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Systematic Review  
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## Regulatory values set to protect marine organisms from chemical pollutants do appear to protect corals, except for the metal copper and the pesticides 'diuron' and 'irgarol 1051'

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**Toxicity thresholds of 56 chemical pollutants for tropical reef-building corals were derived from experimental ecotoxicological studies from 181 articles. They were compared to regulatory values that are used to protect marine organisms in general, and which are calculated by extrapolating the results of toxicity tests that have generally been carried out on non-coral species. Overall, the regulatory values were found to be protective of corals for the chemicals assessed, except for copper and the pesticides 'diuron' and 'irgarol 1051'.**

### Why is this Evidence Synthesis Needed?

Tropical coral reefs provide important ecosystem services to millions of people, but 75% of these reefs are currently threatened by both climate change and local stressors, the latter including chemical pollution from poor land management, agriculture, and industry. While countries cannot solve the climate change problem alone, they can seek to reduce local stressors such as chemical pollution, which can exacerbate the effects of climate change on corals. To introduce effective chemical pollution regulation for coral reefs, policy makers and environmental managers need data on the chemical pollutants to which reefs are exposed and their impact. To provide evidence of impacts, we systematically reviewed experimental studies assessing the toxicity of chemical pollutants to tropical reef-building corals, which are the main engineer species of reef ecosystems. All categories of chemical pollutants were included except nutrients (i.e., pesticides, metals, hydrocarbons, ultraviolet filters, microplastics, pharmaceuticals, dispersants, detergents, nanoparticles). From the quantitative estimates of effects, we determined toxicity thresholds as the highest exposures tested at which no statistically significant adverse effects were observed, and we compared them to regulatory predicted no-effect concentrations for the protection of marine organisms, to assess whether these reference values are indeed protective of corals.

This Collaboration for Environmental Evidence Systematic Review compiles all the experimental studies evaluating the toxicity of chemical pollutants to tropical reef-building corals to calculate toxicity thresholds and to assess whether existing regulatory thresholds are protective of corals. The review summarizes evidence from 181 articles corresponding to 847 studies.

## Main Findings

### *What studies are included?*

This systematic review includes experimental studies assessing the toxicity of chemical pollutants to tropical reef-building corals. The effects of chemical exposures on corals from 847 studies corresponding to 181 articles published between 1971 to 2022 are synthesised. The most commonly studied coral species were fast-growing branching species, because they can be easily broken down into small nubbins, and therefore, can be easily used in experiments with multiple replication of chemical concentrations and sampling times.

### *What are the toxicity thresholds of chemical pollutants for tropical reef-building corals?*

From the quantitative estimates of effects of 2706 exposures, 105 toxicity thresholds are identified, corresponding to 56 chemicals or mixtures of chemicals, and covering six coral responses (coral mortality, growth, settlement, fertilisation, symbiont density (bleaching) and photosynthetic performance). No toxicity thresholds can be derived from the collected data for the categories microplastic, pharmaceutical and nanoparticle, mainly because there were fewer than five increasing exposures tested. The 105 toxicity thresholds have been derived from tests on 28 coral species, and more than half of the toxicity thresholds involve early life stages. The exposure durations associated with toxicity thresholds exposure concentrations are generally short (less than or equal to 24h). The existing studies thereby mainly address short-term, acute ecotoxicological effects of chemical pollutants, while corals in natural conditions may be exposed to continuous exposure. When toxicity thresholds were compared to reference values set for the protection of marine organisms by environmental agencies, the reference values appear to be protective of corals for all but three chemicals assessed: the metal copper and the pesticides 'diuron' and 'irgarol 1051'.

### **What are the Implications of the Review Findings?**

This systematic review provides an open-access database on the known ecotoxicological effects of chemical exposures on corals. It also provides key information to contextualise the results, such as the experimental conditions (experimental system, pH, temperature), the life stage of the tested species, or the effective (i.e., real) exposure concentration if measured. This database can assist managers in the ecological risk assessment of chemicals, by allowing easy determination of various ecotoxicological thresholds.

Several limitations of the toxicity tests synthesised were however noted, highlighting the urgent need for standardized toxicity tests for corals. In particular, effective concentrations exposure was not measured in over half of the studies. Furthermore, we recommend that most of the currently available data on coral toxicity should be replicated independently and extended to corals from less studied geographical regions and functional groups.



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Credit: NASA image created by Jesse Allen, using Landsat data provided by the United States Geological Survey

### **Synthesis Time Frame**

The review authors searched for studies published before January 3, 2022. This CEE Systematic Review was published in March 2023.

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