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Water Hyacinth as Indicator of Heavy Metal Pollution in the Tropics

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The water hyacinth (*Eichhornia crassipes*) is a common aquatic plant in many tropical countries. Its ability to absorb nutrients and other elements from the water has made it possible to use it for water purification purposes (e.g. Chigbo et al. 1982, Muramoto and Oki 1983). *Eichhornia*, especially stems and leaves, have been successfully used as indicators of heavy metal pollution in tropical countries (Ajmal et al. 1985, Pfeiffer et al. 1986). The uptake of heavy metals in this plant is stronger in the roots than in the floating shoots (Jana 1988). Metallothionein-like compounds have been found from roots of this species after cadmium exposure (Fujita 1985). The purpose of this investigation was to study the possibilities of using roots of water hyacinth as a biological indicator of metal pollution in tropical aquatic ecosystems.

MATERIAL AND METHODS

The basin of the river Sagua la Grande covers 2, 170 km^2 and the length of the river is 163 km. However, the sampling sites of this study extended for only 25 - 30 km (Fig. 1). The city of Sagua la Grande has approximately 60, 000 inhabitants, a chlor-alkali plant, a smelter and minor industrial plants. According to a study by Gonzalez and Lera (1987) on river sediments the city pollutes the river with Pb, Zn, Cu and Cd but not with Cr or Ni.

Samples were taken six times during the years 1985 to 1988 (Table 1) in the river Sagua la Grande, central Cuba. For different reasons (occurrence of water hyacinth, water level, etc), it was not possible to collect samples from all sites at all times. Reference samples were collected from the river San Juan (Matanzas; SJ1 and SJ2 in Table 1), from the dam Alacranes (Villa Clara; P10) and from the lagoon Segundo Frente (Santiago de Cuba; L17).

Roots of water hyacinth were collected by hand, rinsed with river water, packed in nylon bags and transported to the laboratory where they were washed with tap and twice distilled water. The samples were dried at 45^{o}C (the samples were also used for Hg analyses) and cut with stainless steel scissors. One gram of the sample (2 g in March 1987) was digested in concentrated HNO_3 / $HClO_4$. The metal contents were determined by flame atomic absorption spectrometry with background correction (SATURN 2). The accuracy of this method for biological materials was tested in an international intercalibration (lab 50A in Anonymous 1987) using IAEA reference materials.

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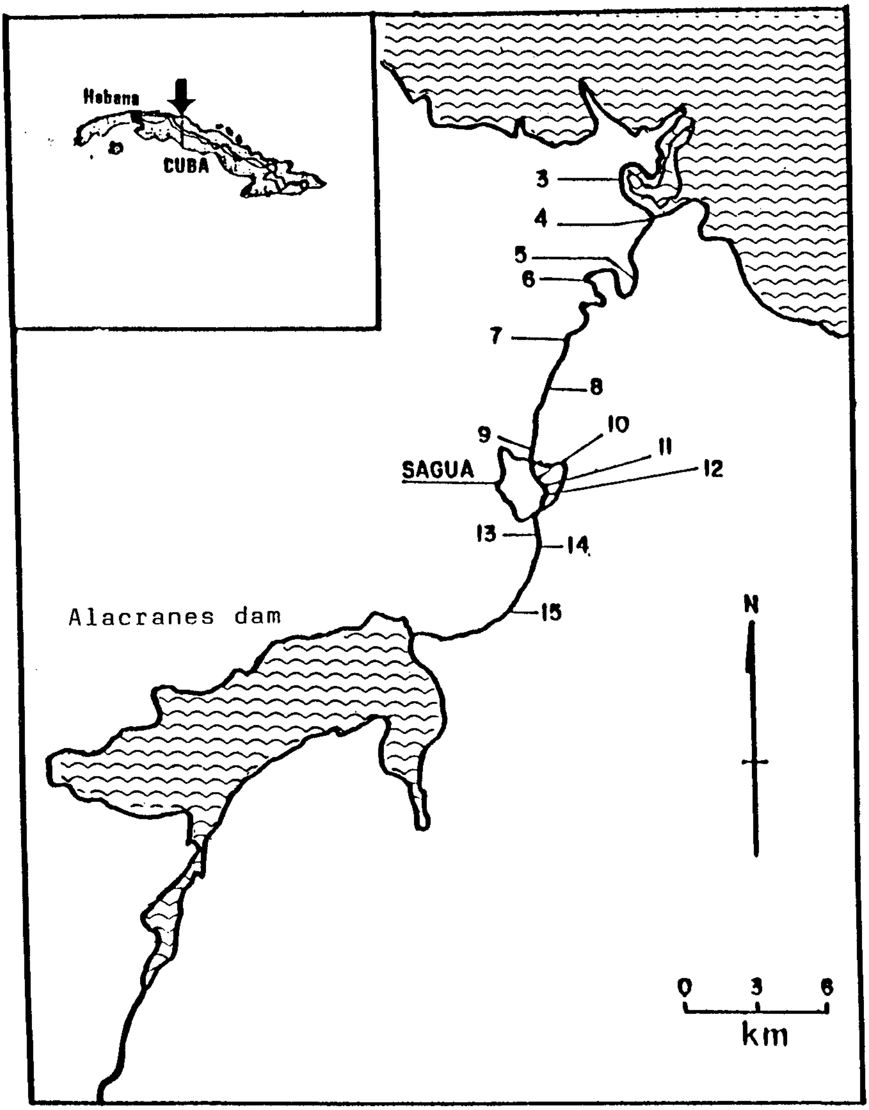

