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A Global Dataset on Nutrient Removal Capacity by Marine Macroalgae

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Eutrophication driven by excessive nutrient inputs poses a growing threat to marine ecosystems worldwide. Macroalgal aquaculture has been recognized as a promising nature-based solution to mitigate nutrient enrichment; however, a systematic global synthesis of nutrient removal capacity across macroalgae species under varying environmental conditions remains lacking. Here, this study presents the first comprehensive open-access global dataset on nutrient removal capacity by marine macroalgae. The dataset comprises 2,011 records from 149 theses or peer-reviewed articles published between 1995 and 2024, covering 113 macroalgae species from 234 sampling sites across 23 countries on six continents. Each record includes publication details, geographic and taxonomic information, environmental parameters, and macroalgal nutrient removal performance (removal rates, efficiencies, and amounts). The dataset is organized into multiple Date tables, including subsets for nutrient-specific removal metrics and *in situ* experiments, thereby enabling tailored analyses. This resource provides the most extensive synthesis to date of macroalgal nutrient uptake capacity, and supports evidence-based functional macroalgal aquaculture planning, targeted eutrophication management, and marine ecosystem restoration.

Background & Summary

With the the accelerating pace of industrialisation worldwide and the rapid growth of coastal populations, the utilisation of marine resources and the protection of marine ecological environments have attracted increasing global attention[1–3]. In recent decades, coastal eutrophication, exacerbated by anthropogenic activities, has become more frequent[4–7]. Numerous studies have demonstrated that eutrophication is a major driver of harmful algal blooms and the deterioration of coastal marine environments[3,8,9]. Non-point source pollution from agricultural activities[4], direct industrial effluent discharge[7,10], urban runoff[11], and atmospheric deposition derived from fossil fuel[10,12] combustion are among the main contributors to nutrient enrichment in coastal waters. Currently, human-induced nutrient inputs are still on the rise, and large areas of the global ocean now exhibit varying degrees of eutrophication trends[5,7]. For instance, in China alone, over 1,200 red tide events have been reported in coastal seas during the past two decades, affecting an area exceeding 160,000 square kilometres[13]. Notably, recent studies indicate a significant shift in algal blooms from micro- to green tides around China, driven by increasing eutrophication and climate change[14].

Eutrophication is primarily caused by excessive levels of nitrogen and phosphorus nutrients in water bodies[5,15]. It is important to note, however, that these nutrients are also essential for plant growth and metabolism[16], playing a vital role in sustaining ecosystem functioning in marine waters[17–19]. Among existing eutrophication control measures, large-scale macroalgal cultivation has gained attention not only as an economically valuable industry, but also as a nature-based solution for restoring marine environments[20–22]. Numerous studies

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have demonstrated the nitrogen and phosphorus removal capabilities of macroalgal species such as *Gracilaria lemaneiformis*[23], *Pyropia yezoensis*[24], *Saccharina japonica*[25], and *Ulva lactuca*[16]. For example, *Pyropia haitanensis* exhibits strong growth and rapid nitrogen and phosphorus uptake under high nutrient conditions[26]. He *et al.*[24] investigated the potential of cultivating *Pyropia yezoensis* to reduce eutrophication pollution under natural marine conditions, while Hong *et al.*[25] reported that *Saccharina japonica* achieved maximum ammonia nitrogen (NH_4^+-N) removal efficiency of 4.77 μg g^{-1} FW h^{-1} at a light intensity of 41 μmol m^{-2} s^{-1}. Similarly, Al-Hafedh *et al.*[21] found that *Ulva lactuca* collected from the Red Sea could remove over 85% of nitrogen, phosphorus, and other nutrients simultaneously.

Environmental factors such as seawater pH[27], temperature[18], salinity[28,29], light intensity[25,30] and photoperiod[30,31], as well as density[32,33], significantly influence macroalgal nutrient, such as nitrogen and phosphorus uptake. Temperature regulates enzyme activity within macroalgal and alters transporter protein conformation, thus influencing the absorption process of soluble nutrients on the surface of macroalgal[27,34]. Seawater salinity regulates nutrient transport processes by altering osmotic pressure within the plants of macroalgal[28,29]. Light intensity provides the energy necessary for nutrient absorption in macroalgal, representing a major limiting factor for their nutrient absorption rate[25,30,31]. Unfortunately, despite the well-documented influence of these environmental variables on nutrient uptake[33–36], no comprehensive dataset has integrated species-specific removal metrics across varying conditions, hindering optimal macroalgal cultivation design. Therefore, establishing an open-access database to comprehensively compile the nutrient uptake performance of global macroalgae species under varying environmental conditions, will greatly facilitate the optimisation of macroalgal cultivation in coastal waters and support the development of ecological restoration strategies for eutrophic marine environments.

