Global Biogeochemical Cycles

Supporting Information for

Constraints and Drivers of Dissolved Fluxes of Pyrogenic Carbon in Soil and Freshwater Systems: a Global Review and Meta-analysis

R. B. Abney[1], M. E. Barnes[2], A. Moss[1], and F. Santos3

[1]Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA.

[2]Biological Sciences Division, Pacific Northwest National Laboratory, Richland, WA.

[3]Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN.

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Additional Supporting Information (Files uploaded separately)

Introduction

This supporting information includes some detailed methodological information, two supporting figures, two supporting tables, and metadata information for supporting dataset that is uploaded separately.

Text S1. Detailed methodology for meta-analysis

In 2021, we conducted a meta-analysis of peer-reviewed publications using Web of Science. The search terms we used were "dissolved OR particulate OR colloidal" and "PyC OR pyrogenic carbon OR black carbon OR BC OR PyOM OR pyrogenic organic matter OR charcoal OR biochar". We limited our search to papers written or translated to English and that were books, articles, and reviews. This search yielded 12,776 articles, and we removed 442 duplicates. In the following appraisal steps, we included papers that (1) concern the aqueous transport of PyC in natural systems including inland/terrestrial waters and within the soil system; (2) where aqueous transport is in the dissolved and/or particulate and/or colloidal phase; (3) concern in-lab PyC studies with dissolution, when the PyC was from plant derived material; (4) that described the chemical composition of DOM that includes a method to quantify or characterize PyC; (5) focus on biochar and they measure the dissolved concentration or quality of PyC. We excluded papers that met the following criteria: (1) dPyC was in salt marshes, ocean, atmosphere, estuaries (exclusion keywords: aerosol, PM2.5, sewer sludge); (2) dPyC was not quantified or characterized (e.g., only DOC is measured); (3) non-plant derived biochar or charcoal as a source of dPyC; (4) key terms "black carbon," "pyrogenic," "charcoal," "biochar," or "fire" are not found in the text; and (5) papers were reviews or syntheses. In the extraction step, we read the papers in detail and used the questions in Table S1 to extract data, which were inputted into excel.

