



Using composting beds to treat acidity in saline drain water

Introduction

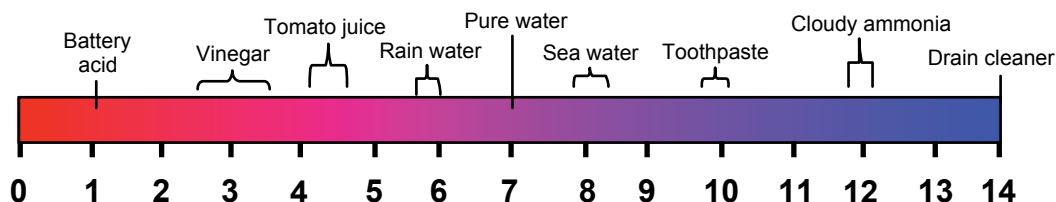
Acidic saline water is common in drains used to manage shallow saline watertables in the Wheatbelt. The water often has high concentrations of dissolved aluminium, iron and trace metals such as lead, nickel, copper and zinc (Shand & Degens 2008). Such drain water would threaten aquatic and bird life in waterways and lakes if it reached these environments (Shand & Degens 2008). Treating the water to neutralise the acidity and remove dissolved metals may be needed to manage these risks.

Key points

- Composting beds in drains or at the ends of drains can be a low-maintenance way of treating acidic saline drain water.
- The treatment systems can handle very acidic water and remove a range of trace metals.
- The key to success is using the correct organic mix and sizing the treatment systems to the acidity load to be treated.

pH and why it is important to water

pH is a measure of the acid or alkaline property of water commonly ranging from 0 to 14, where a pH < 7 is acidic, pH 7 is neutral and pH > 7 is alkaline. pH reflects the balance of hydrogen ions (acid) and hydroxide ions (alkaline) which make up part of the acidity or alkalinity of water that is often due to other things dissolved in the water such as metals, bicarbonate or carbon dioxide gas.



Low pH or acidic water is corrosive and harmful to aquatic life and can contain metals that can also affect aquatic life.

Acidity in drain water can be treated by adding neutralising materials to raise pH or by using microbial processes to neutralise and trap metals. Some simple technologies using these basic principles have been adapted from treating similarly acidic water generated after some mining operations (Degens 2009). While the treated water may still be saline the risks from acidity and dissolved metals can be greatly minimised and the potential uses for the water expanded.

Typical acidic drain waters in the WA Wheatbelt are saline, have a pH between 3.2 and 4.5 and contain high concentrations of dissolved metals such as aluminium and iron. Treatment of these waters aims to remove the majority of the dissolved metals and raise the pH to where it will equilibrate at around 6.5.

This information sheet introduces a treatment approach using composting beds.



What are composting beds?

Composting beds are mixtures of organic materials (see box *Materials for composting beds*) kept permanently waterlogged and in low oxygen conditions to encourage the growth of the microbes that generate bicarbonate and substances that trap dissolved metals. The microbes reduce sulfate in the salt water to hydrogen sulfide (rotten egg gas) during the decomposition of organic materials. Bicarbonate is produced as a by-product of sulfate reduction. The hydrogen sulfide reacts with dissolved metals to form insoluble, often black, sludges (sulfide minerals) that settle out and are retained in the composting mixture (Fig. 1).

Figure 1 Black sludges coating organic materials as a result of microbial treatment of acidity



Materials for composting beds

Fast decomposing, high quality:
composted manure, silage, spent or waste grain, fresh plant material (milled), mushroom compost, sewage sludge

Slow decomposing, low quality:
straw, oil mallee distillation residues, wood chips, sawdust, harvester chaff, stubble

Cost range - \$15 to \$40 per m³ depending on transport and source material costs

In the composting beds, acidic water percolates *through* the organic mix or slowly flows *over* the top while acidity is neutralised by alkaline water seeping from the organic mix. The beds function most effectively when the microbes can produce alkalinity by sulfate reduction fast enough to neutralise the acidic water moving through. If the composting bed cannot produce alkalinity fast enough to neutralise the acidity moving through the bed, the treatment effectiveness will be hampered because the microbes do not perform well in low pH water.

Where might these be used?

Composting beds can be used treat acidic water either in drain *bases* as the water seeps into the drain bases or at the *ends* of drains before water is released from the drainage system. The two approaches require different attention to design and offer different benefits and limitations (see Degens 2009 for details).

In drain bases

Treatment in drain bases uses pools that are common in drains and the already available constructed spaces (Fig. 2). The beds treat the water as it seeps into the drain and keep the

trapped metals in the drain. Construction might initially involve deepening a drain (without broadening the base) to accommodate the waterlogged bed. This may be cheaper than digging the equivalent larger area, often to greater depth, at the end of a drain.

At drain ends

Treatment using composting beds at drain ends involves constructing permanently waterlogged pits through which drain water flows (Fig. 3). The organic materials in the pits need to be near the local watertable and at a level that allows water to flow from the end of the drain through the treatment area. Shallow ponds are often needed at the outlet of the wetland pits to trap iron precipitated by the treatment. These drain-end systems often allow more treatment control as it is easier to add more treatment area and to control water flows into and out of the systems than to add to in-drain composting beds.



