What evidence exists on the impacts of chemicals arising from human activity on tropical reef-building corals? A systematic map protocol

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Abstract

Background: Tropical coral reefs cover ca. 0.1% of the Earth's surface but host an outstanding biodiversity and provide important ecosystem services to millions of people living nearby. However, they are currently threatened by both local (e.g. nutrient enrichment and chemical pollution of coastal reefs, arising from poor land management, agriculture and industry) and global stressors (mainly seawater warming and acidification, i.e. climate change). Global and local stressors interact together in different ways, but the presence of one stressor often reduces the tolerance to additional stress. While global stressors cannot be halted by local actions, local stressors can be reduced through ecosystem management, therefore minimizing the impact of climate change on reefs. To inform decision-makers, we propose here to systematically map the evidence of impacts of chemicals arising from anthropogenic activities on tropical reef-building corals, which are the main engineer species of reef ecosystems. We aim to identify the combinations of chemical and coral responses that have attracted the most attention and for which evidence can be further summarized in a systematic review that will give practical information to decision-makers.

Methods: The systematic map will follow the Collaboration for Environmental Evidence Guidelines and Standards for Evidence Synthesis in Environmental Management. We will search the relevant literature using English terms combined in a tested search string in two publication databases (Web Of Science Core Collection and Scopus). The search string will combine terms describing the population (tropical reef-building corals) and the exposure (chemicals). We will supplement this literature with some more obtained through search engines, specialist websites, and through a call to local stakeholders. Titles, abstracts, and full-texts will then be successively screened using pre-defined eligibility criteria. A list of pre-defined variables will then be extracted from full-texts. Finally, a database of all studies included in the map with coded metadata will be produced. The evidence will be described in a map report with text, figures and tables, and a matrix showing the distribution and frequency of included study into types of exposure and types of outcomes will be computed to identify potential knowledge gaps and knowledge clusters.

Keywords: Contamination, Hermatypic, Nutrients, Pollution, Scleractinian

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Background

Tropical coral reefs cover ca. 0.1% of the Earth’s surface but they host an outstanding biodiversity [1] and provide important ecosystem services to millions of people living...
According to the type of pollution, the host, the symbiont on the subject (e.g. [22, 23]), they often tackled only one environmental stressors. While several reviews have focused and interactions among pollutants or with other environments is a vast subject, due to the many possible pollutants, damages [19–21]. The effect of water pollution on corals is very large (all chemicals and all types of coral response should be considered) the first step of this assignment is to produce a systematic map of the evidence. We will thus be able to identify the combinations of chemicals and coral responses that have been the most documented and for which evidence can be further summarized in a systematic review.

**Objective of the review**

**Primary question**

The primary question of this systematic map is: What evidence exists on the impacts of chemicals arising from human activities on tropical reef-building corals? The above primary question has the following key elements:

- **Population:** All tropical reef-building coral species (hermatypic scleractinian species, *Millepora* sp., *Heliopora* sp. and *Tubipora* sp.).
- **Exposure:** All natural, geogenic and synthetic chemicals coming from human activities.
Comparator: Population not exposed to chemicals; Population prior to chemical exposure; Population exposed to a different concentration of chemicals.

Outcomes: All outcomes related to tropical reef-building corals, from molecular level (e.g. gene expression, enzyme activities) to community level (e.g. coral cover, species richness) (Fig. 1).

Methods
The systematic map will follow the Collaboration for Environmental Evidence Guidelines and Standards for Evidence Synthesis in Environmental Management [29] and it conforms to ROSES reporting standards [30] (see Additional file 1).

Searching for articles
Search terms and languages
Searches will be performed using search terms exclusively in English language. The search with English search terms can however retrieve articles written in languages other than English, and articles written in English and French will be included (see section Eligibility criteria). The list of search terms is presented in the next section (see Search strings).

Search string
A scoping exercise in Web of Science Core Collection (WOS CC, see the institutional subscriptions used in section “Bibliographic databases”) database was conducted to build the search string, using terms describing population and terms describing exposure (Additional file 2). To describe exposure, a detailed list of all the chemicals is impossible to establish because of their large number—for example the European Inventory of existing commercial chemical substances (ENIECS) includes more than 100,000 chemicals [31]. We therefore adopted the following approach to capture all the chemicals that could have an impact on corals. We listed the terms according to four levels of increasing specificity: (i) generic terms (e.g. contamination, pollution, chemicals); (ii) pressures (e.g. sewage, runoff) and usages (e.g. consumer product, biocide); (iii) classes of chemicals (e.g. nutrient, metal, pesticide, cosmetic, detergent, microplastic, petroleum); and (iv) within some classes of chemicals (e.g. metal), specific chemicals identified based on expert knowledge and whose impacts have been particularly studied in tropical corals (e.g. nickel, copper). Finally, the best combination of search terms obtained (i.e. that gave the highest comprehensiveness and specificity) is described below (Web Of Science format):

\[ TS = (\text{coral}$\text{AND (contamin* OR pollut* OR toxicant$ OR chemical$ OR "industrial discharge" OR runoff OR... \text{AND...})}) \]

