Fig. 1

Controls over dissolved Fe within ground and surface water micro-environments in a subtropical coastal setting, Australia

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Introduction

In addition to causing the general degradation of water quality, nutrients such as N, P and Fe can contribute to toxic blooms of the cyanobacteria, *Lyngbya majuscula*, which has negative impacts on marine ecology and human health. *Lyngbya* blooms have been found in close proximity to this study area and in other areas along the coast of SE Queensland and are of great concern to governmental organisations and the wider community.

Lyngbya washed up on a beach in south-east QLD

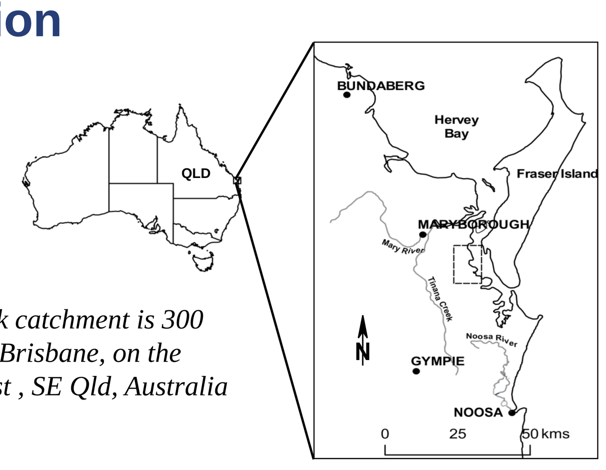
A multi-disciplinary study with particular emphasis on controls over Fe distribution has been conducted in managed *Pinus* plantation catchments on the Fraser Coast in sub-tropical Queensland, Australia. Previous research established that there are overall high concentrations of Fe in the soils and sediments (Löhr 2010) of this study area and high levels of bacterial activity (Lin et al. 2011). This study focuses on processes that affect the mobilisation and transport of Fe in the surface and groundwaters of this region. These processes are described here as they occur at one surface and two ground water sites.

Looking out from the top of the Poona catchment towards Fraser Island, a popular tourist destination

