EARTH SYSTEMS
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CASE STUDY

Passive Arsenic Removal from Water

Earth Systems provides specialist advice in the design, installation, and monitoring of passive and active water treatment systems, with a particular focus on mine impacted waters, including Acid & Metalliferous Drainage (AMD) and Neutral & Metalliferous Drainage (NMD). Recently, Earth Systems was commissioned to design and install a Permeable Reactive Barrier (PRB) for the removal of soluble arsenic from water at a derelict mine site in New South Wales, Australia.

BACKGROUND

Earth Systems was engaged to design and provide geochemical oversight of the remediation of the decommissioned Arsenic-Tin mine and smelting area near Emmaville, NSW, Australia.

Greater than 20,000 m^3 of potentially acid forming sulfidic mine waste materials were excavated and placed into a purpose-built containment cell. Mine wastes were blended with limestone to manage stored acid salts and future acid generation, and strategically layered and compacted to minimise air entry and therefore the oxidation of sulfide minerals. The potential arsenic migration through the cell was also limited by the placement of specific arsenic adsorption layers to immobilise residual arsenic.

The ore processing area at the derelict mine site hosts historic refinery structures that were used to transform arsenic bearing ore (arsenopyrite – FeAsS) into arsenic trioxide concentrate (arsenolite - As_2O_3). These refinery structures contain significant volumes of residual, highly soluble, arsenic salts, which were a leading contributor to elevated concentrations of dissolved arsenic discharging from the site. An initial component of the remediation was the installation of a Permeable Reactive Barrier (PRB) for the passive immobilisation of soluble arsenic.

PRB DESIGN

The PRB was designed to intercept and contain surface runoff and shallow groundwater affected by residual arsenic salts from the refinery. The surface and groundwater undergo passive treatment for pH control, before flowing into the PRB. The PRB consists of two large HDPE lined channels (40m × 1.6m × 1m [L × D × W]; and 30m × 2.3m × 2.1m) which combined contain close to 200 tonnes of reactive substrate (see red bands in Figure 1).

The PRB removes soluble arsenic by adsorbing it to the reactive minerals. A suitable PRB substrate was identified and subjected to a series of geochemical and mineralogical tests. The PRB substrate is rich in iron and aluminium, and the mineralogy dominated by iron oxides / hydroxides (e.g., hematite, goethite, and maghemite) and aluminium hydroxides (e.g., gibbsite and boehmite). Experiments to quantify the substrates' ability to adsorb arsenic were conducted at a range of soluble arsenic concentrations (~250 – 2,000 mg/L) at both acidic and near-neutral pH conditions. After only 24 hours contact time with the reactive substrate, between 71% and 96% of the soluble arsenic was removed during this confirmation test work. The PRB substrate was deemed to be geochemically suitable, and the material was screened to select a specific grainsize range to optimise adsorption and flow through the PRB, and installed on site.

PERMEABLE REACTIVE BARRIER EFFICIENCY

The typical untreated (inflow) water is acid (pH ~3.5) with elevated concentrations of dissolved arsenic (20-60 mg/L), as well as elevated copper, cadmium, zinc, antimony, aluminium, and lead. Indicative water chemistry monitoring shows arsenic removal efficiencies of greater than 98%, and significant removal of other contaminants (see Table below).

Parameter*	Inflow (mg/L)	Outflow (mg/L)
Monitoring Event 1		
Arsenic	48.0	0.008
Zinc	0.58	<0.005
Copper	0.044	<0.001
Aluminium	0.34	<0.5
Cadmium	0.0081	<0.0002
Antimony	0.007	<0.005
Monitoring Event 2		
Arsenic	21.0	0.004
Zinc	0.5	<0.005
Copper	0.018	<0.001
Aluminium	0.19	<0.05
Cadmium	0.0056	<0.0002
Antimony	0.019	<0.05

**All reported metal(loid) concentrations are for filtered samples.*

Figure 1. Aerial view of the refinery structures (foreground) and the two lined PRB channels containing reactive substrate (red).

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