The Environmental Fate and Behaviour of Antimony in the Coastal Floodplain System of the Macleay Catchment, with Comparisons to Arsenic

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Abstract

Antimony (Sb) has been used throughout human history, but recently anthropogenic emissions and recognition of harmful effects on humans and the environment has led to concern over the lack of knowledge about the environmental fate and behaviour of this metalloid. The coastal floodplain of the Macleay Catchment in northeastern NSW, Australia, has been shown to be subject to mining related enrichment of Sb and to a lesser extent, As. The aims of this thesis were to elucidate aspects of Sb behaviour in this system, and to compare the findings with the behaviour of As. The extent of the enrichment of both metalloids in the soils of the floodplain, and the concentrations in selected pastures and surface waters were determined. Possible influences on mobility and availability of both metalloids in selected soils and under specific management regimes were also examined. In addition, the sorption behaviour of Sb (V) was investigated for 2 floodplain soils and 2 dominant soil phases. A review of the available literature indicated that the aims of this thesis had not been addressed previously.

Analytical methods for the determination of total metalloid concentrations in soils and metalloid concentrations in soil extracts at the University of New England were developed as necessary precursors to further investigations. Subsequent floodplain sampling showed that approximately 90 % of the floodplain is enriched in As and Sb, and 6 - 8 % of the floodplain contains As and Sb concentrations greater than current Australian soil ecological investigation guideline values. Variation in surface and depth distributions indicated flood-related deposition of both metalloids. The soil enrichment was reflected in the pasture and surface water metalloid concentrations. The results suggested higher relative metalloid availability than is typical at grossly (> 100 mg kg^{-1} Sb and/or As) contaminated sites.

The availability of both metalloids to pasture species were related to flooding in selected acid sulfate affected soils under controlled and field conditions, although only the availability of Sb appeared to also be related to the proportion of Fe present in the soil in the non-crystalline oxyhydroxide form. In addition, it was determined that flooding these soils over the short periods (weeks) practical in the field would not induce significant soil reduction as an acid sulfate management technique. Flooding,

however, may increase the availability of both metalloids, depending on the amount and form of Fe in the soil.

Adsorption batch trials were undertaken to elucidate the binding of Sb to the soils investigated in the glasshouse trial, and two dominant phases of these soils. During the adsorption trials, the soils investigated sorbed 80 - 100 % of the added Sb (V) at pH values less than approximately 6.5. Amorphous Fe hydroxide retained > 95 % of the added Sb in all adsorption experiments, while humic acid sorbed up to 60 % of the added Sb at acidic pH values.

In addition, a limited exposure assessment and risk characterisation for generic floodplain populations with the highest metalloid exposure was undertaken. They showed that up to 23 % of the tolerable daily intake of Sb was provided by the few pathways of exposure included in the assessment, and that the acceptable daily intake of As may be exceeded under certain conditions.

Declaration

I certify that the substance of this thesis has not already been submitted for any degree and is not currently being submitted for any other degree or qualification.

I certify that any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

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Raw data have been supplied as appendices on a compact disc at the end of this thesis.

Table of Contents

List of Figures

List of Tables