

Online Resource 3

PRISMA 2020 Checklist

Photocatalytic Degradation of Malachite Green: A Systematic Review of Catalyst Performance, Mineralization, and the Reporting Gaps Limiting Environmental Application

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Locations are given by manuscript section, table or figure rather than by page number, as pagination may change during typesetting. "Online Resource 1" and "Online Resource 2" refer to the supplementary spreadsheets; "Text S1" and "Text S2" refer to the supplementary methods notes.

Section	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Title page title states "A Systematic Review of Catalyst Performance, Mineralization, and the Reporting Gaps Limiting Environmental Application"
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Abstract states systematic review and comparative quantitative synthesis, 24 studies (2020–2025), outcomes compared, and limitations
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Section 1 (Introduction)
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Section 1 (Introduction), final paragraph; Section 2.1 ("Question:") and Section 2.2 (PICO)
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Section 2.2 (Eligibility Criteria, PICO and exclusion list); grouping by catalyst class in Sections 3.2 and 3.3
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted. Specify the date when each source was last searched or consulted.	Section 2.1 PubMed, Scopus, Web of Science; searched June 2025, updated March 2026 with an identical strategy
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Section 2.1 full Boolean string, MeSH usage, English-language and date limits, database-specific syntax adjustments

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Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used.	Section 2.3 two reviewers (F.F., A.Sh.) screened independently and in parallel, discrepancies resolved by discussion; Zotero used for reference management and duplicate detection; no automation tools were used for screening decisions
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from investigators, and if applicable, details of automation tools used.	Section 2.3 data extracted independently by both reviewers, discrepancies cross-checked against the original publications; study authors were not contacted
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought, and if not, the methods used to decide which results to collect.	Section 2.3 removal efficiency, apparent rate constant, adsorption capacity, reaction time, mineralization (TOC/COD), reusability. Where more than one condition was reported, the highest value stated by the authors was used (Text S1)
	10b	List and define all other variables for which data were sought. Describe any assumptions made about any missing or unclear information.	Section 2.3 catalyst type, synthesis method, lamp type, catalyst dose, initial MG concentration, country, year. Missing rate constants recalculated as $k = -\ln(1 - X)/t$ with X capped at 0.9999; missing values left blank rather than imputed (Texts S1–S2)
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used.	Section 2.4 no validated instrument exists for laboratory photocatalysis studies (RoB 2 and ROBINS-I are clinical tools); a custom 13-domain qualitative appraisal rubric was developed and applied independently by both reviewers, disagreements resolved by consensus (Table S1, Online Resource 1)

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Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Section 2.3 percentage removal efficiency, apparent pseudo-first-order rate constant k (min^{-1}), adsorption capacity (mg g^{-1}), reaction time (min), number of reuse cycles; no pooled effect estimates were computed
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis.	Section 2.3 all 24 eligible studies entered the synthesis; Fig. 5 excludes one study (MG-MI) for which no catalyst dose was reported, leaving 23 entries (Text S1)
	13b	Describe any methods required to prepare the data for presentation or synthesis.	Section 2.3 and Texts S1–S2 unit harmonization (hours to minutes, doses to g L^{-1}), recalculation of unreported rate constants, min–max normalization of k , capacity and reuse, inversion of reaction time, ordinal scoring of irradiation source
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Tables 1–2; Figs. 2–6; construction described in Texts S1–S2; underlying dataset in Online Resource 1
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Section 2.3 meta-analysis was not appropriate owing to methodological heterogeneity in catalyst loading, irradiation, reactor configuration and initial MG concentration; a Synthesis Without Meta-analysis (SWiM) approach (Campbell et al. 2020) was used, with descriptive comparison performed in Microsoft Excel
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	Sections 3.3–3.5 and 4.1–4.4 heterogeneity explored descriptively by catalyst class, irradiation source and dose; formal statistical heterogeneity measures were not applicable as no pooled

