Acid sulfate soils in Queensland

Acid sulfate soils (ASS) are marine or estuarine sediments that contain iron sulfide minerals, commonly pyrite. When these soils are exposed to air by excavation or drainage, they produce large amounts of sulfuric acid (battery acid). The acid causes damage by itself, and can also release toxic quantities of iron, aluminium, and heavy metals from the soil. These pollutants can seep into waterways, killing fish, other aquatic organisms and vegetation. Concrete and steel structures in ASS areas are vulnerable to acid attack and may degrade rapidly, needing replacement before their planned lifespan is over.

How are acid sulfate soils formed?

Acid sulfate soils are formed when seawater or other sulfate-rich water (e.g. some types of groundwater) mixes with land sediments containing iron oxides and organic matter under waterlogged, anaerobic (oxygen free) conditions (Figure 1). These conditions are ideal for sulfate-reducing bacteria to flourish. It is these bacteria that form the pyrite—the reactive component of acid sulfate soils. The sulfides produced are stable until exposed to air, at which point they produce sulfuric acid.

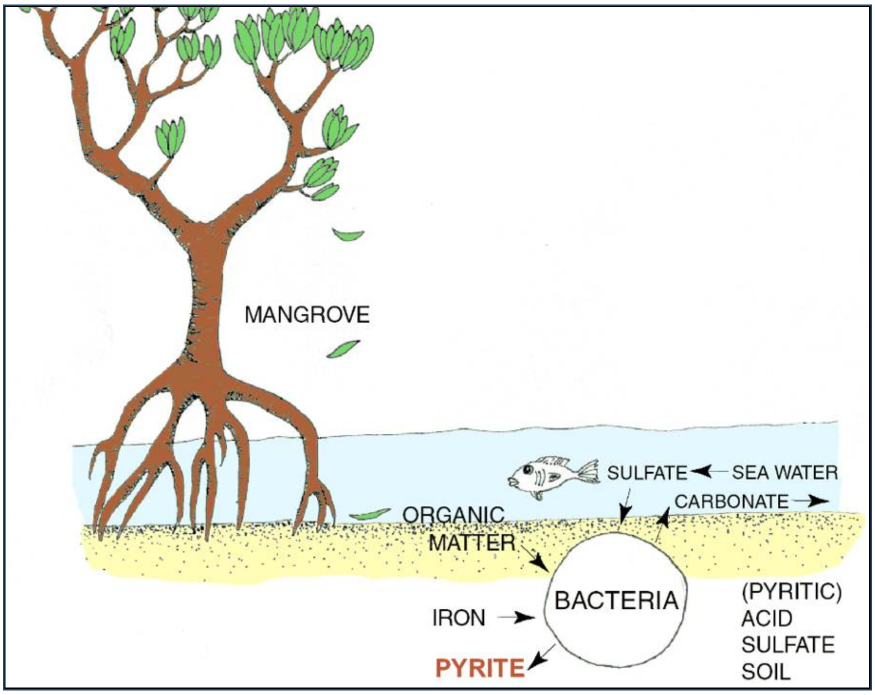

Figure 1. Acid sulfate soils formation.

Where do acid sulfate soils occur?

There are an estimated 2.3 million hectares of acid sulfate soils along 6500 kilometres of Queensland coastline (Powell and Martens, 2005). Acid sulfate soils are typically found at elevations less than five metres above sea level, in lowland areas such as estuaries and floodplains, tidal mangrove flats, lakes and wetlands, and swamps (Figure 2). However, acid sulfate soils can be found at much higher elevations and also inland from the coast, wherever the sulfide-forming conditions are found. Acid sulfate soils are still being formed today.

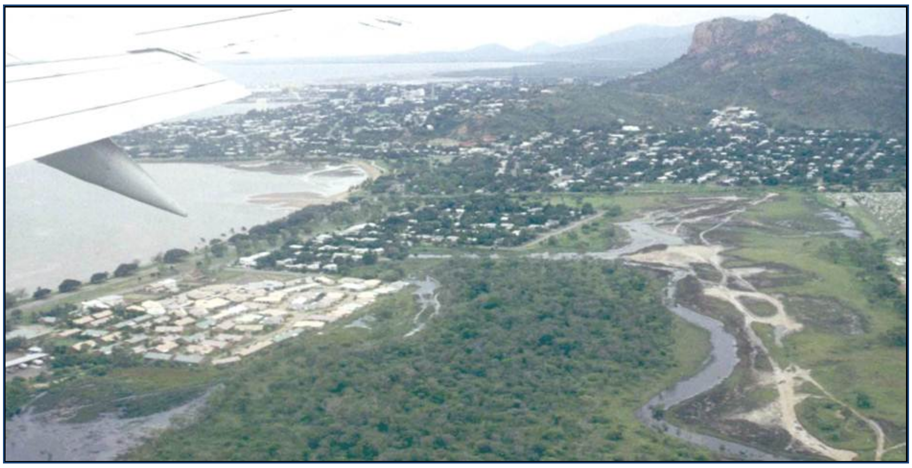

Figure 2. A coastal lowland – ideal acid sulfate soil forming environment.

