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ABSTRACT

This research project is aimed at assessing the soil organic carbon (SOC) sequestration potential of reclaimed minesoils (RMS). The experimental sites, owned and maintained by the American Electrical Power, are located in Guernsey, Morgan, Noble, and Muskingum Counties of Ohio. These sites, characterized by age chronosequences, were reclaimed with and without topsoil application and are under continuous grass or forest cover. Among the three sites chosen for this study one was reclaimed in 1978 (Cumberland), one in 1987 (Switch Grass) and one site was reclaimed in 1994 (Tilton's Run). All three sites were reclaimed with topsoil application and were under continuous grass cover. Eighteen experimental plots were developed on each site. Five fertilization treatments were applied in triplicate on each experimental site. During this quarter, water infiltration tests were performed on the soil surface in the experimental plots. Soil samples were analyzed for soil moisture characteristics. This report presents the data on infiltration rates, volume of transport and storage pores, and available water capacity (AWC) of soil. The infiltration rates after 5 min (i_5) showed high statistical variability (CV > 0.62) among the three sites. Both steady state infiltration rate and cumulative infiltration showed moderate to high variability (CV > 0.35). The mean values for the infiltration rate after 5 min, steady state infiltration rate, and cumulative infiltration were higher for Switch Grass (2.93 ±2.05 cm min^{-1}; 0.63 ±0.34 cm min^{-1}; 113.07 ±39.37 cm) than for Tilton's Run (1.76 ±1.42 cm min^{-1}; 0.40 ±0.18 cm min^{-1}; 73.68 ±25.94 cm), and lowest for Cumberland (0.63 ±0.34 cm min^{-1}; 0.27 ±0.19 cm min^{-1}; 57.89 ±31.00 cm). The AWC for 0-15 cm soil was highest at Tilton's Run (4.21 ±1.75 cm) followed by Cumberland (3.83 ±0.77 cm) and Switch Grass (3.31 ±0.10 cm). In 15-30 cm depth Switch Grass had higher AWC (3.15 ±0.70 cm) than Tilton's Run (3.00 ±0.43 cm) and Cumberland (2.78 ±0.34 cm). In 30-50 cm depth Tilton's Run had higher AWC (4.31 ±1.25 cm)

than Switch Grass (3.18 ±0.70 cm) and Cumberland (2.95 ±1.07 cm). The volumes of transport and storage pores were fairly similar among sites up to 30 cm depth, but were variable for 30-50 cm depth. These preliminary results along with those reported earlier for the third quarter suggest that the management effects are important and indicative of these sources of variability.

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1.0 **Executive Summary**

This research project is aimed at assessing the soil organic carbon (SOC) sequestration potential of reclaimed minesoils (RMS) and is supported by US Department of Energy- National Energy Technology Laboratory. The proposed research focuses on: (1) assessing the sink capacity of RMS to sequester SOC concentration in selective age chronosequences, (2) determining the rate of SOC sequestration, and its spatial (vertical as well as horizontal) and temporal variations, (3) developing and validating models of SOC sequestration rate, (4) identifying the mechanisms of SOC sequestration in RMS, (5) assessing the potential of different methods of soil reclamation on SOC sequestration rate, soil development, and changes in soil mechanical and water transmission properties, and (6) determining the relation between SOC sequestration rate, and soil quality in relation to soil structure and hydrological properties.

Before 1972, surface mining operations were performed by removing the soil and underlying strata and piling them on a side. After mining operations were complete, the excavated area was planted to trees or grass without grading or reclamation due to the nonexistence of any specific guidelines. After 1972, Ohio Mineland Reclamation Act (also 1977 SMCRA) made it mandatory to grade the area back to its original topography and reclaim it with topsoil application prior to sowing grass or planting trees. In this project, several experimental sites were identified, which were reclaimed both prior to SMCRA regulation (without topsoil under grass or forest) and after (with topsoil under grass or forest). All these sites, characterized by distinct age chronosequences of reclaimed minesoil, are located in Guernsey, Morgan, Noble, and Muskingum Counties of Ohio, and are maintained and owned by the American Electrical Power. The last step in the reclamation is application of treatments to facilitate vegetation growth (mostly seeding grass). Treatments have significant influence the rate of soil development, this study was designed with the objective of assessing the potential of different methods of soil reclamation on SOC sequestration rate, soil development, and changes in soil physical and water transmission properties.

