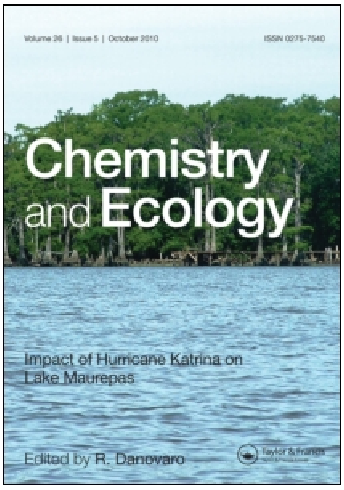

Chemistry and Ecology
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713455114

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To cite this Article Bonforte, G. , Guzzi, L. , Martinotti, W. and Queirazza, G.(1986) 'Identification and Choice of a Biological Indicator for the Study of the Contamination of a River Environment by Heavy Metals', Chemistry and Ecology, 2: 3, 199 — 204

To link to this Article: DOI: 10.1080/02757548608080726

URL: http://dx.doi.org/10.1080/02757548608080726

Chemistry in Ecology, 1986, Vol. 2, pp. 199–204
0275-7540/86/0203-0199 $18.50/0

Identification and Choice of a Biological Indicator for the Study of the Contamination of a River Environment by Heavy Metals†

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(Received 28th October, 1983)

Biological indicators are efficient tools for establishing pollution levels in a given environment (Phillips, 1980). In this study the organisms used are endowed with the ability to accumulate heavy metals in the river ecosystem, where a biological indicator may be preferable to direct analysis of water samples as a means of monitoring pollution (Popham and D'Auria, 1981). Further, biological indicators provide estimates of the average level of pollution over a given period of time, and can discriminate a given pollutant present in water on the basis of its biological availability. The selection of a suitable organism, however, should fulfil other requirements, thus it must be sedentary, abundant in various environments and longeval. In the Po river a bivalve mollusc (*Unio elongatulus*) and some macrophytes (*Potamogeton crispus*, *Lagarosiphon major*, *Miriophyllum verticillatum*, *Phragmites*

† Presented to the Symposium in Analytical Problems in the Marine Environment, Genoa, 23–24 May, 1983.

communis), known for their bio-accumulative properties (Ravera, 1966, 1973) have been identified as possible biological indicators of heavy metals (Pb, Cd, Cu, Zn, Ni, Co, Cr, Mn, Fe).

The survey was conducted from May 1978 to December 1979 near the hydroelectric power station of Serafini Island, in a section of the Po river dominated by a low hydrodynamic energy. The sampling plane was as follows:

	Sampling conditions		
Year	Water	Aquatic organisms	Sediment
1978	*Dissolved and suspended fractions*: continuous daily sampling with filtration (0.45 μm) (10 integrated samples per month)	monthly sampling	monthly sampling
1979	*Total sample*: continuous sampling carried over a 2–3 days period (12 integrated samples per month)	fortnightly sampling	—

Figure 1 shows the average levels of the heavy metals in the mollusc *Unio*, aquatic macrophytes and in water samples. The figure also gives the range of the concentration factors ($FC = [X]_{organism}/[X]_{water}$) for all the organisms considered.

TABLE I
Results of the stepwise multiple regression analysis for metal contents between *Unio elongatulus* vs. sediment and water (dissolved and suspended fractions)

Parameter	Cr	Mn	Fe	Co	Ni	Cu	Zn	Cd	Pb
metal ($\mu g \cdot g^{-1}$ or $\mu g \cdot l^{-1}$)									
x_1 Sediment	0.84	0.93	0.50	*	0.91	1.00	0.65	*	0.48
x_2 Dissolved fraction (15 days)	—	0.81	—	0.62	—	0.70	0.70	1.00	0.55
x_3 Dissolved fraction (30 days)	0.99	0.92	0.71	—	0.91	—	0.90	0.93	0.74
x_4 Suspended fraction (15 days)	0.97	—	1.00	—	0.92	0.78	0.95	0.88	0.99
x_5 Suspended fraction (30 days)	1.00	0.79	0.97	0.37	0.90	0.87	—	0.23	—

