TRACE METAL CONCENTRATIONS IN MARINE ORGANISMS FROM ST. VINCENT GULF, SOUTH AUSTRALIA

W. A. MAHER

Water Research Centre, Canberra College of Advanced Education, PO Box 1, Belconnen ACT 2616, Australia

(Received July 2, 1985; revised November 25, 1985)

Abstract. Trace metal concentrations were measured in the tissues of fish, molluscs, crustaceans and macrophytes from St. Vincent Gulf, South Australia. The concentrations of the measured metals (Cd < 0.025 to 2.1 $\mu g\ g^{-1}$; Cu 0.51 to 91 $\mu g\ g^{-1}$ 5 Pb 0.02 to 3.6 $\mu g\ g^{-1}$; Zn 15 to 110 $\mu g\ g^{-1}$) are similar to those from unpolluted areas and thus give no indication of pollution.

1. Introduction

The St. Vincent Gulf marine ecosystem (Figure 1) is subject to urban and industrial wastes from a major industrial centre – Adelaide; and to diffuse agricultural runoff. Such inputs are known to contain trace metals and are likely to lead to an increase in the concentrations of trace metals in the coastal zone, some of which are toxic and may endanger human health.

To assess the extent of trace metal pollution in the Gulf, marine organisms were collected and tissue trace metal concentrations measured to provide estimates of the inputs of biological available metals to the Gulf.

2. Materials and Methods

2.1. Collection and Preparation of Samples

All organisms were obtained from St. Vincent Gulf during 1981-1983 and transported to the laboratory frozen in plastic bags. Molluscs, crustaceans and macrophytes were collected by scuba diving, fish were obtained from commercial sources. Macrophyte specimens were washed with distilled water to remove salts and small invertebrates. Fish, molluscs and crustaceans were separated into component tissues, no organism was deputated before analysis.

Specimens were freeze dried, placed in plastic bags, frozen using liquid nitrogen and ground in the plastic bags (< 200 μm) before analysis.

2.2. Analysis

Samples (< 0.5 g) were weighed into 30 mL pyrex test tubes, 3 mL of concentrated HNO_3 added and solutions digested at 70 °C using an aluminum block. After cooling, digests were diluted to 10 mL with distilled water and stored in polyethylene vials. BDH 'Aristar' nitric acid was used for digestions and all glassware was boiled with 50% (v/v)

Water, Air, and Soil Pollution **29** (1986) 77–84.

