The Responses of Soil Mineral-associated Organic Carbon to Exogenous Carbon Additions: a Protocol for a Systematic Review and Meta-analysis

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Protocol

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Abstract

Background: Increased exogenous carbon inputs into soils under global climate change can induce soil organic carbon (SOC) decomposition, which has profound effects on carbon cycle and feedback on climate change. Soil mineral-associated organic carbon (MAOC) is the SOC protected from decomposition through association with minerals. Recent studies demonstrated that MAOC can be mineralized due to exogenous carbon inputs. The objective of this study is to provide the methods used to explore the effect of exogenous carbon inputs on MAOC and the controlling factors.

Methods: We will search for the potential studies that evaluating the influence of carbon additions on MAOC content and decomposition through the Web of Science, Scopus and China National Knowledge Infrastructure until August 2021. If the studies searched by using keywords meet the inclusion criteria, then they were included. The STATA software (version 15.0) will be used to perform data analysis. The results include the content and decomposition intensity of MAOC induced by exogenous carbon additions and the controlling factors. Study selection, data extraction, and assessment of bias risk will be conducted by two reviewers independently. Subgroup analysis will be carried out to explore sources of heterogeneity when heterogeneity is observed. Sensitivity analysis will be used to assess the robustness of the analyses.

Discussion: This study will provide useful methods for exploring the effect of carbon additions on MAOC and the controlling factors.

Introduction

Soil contained more carbon than vegetation and atmosphere combined in terrestrial ecosystems, thus the slight change of soil organic carbon (SOC) content due to environmental factors may have a great impact on atmospheric CO_2 concentration and climate change [1, 2]. SOC content mainly depends on formation through the transformation of exogenous carbon inputs and the decomposition by microorganisms [3]. Increasing SOC content benefits for improving soil fertility, ensuring food security and mitigating global climate change [4]. Exogenous organic carbon (C) inputs into soils increase through above-ground litters and underground exudates due to elevated CO_2 concentration [5]. The increased C inputs can increase SOC formation, but also promote SOC decomposition, a phenomenon known as the priming effect [6]. Previous studies have shown that the priming effect increased SOC decomposition by 14.8–59.4% [7–9]. Thus, it is important to improve the understanding of the responses of the SOC content to exogenous C inputs for the prediction of C dynamic and its feedbacks on climate change.

SOC is heterogeneous and composed of organic compounds at different decomposing phases [10]. Just because of this, it is difficult to understand the SOC dynamic and predict its response to increased C inputs under global climate change. Separating bulk SOC stocks into different fractions varying in stability and turnover times allows a more accurate prediction of SOC vulnerability to exogenous C inputs [11]. The common fractions of SOC include aggregate-associated, density and oxidation fractionations.

Mineral-associated (MAOC) and particulate (POC) organic carbon, are suggested to be the best fractionation method for SOC dynamic study through the combination of aggregate-size and density method [12]. POM is mainly derived from plants and not protected by the occlusion in aggregates and has short mean residence times (about years to decades). MAOC is mainly formed by labile organic C of microbial transformation and associated with mineral surface, can persist for longer time and has lower accessibility to microbial community compared with POC [13–15]. Besides, MAOC accounts for 60–90% of total SOC [12]. Therefore, it is important to determine how this SOC fraction responds to exogenous C inputs to predict climate-C dynamic feedbacks in the context of climate change.

Bulk SOC showed the positive, neutral and negative priming decomposition due to the exogenous C additions [6, 16, 17]. Some meta-analysis studies demonstrated positive priming response is a common phenomenon to C inputs and depends on the ecosystem, the rate and type of C inputs, soil properties and experiment conditions [18–20]. MAOC has been demonstrated to be decomposed when adding labile C [20], which challenges the view of stability of MAOC. Nitrogen additions have been shown to affect the SOC fractions through a meta-analysis [21]. The effects of exogenous C inputs on MAOC and the controlling factors still lack quantitative review. The study aims to provide methods for determining the effects of exogenous C additions on MAOC content and decomposition, and their controlling factors.

Methods

Design and registration

We will conduct a systematic review and meta-analysis of the response of MAOC to exogenous carbon additions. We will follow the Preferred Reporting Items for Systematic Reviews and Meta-Analysis to report this study.