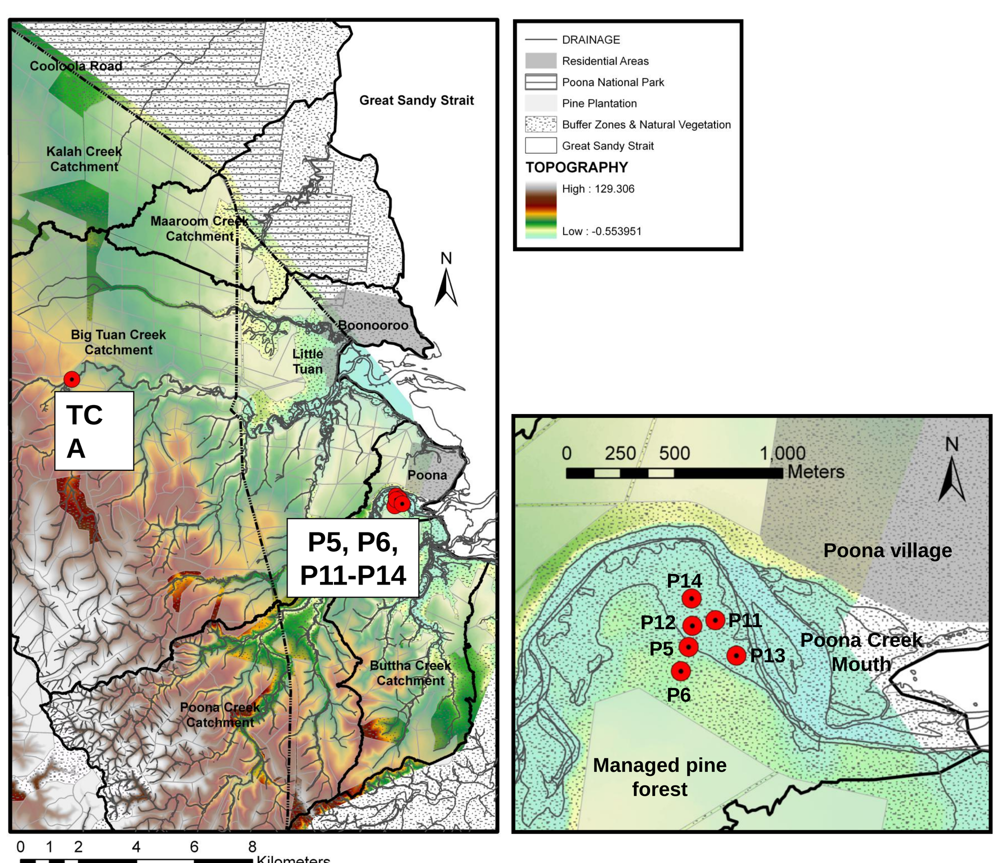
Aim

- Identify and investigate processes that potentially affect the transport of iron within these coastal catchments

Study Location



Poona Creek catchment is 300 km north of Brisbane, on the Fraser Coast , SE Qld, Australia



Methods

- In-situ measurements of Eh, DO, pH, EC, T
- Fe_{total}, Fe(II): AQ2 discrete analyser – phenanthroline method
- Fe(III) by difference
- H_2S: Methylene blue method (Eaton & Andrew, 2005)
- $\delta^{13}C$, $\delta^{34}S$, $\delta^{15}N$: GNS Isotope Laboratory, NZ
- DOC: Shimadzu TOC-5000A Analyzer

Results

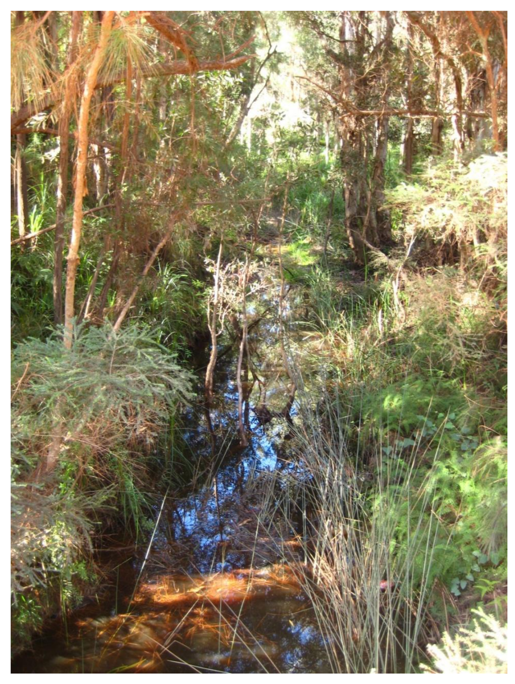
	SITE ID			
PARAMETER	**P5**	**P6**	**TCA1**	**TCA2**
pH	5.6	4.9	5.3	5.3
Eh (mV)	+52	-50	-76	+22
DO (mg/L)	4.2	0.1	0.1	0.2
Fe(II) (mg/L)	38.4	5.7	29.8	n.a.
Fe(III) (mg/L)	17.4	0.6	9.1	n.a.
DOC (mg/L)	40.3	7.8	22.1	n.a.
FeRB (cells/mL)	ca.10^4	ca.10^8	n.a.	n.a.
FeOB (cells/mL)	ca.10^2	ca.10^4	n.a.	n.a.
$\delta^{13}C$ ‰ VPDB	-17.7	-20.0	-19.4	n.a.
$\delta^{15}N$ ‰ AIR	-1.4	6.8	7.4	n.a.
$\delta^{34}S$ ‰ VCDT	19.3	19.0	32.6	n.a.
H_2S (mg/L)	0.9	4.3	0.3	n.a.
SRB (cells/mL)	ca.10^5	ca.10^3	n.a.	n.a.
SOB (cells/mL)	ca.10^3	ca.10^3	n.a.	n.a.