This study presents the first and most comprehensive open-access global dataset on nutrient removal capacity by marine macroalgae. It addresses a critical research gap: the lack of a unified, standardized repository integrating data across diverse geographic regions, experimental conditions, and macroalgal species. By providing systematic and accessible data support for global marine ecological research, this work offers a scientific basis for international applications in macroalgal bioremediation, eutrophication management, and sustainable marine aquaculture planning. As such, this dataset represents the most comprehensive resource to date on the ecological performance of macroalgae in mitigating marine eutrophication.

Methods

Data compilation. Global dataset on nutrient removal capacity by marine macroalgae compiled records of removal rate, removal efficiency, and removal amount of various macroalgal species reported in existing global studies. To obtain research data on nutrient removal performance of macroalgae under different environmental conditions, we conducted a systematic literature search across multiple databases, including Web of Science (WOS), Engineering Village Compendex (EI), Elsevier ScienceDirect (SD), China National Knowledge Infrastructure (CNKI), China Science and Technology Journal Database (CSTJ), and Wanfang Data. The scope of the search covered master's and doctoral dissertations as well as peer-reviewed publications published between 1995 and 2024. The search strategy employed the following query:

"((TS = (macroalgae OR marine macroalgae OR seaweeds OR seaweed OR large-scale seaweed OR macroscopic algae OR large macroalgae OR large algae OR *Laminaria japonica* OR *Undaria pinnatifida* OR *Sargassum** OR *Porphyra** OR *Sargassum fusiforme* OR *Ulva lactuca* OR *Enteromorpha prolifera* OR *Sargassum thunbergii* OR *Gracilaria lemaneiformis*)) AND (TS = (absorb* OR remove*)) AND (TS = (nitrogen OR N OR phosphorus OR P)))". To further mitigate the risk of overlooking underrepresented species not explicitly named in the search string, supplementary manual searches were conducted by screening the reference lists of eligible articles.

This search yielded a total of 3,662 research articles up to August 2024. Subsequently, each potentially relevant study was assessed against the following criteria to determine its eligibility for inclusion in the final dataset. Firstly, the study must focus on a single macroalgal species rather than a mixture of multiple species. Secondly, the macroalgae investigated must originate from marine environments, with taxonomic identity (scientific name), collection site, measurement methods, and environmental conditions explicitly reported. Thirdly, the study must provide measurements of at least one nutrient removal indicator by macroalgae, including direct measurements (calculated from nutrient concentrations in seawater) and indirect estimates (derived from nutrient content in macroalgal tissue), such as the removal rate, removal efficiency, or removal amount of total nitrogen (TN), NH_4^+-N, nitrate nitrogen (NO_3^--N), nitrite nitrogen (NO_2^--N), total phosphorus (TP), or phosphate (PO_4^{3-}-P). Fourthly, the study was required to provide novel data not previously reported in the literature, extractable directly from text, tables, or figures (data from figures were extracted using Origin 2021 software; see Fig. 1).

Following screening, the final dataset comprised 2,011 records derived from 149 independent studies, covering 113 macroalgae species (Fig. 2). Each record included the following information: (1) publication details, including the title, journal name, first author, and year of publication; (2) geographical information, including the country, marine region, and precise location (latitude and longitude) of the study; (3) taxonomic information, including phylum, order, family, genus, and species (scientific name); (4) environmental parameters, such as seawater pH, temperature, salinity, light intensity, photoperiod, density, biomass (fresh weight, FW), and experimental duration; and (5) nutrient removal data, including removal rate, removal efficiency, and removal amount of TN, NH_4^+-N, NO_3^--N, NO_2^--N, TP, and PO_4^{3-}-P.

Data treatment. The dataset compiled records of removal rate, removal efficiency, and removal amount of various macroalgal species under varing environmental conditions, with each entry documented as an independent row. For each record, a DOI link was provided to ensure direct access to the original literature.