Figure 1. The study area.

RESULTS AND DISCUSSION

The lowest concentrations of metals were found in water hyacinths taken upstream from the city of Sagua (sites 15 - 13), which are considered less polluted (Table 1). Highest concentrations were found in the zone situating near Sagua city (sites 12-9) which receives urban and industrial effluents. In the river downstream from the city (sites 8 - 3), levels of metal in hyacinth root were lower than within the city but indicated still influence of pollution from the city.

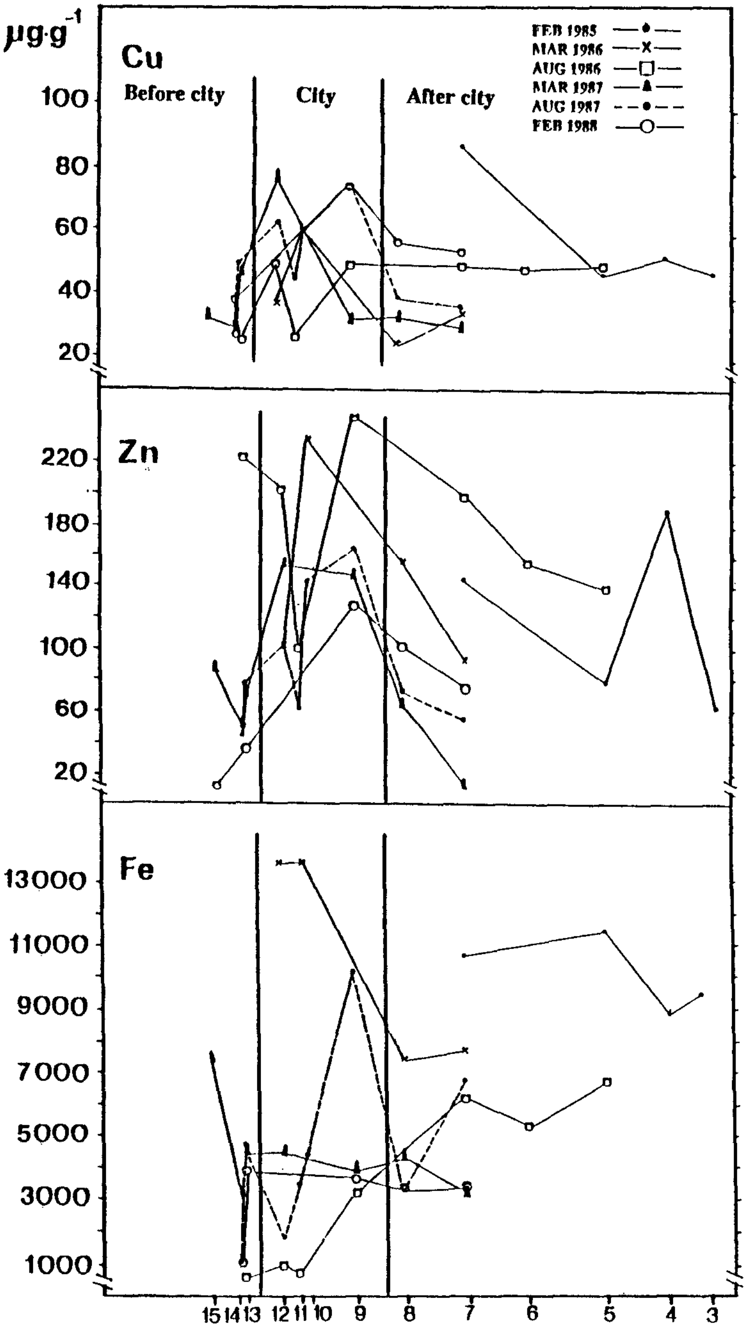

Figure 2. Levels of metals in *Eichhornia crassipes* roots along the River Sagua la Grande. The numbers of the sampling sites refer to Fig. 1.

Table 2. Levels of metals (mg kg^{-1} dry wt) of roots of *Eichhornia crassipes* collected from three zones of River Sagua and from reference sites.

		N	mean	S.D.
Cu	A. before city	8	34	9.9
	B. within city	12	55	17
	C. after city	15	47	15
	D. reference	4	15	8.5
Zn	A. before city	8	76	65
	B. within city	12	150	58
	C. after city	15	110	55
	D. reference	4	78	40
Fe	A. before city	8	3300	2300
	B. within city	12	5400	4500
	C. after city	15	6600	2700
	D. reference	4	6000	2700
Mn	A. before city	8	4500	2400
	B. within city	12	5100	2500
	C. after city	15	12000	9800
	D. reference	4	1900	1300
Pb	A. before city	2	18	13
	B. within city	10	51	24
	C. after city	8	30	9.3
	D. reference	1	16	
Cr	A. before city	4	26	16
	B. within city	10	38	20
	C. after city	13	32	12
	D. reference	2	38	28
Co	A. before city	5	10	5.6
	B. within city	12	12	4.9
	C. after city	13	16	8.9
