

A survey of marine contamination from mining-related activities on Marinduque Island, Philippines: Porewater toxicity and chemistry

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The Island of Marinduque, Philippines, was the site of intensive copper mining activities for several decades. Environmental and health concerns were raised after a mine tailings spill from an open-pit copper mine, in 1996. In addition to the mine-tailings spill, environmental concerns existed due to acid-rock and metal-rich drainage into local rivers, and to two causeways constructed with mine tailings which extend into the marine environment in the vicinity of coral reefs. As part of a preliminary environmental assessment, potential adverse effects in the marine environment were analyzed through toxicity tests and chemical analyses of pore waters. Samples were collected *in situ* by vacuum applied through syringes attached to ground glass aquarium air stones. Sampling was conducted at sites potentially affected by the mine tailings spill or under potential influence of the two causeways, and three reference samples were collected in the marine reserve of Tres Reyes, out of the influence of mining activities. Toxicity tests analyzing sea urchin, *Arbacia punctulata*, fertilization and embryological development exhibited significant adverse effects in two samples collected near one of the mine tailings causeway. The most severe effects were observed in the two samples collected nearest to the Calancan Bay tailings causeway, with significant toxicity at a 25% porewater dilution at Station 2 and at a 50% porewater dilution at Station 3 (Fig. 1). Chemical analyses of the porewater samples exhibited elevated concentrations of several metals at the toxic stations, particularly Cd, Co, Cu, Ni, Pb and Zn at station 2, and Co, Ni and Zn at station 3 (Table 1).

Table 1. Measured dissolved concentrations of metals ($\mu\text{g/L}$) in pore waters from station 1 to 12, on the coast of Marinduque Island, Philippines.

Station	Cd	Co	Cu ¹	Ni	Pb	Zn
1	<0.2	<0.2	10	<1	<0.5	20
2	2	5	300	10	18	320
3	<0.2	3	10	6	0.7	100
4	<0.2	<0.2	10	<1	<0.5	10
5	<0.2	0.4	10	<1	<0.5	20
6	<0.2	0.5	10	1	<0.5	20
7	<0.2	0.8	20	<1	<0.5	30
8	<0.2	<0.2	30	<1	1	10
9	<0.2	<0.2	8	<1	<0.5	9
10	<0.2	<0.2	10	<1	<0.5	20
11	<0.2	0.4	10	1	<0.5	10
12	<0.2	0.4	10	<1	<0.5	20
Average conc. in seawater	0.1	0.003	0.1	0.48	0.001	0.39

¹A possible analytical interference with chloride in the waters may mean that copper concentrations in all but low-chloride samples 8 and 9 are too high by 1-10 $\mu\text{g/L}$.

The results obtained in the current study suggest that the area adjacent to the Calancan causeway is adversely affected by metals leaching into the marine environment from the mine tailings disposal. Visual observations at the sites also indicated biological degradation, with

only one species of small fish observed at station 2 and heavy siltation and smothered coral seen at station 3. Pore water from stations 4 and 5 (Fig. 1) was not toxic to sea urchin early life stages, but a large amount of silt covering corals was still observed at those sites, suggesting that although there was no evidence of biological degradation caused by chemical contamination, a physical impact might be caused by siltation due to erosion of fine particulate matter from land. This preliminary survey suggests that effects related to past mining activities are still evident and warrants a more comprehensive study to assess the severity and areal extent.

Figure 1. Map of Marinduque Island, showing porewater sampling stations and toxicity test results with *A. punctulata* fertilization and embryological development tests.

