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Assessment of Sediment Toxicity in San Vicente Bay, Central Chile, Using the Amphipod *Ampelisca araucana*

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The region around the Biobio river mouth, located in central Chile, has been described as the most polluted coastal zone in the country. Pollution comes as a consequence of intense port activities and constant raw sewage discharges of domestic and industrial origin (Ahumada and Rudolph 1989, Ahumada et al. 1989, Chuecas 1989). The San Vicente bay, located north of the Biobio river mouth, harbors a port on its north side and has several points of discharge of industrial and domestic effluents (Ahumada 1992, see Fig. 1). It has been shown that the water column surrounding the San Vicente port (Fig. 1) is enriched with organic matter and metal toxicants well above natural levels (Ahumada 1992). Test water from two localities near the port reduces fertilization of the sea urchin *Arbacia spatuligera,* while in other six localities there is only slight difference, or none at all, with a control, nonpolluted site at Coliumo Bay, 31 km to the north of San Vicente bay (Riveros et al. 1996). Ahumada (1992) also found accumulation of metal toxicants in sediments from the port area, and a general scarcity of infaunal organisms. However, the status of the sedimentary habitat within the bay by means of experimental toxicity test has not been assessed. To fill in this gap, we performed acute toxicity test with the amphipod *Ampelisca araucana.* Amphipods of this species are common inhabitants of sedimentary habitats in central Chile (Gonzalez 1991) and this is the first time in with they are used for bioassay testing of Chilean costal sediments. Thus this work will also provide the experimental basis for a more general use of the test in other regions of the country.

MATERIALS AND METHODS

Samples of sediment were taken in March and April 1996 from two localities in San Vicente bay, separated by 3.8 km (Fig. 1). The water column from the San Vicente port (SVp) site was described as highly polluted from sea urchin fertilization tests, while the water column from Lenga Beach (LB) was found nonpolluted (Riveros et al. 1996). The SVp site was sampled at three sites between 5 and 1200 m from the shore,

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while the LB site was sampled at two sites between 250 and 500 m from the shore. Samples of sediment were taken with a Smith-McIntire dredge (0.027 m^2 mouth area), and transported to the laboratory at 4°C for its use in the bioassays. The physico-chemical characteristics of the bottom water (S, T°, pH and oxygen concentration by Winkler tritation) and of the sediments (granulometric composition and organic matter content by calcination and gravimetric difference) were measured. A third sample of sediments, which served as control, was taken from a nonpolluted site at Coliumo Bay (CB), 31 km to the north of San Vicente bay (Fig. 1).

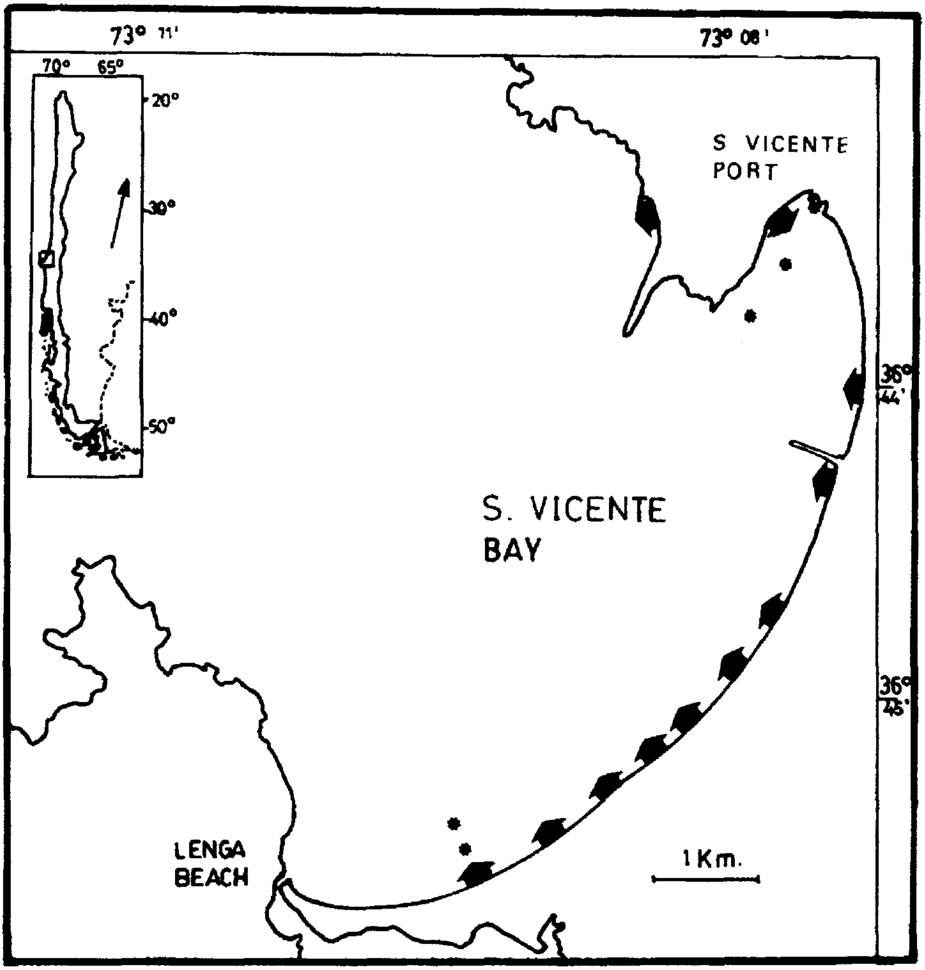

Figure 1. Lenga Beach (lower asterisks) and San Vicente port (upper asterisks) sampling sites and points of discharge (arrows) in San Vicente Bay, central Chile.