( ) sampling period
* not determined
— not correlated
----- Most closely correlated parameter in the single correlation
—— Parameter with the highest effect on the multiple correlation

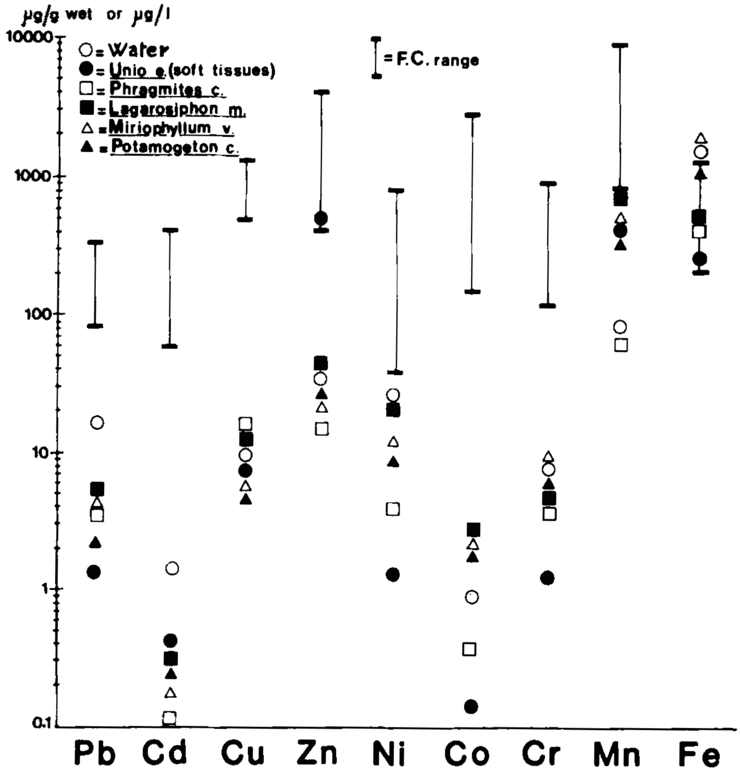

FIGURE 1 Average levels of heavy metals in fresh water mollusc (*Unio elongatulus*, soft tissues), in water samples (μg/l) and F.C. ($\mu g/g_{wet}$)/($\mu g/cm^3$) coming from the Po river nearby Serafini Island (middle course), year 1978.

The resulting metal concentration values do not clearly identify only one organism with high accumulator capacity for all the metals. Nevertheless it can be said that in general *Unio* is preferable to the macrophytes since it lives in muddy and sandy environments where no macrophytic vegetation exists.

It was also confirmed by a stepwise multiple regression analysis that the content of the majority of the metals in suspended phase and sediment more closely correlates than the dissolved phase with the content of the metals in the mollusc (Table I). According to Karbe *et al.* the concentration ratios were calculated through the