Notes: TCA1 and TCA2 are sampled from the same location (TCA). TCA1 has been sampled close the bottom and TCA2 0.4m above

n.a. = not analysed, FeRB = Fe reducing bacteria, FeOB = Fe oxidising bacteria, SRB = sulphate reducing bacteria, SOB = sulphate oxidising bacteria . Cultivable bacterial numbers from Lin et al. (2011)

Discussion

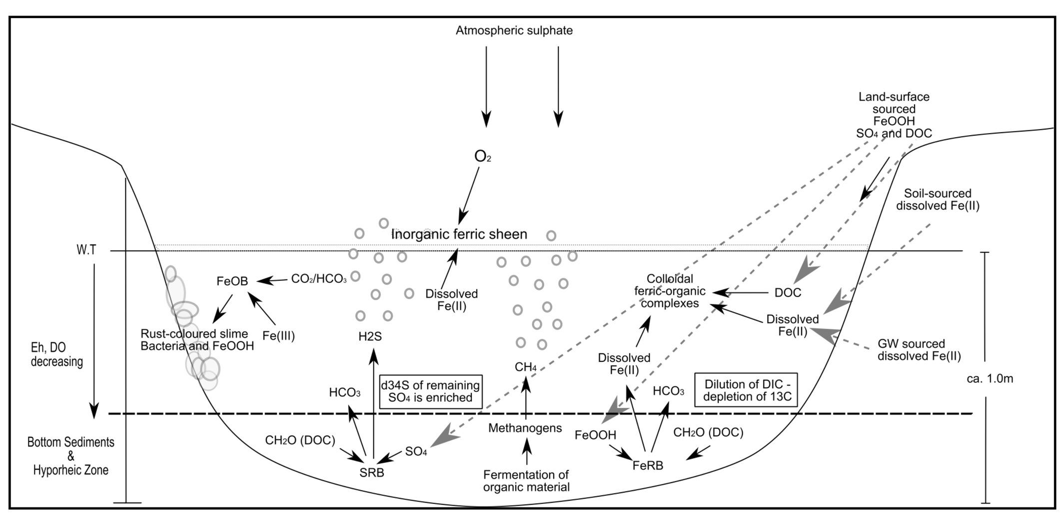
Micro-environment: Tuan Creek



Surface water site in Big Tuan Creek. This site is located ca.17 km inland from the Great Sandy Strait in an ephemeral stream. The adjacent riparian vegetation is mainly native, however, substantial exotic pine organic materials have also been observed in the stream

Micro-processes

- A gelatinous rust-coloured slime was observed indicating microbial Fe(II) oxidation
- An oily rainbow-coloured sheen was observed on the water surface indicating abiotic Fe(II) oxidation
- Organic complexation of Fe(III) – high 'dissolved' Fe(III) concentration
- Reduction of FeOOH occurring in hyporheic zone – high dissolved Fe(II)
- Sulphate reduction also evident – high $\delta^{34}S$, dissolved H_2S present
- High levels of DOC enable FeOOH and SO_4 reduction by providing a C substrate for microbes



