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METALS IN SCALLOPS

Los Angeles County's submarine discharge of municipal wastewater off the Palos Verdes Peninsula is the single largest man-related source of trace metals to the marine ecosystem off southern California. The 1974 annual mass emission rates of chromium, copper, and zinc via this discharge were approximately 400, 300, and 850 metric tons, respectively (roughly ten times the corresponding inputs measured in 1971-72 surface runoff from southern California). As a result, bottom sediments around this submarine outfall system are highly contaminated by a number of trace metals. Here we report abnormal levels of seven metals in three tissues of filter-feeding rock scallops (*Hinites multirugosus*) that were collected in the discharge zone and thus had been exposed to suspended wastewater particulates. (The adductor muscle of this bivalve mollusc is considered to be a delicacy, and the scallops near the discharge area sought by sport divers.)

PROCEDURES

During 1974, divers collected eight scallops 5 to 10 cm in diameter from depths of about 20 m at three stations between Whites Point and Point Vicente, less than 1 km off Palos Verdes Peninsula; six scallops also were taken from control stations at similar depths off Santa Catalina and Santa Barbara Islands. The samples were frozen in plastic bags upon collection. Later, digestive gland, gonad, and adductor muscle tissues were excised from each specimen before it was fully thawed, using a new carbon steel scaple and a cleaned teflon sheet; the tissues were placed in cleaned polyethylene vials. Care was taken to avoid contaminating the gonadal or muscle tissue samples with sediments or juices from the digestive glands.

After net weight was determined, each tissue sample was digested in 10 ml of a 1:1 dilution of nitric acid solution (ultrahigh-purity reagent grade) until the remaining volume was about 3 ml. This procedure was repeated once, and the final residue was filtered through an acid-washed Whatman No. 40 filter. The filtrate was then diluted to an appropriate volume, and the treated sample was analyzed by atomic absorption spectrometry. Silver, chromium, copper, nickel, and lead were measured by injecting 2.5 pi of sample into a graphite furnace; cadmium and zinc levels were determined by aspirating the sample into an air-acetylene flame.

Process blanks were analyzed with all samples. Typical blank corrections were less than 10 percent of the gross concentrations observed, except for chromium, nickel, and zinc in adductor muscle, where the blank corrections were 15 to 20 percent of the gross concentrations. To test recovery efficiency, residues of the digestion process were redigested following the same procedure used initially but using only 5 ml of 1:1 nitric acid solution; levels measured in the residue generally were less than 5 percent of the concentrations found in the first digestion.

RESULTS AND DISCUSSION

Table 1 presents median and mean concentrations of seven metals in the tissues of the eight scallops from the outfall area and the six specimens from the island control stations. The estimated 95 percent confidence limits of the means, assuming normal distributions, are also given. A comparison of the medians and means (which have an average ratio of 0.93 ± 0.07 at the 95 percent confidence limit) suggests that the distributions of concentrations of most metals are not highly skewed. Therefore, for each metal, we have calculated the ratio of the mean concentration for outfall and control samples; 'these "contamination ratios" are listed in Table 2.

It seems clear from these data that, during 1974, purplehinged rock scallops living inshore of the JWPCP discharge were accumulating trace metals above normal levels: Sixteen of the 19 contamination ratios are greater than 1.0. The ratios for chromium are the largest (19, 6.7 and 7.0 for digestive gland, gonad, and adductor muscle, respectively), and the 95 percent confidence limits listed in Table 1 indicate that these differences are statistically significant.

In our past studies with molluscan bioindicators, we have generally used digestive gland concentrations to locate possible metals contamination because concentrations are usually higher in this tissue than in the gonad or adductor muscle. However, these values may not be representative of the degree to which metals are actually incorporated into the body tissues, because the digestive gland sample may contain ingested particulates contaminated by metals that are not biologically available. Therefore, the gonad and muscle contamination ratios found in this study are of special interest. Eleven of the twelve values exceed 1.0, and for each of the six metals measured (lead was undetectable in these tissues), at least one of the two ratios is greater than 2.0.

As shown in Table 1, the mean concentration of lead in the digestive gland of the outfall scallops was 13 ppm, 650 times the mean concentration measured in the gonad and 1,300 times higher than the mean for muscle tissue. These results indicate that, to the first order, elevated concentrations measured in the gonad and muscle tissues were not caused by contamination from the digestive glands during dissection. Thus, rock scallops exposed to municipal wastewater discharges do appear to be capable of physiologically incorporating at least six potentially toxic trace metals in their gonadal or muscle tissue to levels at least twice normal concentrations.

