# Effect of Biochar derived from Solid Part of Anaerobic Digestion Effluent from Slaughter House Wastewater on Clayey Soil Aggregate Stability

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## Introduction

### Soils in Guanajuato, Mexico

Vertisols in Guanajuato, Mexico contain high contents of clay and suffer from poor soil physical properties such as low infiltration and poor aeration due to unstable rainfall and long term and over use of chemical fertilizers.

### Soil Aggregation

Soil aggregates play major roles for sound physicochemical and biological functions of soils. Organic matters can improve soil physical structures such as aggregates due to enhanced microbial activities. Clayey soils form soil aggregates with organic matters and clay minerals on variable charged surfaces through ligand exchange reactions.

### Anaerobic Digestion Effluent

One of major industries in Guanajuato is meat production daily releasing 2 million L of wastewater. Treating the wastewater with anaerobic digestion leaves large volume of anaerobic digestion effluents (ADEs). Utilization of ADEs needs to be implemented.

## Objectives

To evaluate soil aggregate formation and stability induced by application of biochar derived from ADE from slaughter house near Guanajuato.

- ✓ Soil Respiration
- ✓ Soil Aggregate Distribution
- ✓ Mean Weight Diameter

## Materials and Methods

### Incubation Study

◆ **Phaeozem and Vertisol** (Guanajuato, Mexico)
- ✓ Oven dried (45°C) with 2 mm sieved

◆ **Anaerobic digestion effluent biochar** (Guanajuato, Mexico)
- ✓ Solid part pyrolysed under oxygen limitation
- ✓ Pyrolysis temperatures at 550°C (BC550) and 800°C (BC800)
- ✓ Oven dried (105°C) with 150 µm sieved
- ✓ Applied at 1% (w/w) to 50 g of soil

◆ **Incubation conditions**
- ✓ In an incubator at approximately 30°C for 40 d
- ✓ Water contents maintained at 50% of water filled pore space

◆ **Experimental treatments**
1. Phaeozem
2. Phaeozem +BC550 (Ph550)
3. Phaeozem +BC800 (Ph800)
4. Vertisol
5. Vertisol+BC550 (Ve550)
6. Vertisol+BC800 (Ve800)

Table 1. Basic properties of soils

| Soil | pH | Sand (%) | Silt (%) | Clay (%) |
|---|---|---|---|---|
| Phaeozem | 7.6 | 42 | 29 | 29 |
| Vertisol | 5.6 | 42 | 23 | 35 |

### Study 1. Physicochemical Study

◆ **Biochar yields**
◆ **Thermogravimetric analysis**
- ✓ Ash, volatile matter, and fixed carbon

◆ **Chemical analyses**
- ✓ pH, total C (TC), total N (TN), water extractable organic carbon (WEOC)

### Study 2. Soil Respiration

◆ **Closed Static Chamber Method of Alkali Trapping**
- ✓ Collecting dates : Day 0, 0.5, 1, 2, 3, 4, 5, 6, 7, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38 and 40

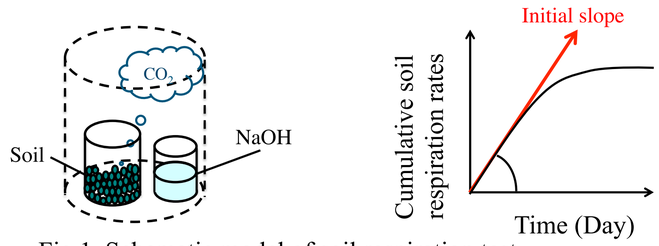



Fig.1. Schematic model of soil respiration test

### Study 3. Soil Aggregate Distribution

◆ **Water sieved method**
- ✓ Sieving sizes : 20, 106, 250, 500, 1000, and 2000 µm diameter

◆ **Mean Weight Diameter**
- ✓ $MWD\ (mm) = \Sigma\ (\bar{x}_i \times w_i)$
  - $\bar{x}_i$ Representative sieve size
  - $w_i$ Proportion of soil weight on the each sieve size

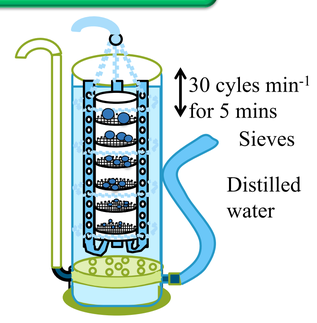



Fig.2. Schematic model of soil aggregate size distribution

## Results and Discussion

### Study 1. Physicochemical study

Table 2. Yields of biochars

| Temperature | Raw material (g) | Biochar (g) | Yield (%) |
|---|---|---|---|
| BC550 | 80 | 22.0 | 27.5 |
| BC800 | 80 | 20.3 | 25.4 |

- ➢ Larger yield with BC550 than BC800 due to loss of volatile matter (Table1)
- ➢ Greater volatile matter and WEOC in BC550 than in BC800 (Table2)

