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Oysters and acid sulfate soil outflows

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Introduction

The Sydney rock oyster (*Saccostrea glomerata*) is produced in areas of some estuaries that are at times impacted by outflows originating from acid sulfate soils (ASS). Fish kills and fish disease are some obvious impacts of acid sulfate soil outflows. The effects on oysters are not as noticeable, but can be easily identified.

What are acid sulfate soils?

ASS are naturally occurring soil and sediment that contain iron sulfides, usually distributed through the subsoil. These soils may be found in low-lying areas, such as floodplains surrounding estuaries, coastal lagoons and embayments. There are approximately 600,000 ha of ASS along the estuaries and coastline of NSW. Not all ASS contain acid. Under most natural conditions, where the soil remains waterlogged, ASS remain harmless. Waterlogged ASS have the potential to produce acid if they dry out. When iron sulfides are exposed to air – by drainage or excavation of the soil, when the water table is lowered artificially, or during droughts or prolonged dry weather – they react with oxygen in the air or water, and can produce large quantities of sulfuric acid. This acid is stored in the soil, and is usually released after rain, or after flood waters have drained away. The sulfuric acid attacks soil minerals, releasing metals contained in the soil, including iron, aluminium, manganese and arsenic. Further information about ASS can be found at:
http://www.dpi.nsw.gov.au/reader/soil-acidss

What are acid sulfate soil outflows?

Levels of acid are generally measured using a pH scale of 0–7. Normal tap water has a pH of 7; it contains no acid, and is considered ‘neutral’. As the pH level decreases by 1 in the scale, the acidity of the measured solution increases tenfold. ASS-affected waters are acidic, generally recording pH levels of 2–6 in the field. For instance, in a normal, healthy estuary, unaffected by ASS outflows, the pH of the water is about 8; however, in parts of estuaries affected by ASS outflows, the pH can fall to as low as 4, which means there is 10,000 times (10 x 10 x 10 x 10) the amount of acid in the water.

Artificial drainage of estuarine floodplains has accelerated oxidation of iron sulfides, by unnaturally drying the ASS beneath many floodplain areas. The drains provide an efficient pathway for ASS-affected water to enter estuaries. Following high rainfall, extensive areas of an estuary can be acidified, particularly after long dry spells. Acidification of waterways severely degrades estuarine ecosystems; it can cause fish and oyster kills, fish disease, and impact oysters.

Visual indicators of acid sulfate soil-affected waters

ASS-affected waters can cause a dramatic change in the appearance of floodplain drain and estuarine waters. An early indicator of acidic water from ASS is a sudden change in water colour, from turbid brown to either crystal clear or azure blue/green following a flood.

Figure 1. Acid sulfate soil-affected waters can appear very clear. This is caused by low pH (3-4) and high levels of dissolved aluminium, which clarifies the water.

Figure 2. Acid sulfate soil outflows can also appear blue-green at pHs below 5, or milky white at pHs just above 5. This appearance is caused by the presence of very fine particles of aluminium minerals suspended in the water column.

Figure 3. Examples of acid sulfate soil outflows appearing yellow to red due to the presence of iron minerals. High levels of iron at low pHs (<4) appear yellow; at higher pHs the water appears red, due to the fine particles of iron minerals suspended in the water column.

Water impacted by ASS outflows on a longer-term basis can also appear milky or yellow to red, depending on the chemistry of the water. A graphic indicator of acid-impacted drains is rusty-coloured water, caused by the presence of iron oxides.

The effects of acid sulfate soil outflows on oysters

Research has shown that ASS outflows are harmful to the Sydney rock oyster (Dove and Sammut, 2007a; 2007b). American studies have found that a number of bivalve species are unable to tolerate pH levels below 7 (Bamber, 1987; 1990). Some of the direct impacts to Sydney rock oysters caused by exposure to ASS outflows include increased mortality, reduced growth, shell dissolution, reduced feeding activity and soft tissue damage (Dove and Sammut, 2007a; 2007b). Additionally, iron minerals in ASS-affected waters are ingested by oysters, settle on the gills, and form a thick, red coating on the surface of the shells.

