



## Regulation of soil organic carbon stock with physical properties in alluvial soils of Bihar

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ARTICLE INFO	ABSTRACT
<p>Received : 16 July 2021            Revised : 24 October 2021            Accepted : 27 January 2022</p> <p>Available online: 17 April 2022</p> <p><b>Key Words:</b>            Correlation            Soil organic matter (SOM)            Soil organic carbon (SOC)            Wet aggregate stability (WAS)            Clay            Sand            Silt</p>	<p>Soil temperature and water content govern the breakdown of soil organic matter (SOM), which has a large impact on SOC storage. Apparently soil organic carbon is an excellent indicator of soil health. In this experiment, the association between several soil health indices such as soil organic carbon (SOC), soil texture, and wet aggregate stability was investigated (WAS). It was discovered that there is a substantial positive relationship between wet aggregate stability and soil organic carbon storage. Soil carbon store in East Champaran soils ranged from 5.27 to 19.60 mg/ha, with an average of 12.98 mg/ha. The wet aggregate stability ranged from 3.82 to 36.43 %, with a mean of 16.11 %. Wet aggregate stability was shown to increase as the organic carbon storage in the soil increased. This experiment also indicated that clay (%) and silt (%) had a direct impact on wet aggregate stability and, as a result, soil organic carbon storage. As a result, wet aggregate stability and soil texture have a direct and favourable influence on soil organic carbon storage in East Champaran, Bihar soils.</p>

### Introduction

In the worldwide terrestrial carbon cycle, soil organic carbon (SOC) is the single greatest carbon store (Abdalla *et al.*, 2018). It has a carbon content of around 1500 Pg, which is higher than the carbon content of plants and atmospheric reservoirs on average (Zhang *et al.*, 2018). Due to its high percentage, even modest changes in its concentration can result in significant increases in CO<sub>2</sub> emissions, resulting in global warming (Zhao *et al.*, 2006, 2018). Mineralization of SOC is a critical phase in the release of fertiliser, soil nutrients, quality improvement, greenhouse gas emissions, and, ultimately, food production (Cai *et al.*, 2016; Mustafa *et al.*, 2020; Wang *et al.*, 2008; Soderstrom *et al.*, 2014). To better soil fertility management, climate change mitigation, and food safety, a complete examination of all the features

and variability of SOC mineralization processes is necessary (Mustafa *et al.*, 2020). Aggregate stability is a soil quality indicator that is linked to the quantity of organic matter in the soil. Soil organic matter makes soil surface aggregates more stable, allowing them to withstand moisture and mechanical forces from tillage equipment and vehicle activity (Hernanz *et al.*, 2002, Tisdall and Oades, 1982; Oades, 1984). A substantial link between SOC and macro and micro aggregate structural stability (250 mm) has been discovered in several research on diverse soils and climatic situations (Hernanz *et al.*, 2002; Cannell and Hawes, 1994). Complete SOC is widely recognised as a dynamic process with several components, and increasing the amount of carbon sequestered in these components is critical for reducing carbon

conversion to greenhouse gases and avoiding climate change. (Mustafa *et al.*, 2020; Mikha & Rice, 2004) The breakdown of organic matter in soil is one of the most significant processes that contribute to the long-term sustainability of SOC and carbon sequestration in soil aggregation (Mustafa *et al.*, 2020, Lal, 2004; Six *et al.*, 2004; Abrar *et al.*, 2020). By physically protecting SOC from mineralization, soil aggregates serve a crucial role in soil fertility maintenance and structure. It is also recognised as a crucial indicator of the formation, deterioration, and stability of soil structures (Mustafa *et al.*, 2020, Six *et al.*, 2004; Abiven *et al.*, 2009). In recent decades, the amount of inorganic and organic fertilisers used in agricultural operations has increased, raising the danger of soil depletion, which is connected to unsustainable resource use practises (Mustafa *et al.*, 2020, Bronick and Lal, 2005; Guo *et al.*, 2019). As a result, it is strongly advised to adopt optimal fertilisation strategies to improve soil quality, soil C sequestration, and agronomic efficiency (Mustafa *et al.*, 2020, Guo *et al.*, 2018; Tanveer *et al.*, 2019). The primary goal of this study was to determine if aggregate stabilisation, in association with soil texture, plays a major influence in SOC storage management.

## Material and Methods

### Description of the site, the experimental setup, and soil sampling:

Muzaffarpur is geographically located in Bihar between 26°07'N and 85°24'E with sub-tropical climate. East Champaran is geographically located in Bihar between 26°38'N and 84°54'E at an elevation of 62 m above sea level (a.s.l.). The area is characterized by a Hot Subhumid (moist) climate, with hot, humid summers and mild winters. The yearly average rainfall is 1202 mm. The major soil types are Udifluvents, Haplaquents, Paleustalfs alluvial with silty to sandy loam texture, and calcareous nodules (kankar).