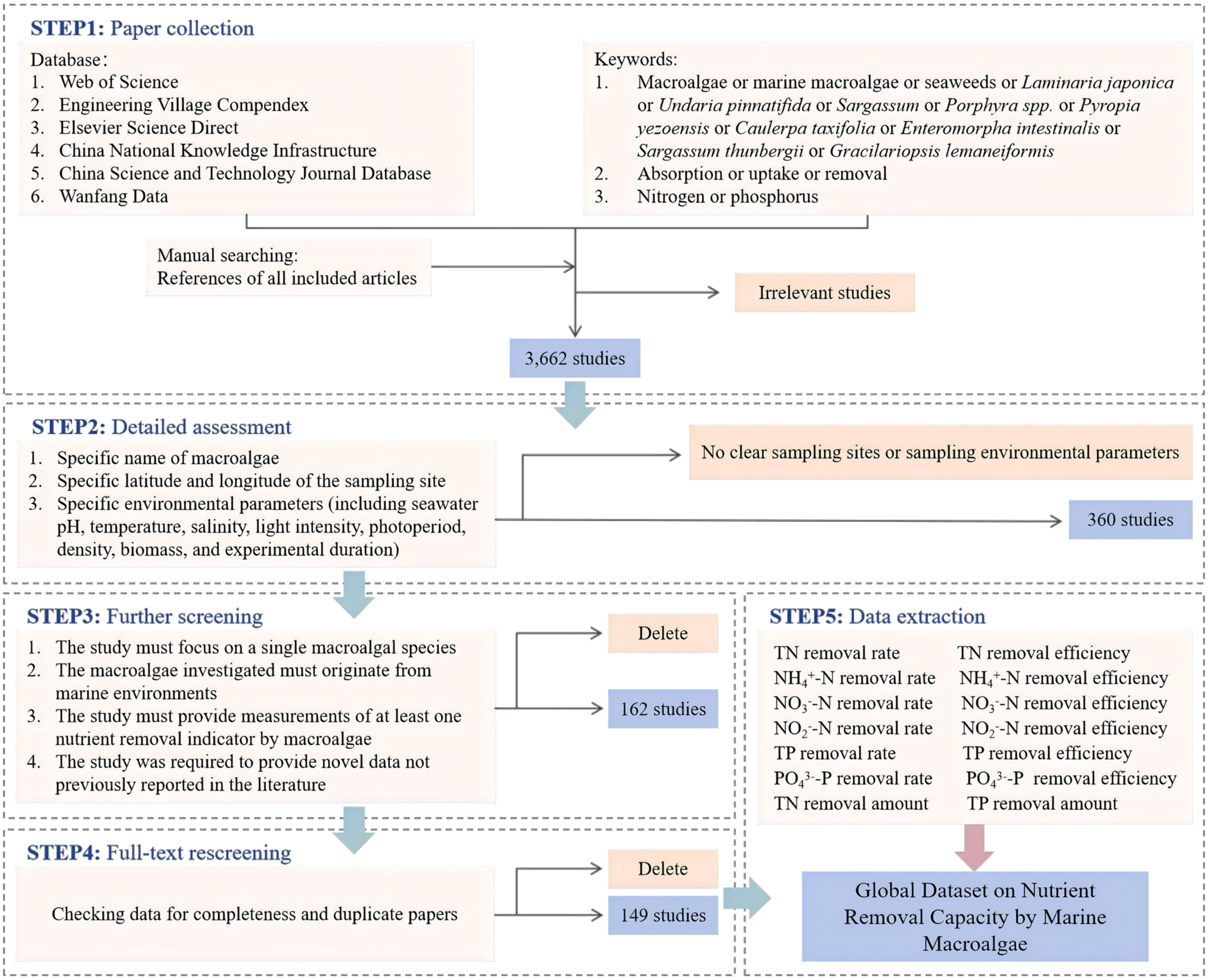

Fig. 1 Methodological framework diagram for constructing the global dataset on nutrient removal capacity by marine macroalgae. The detailed workflow is described in the main text.

