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Heavy Metals in the Epiphytic Vegetation of Arusha, N. Tanzania

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Abstract: Heavy metals (iron, nickel, copper, cadmium, zinc, mercury and lead) were determined from epiphytic mosses and lichens growing on trees in Arusha, northern Tanzania. The metal concentrations were significantly higher in the town than in a control area 10 km outside the town. Fe and Ni were quite evenly distributed, the main source obviously being dust particles. The highest Cu concentrations were caused by the use of Cu-fungicides at a coffee estate. Elevated Pb and possibly Cd concentrations are due to the traffic at the busy Uhuru Road. One elevated Hg value was found in the town but the source is unknown.

INTRODUCTION

Arusha town, situated in northern Tanzania, has recently grown rapidly in size. In 1978, the population of the town was about 55 000 people. Today it is estimated to 200 000. The rapid growth of the town is due to three factors. Firstly, its cool weather and good communication has attracted several international organizations and research institutes such as PAPU, ESAMI, CIRDAFRICA, Commonwealth secretariat etc. Secondly, being situated nearest Mt. Kilimanjaro and the famous national parks of Serengeti, Ngorongoro and Lake Manyara, Arusha is one of the biggest tourist towns in Tanzania and one of the most famous ones in East Africa. Thirdly, because of the above factors, the town has attracted a lot of large and small scale industries. Major industries include the tyre manufacturing plant of E. Africa General Tyre Ltd., the Kilimanjaro Textile Industry, the East African Fibreboards Industry and several food processing factories.

With the exception of local garages dealing with paint spraying and welding which are scattered all over the town, most small scale industries dealing with metal works are found in the south-western area. The metal works in the area include black smiths works, metal galvanising plants, foundry works, welding, and various small scale industries producing small metal articles such as nails, pans, spoons and electrical goods.

Parallel with the increase in the town's population and industries the traffic has also been increasing. The town has recently been flooded with Japanese reconditioned and perhaps inefficient vehicles, particularly saloon cars and pick-ups, which have seriously increased the air pollution.

Situated at the foot of Meru and Kilimanjaro mountains, the tropical weather in the Arusha area is ideal for the growth of coffee. Big coffee estates surround the town. In raising the coffee, huge amounts of pesticides are used. Among these are copper-based fungicides such as copper oxychloride, cupric oxide and cupric hydroxide. These are sprayed up to ten times a year in order to control the notorious coffee berry disease (*Collectotrichum coffeanum*). Naturally, dust residues of these are frequently blown by wind into the Arusha town, thus increasing the metal pollution in the town.

MATERIAL AND METHODS

The study area included a cross section of the town from east to west along the busiest Uhuru road (Fig. 2). Samples of epiphytic vegetation were collected in 1990 from two heights: 1,5 m and 5 m above the ground. A control sample was collected from a bushy area more than 10 km away from the town (heigh 1,5 m). The samples were dried at room temperature and sent to Finland for analysis.

The homogenized samples were dried overnight at 40 °C for Hg analyses and at 105°C for other metals. After drying, samples to be analysed by flame absorption spectrophotometer for analyses of metals other than Hg were weighed to 1 g, dry-ashed for 4 h at 460 °C, dissolved in 10 ml concentrated HCl, evaporated to 5 ml and diluted to 50 ml with distilled water. Those plant samples to be analysed by graphite furnace AAS technique were digested according to the following procedure: 0,5 g subsamples were weighed and digested in 5 ml 65% extremely pure nitric acid for 1 h at 75 °C, 4 h at 105 °C and 4 h at 170 °C. The wet ashed samples were filtered and diluted to 25 ml with distilled water. Finally, the sample solutions were analysed for their metal concentrations by a flame atomic absorption spectrophotometer (Varian SpectrAA-40) or by graphite furnace AAS (Varian SpectrAA 40 equipped with GTA-96).

For Hg-analyses the samples were digested in 5 ml of suprapure HNO_3 – H_2SO_4 - mixture (1:4) for 4 h at 85 °C. Then the samples were diluted to 100 ml by distilled water and analysed by a cold vapour atomic absorption spectrophotometer (Perkin-Elmer MAS-50).

RESULTS AND DISCUSSION

For all metals the concentrations were higher in Arusha than in the control sample (Table 1, Fig. 1). Normally the differences between the two sampling heights were small.