What happens when acid sulfate soils are disturbed?

Acid sulfate soils are benign when in a waterlogged environment. However, when these soils are drained or excavated, oxygen from the atmosphere reacts with the iron sulfides in the soil. This results in the production of sulfuric acid (battery acid), which can reduce soil pH to less than 2. The acid breaks down the soil structure, releasing toxic quantities of iron, aluminium and other metals from the soil.

The acid and metals remain in the soil until rainfall is sufficient to leach them out. The acid and metals may then leak into nearby waterways, creeks and streams, often with catastrophic environmental and economic impacts.

Land uses that may be affected by acid sulfate soils include residential and canal developments, road construction, aquaculture, marinas, golf courses, agriculture, sand and gravel extractions, ditching for mosquito control, drainage works, national parks and reserves, and coastal lake developments.

Environmental impacts

The acid water and toxic heavy metals can kill fish and also increase their susceptibility to diseases such as ‘red spot’ (Figure 3). Avoidance of acid water environments by aquatic organisms can lead to overcrowding and stress, and ultimately death, as they try to escape undesirable conditions.

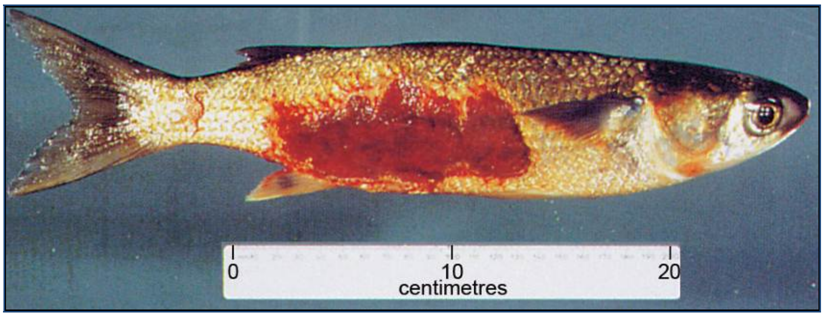

Figure 3. Acid water can increase susceptibility of fish to diseases such as ‘red spot’.

The soluble iron released from acid sulfate soils changes form when it contacts more alkaline water. This results in the production of rust-red iron oxide scum, the depletion of oxygen from the water, and the production of more acid (Figure 4). Aquatic organisms and vegetation may be killed by these reactions. The iron scum can smother plants, cause unsightly stains on concrete and soil, and can even clog pipes and aquifers. Iron combined with organic matter can travel into coastal waters and contribute to blooms of algae such as the cyanobacteria *Lyngbya majuscula*.

Figure 4. Iron scum smothers vegetation and coats structures.

The aluminium released by exposure of acid sulfate soils is toxic and can kill aquatic organisms and vegetation. Acidic water leached from acid sulfate soils can appear very clear but can contain toxic quantities of aluminium.

Acidic conditions created by the leakage of sulfuric acid into waterways can result in a change in ecological diversity. For example, acid tolerant water lilies and sedges can take over lakes and streams. These species can prevent light from reaching bottom-dwelling organisms and vegetation, resulting in their death. Acid-tolerant *Phragmites australis* (a tall grass species) can encroach into acid sulfate affected areas where other vegetation has died or growth is poor.

Structural impacts

Sulfuric acid can degrade concrete and steel infrastructure, such as drainage pipes, stormwater pipes, building foundations, and bridges (Figure 5). The acid chemically reacts with the lime in the concrete, dissolving the cement and exposing the reinforcing and aggregate. The acid can also attack steel and lead to structural weakness and failure.

When acid sulfate soils are exposed, they will often shrink and crack. This can result in subsidence and cracking of foundations.

Managing and treating acid sulfate soils

Some basic management options for acid sulfate soils include avoiding problem areas, minimising the area and volume of disturbance, and mixing a neutralising agent (e.g. lime) into the soil to neutralise the acid. A soil scientist experienced in acid sulfate soils management should be consulted in the planning stages of a project.

References

Powell, B. and Martens, M. (2005) A review of acid sulfate soil impacts, actions and policies that impact on water quality in Great Barrier Reef catchments, including a case study on remediation at East Trinity. *Marine Pollution Bulletin*, Vol. 51, nos. 1-4, pp. 149-164.

Figure 5. Degradation of concrete by acid water.

Further information

This and other science notes are available from the Queensland Government website www.qld.gov.au – search 'science notes' or for further information about this science notes series phone **13 QGOV** (13 74 68) – Ask for science notes – L60. Other science notes related to this topic include:

- L61: Identifying acid sulfate soils
- L62: Managing acid sulfate soils
- L64: Using acid sulfate soils maps

For more information on acid sulfate soils, visit < http://www.qld.gov.au/environment/land/soil/acid-sulfate/> or email soils@qld.gov.au.

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