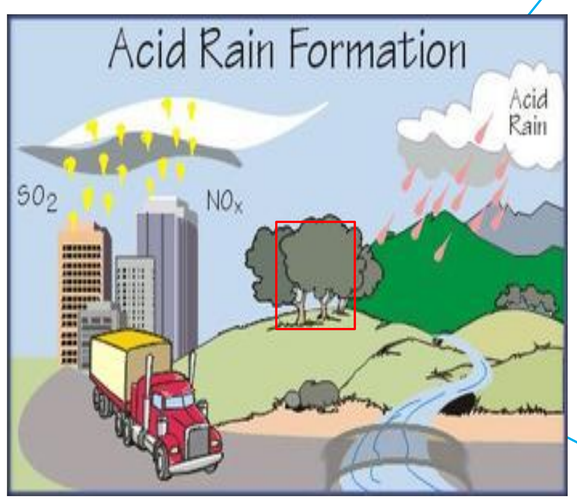
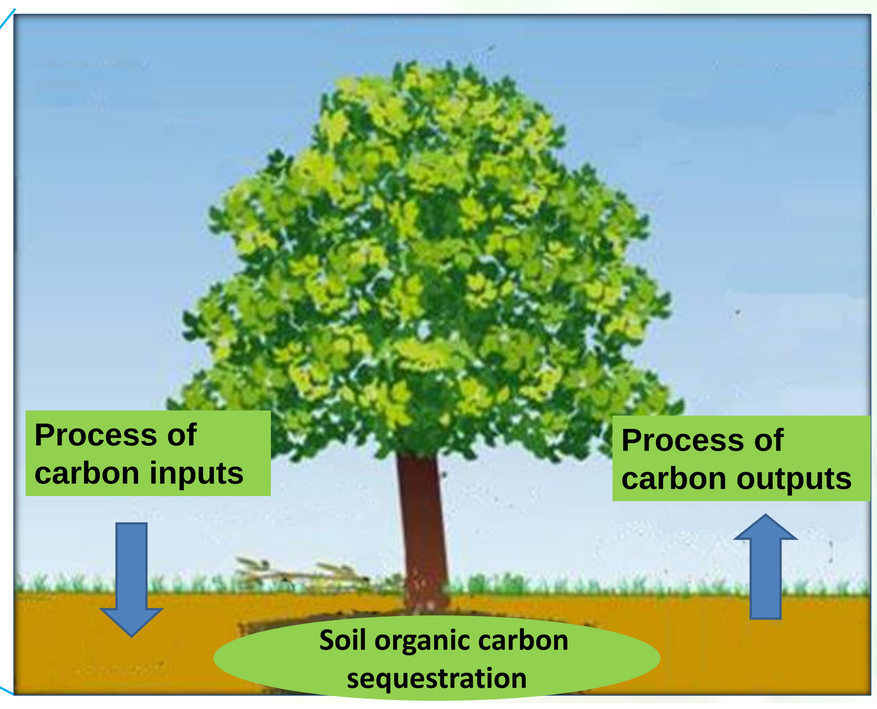
Dinghushan Forest Ecosystem Research Station, Chinese Academy of Sciences

Simulated Acid Rain Controlled Experiment Platform

Introduction

- With the continuing increase in anthropogenic activities, the fast developing areas such as southern China, are suffering severe impact by acid rain.
- Long-term leaching of acid rain could aggravate the soil acidification, affect the processes of soil organic carbon input and output, and the carbon sequestration capacity of soil.
- Understanding the responses of forest soil carbon sequestration to acid rain is crucial for predicting the present and future carbon budget dynamics in terrestrial ecosystems.



