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High-resolution rare earth and other trace metal records in Porites sp. coral in Nha Trang Bay (Viet Nam), western South China Sea: Impact of recent coastal development and human activities

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Massive corals with well defined annual growth bands have been widely used as a biomonitor of the marine environment. Environmental data deducted from coral skeletons has become valuable for sites where instrumental data are either not available, or records are short, discontinuous and poorly resolved. Nha Trang Bay, located in Central Vietnam, in the western region of the South China Sea, is such a site. Recent coastal development of Nha Trang city has raised public concern about the increasing pollution of the bay and the subsequent degradation of the coral reefs. To gain a better understanding of how recent anthropogenic activities have contributed to pollution and degradation of the coral reefs in Nha Trang Bay, this study used a Porites sp. coral, living on a reef in Nha Trang Bay, to reconstruct environmental data back to a point in time, prior to any major coastal development in Nha Trang city. Analysis of the coral enabled a fourteen year record of trace element data (rare earth and other trace elements) to be generated from 1995 onwards. Data shows that concentrations of trace elements in the coral increased as soon as the coastal development projects, e.g. road, port, and resort constructions, commenced at the end of 2000. From 2000 onwards, trace element patterns showed the development of four peaks with extremely high concentration, which are directly comparable to values found in Porites sp. corals from other highly polluted places reported elsewhere in the world. The timing of these peaks is coincident with the start of port and river dredging and dumping activities. Studies by other researchers of the chemistry of dredged materials collected at ports and riverbeds elsewhere in the world show that dredged materials from riverbed are typically enriched with trace metals. This is thought to be a result of their co-precipitation with suspended materials, which takes place in the mixing zone before entering the sea, with dredged material from port seabeds being typically contaminated by trace metals derived from port activities. Their leaching tests show that a major proportion of trace metals bound to dredged materials is released into solution, resulting in increased turbidity and decreasing pH. As demonstrated in our study, the pattern of rare earth elements departed from a typical sea-water-like pattern which is highly depleted in the light rare earth elements, to the shale-like pattern. Similarly, the Cerium anomaly, a proxy for a seawater redox conditions, has evolved from a more negative characteristic and temporally approached to less negative pattern relative to its neighbour elements ((La/Lu)N: $\sim$ 0.6 before 2000, but >1 after 2000). Thus the noted change in the characteristic pattern of rare earth elements appear to indicate that the sea-water of the Nha Trang bay developed an increase in turbidity and a decrease in pH with consequent depletion in oxygen levels when the dumping activities occurred. Such water condition can persist for a year after dredging and dumping activities. This suggests that these activities would have contributed to a recently reported degradation of water quality and the ecosystem, e.g. a decrease in the coverage of the coral reefs and a decreasing number of other marine organisms, in Nha Trang Bay.