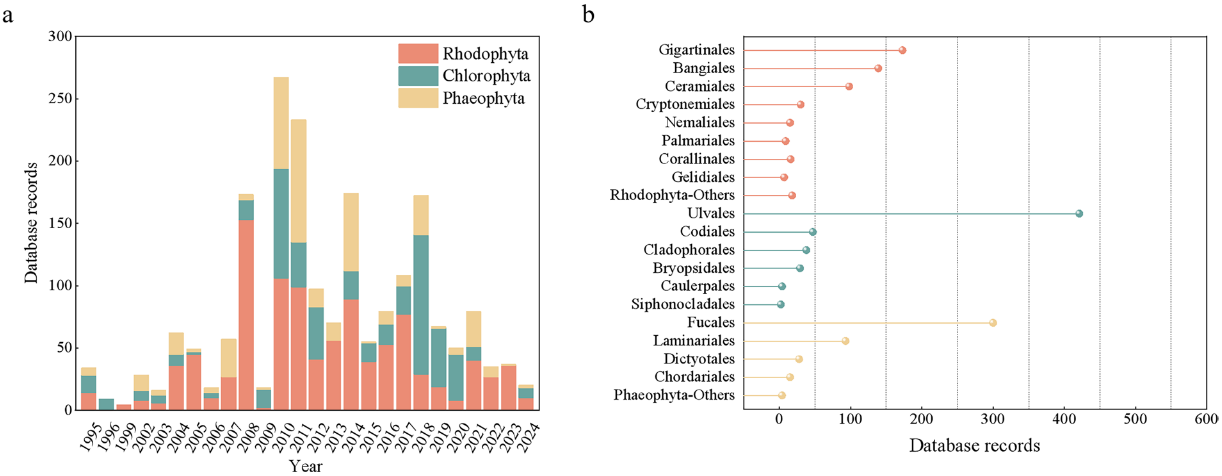

Fig. 2 Taxonomic coverage of the dataset. (**a**) Number of database records of different macroalgal phyla with respect to publication year. (**b**) Number of dataset records for different macroalgal orders. All data were obtained from published studies.

The primary Date Table 1: Comprehensive Dataset contains all data (2,011 records), which were further organised into six independent Date tables, each providing detailed records the removal rates and removal efficiencies of nutrient-specific by macroalgae. In addition, field study data were separately organised into Date table 8: Field dataset (46 records), which contained the total removal amounts of nitrogen and phosphorus by macroalgae *in situ* environment.

Macroalgal scientific names was classified and standardised using the World Register of Marine Species (WoRMS; www.marinespecies.org)[34,37]. Cross-checked the scientific names of macroalgae collected with internationally recognised standardised names and associated taxonomic information, including taxonomic rank, hierarchy, and units. Entries that could not be matched with WoRMS (including those with spelling errors) or were considered doubtful were excluded from the dataset. For studies that did not provide information on the marine region of macroalgae, the relevant details were supplemented using latitude and longitude coordinates. In cases where photoperiod data were not reported, values were assigned a default of 12 h[30]. All biomass data in the dataset were expressed as fresh weight. Where dry weight (DW) was reported in the original studies, values were converted using the corresponding moisture content provided in the publications. For experiments where nutrient removal efficiency reached saturation (100%) over time, the recorded experimental duration represents the minimum time required to achieve complete depletion. The nutrient removal rate ($\mu g\ g^{-1}$ FW h^{-1}) and removal efficiency (%) of macroalgae were calculated according to Eqs. (1, 2), respectively:

$$Removal\ rate = \frac{[(C_0 - C_t) \times V]}{m \times \Delta t} \tag{1}$$

$$Removal\ efficiency = \frac{C_0 - C_t}{C_0} \times 100\% \tag{2}$$

Where C_0 and C_t denote the initial and final nutrient concentrations (mg L^{-1}), respectively. V represents the seawater volume (L), m is the fresh weight biomass of macroalgae (g FW), and Δt (h) denotes the experimental duration.

The nutrient removal amount (kg) of macroalgae was estimated using Eq. (3):

$$Removal\ amount = W\% \times M \tag{3}$$

Where W% denotes the percentage of nutrient content of macroalgae tissue, and M is the macroalgae dry weight (g DW).

Data Records

This dataset is publicly accessible, and both the dataset itself and complete reference list are available for download from the Figshare repository[38]. Global dataset on nutrient removal capacity by marine macroalgae comprises eight independent Date tables, the details of which are summarised in Table 1. Each record within the Date tables provides publication details, geographic information, taxonomic details, environmental parameters, and macroalgal nutrient removal performance. Definitions and descriptions of the dataset variables (columns) are provided in Table 2.

Taxonomic coverage. The dataset represents the most comprehensive compilation to date of macroalgal nutrient removal data, including removal rates, removal efficiencies, and removal amounts. It encompasses 113 macroalgal species belonging to 51 genera, 31 families, 19 orders, and 3 phyla. Among these, Rhodophyta accounted for more than half of the nutrient removal records (51%, 1,034 records), comprising 9 orders, 17 families, and 31 genera. Chlorophyta (541 records) and Phaeophyta (436 records) contributed 27% and 22% of the dataset records, respectively (Fig. 2).

Data Overview

Spatial and temporal coverage. The dataset comprises 2,011 records of nutrient removal by 113 macroalgae species collected between 1995 and 2024 from 234 sampling sites. These sampling sites are distributed across six continents and 23 countries, with the majority located in China, followed by the United States, New Zealand, and South Korea. The sampling sites cover a wide range of global marine regions, including the East China Sea, South China Sea, Yellow Sea, and Bohai Sea in the Pacific Ocean, the North Sea, Caribbean Sea, and Gulf of Guinea in the Atlantic Ocean, and the Red Sea and Arabian Sea in the Indian Ocean. It should be noted that this dataset exhibits a distinct northern hemispheric concentration in its spatial distribution, particularly in the temperate and subtropical zones of East Asia (primarily China) between 20° and 40°N (Fig. 3)[7,31]. This distribution is consistent with the region's status as a global hub for macroalgal aquaculture and bioremediation research. Consequently, data on macroalgae in tropical (low-latitude) and polar (high-latitude) regions are relatively scarce. Users should fully account for this spatial limitation when applying these nutrient removal parameters to ecosystems outside temperate zones.

