TECHNICAL NOTE

Dr Ian Fordyce, Kalannie, September 2005

Drain Precipitates/Sediments (from Final Report on Feasibility Study, Oct. 2005)

There are no published accounts about the geochemistry and mineralogy of precipitates in WA drains. However, there have been reports of high concentrations of heavy metals and rare earths in drain discharge (Ali *et al*. 2004; Steve Rogers, CSIRO, pers. comm.), raising concerns about possible pollution in ‘downstream’ wetlands. This concern seems to have developed from the recent recognition that acid groundwater is widespread in the southwest of WA (Coleman & Meney 2003, Dogramaci & Degens 2003).

A group led by CRC LEME (Co-operative Research Centre for Landscape Environments and Mineral Exploration) and including the WA Department of Agriculture and the WA Department of Environment has been researching this heavy metal issue as part of the Engineering Evaluation Initiative (EEI). Although their study has focussed largely on the Avon Catchment, at YYCMG’s request, the study has been extended to include parts of the Yarra Yarra Catchment. Much of the information we have collected from pits and bores over many years has been made available to the group and, in return, some of their findings are available to YYCMG.

The groundwater that flows into newly excavated pits is of special interest, as it is likely to be fairly representative of drain water at that site – more so than bore water, at least. In the feasibility project, we collected water from pits (three pits in each of 10 subcatchments) on the day following excavation, and again after three months. Electrical conductivity and pH were measured at the site. Filtered samples were sent to the CSIRO, Land and Water laboratory in Adelaide for analysis of a comprehensive suite of metals, rare earths and radioactive elements, as well as standard cations and anions.

George & Rogers (2004) and Rogers & George (2005) reported that drains on the WA wheatbelt fall into two broad groups – those that are approximately neutral and those that are strongly acid – with very few intermediates. We observed a similar dichotomy in pits. Those in the north of the Yarra Yarra region (say, north of latitude 13^{o} 50’ S, approximately Maya East Rd) had a pH value in the range 6.5-8.0. Most of those in the south were in the range 3.5-5.0. The northern pits, i.e. those with neutral or near-neutral groundwater, were associated with red-brown loams, with a distinct calcareous (calcrete), siliceous (silcrete), and/or ferruginous (ferricrete) hardpan (Fig. 1). Strongly acid groundwater, on the other hand, was associated with shallow duplex soils, where yellow sand was underlain directly (at depths of only 15-50 cm) by light brown or yellow clay (Fig. 2). The table below shows the subcatchments investigated in the current project, with the corresponding pH of groundwater encountered in pits.

Table . 1. Groundwater pH in pits excavated during Autumn, 2005. Subcatchments are listed from north to south. Each pH figure is the average (± standard error) from at least three pits along the main drainage line in each subcatchment.

Subcatchment	Groundwater pH
Canna-Gutha 45	7.4 ± 0.2
Bowgada 3	7.4 ± 0.3
Perenjori 13	6.7 ± 0.3
Mongers 29	7.9 ± 0.3
Mongers 16	nd
Mongers 17	6.5 ± 0.9
Mongers 55	3.8 ± 0.2
Jibberding 19	4.8 ± 1.1
Goodlands 33	6.7 ± 0.2
Burakin 27	4.9 ± 0.5

nd: not determined

In their preliminary survey of drains in the Avon Catchment, Rogers & George (2005) identified three broad types of precipitate as potential hosts for heavy metals, namely

- red crusts and gels (iron oxyhydroxides; Fig. 3a)
- white films and gels (aluminosilicates; Fig. 3b)
- black ooze (monosulphides; Fig. 3c).

We have recognised examples of each of these types in existing drains in the Yarra Yarra Catchment. In addition, some drain-wall crusts (Fig. 3d) of carbonate (e.g. lime), sulphate (e.g. gypsum) and halide (e.g. salt) are known from other areas to contain trace concentrations of metals as impurities (e.g. Kohut & Dudas, 1993).

Samples from Yarra Yarra, as well as other parts of the wheatbelt, are being examined by an independent group at the University of Western Australia in Perth. Although this research is at only an early stage, it is clear from mineralogical work completed so far that some of the hosts are in fact hydrous or amorphous species. That is, they have no well-defined crystalline structure, but have instead a temporary and precarious existence, which depends on immediate environmental conditions (such as temperature, humidity, acidity and/or exposure to air). Amorphous phases are unstable and can change chemically (releasing whatever trace elements they include) to form stable minerals. Many of these minerals, such as iron oxides, are relatively stable in rainwater, but become soluble (along with their cargo of metals) under strongly acid conditions.

A more-detailed knowledge of the chemistry of drain water and precipitates will allow us to devise effective management strategies and plan for any problems that might arise from the composition of drain sediments. For example, if a drain is blocked and allowed to dry out, black monosulphide muds will react with oxygen in the air to generate acid. When flow resumes, the water will become considerably more acidic and capable of carrying higher concentrations of most trace elements, including heavy metals such as copper and cadmium. Another research finding that has management implications is that many of the minerals that are known to carry metals have specific requirements for oxygen (or the lack of it). This means, for example, that solubility might be enhanced in strongly reducing conditions, such as those produced by decomposing matter (Fig.4). For this reason alone, quite apart from hydraulic considerations like maintaining an unobstructed flow and scale (iron oxide) build-up on walls, it is important to clean drains periodically.