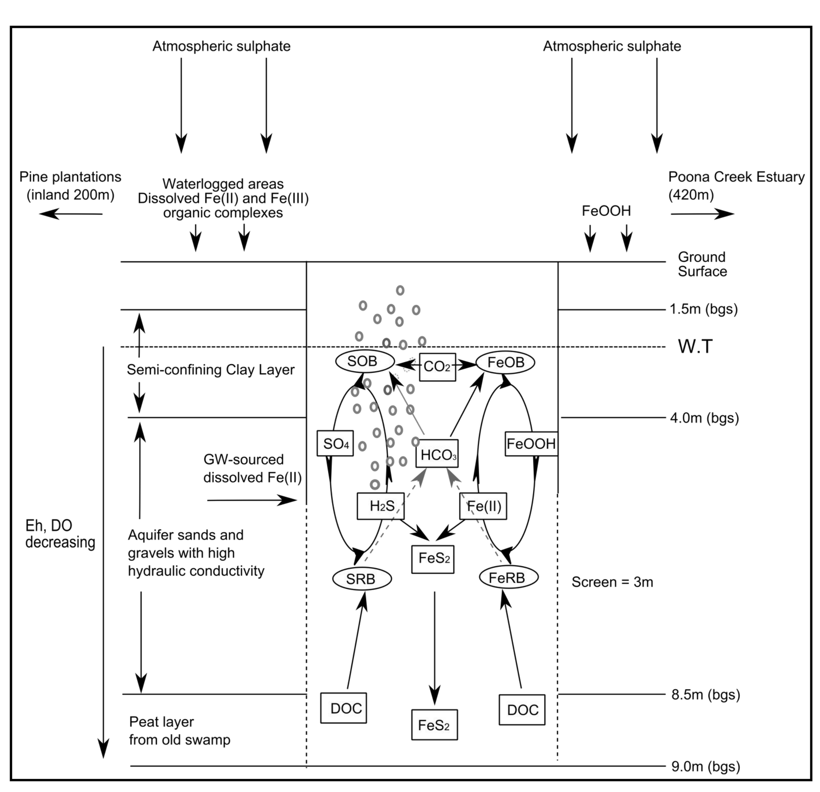
Microprocesses occurring at the sampling site TCA in Tuan Creek

Micro-environment: Monitoring well P6

P6 is located in a transect of monitoring wells drilled parallel to this road. This monitoring well is only 420m from the estuary but due to vertical confining clays is still fresh and is subject to tidal intrusion only during extreme conditions.

Micro-processes

- Cultivable bacteria numbers indicating high Fe and S microbial activity
- Higher numbers of FeRB reflected in Fe(II)/Fe(III) ratio
- H_2S concentration very high due to SRB
- Depletion of $\delta^{13}C$ due to conversion of DOC to DIC by microbes
- Carbon substrate provided by peat layer in semi-confined aquifer conditions
- Dissolved Fe(II) and S complex to make FeS_2 (pyrite) which precipitates out of solution

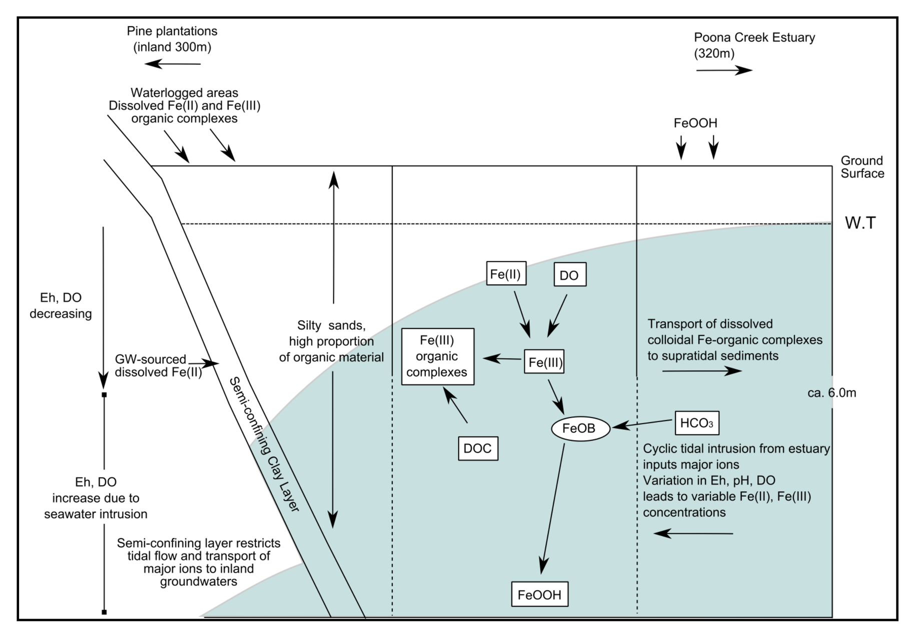


Microprocesses occurring at P6 in the alluvial sediments near Poona Creek estuary