Soil samples were collected at 0-15 cm soil depth, air-dried for 6 days, passed through a 2 mm sieve and kept for analysis of wet aggregate stability (WAS), soil texture, and SOC.

### Assessment of soil texture:

14g (+/- 0.1g) of sieved soil was added to a 50 ml centrifuge tube holding 42 ml of a dispersant 3%

sodium hexametaphosphate solution. To completely disperse soil into suspension, it was continuously agitated for 2 hours on a shaker. The whole contents were sieved onto a 0.053 mm sieve assembly over a plastic funnel above a 1L beaker. The sand that has accumulated on top of the sieve is collected in a metal container and put aside.

Silt and clay particles were collected in a 1L beaker and stirred to re-suspension before being allowed to settle for 2 hours. Before measuring dry weight, both the sand and silt fraction cans were dried at 105°C to a consistent weight. Percent sand, silt, and clay were then calculated as follows:

Sand % = (mass of oven dry sand/ mass of original sample) x 100%

Silt % = (mass of oven dry silt / mass of original sample) x 100%

Clay % = 100 - (Sand % + Silt %)

### Assessment of wet stable aggregate:

4g of air-dried, 2-mm aggregate soil sample was included in each 0.25-mm sieve. Initially, the precise weight of each sample was recorded. Each soil sample was reproduced in replication, resulting in a total of four samples per eight-sieve batch. In an Eijkelkamp machine, soil samples were dispersed for 3 minutes with 100mL distilled water and then for 10 minutes with a 2g/L sodium hexametaphosphate solution. Both solutions were filtered using pre-weighed filter sheets. After being oven-dried at 105°C, each filter paper was weighed. % stable aggregate was calculated using the following equation:

$$\% \text{ stable aggregates} = \frac{\text{Weight of soil in dispersing solution}}{\text{Weight of soil in dispersing solution} + \text{weight of soil in water}}$$

### Assessment of soil organic carbon, soil organic matter, and soil organic carbon stock:

The amount of soil organic carbon (SOC) was calculated using the Walkley and Black technique (1934). The calculated SOC was then multiplied with Von Bemlen factor (1.724) to determine soil organic matter (SOM). SOC stock was calculated by multiplying area (m<sup>2</sup>), bulk density (Mg m<sup>-3</sup>), soil depth (m), and SOC (percent).

### Statistical analysis

Statistical analysis was done using SPSS software version 16.0.

**Results and Discussion**

**Variation of soil organic carbon (SOC) and soil organic matter (SOM) in Alluvial soils of Bihar**

The soil system regulates plant growth in the terrestrial ecosystem (Nath *et al.*, 2021). SOM and SOC play a vital role in good plant growth and soil health. SOM is one of the sources and sink of SOC. SOC in these studied soil samples of Muzaffarpur varied between 0.32 – 0.73 % and in case of East Champaran varied between 0.24-0.99 % with a mean of 0.66 %. SOM ranged from 0.46 to 1.71 % with a mean of 1.13 % (Figure 1). The data of SOC and SOM revealed that increase in SOC improves SOM content. Both SOM and SOC were positively correlated. One of the most important elements affecting soil stability is organic matter (Hernanz *et al.*, 2002; Follett and Peterson, 1988; Ekwue, 1990). The surface layer of soil was found to be

stable with greater SOC content (Hernanz *et al.*, 2002, Kay *et al.*, 1994).

**Wet aggregate stability and soil organic carbon stock**

Soil carbon stock in soils of Muzaffarpur varied between 6.43 to 14.63 Mg ha<sup>-1</sup> and East Champaran varied between 5.27-19.60 Mg ha<sup>-1</sup> with an average of 12.98 Mg ha<sup>-1</sup> respectively. Wet aggregate stability of Muzaffarpur varied between 5.17 to 40.17 % and in case of East Champaran varied between 3.82-36.43 % with a mean of 16.11 % (Figure 2). WAS increase with increase in SOC store. Aggregate protects SOM by physical disconnection (Chaplot *et al.*, 2015; Schmidt *et al.*, 2011). This experiment revealed that soils with the highest aggregate stability are characterized by more SOC stock.

