projects, and
- publicise the environmental benefits to the broader catchment community.

The most crucial elements appear to be firstly the human, the personality of the coordinators and then institutional, the organisational and legislative constraints within which negotiations can be undertaken with local council and state agencies. The paper also discusses how policies can be developed to promote the change process with diverse stakeholder groups. Such information may be of interest to organisations involved in the management of diffuse source pollution.

For a copy of the above paper contact the Information Officer on (02) 6626 1355 or christina.clay@dpi.nsw.gov.au Also available from the Information Officer is a report summarising the benchmarking survey conducted in NSW.

Height of acid sulfate soils gives clue to Holocene sea levels

Wilson B. P. (2005) *Elevations of sulphurous layers in acid sulfate soils: what do they indicate about sea levels during the Holocene in eastern Australia*? Catena 62: 45-56

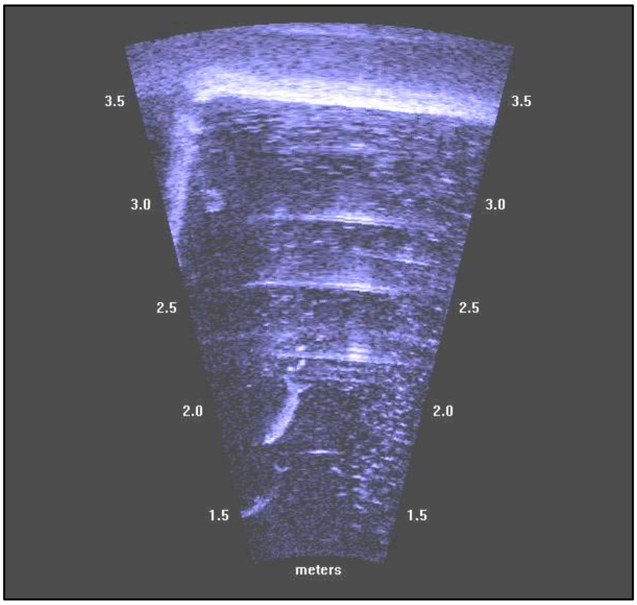
A study of 346 acid sulfate soil profiles from NSW's coastline has indicated that sea levels during the Holocene period could have been higher than first thought. The elevation of acid sulfate soils within these profiles show sulfidic sediment located above present day sea level at two distinct different heights.
Models of coastal acid sulfate soil development suggest that the most favourable conditions for pyrite formation will occur between mean high water level and mean low water level and will occur in organic-rich, near-shore, estuarine environments. Estuarine environments are suited to the development of pyrite because sulfate from sea water and iron oxides from terrestrial sediments can combine through bacterially mediated processes to produce pyrite. Therefore sea level change will affect the position of pyritic sediments in the landscape.
The location of sulfidic sediment at two distinct different heights can be explained by two possibilities. Firstly, two periods of higher sea level during the Holocene could result in sulfurous materials at different levels. Secondly, the estuarine 'barrier system' which developed along the NSW coastline during the Holocene, impounded a series of estuarine mud basins. This could have resulted in the formation of sulfurous materials at higher elevations along the edge of the lakes and at lower elevations on the lake beds themselves.

For a copy of the above paper contact the Information Officer on (02) 6626 1355 or christina.clay@dpi.nsw.gov.au

DIDSON – the truth behind the underwater world of fish

NSW Department of Primary Industries is using state-of-the-art DIDSON technology to monitor fish in remediated drains and waterways. The **D**ual **ID**entification **SON**ar is an underwater acoustic camera capable of observing fish behaviour and movement in water with very low visibility.
The DIDSON is a new research tool that allows fish to be observed in their natural habitat without disturbing them. The camera is currently being used on the North Coast of NSW to observe how fish manoeuvre through floodgates as well as measuring the number of fish moving into remediated waterways.
A project currently running on the Clarence floodplain will compare fish use of natural floodplain creeks to that of modified floodgated water courses.

For further information contact Bryan Green on (02) 6626 1381 or bryan.green@dpi.nsw.gov.au



Imagery produced by the DIDSON; a mullet swimming through an opened floodgate.

Understand surrounding soil properties before opening floodgates

Johnston S.G., Slavich P.G. & Hirst P. (2005) *Opening floodgates in coastal floodplain drains: effects on tidal forcing and lateral transport of solutes in adjacent groundwater* Agricultural Water Management 74:23-46

Knowing the hydraulic conductivity of local soils is important before opening floodgates.