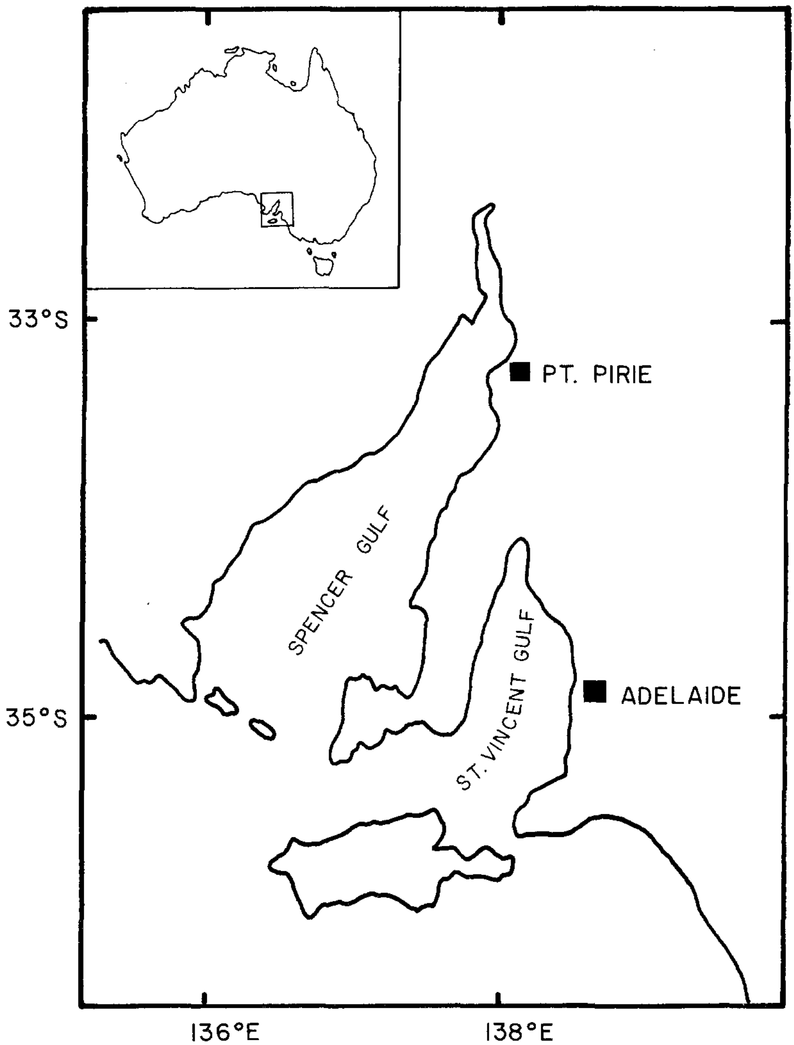

Fig. 1. Study location.

nitric acid, rinsed with deionized distilled water and oven dried before use. Trace metals (Cd, Cu, Pb, and Zn) were determined in the diluted digests by either flame atomic absorption spectrometry or electrothermal atomic absorption spectrometry using a Varian Techtron AA6 spectrometer with deuterium background correction and a CRA-63 carbon furnace. The accuracy of the determination procedure was assessed by the analysis of a standard reference material, Oyster tissue NBS 1566 (Table I).

Blanks and the concurrent analysis of the standard reference material were used to detect possible contamination during analysis.

TABLE I

Determination of trace metals in NBS reference material

Material	Cd	Cu	Pb	Zn
	(μg g^{-1} dry wt)			
Oyster 1566	3.5 ± 0.4	63.0 ± 3.5	0.48 ± 0.04	852 ± 14
This study	3.7 ± 0.6	61 ± 5	0.50 ± 0.13	861 ± 23

3. Results and Discussion

3.1. Trace Metal Concentrations

The trace metal concentrations found in marine organisms are given in Tables II, III, and IV. Comparison of the values with those measured in marine organisms from other areas in Australia (Table V) shows metal concentrations are close to lower values indicating little wide spread trace metal pollution in the Gulf. Metal concentrations are also below the geometric mean concentrations of metals found in different taxa from overseas areas (Table VI).

TABLE II

Trace metal concentrations in fish

Organism	No.	Length (cm)	Cd	Cu	Pb	Zn
			(μg g^{-1} dry wt)			
Sillaginodes punctatus	5	18–29				
muscle			<0.025	0.85 ± 0.29	0.051 ± 0.001	35 ± 5
liver			<0.025	1.5 ± 0.2	0.061 ± 0.001	62 ± 5
gills			<0.025	1.70 ± 0.15	0.96 ± 0.03	68 ± 7
Arripus georgianus	4	19–26				
muscle			<0.025	1.3 ± 0.9	<0.02	55 ± 4
liver			<0.025	6.0 ± 0.6	<0.02	88 ± 6
gills			<0.025	4.0 ± 0.7	<0.02	110 ± 3
Hyporhamphus australis	5	16–23				
muscle			<0.025	0.51 ± 0.06	0.04 ± 0.09	15 ± 3
liver			<0.025	0.70 ± 0.09	0.050 ± 0.06	20 ± 5
gills			<0.025	0.72 ± 0.08	0.08 ± 0.04	50 ± 2
Platycephalus bassensis	4	20–28				
muscle			<0.025	1.1 ± 0.3	0.05 ± 0.03	30 ± 5
liver			<0.025	1.4 ± 0.3	0.03 ± 0.01	27 ± 5
gills			<0.025	1.6 ± 0.2	0.07 ± 0.04	61 ± 5