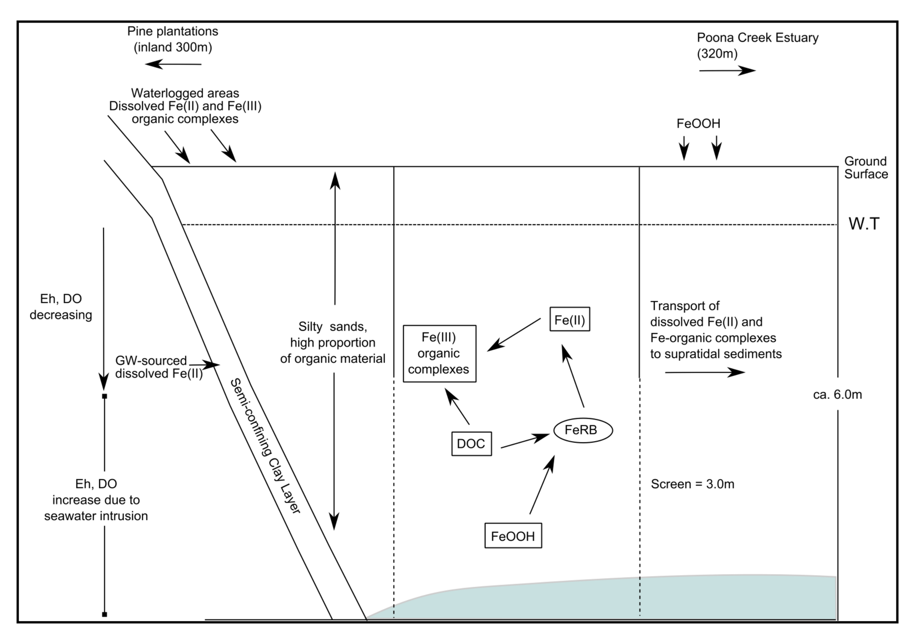
Micro-environment: Monitoring well P5

A monitoring well (P11) within the supratidal flats adjacent to Poona estuary located ca. 120m coastward of P5. This well also had appreciable but lower concentrations of Fe(II) and Fe(III) indicating that similar micro-processes are occurring within the supratidal areas

- P5, located 300m from the estuary is at the interface between fresh inland and subterranean estuarine waters
- The sediment profile consists of silts, sands and organic materials that provide DOC for microbial reduction of Fe(III) and SO_4 and for Fe(III) organic complexation
- 'Iron curtain' effects (precipitation of FeOOH due to saline intrusion and associated rise in pH) results in very high concentrations of Fe
- Subsequent reduction of FeOOH during lower tides results in high dissolved Fe(II)
- Cultivable bacteria numbers are not as high as P6 but still indicate significant Fe and S microbial activity
- Gleying (blue-green colouring indicating presence of Fe(II)) in sediments and appreciable Fe [Fe(II) 0.7-5.7mg/L, Fe(III) 0.7-6.6mg/L] measured in supratidal flat samples [P11 – P14] indicate transport of Fe closer to estuary



Microprocesses occurring at P5 under high tide conditions



Microprocesses occurring at P5 under low tide conditions

Note: The processes in both diagrams are active to varying degrees at all times. This approach has been taken to simplify the depiction of these processes.

Conclusions

Bacterial activity and organic carbon are very important contributors to the form of Fe within these types of coastal catchments through the following processes.

1) Microbial reduction of Fe oxyhydroxides to dissolved Fe(II) mobilises Fe for transport
2) Organic material input to surface and groundwater systems provide a carbon substrate for microbial reduction
3) Organic material also enables the organic complexation of Fe(III) and stabilises Fe(III) for transport through catchments
4) Iron curtain effects lead to an increase in Fe at saline/fresh interfaces

These processes can influence the transport of Fe to marine waters and potentially contribute to *Lyngbya* blooms. Although well-known, they are often ignored when carrying out environmental assessments. These examples emphasise the importance of considering the role of microbes and organic material in the transport of Fe to coastal waters.

Acknowledgements

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