# HEAVY METAL CYCLING IN FORMER INDUSTRIAL LAND: IMPLICATIONS FOR SAFE AND EFFECTIVE URBAN RENEWAL

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## Introduction

In Victoria, Australia, the largest urban renewal project in Australian history is currently underway close to Melbourne's CBD (Bolton et al., 2013). Named the Fishermans Bend Urban Renewal Area (FBURA), many individual sites have contaminated the underlying soils and groundwater as a result of poor waste management. The geology of the FBURA comprises a sequence of unconsolidated heterogeneous coastal sediments, overlain by a heavily contaminated fill layer of varying composition and thickness. Heavy metals are significant contaminants of concern at the FBURA, specifically, arsenic, cadmium, chromium, copper, lead, nickel and zinc. Lead concentrations are particularly elevated in the fill, with a maximum concentration of 12,340 mg/kg. The physical and chemical conditions that may influence metal transport within the sediments of the FBURA include the presence of clays and organic matter, areas of reducing conditions, and areas of low pH. Preliminary data suggests three primary processes of metal cycling are occurring: leaching of certain metals from the contaminated fill layer into the underlying sand aquifer, export via permeable zones in the sand aquifer, and re-adsorption of metals in deeper clay and silt layers.

## Methods

A hand-held x-ray fluorescence (XRF) device was used during drilling and installation of 36 boreholes across the FBURA in order to measure heavy metal concentrations in the soils at approximately 20-50 cm depth intervals. Preparation of each soil sample included homogenisation followed by arrangement into thick blocks, laid on a flat, plastic surface. Each sample was measured in at least two different locations to assess and control for sample heterogeneity. In addition to the XRF, 15% of soil samples were submitted to an accredited laboratory for heavy metal analysis, in order to create correlation curves for each metal.

## Results

Three major lithology types were encountered during drilling at the FBURA and are described in Table 2.

**Table 2.** Description of the four major lithology types encountered at the FBURA and their approximate thicknesses.

| Lithology | Description | Approximate Depth |
|---|---|---|
| Fill | Clay, silt, sand and rubble with waste material (e.g. red brick fragments, plastic, metal, gasworks waste). Thickness of the fill layer is highly variable, but typically between 0.5 and 2.0 m. | 0 to 2 m |
| Port Melbourne Sand (PMS) | Aeolian beach deposits; stratified fine to medium sand, pale grey (occasionally brown), with shelly sand and minor silty or clayey sand. Minor gravel layers present. | 2 to > 5m |
| Coode Island Silt (CIS) | Soft dark grey-brown silty clay, clay, silt with fossils and plant material; occasional sand lenses, minor peat beds. Strong sulphurous odour. | >5 m |

The XRF results indicate extremely variable heavy metal concentrations in the fill material, likely due to the heterogeneous nature of the fill itself. Metal concentrations were significantly lower in the PMS when compared with the overlying fill material and the underlying CIS. Metal concentrations were particularly low in gravel layers. These results indicate that metals leached from the fill material into the PMS are flushed out of the groundwater system due to a lack of adsorption properties of the sands and gravels. In contrast to the PMS, metals which leach into, or exist naturally in, the CIS tend to remain in this lithology due to the clay's adsorption properties. This has implications for the overall contribution of groundwater pollution to sensitive surface water discharge points, indicating that the PMS is potentially a preferential pathway for metal migration. Figure 1 shows examples of plots of lithology and metal distribution against depth for selected boreholes (GW28 and GW37). The pale brown, pale grey and dark grey colours refer to fill material, PMS and CIS, respectively.

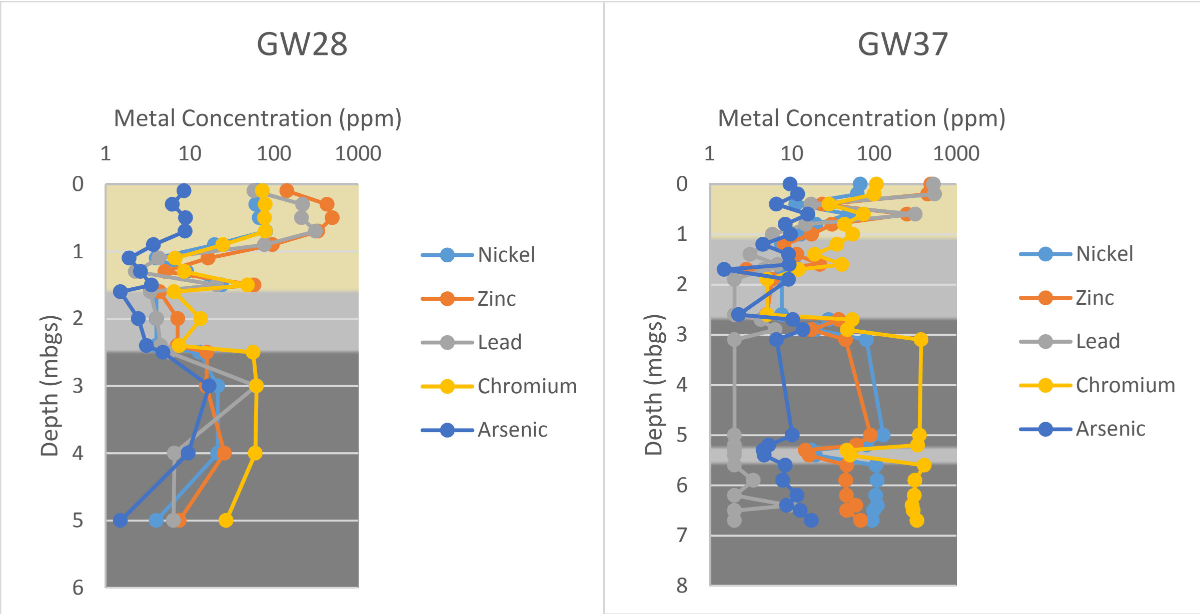


**Figure 1.** Plots of lithology and heavy metal distribution (Ni, Zn, Pb, Cr, As) against depth for GW28 and GW37.

## Conclusion

Urban renewal projects, such as the FBURA in Victoria, Australia, are becoming increasingly common across the world as governments strive to provide affordable housing and access to essential services for their citizens. However, these areas are often contaminated, in particular with heavy metals. This research has identified elevated concentrations of heavy metals in the soils and groundwater at the FBURA and has undertaken an assessment of the importance of metal leaching from contaminated fill into groundwater. Other important processes for metal cycling appear to be the export of metals from the groundwater system via permeable zones in the sand aquifer, and re-adsorption of metals in deeper clay layers. Understanding the sources, transport mechanisms and geochemical controls on heavy metal migration and mobility in the environment is essential for protecting public health and the environment.

## References

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