K-STATE Research and Extension

Soil Physical Properties at an Abandoned Mine in Central USA

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Introduction

Contaminated soils from mining pose problems for people living within the Tri-State area, located in southwest Missouri, southeast Kansas, and northeast Oklahoma. Galena, KS, is part of the Tri-State Mining area where Pb and Zn were mined. To reduce bioavailability of these heavy metals, amendments were added to the soils in May, 2006 (Baker et al., 2011). Baker et al. (2011) studied the effect of amendments on soil microbiology. However, they did not study the physical characteristics of the soil. Therefore, in November, 2014, 8.5 years after additions of combinations of compost, lime, and bentonite, the mine waste sites were sampled to determine water content, bulk density, hydraulic conductivity, wet aggregate stability, and aggregate size distribution to see if the amendments had long-term effects on the physical properties of the waste materials.

Objectives

Determine the effect of different soil amendments 8.5 years after addition on the following soil physical properties (Fig.1).

- Hydraulic conductivity (k)
- Bulk density (BD)
- Water content (WC)
- Aggregate stability
- Particle size distribution

Fig. 1: Taking soil physical measurements

Materials and Methods

The study area was located in Galena, KS, within the Tri-State Mining area. There were two sites (Figs. 2 and 3) and at each site there were 7 treatments consisting of combinations of low and high compost, lime, and/or bentonite. Detailed information regarding the treatments of the plots can be found in Baker et al. (2011).

Fig. 2: Plots from site A

Fig. 3: Plots from site B

Methodology:

- Infiltration rate and hydraulic conductivity were determined by using the method of Zhang (1997).
- Geometric mean diameter (GMD) and mean weight diameter (MWD) were determined using wet aggregate stability standard methods .
- Bulk density was determined using a standard method.
- Gravimetric water content was determined by using the following equation:

$$\textit{Soil water content}\ (g/g) = \frac{(\textit{moist soil} - \textit{oven dry soil})}{(\textit{oven dry soil})}$$

- GMD, geometric standard deviation (GSD), and the <0.84 mm fraction [wind erodible fraction (WEF)] were determined on dry aggregates using a rotary sieve.

Results

Results are shown in Tables 1, 2, and 3.

Table 1. Water content, bulk density, and hydraulic conductivity at sites A and B. Means followed by the same letter are not statistically different at p= 0.10.

Treatment	Water Content (g/g) 100		Bulk Density Mg/m³		Hydraulic conductivity (cm/s) x 10⁴	
	Site A	Site B	Site A	Site B	Site A	Site B
Control (CO)	9.9 a	9.85 ab	1.14 a	1.12 bc	3.3 b	2.15 bc
Low compost (LC)	13.2 a	9.98 a	0.97 a	1.27 a	9.98 a	1.44 c
High compost (HC)	9.32 a	9.18 ab	1.63 a	1.11 c	4.35 b	3.55 bc
Low compost + lime (LCL)	8.96 a	8.33 ab	1.14 a	1.19 abc	4.11 b	7.92 a
High compost + lime (HCL)	13.67 a	8.55 ab	0.99 a	1.18 abc	4.8 b	3.1 bc
Low compost + lime + bentonite (LCLB)	13.66 a	8.41 ab	1.02 a	1.27 a	5.79 b	5.41 ab
High compost + lime + bentonite (HCLB)	11.36 a	7.99 b	1.04 a	1.25 ab	4.78 b	3.49 bc

In general at site A, there were no differences in WC, BD, and k. At site B, WC, BD, and k varied, but there were no consistent differences among treatments.

Table 2. Wet aggregate stability at sites A and B, sand free. For letters following numbers, see legend of Table 1.

Treatment	GMD mm		MWD mm	
	Site A	Site B	Site A	Site B
Control (CO)	2.04 a	1.98 ab	5.28 a	4.01 a
Low compost (LC)	1.96 a	1.90 ab	4.81 a	3.80 a
High compost (HC)	2.02 a	1.85 b	4.65 a	3.46 a
Low compost + lime (LCL)	2.01 a	1.97 ab	4.51 a	4.06 a
High compost + lime (HCL)	2.02 a	1.95 ab	4.65 a	3.44 a
Low compost + lime + bentonite (LCLB)	1.96 a	2.05 a	4.16 a	4.13 a
High compost + lime + bentonite (HCLB)	2.04 a	1.83 b	4.78 a	3.04 a

At site A, GMD and MWD did not differ among treatments. At site B, MWD did not differ among treatments. At site B, LCLB had the largest GMD and LCL and HCLB had the smallest GMD.

Table 3. Dry aggregate size distribution at sites A and B. For letters following numbers, see legend of Table 1.

Treatment	%<0.84		GMD		GSD	
	Site A	Site B	Site A	Site B	Site A	Site B
Control (CO)	10.37 a	8.00 a	57.54 b	63.59 b	49.02 ab	33.07 a
Low compost (LC)	10.30 a	6.76 ab	59.27 ab	68.34 a	46.14 ab	27.85 abc
High compost (HC)	9.71 a	8.04 a	60.94 ab	70.01 a	43.00 ab	28.88 ab
Low compost + lime (LCL)	9.59 a	7.25 ab	65.73 a	63.88 b	37.12 b	27.79 abc
High compost + lime (HCL)	11.99 a	7.06 ab	58.35 ab	69.95 a	51.19 a	26.87 abc
Low compost + lime + bentonite (LCLB)	11.08 a	5.41 b	60.14 ab	69.36 a	47.31 ab	21.98 c
High compost + lime + bentonite (HCLB)	10.34 a	4.93 b	61.91 ab	68.87 a	43.42 ab	24.26 bc

At site A, <0.84 mm fraction did not vary; but GMD and GSD did vary with no consistency among treatments. The largest GMD was with LCL and the largest GSD was with HCL. At site B, the greatest value for the <0.84 mm fraction occurred with the control and HC. The control had the smallest GMD and the largest GSD.

Conclusion

Even 8.5 years after treatments, significant treatment effects on soil physical properties were observed, especially at site B. The control and HC treatments at site B had the highest <0.84 mm fraction, and the LCLB and HCLB treatments had the lowest <0.84 mm fraction. Although, differences occurred among treatments for WC, BD, and k there was no consistency due to treatments.

References

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