Opening floodgates in order to improve drain water quality has become common practice along the east coast of Australia. The controlled exchange of tidal estuarine water can reduce acidity and improve oxygen levels in coastal drainage systems.

Although opening floodgates can improve water quality, research has shown the importance of assessing the hydraulic properties of surrounding soil before doing so. Two drainage systems on the Clarence floodplain were monitored to assess the impact of floodgate opening on surrounding groundwater tables and the lateral movement of salt. The two sites, located at Romiaka Channel and Shark Creek, were selected for their contrasting soil properties. The Romiaka drainage system is surrounded by soils with low hydraulic conductivity and minimal potential for lateral water movement. The surrounding land is relatively high in elevation and the hydraulic gradient runs towards the drain. In comparison the Shark Creek drainage system has soils with high hydraulic conductivity and the potential for large scale lateral water movement. The surrounding land is low in elevation and has seasonally fluctuating hydraulic gradients.

Both drainage systems were closely monitored whilst the floodgates were opened. At Romiaka the groundwater table was influenced by the tide 10 meters away from the drain bank, however lateral salt seepage was contained to within 4-6 meters. Whilst the floodgates were opened the groundwater table remained higher than the drain water level, keeping the hydraulic gradient moving towards the drain minimising any lateral salt movement.

In comparison at Shark Creek the groundwater table was influenced by the tides over 300 meters away from the drain. Salt penetrated over 80 meters into surrounding soil and tidal exchange changed the hydraulic gradient so it moved away from the drain, enhancing any salt intrusion. The extensive salt seepage occurred quickly, aided by the extensive macropores located in sub surface horizons.

The two different responses are largely a function of the sites’ soil properties and the hydraulic gradients that developed. This study demonstrates that opening floodgates at sites with high hydraulic conductivity may increase salt seepage into surrounding soil, a significant concern for agricultural industries. Tidal exchange in these areas also has the potential to increase acid discharge, with the daily low tides creating a hydraulic gradient for acidic groundwater to enter into nearby drains. Assessing the properties of surrounding soil prior to opening floodgates becomes an important step in preventing the unintended saline intrusion into shallow groundwater.

For a copy of the above paper contact the Information Officer on (02) 6626 1355 or christina.clay@dpi.nsw.gov.au

Pasture takes up arsenic in floodplain swamps

Tighe M., Ashley P., Lockward P. and Wilson S. (2004) *Soil, water and pasture enrichment of antimony and arsenic within a coastal floodplain system* Science of the Total Environment 347: 175-186

A recent study has found that approximately 90% of the Macleay floodplain, located on the North Coast of NSW, contains elevated levels of arsenic and antimony. Arsenic (As) and antimony (Sb) are metallic elements often found at high levels around smelters, chemical plants and mines. Arsenic is known for its toxic, poisonous nature, whilst less is known about the effects of antimony.

The study identified that 6–8% or 1200 ha of the Macleay floodplain contains arsenic and antimony levels greater than current Australian soil environmental investigation levels. The metals are thought to have originated from historical mining activities in the upper catchment and deposited on the floodplain during flood events. The highest concentrations of the two metals were found in low lying freshwater swamps.

The extreme environmental conditions possible in floodplain swamps, such as those relating to acid sulfate soils and waterlogging, may contribute to the increased presence of arsenic and antimony which has the potential to contaminate surface water and pasture.

The investigation noted that compared to antimony, arsenic occurred at different depths in the swamp soil profiles, and was often recorded at higher background levels. This suggests that some of the arsenic may have been produced through the oxidisation of local acid sulfate soils.

Pasture growing in low lying floodplain areas has been found to take up arsenic.

As suspected surface water and pasture sampled from these low lying areas contained elevated levels of arsenic and antimony. Surface water concentrations were found up to 10 and 21 times above drinking water guideline values and 2.9 and 6.9 times above freshwater habitat trigger values for arsenic and antimony, respectively.

Analysis of pastures shows enrichment of both elements and a strong relationship between total soil elemental levels and pasture elemental concentrations. Pasture uptake of arsenic and antimony was recorded at up to 6.4 and 2.2 mg kg^{-1} respectively.

Significant relationships between pasture and total soil levels imply higher relative availability than is typical at grossly contaminated sites. Implications on how mobile and available these contaminates are in acid sulfate soil environments are discussed within the paper.

For a copy of the above paper contact the Information Officer on (02) 6626 1355 or christina.clay@dpi.nsw.gov.au

Australian Government

ACID SULFATE SOILS
information and awareness

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