Fractionation of soil organic carbon under different land management in dry tropics, south India

EGU General Assembly 2020

Eito Nonomura[1], Soh Sugihara[1], Mayuko Seki[1], Hidetoshi Miyazaki[2], Muniandi Jegadeesan[3],Pandian Kannan[3], and Haruo Tanaka[1]

[1]Tokyo University of Agriculture and Technology, Tokyo, Japan (s190131r@st.go.tuat.ac.jp)
[2]Global Environmental Forum, Tokyo, Japan [3]Tamil Nadu Agricultural University, Tamil Nadu, India

Background and objective

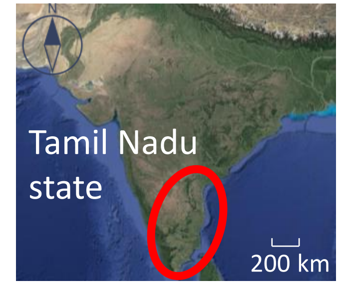
- An understanding of the mechanisms of SOC stabilization is essential to develop the appropriate management for C sequestration and soil health
- In southern India, soil C stocks are inherently low in cropland, despite relatively high clay contents **(Clay>ca. 30%, OC<ca. 5 g C kg^{-1} soil)**
- Physicochemical parameters (e.g. Al and Fe contents, exchangeable Ca) affect SOC content and stabilization

To improve the SOC dynamics in southern India, we…

(1) evaluated the effect of land management on SOC accumulation by physical fractionation, and

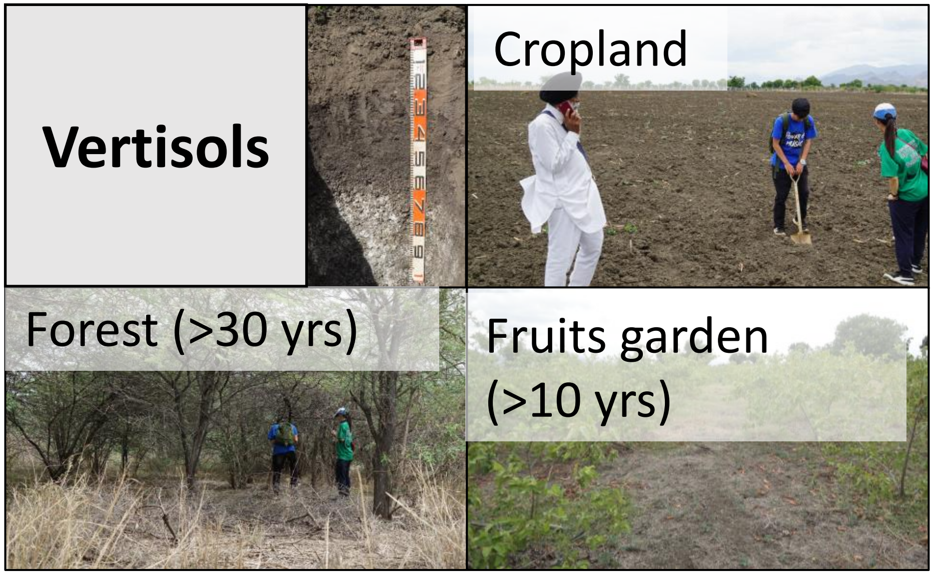
(2) investigated the drivers of C accumulation for each fraction

Materials and Methods – Site description



Study site

- Tamil Nadu State, southern India
- 2 representative sites for Vertisols and Alfisols
- We collected topsoil (0-10 cm) from 3 treatment



