Case study 1: Bioreactor wall South-East Queensland

Project leader and partnerships	Department of Agriculture and Fisheries collaborating with Queensland University of Technology
Funding source	Department of Environment and Science (Resilient Rivers Initiative)
Project length	Two years (June 2017 – June 2019) of intensive monitoring completed Continuation of some monitoring
Region	South East Queensland (Glass House Mountains)
Production system	Pineapples
Date of installation	14th June 2017
Length of installation	Three working days for installation (two weeks including design and site selection)
Bioreactor type	Wall bioreactors (one softwood, one hardwood)
Project objective	Research trial to quantify nitrate removal performance.

Summary of the landscape

The two bioreactor walls were located downslope of a pineapple production system. They were located perpendicular to the slope and parallel to the adjoining waterway, with the intent of intercepting shallow groundwater and any nitrate leaching through the soil profile from the pineapple crop. One wall was filled with softwood chips and the other hardwood chips. The soil at the bioreactor site is a free draining kurosol and overlies a clay layer.

Average rainfall and temperature

The area has a humid subtropical environment with average daily temperatures ranging from 14.0°C to 25.8°C. During the monitoring period mean annual rainfall was approximately 800 mm per year.

Sizing and volume capacity

The walls were approximately 20 m long, 1 m deep, and 1.4 m wide. The final volume of the softwood and hardwood walls was 27.9 and 26.2 m³ respectively.