TABLE III

Trace metal concentrations in molluscs

Organism	No.	Length (cm)	Cd	Cu	Pb	Zn
			(μg g⁻¹ dry wt)			
Pecten alba	5	6.5–7.5				
muscle			0.51 ± 0.03	0.81 ± 0.11	0.71 ± 0.30	36 ± 12
viscera			1.93 ± 0.31	3.1 ± 0.5	2.1 ± 0.1	32 ± 8
Equichlamys bifrons	5	6.5–7.5				
muscle			0.34 ± 0.06	3.2 ± 0.9	0.65 ± 0.41	36 ± 4
viscera			1.6 ± 0.4	6.1 ± 0.8	1.3 ± 0.2	30 ± 4
Pinna bicolor	5	9–14				
muscle			0.34 ± 0.07	1.1 ± 0.3	0.52 ± 0.14	50 ± 6
viscera			0.39 ± 0.08	2.7 ± 0.8	1.1 ± 0.4	100 ± 25
Sepioteuthis australis	4	17–28				
muscle			<0.025	24 ± 2	0.96 ± 0.31	60 ± 8
viscera			<0.025	91 ± 6	0.72 ± 0.14	101 ± 4
Haliotis ruber	5	8–12				
muscle			0.9 ± 0.3	5 ± 1	0.55 ± 0.27	40 ± 6
viscera			1.1 ± 0.2	11 ± 3	0.56 ± 0.31	84 ± 7

TABLE IV

Trace metals in other organisms

Organism	No.	Length (cm)	Cd	Cu	Pb	Zn
			(μg g⁻¹ dry wt)			
Crustaceans						
Penaeus latisulcatus	8	4.5–6.0				
muscle			0.11 ± 0.04	5.7 ± 0.8	0.31 ± 0.04	16.4 ± 4.8
viscera			0.1 ± 0.08	28 ± 6	1.41 ± 0.46	55 ± 15
Portunus pelagicus	3	12–16				
muscle			0.25 ± 0.06	15 ± 4	0.71 ± 0.13	36 ± 17
viscera			2.1 ± 1.2	24 ± 5	1.3 ± 0.4	58 ± 14
Seagrasses/macroalgae						
Posidonia australis	6	30–35	0.6 ± 0.2	2.3 ± 0.3	2.1 ± 0.3	33 ± 4
Posidonia sanuosa	6	30–35	0.37 ± 0.21	1.9 ± 0.5	1.6 ± 0.4	38 ± 8
Ecklonia radiata	6	35–50	0.78 ± 0.07	3.8 ± 0.2	3.6 0.7	73 ± 12
Ulva (sp)	5	4–6	0.4 ± 0.02	1.5 ± 0.3	2 ± 0.5	24 ± 8

Cadmium concentrations are generally lower in fish than other organisms (see Tables V and VI). In this study no Cd was detected in any fish tissues (Table II). High concentrations of Cu were found in the crustaceans and the mollusc *Sepioteuthis australis* relative to other organisms, but some molluscs and crustaceans contain high