Figure 2 Example of an in-drain composting bed treating acidic drain water (in the Wallatin Creek catchment)



Figure 3
A composting bed in a pit constructed at the end of a drain near Beacon

How well do they work?

Composting beds can work well in the short term using simple, cheap mixes of slow and fast decomposing organic materials. Long-term treatment is more likely by using mixes with better quality organic materials (see box *Materials for composting beds*). Composting beds can raise the pH from less than 3.5 to more than 6.5 and remove from the water all acidity and a wide range of metals including iron, aluminium, lead, nickel, copper and zinc (Degens 2009).

In-drain composting beds

In-drain composting beds can successfully treat acidic water if the organic mix is right and the acidity loading in water seeping into the drain is not too much. The drain water pH was raised from less than 3.5 to more than 5.5 and as high as 6.6 using a simple organic bed in 200 m of drain in Wallatin Creek (Fig. 4). To maintain complete treatment extra-fast decomposing materials such as spoilt grain had to be added. This indicated that such a mix is needed when *setting up* the composting beds rather than adding later.

As space for in-drain composting beds is limited, improving the mix of organic materials rather than increasing the volume may be necessary for adequate treatment. Even when treatment beds are overwhelmed with acidity, the water may be partially neutralised, making it much easier to finish treatment using other low-cost methods.

When in-drain composting beds work well, water from treatment systems has the capacity to neutralise water downstream for some distance. At Wallatin Creek the 200 m long composting bed neutralised water (i.e. raised the pH above 7) for more than 600 m downstream.

Drain-end beds

Composting beds in shallow pits at drain ends (wetland pits) can achieve high treatment rates, similar to in-drain beds (Degens 2009). A cheap mix of composted sheep manure laid

beneath straw in a 300 m² pit at Beacon treated 500 kL of very acidic water with pH as low as 2.8 for up to 6 months (Fig. 5). This was not sustained much beyond 12 months and reducing the flows resulted in most water evaporating rather than flowing out of the wetland. Using an organic mix with a higher percentage of decomposable material would have increased the treatment capacity and duration.

Even when the pH falls below 4 (i.e. more acidic), most composting beds can still reduce acidity by up to half, although they tend to be less effective in removing trace metals like aluminium, lead, nickel and copper.

What do you need to know to build a composting treatment system?

A 'one size' treatment system does not fit all acidic water. The most important aspect of building a successful composting bed is to ensure that the system is big enough to handle the acidity loading. Composting systems are sized according to the load to be treated daily. It is necessary to have some idea of the drain water's acidity load and whether it varies. This can be estimated by measuring flows and acidities several times during a year (see Degens 2009 for further details).

Composting beds work on a treatment per day by area basis and hectares of land might be needed if treating flows from drains tens of kilometres long. A simple 'rule of thumb' is that every 1000 litres of water containing 0.5 kg of acidity (see Degens 2009 for a description of this) needs to be held for a day in a minimum 143 m² of composting bed. This builds in a safety factor to guarantee treatment over a long period, provided that a good mix of organic materials is used. The area needed may be greatly reduced if the organic mix contains a higher percentage of high quality materials (see box *Materials for composting beds*). Extra area may also be needed to aerate water from the composting beds. For in-drain treatment, the area available for treatment beds is limited, but this might be compensated by using better quality organic mix (see box *Materials for composting beds*).