Fig. 1 Description of the outcomes of the primary question organized by biological levels. All outcomes related to tropical reef-building corals will be considered including but not restricted to those presented here
run-off OR sewage OR eutrophication OR effluent OR waste OR seawater OR waste-water OR "shipping" OR biocide OR "industrial product" OR "consumer product" OR "household product" OR "biocidal product" OR disinfect OR nutrient OR oil OR metal OR pesticide OR herbicide OR insecticide OR fungicide OR antifoul OR anti-foul OR organochlorine OR "flame retardant" OR detergent OR "perfluorinated compound" OR pharmaceutical OR "personal care product" OR cosmetic OR PAH OR petroleum OR hydrocarbon OR microplastic OR nanoparticle OR nano-particle OR "endocrine disrupter" OR "organic compounds" OR dispersant OR metalloid OR solvent OR petrochemical OR additive OR preservative OR plasticizer OR hormone OR "transformation product" OR "degradation products" OR byproduct OR sunscreen OR "UV filter" OR "ultraviolet filter" OR antibiotic OR phthalate OR PCB OR cyanide OR chlordecone OR nickel OR copper OR zinc OR cadmium OR mercury OR iron).

Estimating the comprehensiveness of the search
To assess the comprehensiveness of the search string, we used a test list of 58 articles considered by the review team as relevant to answer our question and spanning a wide range of chemicals (Additional file 3).

Bibliographic databases
Given the number of articles retrieved by our search string during the scoping exercise and the resources available to conduct the systematic map, we will perform searches on two online publication databases. We selected two multidisciplinary databases Scopus (Elsevier) and WOS CC (Clarivate Analytics) that we can access through a CNRS (the French National Centre for Scientific Research) subscription. Scopus is the largest citation database of peer-reviewed literature and WOS CC is the world’s original citation index for scientific and scholarly research. Both databases are well-suited for use as principal search system to evidence synthesis [32]. Among the 58 articles of our test list, 97% (56/58) were indexed in Scopus and 97% (56/58) in WOS CC (Additional file 3) indicating that both databases were highly relevant for our literature search. We will adapt the abovementioned search string to fit the search facilities of the Scopus database (Additional file 4).

We had access to the following WOS CC Citation Indexes: Science Citation Index Expanded (SCIE-EXPANDED, 1900-present), Social Sciences Citation Index (SSCI, 1956-present), Arts & Humanities Citation Index (A&HCI, 1975-present), Conference Proceedings Citation Index- Science (CPCI-S, 1998-present), Conference Proceedings Citation Index- Social Science & Humanities (CPCI-SSH, 1998-present), Emerging Sources Citation Index (ESCI, 2015-present); and Chemical Indexes: Current Chemical Reactions (CCR-EXPANDED, 1985-present, includes Institut National de la Proprieté Industrielle structure data back to 1840), Index Chemicus (IC, 1993-present). We had access to all Scopus database (1788-present). No time restriction will be applied during searches.

Details on number of search hits returned by the search string on the two databases are provided in additional file 2.

Internet searches
Additional searches of literature will be performed using three search engines:
- CORE (https://core.ac.uk/)
- Google Scholar (https://scholar.google.fr/)
- GreenFILE (http://www.greeninfoonline.com).

The search string developed during the scoping exercise on WOS CC database will be adapted to fit the search facilities of these search engines (for instance Google Scholar allows limited Boolean operators and search string is limited to 256 characters ([33], Additional file 4). Searches will be performed on titles, then the results will be sorted by relevance and the first 400 hits will be extracted. Extraction of results from CORE will be done one by one into Zotero using the Zotero connector for web browser. Results from Google Scholar will be extracted using the software Publish or Perish version 7.15.2643.7260 (https://harzing.com/resources/publish-or-perish, accessed 16 March 2020). Results from GreenFILE will be extracted using the offered export facilities (results can be sent by email in various bibliographic formats e.g. RIS format).

Additionally, we will also search for dissertations in ProQuest Dissertations and Theses (https://search.proquest.com/, Publicly Available Content Database), Open Access Theses and Dissertations (https://oatd.org/) and the French thesis repository (https://www.theses.fr/). The search string will be adapted to fit the specificities of each repository. Searches will be performed on titles, then the results will be sorted by relevance and the first 100 hits will be extracted.