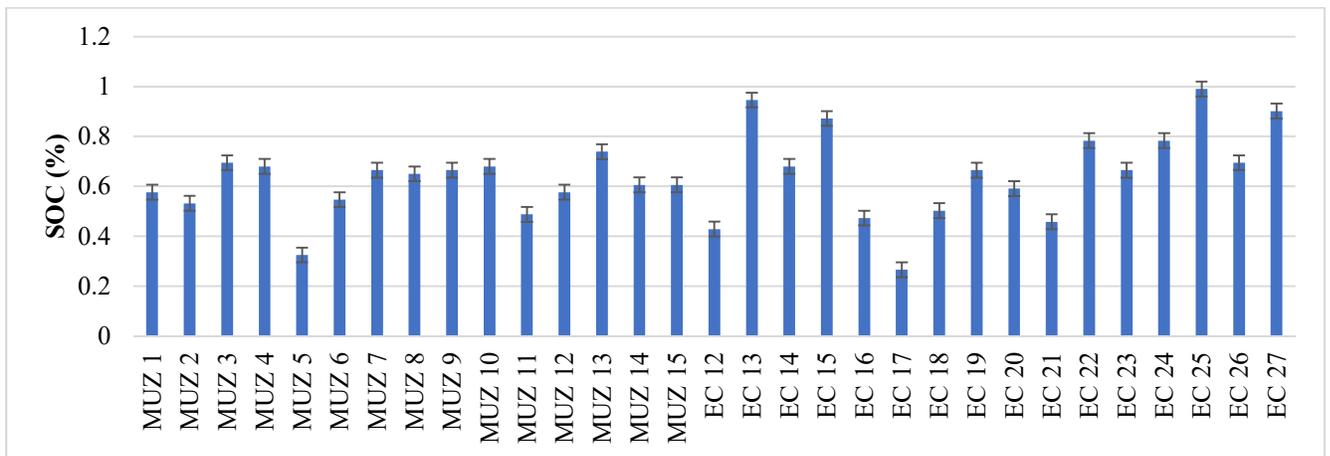


Figure 1: Level of soil organic matter (SOM) and soil organic carbon (SOC) in Alluvial soils of Bihar.

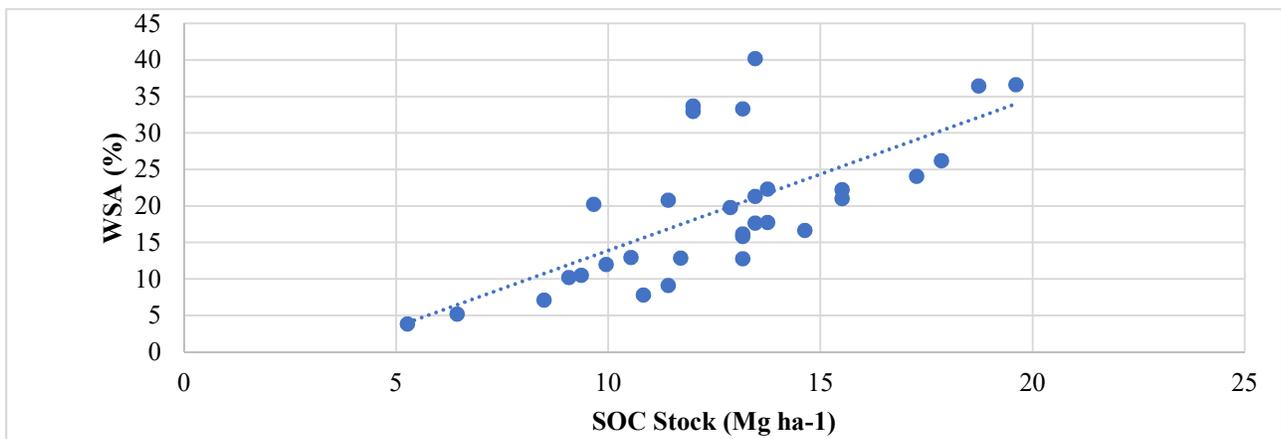


Figure 2: Relationship between wet aggregate stability (%) and SOC stock in alluvial soils of Bihar.

A possible explanation of this result could be attributed to soil organic matter content and quality. Binding agents, which are typically polysaccharides derived from exocellular mucilages and root exudates, situated between aggregates may create an active pool (Chaplot *et al.*, 2015; Von Lützow *et al.*, 2008), resulting in significant SOC storage. In high aggregate stability soils, fresh plant residues, as well as various faunal and microbial residues, which constitute alternate pools of easily accessible SOM to decomposers (Chaplot *et al.*, 2015; Von Lützow *et al.*, 2008), are more likely to be found than in low aggregate stability soils. Plant organic residue, as well as microbial and microfaunal waste, including fungal hyphae in various stages of decomposition, make up the light fractions (Chan and Heenan, 1999; Jansen *et al.*, 1992). According to the soil aggregation hierarchical model, there are efficient stabilizing agents for soil macroaggregates (Tisdall and Oades, 1982). The increased microbial activity led these light fraction materials to disintegrate preferentially and they are primarily associated with macro-aggregates which

played a major role in aggregate stability (Chan and Heenan, 1999).