	D. reference	1	8.5	

It was not always possible to collect samples from all sites, but we normally analyzed samples from all three zones. The fluctuations of Cu, Zn and Fe are presented in Fig. 2. Despite considerable temporal variations there is a clear increase in metal levels of *Eichhornia* roots starting from the city downstream. In general, there were significant differences between the values above and within or below the city (Table 3). This was also true for Mn which has not been considered a good indicator of urban effluents. The differences in iron contents are less distinct, which possibly indicates that iron would not be as good an indicator of urban effluents as e.g. copper and zinc (cf. Salomons and Förstner 1984). The variations between sampling periods and sampling sites may be explained by the numerous factors affecting the uptake of metals by water hyacinth (discharges, water volume, etc.). Also the age of the water hyacinth may affect the concentrations.

The samples collected from polluted and unpolluted areas show the ability of *Eichhornia crassipes* to accumulate heavy metals in the root and serve as a bioindicator of metal pollution.

Table 3. Percent probability of differences between groups (ANOVA) for four metals. A = Before city, B = Within city, C = After city, D = Reference sites.

	Cu				Zn		
	B	C	D		B	C	D
A	99.3	95.5	99.0	A	98	86	4.8
B	-	81.6	99.9	B	-	93.7	96
C	-	-	99.9	C	-	-	66
	Fe				**Mn**		
	B	C	D		B	C	D
A	75	99	89	A	38	94.6	92.2
B	-	60	19	B	-	97	96.8
C	-	-	30	C	-	-	93.3

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