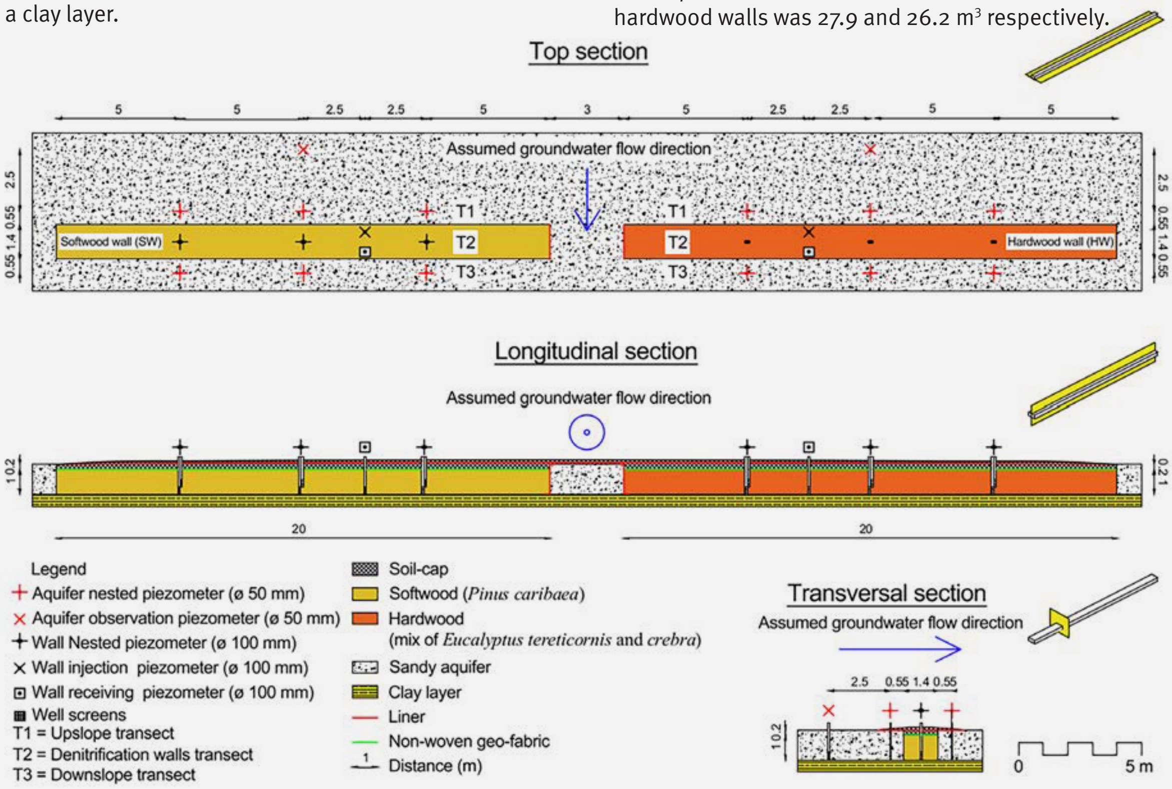

Figure 1 Design of the bioreactor walls showing transects. Source: QUT

Design features

Each bioreactor (Figure 1) is rectangular in cross-section and featured three transects of nested piezometers parallel to the wall, located up-gradient (T1), within (T2) and down-gradient (T3) of the wall. There are nested piezometers to intercept two regions of the aquifer and the bioreactors, set at 0.0-0.3 m and 0.3-0.6 above the clay layer.

Water source

The bioreactor receives shallow groundwater recharged by rainfall. The groundwater only flows intermittently during the year, with the majority of flow during the wetter summer months (November – April). The direction of shallow groundwater flow was at a 30-45° angle to the bioreactors.

Construction methods and materials

The bioreactor walls were constructed by digging two trenches perpendicular to the assumed groundwater flow direction (Figure 2). The bioreactor depth was determined by the underlying shallow clay layer and the width was determined by the excavator bucket dimensions. A three-metre gap was left between the two trenches and black plastic was placed on the sides of the soil bank to prevent water flowing between the two walls.

Figure 2 Construction of bioreactor walls.

PVC piezometers for water sampling were installed above, in the centre and below the trench at intervals along their lengths (Figure 3). The piezometers were prepared by drilling 5 mm perforations around the base of the pipe for a 0.5 m length to allow for water sampling. Piezometers were wrapped in a 2 mm geo-fabric, to avoid fine particles entering the piezometers. Three 100 mm PVC piezometers were installed and mesh bags filled with woodchips were placed in the piezometers to enable woodchips to be collected and analysed for degradation.

The bioreactors were filled with approximately 20 mm woodchips. The softwood used was *Pinus caribaea* and the hardwood was a mix of *Eucalyptus tereticornis* and *Eucalyptus crebra*. Geofabric was placed on top of the woodchips and both systems were covered with a 20 cm deep soil cap. A heavy-duty plastic liner was placed on top of the soil cap to prevent contamination of the walls with rain and surface run-off.

Manual gas sampling chambers were installed upslope, on top, and downslope of the bioreactors (six per bioreactor). Additional piezometers were installed up slope of each bioreactor, to extend the groundwater monitoring network.

Figure 3 Location of wall downslope of pineapple crop, showing layout of monitoring piezometers (green buckets).

Costs

The bioreactor walls cost approximately $\$50\ m^{-3}$ based on machinery (hire, driver), woodchip (including delivery) and grass seeding.

Performance

100% removal efficiency in both bioreactor walls, likely due to nitrate limited conditions.

Softwood wall: 0.0-5.0 g N $m^{-3}\ d^{-1}$ with an average of 2.0 g N $m^{-3}\ d^{-1}$.

Hardwood wall: 0.0-5.7 g N $m^{-3}\ d^{-1}$ with an average of 1.6 g N $m^{-3}\ d^{-1}$.

Monitoring regime (intensity and frequency)

The bioreactor walls were monitored once a week (when saturated) for a period of 24 months. The following water quality parameters were analysed: nitrate, ammonium, dissolved organic carbon, dissolved oxygen, pH and temperature.

Water samples for dissolved greenhouse gas analysis were collected weekly for 18 months (nitrous oxide, carbon dioxide and methane).

Gas samples for greenhouse gas surface emissions (nitrous oxide, carbon dioxide, and methane) were monitored for a period of four months.

Saline tests were completed once the system was fully saturated.

Troubleshooting

The bioreactor was installed at a 30-45° angle to the direction of shallow groundwater flow which created bypass flow.

What would you do differently?

Pre-determine the hydrogeology of the landscape to determine the best location and design for the bioreactors.

For more information:

Manca, F., De Rosa, D., Reading, L. P., Rowlings, D. W., Scheer, C., Layden, I., Irvine-Brown, S., Schipper, L. A., and Grace, P. R. (2020). Nitrate removal and greenhouse gas production of woodchip denitrification walls under a humid subtropical climate. *Ecological Engineering* **156**, 1-10

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