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			estimates were computed (Section 2.3)
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	Section 2.3 formal sensitivity analysis not applicable; robustness addressed qualitatively via the appraisal rubric and by examining the influence of experimental conditions. Three hybrid or variant systems were retained but flagged as not directly comparable
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	Section 2.4 and Section 4.6 no formal instrument (e.g. funnel plot, Egger's test) was applicable in the absence of pooled estimates; selective-outcome reporting was assessed qualitatively through the appraisal domains covering mineralization, reusability and real-sample testing, and the resulting reporting gaps are quantified in Section 3.4
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	Section 2.4 and Section 4.6 GRADE was not applied, as it is designed for clinical outcome domains; certainty was appraised narratively across the 13 rubric domains, and the limits on confidence are stated explicitly in Section 4.6
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Section 3.1 and Fig. 1 (PRISMA 2020 flow diagram) 4,274 records identified; 769 removed before screening; 3,505 screened; 341 full texts assessed; 24 studies included
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Section 3.1 and Fig. 1, 317 full-text exclusions with reasons: not photocatalytic degradation (n = 114), dye other than MG (n = 161),

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			insufficient efficiency or reusability data (n = 12), irradiation source unspecified or out of scope (n = 30)
Study characteristics	17	Cite each included study and present its characteristics.	Section 3.2, Table 1 and Table 2; all 24 studies cited individually
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Section 3.4 and Table S1 (Online Resource 1) per-domain narrative assessment for each of the 24 studies
Results of individual studies	19	For all outcomes, present, for each study, summary statistics for each group and effect estimates, with precision, ideally using structured tables or plots.	Tables 1–2; Figs. 5–6; Online Resource 1. Precision measures (e.g. replicate variability) were rarely reported by the primary studies noted in Sections 3.4 and 4.6
Results of syntheses	20a	For each synthesis, briefly summarize the characteristics and risk of bias among contributing studies.	Sections 3.2 and 3.4
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision and measures of statistical heterogeneity.	Sections 3.3–3.5, Figs. 2–6. No meta-analysis was performed; results are presented as a comparative quantitative synthesis
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Sections 3.3, 3.5 and 4.1–4.4 effects of irradiation source, catalyst dose and catalyst class on reported performance
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	Not applicable no pooled estimates; robustness discussed narratively in Section 4.6
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis.	Section 3.4 mineralization confirmed in 10 of 24 studies, real-wastewater validation in 1 of 24, reuse cycle counts absent for 3 catalysts; discussed in Sections 4.5 and 4.6
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Section 4.6 findings describe laboratory performance only; normalization in Fig. 6 is relative to the included studies

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			rather than an absolute benchmark, and rankings should not be extrapolated to full scale without further validation
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Sections 4.1–4.5 and Section 5
	23b	Discuss any limitations of the evidence included in the review.	Section 4.6 heterogeneity, sparse mineralization and toxicity data, minimal real-effluent validation, uneven durability reporting
	23c	Discuss any limitations of the review processes used.	Section 4.6 no prospective registration, unvalidated appraisal rubric, three databases and English-language publications only, recalculated rate constants as conservative approximations
	23d	Discuss implications of the results for practice, policy, and future research.	Sections 4.5, 4.6 and 5 standardized LED-based protocols, mineralization and leaching reporting, real-wastewater testing, ML-ready datasets
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Section 2 (Methodology), opening paragraph the review was not prospectively registered
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Section 2 no prospective protocol was prepared or publicly posted; also stated in Section 4.6
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Not applicable — the review was not registered and no protocol amendments were made
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Section 7 (Statements and Declarations) Funding: no funding was received
Competing interests	26	Declare any competing interests of review authors.	Section 7 the authors declare no competing financial or non-financial interests

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Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Section 7 (Data availability) extracted data, rate-constant recalculations and normalization formulas in Online Resources 1 and 2; Texts S1–S2 describe figure construction; this completed checklist is Online Resource 3. Further data available from the corresponding author on reasonable request

Reference:

Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, Chou R, Glanville J, Grimshaw JM, Hróbjartsson A, Lalu MM, Li T, Loder EW, Mayo-Wilson E, McDonald S, McGuinness LA, Stewart LA, Thomas J, Tricco AC, Welch VA, Whiting P, Moher D (2021) The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* n71. <https://doi.org/10.1136/bmj.n71>