Trace metal contamination of soils and sediments in the Port Kembla area, New South Wales, Australia

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Trace Metal Contamination of Soils and Sediments in the Port Kembla area, New South Wales, Australia

A thesis submitted in (partial) fulfillment of the requirements for the award of the degree

Master of Environmental Science- Research

from

University of Wollongong

by

Yasaman Jafari

School of Earth and Environmental Sciences

2009
Preface

The information in this thesis is entirely the result of the investigations conducted by the author, unless otherwise acknowledged, and has not been submitted in part, or otherwise, for any other degree or qualification.

Yasaman Jafari
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Abstract

Anthropogenic emissions of metals from industrial activities such as smelters are an international problem, but there is limited published information on emissions from Australian smelters. The objective of this study was to investigate the regional distribution of trace metals in soils and sediments in the vicinity of the industrial complex of Port Kembla, New South Wales, Australia, which comprises a former copper smelter, an integrated steelworks and associated industries.

Thus, 95 soil samples from the Port Kembla area and 3 vibracores from Griffins Bay in the adjacent Lake Illawarra were collected. X-Ray Fluorescence Spectrometry (XRF) was used to determine 37 trace element concentrations in both soil and sediment samples. The extent of total metal contamination by As, Cu, Pb, Se, Sn and Zn in soils was greatest in samples located close to the Port Kembla copper smelter stack, suggesting contamination due to anthropogenic activities. The mean enrichment factors for As, Cu, Pb and Zn in soil samples are higher than 4 while Se and Sn are elevated above background values by about 2.5-3.5 times. Although the enrichment factor for Cr at about 13.6 is the highest one among trace metals in soil samples of the study area, Cr concentrations increase on moving farther from the copper smelter stack. In soil samples, mean Cd and Zn concentrations exceed acceptable ranges in ANZECC and ARMCANZ (1992) soil contamination guidelines while the average Cu concentrations are significantly above both ANZECC and ARMCANZ (1992) and Dutch guidelines.

Single extraction techniques were used to determine HCl and EDTA extractable amounts of 37 trace elements in the soil samples with analysis by XRF. The amounts of extractable Cu, Pb and Zn decrease significantly with the increase of distance from the stack, with mean bioavailable percentage of 22.3, 27.6 and 42.5 in HCl and 31.5, 37.2 and 33.3 in EDTA tests, respectively.

The distribution of Cu, Pb and Zn in the upper 20 cm of sediment of the vibracores in Griffins Bay is directly related to the proportion of mud-dominated sediment and inputs from local industrial sources. Mean trace metal enrichment factors for Pb and Zn were greater than 12 in mud-dominated sediments while Cu and Ni concentrations are elevated above background values by more than 6 times. Mean enrichment factors for As, Cr and V
were between 2 and 5. Core 1 is sand-dominated and showed lower mean enrichment factors of 3.7 and 6 for Pb and Zn, respectively. Isotope dating of *Notospisula trigonella* determined sedimentation rates of about 0.30-0.78 mm/year in sediments prior to industrial activity in the area. Trace metal-depth concentration profiles have been used in conjunction with the time of industrial development, to determine sedimentation rates of 1.4-3.5 mm/year in younger sediment samples in this study. According to ANZECC & ARMCANZ (2000) guidelines, sediment samples in the current study do not exceed the high trigger value (ISQG-high). In core 1, the average concentrations of elements are obviously below the low trigger value (ISQG-low). In core 2, these values are between the low and high trigger values except for Cr and As which are below ISQG-low, while core 3 shows the same pattern as core 2 except for Pb values which are below the ISQG-low trigger. In all three cores, As concentrations are low and never exceed the low trigger values, while Cd concentrations observed are between the two trigger values.

Significant positive correlations among some trace elements such as Cu, Zn, As, Cd, Sn and Pb indicate a common but not necessarily unique source for these trace metals. Therefore, based on the results of the current study, which are in agreement with previous works, it can be concluded that distinctive, fugitive industrial particle emissions from Port Kembla industrial complex appear to have contaminated the surrounding soils and sediments.
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