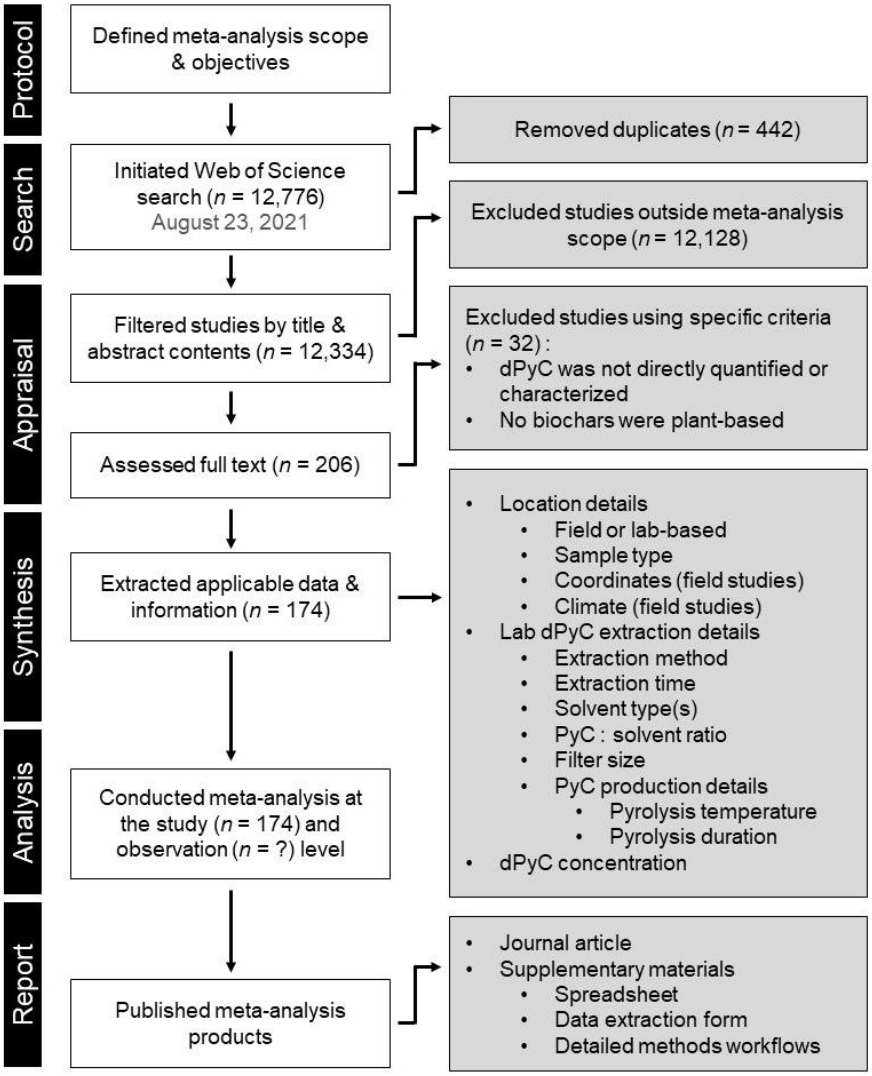

Figure S1. Flowchart depicting the steps of systematic literature review and meta-analysis based on the PSALSAR method outlined by Mengist et al. (2020).

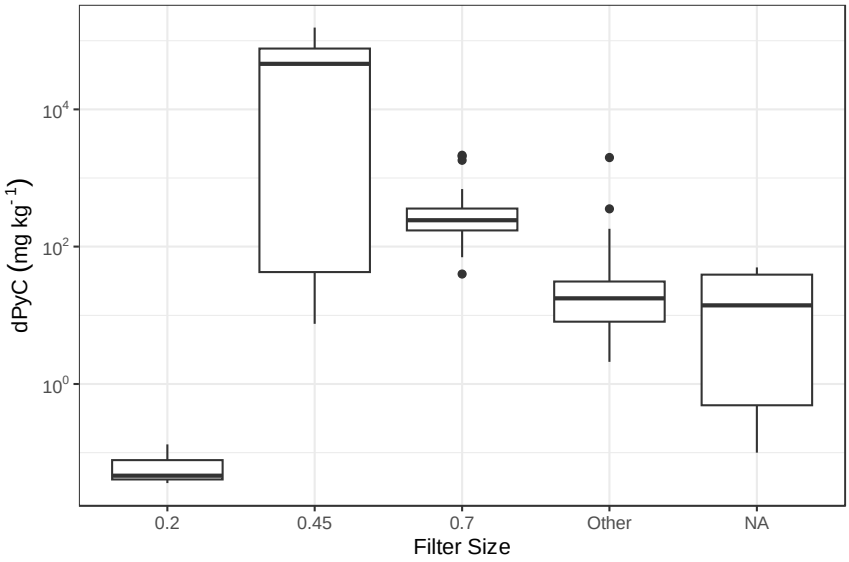

Figure S2. Relationship between reported filter size and dPyC concentration in laboratory-based studies. There are significant differences in dPyC concentration between each of the filter sizes ($\chi 2$ = 40.268; df = 3; p < 0.05).

