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Lichens as Bioindicators of Aerial Fallout of Heavy Metals in Zaria, Nigeria

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Lichens and other epiphytic cryptogams possess efficient ion-exchange mechanisms which enable many species to accumulate airborne metals and which probably contribute to their tolerating metals at concentrations high enough to cause death to other plant species (Hale 1974). For example, this has been demonstrated by the high concentrations of radionuclides and heavy metals found in lichens, findings which suggest their possible use as pollution monitors (Brown et al. 1976; Hawksworth and Rose 1976; Pilegaard et al. 1979; Rasmussen 1977). Accordingly, Bioleau et al. (1982) demonstrated a direct relationship between the distribution pattern of lichens and the trace metal content of the surrounding air. Nyangababo (1987) found that the heavy metal content of lichens was related to the network of roads and the distribution of industrial emissions in Kampala, Uganda. The present study used lichens to assess the aerial fallout of heavy metals from traffic in Zaria, northern Nigeria.

MATERIALS AND METHODS

Samples of foliose-type of lichens (genus *Parmeli*) were collected along the Zaria-Sokoto highway and from a residential location within the Ahmadu Bello University main campus of Samaru during the beginning of the Harmattan (dry) season. Samples were collected from trees immediately along the road and at various points away from the road, and were made of 5 composites of *Parmelia* taken from each point.

Samples (4 g) were dried to constant weight at 60°C in a hot air oven and cooled in a desiccator. The dry material (2 g) was then ashed in a muffle furnace for 6 hr at 460°C, and the ash was cooled in a desiccator

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for 24 hr. The ashed samples were digested for 3 hr on a hot plate at 85°C using 20 mL of a 1:1 (w/v) hydrochloric acid:water mixture. The digests were extracted using deionized water and filtered into 25 mL polyethylene bottles. The concentrations of Cr, Cu, Fe, Pb and Zn (ug/g dry weight) were determined in duplicate by atomic absorption (APHA 1985) on a Perkin Elmer Model 306. Standards containing known amounts of these metals and blank samples were subjected to the same procedure to estimate recovery rates and to check for contamination. The average recovery was 96-97%, as previously reported (Kapu et al. 1991).

The data were statistically analyzed using multivariate repeated measures analysis implemented as a "profile analysis" (Morrison 1976). Observations were weighted by the number of lichens (5) in a composite.

RESULTS AND DISCUSSION

Tables 1 and 2 present concentrations of heavy metals in lichens from the two study sites. With the exception of Fe, the concentrations of the metals decreased significantly ($P < 0.001$) with distance of each lichen-tree from the highway (Table 3). In contrast, there was no consistent change in lichen metal concentrations with distance from the residential road (Table 2). Based on rejection of the profile-analysis hypotheses of equal treatment levels, equal response means, and parallelism of treatment means (Morrison 1976), the highway data revealed three significantly different ($P < 0.05$) concentration bands: 2-10 m, 30-45 m, 60-90 m. The concentrations of Pb, Cu, Zn, and Cr in lichens from the residential road, and Fe from both sites, showed no consistent changes and were not included in the profile analysis.

Metal concentrations found in this study were much lower than those reported for developed countries (Hawksworth and Rose 1976; Richardson 1974; Hale 1974) or for urban and rural areas in Kampala, Uganda (Nyangababo 1987). The differences in the distributions between the highway (Table 1) and residential area (Table 2) suggest that the Samaru-Zaria environment was contaminated from aerially-dispersed heavy metals. The higher metal levels in lichens from highway sites indicates that traffic density was a major contributing factor to heavy metal fallout in these areas. The similarity in the spatial distribution of heavy metals at the residential site (Table 2) probably reflects the background levels of the metals. The spatial data suggests that automotive emissions may have slightly increased Pb and Cr concentrations over background.

Table 1. Average concentrations (ug/g dry weight) of heavy metals in composite samples of 5 lichens along the Zaria/Samaru-Sokoto Highway in northern Nigeria with average daily traffic of 7800 vehicles.

Distance (m)	Pb	Cu	Zn	Cr	Fe
2	115.0	8.5	9.0	50.0	308
10	88.8	11.0	6.0	11.0	294
30	8.4	2.9	5.0	5.0	307
45	6.9	2.3	5.3	5.0	310
60	2.5	1.6	4.6	1.6	296

Table 2. Average concentrations (ug/g dry weight) of heavy metals in composite samples of 5 lichens along a residential road in the Samara Campus, Ahmadu Bello University, Zaria.

Distance (m)	Pb	Cu	Zn	Cr	Fe
2	3.0	6.0	4.6	3.3	307
10	6.3	5.3	6.3	5.0	316
30	3.8	4.8	5.4	5.3	318
60	2.5	6.6	4.5	5.3	311
90	1.3	6.3	4.9	5.0	315

Table 3. Analysis of variance for concentrations of heavy metals in composites of 5 lichens with distance from the edge of the Zaria/Samaru-Sokoto Highway.

Source	F-Ratio (1,28 df)	P
Cr	318	<0.001
Cu	109	<0.001
Fe	4	0.056
Pb	217	<0.001
Zn	426	<0.001

Industries capable of emitting these pollutants, and more automobiles, have been introduced into these areas since 1980. Consequently, current concentrations of heavy metals in biological and environmental media are expected to be higher than the levels reported here and in other studies (Kapu et al. 1989, 1991). Given the poor nutrition and sanitation in these areas of Nigeria, an appreciable increase in heavy metal concentrations in the environment could cause adverse health effects in the exposed populations, especially children, living in villages along the highway. Follow-up studies to monitor the bioaccumulation of contaminants are being developed in order to evaluate whether health risks from heavy metals have actually increased.

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