The mean and median values for cadmium in the digestive gland and gonads of the Palos Verdes specimens were lower than those for the island controls (Table 1). We made similar observations in previous studies of metals in flatfish taken by trawl from the two areas. Liver tissue from Dover sole (Micros tomus pac-ificus) known by their high DDT levels and high incidence of fin erosion disease to have inhabited the highly contaminated sediments had significantly lower concentrations of cadmium than did the livers of island control specimens; the outfall-to-control ratio was 0.33 (de Goeij et al. 1974). Analyses of subsequent collections using a different laboratory and analytical technique confirmed this observation, yielding an outfall-to-control ratio of 0.59 (McDermott et al. 1976). In addition, analyses of the digestive glands of intertidal mussels we collected at the base of the Palos Verdes outfalls and at island control stations during 1971 yielded an outfall-to-control ratio for cadmium of 0.81 (Coastal Water Research Project 1973).

The relatively low cadmium levels often found in some tissues of organisms living around the Palos Verdes outfalls may be related to the high levels of DDT residues that have accumulated there from past wastewater discharges. Concentrations of total DDT in sediments, mussels, and flatfish from the region are 100 to 1,000 times those measured in samples from island control areas (Coastal Water Research Project 1973). Recently, Nimmo and Bahner (in press) have reported that exposure of a penaeid shrimp to methoxychlor (a chlorinated pesticide somewhat similar to DDT) appeared to depress the muscle tissue concentrations of cadmium in this organism. It is possible that animals off Palos Verdes are showing a similar effect.

CONCLUSIONS

Although the results of this study point to a potential problem from waste metals discharged via municipal outfalls, we do not yet know the degree to which these elevated metals levels affect the rock scallop or its predators (including man). Standards for these metals in seafood have not yet been established. As with other classes of chemical contaminants (such as chlorinated hydrocarbon and petroleum residues), toxicity information that relates abnormal tissue concentrations with adverse biological effects is needed. Results from field studies such as those reported here are a necessary first step in conducting relevant toxicity tests.

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Table 1. Trace metal concentrations (mg/wet kg) in tissues of the scallop *Hinites multrugosus* collected during 1974 from the Palos Verdes outfall zone and from island control stations.*

	Digestive Gland		Gonad		Adductor Muscle	
	Outfall	Control	Outfall	Control	Outfall	Control
Silver						
Median	2.3	0.26	0.075	0.015	0.022	0.006
Mean	2.3	0.31	0.080	0.018	0.026	0.008
± 95% CL**	1.2	0.17	0.031	0.017	0.018	0.008
Cadmium						
Median	490	600	2.4	4.1	0.92	0.33
Mean	520	540	2.6	5.4	0.95	0.34
± 95% CL	210	150	1.0	5.9	0.26	0.07
Chromium						
Median	48	2.2	2.2	0.38	0.31	≤0.03
Mean	41	2.2	2.6	0.39	0.35	0.05
± 95% CL	19	1.2	0.73	0.13	0.12	0.06
Copper						
Median	170	48	3.3	1.9	0.29	0.11
Mean	190	64	3.2	2.2	0.41	0.16
± 95% CL	95	42	0.53	1.3	0.25	0.11
Nickel						
Median	1.3	1.4	0.30	0.15	0.22	0.10
Mean	1.3	1.5	0.72	0.26	0.22	0.12
± 95% CL	0.55	0.28	0.73	0.27	0.10	0.13
Lead						
Median	14	5.1	<0.02	<0.02	<0.01	<0.01
Mean	13	4.4	<0.02	<0.02	<0.01	<0.01
± 95% CL	7.3	3.7	–	–	–	–
Zinc						
Median	120	90	48	10	24	22
Mean	130	100	46	20	25	22
± 95% CL	35	46	15	18	3.8	1.8

*Values based on analyses of 8 scallops from the outfall area and 6 from the island stations.

**Confidence limit.

Table 2. "Contamination rations" (outfall-to-control region ratios of mean metal concentrations) for seven metals in three scallop tissues.

Metal	Digestive Gland	Gonad	Adductor Muscle
Silver	7.4	4.4	3.2
Cadmium	0.93	0.48	2.8
Chromium	19	6.7	7.0
Copper	3.0	1.4	2.6
Nickel	0.87	2.8	1.8
Lead	3.0	—	—
Zinc	1.3	2.3	1.1