Table 3. Chemical properties of soils and biochars

| Parameter | Phaeozem | Vertisol | BC550 | BC800 |
|---|---|---|---|---|
| pH | 7.6 | 5.6 | 8.6 | 9.3 |
| TN (g kg$^{-1}$) | 0.47 | 0.2 | 27 | 46 |
| TC (g kg$^{-1}$) | 17.7 | 7.11 | 251 | 343 |
| $NH^+_4$-N (mg kg$^{-1}$) | 3.38 | 21.6 | n.d. | n.d. |
| $NO^-_3$-N (mg kg$^{-1}$) | 10.1 | 3.17 | n.d. | n.d. |
| WEOC (µg g$^{-1}$) | n.d. | n.d. | 1063 | 955 |
| TOC (g kg$^{-1}$) | 12.1 | 4.9 | n.d. | n.d. |
| CEC (cmol$_c$ kg$^{-1}$) | 52.5 | 26.0 | n.d. | n.d. |
| Volatile matter (%) | n.d. | n.d. | 37.2 | 16.4 |
| Fixed carbon (%) | n.d. | n.d. | 15.4 | 15.9 |
| Ash (%) | n.d. | n.d. | 42.8 | 64.0 |

### Study 2. Soil Respiration

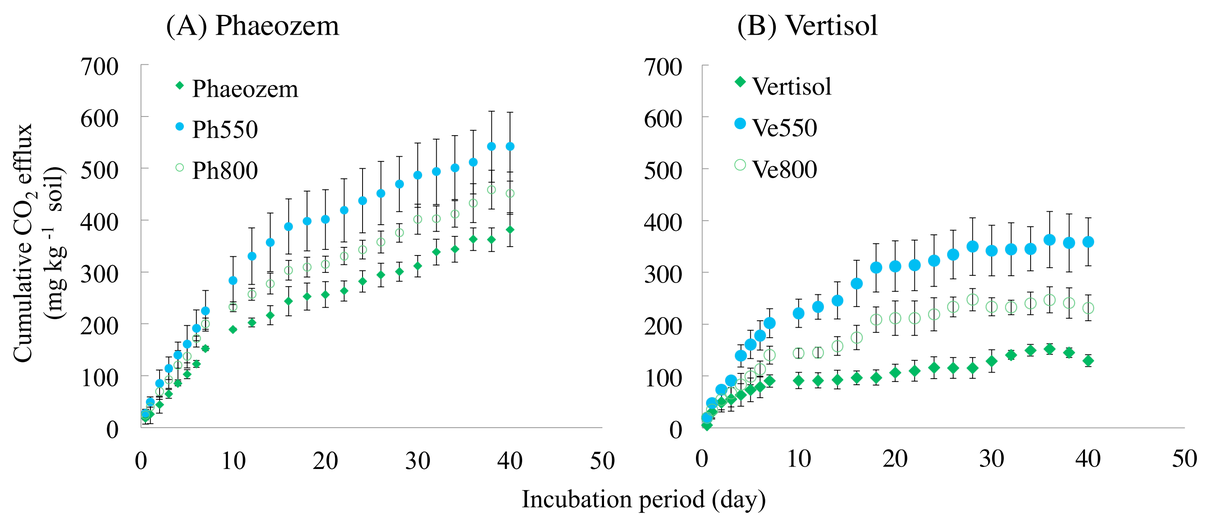



Fig. 3. Changes of the gross cumulative soil respiration in (A) Phaeozem and (B) Vertisol

- ➢ Cumulative $CO_2$ effluxes in both soils with BC rapidly increased during first 16 d of incubation.
- ➢ Cumulative $CO_2$ effluxes with BC550 were significantly greater than those with BC800 for both soils.

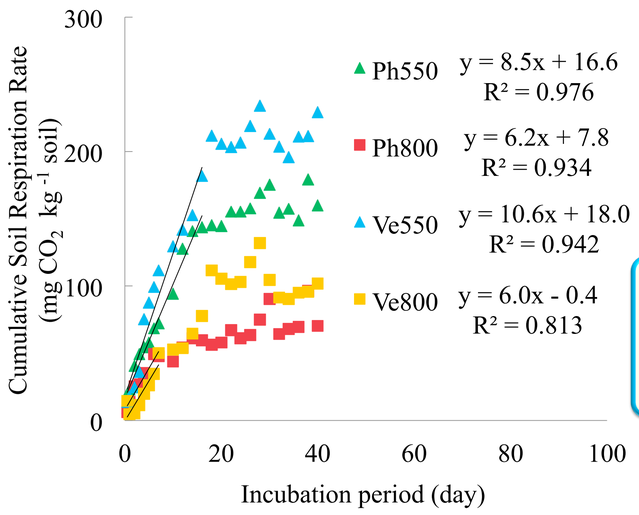



Table 4. The initial slope of cumulative soil respiration rates (mg $CO_2$ kg$^{-1}$ soil day$^{-1}$)

| | |
|---|---|
| Ph550 | 8.5 |
| Ph800 | 6.2 |
| Ve550 | 10.6 |
| Ve800 | 6.0 |

- ➢ Greater WEOC in BC550 may have caused greater cumulative soil respiration rates than BC800.

