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Trace Metals in Gills of Fish from the Arabian Gulf

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Complexation of metals by coordinate linkages with appropriate organic molecules in biological tissues is an important process involved in metal accumulation by aquatic organisms (Wong et al. 1978). Fish respiratory systems differ from all other systems because damage to gills has immediate impacts on the rest of the fish's body (Satchell 1984). Veer et al. (1990) observed significant correlation between gill-metal concentration and whole-body weight. More nickel is accumulated in gill tissue of the catfish (*Clarias batrachus*) than in the liver or intestine (Ray et al. 1990). More cadmium is accumulated in gill tissue of the fish *Heteropneustes fossilis* (Bloch) and *Channa punctatus* (Bloch) than in the liver or kidney (Gupta 1988). When exposed to lethal and sublethal concentrations of copper, gills of the freshwater fish *Labeo rohita* (Hamilton) showed the highest degree of copper accumulation (Radhakrishnaiah 1988).

Petroleum and petrochemical industry wastes contribute significantly to metal enrichment of the Arabian Gulf marine environment (Sadiq and Zaidi 1985). Because accumulation of metal ions is significant in gills, levels of Cd, Cr, Cu, Ni and Pb were investigated in gills of fish from potentially impacted areas along the western side of the Arabian Gulf after the 1991 oil-spill.

MATERIALS AND METHODS

The NOAA-R/V Mt. Mitchell scientific cruise was designed to investigate impacts of the 1991 oil-spill on the marine environment of the Arabian Gulf. Fish were sampled both by hook and line and trawling

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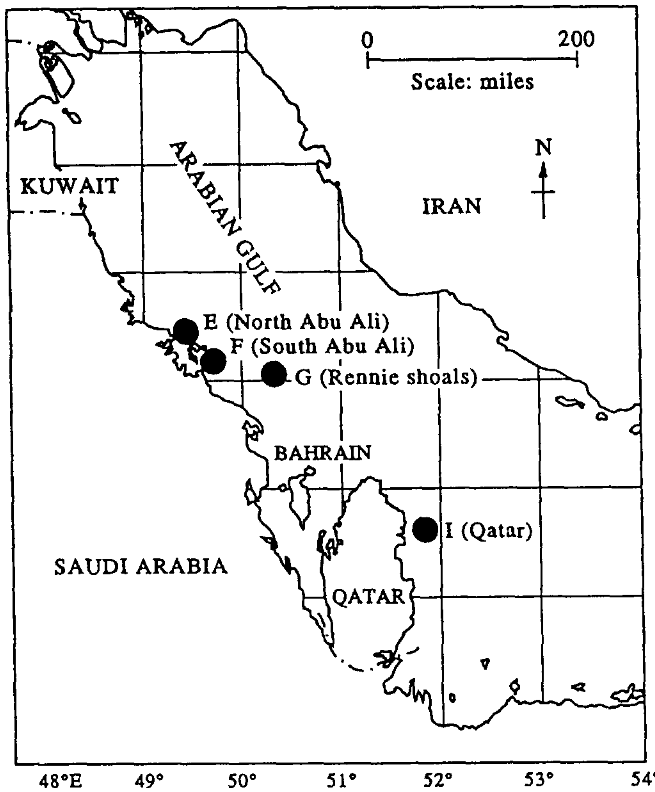

Figure 1. Fish sampling locations (●) in the Arabian Gulf.

during April 1992 on Leg IV of the cruise. After capture, the fish were classified and weighed. Gills of individuals were dissected on board and collected separately in clean plastic bags, sealed and kept frozen at -20 ^{o}C until analysis in the laboratory. Based upon the availability of species type, number and size of collected fishes, samples to be analyzed were selected from four sampling stations: north Abu Ali, south Abu Ali, Rennie Shoals and Qatar (Fig 1). Five metals were investigated: Cd, Cr, Cu, Ni and Pb.

The metal concentrations were determined according to the method developed and varified (using tuna fish, bovine liver and oyster tissue standard reference materials from the National Bureau of Standards, Washington DC) by Denton and Burdon-Jones (1986). The samples were thawed at room temperature and dried at 65 ^{o}C to a constant weight. Before use, glassware was cleaned by refluxing with hot nitric acid and thoroughly rinsed with double distilled water. A known amount of dried sample was weighed into a 100-ml Pyrex Erlenmeyer flask. The flask was loosely capped with a Teflon stopper and the sample was digested with 10 ml of silica-glass distilled nitric acid at 110-135 °C. After 2 days, the solution was evaporated to dryness and digestion was completed by adding 2 ml of a 1:1 mixture of nitric and perchloric acids. The residue remaining in the flask was dissolved in 2 N nitric acid and analyzed by flame atomic absorption spectrometry. The concentrations were determined from the standard addition calibration curve [μg metal/g sample (dry weight) = A x V / D, where A is concentration of metal in processed sample from calibration curve (mg/ml), V is final volume of the processed sample (ml) and D is dry weight of the sample (g)]. The recovery of metals was calculated on the basis of recovery of used standards. Recovery ranges were 80-94%, 75-86%, 75-90%, 79-98% and 78-93% for Cd, Cr, Cu, Ni and Pb respectively. The influence of total body weight on gill metal concentration was studied using linear regression analysis.