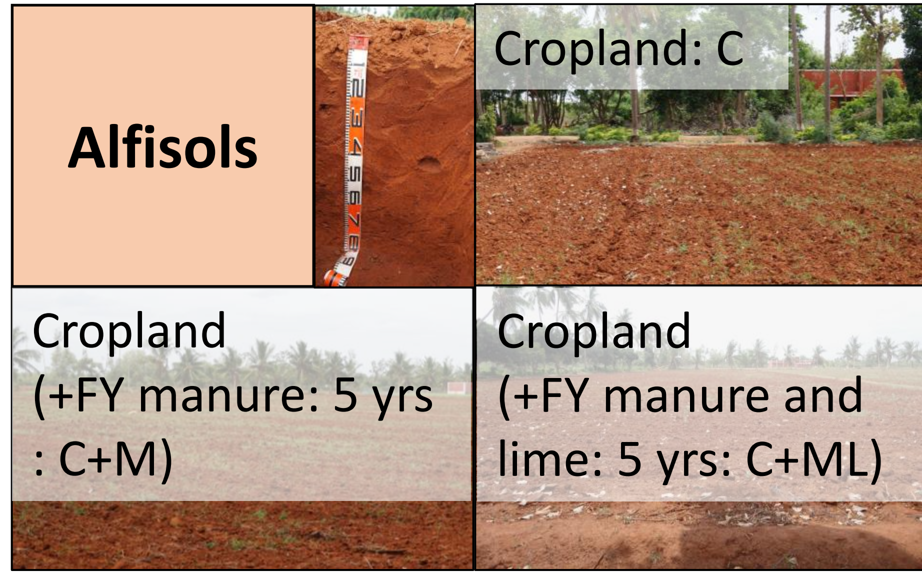


Table Physico-chemical properties of Vertisols and Alfisols

		$pH(H_2O)$	TC $g\ kg^{-1}$	Al_o $g\ kg^{-1}$	Fe_o $g\ kg^{-1}$	Ca_{ex} $cmol_c\ kg^{-1}$	Mg_{ex}	CEC $cmol_c\ kg^{-1}$
Vertisols	Cropland (n=3)	8.9	4.3	1.5	0.2	50.5	10.7	61
	Forest (n=3)	8.5	6.1	1.5	0.2	50.0	11.7	62
	Fruit Garden (n=3)	9.6	5.5	1.2	0.2	40.9	12.0	54
Alfisols	C (n=3)	6.0	6.3	0.6	0.2	2.1	0.8	13
	C+M (n=3)	6.7	7.5	0.4	0.2	1.2	1.0	11
	C+ML (n=3)	7.4	8.2	0.4	0.1	5.8	1.7	10

Al_o, Fe_o: Oxalate-extractable Al and Fe. Ca_{ex}, Mg_{ex}: Ammonium acetate-extractable Ca and Mg.

Materials and Methods - Chemical analysis

- Different SOC pools by density and size fractionation (Diochon et al. 2016).
- Each fraction was analyzed by elemental analysis (C, N).