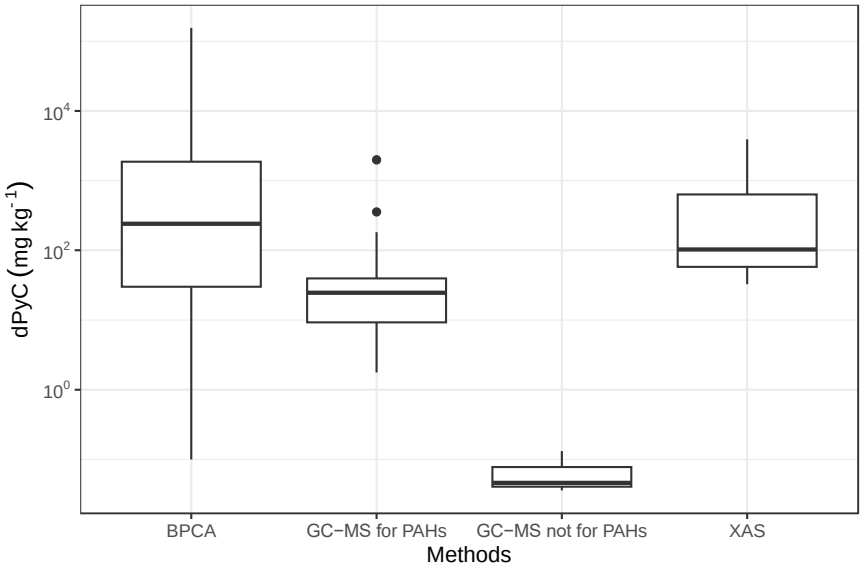

Figure S3. Relationship between method and dPyC concentration in laboratory-based studies. There are significant differences in dPyC concentration between BPCA and each of the PAH methods, but not between XAS and any of the other methods ($\chi 2$ = 26.953; df = 3; p < 0.05).

1.	Citation information
2.	Publication year
3.	What country were field observations made in?
4.	What location were field observations made in (state, province, etc.)?
5.	Latitude of individual observation
6.	Longitude of individual observation
7.	Was this observation collected in the field or lab?
8.	What koppen climate zone does this Lat/Long correspond to?
9.	What climate bin does this observation belong in (Polar, Temperate, etc.)?
10.	How did the study report the climate?
11.	Study reported MAT (C)?
12.	Study reported MAP (cm)?
13.	Vegetation type (study reported)?
14.	Soil type (study reported)?
15.	Soil depth for collected sample?
16.	Sample type of the following: Soil Lab Extract, Char Lab Extract, Precipitation, Flowing Water, Still Water, Soil Water.
17.	Biochar feedstock, of the following types: wood, herbaceous, other.
18.	Methods, of the following categories:
19.	Filter size
20.	Concentration of dPyC in mg/L
21.	Concentration of dPyC in mg/kg
22.	Concentration of dPyC in % of spectrum (1H and 13C NMR)
23.	Concentration of dPyC in DOC in mg/L
24.	Concentration of dPyC in DOC in mg/kg
25.	Was PyC measured in bulk soil? (Yes/No)
26.	Concentration of PyC in bulk soil
27.	Was carbon concentration measured in charcoal? (Yes/No)
28.	Concentration of C in charcoal?
29.	Was PyC measured in charcoal? (Yes/No)
30.	Concentration of PyC in charcoal.
31.	What method was used for solid PyC characterization (in charcoal or soil)?
32.	What was the ratio of solid to liquid for extraction of dPyC (lab studies)?
33.	What solvent type was used to extract dPyC from the following categories (lab studies):
34.	What was the maximum temperature reached for lab-made biochar (C)?
35.	How long was the biochar burned (hours)?
36.	Other notes
37.	What journal was the study published in?

Table S1. Data extraction template for dPyC meta-analysis.

Sample name	dPyC $\Delta^{14}C$	dPyC Age (years)	Reference
Precipitation			
Nam Co	-	1080	Li et al. (2018)
Lhasa	-	1750	
Chengdu	-	2300	
Kunming	-	2600	
Kathmandu	-	2200	
Tributary			
Negro	-20	-	Coppola et al. (2019)
Trombetas	14	-	
Tapajós	-771	-	
River			
Solimões	0	-	Coppola et al. (2019)
Amazon	-293 (307)	-	
Santa Clara River	-567 (184)	-	Masiello and Druffel (2001)
Changjiang (CRO3)	-64.9	475	Wang et al. (2016)
ECS-P02	-152	1230	
ECO-P04	-283	2620	
Huanghe River - January	-138 (19)	1142 (179)	
Suwannee River	-202	410	Ziolkowski and Druffel (2010)
Amazon influenced	-629	10,400	
Ocean			
Surface ocean	-450	4800 (620)	Coppola and Druffel (2016)
Deep ocean	-945	23,000 (3000)	

Table S2. Radiocarbon aging of dPyC across different sample types with standard deviation in parentheses when means are reported.

