LANDFORM

THE DEVIL'S SOILS: THE SOILS THAT BITE BACK

Steve Appleyard

THE first Europeans who settled in coastal areas of Australia brought with them a myth from the Old World about the role of humans in dominating the land, and about how ever-willing soils would offer up the fruits of the earth to their Masters. But in doing so, they forgot their own stories, told since at least the Middle Ages, of the soils that would not be dominated but would bite back.

People who used to live on the North Sea coast of what is now Germany knew these soils as *Maiboldt*, the Devil's soils. To the Dutch, *Kattekleigronden* were soils inhabited by evil spirits that refused to give a crop. We now generally call these materials "Acid Sulfate Soils" (ASS).

ASS are naturally occurring waterlogged soils that contain iron sulfide minerals, generally as the mineral pyrite. These soils are mainly found in coastal regions of Australia (Figure 1) and mostly have been formed during the last 10 000 years when the sea level rose to near its current position after the last ice age.

These soils are absolutely benign when undisturbed. They are also very unexciting to look at, and consist mainly of grey or greenish-grey clayey, silty or sandy materials below the water table, often with orange or yellow iron-rich mottles just at, or above the water table.

But don't be fooled by their appearance. These soils are anything but dull if they are drained or dug up without care.

The pyrite they contain can react with oxygen from the air to form a toxic brew of sulfuric acid, metals leached from soil minerals and often arsenic that has been trapped within pyrite crystals. This acid leachate can be washed into drains or into groundwater and can cause a variety of environmental problems. These include causing fish kills due to deoxygenation and aluminium toxicity; loss of biodiversity in estuaries, wetlands and waterways; contamination of groundwater resources by acid, arsenic, heavy metals and other contaminants; loss of agricultural productivity; and, corrosion of concrete and steel infrastructure by acidic soil and water.

The National Committee for Acid Sulfate Soils estimates that there is potentially $10 billion worth of liability in coastal regions of Australia if the disturbance of these soils is not well managed.

Historical background

Environmental effects caused by the drainage of ASS in Australia were first described in WA in 1917. The Government Geologist of the time, H.P. Woodward,

Figure 1. Coastal areas of Australia where there is a high risk of acid sulfate soils occurring

visited an agricultural development at Torbay near Albany where entire crops had been killed following the construction of an extensive drainage scheme. Woodward identified pyrite oxidation caused by the drainage as the source of the acidity, and he recommended intensive liming of drain water and soils to control the problem. Soils in the area are still acidic and generating acidic leachate more than 100 years later.

However, the lessons learnt were quickly forgotten, and ASS were not "rediscovered" in WA until 20 years later (which was still 30 years earlier than the description of these materials from the eastern seaboard). Teakle and Southern from the Department of Agriculture identified highly pyritic peaty soils in many areas on the Swan Coastal Plain and on the South Coast. In many areas there was evidence that pyrite oxidation was occurring due to soil disturbance and drainage. Once again, this work was largely forgotten until the 1960s when it was picked up by researchers working on ASS on the eastern seaboard where concern arose because of outbreaks of the fish fungal disease Epizootic Ulcerative Syndrome (EUS or "Red Spot" disease) which were thought to be exacerbated by exposure of fish to acidic water.

In WA the problem was generally not considered significant, however, this view changed in January 2002 with the discovery of widespread groundwater acidity problems and contamination by arsenic caused by the disturbance of sulfide-rich peat soils for urban development in Stirling. Not only were ASS present in the heart of the Perth Metropolitan Region, but also their

continued on page 13

LANDFORM

continued from page 12

disturbance was causing arsenic and acidity contamination in a resource that provides about 70% of Perth's water usage and which is accessed by more than135 000 domestic bores!

What's happening now in WA

The Western Australian Acid Sulfate Soil Working Group has been established to oversee the development and implementation of measures to manage environmental effects caused by ASS disturbance in the State. Department of Environment is mapping at-risk soils and has developed management guidelines; the Department of Planning and Infrastructure has developed planning guidelines and workshops have been held. A State Strategy is being developed.

However, there is a very long way to go, particularly for ensuring that existing land use and groundwater abstraction in high-risk areas does not cause environmental problems or lead to widespread groundwater contamination by arsenic or other by-products of pyrite oxidation.

For more detail, contact Steve Appleyard or Stephen Wong at DoE for a list of relevant websites:
email steve.appleyard@environment.wa.gov.au
or stephen.wong@environment.wa.gov.au

Dr Steve Appleyard is the principal officer involved with acid sulphate soils at Department of Environment. He can be contacted on 9222 8626

Identifying Acid Sulfate Soils (ASS)

and indicators of their disturbance on your property

The term "Acid Sulfate Soil" refers to a whole soil profile consisting of oxidising materials above the water table (known as "Actual Acid Sulfate Soil" or AASS) and unoxidised material below the water table (known as "Potential Acid Sulfate Soil" or PASS). To identify these you will need to be able to dig a test pit to just below the water table and be able to measure pH (with pH test papers or a meter). ASS are most likely to occur in low-lying swampy areas of your property where the water table is near the surface. Typically, these are areas where Melaleucas, Saltwater Sheoaks and rushes grow.

Firstly, look at the material above the watertable. It will typically have a mottled appearance. Mix about 1 teaspoon of soil material with about 5 teaspoons of distilled water and measure the pH. AASS materials typically have a field pH of less than 4. The presence of straw-yellow to butter-yellow mottles in the soil profile is indicative of AASS – these are made up of an iron sulfate mineral called jarosite which only forms when the soil pH is less than about 3.5.

Now look at the material below the water table. This may vary in texture (clay, silt or sand) but will typically have a "gun metal" grey colour, often with an odd greenish tinge that disappears rapidly on exposure to air. The pH of a soil paste of this material is usually about 7 to 8. Now put a sample in a Zip-lock sandwich bag and leave in a warm place indoors (not too hot, and do not let the material dry out). If you see yellow mottles of jarosite developing in the material, it is definitely PASS.

For a more rapid assessment of PASS, react one teaspoon of soil with 5 teaspoons of 30% hydrogen peroxide in a small plastic container (**CAUTION!** This is a very hazardous chemical that can cause severe burns –always wear gloves and eye protection when using concentrated hydrogen peroxide). If the material is PASS, there will be a violent reaction after about 5 to 10 minutes, and the final pH of the solution may be less than 3. The greater the pH change, and the lower the final pH, the higher the pyrite content of the soil is likely to be.

In addition to looking at soil profiles, there are a number of visual indicators that ASS have already been disturbed and are generating acid on your property. Typical signs in drains or other surface water bodies are: opaque yellow-brown or red-brown water due to a thick suspension ("floc") of iron oxides; turquoise milky coloured water due to aluminium oxide floc; or crystal-clear water with iron or aluminium precipitates sitting on the bottom. You may also see a jet-black oily looking material accumulating on the bottom in deeper parts of your drains. This is iron monosulfide black ooze which forms as a result of dissolved iron reacting with organic carbon in drains. This material is washed away when there is heavy rainfall, and can rapidly deoxygenate water and cause fish kills in water bodies that receive discharge from drains.

In areas where ASS have been disturbed you are also likely to see iron monosulfides forming at the surface, usually beneath cyanobacteria mats or adjacent to clumps of vegetation. This material oxidises during dry summer months to form acidic salts that are washed into surface drainage with the first rainfall of the season.