Interpretation of heavy metal concentrations in the surficial sediment from the Makirina Bay using aluminium as reference element

P. Vreča — Department of Environmental Sciences, Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia

T. Dolenec — Department of Geology, University of Ljubljana, Aškerčeva 12, 1000 Ljubljana, Slovenia

M. Šparica — Geological Institute, Sachsova 2, 10000 Zagreb, Croatia

Heavy metal concentrations were studied in surficial sediment from Makirina Bay to determine whether natural or anthropogenic enrichment of the metals is occurring. Metal concentrations of Al, Co, Cu, Ni, Pb and Zn were determined using inductively coupled plasma emission spectrometry. The coastal sediment of the Makirina Bay in the central Adriatic Sea represents an important source of healing marine mud which could be used for medical treatment. The sediment constitutes mostly of clay minerals, quartz, dolomite and calcite. Halite, gypsum, aragonite and pyrite are also present.

Particulate metals from natural and anthropogenic sources accumulate together in the sediment. In order to evaluate the level of metal pollution in the area the proportions originating from the two sources should be determined (Din, 1992). The problem is that metals occur naturally in sediments and that their concentrations vary with mineral composition and grain size. To overcome this problem, normalization to a reference element is a useful tool (Loring, 1991, Schropp *et al.*, 1990). With such a geochemical method it is possible to compensate for mineralogical as well as the natural granulometric variability of metal concentrations in the sediment. With such normalization method it is also possible to detect the anthropogenic metal contribution to the sediment (Din, 1992). Heavy metals in coastal sediments are usually associated with fine-grained fraction mainly constituted of clay minerals (Loring, 1991). One of the main components of these minerals is aluminium which is generally not influenced by anthropogenic sources (Din, 1992) and because of this it is recommended as a reference element (Din, 1992, Schropp *et al.*, 1990).

Regression analysis for log-transformed data was run for Co, Cu, Ni, Pb and Zn using Al as the independent variable. Then heavy metal:aluminium ratios were calculated. Data points on the regression line with higher or lower ratios than the 95% prediction limit were removed. High ratios probably indicate anthropogenic metal enrichment (Schropp *et al.*, 1990). In our case three data points in the vicinity of the Kapela-Tisno road with high heavy metal:aluminium ratios show an anthropogenic enrichment in the surficial sediment of Makirina Bay. Those data points were removed.

All five heavy metals exhibit a highly significant positive linear correlation with aluminium (Table 1) with correlation coefficient $0.92 < r < 0.98$. After Loring (1990) the strength of the correlation varies from element to element and from area to area because of variation in mineralogical composition related to origin rather than to particle size. Scatterplots for Co, Cu, Ni, Pb and Zn *vs* Al are shown on Fig. 1. It is interesting that the regression lines of Ni, Pb and Zn have very similar slopes (Fig. 1, Table 1). The slopes of regression lines of Co and Cu are slightly gentle (Fig. 1, Table 1). The similar slopes of regression lines and high positive correlation

TABLE 1. Linear correlation coefficients for metals and aluminium, according to the relationship log $(metal_{ppm}) = a + b\ [log(Al_{ppm})]$

Metal	n	r	Slope	Intercept
cobalt	23	0.93*	0.89	−2.83
copper	23	0.92*	0.92	−2.42
lead	23	0.96*	1.11	−3.39
nickel	23	0.98*	1.13	−3.41
zinc	23	0.98*	1.15	−3.26

* $\alpha < 0.05$

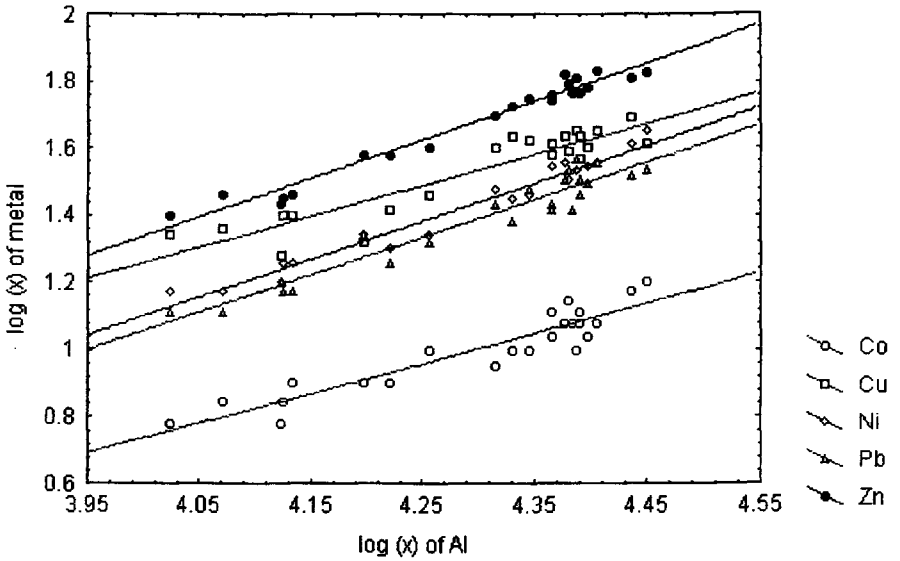

FIG. 1. Scatter plots of Co:Al, Cu:Al, Ni:Al, Pb:Al and Zn:Al for surficial sediment of the Makirina Bay.

between metals and aluminium is probably due to the similar chemical properties of heavy metals (similar ionic radius) and to the same origin and transport processes of the heavy metals in the sediment. Higher heavy metal concentrations in surficial sediment of Makirina Bay are associated with an aluminium content higher than 1.9%, which is due to higher clay mineral content in the central part of the Bay. Clay minerals probably originate from erosion of soil and, because of their fine-grain size, are transported to the central part of the Bay. Lower concentrations of heavy metals are associated with coarser sediments in the coastal part of the Bay with aluminium concentrations lower than 1.9%. Coarser sediment from Makirina Bay contains more quartz and detritial dolomite and less clay minerals.

References

Din, Z.B. (1992) *Marine Pollution Bulletin*, **24**, 484–8.

Loring, D.H. (1990) *Marine Chemistry*, **29**, 155–14.

Loring, D.H. (1991) *ICES J. Mar. Sci.*, **48**, 101–15.

Schropp, S.J., Lewis, F.G., Windom, H.L., Ryan, J.D., Calder, F.D. and Burny, L.C. (1990) *Estuaries*, **13**, 227–9.