Alteration of noble metal geochemical cycles due to sewage disposal

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Introduction

Sewage sludges are anaerobically digested or aerated end products of wastewater treatment and purification. Worldwide production of the solid waste product, i.e. the sludge resulting from wastewater treatment, reaches the magnitude of 82 million tonnes per year (dry matter). The majority of sewage sludge is dumped on land or at sea and only a portion of the solid waste product is recycled for other purposes. Wastewater release to the oceans, burning of the sludges in high-temperaure incinerators and the application of sewage as fertiliser to agricultural land causes alteration of heavy metal geochemical cycles. Large scale perturbations of the natural heavy metal cycles especially occur in coastal waters adjacent to heavily populated areas (Galloway, 1979). Global metal injections into the oceans and atmosphere from municipal sewage have been estimated to be at 3,000 t of cadmium, 55,000 t of chromium, 42,000 t of copper, 15,000 t of lead, 440,000 t of iron, 7,400 t of manganese, 17,000 t of nickel, 2,300 t of silver and 100,000 t of zinc per annum (Galloway, 1979; Nriagu and Pacyna, 1988)In addition to the commonly reported heavy metal and organic pollutant loads of sewage sludges, sewage sludges contain elevated gold and PGE (platinum-group elements: Pt, Pd, Rh, Ru, Os, Ir) concentrations (Furr *et al.*, 1976; Mumma *et al.*, 1983, 1984, 1988; Lottermoser, 1994). The aims of this contribution are:

(a) to document the gold and PGE contents of sewage sludges, i.e. to demonstrate the noble aspects of sewage; and

(b) to evaluate the impact of sewage disposal on the natural geochemical cycle of gold.

Table 1. Range of precious metal contents of municipal sewage sludges.

	Germany	USA	Australia
Au	0.28 to 56.0	0.08 to 12.9	0.08 to 2.35
Pt	<0.01 to 1.07	0.05 to 0.74	
Pd	0.038 to 4.7	0.23 to 16.2	
Ru	<0.002 to 0.39	0.05 to 7.05	
Rh	<0.002 to 0.39	0.08 to 2.70	
Ir	0.0006 to 0.0265	0.05 to 0.46	
Os	<0.003 to <0.051	0.06 to 3.18	

All contents given in ppm in dried matter. Data for the USA and Germany taken from Furr *et al.* 1976; Mumma *et al.*, 1983, 1984, 1988; Lottermoser, 1994. na: not analysed. Number in parathenses refer to number of samples.

Materials and methods

Representative sewage sludge samples (approximately 1kg) were collected from municipal wastewater plants which are widely scattered throughout southeastern Australia. Most samples are dewatered anaerobic/aerobic digested products and derived from lagoons, oxidation ditches and digesters. The sludges were analysed for their precious metal contents at the Analabs® laboratories, Brisbane, Australia. Standard analytical techniques included aqua regia digest and atomic absorption spectrometry for gold (detection limit; Au: 20ppb), lead fire assays and direct coupled plasma spectrometry of the fire assay bead for gold, platinum and palladium (detection limits; Au: 2 ppb, Pt: 2ppb, Pd: 2ppb), and nickel fire assays and induced coupled plasma mass spectrometry of the fire assay bead for platinum, palladium, ruthenium, rhodium and iridium (detection limits; Pt, Pd, Ru, Rh, Ir: 0.5ppb).

Results

Australian sewage sludges show variable gold, platinum and palladium contents and a restricted range of ruthenium, rhodium and iridium values (Table 1). These samples have consistently high gold and palladium, intermediate platinum, and low ruthenium, rhodium and iridium concentrations. Sewage sludges from Germany, the United States and Australia generally exhibit similar noble metal distributions (Table 1).

Discussion

In Australia an estimated 800 to 1000 tonnes of sewage sludge (dry matter) accumulate every day (Sparkes, in Daglish 1990). Of this total 9% goes to agricultural use, 30% to non-agricultural land, 5% to dedicated land, 24% to lagoon stockpile, 18% to landfill, 13% to ocean, and 2% is incinerated (Sparkes, in Daglish 1990). Ocean outfall systems represent an extreme example for the waste of metals to the hydrosphere. Stream, shore and ocean outfall areas are known not only for their potentially high concentrations of heavy metal and organic pollutant loads but also for exceptionally high gold, silver and palladium values (e.g. Los Angeles, USA; Athens, Greece). Precious metal values in these areas reach ore grade.Quantitative estimates of gold masses accumulating in sludges of industrialised countries imply that 100 tonnes of gold are accumulating in sewage sludges per annum (Lottermoser and Morteani, 1993). In comparison annual global metal production from geological ores amounts to over 1,600 tonnes of gold.Quantitative estimates for gold accumulations in wastewaters have been performed for global releases to the environment. Global metal injections into the oceans, soils, hydrosphere and atmosphere from municipal sewage have been estimated to be at 100 tonnes of gold.

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