Geochemical and mineralogical work, begun during the current feasibility study, will continue in future years. We acknowledge the assistance of the WA Department of Agriculture in introducing YYCMG to recent research in this field and to some of the researchers.

References

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Fig. 1. Soil profile in pit PJ13P1, Perenjori 13 subcatchment. Light brown sandy loam (0-35 cm) underlain by pale hardpan (30-80 cm), underlain by mottled red-brown/green-grey clay.

Fig. 2. Soil profile in pit JB19P3, Jibberding 19 subcatchment. Pink and red-yellow sandy loam (0-35 cm) underlain abruptly by pale yellow clay. Boundary highlighted by crowded roots.

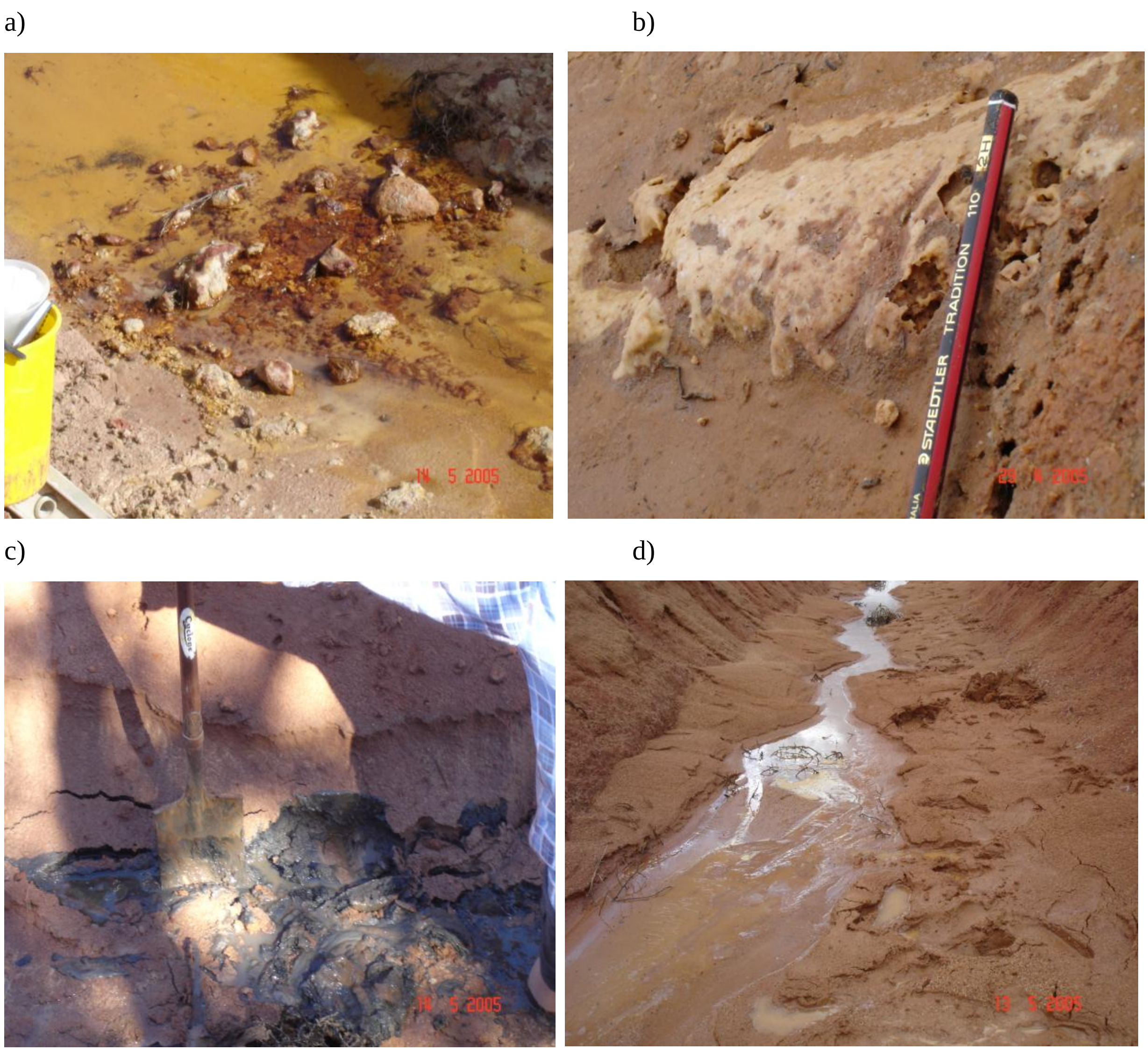

Fig. 3. Precipitates found in Yarra Yarra drains; a) iron oxyhydroxides; b) gypsum; c) monosulphides; d). aluminosilicates

Fig. 4. Drain precipitate; Note rust-coloured iron minerals on the drain floor are being dissolved close to the decomposing matter to form a black halo.