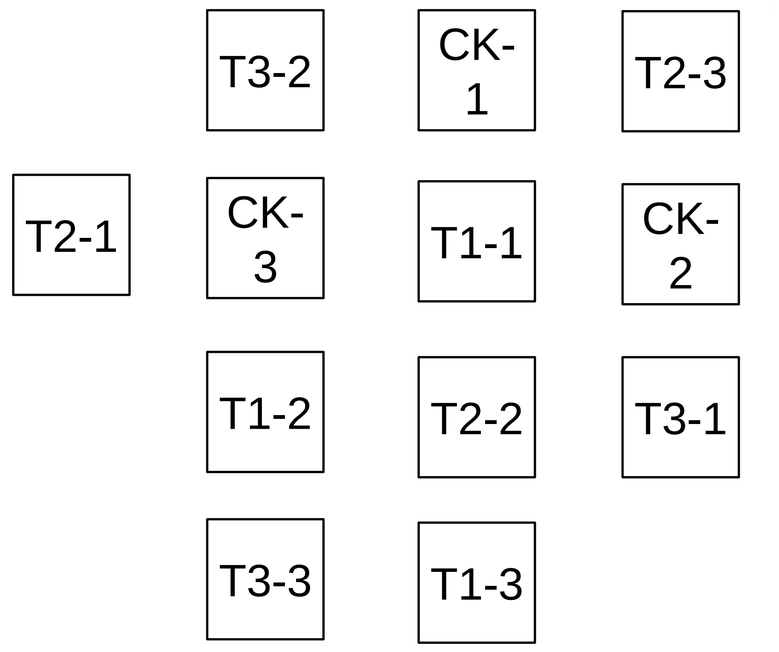


Research contents

- Above- and below-ground biomass
- Litter decomposition rate and the fate of decomposed litter carbon
- Soil respiration and soli greenhouse gases (CO_2, CH_4, N_2O) fluxes
- Soil carbon pool and different carbon components
- Soil microbial community and soil enzyme activities

Experimental design

- We conducted the field experiments with simulated acid rain (SAR) treatments in three subtropical forests: Pine Forest (**PF**), Coniferous and Broadleaved Mixed Forest (**MF**) and Monsoon Evergreen Broadleaved Forest (**BF**).
- **Four treatments** of SAR: Control (**CK**, pH-4.5), **T1** (pH-4.0), **T2** (pH-3.5) and **T3** (pH-3.0); each treatment has **three replications.**
- From June 2009, **40 L** of acid rain solutions were sprayed into each plot **every two weeks**.
- **Twelve plots** (10 m×10 m).



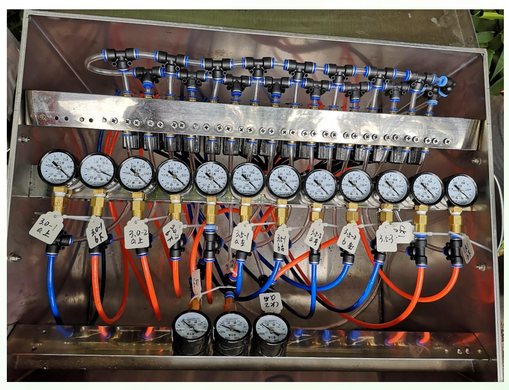
^{13}C-labelled leaf litter decomposition experiment

Aims

To investigate the effects of environmental change (*e.g.* acid rain) on the fate of decomposed litter carbon (three decomposition pathways: catabolism, fragmentation, and leaching).

Methods

- The ^{13}C-labelled litter was obtained from *Schima superba* and *Castanopsis chinensis* saplings grown for ten months in a large growth chamber under continuous label with 99% $^{13}CO_2$.
- The ^{13}C-labelled litter decomposition experiment was conducted at SAR platform in September, 2019.
- A two-compartment isotope mixing model was used to quantify the different decomposition components (respired CO_2, soil organic carbon, dissolved organic carbon).



Forest succession

PF

MF

BF

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Results

- Soil pH values were decreased significantly under the SAR treatment (Fig. 1).

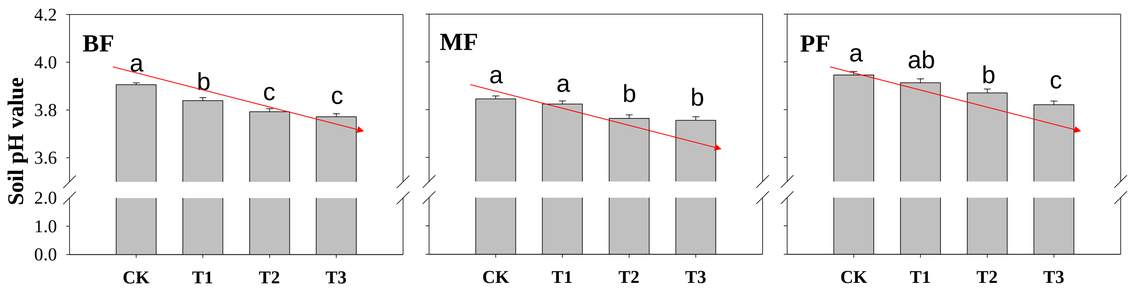

Fig. 1. Mean soil pH value in the BF, MF and PF under different SAR treatments. Different lowercase letters denote significant difference (p=0.05) between treatment.

- The SAR treatment significantly decreased mean soil respiration rate in BF and MF during the wet season (Table 1).

Table 1 Mean soil respiration rate in the PF, MF and BF under different SAR treatments.