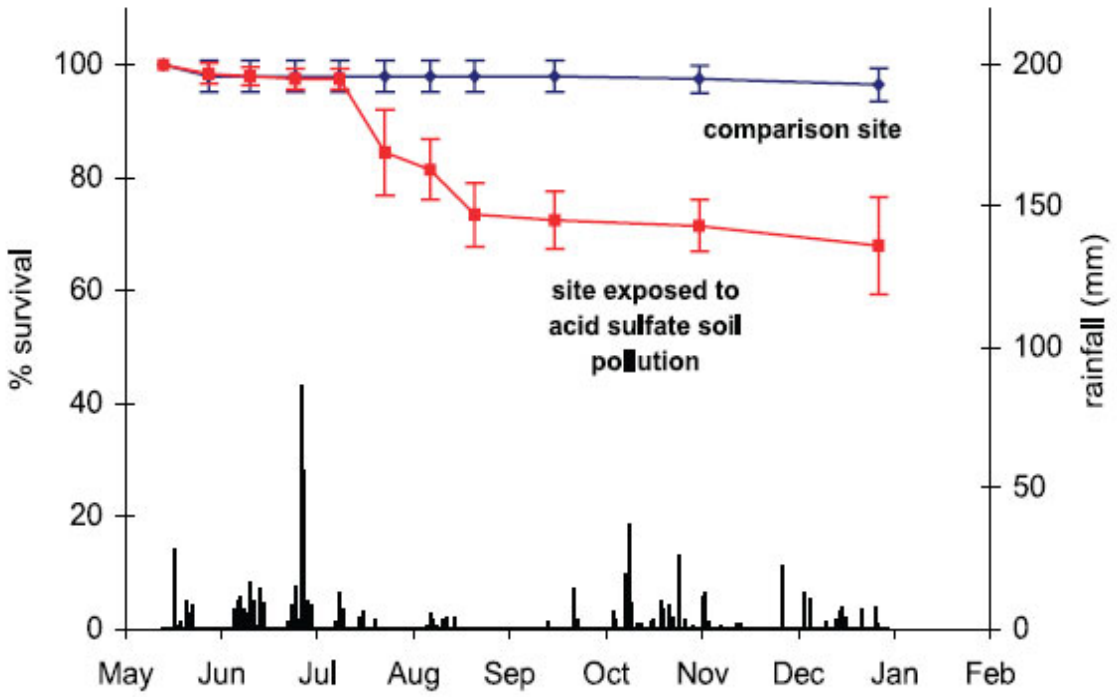

Figure 4. At a site on the Manning River, about 25% of the oysters exposed to acid discharged from ASS died following heavy rain in late June. Error bars show 95% confidence intervals.

The following pictures show examples of the effects of acid sulfate soil outflows on oysters

How to identify the effects of acid sulfate soil outflows on oysters

Iron-rich coating on oyster trays, racks or the stream bank. Iron is a very good indicator of the presence of acidity.

Bleached and degraded shells are revealed when the iron-rich coating is removed. Severe shell bleaching occurs during extended exposure to acid sulfate soil outflows. Episodic acute events may not result in shell bleaching.

Red discolouration of the soft tissue (particularly the gills), which is caused by high levels of iron.

What are the recognisable impacts of acid sulfate soil outflows on oysters?

Red shells caused by the iron minerals settling on the oysters.

Perforation occurs in the back section of oyster shells, after approximately 25 days of chronic exposure to acid sulfate soil outflows.

How to minimise the effects of acid sulfate soil outflows on oyster production

- Avoid areas that become acidified after high rainfall, to reduce potential problems associated with ASS outflows.
- If oysters are located in areas prone to acidification, it is advisable to relocate oysters in the event of high rainfall.
- Spat (baby oysters) to bottle-size oysters are impacted by ASS-affected water to a much greater extent than larger bistro- or plate-size oysters. Farming smaller oysters in areas affected by ASS outflows is not recommended.

The solution to the problem of ASS outflows into estuarine areas will be achieved by better management of acidification at its source, which aims to reduce the magnitude and frequency of discharges, and prevent further disturbance of iron sulfides. A cooperative approach by all stakeholders is continuing to address impacts caused by ASS. Many flood mitigation authorities have programs in place to manage floodgates and drainage systems to improve water quality. Local councils work cooperatively with NSW DPI, NSW DECC, researchers, industry and the five coastal Catchment Management Authorities in NSW.

Further Reading

Bamber, R.N. 1987. The effects of acidic sea water on young carpet-shell clams *Venerupis decussata* (L.) Mollusca: Veneracea. Journal of Experimental Marine Biology and Ecology, 108, 241 -260.

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Further information

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