Information sources

We will search for potential studies investigating the effect of exogenous carbon additions on MAOC including its content and decomposition using Web of Science, Scopus and Chinese National Knowledge Infrastructure (CNKI) until August 2021.

Search strategy and eligibility criteria

Two reviewers will search the literature independently. The keywords and their combination will be used to identify proper studies and the search strategy will be listed as follows:

#1 soil mineral-associated carbon or soil mineral-associated carbon matter or MAOC or MAOM or MOM

#2 enrichment or addition or application or input or amend

#3 labile organic C or fresh organic C or external organic C or exogenous organic C or litter or straw or residue or substrate

#3 content or distribution or respiration or mineralization

#4 decomposition or respiration or CO_2 or mineralization or distribution or content

#5 #1#2 #3 and #4

#6 #5 NOT (review or meta-analysis [Title])

#7 #6 NOT (meeting or abstract or letters or other [Publish Type])

Then we will select the final studies manually after #7 based on the following criteria:

□) The study was conducted in terrestrial ecosystems, or the soils used for laboratory incubation were collected from terrestrial ecosystems.

□) The study separated MAOC from POM through the method of particulate size or density fractions or their combination, and reported MAOC-derived CO_2 in the incubation experiment or MAOC content in the field or incubation experiment.

□) The study included the control treatment (without C additions), and treatment (C additions).

□) Means, standard deviations (SDs) or standard errors (SEs), and the number of replicates for control and treatment groups could be obtained from text, tables or digitized graphs.

The three databases will use a similar search strategy. A flow diagram demonstrating the entire study selection process is shown in Fig. 1.

Data collection and analysis

We will collect information from each included study, including first author, publication date, study site and its basic information (longitude, latitude, MAT, MAP, and soil type), ecosystem, the forms and rates of C additions, experiment duration, and the means and SD or SE of MAOC-CO_2 and MAOC content and the replicates from treatments and control. we will categorize them into topsoils (0–20 cm) and subsoils (below 20 cm depth) when studies include soils from multiple layers at the same site. All unit of MAOC content or MAOC-CO_2 will be converted to be the same during data collection. We will use mean difference as an effect size to indicate the effects of C additions on MAOC decomposition. The random effect model will be chosen when the heterogeneity is above 50%.

To test the general effects of C additions on MAOC content and priming decomposition, we will calculate the mean effect size and its corresponding 95% confidence interval (CI) using the mixed-effects model. The subgroup analyses and meta-regression analyses will be used to explore sources of heterogeneity when the heterogeneity is observed. Subgroup and meta-regression analyses will be carried out on ecosystems, the rates and the forms of C additions, surface and subsurface soils, experiment duration, soil properties including the content of carbon, nitrogen, the ratio of carbon to nitrogen, clay, silt and sand.

We will carry out the sensitivity analysis to evaluate the bias. In addition, we will explore potential publication bias using funnel plots, trim and fill method, and the Egger test. All calculations will be performed using Review Manager (version 5.3) and STATA (version 13.1) software.

Discussion

MAOC is considered as the stable fraction of SOC and plays an important role in long-term SOC storage, and C and N cycling. MAOC can be decomposed due to exogenous C additions [22], challenging the view that MAOC is stable due to association with soil minerals. Some studies focused on the response of bulk SOC to exogenous C inputs [18–20] and nutrient addition [23]. They showed exogenous C inputs enhanced the priming decomposition of bulk SOC, depending on the ecosystem type, the rate and type of C inputs, soil properties, experiment conditions and nutrient status. In addition, SOC fractions including MAOC content was affected by nitrogen additions [21]. However, there is no published systematic review and meta-analysis to investigate the effect of C additions on MAOC content and priming decomposition. We hope that this study will provide useful methods for exploring the effect of exogenous C additions on MAOC storage and priming decomposition and their controlling factors.