Forest	Season	CK	T1	T2	T3
PF	Wet season	3.69±0.21 a*	3.63±0.59 a*	3.60±0.55 a*	3.61±0.06 a*
	Dry season	2.46±0.23 a*	2.56±0.67 a*	2.44±0.41 a*	2.27±0.25 a*
MF	Wet season	3.72±0.16 a*	3.78±0.11 a*	3.41±0.03 b*	3.12±0.20 b*
	Dry season	2.27±0.18 a*	2.24±0.15 a*	2.12±0.28 a*	1.95±0.13 a*
BF	Wet season	3.72±0.16 a*	3.64±0.28 a*	3.29±0.32 ab*	3.03±0.05 b*
	Dry season	2.43±0.03 a*	2.49±0.06 a*	2.27±0.27 a*	2.09±0.12 a*

- Annual soil CO_2 efflux in BF and MF were significantly decreased under the SAR treatment (Fig. 2).

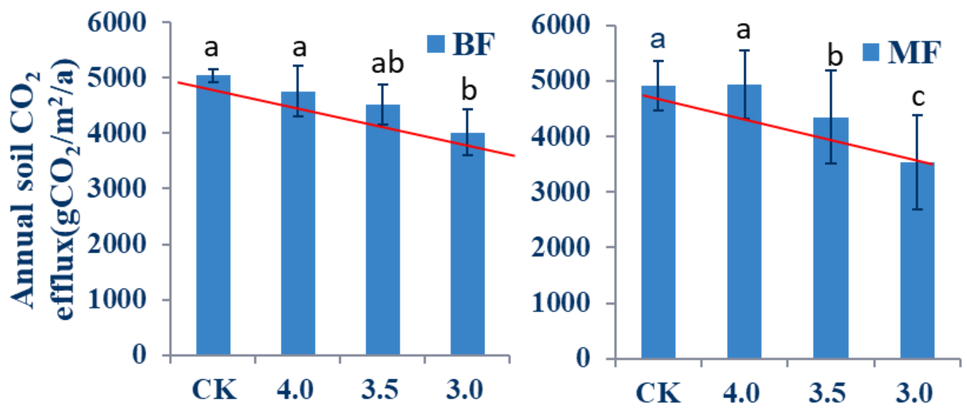

Fig. 2. Annual soil CO_2 efflux in the MF and BF under different SAR treatments. Different lowercase letters denote significant difference (p=0.05) between treatment.

- During the two-year period of litter decomposition, the SAR treatment significantly decreased the litter decomposition rate (Fig. 3).

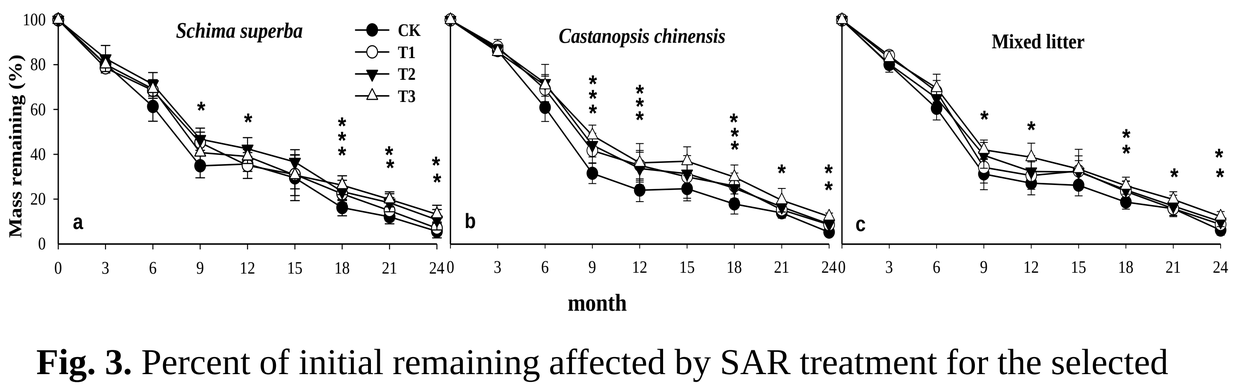

Fig. 3. Percent of initial remaining affected by SAR treatment for the selected dominant tree species in monsoon evergreen broad-leaved forest. One to three asterisk(s) (*) above each sample date indicate(s) a significant difference between CK and one to three SAR treatment(s).

- Soil total organic carbon (TOC) concentration was increased significantly under the SAR treatment in BF. However, the soil TOC in the MF and PF haven't significant differences between the SAR treatment.

- The passive organic carbon was increased significantly with the decreased pH values of the SAR treatment in BF and MF (Fig. 4).

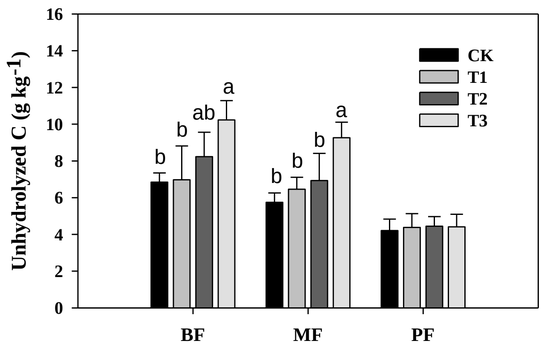

Fig. 4. Soil unhydrolyzed organic carbon concentration under different SAR treatments.