#### **Descriptive statistics of sand, silt, and clay content in Alluvial soils of Bihar**

The textural class of studied soil samples was silt loam. The sand % varied between 6.16–41.58 % with a mean of 19.60 and while the clay % ranged from 52.46 to 83.11% with a mean of 71.49 (Table 1). The maximum and minimum data of clay were 3.22 and 17.94 respectively with a mean of 8.95. The positive skewness data of sand (0.67) and clay (0.48) revealed that the right side of the distribution has a longer or flatter tail, and also data are fairly symmetrical. The negative skewness data of silt (-0.60) suggests that the left side distribution is longer or flatter than the tail on the right side. Besides the negative skewness (-0.60) revealed that the data are highly skewed (Table 1). The negative kurtosis of sand (-0.82), silt (-0.91), and clay (-0.60) revealed that the distribution curve had flattened top than the normal curve and platykurtic distribution is found.

**Table 1: Descriptive statistics of sand, silt and clay content in soil samples of alluvial soils of Bihar.**

<b>Descriptive parameters</b>	<b>Sand (%)</b>	<b>Silt (%)</b>	<b>Clay (%)</b>
<b>Mean</b>	19.60 (+2.04)	70.69 (+1.81)	9.71 (+0.91)
<b>Median</b>	16.60	74.59	9.11
<b>Std. Deviation</b>	11.89	10.11	4.28
<b>Variance</b>	141.29	102.13	18.34
<b>Skewness</b>	0.67 (+0.41)	-0.60 (+0.41)	0.48 (+0.41)
<b>Kurtosis</b>	-0.82 (+0.85)	-0.91 (+0.85)	-0.60 (+0.81)
<b>Range</b>	35.46	30.65	14.72
<b>Minimum</b>	6.14	52.46	3.22
<b>Maximum</b>	41.60	83.11	17.94

#### **Correlation among SOC (%), SOM (%), SOC stock, WAS, Sand (%), Silt (%), and Clay (%) in Alluvial soils of Bihar**

The correlation coefficient among SOC (%), SOM (%), SOC Stock, WAS, Sand (%), Silt (%), and Clay (%) was highly significant (Table 2). It was also observed that soil organic carbon (SOC) was positively significant correlated (0.696\*\*) with wet aggregate stability (WAS) and negatively significant correlated (-0.682\*\*) with sand percentage at 0.01 level of significance. Similarly, SOC stock was

significantly correlated with water aggregate stability (WAS), silt and clay percent. However, negative correlation observed between SOC and sand (%). Sand has a negligible contribution towards the SOC stock build-up in the soil. Table 2 displays that water aggregate stability (WAS) has a negative correlation with sand (%) and a positive correlation with both silt (%) and clay (%). Silt (Thomasson, 1978), sand (Williams, 1970), and clay fractions (Kemper & Koch, 1966) have been identified as having a significant impact on the stability of soil aggregates.

**Table 2: Correlation between SOM (%), SOC (%), Soil Organic Carbon stock, WAS, Sand (%), Silt (%) and Clay (%) of alluvial soils of Bihar**

	SOM (%)	SOC (%)	SOCstock (Mg/ha)	WAS (%)	Sand (%)	Silt (%)	Clay (%)
<b>SOM (%)</b>	1						
<b>SOC (%)</b>	0.806**	1					
<b>SOCstock (Mg/ha)</b>	0.806**	1.000**	1				
<b>WAS (%)</b>	0.397**	0.696**	0.695**	1			
<b>Sand (%)</b>	-0.493**	-0.682**	-0.683**	-0.480**	1		
<b>Silt (%)</b>	0.438**	0.655**	0.658**	0.462**	-0.937**	1	
<b>Clay (%)</b>	0.336**	0.348**	0.343**	0.243**	-0.565**	0.241	1

\*\*Correlation is significant at the 0.01 level.

## Conclusion

The link between wet aggregate stability, soil texture, and soil organic carbon was studied in this study (SOC). The preceding experiment indicated a considerable positive association between soil aggregate stability (WAS) and SOCstock. Clay (%), silt (%), and soil organic matter (SOCstock) properly proxied wet aggregate stability (WAS) and SOCstock (SOM). SOCstock was much higher in soils with the highest stable aggregate stability than in soils with the lowest stable aggregate stability. The main influential factors on clay (%), silt (%), soil organic matter (SOM), and mineralization of organic carbon (aggregate associated) in the soil studied were SOC stocks and aggregate stability, according to correlation analysis. Future study should focus on the primary

reasons of SOC sequestration in component C fractions, as well as potential protective factors.

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## Conflict of interest

The authors declare that they have no conflict of interest.

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