SOIL AND WATER CONTAMINATION BY ARSENIC FROM A TANNERY WASTE

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Abstract. The pollution of soil by arsenic contained in tannery waste is reported. Over 81 years of operation, a variety of arsical compounds including sodium arsenite were used as pesticides at the tannery, the arsenic finding its way to the site in question as liquid waste which was disposed of either by burial or spray irrigation. X-ray Fluorescence Spectrometry (XRF) was used to determine the levels of arsenic in the soil. Concentrations recorded were comparable to those in soils polluted by agricultural use of arsical pesticides or by contamination from mining activities. In contrast to arsenic pollution from other sources however, contamination extends to a considerable depth through the soil profile. Analysis of soil water by hydride generation atomic absorption spectrometry showed evidence of arsenic movement through this medium although penetration had not extended to the groundwater. Batch leaching of soil samples with distilled water confirmed the potential mobility of arsenic.

1. Introduction

Arsenic is known to exist most commonly in the oxidation state os −3, +3 and +5. It forms a variety of inorganic and organic compounds, of which only a small number are known to occur naturally (Kirk Othmer, 1978). The environmental behaviour of arsenic has been reviewed by Woolson (1977) and more recently by Irgolic (1988) and Tanaka (1988).

Normal soils have arsenic levels below 40 ppm (Woolson, 1983). Concentrations of arsenic in contaminated soils vary as a result of the nature of the contamination, proximity to the source and time since deposition. Walsh (1977) reported on a number of sites contaminated with arsenic as a result of former agricultural activities. Orchard sites showed the highest levels of contamination with maximal soil arsenic concentrations of 124,238 and 2000 mg kg⁻¹ at three different sites. Mining industries frequently produce arsenic-containing wastes, the element being a minor constituent (usually as arsenopyrite) of many ores. A contaminated area near an old lead smelter had a maximal arsenic level of 2000 mg kg⁻¹ (Tempel et al., 1977), whilst values between 500 and 9300 mg kg⁻¹ have been reported in areas close to gold smelters in Canada (Hutchinson, 1982). Wood, treated with copper chrome arsenate preservative can also contaminate soils with it comes in contact. The contamination is determined by the type of copper chrome arsenate treatment employed, with effects on both the level of soil arsenic and the depth of penetration. Observed soil residues at such sites range from 70 to 220 mg kg⁻¹.

Arsenic was widely used as a pesticide in the treatment of hides. The formulation registered for use in Queensland contained 650 g l⁻¹ sodium arsenite as the active ingredient (Queensland Department of Primary Industries, personal
The possibility of use of unregistered pesticides (particularly in earlier times) cannot be ruled out. It would be expected that some wastes from the industry could contain appreciable levels of arsenic, although the potential exists for contamination of tannery sites, little has been published on this topic.

Craiglea State School is situated on a site in Brisbane, Queensland, Australia, which was previously used as a waste disposal area for a tannery. The tannery operated for a period of 81 years between 1891 and 1972. Liquid wastes were pumped or transported by tanker to the site and disposed of by either spray irrigation or burial. Composition and volume of the waste streams are unknown but arsenical pesticides were widely used at the tannery. We report arsenic levels in soil, seepage water, groundwater and soil leachates. The results are considered in terms of remediation and environmental health.

2. Material and Methods

2.1. Sampling Strategy

Analysis of preliminary samples showed the arsenic contamination to be widespread and hence the whole school area was sampled on an intensive basis. Initial sampling was performed wherever possible on a triangular grid pattern (cf. Parkhurst, 1984), particularly in places where the grid points were spatially separated by distances of 4m or more. It was not always possible to adhere strictly to the grid pattern because of obstacles, especially when close to school buildings. The topography of the schoolground was such that exact location of the points prior to sampling would have been difficult. Therefore the sample points were laid out roughly with the aid of a tape and their position subsequently located accurately on the cadastral map by a surveyor.

2.2. Sampling Methods

Surface and immediate subsurface soil samples were removed by use of a hand auger. The auger was forced into the soil to a depth of 125 mm, the root zone removed and the soil treated as the surface sample. The next layer (125–250 mm) was then removed, discarded and finally the second subsurface sample obtained by removing the 250–375 mm layer. Where depth samples were required, a power auger was used to remove the top 600 mm of soil. The hole was cleaned out with the aid of a hand auger and the hand auger then forced a further 125 mm into the soil to remove the sample. As it was desired to measure soluble arsenic in seepage water, samples were not acidified upon collection but were passed through a 0.45 μ cellulose acetate membrane filter and the filtrate analysed as soon as possible.

2.3. Analysis

2.3.1. Soil Samples

Samples Preparation. Soil samples were treated according to AS 1289 as follows. Soil was mixed well and 200–300 g. portions transferred to an aluminium pie