- **Procedure**

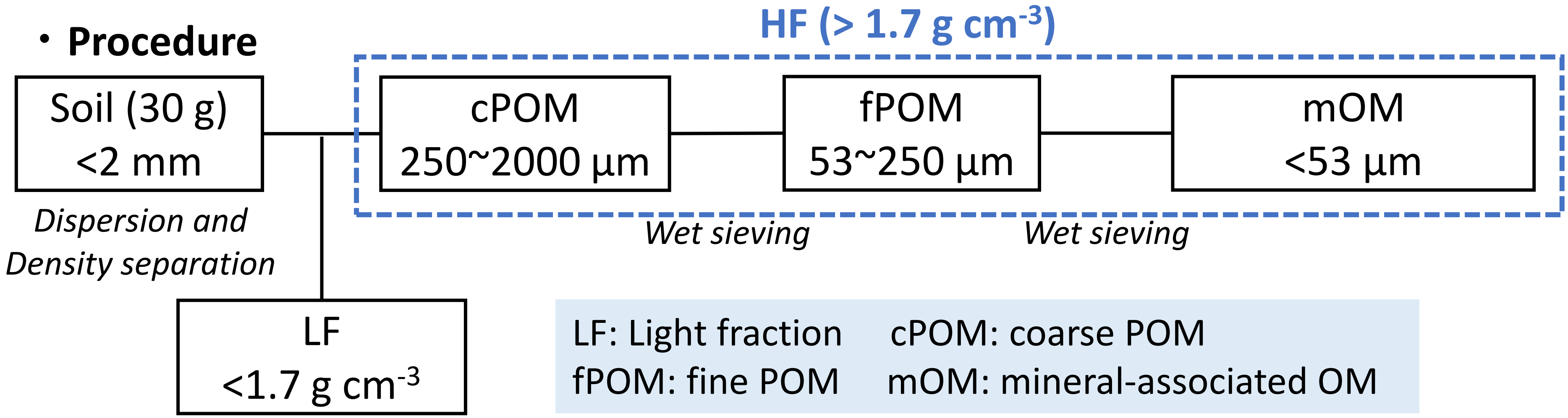
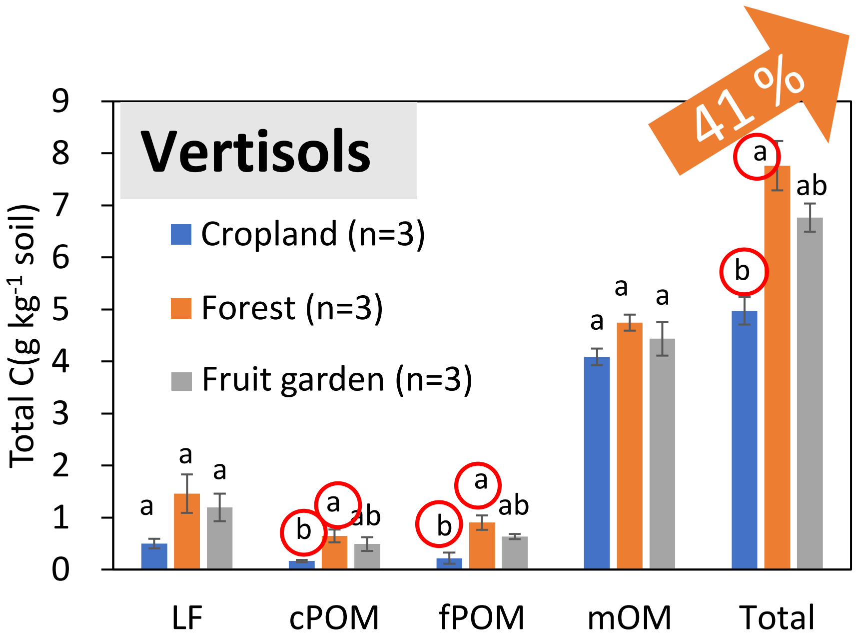
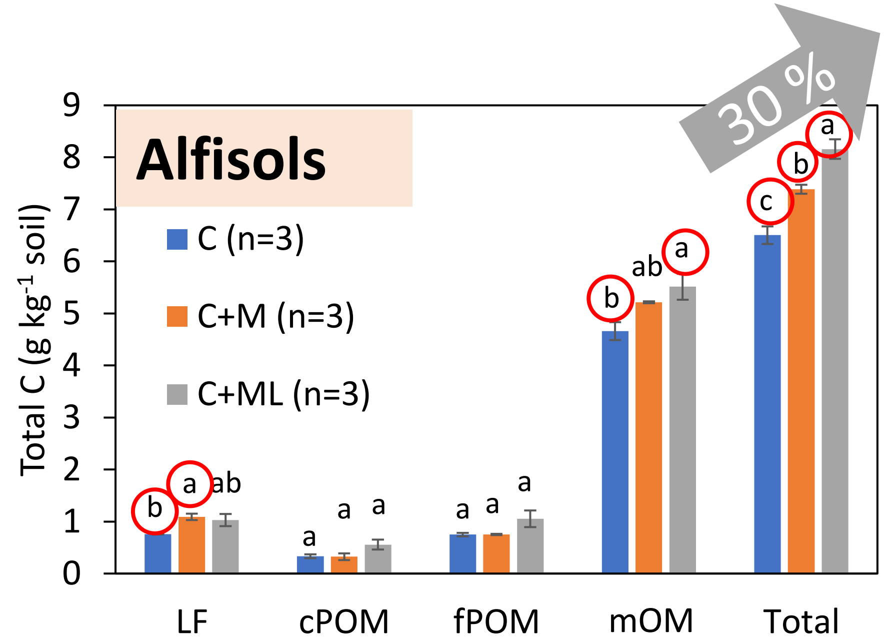


Table Soil mass distribution of physical fractions

mass(%)		LF	cPOM (2000-250 µm)	fPOM (250 -53 µm)	mOM (<53 µm)
Vertisols	Cropland (n=3)	0.2	18	6	76
	Forest (n=3)	0.5	17	12	70
	Fruit garden (n=3)	0.4	19	14	67
Alfisols	C (n=3)	0.3	31	26	42
	C+M (n=3)	0.5	36	27	37
	C+ML (n=3)	0.5	34	31	35

Results and discussions - C contents in SOC fractions





Different letters indicate significant difference between treatments ($p<0.05$)

- Forest management increased C contents of **cPOM, fPOM**, contributing higher total C contents in forest
- no significant effects on C contents in LF, mOM

- Lime and FY manure application to cropland increased C contents of **mOM**, contributing higher total C contents in C+ML
- no significant effects on C contents in cPOM, fPOM

What is the drivers of C contents of each SOC pool sizes?