TABLE V

Trace metal concentrations in marine organisms from Australian coastal areas

Location/taxa	Tissue		Cd	Cu	Pb	Zn	Reference
			(μg g^{-1} dry wt)*				
Fish							
New South Wales Coast (NP)	Whole		0.05–0.5	0.5–14	0.5–20.5	2.5–120	Bebbington *et al.*, 1977
Derwent Estuary Tasmania (P)	Whole	<	0.25–53.5	1.25–45	–	20.5–733.5	Eustace, 1979
Cockburn Sound W.A. (P)	Muscle		0.1–2.9	0.2–29	0.8–22.2	6–404	Plaskett and Potter, 1979
Swan-Avon Estuary W.A. (NP)	Muscle		0–0.76	0.59–3.7	0.61–4.64	8.8–73.9	Marks *et al.*, 1980
St. Vincent Gulf S.A.	Muscle	<	0.025	0.51–1.3	0–0.051	15–35	This study
Molluscs							
Tasmanian Waters (MP)	Whole	<	10–99	105–620	–	2430–38350	Thrower and Eustace, 1973
Port Phillip Bay VIC (MP-P)	Whole		2–7.25	1–90.8	3.55–50.1	2–7.25	Phillips, 1976
	Whole		5.3–24.8	–	–	–	Talbot *et al.*, 1976a, b
Port Phillip Bay VIC (MP-P)	Muscle		–	–	1.3–17.8	–	
	Viscera		–	–	1.4–32.6	–	
Westernport Bay VIC (NP)	Whole		0.35–8.2	1.7–8.2	0.3–4.2	141–3051	Harris *et al.*, 1979
Cleveland Bay QLD (NP)	Whole		0.11–1.13	3.97–10.51	0.43–2.75	41.9–151.5	Klumpp and Burdon-Jones, 1982
Townsville Harbour QLD (P)	Whole		0.38–3	5–13.6	ND–10	55.7–179.6	Klumpp and Burdon-Jones, 1982
Cockburn Sound W.A. (P)	Whole		1.0–43.5	3.5–200.5	3.5–24	85–5950	Talbot and Chegwidden, 1982
South East Australia (NP)	Whole		1.15–4.7	5.15–24.6	1.85–32.35	63.65–352.8	Wootton and Lye, 1982
St. Vincent Gulf S.A.	Muscle	<	0.025–0.51	0.8–24	0.52–0.96	36–60	This study
	Viscera	<	0.025–1.93	2.7–91	0.56–2.1	30–101	
Crustaceans							
Western Port Bay VIC (NP)	Whole		0–0.8	30–334	0.4–9	61–225	Absanullah *et al.*, 1980

TABLE V (continued)

Location/taxa	Tissue	Cd	Cu	Pb	Zn	Reference
		($\mu g\ g^{-1}$ dry wt)*				
Cockburn Sound W.A. (P)	Muscle	0.5–7.5	6.5–50.5	1–15	43–161	Talbot and Chegwidden, 1982
	Hepatopancreas	13–341	20.5–567.5	1.5–50	110–1280	
St. Vincent Gulf S.A.	Muscle	0.1–0.5	5.7–15	0.31–6.7	16.4–36	This study
	Viscera	0.1–2.1	24–28	1.3–1.41	55–58	
Macroalgae/seagrasses						
Western Port Bay VIC (NP)		0.03–0.49	1.3–10.6	0.9–8.4	18–67	Harris *et al.*, 1979
Cockburn Sound W.A. (P)		0.2–1.6	0.6–9.3	0.2–1.7	24.7–169.4	Talbot and Chegwidden, 1982
St. Vincent Gulf S.A.		0.1–0.78	1.5–3.8	0.2–3.6	24–73	This study

(NP) non-polluted.
(MP) medium polluted.
(P) polluted.
(ND) non detectable.
* wet weight values converted to dry weight values assuming 80% moisture.

TABLE VI

Geometric mean found in different taxa from overseas areas (Bryan, 1976)

Taxa	Cd	Cu	Pb	Zn
	($\mu g\ g^{-1}$ dry wt)			
Fish	0.2	3	3	80
Molluscs				
Bivalves	2	10	5	100
Cephalopods	5	130	3	250
Crustaceans	1	70	1	80
Seaweeds	0.5	15	4	90

Cu concentrations under natural conditions due to storage of Cu in proteins (Scott and Major, 1972) and the presence of haemocyanin in blood (Brooks and Rumsby, 1965; Bryan, 1976).

Lead is not accumulated by organisms in uncontaminated areas, molluscs usually containing the highest Pb concentrations (Bryan, 1976). In this study all organisms had low Pb concentrations with molluscs and crustaceans having similar Pb levels and fish containing significantly ($P > 0.99$) lower Pb concentrations.

The tissues contained appreciable quantities of Zn. The levels of Zn were low compared to those in organisms from polluted areas (Table V) and the presence of zinc is attributed to functional reasons rather than pollutant sources.

