HEAVY METALS IN ORGANISMS AND SEDIMENTS FROM THE EAST COAST OF LUNDY

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Introduction

Heavy metals can be expected to occur in all soils, rivers, and oceans as a result of weathering and transportation processes. Although some are essential in traces to certain organisms, it is possible for some heavy metals to have toxic effects if present at sufficiently high concentrations. One important facet of their environmental behaviour is their ability to be concentrated in organisms. Titanium, for example, occurs in some ascidians at more than one million times its concentration in sea water. Since man is at the head of a food chain he may be potentially exposed to some degree of risk when high concentrations of heavy metals are found in creatures lower in the food chain.

There have been several reports recently of elevated concentrations of heavy metals in a number of localised areas in British coastal waters. Adbullah *et al.* (1972) report high concentrations of copper, lead, cadmium, and zinc in sea water from certain sections of Liverpool Bay, Cardigan Bay, and the Bristol Channel. In some cases these increased levels are the result of human influences, but natural processes cause enhancement in some areas. The concentration of cadmium in the eastern part of the Bristol Channel reaches over 4μg/l (or thirty to forty times that of the open sea). Butterworth *et al.* (1972) report parallel findings to those of Abdullah *et al.* (1972). These authors showed that this contamination was apparent in certain organisms which they analysed, and that its influence was detectable at Hartland Quay only 20 km from Lundy.

The main purpose of this visit to Lundy was to obtain samples of certain organisms and sediments from the soft substrate areas on the east coast, for measurement of several trace metals including those which are most significant from the standpoint of environmental pollution. Such measurements give useful background information against which any subsequent changes in concentration can be assessed. This report is an initial account of the copper levels in the organisms, analysed at Southampton, and the concentrations of lead, copper, zinc, and cadmium in the sediments, analysed at Menai Bridge. A subsequent report will give the mercury and arsenic levels found in the organisms.

Sample Collection and Analysis

The sub-littoral samples were collected by diving methods since apparatus such as grabs and dredges may, in some circumstances, give non-representative samples. The diving was carried out from an inflatable boat. Organisms were collected in large plastic bags, and on surfacing, transferred to a large plastic tub in which they were allowed to purge their gut contents. Surface sediment was collected in self-sealing plastic bags. The organisms and sediments were deep frozen. Before analysis the samples were freeze dried, and ground to a powder in a ball-mill. For the determination of copper in tissues the dried material was oxidised using nitric and perchloric acids. The residue was dissolved and atomic absorption spectrophotometric analysis carried out on the clear solution. The latter method was also used for analysis of metals leached from the sediments by a mixed acid reducing agent, as described by Chester and Hughes (1967). This technique of analysis does not include that fraction present in the lattice structures of land derived components such as clars and silts. This point should be kept in mind when comparing the results of some other workers who have analysed the total metal contents of sediments.

Results apd Discussion

(a) Organisms

The copper results are presented in Table I. The soft corals, *Alcyonium glomeratum* (=*couchi*) and *Alcyonium digitatum*, and the spiny starfish, *Marthasterias glacialis*, show very similar concentrations, which are lower than those in the molluscs and crustaceans. There are few published data with which these values can be compared. Riley and Segar (1970) analysed one specimen of *Alcyonium digitatum* from the Isle of Man which had a slightly higher concentration of 9·7 ppm.

The common scallop, *Pecten maximus*, collected from Knoll Pins had an average concentration of 6·1 ppm for dried soft parts excluding digestive organs. Segar *et al.* (1971) report a concentration of 3·3 ppm for the entire soft parts of *Pecten* collected from the Isle of Man. The present results for copper in muscle, gills, vellum, and ovary are in good agreement with the findings of Segar *et al.* (1971) and those of Brooks and Rumsby (1965) for a related species, *Pecten novae-zelandiae*, from New Zealand waters. The concentration of copper in *Nucella lapillus* is high compared with other Lundy organisms analysed. A similar value has been found for a specimen from the Shetland Islands (H. S. Matharu, unpublished data). Higher concentrations of copper have been observed from many areas of the English south coast. In particular a sample collected from Stokes Bay, an area in The Solent, has been found to contain 445 ppmof copper.

The concentration of copper found for the chela of the edible crab, *Cancer pagurus*, was similar to that in *Nucella lapillus*. Higher values of copper were found for the front appendages of this organism and for the crawfish, *Palinuras elephas*.

In summary, the concentration of copper in the organisms appears to vary with species in a way which would be expected from studies in other regions, and they are very similar to those reported from areas which have not been subjected to anthropogenic inputs of the element.