Results and discussions – Drivers of SOC fraction

Table Correlation coefficients between C content of fractions and soil properties

Vertiols	Vertisols (n=9) *: $p<0.05$, **: $p<0.01$			
	LF	cPOM	fPOM	mOM
pH	-0.11	-0.06	-0.24	-0.18
Total C	0.90**	0.90**	0.96**	0.35
Ca_{ex}	-0.24	-0.31	-0.09	-0.07
Mg_{ex}	0.36	0.33	0.52	-0.03
CEC	-0.06	-0.13	0.05	0.01
Al_o	-0.22	-0.31	-0.10	-0.05
Fe_o	-0.67*	-0.62	-0.59	-0.16
mass of LF	0.97**	0.90**	0.82**	0.06
mass of cPOM	0.30	0.30	-0.12	-0.38
mass of fPOM	0.59	0.62	0.74*	0.40
mass of mOM	-0.69*	-0.72*	-0.67	-0.22

- No correlation between every fractions and minerals (Al_o, Fe_o, Ca_{ex})

⇒ cPOM, fPOM, mOM was not related to Al, Fe oxides, Ca contents, and mass of mOM

Results and discussions – Drivers of SOC fraction

Table Correlation coefficients between C content of fractions and soil properties

Alfisols	Alfisols (n=9)	*: $p<0.05$, **: $p<0.01$		
	LF	cPOM	fPOM	mOM
pH	0.62	0.69*	0.63	0.72*
Total C	0.55	0.58	0.64	0.76*
Ca_{ex}	0.00	0.60	0.82**	0.62
Mg_{ex}	0.31	0.82**	0.84**	0.65
CEC	-0.75*	-0.47	-0.24	-0.47
Al_o	-0.81**	-0.45	-0.44	-0.78*
Fe_o	-0.46	-0.29	-0.22	-0.26
mass of LF	0.91**	0.43	0.07	0.47
mass of cPOM	0.77*	0.15	-0.24	0.18
mass of fPOM	0.00	0.53	0.85**	0.71*
mass of mOM	-0.79*	-0.48	-0.27	-0.61

- Strong and negative correlation between mOM and Al_o

⇒<u>mOM-C is related to Al oxides, and decreasing with Al_o contents, possibly caused by pH increase (from pH 6.0 to 7.4)</u>

- Positive correlation between cPOM, fPOM and Ca_{ex} and Mg_{ex}

⇒cPOM- and fPOM-C are associated with Ca/Mg, such as ion-bounding, in Alfisols

Summary 1

In southern India,

(1) Effect of land management on SOC fraction

Vertisols: Forest management (>30yrs) increased C from **5.0 to 7.8 g C kg^{-1}**, mainly contributed by cPOM (17 % of increased C) and fPOM (24 % of increased C)

Alfisols: Lime and Farmyard manure application in cropland (5yrs) increased C from **6.5 to 8.2 g C kg^{-1}**, mainly contributed by mOM (52 % of increased total C)

Summary 2

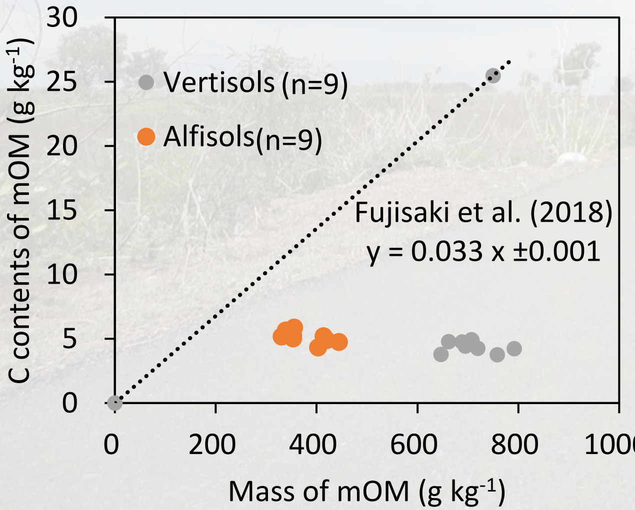
In southern India,

(2) Drivers of C accumulation (caused by land management) for each fraction

Vertisols: Organo-mineral interaction of Al/Fe/Ca in cPOM, fPOM, mOM was not clear **(=different from "Beyond Clay" theory; Rasmussen et al. (2018))**

⇒**It indicates there should be another SOC stabilization mechanism in addition to organo-mineral interaction in "Vertisols of dry tropics"**

Alfisols: mOM is related to Al oxides, and decreasing with Al_o contents, maybe caused by pH increase (from pH 6.0 to 7.4)



Relationship between OC amount of mOM and mass of fine particles < 53 µm.

Question

Why were OC saturation levels of Alfisols and Vertisols low, especially in Vertisols, compared to referred meta-data (Fujisaki et al. (2018)).

Acknowledgement; Japanese Society for the Promotion of Science, KAKENHI, Grant Numbers #17H06171, #17K19308, #18H02315, and #20H03113 financially supported this work.