The Food Standards Committee (Anon 1984) of the Australian National Health and Medical Research Council (ANHMRC) has recommended levels that Cd, Cu, Pb and Zn in fish and shellfish should not exceed (Table VII). If it is assumed that organisms contained 80% moisture none of the ANHMRC recommended standard values are exceeded.

TABLE VII

ANHMRC recommended levels for Cd, Cu, Pb and Zn in fish and shellfish (Anon, 1984).

Taxa	Cd	Cu	Pb	Zn
	(μg g^{-1} wet wt)			
Fish	0.2	10	1.5	150
Molluscs	2.0	70	2.0	1000
Crustaceans	0.05	10	1.5	150

3.2. Tissue trace metal concentrations

Besides differences between trace metal concentrations in organisms, differences in trace metal concentrations occurred between tissues.

Fish had higher trace metal concentrations in liver and gill tissues relative to muscle tissues (Table II); liver and gill tissue containing approximately the same concentrations of metals. Molluscs and crustaceans contained higher trace metal concentrations in viscera relative to muscle tissues (Tables III and IV). These results were expected as livers are the major storage site of metals in fish, while viscera (gills, hepatopancreas) is the major storage site of metals in molluscs and crustaceans (Bryan, 1976; Fowler, 1982).

4. Conclusion

Comparison of trace metal valves with those measured in other areas of Australia known to be subject to urban and industrial influences revealed that trace metal concentrations are close to lower values indicating no widespread measurable trace metal pollution in St. Vincent Gulf. Further investigation of trace metal concentrations in sessile marine organisms near known anthropogenic inputs needs to be undertaken to fully assess the effects of point sources.

References

Anon. 1984, *Metals and Contaminants in Food*, National Health and Medical Research Council, Can Serra. Paper AIZ.

Absanullah, M., Negilski, D. S. and Tawfik, F.: 1980, *Aust. J. Mar. Freshwater Res.* **31**, 847.

Bebbington, G. N., MacKay, N. J., Chvojka, R., Williams, R. J., Dunn, A., and Auty, E. H.: 1977, *Aust. J. Mar. Freshwater Res.* **28**, 277.

Brooks, R. R. and Rumsby, M. G.: 1965, *Limnol. and Oceanog.* **10**, 521.

Bryan, G. W.: 1976, 'Heavy Metal Contamination in the Sea', *Marine Pollution*, in Johnston, R. (ed), Academic Press, pp 214-228.
Eustace, I. J.: 1979, *Aust. J. Mar. Freshwater Res.* **25**, 209.
Harris, J. E., Fabris, G. J., Statham, P. J., and Tawfik, F.: 1979, *Aust. J. Mar. Freshwater Res.* **30**, 159.
Klumpp, D. W. and Burdon-Jones, C.: 1982, *Aust. J. Mar. Freshwater Res.* **33**, 285.
Marks, P. J., Plaskett, D., Potter, I. C., and Bradley, J. S.: 1980, *Aust. J. Mar. Freshwater Res.* **31**, 783.
Plaskett, D. and Potter, I. C.: 1979, *Austr. J. Mar. Freshwater Res.* **30**, 607.
Phillips, D. H.: 1976, *Mar. Biol.* **38**, 71.
Scott, D. M. and Major, C. W.: 1972, *Biol. Bull. Mar. Biol. Lab., Woods Hole* **143**, 679.
Talbot, V., Magee, R. J., and Hussain, M.: 1976a, *Mar. Pollut. Bull.* **7**, 84.
Talbot, V., Magee, R. J., and Hussain, M.: 1976b, *Mar. Pollut. Bull.* **7**, 234.
Talbot, V. and Chegwidden, A.: 1982, *Aust. J. Mar. Freshwater Res.* **33**, 779.
Thrower, S. J. and Eustace, I. J.: 1973, *Aust. Fisheries* **32**, 7.
Wootton, M. and Lye, A. K.: 1982, *Aust. J. Mar. Freshwater Res.* **33**, 363.