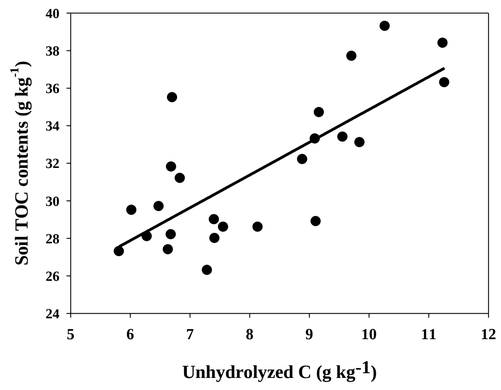

Fig. 5. Relationship between soil total organic carbon and soil unhydrolyzed organic carbon.

- Significantly positive correlation was found between soil organic carbon and passive organic carbon (Fig. 5).

- The SAR treatment significantly inhibited the total microbial biomass, especially bacterial biomass and fungal biomass (Fig. 6).

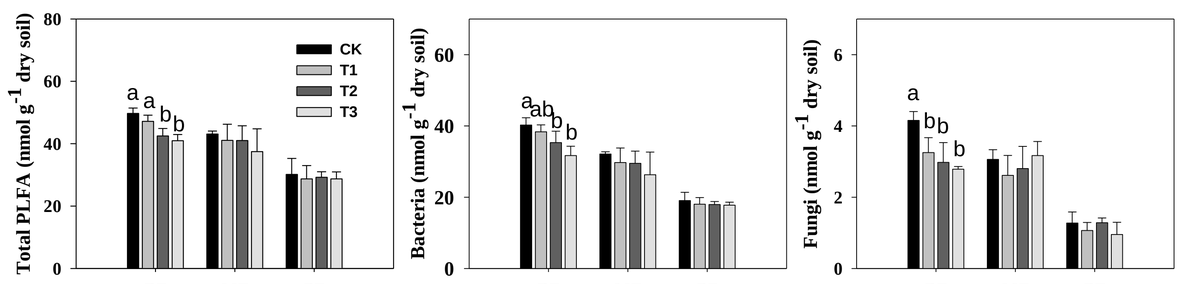

Fig. 6. Variation of soil microbial PLFAs changes under different SAR treatments in BF, MF and PF.

- The oxidase activities associated with the decomposition of organic carbon are also suppressed under the SAR treatment. A significant negative correlation was found between oxidase activity and passive organic carbon (Fig. 7).

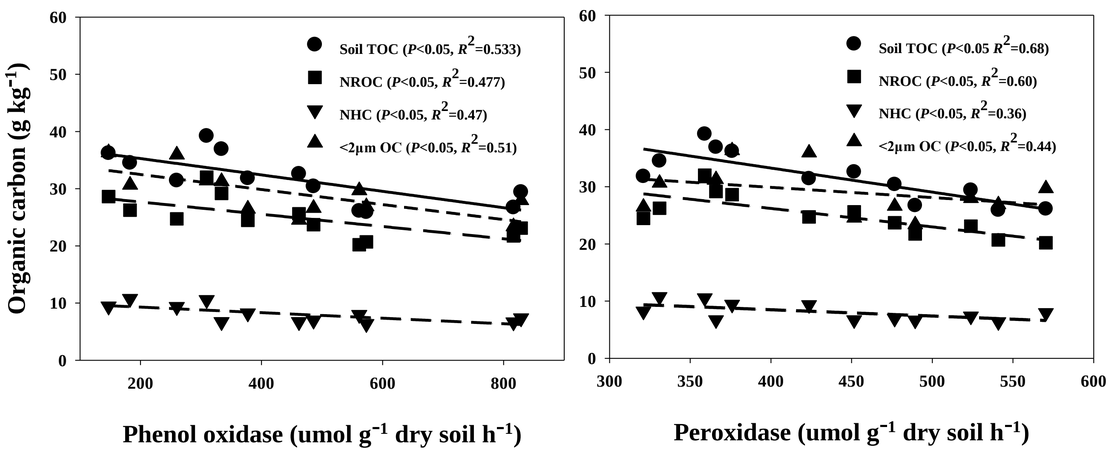

Fig. 7. Correlation of soil oxidase activities with soil total organic carbon and passive organic carbon fractions under different SAR treatments.

Conclusion

- The above results indicate that, under the long-term SAR treatment, soil organic carbon mineralization rate is slowed, and the residence time of organic carbon in soil might be lengthen, so this part of organic carbon can be preserved and accumulated in soil. Furthermore, the increase of passive organic carbon can enhance organic carbon stabilization in soil, especially in the monsoon evergreen broad-leaved forest.