Water infiltration tests were conducted between 1st July and 1st August, 2005. During this period, soil analysis was carried out in the lab to determine soil moisture characteristic curves. This report presents the results of infiltration rates after 5 min, steady state infiltration rates and cumulative infiltration, available water capacity (AWC) of soil, volumes of storage pores and transmission pores, from the experimental plots at three sites with topsoil application. Cumberland was reclaimed in 1978, Switch Grass in 1987 and Tilton's Run in 1994. The statistical variability was assessed by descriptive statistics, and variations in soil properties were expressed by ranking the coefficient of variation (CV) into different classes.

The infiltration rates after 5 min (i_5) showed high statistical variability (CV > 0.62) for Cumberland, Switch Grass and Tilton's Run. Both steady state infiltration rate and cumulative infiltration showed moderate to high variability (CV > 0.35) for all sites. The mean values for the infiltration rate after 5 min, steady state infiltration rate, and cumulative infiltration were higher for Switch Grass (2.93 ±2.05 cm min^{-1}; 0.63 ±0.34 cm min^{-1}; 113.07 ±39.37 cm) than for Tilton's Run (1.76 ±1.42 cm min^{-1}; 0.40 ±0.18 cm min^{-1}; 73.68 ±25.94 cm), and lowest for Cumberland (0.63 ±0.34 cm min^{-1}; 0.27 ±0.19 cm min^{-1}; 57.89 ±31.00 cm). The AWC for 0-15

cm soil was highest at Tilton's Run (4.21 ±1.75 cm) followed by Cumberland (3.83 ±0.77 cm) and Switch Grass (3.31 ±0.10 cm). In 15-30 cm depth Switch Grass had higher AWC (3.15 ±0.70 cm) than Tilton's Run (3.00 ±0.43 cm) and Cumberland (2.78 ±0.34 cm). In 30-50 cm Tilton's Run had higher AWC (4.31 ±1.25 cm) than Switch Grass (3.18 ±0.70 cm) and Cumberland (2.95 ±1.07 cm). The volumes of transport and storage pores were fairly similar among sites up to 30 cm depth, but were variable for 30-50 cm depth. These preliminary results along with those reported earlier for the third quarter suggest that the management effects are important and indicative of these sources of variability.

2.0 Experimental

2.1 Experimental Sites

The experimental sites were reclaimed after the 1972 Ohio Mineland Reclamation Act or the 1977 surface mining reclamation and control act (SMRCA), and were under continuous grass. These sites were reclaimed in conformity to SMCRS law and topsoil was applied as the last surface layer. These sites are located on land maintained by the American Electric Power (AEP) Co., and are located along the borders of Guernsey, Noble, and Muskingum Counties of Ohio. This report includes the analysis of physical soil data from three experimental sites with topsoil application. These sites are: Cumberland (CL) reclaimed in 1978, Switch Grass (SG) reclaimed in 1987, and Tilton's Run (TR) reclaimed in 1994. All the experimental plots are under continuous grass cover (Figs. 1 and 2).

At each site, treatments were applied to the experimental plots on *28 and 29th June 2005*: F(I)-fertilization (N:P:K = 179:40:74 kg/plot); F(II)- fertilization (N:P:K = 358:80:147 kg/plot); M-manure (27 kg/plot); C- compost (24 kg/plot). All these plots were mowed on April 11, 2005. During April to July, soil sampling for three depths was carried out on all the plots to assess physical properties of soil, and in July water infiltration tests were carried out.

2.2 **Analysis of Physical Soil Properties**

2.2.1 **Water Infiltration**

Water infiltration tests were performed with a double ring infiltrometer on the soil surface at each experimental plot and each site during July 2005 (Bouwer, 1986; Reynolds et al., 2002).

The infiltration rate after 5 min (i_5) and after 2 h (i_c), and the cumulative infiltration in 2 h (I) were recorded.