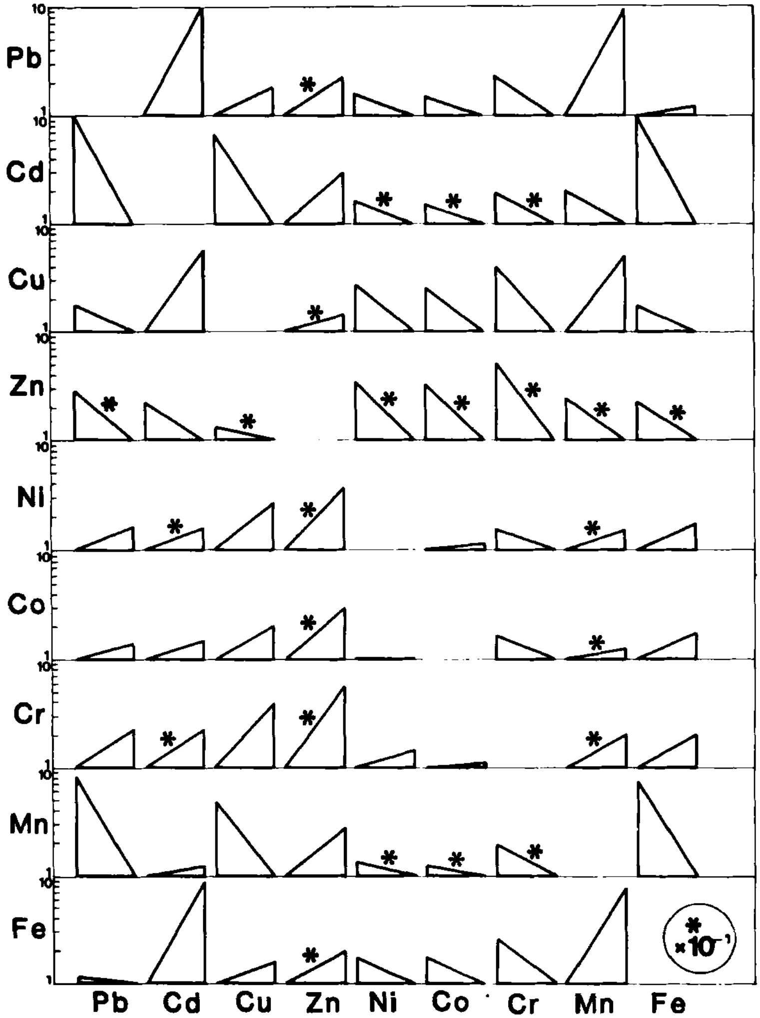

FIGURE 2 Comparison between the concentration element ratios calculated for *Unio elongatulus* (soft tissues) and *Potamogeton crispus*. Each triangle shows the increase or decrease of the ratios by comparison between *Unio* (left) and *Potamogeton* (right). For example the triangle at the bottom left side gives for the *Unio* a Mn/Pb ratio 9.5 time greater than for the *Potamogeton*.

relationship $([X]_{\text{Unio}}/[Y]_{\text{Unio}})/([X]_{\text{macr.}}/[Y]_{\text{macr.}})$ to evaluate the absorption ability in *Unio* as opposed to aquatic macrophytes.

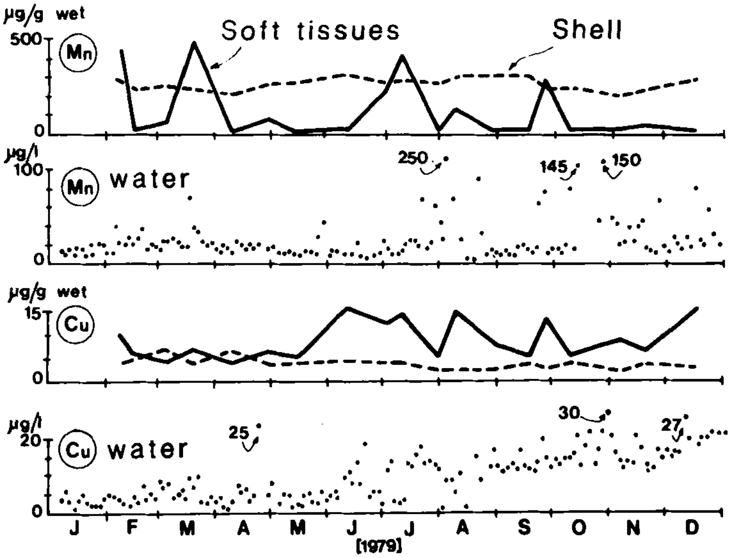

FIGURE 3 Seasonal variations of the Mn and Cu concentrations in *Unio elongatulus* (soft tissues and shell) and in Po river water.

Figure 2 shows for *Unio* a definite trend to accumulate Zn and Cd as compared with the *Potamogeton*. On the other hand, the elements Ni and Co are found in larger concentrations in the macrophyte. For the other metals, no definite preference was noticed. Similar results were obtained from the other comparisons.

In 1979, a study was carried out on the seasonal variations of the various metal present in *Unio*, both in the soft tissues and in the shell in relation to the Po river-water content. Figure 3 illustrates the specific case of Mn and Cu. From these trends it is possible to deduce the inaccuracy of *Unio* as an indicator of ambient levels of Mn, unlike the other heavy metals (e.g., Cu), owing to the change in seasonal metabolic activity probably associated with the growth of the mollusc (Frazier, 1975, 1976).

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