From 2003 to 2015, Rhodophyta dominated the published literature on macroalgae and reached a publication peak around 2008, a trend that aligned with the rapid development of the phycocolloid industry during this period and thus drove a surge in Rhodophyta research due to its commercial significance[39]. From 2010 to 2018, publications focusing on Chlorophyta and Phaeophyta rose steadily; the sustained publication peak after 2010 corresponded to the large-scale green tide in 2008 and the 2011 *Sargassum* bloom in the Atlantic Ocean, which prompted researchers to urgently explore the bioextraction potential of such bloom-forming species[40,41]. Consequently, research into Chlorophyta and Phaeophyta surged on account of their vital role in ecological remediation.

Date table list	Date table name	Content
Date Table 1	Comprehensive Dataset	Comprehensive Dataset includes data on nutrient removal by macroalgae, such as TN, NH_4^+-N, NO_3^--N, NO_2^--N, TP, PO_4^{3-}-P removal rate, removal efficiency, and removal amount
Date Table 2	Total Nitrogen Dataset	Total Nitrogen Ddataset including TN removal rate and removal efficiency from of macroalgae Date Table 1: Comprehensive Dataset
Date table 3	Ammonia Nitrogen Dataset	Ammonia Nitrogen Dataset including NH_4^+-N removal rate and removal efficiency of macroalgae from Date Table 1: Comprehensive Dataset
Date table 4	Nitrate Nitrogen Dataset	Nitrate Nitrogen Dataset including NO_3^--N removal rate and removal efficiency of macroalgae from Date Table 1: Comprehensive Dataset
Date table 5	Nitrite Nitrogen Dataset	Nitrite Nitrogen Dataset including NO_2^--N removal rate and removal efficiency of macroalgae from Date Table 1: Comprehensive Dataset
Date table 6	Total Phosphorus Dataset	Total Phosphorus Dataset including TP removal rate and removal efficiency of macroalgae from Date Table 1: Comprehensive Dataset
Date table 7	Phosphate Dataset	Phosphate Dataset including PO_4^{3-}-P removal rate and removal efficiency of macroalgae from Date Table 1: Comprehensive Dataset
Date table 8	Field Dataset	Field Dataset including TN and TP removal amount of macroalgae in *in-situ* experiments from Date Table 1: Comprehensive Dataset

Table 1. Description of the functional Date tables in the dataset.

Technical Validation

Global dataset on nutrient removal capacity by marine macroalgae was curated by the administrator (P.L. Xie) (Fig. 1). Prior to data extraction, the authenticity of the raw sources and data was verified. Raw data were extracted directly from the text, figures, and tables of the publications after reading each paper at least three times, and were recorded using a standardised template to minimise spelling errors and inconsistencies. Data sources that were difficult to interpret or lacked extractable raw data were excluded. After data collection, quality control was implemented through the following procedures:

(1) Source verification. All data have undergone independent verification by a second person. The original entries were first checked by the data recorder and subsequently cross-checked by a verifier. The column "Person entering data" documents the recorder, while the column "Person verifying data" identifies the verifier.
(2) Data cross-checking. Publication details, taxonomic information, and geographical coordinates were re-verified in March 2025. Taxonomic information were standardised using WoRMS, and in cases of inconsistency with the published record, the most up-to-date nomenclature and taxonomy system from WoRMS were adopted. Geographical coordinates were cross-checked using Google Maps to ensure their location within marine areas. For the geographic coordinates initially assigned to nearshore land areas, substitution was made with the closest marine coordinates within a 2 km distance from the original on-shore coordinates. All data points requiring coordinate adjustment beyond this threshold were excluded to preserve spatial fidelity. All geographical coordinates values were converted into a unified standard format.
(3) Duplicates and outliers screening. Records with identical macroalgal species and geographic coordinates were cross-validated, and duplicate entries were removed. Outliers were assessed using statistical boxplot analysis with the 1.5 × interquartile range (IQR) set as the screening threshold. Suspect values (i.e., those below $Q1 - 1.5 \times IQR$ or above $Q3 + 1.5 \times IQR$) were verified with the original literature: erroneously recorded values were corrected, while values that were recorded accurately yet exhibited anomalies were retained, allowing subsequent users to independently determine whether to retain or exclude such values based on their specific research objectives and analytical requirements.
(4) Formatting and consistency checks. Data formats were checked column by column (e.g., numeric versus string variables), and any errors in numeric fields were corrected. Missing data were imputed where feasible. To assess data completeness, we quantified the proportion of valid records for each key variable (Fig. 4a). Physicochemical parameters (Temperature, Photoperiod, pH, Salinity) exhibited high completeness (>83%), with less than 17% of records missing for these variables. Missing temperature values were imputed using local temperature data; missing photoperiod values were filled with a 12 h default; and missing pH and Salinity values were supplemented by querying pH and Salinity data from the same or adjacent sea areas in the database. The remaining physicochemical parameters (Light intensity, Density, Biomass, Experimental duration) had completeness ranging from 70% to 98%; nutrient parameters (NO_2^--N concentration, TP concentration, TN concentration, NH_4^+-N concentration, PO_4^{3-}-P concentration, NO_3^--N concentration) had completeness between 9% and 58%. Since these data could not be imputed via database queries, missing values were flagged as "NA" and excluded from statistical analyses to avoid bias (Fig. 4b).

