ACID SULFATE SOILS & ACIDIC DRAINAGE

IMPACTS ON COASTAL WATERWAYS OF SOUTH WEST WESTERN AUSTRALIA

WHAT ARE ACID SULFATE SOILS?

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Soils containing iron sulfides, generally pyrite, are referred to as acid sulfate soils (ASS). Pyrites are a potential acid source when they remain locked in the soil. When exposed to air they become an actual acid source as sulfuric acid is released from the pyrite. (Figure 1).

(Figure 1)

LOCKED IN

RELEASED

The term acid sulfate soil includes soils where the acidity remains locked in the soil and also soils where the acidity has been released. The formal terms for these are potential acid sulfate soils (PASS) and actual acid sulfate soils (AASS).

The difference between the two reflects the current chemical state of the material. For example:

When the acidity is 'locked in' it means the soils have not been oxidised or exposed to air. These soils generally remain in waterlogged sediments and have a pH of 6.5 to 7.5. The soil profile provided shows this layer as a wet grey mud.

Once pyrite is exposed to air the acidity is 'released' as sulfuric acid. These soils may contain yellow/orange flecks or orange mottling within the soil profile.

HOW ARE THEY FORMED?

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Sulfate reduction is an anaerobic process that is controlled by bacteria in organically rich sediments in productive marine and estuarine environments. To make pyrite the process requires four ingredients including a supply of organic matter, bacteria, sulfate and iron.

Coastal landscapes generally have the greatest quantities of stored pyrite and those of most concern in Australia are the pyrites that formed over 10,000 years ago after the last major sea-level rise.

WHERE ARE THEY FOUND?

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Acid sulfate soils are widespread around coastal landscapes and are also locally associated with inland freshwater wetlands.

They are a natural feature of our coastal landscapes and may be associated with a variety of waterlogged soil types. In Western Australia these include dark organic rich soils and muds, peaty wetland soils, some pale grey sands (Bassendean sands and Spearwood sands) and 'coffee rock' (cemented iron and/or organic rich sands) found below the watertable.

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In the south west of the State shallow acid sulfate soils have been found in riverine, estuarine and coastal lowland areas such as brackish lakes, salt marshes, salt pans, swamps and seasonally inundated plains.

The Department of Environment and Conservation (DEC) has produced Acid Sulfate Soil Risk Maps for the State. They provide a broad-scale indication of the areas where soil acidity due to pyrite is most likely to occur. The maps define high, medium or low risk areas for the occurrence of acid sulfate soils.

ARE ACID SULFATE SOILS LIKELY TO BE A PROBLEM?

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In most situations these soils are not a problem as they remain quite stable in waterlogged sediments.

Under these natural conditions small amounts of acid may be released. For example, by weathering and erosion along a river bed or through drying and re-wetting of sediments in lakes and wetlands.

In these cases estuarine and marine waters are able to neutralise the acid as it is released slowly from the soil and with little or no impact on water quality, plants and animals. The soil is also able to buffer some of the acid. In freshwater systems this natural buffering is less effective in neutralising this acid.

WHEN DO ACID SULFATE SOILS BECOME A PROBLEM?

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The problem with these soils arises when the pyrite layer becomes rapidly exposed to air, producing sulfuric acid in quantities that can limit a systems ability to neutralise it.

ACTIVITIES THAT MAY GENERATE ACID IN CERTAIN AREAS

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1) Building constructed wetlands and ponds for beautification of new urban developments and management of stormwater,
2) Major earthworks including large scale excavations for canal developments and estates,
3) Infrastructure earthworks including digging for clearways, roads and railways and excavating for sewage pipes, power lines and drainage channels,
4) Maintenance dredging for the management of boating channels and canal estates
5) Digging drainage channels to manage waterlogging in agricultural areas and
6) Lowering of the groundwater table through over use of groundwater and also from reduced rainfall.

ACID SULFATE SOIL: IMPACTS ON WATER

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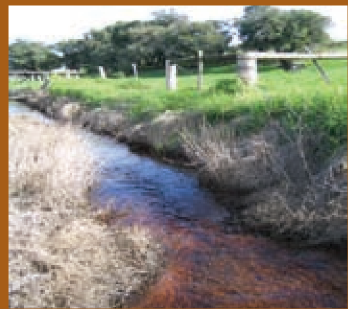
Water quality indicators

Localised disturbance of acid sulfate soils may lead to reduced water quality in urban and agricultural waters. Potential indicators of acidic drainage are shown below:

Iron floc: can appear in water at pH below 4 and can persist in floc form at high pH. They are coloured red-brown or brown-yellow. Floc of this nature generally appear throughout the whole water body.

MBO: are monosulfidic black oozes. Characteristically these sediments are jet black and oily looking with a gel like consistency that makes them hard to handle. They often occur in drains which carry acidic drainage although they can also occur in natural ecosystems (e.g. wetland and estuarine sediments not subjected to acidic drainage).



Rosé water: may indicate high iron content. On contact with alkaline water iron flocs may result. Notice how acid water has killed off surrounding vegetation.

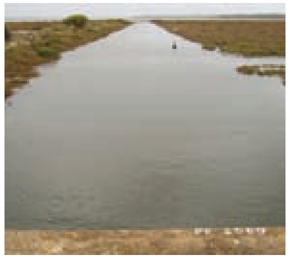
Some of these indicators may also be attributed to natural processes, eutrophication, urban/agricultural/industrial pollution or mining activities.

Blue green water: is caused by aluminium floc and occurs at pH 4 to 5.

Milky white water: at pH 5 or 6, aluminium can change form to a milky-white appearance.

