Managing acid sulfate soils

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.

Common land uses on acid sulfate soils include canal and residential estates, marinas, sand and gravel extraction, agriculture, road construction, aquaculture and golf courses.

In many circumstances, acid sulfate soils can be successfully managed. However, inappropriate management may result in degraded areas, long-term engineering problems, reduced productivity and the release of pollutants from the soil.

There are a variety of management options available to treat acid sulfate soils. Selection of an appropriate management option will depend on the physical and chemical characteristics of the acid sulfate soil, the hydrological circumstances and the environmental sensitivity of the site. Where a major disturbance of acid sulfate soils is being proposed (i.e. >100m^3 disturbed), a soil scientist or engineer experienced in acid sulfate soils management should be consulted. It is essential that an acid sulfate soil investigation be carried out at each site prior to any disturbance to help determine the most appropriate management.

Preferred management strategies

Avoidance

Avoidance is the most preferred management strategy, and should always be attempted at the planning and design stages of a project. Acid sulfate soils are inert when left in waterlogged, undisturbed conditions. Avoidance is often the most environmentally responsible and cheapest option.

Minimisation of disturbance

If acid sulfate soils cannot be avoided, their disturbance should be minimised. Strategies that aim to minimise the disturbance of acid sulfate soils include:

- re-design of earthworks for sites with a variable distribution of acid sulfate soils so that areas with high levels of sulfides are avoided
- limiting disturbances on site so that only shallow disturbances are undertaken
- re-design of existing drains so that they are shallower and wider and do not penetrate sulfidic layers
- minimising groundwater fluctuations by avoiding activities such as dewatering, deep drainage, and the installation of groundwater extraction bores. It is advisable to seal off surrounding sediments using sheet piling during unavoidable excavation and then use basement tanking to exclude groundwater.

Neutralisation

Neutralisation of acid sulfate soils involves mixing neutralising/alkaline materials into the soil. Superfine agricultural lime (calcium carbonate) is the best choice for acid sulfate soil application. Thoroughly mixing the appropriate amount and type of neutralising material into disturbed acid sulfate soils will neutralise any acid produced. Agricultural lime has an alkaline pH and buffers any acid produced whilst raising the soil pH to acceptable levels. Spreading the soil into thin layers in a treatment area and ploughing in lime is the most common method, but some projects are employing soil mixing machines to apply lime (Figure 1).

Figure 1 – Lime application for treatment of acid sulfate soils.

Hydrated lime (calcium hydroxide), is often more appropriate for treating acid waters due to its higher solubility (Figure 2). Once the acid water has been treated to pH 6.5–8.5 and metals (particularly iron) have been reduced to appropriate levels, it can usually be safely released from the site at a controlled rate to prevent significant changes to the quality of offsite waters (previous approval required). The amount of neutralising agent required depends on soil and water test results and the treatment agent chosen. Materials that can be used include quicklime (calcium oxide), sodium bicarbonate, dolomite (calcium magnesium carbonate), and some industry by-products.

Figure 2 – Hydrated lime can be mixed into slurry and pumped into a pond containing acidic water to neutralise the acid.

The alkalinity of neutralising materials and their chemical composition varies greatly and some need to be handled with caution. For example, calcium hydroxide is highly alkaline (pH 12) and can harm the environment if over applied. Some neutralising agents are also very corrosive. Industry by-products may contain metals and therefore require testing prior to use.

Hydraulic separation

Hydraulic separation is suitable for coarse-textured sediments (i.e. sandy material) containing iron sulfides. Mechanical methods, such as sluicing or hydrocycloning, are used to hydraulically separate the sulfides from the coarser textured materials. This is an effective form of management in areas when the sediments contain less than 10–20 per cent clay and silt, and have low organic matter content. The separated sulfidic material extracted via the process requires special management involving either neutralisation or strategic reburial.

Strategic reburial

Strategic reburial involves the placement of potential acid sulfate soils into a void, where the soils can be permanently maintained in anaerobic (wet, oxygen-free) conditions at all times. The void can be covered with surface water (e.g. within the base of a lake), or covered by groundwater and compacted soil. The risks associated with this technique depend in part on the nature of the material to be buried. If material is not reburied quickly and is allowed to dry, oxidation and acid production will occur. Any excavated material that has begun to oxidise will require neutralising prior to placement below permanent water.

Higher risk management strategies

Some strategies for managing acid sulfate soils are high risk and are therefore generally inappropriate. These strategies include stockpiling acid sulfate soils, strategic reburial of soils with existing acidity, large-scale dewatering or drainage and vertical mixing.

Management plans

A good management plan will ensure that techniques to treat and manage acid sulfate soils are effective, and that adverse environmental impacts do not occur. Development of a thorough monitoring program is recommended as part of any management plan. Monitoring of soil and water should occur before, during and after disturbance to assess likely impacts.

Figure 3 – An automated water quality monitoring system with pH, temperature and conductivity meters, a data transmitter and independent power source (solar panel and backup battery). Systems like this require cleaning and calibration around once per week and their output can be monitored remotely.

References

Queensland Government (2013a) Queensland Acid Sulfate Soil Technical Manual: Soil Management Guideline. Department of Science, Information Technology, Innovation and the Arts, Brisbane.

Queensland Government, (2013b) State Planning Policy Guideline: Planning and Development Assessment Guide for Acid Sulfate Soils. Queensland Department of State Development, Infrastructure and Planning, Brisbane.

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 – Land Series L62. Other science notes related to this topic include:

- L60—Acid sulfate soils in Queensland
- L61—Identifying 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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