Usage Notes

Each record (row) in the dataset contains publication details, geographic information, taxonomic information, associated environmental parameters, and macroalgal nutrient removal data. Notably, all variables use consistent units. The dataset comprises eight independent Date tables, with Date Table 2-8 derived from Date Table 1: Comprehensive Dataset. Specifically, Date Table 2–7 document the nutrient-specific removal rates and removal efficiencies of macroalgae, while Date table 8: Field Dataset contains *in-situ* nitrogen and phosphorus removal amounts data by macroalgae across different marine regions.

Variable	Description
Number	The number of the published article, the same article belongs to the same number
Title	Title of the published article
Journal	Journal of the published article
Author	First author of the published article
Year	Publication year of the article
Country	Country where the study was conducted
Marine area	Marine area where the study was conducted
Longitude	Longitude converted to Degrees Minute Second (DMS)
Latitude	Latitude converted to DMS
Phylum	Rhodophyta, Chlorophyta, Phaeophyta
Order	Taxonomic order as per WoRMS
Family	Taxonomic family as per WoRMS
Genus	Taxonomic genus as per WoRMS
Scientific name	Scientific name as per WoRMS
pH	Seawater pH of the experiment
Temperature °C	Seawater temperature of the experiment in °C
Salinity	Seawater salinity of the experiment
Light intensity μmol m^{-2} s^{-1}	Light intensity of the experiment, with units converted to μmol m^{-2} s^{-1}
Photoperiod h	Duration of light received by the macroalgae in the experiment over a 24-hour cycle, in h
Density g L^{-1}	Density of macroalgae in the experiment, with units converted to g L^{-1}
Biomass g FW	Biomass of macroalgae in the experiment, with units converted to g FW
Experimental duration h	Total duration from start to finish of the experiment, with units converted to h
Data category	Data collected from experimental or field data
TN concentration mg L^{-1}	Initial seawater TN concentration, with units converted to mg L^{-1}
NH_4^+-N concentration mg L^{-1}	Initial seawater NH_4^+-N concentration, with units converted to mg L^{-1}
$NO^-{}_3$-N concentration mg L^{-1}	Initial seawater NO_3^{--}-N concentration, with units converted to mg L^{-1}
NO_2^--N concentration mg L^{-1}	Initial seawater NO_2^--N concentration, with units converted to mg L^{-1}
TP concentration mg L^{-1}	Initial seawater TP concentration, with units converted to mg L^{-1}
PO_4^{3-}-P concentration mg L^{-1}	Initial seawater PO_4^{3-}-P concentration, with units converted to mg L^{-1}
TN removal rate μg g^{-1} FW h^{-1}	TN removal rate by macroalgae given in the study. For the data on TN concentration, it was calculated as TN removal rate by using Eq. (1), with units converted to μg g^{-1} FW h^{-1}
NH_4^+-N removal rate μg g^{-1} FW h^{-1}	NH_4^+-N removal rate by macroalgae given in the study. For the data on NH_4^+-N concentration, it was calculated as NH_4^+-N removal rate by using Eq. (1), with units converted to μg g^{-1} FW h^{-1}
NO_3^--N removal rate μg g^{-1} FW h^{-1}	NO_3^--N removal rate by macroalgae given in the study. For the data on NO_3^--N concentration, it was calculated as NO_3^--N removal rate by using Eq. (1), with units converted to μg g^{-1} FW h^{-1}
NO_2^--N removal rate μg g^{-1} FW h^{-1}	NO_2^--N removal rate by macroalgae given in the study. For the data on NO_2^--N concentration, it was calculated as NO_2^--N removal rate by using Eq. (1), with units converted to μg g^{-1} FW h^{-1}
TP removal rate μg g^{-1} FW h^{-1}	TP removal rate by macroalgae given in the study. For the data on TP concentration, it was calculated as TP removal rate by using Eq. (1), with units converted to μg g^{-1} FW h^{-1}
PO_4^{3-}-P removal rate μg g^{-1} FW h^{-1}	PO_4^{3-}-P removal rate by macroalgae given in the study. For the data on PO_4^{3-}-P concentration, it was calculated as PO_4^{3-}-P removal rate by using Eq. (1), with units converted to μg g^{-1} FW h^{-1}
TN removal efficiency %	TN removal efficiency by macroalgae given in the study. For the data on TN concentration, it was calculated as TN removal efficiency by using Eq. (2)
NH_4^+-N removal efficiency %	NH_4^+-N removal efficiency by macroalgae given in the study. For the data on NH_4^+-N concentration, it was calculated as NH_4^+ removal efficiency by using Eq. (2)
NO_3^--N removal efficiency %	NO_3^--N removal efficiency by macroalgae given in the study. For the data on NO_3^--N concentration, it was calculated as NO_3^--N removal efficiency by using Eq. (2)
NO_2^--N removal efficiency %	NO_2^--N removal efficiency by macroalgae given in the study. For the data on NO_2^--N concentration, it was calculated as NO_2^--N removal efficiency by using Eq. (2)
TP removal efficiency %	TP removal efficiency by macroalgae given in the study. For the data on TP concentration, it was calculated as TP removal efficiency by using Eq. (2)
PO_4^{3-}-P removal efficiency %	PO_4^{3-}-P removal efficiency by macroalgae given in the study. For the data on PO_4^{3-}-P concentration, it was calculated as PO_4^{3-}-P removal efficiency by using Eq. (2)
The tissue N %, m m^{-1}, DW	The N content in macroalgal tissues in %, m m^{-1}, DW
TN removal amount kg	TN removal amount by macroalgae, estimated from the tissue N if only it is provided (without specific TN removal amount)
The tissue P %, m m^{-1}, DW	The P content in macroalgal tissues in %, m m^{-1}, DW
TP removal amount kg	TP removal amount by macroalgae, estimated from the tissue P if only it is provided (without specific TP removal amount)
Person entering data	Author that entered the data
Person verifying data	Author that verified the data
DOI	Digital Object Identifier link for the original publication source