RESULTS AND DISCUSSION

Average and standard deviation of metal concentrations (μg/g dry weight) in fish gills, for the four stations, are shown in Table 1. The average metal concentrations decreased in the order Pb (6.25 - 11.37 μg/g) > Cr (5.50 - 7.55 μg/g) > Cu (3.34 - 4.14 μg/g) > Cd (0.80 - 1.53 μg/g) > Ni (0.20 - 0.47 μg/g). The highest average concentration of Cd was observed from the Qatar station whereas the highest average concentrations of Cr, Pb and Ni were observed in fish from north Abu Ali, south Abu Ali and Rennie Shoals, respectively.

Compared with Pb, Cr and Cu, the low concentrations of Ni and Cd may indicate low affinity of gill tissues for both metals. The low binding affinity of gills for Cd in rainbow trout (*Oncorhynchus mykiss*) was confirmed by Reid and McDonald (1991). Because gill-metal concentrations increase with increasing metal concentrations in seawater (Roesijadi and Klerks 1989), the lower levels of Ni and Cd in fish gills may indicate that the water column contains lower Ni and Cd contamination than Pb, Cr and Cu. The high Ni concentrations in marine sediments observed by these investigators and the low Ni concentrations in the gills may indicate that (1) Ni is introduced to the Gulf marine environment associated mainly with the chronic inputs of

Table 1. Average and standard deviation of metal concentrations (µg/g dry weight) in gills of fish from studied locations.

		N. Abu Ali N=8	S. Abu Ali N=15	Rennie Shoals N=13	Qatar N=16
Cd					
	Average	0.94	1.17	0.80	1.53
	S.D.	0.15	0.36	0.44	0.81
Cr					
	Average	7.55	6.61	5.83	5.50
	S.D.	0.78	2.35	1.67	1.15
Cu					
	Average	3.40	4.14	3.84	3.34
	S.D.	0.49	3.21	4.46	1.05
Ni					
	Average	0.24	0.23	0.47	0.20
	S.D.	0.15	0.10	1.00	0.16
Pb					
	Average	10.42	11.37	6.25	11.36
	S.D.	1.37	2.97	2.93	2.39

oil pollution to marine sediments or (2) marine sediments have higher affinity for Ni than gills.

Because of the similarity in concentration patterns (Fig 2), the effect of body weight on trace metal concentrations of Cd, Cr, Cu, Ni and Pb in the gill of sheiry (*Lethrinus kallopterus*), the most abundant among the captured fish, was studied. Linear regressions describing the relationship between body weight and gill trace metal concentrations were calculated by the following equation [$\log_{10}$ (gill metal concentration) = b $\log_{10}$ (total body weight) + log a] (Wu et al. 1984). Fig 3a-e shows that the regression coefficient, b, was <1 for Cd, Cu, Ni, and Pb and >1 for Cr. The correlation coefficient decreased in the order Cu > Pb > Cd > Ni > Cr. Differences in the regression coefficients of these relationships among aquatic organisms were confirmed by Romeo and Gnassia-Barelli (1988). Their results showed that the regression coefficient was <1 for Cu, Fe, Mn and Zn and >1 for Cd.

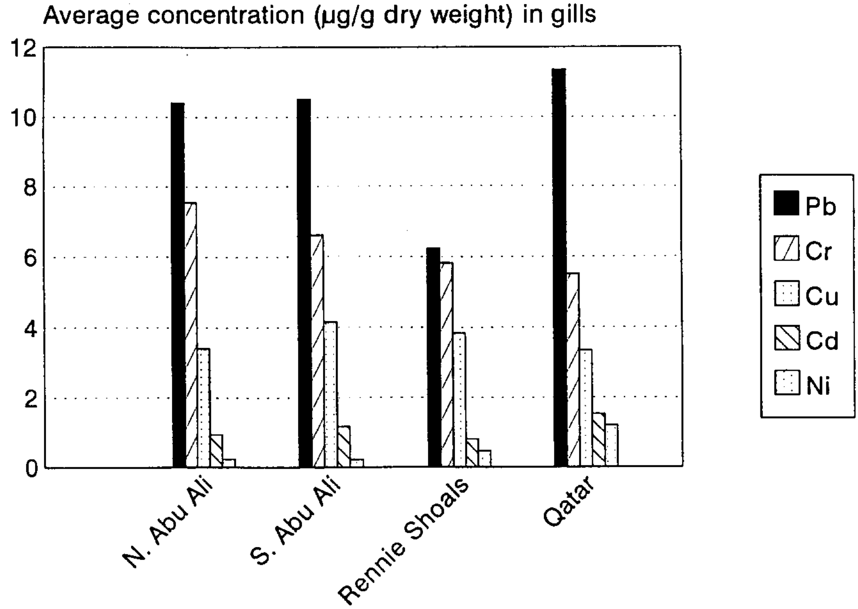

Figure 2. Average metal concentrations (µg/g dry weight) in gills of fish from studied locations