(b) Sediments

(1) Mineralogy. Mineralogy represents one of the major controls in sediment geochemistry by virtue of the composition of the minerals and the sites which they provide for absorption processes. Standard X-ray diffraction procedures identified the main minerals present, in order of peak intensity, in the Knoll Pins sediment as quartz, calcite, plagioclase, feldspar and clay minerals. The calcite represents broken shell material.

Subsequent investigation of the clay minerals revealed the presence of chlorite, illite, and kaolinite. The relative peak intensities of these clay minerals along with comparative data from the Conway Estuary and Menai Straits are given in Table 2. It is evident that there is a marked similarity of the Knoll Pins clay fraction to that of the Menai Straits and Conway Estuary. The sediment mineralogy as a whole corresponds to sediment derived from a nearshore marine environment.

(2) Heavy Metals. The leachable heavy metal concentrations of the Lundy samples are given in Table 3. Duplicate analysis for sediment collected from the Knoll Pins and Gannets Bay are in good agreement. Comparatively little variation between samples is present and that found may be attributed to variation in particle size distribution between the sediments.

Concentrations of lead and zinc are much lower than in sediments taken from the Severn Estuary between Aust and Brean (Butterworth *et al.*, 1972), but this may partly be due to the difference in the fraction measured. These authors report concentrations of lead ranging from 130-200 ppm and zinc ranging from 420-590 ppm. Similar considerations arise in comparing the concentration of copper with the average value of 48 ppm for nearshore sediments given by Wedepohl (1960). However, the average concentration of leachable cadmium in the Lundy sediments of 3·3 ppm is higher than the total cadmium concentration of 0·4 and 0·6 ppm reported respectively for organic muds from

the Irish Sea (Mullin and Riley 1956), and muds from Southampton Water (Leatherland and Burton, in press). This marked enrichment of cadmium is much greater than that found in corresponding sediments from the Solway Firth (Halcrow *et al.*, 1973), or Cardigan Bay (Jones, 1973), but not as high a 8 ppm for leachable cadmium found for the Conway Estuary sediments (R. Jones, unpublished data). Concentrations in this estuary are to some extent influenced by inputs from mineralised zones. Butterworth *et al.* (1972), however, have found comparable values for cadmium in sediments from the Severn Estuary. Although there is no clear evidence at present which indicates the origin of the cadmium it is possible that cadmium has been concentrated in the sediments by absorption from the enriched waters of the Severn Estuary. The method of analysis indicates that cadmium is present in a relatively available form. It is suggested that further analyses for cadmium are undertaken on bottom living organisms and other animals in the vicinity of Lundy.

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Table 1. The Concentrations of Copper in Organisms Collected from Lundy

Species	*Area Collected*	*Dry Weight* (%)	*Copper concentration* (ppm dry weight)
COELENTERATA			
Alcyonium digitatum	Knoll Pins	19·8	3·9
Alcyonium digitatum	Lee Rocks	13·3	4·2
Alcyonium couchi	Quarry Beach	21·7	5·4
Alcyonium couchi	Knoll Pins	26·4	4·1
ECHINODERMATA			
Marthasterias glacialis	Quarry Beach	40·1	4·9
	Quarry Beach	36·3	4·0
MOLLUSCA			
Pecten maximus	Knoll Pins		
Adductor muscle		24·6	1·6
Gills		11·9	8·5
Vellum		20·4	2·8
Ovary		32·3	11·4
Nucella lapillus	Quarry Beach	34·5	41·0
ARTHROPODA			
Cancer paguras	Knoll Pins		
Right chela		4·8	42·3
Left chela		25·4	40·3
Front appendages		19·1	75·2
Palinuras elephas	Lee Rocks		
Hepatopancreas		48·0	13·2
Front appendages		20·0	93·0

Table 2. Relative Peak Intensities for the <5μ Clay Mineral Fraction

Location	Chlorite	Illite	Kaolinite
Lundy (Knoll Pins)	20·7	63·3	16·0
Conway Estuary	24·9	60·6	14·5
Menai Straits	22·3	61·7	16·0
Range of Values at 95% Confidence Limit	±2·1	±2·6	±2·5

Table 3. Heavy Metal Concentrations in Lundy Sediments (ppm)*

Location	Zinc	Lead	Copper	Cadmium	Manganese
Gannets Bay (1)	24·9	38·0	3·8	2·6	149
Gannets Bay (2)	25·8	42·0	4·2	2·7	146
Knoll Pins (1)	36·6	64·0	5·6	4·1	215
Knoll Pins (2)	36·3	64·0	5·7	3·6	204
Lee Rocks	18·9	58·0	4·5	3·5	164

*Precision of method ±10% at the 95% Confidence Limit.