Constructed wetlands

Many constructed wetlands are created by removing sediments which are then used to create a central island. Oxidation may occur impacting surrounding waters and vegetation.



Drainage channels

may act as conduits for transporting acid water from one location to the next.

Groundwater aquifers

may become receiving environments for acidic drainage from disturbed acid sulfate soils or surface waters. This groundwater may then act as a conduit transporting contaminants in groundwater flows.

POTENTIAL AQUATIC IMPACTS

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Acidic drainage from acid sulfate soils can manifest in a number of potential aquatic impacts. These may include:

- Loss of habitat,
- Reproductive stress in fish and invertebrates (e.g. shellfish),
- Accumulation of metals in aquatic plants and animals,
- Dominance of acid tolerant species,
- Increased disease risk in aquatic organisms, and
- Fish kills

The potential impacts depend on the:

- Volume of the acidic water and the metals present (eg. aluminium, iron, arsenic etc.),
- Duration of acidic flows (e.g. days, weeks or months),
- Regularity of acidic flows (e.g. one-off events, sporadic, seasonal or persistent and on-going),
- Surrounding soils and sediments (e.g. type of soil, buffering capacity and contaminants contained within),
- Size of receiving waters (e.g. enabling dilution of acid waters), and
- Type of receiving water - salty or fresh (e.g. buffering capacity of the water).

ACID SULFATE SOIL: IMPACTS ON LAND

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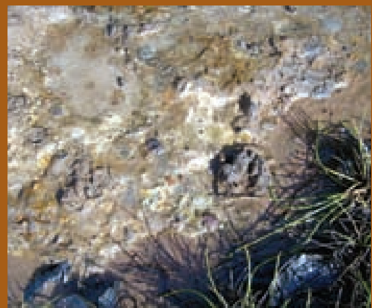
1. Soil indicators

When acid sulfate soil is disturbed and oxidised it may generate a large amount of acidity. One tonne of iron sulfide can produce 1.5 tonnes of sulfuric acid when oxidised.

Potential indicators of disturbed acid sulfate soils on land are shown below:



Jarosite: may be butter coloured or have a mottled orange appearance. Jarosite is a visible indicator of actual acid sulfate soils, although it is not present in all situations.

Scalds: bare patches may indicate acidity of the top soil which would inhibit the growth of plants and crops.

Iron sulfide layer (on the surface): excavated sediments are often left on the surface after a disturbance. Characteristically these sediments become very spongy if they remain uncovered. They often resemble lava flow. If pressure is applied with your foot they slowly spring back.

Iron sulfide layer (below the soil surface): this layer can be clay, loam, sand or peat. It is usually dark grey and soft.

Salt crusts: on the surface of soil may be a by-product of acid sulfate soils.

Soil testing is recommended in all situations to confirm a potential or actual acid sulfate soil problem.

2. Infrastructure

Corroding concrete footings, iron, steel and certain aluminium alloys.

3. Reduce agricultural productivity

Acid scalds, reduce farm productivity and effect agricultural water quality for crops and livestock.

4. Urban landscapes

When used as land fill acid sulfate soils can affect plant growth and landscaping or even prevent establishment of gardens and lawns.

5. Reduce urban aesthetics

Leached acid water can cause rust coloured stains.

6. Noxious odours

Including hydrogen sulfides (rotten egg smell!) and unpleasant metallic fumes.

BEST WAY TO MANAGE ACID SULFATE SOILS IN THE SOUTH WEST:

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avoidance

The best technique for managing acid sulfate soils is to avoid disturbing or draining the iron sulfide layer as iron sulfides are harmless while covered with water.

recognition

It is useful to know what the iron sulfide layer looks like so that when uncovered accidentally it can be re-covered with water immediately. Most often this layer appears as a dark, grey and wet mud, however it can manifest in a number of soil types. Field testing of soil samples can help with this.

shallow drainage

Wide, shallow drains allow surface water to drain quickly from the surface of low-lying land without exposure to the iron sulfide layer beneath. Deep, narrow drains are more likely to expose the iron sulfide layer and leak sulfuric acid into waterways.

liming

Sulfuric acid can be neutralised with agricultural lime, but this is costly for large areas of badly affected land.

water cover

Re-flooding land with freshwater can slow further acidification. The use of freshwater re-flooding requires caution and technical advice before it is applied.


The picturesque Hardy Inlet and the town of Augusta to the West.

For more general information on acid sulfate soils:

Department of Environment and Conservation

The role of the department is to identify ASS in areas at greatest risk from development. For further information contact the Land and Water Quality Branch of the Department of Environment and Conservation on (08) 6364 6500. www.dec.wa.gov.au/management-and-protection/acid-sulfate-soils/index.html.

Planning Bulletin 64

Risk maps of WA sulfate soils are published within Planning Bulletin 64, Acid Sulfate Soils. See the West Australian Planning Commission site for advice and guidance in sub-divisions and land developments with acid sulfate soils. http://www.wapc.wa.gov.au/Publications/213.aspx.

Birdseye view of the Swan Estuary, Fremantle.

Department of Agriculture and Food Western Australia

Identification and management of acid sulfate soils on agricultural lands including preventative measures and acid remediation techniques. http://www.agric.wa.gov.au.

Contaminated Sites Act (2003)

Recent changes to this Act provide an additional statutory tool for the management of acid sulfate soils http://www.environment.wa.gov.au.

National Strategy for the Management of Coastal Acid Sulfate Soils

The Federal, State and Northern Territory Governments have developed a National Strategy for the Management of Coastal Acid Sulfate Soils. The strategy can be downloaded as a Pdf document http://www.environment.gov.au/coasts/cass/index.html

Acknowledgements

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