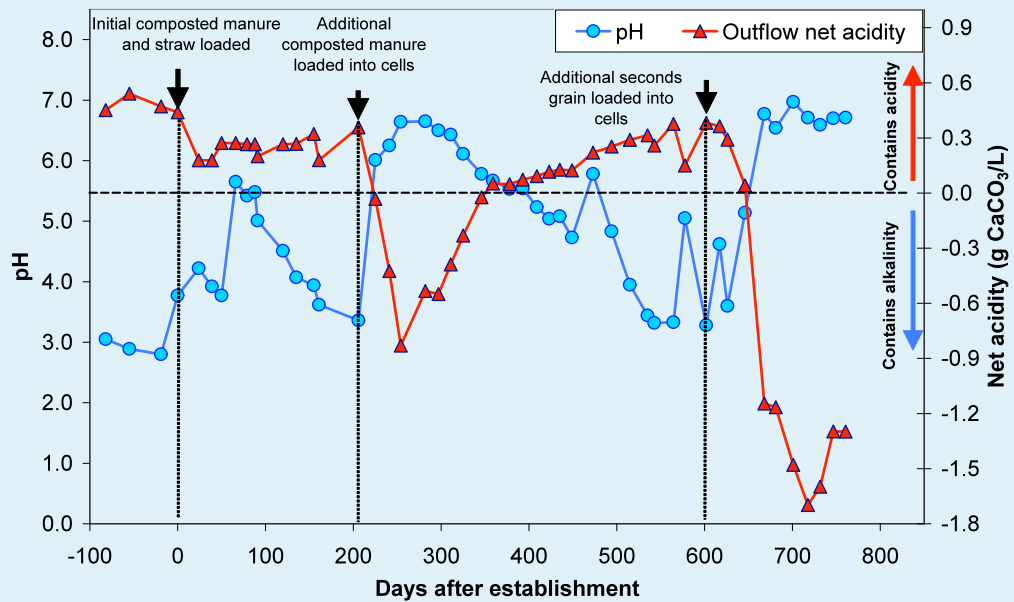


Figure 4 pH and acidity of water from an in-drain composting bed

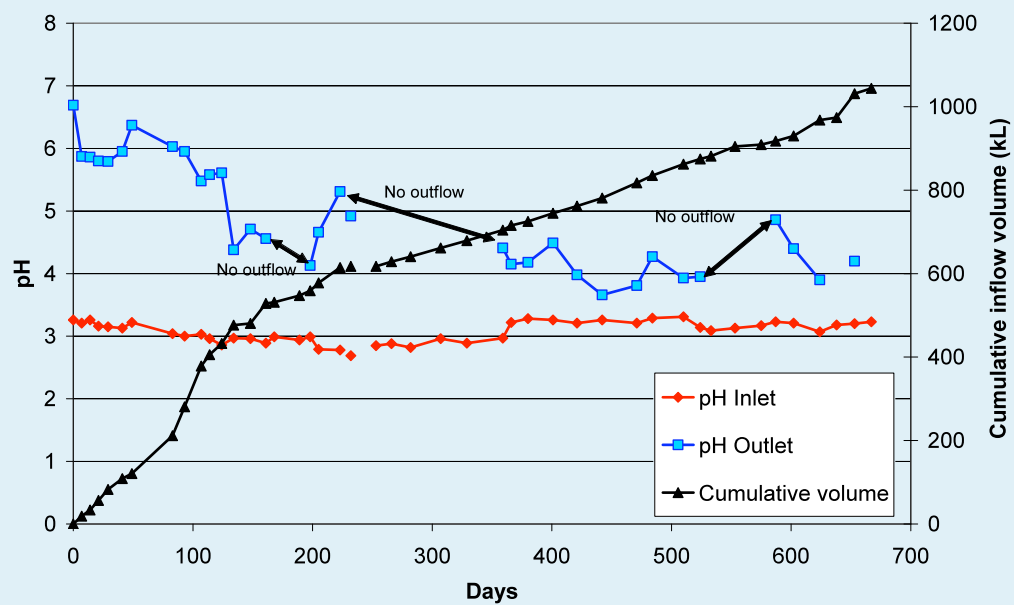


Figure 5 pH and acidity of water into and out of a pilot composting wetland at Beacon



A mix of slow and fast decomposing materials is needed for the best long-term operation. The mix is important because the microbes that fuel the treatment use the organic materials as their food source. The organic materials need to be mostly slowly decomposing materials such as straw or green waste mixed with faster decomposing materials such as manures, fresh plant matter or waste grain. These need to be formed into a bed around 0.3 m thick.

The organic mix must be permanently waterlogged to maintain the low oxygen conditions required to allow the bacteria that reduce sulfate to hydrogen sulfide to flourish. The low oxygen conditions are also important in keeping the metal-trapping sludges in the organic mix stable. The sludges are minerals that contain stored acidity which can be released if the sludges dry out and are exposed to the air.

Drain-end composting beds may be kept permanently waterlogged by digging the wetland deep enough that the base is in contact with the watertable if there is a long-term shallow watertable, or ensuring constant flows. Creating in-drain waterlogged conditions may involve exploiting existing pools or may require deepening the drain (with vertical cutting) to avoid sacrificing depth.

Other design aspects include not using composting beds in drains with a risk of high flows (or bunding the drains to reduce the risk) and the need to retain the waterlogged organic sludges. For both in-drain and end-drain beds, sludges need to be

managed so that they do not dry out but, if they do, the materials must be capped and contained within limestone-rich soil materials.

For more detailed design aspects see the proposed design guidelines (Degens 2009).

Acknowledgements

We acknowledge funding support from the Avon Catchment Council and the cooperation of Wallatin Wildlife and Landcare Inc. and landholders at Beacon and Doodlakine in conducting the pilot treatment trials.

For further information on treating acidic saline drain water

Degens, B 2009, *Proposed guidelines for treating acidic drain water in the Avon catchment, Western Australia: adapting acid mine drainage treatment systems for saline acidic drains*, Salinity and land use impacts series, Report no. SLUI 54, Department of Water.

For further reading on acidic water characteristics and risks

Shand, P & Degens, B 2008, *Avon catchment acid ground-water: geochemical risk assessment*, CRC-LEME Open File Report 191, CSIRO Exploration and Mining, Bentley, WA, accessible at: <http://crlceme.org.au/>.

Related brochures — available from Publications at www.water.wa.gov.au

Degens, B & Shand, P 2009, *Introduction to acidic saline groundwater in the WA Wheatbelt — characteristics, distribution, risks and management*, Department of Water.

Degens, B 2009, *Treating acidity in saline water and sediments in the Wallatin Creek catchment using a hydrated lime dosing unit*, Department of Water.

Contact: Brad Degens (08) 6364 7800; brad.degens@water.wa.gov.au