It is concluded that, although the investigated locations receive different contributions of metal contamination, the patterns of relative abundance of metals in fish gills remain unchanged. The similar patterns of trace metal abundance in the gills could indicate similarity in relative abundance of metals recieved by waters of the Arabian Gulf based on the following: (1) The gill is a principal tissue for concentrating trace metals (Wu et al. 1986), (2) the direct contact between gills and dissolved pollutants, (3) the relationship between fish body weight and gill metal concentration characterizing the accumulation of different metals, (4) the large surface area of gills that act as a barrier between the internal and external environment of marine organisms (Zatta 1985), and (5) differences in gill binding affinity for metals.

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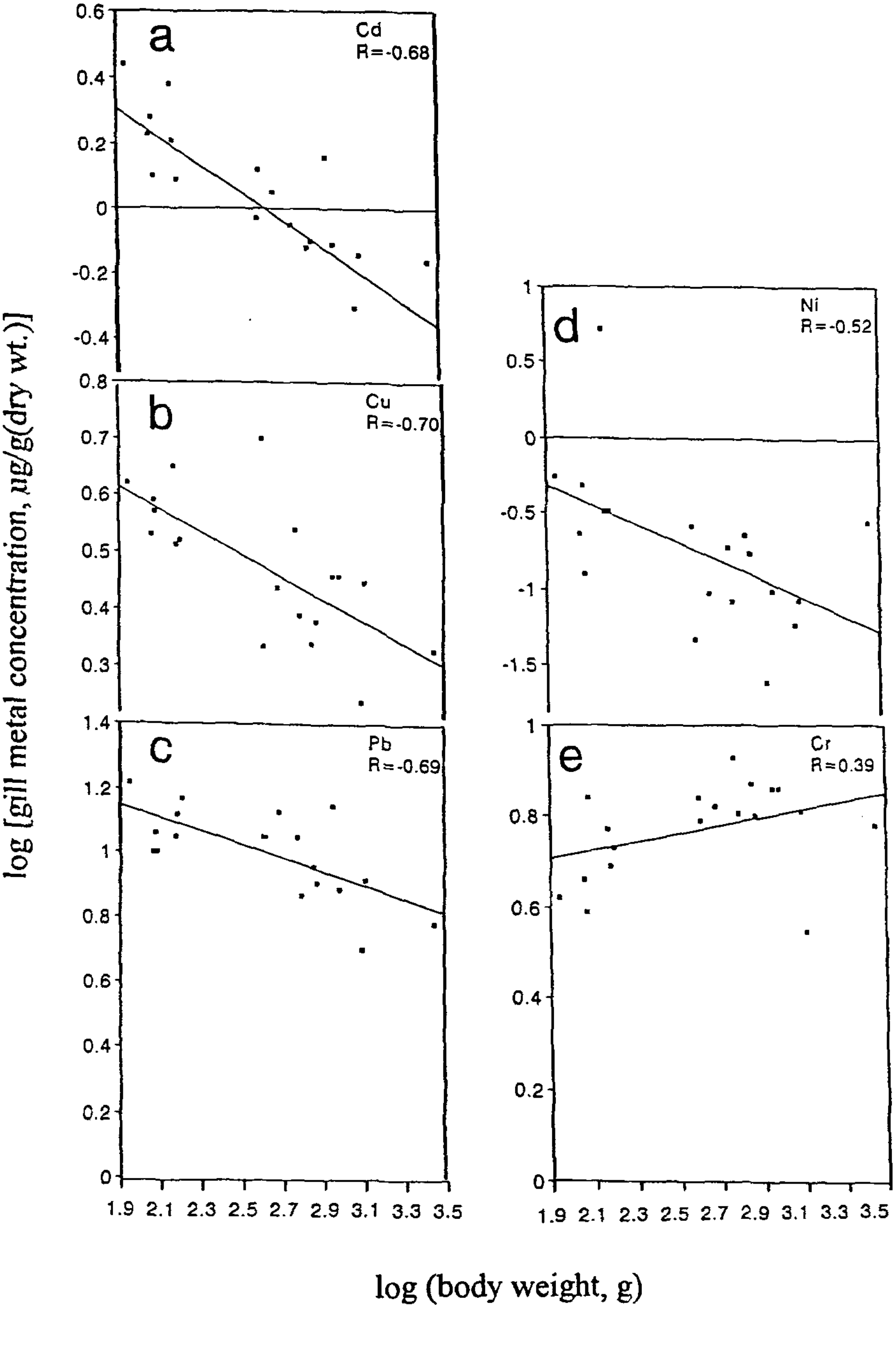

Figure 3. Influence of fish body weight on gill metal concentration.

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