Specialist searches
We will search for links or references to relevant articles and data on the following 11 specialist websites (English- or French-written websites):
- Australian Institute of Marine Science (https://www.aims.gov.au/)
Call for literature
A call for literature will be addressed to the French overseas local authorities. In particular, the local French Coral Reef Initiative (IFRECOR) committees will be contacted.

Assembling and managing search results
The results of all searches will be collated and duplicates will be removed using the package revtools in the R software [34]. The map will be managed with the R and Microsoft Excel softwares, and reference management softwares (EndNote and Zotero) will be specifically used for searching for full-texts.

Article screening and study eligibility criteria
Screening process
Articles will be screened for eligibility in two successive stages: first on titles and abstracts, and second on full-texts. Articles with unclear eligibility status during title/abstract screening will be included for full text screening. The list of articles with unclear eligibility status after completion of full-text screening will be provided with explanation of why they could not be classified. Articles without an abstract and retained based on title screening will directly be screened on their full-text.

Screening will be performed by at least two reviewers. Before screening, we will assess the consistency between reviewers’ decisions by computing the Randolph’s Kappa coefficient on a number of references randomly sampled among the set of articles. We will randomly sample 10% of articles for screening on titles and abstracts, and 5% for screening on full-texts. We will consider a minimal coefficient of 0.6 as an acceptable level of agreement between reviewers, and the process will be repeated until reaching this level. All disagreements between reviewers will be discussed whatever the value of the coefficient, and the definition of eligibility criteria will be improved where necessary.

During all screening process, we will ensure that reviewers will never have to screen their own articles.

Eligibility criteria
At each stage, the eligibility of articles will be assessed using the criteria displayed in Table 1.

The list of articles rejected at full-text screening will be provided with their reasons for exclusion. Reviews and meta-analyses will be excluded but those eligible according to the Population-Exposure-Outcome criteria will be listed in a separate file to make them easily accessible for possible further use.

Study validity assessment
No critical appraisal of study will be performed for the systematic map.

Data coding strategy
A list of variables will be recorded in Microsoft Excel sheet from full-texts for all studies included in the map (full details are given in Additional file 5):

- Bibliographic information (unique identifier, source, title, authors, journal, year, DOI, language and publication type)
- General description of the study (publication content, country, latitude and longitude or location)
- Description of the population (taxon and taxon level)
- Description of the exposure (as described by the authors and as defined by the review team)
- Description of the type of outcome(s) (as described by the authors and as defined by the review team)

Data coding will be performed using an a priori specified CodeBook (Additional file 5) by at least two reviewers. Before the actual coding, a random selection of 1% of articles with a minimum of ten articles will be independently coded by the reviewers and potential disagreements will be discussed and solved, and the CodeBook will be improved where necessary. In case of missing or unclear information, it will be coded as such.

Study mapping and presentation
We will produce a database (Microsoft Excel sheet) of all included studies and their coded data. This database will be open access and included as an appendix
to the systematic map publication. In the map report, a narrative synthesis approach with descriptive statistics, tables and figures will be used to describe the geographical distribution of the included studies as well as their frequencies in the categories specified in the CodeBook. A matrix showing the distribution and frequency of included study into types of exposure and types of outcomes will be computed. The types of exposure and outcomes a priori defined in the CodeBook will be used, but we may also use de novo types that may emerge during the meta-coding process. The matrix will be plotted as a heat map to visually identify potential knowledge gaps and knowledge clusters. We will thus identify the cluster(s) for which a full synthesis of evidence (systematic review) should be possible.

**Supplementary information**

Supplementary information accompanies this paper at https://doi.org/10.1186/s13750-020-00203-x.

**Additional file 1.** ROSES systematic map protocols checklist. ROSES form for systematic map protocols version 1.0.

**Additional file 2.** Search string development. Details of the scoping exercise performed to build the search string.

**Additional file 3.** Test list. List of the 58 articles used to assess the comprehensiveness of the search string.

**Additional file 4.** Search strings. Search strings that will be used for searching in publication databases and search engines.

**Additional file 5.** Coding book. Description of the data that will be extracted for the systematic map.
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Authors’ contributions

The first scoping exercise to build the search string was performed by RS, OP, YR, SB and DYO. Then DYO refined it and all authors discussed and approved the final search string. DYO produced a first draft of the manuscript that was revised by RS and YR. All authors read and approved the final manuscript.

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Availability of data and materials

All data generated or analysed during this study are included in this published article and its supplementary information files.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

In 2018, CFP collaborated with the private company “L’Oréal” for a research work on the impact of sunscreen ingredients on a coral species. LH is currently conducting research on the effects of cosmetic ingredients on young stages of corals of French Polynesia for the private company “Comptoir du Monoi”.

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