Data Set S1. Metadata for Table S3

Study or Observation: Data are organized into study level-information and individual observations (data points)

UniqueID: each line in this dataset has a unique identifier

Study Number: each study included in this dataset has a unique number identifier

Citation: Full citation information for each study

Publication year: year of publication

StudyCountry: Country where study was conducted or data were collected

Study Location: Reported location of study in manuscript

Latitude: latitude coordinate either study-reported or extracted as described in the section above

Longitude: longitude coordinate either study-reported or extracted as described in the section above

FieldorLab: data were collected in field or laboratory settings, study level may be both

Climate: Geiger-Köppen climate classification based on latitude and longitude

Climate Bin: Climate zones were binned into larger climate bins, including polar, cold, tropical, temperate, etc.

Study reported climate: Climate details reported by study

MAT: mean annual temperature, as reported by study

MAP: mean annual precipitation, as reported by study

Vegetation: any vegetation as reported by study

Soil Type: soil description information

Soil Depth: depth of sampling

Sample Type: we categorized our extracted data into the following categories of sample type: flowing water, precipitation, sediment, soil field extract, still water, surface runoff

Biochar feedstock: we characterized the biochar feedstocks into woody, herbaceous, and other. Woody plants have stem that doesn't go away, herbaceous does go away

Methods: BPCA, Chemo-thermal oxidation, FTICR-MS, GC-MS for PAHs, GC-MS not for PAHs, HPLC for PAH, hydrogen pyrolysis, levoglucosan, optics, other

Filter size: 0.2 µm, 0.45 µm, 0.7 µm, not filtered, other, N/A (filtered, but size not reported)

dPyC mg/L: reported concentration of dPyC in mg/L

dPyC mg/kg: reported concentration of dPyC in mg/kg

dPyC % ("dPyC."): reported concentration of dPyC in %

DOC mg/L: reported concentration of DOC in mg/L

DOC mg/kg: reported concentration of DOC in mg/kg

PyC in bulk soil: did the authors report the concentration of PyC in bulk soil (yes/no)

PyC in bulk soil concentration: reported concentration of PyC in bulk soil

Carbon in Charcoal: did the authors report the concentration of C in charcoal (yes/no)

Carbon in Charcoal concentration: reported the concentration of C in charcoal

PyC in Charcoal: did the authors report the concentration of PyC in charcoal (yes/no)

PyC in charcoal concentration: reported concentration of PyC in charcoal

Solid PyC method: method used to determine PyC in bulk soil or charcoal

Lab Extraction Time: extraction times were binned into the following categories (hours): 0-1.4; 1.5-4; 4.1-11.4; 11.5-24; 24.1-48; and >48

Lab Extraction Solvent: Solvents used to extraction dPyC from soils and charcoal were categorized as: acidic, basic, hot water, organic, salt, water, other, N/A

Lab Extraction Method: Mixing, settling, shaking, sonicating, stirring, other, and N/A

Lab Extract Solid to Solution ratio: ratio of solids to solution for extraction

Biochar Maximum Temperature: maximum temperature that the biochar experienced during production (ºC)

Biochar Burn Time (hours): duration of charring for biochar production

Extract Ratio Group: bin for ratio of solid to solution for dPyC extraction from charcoal

Temp Group: bin for temperature of PyC production for dPyC extraction from charcoal

Time Group: bin for time extracted for dPyC extraction from charcoal

Journal: Journal that published the manuscript

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