Amphipods were collected from the CB site using the same dredge as before and separated from the sediment using a 500 µm sieve. In the laboratory, organisms were kept in tanks with constant aeration at a temperature of 13°C, and were fed regularly with *Dunaliella tertiolecta* and *Isochtysis galbana.*

About 300 g (wet weight) of sediments from the CB, LB and SVp localities were used in the bioassays. These were performed in plastic chambers (18 x 7 x 11 cm) with 0.6 l of water, where the sediment occupied 1 cm in the bottom. All procedures were performed at ambient temperature (-15°C). The experimental unit consisted of a group of 10 adult amphipods ca. 6 mm long each. There were 8 replicates for each locality, and treatments were allocated at random among the experimental units. The organisms were exposed to the three types of sediments (treatments) during 10 days, without aeration or food. Time between collection of sediments and amphipods and initiation of the experiments did not exceed one week. The response variable was proportion of survival after the 10-day period.

The water used for both SVp and LB sites was taken from the nonpolluted CB site. Thus, the effect of sediment was isolated from the effect of the water above. This separation between compartments implied a elimination in the toxicant flux from water to sediments, and observation of subsequent survival by the amphipods.

The data on percent survival in each experimental unit was transformed using the angular transformation ($y=\sin^{-1}\sqrt{x}$) previous to the analysis, to normalize and reduce variances. Results of the experiments were analysed using one-way ANOVA and Dunnet's *a posteriori* test with the software TOXSTAT (Gulley et al. , 1988).

RESULTS AND DISCUSSION

The water sampled in the three sites was comparable in salinity and temperature, although the Lenga Beach (LB) site was more oxygenated than the San Vicente port (SVp) and the control Coliumo Bay (CB) sites (Fig. 2). Sediment from the LB site was clearly different from control (CB) sediment in both granulometric composition and organic matter load, while the sediment from the SVp site appeared to be similar to the control site (Fig. 1). Therefore, in terms of both sediment and water characteristics, the SVp site was closer to the control CB site than the the LB site.

The experiments yielded a close similarity in mean survival of amphipods in the sediments from the LB site and the control CB site, while a much lower survival in the sediments from the SVp site was found (Fig. 3). The ANOVA indicated the presence of significant differences in survival of amphipods in sediments from the control CB site and the treatment sites LB and SVp ($F_{2,25}=3.625$, $p<0.05$). The *a posteriori* comparison of treatment sites against control indicated that the LB site did not differ from the control CB site (minimum significant difference=0.270, difference from control=0.079, p>0.05) while it indicated a significant difference between the SVp and control CB site (minimum significant difference=0.246, difference from control=0.308, p<0.05).

