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PREDICTING CONTAMINANT LEACHING POTENTIALS FOR CENTRAL APPALACHIAN OVERBURDEN AND COAL REFUSE MATERIALS

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Project Description and Objectives:

The primary goal of this research program was to determine the leaching potential of a number of elements of concern (As, Cr, Mo, Se, total dissolved solids - TDS, and others) from overburden spoils and coarse/fine coal refuse. The results here improve our understanding of the relative "leachability" of central Appalachian coal mine spoils and refuse materials and reveal considerable detail on bulk TDS components and how they vary among weathered vs. unweathered coal spoil and coarse vs. fine refuse materials from this region.

Applicability to Mining and Reclamation:

This project greatly improves our collective ability to predict the temporal leaching pattern of these elements of concern along with providing new and valuable information on temporal TDS release patterns and ionic components. Our results will allow improved prediction of leachates coming from coal mine spoils and processing wastes and will enhance our understanding of water quality impacts from mining. Results are directly applicable to the Appalachian coal basin and may be widely applicable to other hard rock sedimentary environments.

Methodology:

Over the winter/spring of 2008, we collected 25 bulk field samples of mine spoils and coal refuse (coarse/fine) from SW Virginia and E Kentucky and analyzed them via total and sequential extraction analyses to evaluate the distribution, solubility and bioavailability of elements of concern. From this sample set, we selected 3 spoils and 3 pairs of coarse/fine refuse samples for column leaching (see Figure 1). These 9 materials were then column leached (saturated and unsaturated) for 45 leaching events (four months) and leachates analyzed for pH, electrical conductance (EC), TDS, metals and oxyanions of concern.

ABOVE PHOTO: Photograph of leaching column design used in this study. The columns were dosed twice weekly with 2.5 cm (1 inch) of simulated rainfall under both saturated and unsaturated conditions. Leachates were drained into the bottles/beakers on the bench below, but a water filled portion was maintained above the hose clamps to prevent gas exchange.

Highlights:

The bulk spoil and refuse samples represented a broad range in elemental content, yet did not include extreme values for any elements analyzed with the exception of relatively high As (> 30 mg kg-1) in several samples. The fractional distribution of As, Cr, Mo, and Se indicated that across all materials, these elements occur primarily in recalcitrant mineral fractions (e.g. crystalline oxides and residual). Therefore, under normal coal mining fill leaching conditions we would predict low solubility/bioavailability and leaching potentials.

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Highlights (continued):

In the column leaching experiment, both unweathered mine spoils and fine refuse generated high initial TDS levels (500 to > 5000 mg L-1) which dropped quickly to relatively constant levels (< 1000 mg L-1) in all but two samples. As expected, leachate pH, bicarbonate, Ca, Fe, Mn and sulfate elution were all directly related to fundamental internal acid-base reactions and water saturation. Levels of Se released into initial leachates were significant relative to the current drinking water standard (0.050 mg L-1), even though total Se was relatively low in these samples and predicted to be recalcitrant.

With respect to TDS composition, bicarbonate, Ca, K, Mg, Na, and sulfate were predominant. Under saturated conditions, spoil leachate TDS was dominated by sulfate and bicarbonate. Under unsaturated conditions spoil TDS components were more variable due to acid-base reactions driven by sulfide oxidation and carbonate neutralization interactions. Refuse samples released higher levels of Na than spoils. Surprisingly, this study revealed no major significant or consistent difference between coarse and fine refuse materials for most parameters of long term leaching concern.

Results/Findings:

The fractional distribution of As, Cr, Mo, and Se indicated that across all materials, these elements occurred primarily in recalcitrant mineral fractions (e.g. crystalline oxides and residual) that are presumably resistant to weathering and leaching. This means that under normal environmental conditions, with the pH between 3.5 and 9.0, we would predict low solubility and subsequent leaching of these elements.

Direct comparison of total elemental content of weathered vs. unweathered mine spoils showed that as expected, weathered spoils were considerably leached of Ca compared to unweathered mine spoil. Interestingly, this was not the case for other basic cations like K and Mg.

The elemental composition of leachate solutions from our column leaching study was strongly affected by internal acid-base reactions and saturated versus unsaturated conditions, but there were also differences within the sample groups, mine spoil, and coarse vs. fine refuse.

All samples eluted considerable levels (> 500 mg L-1) of TDS (with high EC) over their initial leaching cycles and samples that contained significant reactive sulfides continued to elute high TDS levels for the duration of the study, regardless of their leachate pH values. Of the materials studied here, the fine refuse samples eluted the highest initial TDS (> 4000 mg L-1), but one shale overburden also eluted considerable TDS.

We noted no or very limited risk for leaching of As, Cr, Cu, Mo, Ni and Zn from these materials under these moderate pH conditions. However, while Se was present at relatively low levels in these materials, it was leached at levels of concern (relative to drinking water MCL's) in initial leachates despite relatively low levels in soluble/bioavailable SEP fractions.

Overall, TDS mass was dominated by six elements/compounds: (HCO3-, Ca, K, Mg, Na, and SO4-2). TDS release from the mine spoil samples was dominated by sulfate under unsaturated conditions and by sulfate and bicarbonate under saturated conditions.

TDS release from coarse and fine coal refuse was very different from mine spoils and contained significant amounts of Na.

Surprisingly, this study revealed no major significant or consistent difference between coarse and fine refuse materials for any parameter of long term leaching concern.

Our results indicate that relatively straightforward batch extraction procedures such as the sequential fractionation procedure (SEP) utilized here can be quite useful in predicting the relative "leachability" of most elements of interest. Selenium appears to be an exception to this finding, however.

Finally, the hydrogen peroxide oxidation potential acidity procedure (PPA) generated a more reliable prediction of which materials would generate significant sulfate and associated TDS/EC levels than more conventional acid-base type accounting methods.

Website Information:

The final project report can be found at **http://www.techtransfer.osmre.gov/NTTMainSite/appliedscience/2007appscience/CompletedProjects/VTLeachingPotentialNPointon07FR.pdf**

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