### Study 3. Soil Aggregate Distribution

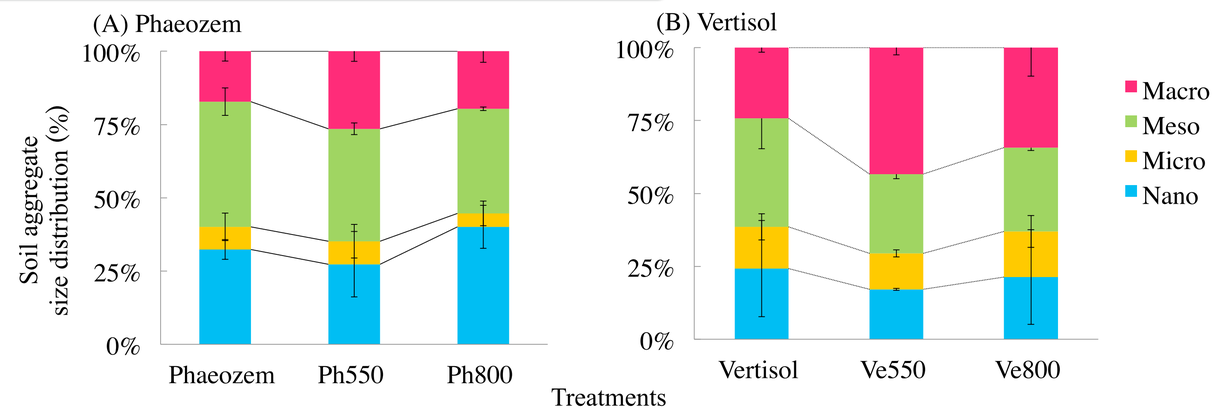



Fig. 5. Soil aggregate size distribution in (A) Phaeozem and (B) Vertisol

- ➢ Increases in macro-aggregate fraction and MWD caused by BC application were greater with BC550 than with BC800.

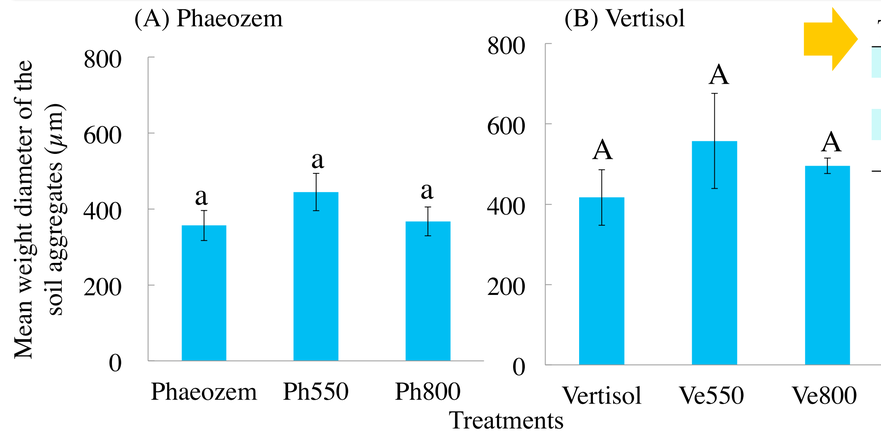
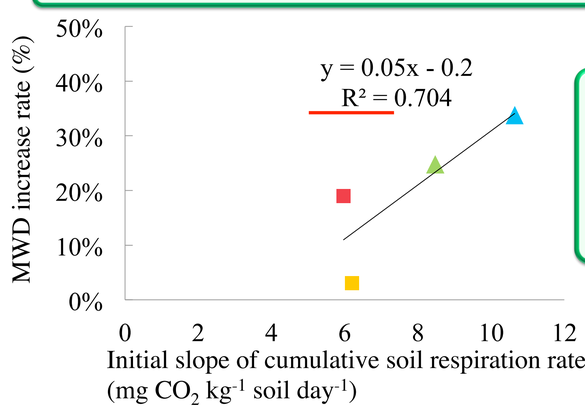



Table 5. MWD increase rate (%)

| | |
|---|---|
| Ph550 | 25 |
| Ph800 | 3 |
| Ve550 | 34 |
| Ve800 | 19 |

Fig. 6. Mean weight diameter of soil aggregates with or without BC incubated during beginning of incubation

- ➢ Greater WEOC in BC550 may have caused increased MWD in BC550-applied soil than BC800-applied soil.




- ➢ Positive correlations between the initial slope of cumulative soil respiration rates and MWD increase rates were observed for both soils combined.

Fig. 7. Correlation between the initial slope of cumulative soil respiration rate and MWD increase rate

## Conclusions

- ➢ Cumulative respiration rates with BC550 and BC800 rapidly increased during first 16 d of incubation in both soils, however those with BC550 were significantly greater than those with BC800 for both soils.
- ➢ Increases in macro-aggregate fraction and MWD caused by BC application were greater with BC550 than with BC800.
- ➢ Positive correlations between the initial slope of cumulative soil respiration rates and MWD increase rates were observed for both soils combined possibly because greater WEOC in BC550 may have caused greater soil respiration rates and MWD than that in BC800.

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