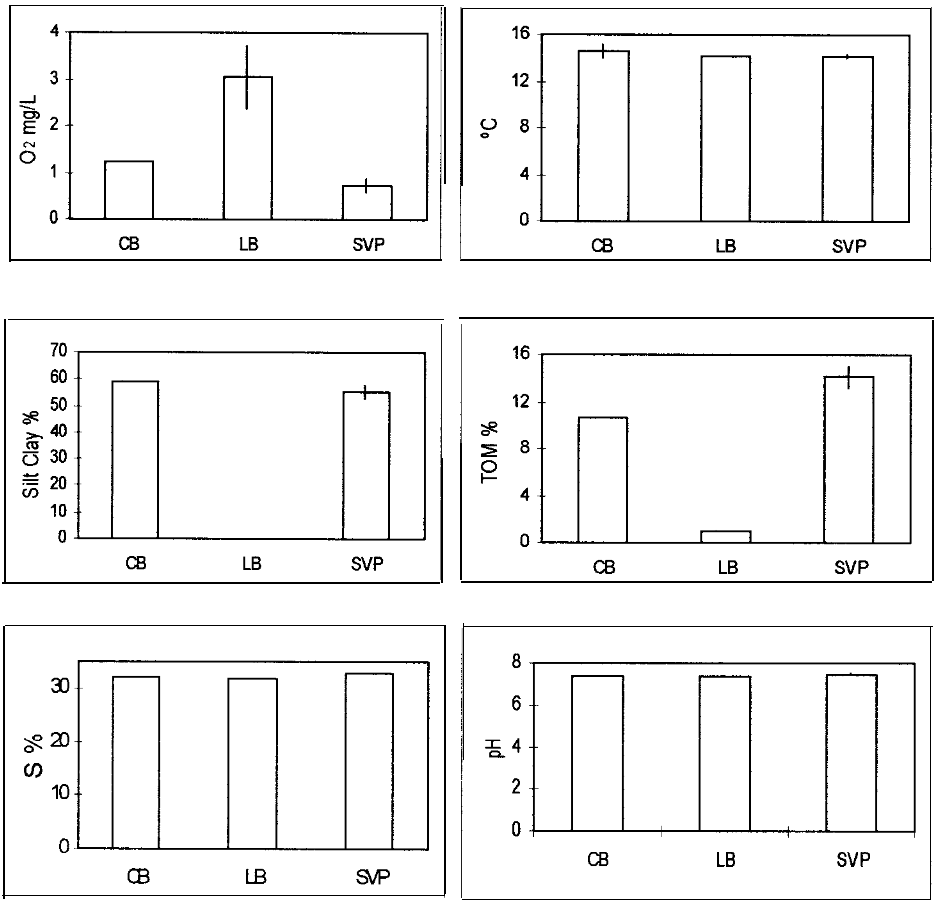

Figure 2. Mean physico-chemical conditions (oxigen concentration, temperature, grain size, total organic matter, salinity and pH) at the Lenga Beach (LB) and San Vicente port (SVP) sampling sites, and at the control (CB) unpolluted site. Bars indicate standard error.

The sedimentary habitat of the San Vicente port (SVp) area in central Chile allows lower survival of amphipods than a nonpolluted control site at Coliumo Bay (CB) and a second test site within the San Vicente bay, the Lenga Beach (LB) site. This lower survival may be due to higher toxicant load or to other features of the SVp sediments. However, our data show that sediments from the SVp site are in fact more similar to the nonpolluted control CB site than the other test site sampled within the San Vicente bay (LB site),in terms of oxygen concentration, granulometric composition, and total organic matter load, while the three sites are almost identical in salinity and temperature. Given that (1) the water column is polluted at the SVp site (Riveros et al. 1996) (2) that sediments are contamined by metals due to human activity (Ahumada 1992) (Cu, Cd, Ni, Cr, Pb y Zn), and that (3) amphipods have been shown to be sensitive to organic and inorganic compounds (Kemp and Swartz 1988, DeWitt et al. 1989, Di Toro et al.1990), pollution appears as the most likely cause for the lower survival of amphipods in sediments from the San Vicente port area. This result extends

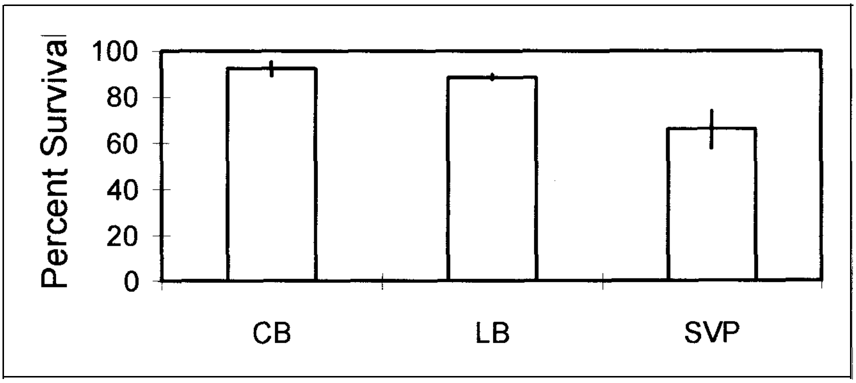

Figure 3. Mean survival of amphipods at the Lenga Beach (LB) and San Vicente por (SVP) sampling sites, and at the control (CB) unpolluted site. Bars indicate standard error.

the polluted status of the water column in San Vicente port to its sedimentary habitat. Moreover, in the field, the toxicant influx is permanent (Ahumada and Rudolph 1989, Ahumada et al. 1989, Chuecas 1989). Thus we would expect the difference from nonpolluted sites to be greater than what we observed in the laboratory, where the influx of toxicants was cut during the experimental period. In San Vicente Bay, pollution as tested from sea-urchin egg fertilization tests (Riveros et al. 1996) and acute amphipod bioassays (Fig. 3), seems to be restricted to the northern port area. The port area then appears as the main source of pollution. The spread of pollution from this source area may be related to water circulation. Carro and Mennickent (1992) and Brito (1993) have described a circulation pattern in the bay that is coincident with the notion of a northwards transport of toxicants, away from San Vicente

Bay. As toxicants flowing through the water column may accumulate in sedimentary habitats (Stumm and Morgan 1981), the area north to the San Vicente Bay may be affected by pollution. This region needs to be studied to evaluate the spread of pollution from its source.

The assessment of toxicity status of coastal sediments is an important component of studies leading to understand the impact of human activities on nearshore marine environments. In this work we report the first experimental analysis of sediment toxicity in Chilean coastal regions by using the amphipod *A. Araucana.* We found the species to be appropriate for laboratory testing and sensitive to common sources of contamination. Furthermore, the species is distributed from the north to the central-south Chilean continental self (González, 1991). Therefore, our experimental procedures can be applied to other regions thus providing valuable evidence to assess the pollution status of sedimentary habitats.

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