Table 2. Description of the fields and variables used in the dataset.

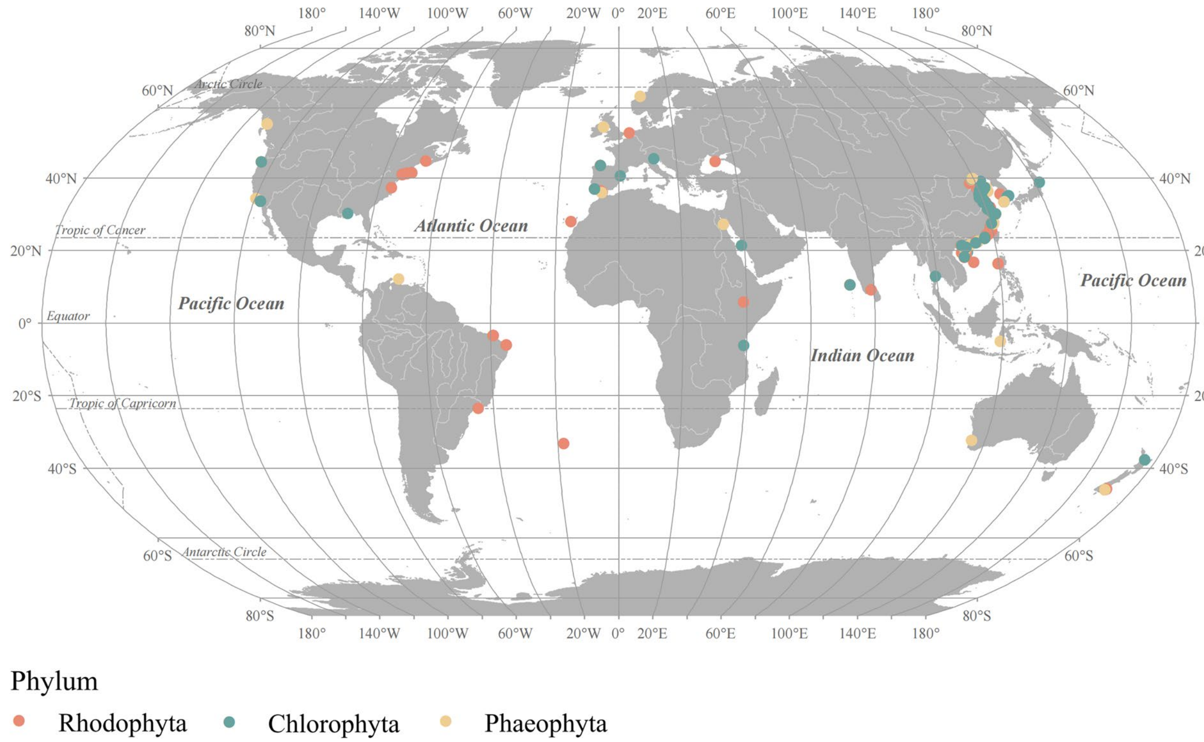

Fig. 3 Spatial distribution of research sites in dataset. Colours indicate macroalgal phyla at each study, covers studies conducted between 1995 and 2024 across six continents and 23 countries.

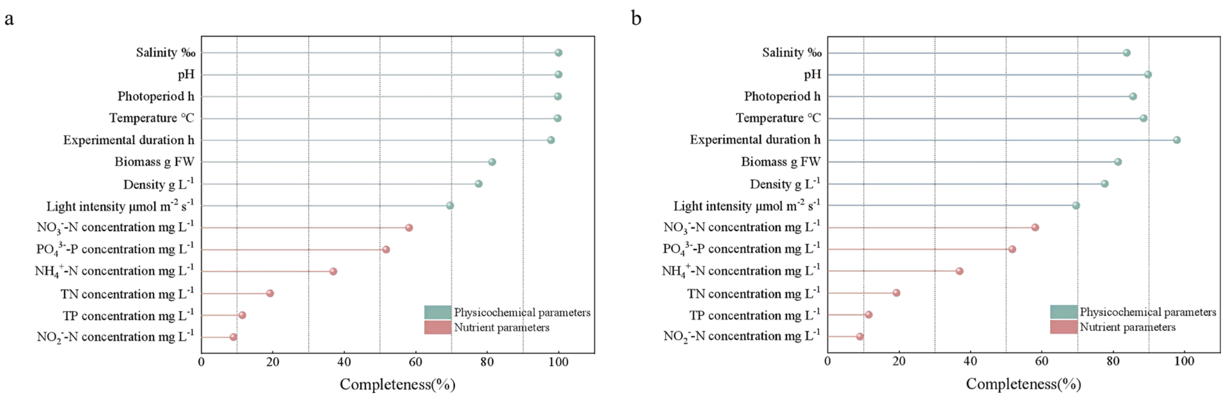

Fig. 4 Percentage of data completeness for key variables in the database. (**a**) Data completeness of key variables (before imputation). (**b**) Data completeness of key variables (after imputation).

To identify temperature-sensitive nitrogen removers, users can filter Data table 3 [Ammonia Nitrogen Dataset] by temperature range and compare removal rates across species; to investigate the effects of light intensity on the nitrate nitrogen removal capacity of macroalgae, users can extract light intensity and nitrate nitrogen removal rate data from the Data table 4 [Nitrate Nitrogen Dataset] to analyze the response relationships between nitrate nitrogen removal efficiencies of typical macroalgal species and different light intensity gradients. Users may select different worksheets and key variables for analysis according to their actual research needs.

It should be noted that removal efficiency follows non-linear first-order kinetics and is subject to saturation effects. Therefore, removal efficiency cannot be directly compared across studies without considering experimental duration, nor can it be linearly normalized to a standard timeframe, as this would lead to data distortion for fast-absorbing species. Users are advised to compare removal efficiency only between studies with similar experimental durations. For broader comparisons involving diverse experimental timeframes, we strongly recommend using the removal rate. Unlike removal efficiency, the removal rate inherently accounts for biomass and time, making it a more robust metric for evaluating nutrient uptake kinetics.

Global dataset on nutrient removal capacity by marine macroalgae provides a valuable reference for selecting suitable macroalgal species for aquaculture-based nutrient removal in specific marine regions, and for designing ecological restoration strategies in eutrophic coastal waters. For any questions related to data usage, users are encouraged to contact the corresponding authors.

Data availability

The dataset and the complete reference list of all 149 studies included are available for download from the Figshare repository[38]. All source data were extracted from publicly available peer-reviewed publications and dissertations.

Code availability

No custom code was used to generate the described dataset.

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Competing interests
The authors declare no competing interests.

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