METAL EXTRACTION FROM ROAD SEDIMENT USING DIFFERENT STRENGTH REAGENTS: IMPACT ON ANTHROPOGENIC CONTAMINANT SIGNALS

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Abstract. Washoff of road deposited sediment into storm drain systems is one of the major contributors to nonpoint source pollution in urban fluvial networks. These sediments contain a variety of potentially toxic organic and inorganic contaminants. Road sediment from 13 locations in an urban (non-industrialized) drainage basin, and soil from 10 background (control) locations were collected to assess total and labile fractions of Al, Co, Cu, Fe, Mn, Ni, Pb and Zn. Four digestions, of varying strength, were used to assess contaminant levels, these included: a total four-acid digestion, a microwave-assisted digestion with concentrated nitric acid (USEPA Method 3051), a 0.5 M ‘cold’ HCl, and a 0.05 M EDTA (pH 7). Road sediment data indicate that Al, Co, Fe, Mn and Ni were primarily lithogenic in origin, while Cu, Pb and Zn showed very significant anthropogenic signals, most probably from vehicle-related sources. Median Pb concentration enrichment ratios for the EDTA extraction were about 42, indicating an extreme anthropogenic signal. The weak extractants (HCl and EDTA) are considered in this study to be superior in their ability to characterize the degree of anthropogenic contamination and should be utilized more widely in environmental contaminant studies.

Keywords: anthropogenic contaminant signals, concentration enrichment ratios, labile (nonresidual) trace metals, lithogenic elements, road deposited sediment

1. Introduction

Metal analysis by spectrometric techniques after total acid digestion or non-destructive total analysis by instrumental neutron activation analysis (INAA) and X-ray spectrometry have been the mainstays of analytical geochemistry. More recently there has been a shift away from reporting only total concentration data in the environmental literature, to providing supplemental analyses for single ‘weak’ leach extractants (Agemian and Chau, 1976; Malo, 1977; Chester et al., 1985) or from sequential extractions (e.g., Tessier et al., 1979; Hall et al., 1996; Quevauviller et al., 1997; Sutherland et al., 2000). Presently, leach data, rather than total decomposition are widely used in a variety of fields, including soil science and agronomy,
geochemistry, plant nutrition, and environmental studies (Kane, 1995). The weak leach approach assumes that trace metals associated with degradable organics and with surface coatings of mineral particles would be more available than those in primary minerals or occluded by secondary mineral structures (Malo, 1977). It is argued that certain extractants provide a means of separating the environmentally significant non-lattice held (anthropogenic) metals from lattice held residual or lithogenic metals. It is these nonresidual metal phases that are most critical from an environmental perspective, since these are most likely to be bioavailable. Therefore, as Gelinas et al. (1998) state, the weak acid leaching approaches offer a better contrast between contaminated and background samples than does the determination of total concentration.

The search for the single most effective extractant that correlates with the bioavailability of a wide array of trace metals is illusive. As Beckett (1989) states, there are few extractants to which contradictory and inconsistent effects have not been attributed by different workers. With this in mind a suite of approaches commonly adopted in the environmental geochemistry literature were applied in this study. The four approaches selected ranged in decomposition strength from the weakest being 0.05 M ethylenediaminetetraacetic acid (EDTA) at pH 7, 0.5 M (cold) hydrochloric (HCl) acid, concentrated (hot) nitric (HNO₃) acid, to a concentrated (hot) four-acid digestion. Road deposited sediments (RDSs) were examined because there are much fewer data available on these environmentally important materials compared to soils or aquatic sediments, and this research is a natural extension of the previous work conducted by Sutherland and Tolosa (2000). The objectives of this study are: (1) to assess the potential mobility of Al, Co, Cu, Fe, Mn, Ni, Pb and Zn from RDS in an urban (non-industrialized) basin with different strength reagents; (2) to characterize those elements that have significant anthropogenic signals, and (3) to determine the influence of extractant strength on degree of contamination signal as assessed by concentration enrichment ratios (CERs).

2. Materials and Methods

2.1. STUDY AREA

Manoa drainage basin is located in southeast Oahu, Hawaii (Figure 1) and was selected for investigation since previous work has shown that fish from Manoa Stream have some of the highest whole-body burdens of Pb and Cu in the rivers and lakes of the U.S.A. (Schmitt and Brumbaugh, 1990; Schmitt et al., 1999). Additionally, bed sediments from this stream are significantly enriched in Pb and to a lesser extent Zn and Cu (Sutherland, 2000). Mobilized road sediment can readily reach Manoa Stream through the ubiquitous storm drain network. As Sutherland et al. (1998) state, sediments located on paved areas (streets, driveways and parking lots) that are directly connected to a city’s storm drainage system, have been