GRASS AND SURFACE SOILS AS MONITORS OF ATMOSPHERIC METAL POLLUTION IN CENTRAL SCOTLAND

F. A. GAILEY (née Yule) and O. LL. LLOYD

Environmental Epidemiology and Cancer Centre, Wolfson Institute of Occupational Health,
Department of Community Medicine, Dundee University, Scotland

(Received May 16, 1983; revised March 23, 1984)

Abstract. A hypothesis has been proposed that some respiratory disease could be causally related to air pollution by metals. To investigate more fully the suggested link between such pollution and respiratory disease in towns in central Scotland, a large number of sites for monitoring the pattern of air pollution within each town was required. The levels of metals in indigenous samplers, namely Agropyron repens and surface soils, were measured within one of these towns, Armadale, to determine the effectiveness of these indicators as high-density monitors of atmospheric pollution by metals. Both surface soils and Agropyron repens were useful monitors of metals, either when a large number of metal levels were required, or when rapid results were desirable. The surveys showed a large range in the values of the metals throughout Armadale for each metal measured; a large variation in values between different metals; and a decline in the concentrations of metals from the vicinity of the town's steel foundry to the periphery of the town.

1. Introduction

In a recent epidemiological study, abnormal and geographical distributions of respiratory disease were investigated in several towns of central Scotland (Lloyd et al., 1981).

In one of these towns, Armadale, several indigenous bio-monitoring surveys have been carried out. The results of a survey of the metallic content of an indigenous moss Hypnum cupressiforme have already been reported (Yule and Lloyd, 1984a).

Two further types of sampler used were: couch grass (Agropyron repens) and surface soils. The results are reported in this article. Grass has been established as a reliable monitor of air pollution by metals in a number of studies, for example, Bull et al. (1977), Czarnowska (1974) and Somashekar et al. (1982). Similarly, surface soils have been shown to be representative monitors of atmospheric metal concentrations; this is illustrated in Buchauer (1973), Barry and Clark (1978), Freedman and Hutchinson (1980), Hanssen et al. (1984). Hence, the use of both of these type of indigenous monitors in the study of Armadale's metal deposition patterns was considered to be worthwhile.

The grass species which was found at all the sites in Armadale was Agropyron repens. This species was selected for monitoring atmospheric metal because it is very hardy, and, at least visibly, not affected readily by pollutants. Moreover, being a perennial grass, it continuously collects metals, although at different rates depending on the season. It is found generally on waste ground and waysides, and hence is likely to have suffered less human interference than is the case with the common species of garden grass. On either side of the stem of the grass, the spikelets are arranged alternately broadside on, which enhances the trapping of particulates. Finally, the roughness of the leaves facilitates the adherence of particulates.
Surface soils possess several advantages as monitors of metal pollution. Metals form relatively stable complexes with surface soil macro-molecules, and hence most metals tend to remain within the surface horizon (Hutchinson and Whitby, 1974; Anderson, 1977). However, some leaching of metals will occur from the surface soils, the exact amount of which cannot be quantified. In general terms the leaching of metals increases as the soil pH decreases, this occurs because the metal ions become more soluble under acidic conditions. The metal content of soil is not affected by metabolic activities; hence uptake and retention mechanisms are more clearly understood than in the plant indicators. There are variables, however, which can alter the retention of metals in soils. These variables complicate the uptake and retention patterns of metals in soils. There does not appear to be an upper limit for the amount of metals a soil can retain. Finally, since soils are the ultimate metal sink in the biosphere, they can affect the metal content of the majority of plant monitors (either as a substrate, or by soil splash and soil blowing (Dreicer et al., 1982); hence a knowledge of metal levels in soil is of value for the interpretation of metal levels in the biomonitors. It seemed logical, therefore, to use soils as monitors at an early stage of a survey of metal pollution. Nevertheless, for reasons described in the discussion, they do not provide information of sufficient reliability to be used on their own for the interpretation of epidemiological data concerning the possible effects of air pollution by metals.

This paper describes a case study of the use of Agropyron repens and surface soils as a monitor of atmospheric pollution.

2. Method

A survey using the technique of the Index of Atmospheric Pollution (I.A.P.) was carried out in Armadale, a small industrial town, during December 1980 and January 1981 (Yule and Lloyd, 1984b). As a result, it was decided that 47 locations (Figure 1) would provide a desirable density of sampling sites within the town. A higher density in the most polluted zone (the vicinity of a steel foundry) was thought necessary. The sites selected were located so that they were as ecologically similar as possible (Table I).

In the field, 5 samples of Agropyron repens were bulked together at each site. Samples were air-dried and stored until analysis could be carried out. The grass was cleaned of extraneous material such as other plant leaves. Any adherent soil particles were shaken off. The grass blades were cut into segments 1 cm in length; they were oven-dried to constant weight at 50 °C, and finally digested by HN03 and analyzed as described previously (Yule and Lloyd, 1984a).

Samples of surface soils were also collected at the 47 survey sites in Armadale. A plastic scraper was used (to reduce metal contamination) for the collection of the top 5 cm of the soil. Five samples at each site were collected and bulked together. After the soil had been oven-dried, extraneous material such as large stones and leaves were removed. The soil was passed through a sieve (with a mesh size of 2 mm) to remove small stones, before being ground through a fine-mesh nylon sieve to break down soil