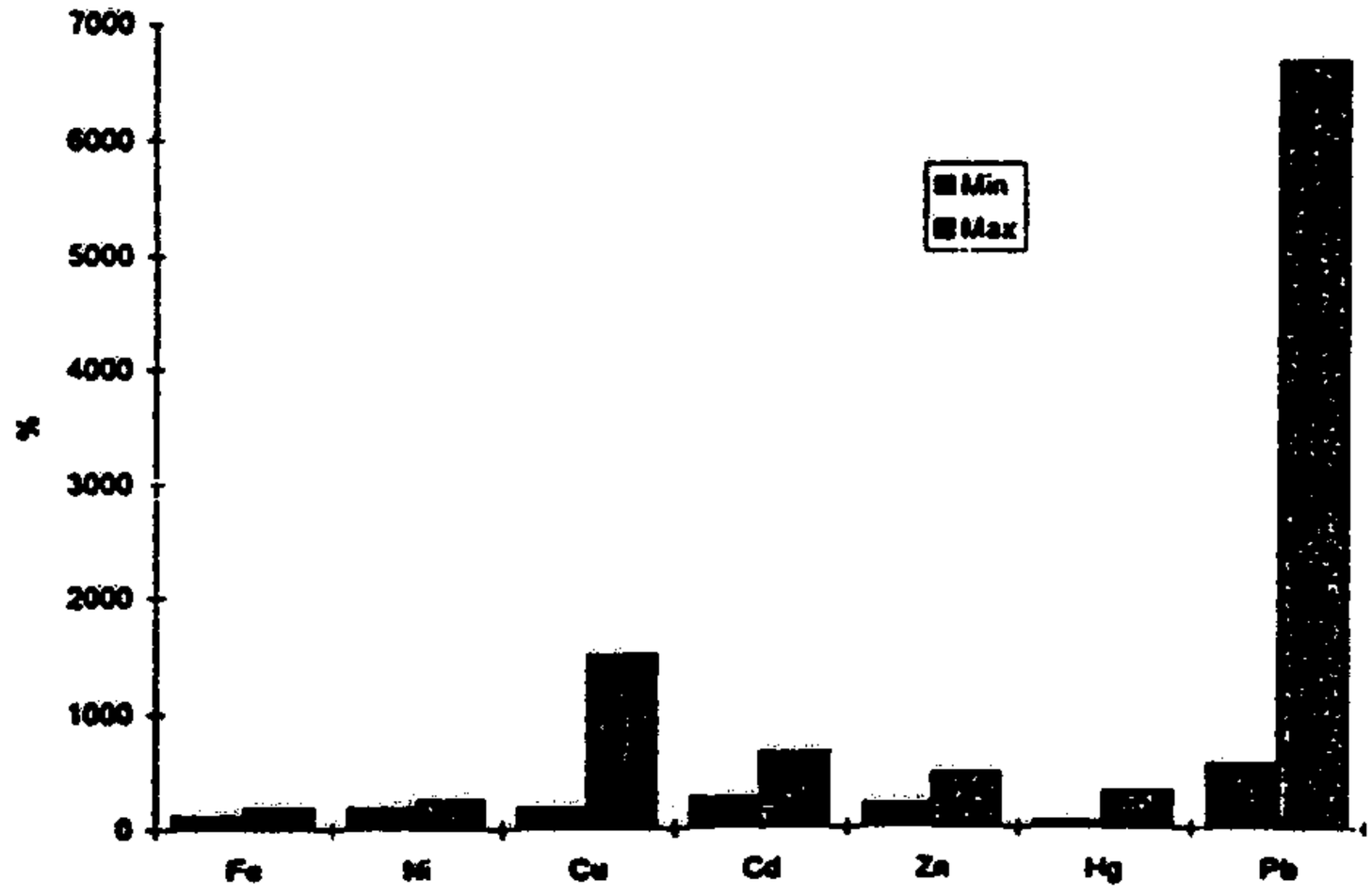

Fig. 1. Minimum and maximum concentrations of metals in lichens from Arusha in comparison to the control sample (control = 100%).

The concentrations of Fe, Ni and Pb were at the same level as in the lichen *Caloplaca aurantia* collected in Tel Aviv (Garty *et al.* 1977) while the levels of Cu, Cd and Zn were lower. On the other hand, the concentrations of Cu, Cd, Zn and Pb exceeded those found from the lichen *Alectoria sarmentosa* in two national parks in USA (Frenzel *et al.* 1990). The Fe concentrations were much higher than in Finland (*Hypogymnia physodes;* Lodenius & Kumpulainen 1983). With the exception of one sample, the Hg concentrations in Arusha were lower than the background mean for the lichen *Hypogymnia physodes* in Finland (Lodenius 1981). The concentrations of Fe, Ni, Cu, Cd, Zn and Pb found here were similar to those found in Norway (*Hylocomium splendens;* Steinnes *et al.* 1994) and Denmark (*Hypnum cupressiforme, Hypogymnia physodes* and *Lecanora conizaeoides;* Pilegaard *et al.* 1979).

Significantly elevated concentrations of lead were found along the traffic-choked Uhuru road. The main sources are obviously motor vehicle exhausts and petrol stations. The sources of copper and zinc may be galvanising industry, metal and paint works within the city and emissions from various foundries in the city suburbs.

The use of epiphytic vegetation has provided an good indicator for heavy metal pollution in Arusha. As the city continues to grow and more and more small scale industries are built, pollution will increase. This can have adverse effects on the health of citizens and also reduce the touristic value of the town. Constant monitoring of the pollution status must be carried out, e.g. by using this methodology.