Declarations

Author Contributions

Conceptualization: Futao Zhang

Data collection: Futao Zhang, YangYe

Data analysis: Futao Zhang, YangYe

Project administration: Futao Zhang

Validation: Bin Zhang

Writing-original draft: Futao Zhang

Writing-review & editing: Futao Zhang, Bin Zhang

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Figures

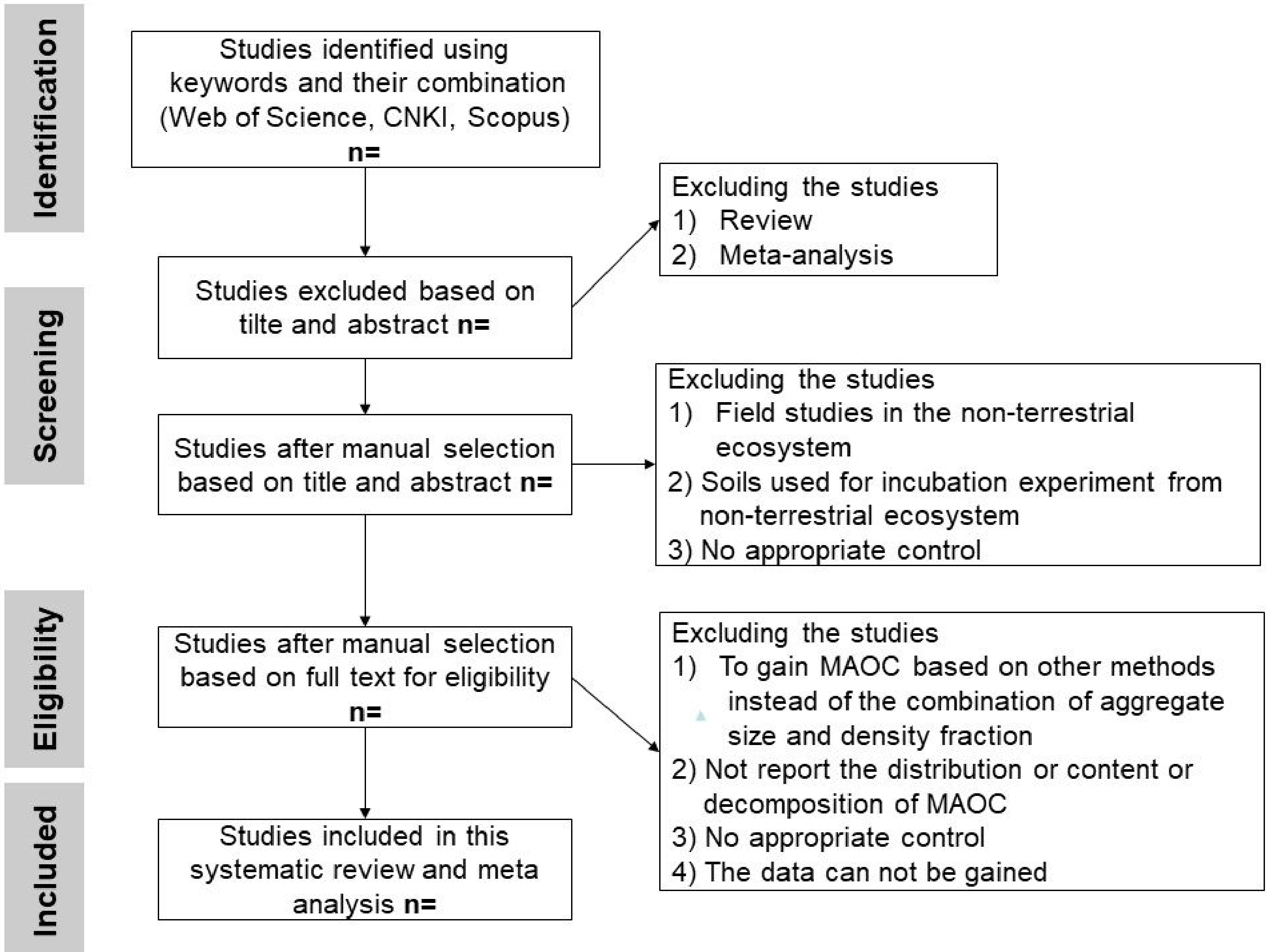

Figure 1

Flow chart of publication inclusion. CNKI, Chinese National Knowledge Infrastructure; MAOC, mineral-associated organic carbon.

Supplementary Files

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- PRISMAPchecklist.doc