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Contaminant Dynamics and Trends in Hyperalkaline Urban Streams

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Streams in post-industrial urban areas can have multiple contemporary and historic pressures impacting upon their chemical and ecological status. This paper presents analysis of long term data series (up to 36 years in length) from two small streams in northern England (catchment areas 0.5-0.6km2). Around 3.5 million m3 of steel making slags and other wastes were deposited in the headwater areas of the Howden Burn and Dene Burn in northeast England up to the closure of the workings in the early 1980s. This has led to streams draining from the former workings which have a hyperalkaline ambient pH (mean of 10.3 in both streams), elevated alkalinity (up to 487 mg/L as $CaCO_3$) from leaching of lime and other calcium oxides / silicates within the slag, and enrichment of some trace elements (e.g. aluminium (Al), lithium (Li) and zinc (Zn)) including those which form oxyanions mobile at high pH such as vanadium (V). The high ionic strength of the waters and calcium enrichment also leads to waters highly supersaturated with calcium carbonate. Trace contaminant concentrations are strongly positively correlated, and concentrations generally diminish with increased flow rate suggesting the key source of metals in the system is the highly alkaline groundwater draining from the slag mounds. Some contaminants (notably Cr and ammonium) increase with high flow suggesting sources related to urban runoff and drainage from combined sewer overflows into one of the catchments. Loading estimates instream show that many of the contaminants (e.g. Al, V and Zn) are rapidly attenuated in secondary calcium carbonate-dominated deposits that precipitate vigorously on the streambeds with rates of up to 250 g $CaCO_3$/m2/day. These secondary sinks limit the mobility of many contaminants in the water column, while concentrations in secondary deposits are relatively low given the rapid rates at which Ca is also attenuated. Long-term trend analysis showed modest declines in calcium and alkalinity over the monitoring period and these are not accompanied by significant declines in water pH. If the monotonic trends of decline in alkalinity and calcium continue in the largest of the receiving streams, it will be in the region of 50-80 years before calcite precipitation would be expected to be close to baseline levels, where ecological impacts would be negligible. The data show the value of long-term water quality datasets in managing post-industrial catchments where there may be multiple pressures on water quality.