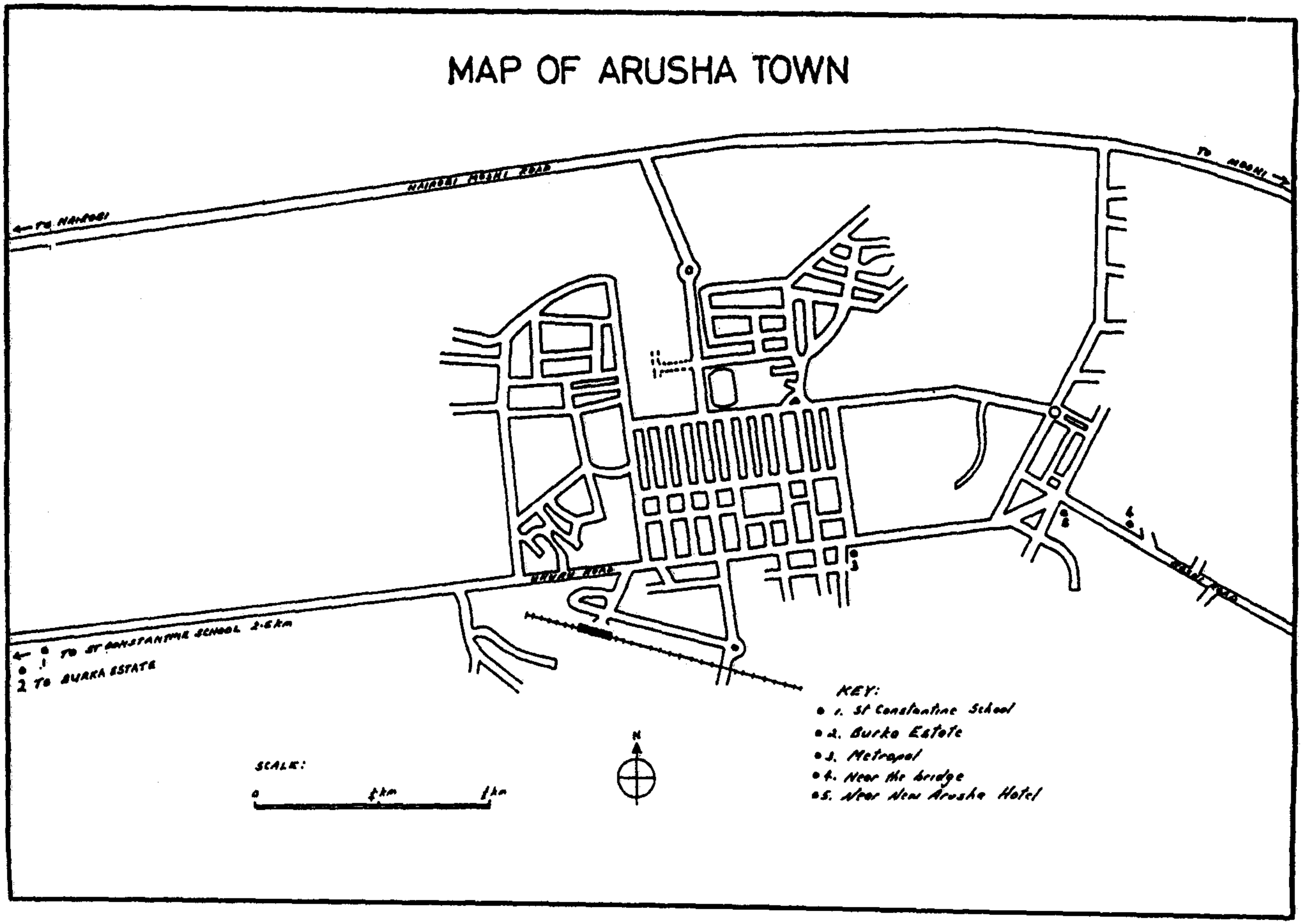

Fig. 2. Sampling sites in Arusha.

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Table 1. Metal concentrations (µg/g dry weight) of epiphytic moss and lichen samples from Arusha 1990

Site	heigh m	Fe	Ni	Cu	Cd	Zn	Hg	Pb
1	1.5	31 000	40	70	0.27	120	0.06	31
2	1.5	27 000	38	300	0.21	140	0.06	28
	5	26 000	33	140	0.22	140	0.05	41
3	1.5	28 000	43	47	0.52	220	0.32	180
	5	29 000	46	52	0.49	220	0.36	210
4	1.5	22 000	35	35	0.27	180	0.10	110
	5	20 000	30	38	0.30	180	0.09	120
5	1.5	21 000	34	62	0.25	110	-	22
	5	24 000	34	55	0.34	240	0.15	260
Control	1.5	17 000	16	20	0.08	51	0.10	3.9

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