2.2.2 **Soil Moisture Characteristics Curve**

Triplicate intact soil cores from 0-15 cm, 15-30 cm and 30-50 cm depth were sampled at each site. Soil moisture characteristics involving measurements of the soil moisture content/soil moisture potential relationship for low suction within the range of saturation point (0 MPa) and 0.01 MPa suction, and for high suction within the range of 0.01 MPa and 1.5 MPa suction were obtained (Laboratory Manual Of Soil Physics, The Ohio State University). The volume of transport pores (VSP) was assessed as the difference in volumetric water content (θ) at saturation and 6-kPa. The volume of storage pores (VTP) was assessed as the difference in volumetric water content (θ) at 6-kPa and 1500-kPa. The available water capacity (AWC) was assessed as the difference in volumetric water content (θ) at 300-kPa and 1500-kPa.

2.4. **Statistical Analysis**

Descriptive statistics including mean, standard deviation, CV, maximum, minimum, skewness, and kurtosis were obtained for each infiltration variable using the Statistical Analysis System (SAS Institute, 1989).

3.0 **Results and Discussion**

3.1 **The Variability of Water Infiltration**

Table 1 lists the descriptive statistics of the original data from Cumberland (CL), Switch Grass (SG) and Tilton's Run (TR) including mean, median, coefficient of variation, skewness, kurtosis, maximum and minimum values, respectively. The mean values for the infiltration rate after 5 min (i_5) were higher than the median values, and data were not normally distributed. Despite some skewness in the data for steady state infiltration rate (i_c) and cumulative infiltration (I), the mean and median values for all these parameters were similar except for I at CL. The median for i_c and I was either equal to or smaller than the mean, and data were normally distributed. The standard error of the mean for i_5, i_c and I was higher at SG than at CL and TR sites. The variability was high in i_5 for all sites (CV > 0.62). The variability was high in i_c and I for CL (CV > 0.54), and moderate for SG and TR sites (CV > 0.35 for both). The mean values for infiltration rate after 5 min, steady state infiltration rate, and cumulative infiltration were higher for SG (2.93 ±2.05 cm min^{-1}; 0.63 ±0.34 cm min^{-1}; 113.07 ±39.37 cm) than for TR (1.76 ±1.42 cm min^{-1}; 0.40 ±0.18 cm min^{-1}; 73.68 ±25.94 cm), and lowest for CL (0.63 ±0.34 cm min^{-1}; 0.27 ±0.19 cm min^{-1}; 57.89 ±31.00 cm).

3.2 **Soil Moisture Characteristics**

The mean values for VTP and VSP for 0-15 cm depth were fairly similar for all sites, except for VSP at TR (Table 2). The VSP at TR was higher (0.31±0.12) than at CL (0.27±0.05) and SG (0.26±0.01). The AWC was higher at TR (4.21 ±1.75 cm) than at CL (3.83 ±0.77 cm), and both were higher than at SG (3.31 ±0.10 cm). For 15-30 cm depth the mean values of VTP and VSP were also fairly similar. The VSP was slightly higher for SG (0.24 ±0.05) than for TR (0.21 ±0.03) and CL (0.20 ±0.02). The AWC for 15-30 cm was higher at SG (3.15 ±0.70 cm) than at TR (3.00 ±0.43 cm) and at CL (2.78 ±0.34 cm). The mean values for VTP, VSP and AWC for 30-50 cm depth were variable among sites. The VTP was higher at CL (0.07 ±0.03) than at SG (0.05 ±0.01) and at TR (0.03 ±0.02). The TR site had higher mean values for VSP and AWC

(0.23 ±0.06; 4.31 ±1.25 cm) than SG (0.19 ±0.04; 3.18 ±0.70 cm) and CL (0.16 ±0.05; 2.95 ±1.07 cm).

4.0 **Conclusions**

The preliminary results of descriptive statistics show that most of the data for water transmission were normally distributed. However, infiltration rate after 5 min showed a high variability among the sites, and at Cumberland the statistical variability was high for steady state infiltration rate and cumulative infiltration for the experimental plots. The experimental plots for the Switch Grass site had the highest infiltration rates followed by Tilton's Run while they were the lowest at Cumberland. The volume of transport pores and volume of storage pores for 0-15 cm and 15-30 cm depths were fairly similar among three sites. For 30-50 cm depth, however, the volume of transport pores was higher at Cumberland than at Switch Grass and Tilton's Run sites. In comparison, the volume of storage pores was higher at Tilton's Run than at Switch Grass and Cumberland sites. The differences between the sites in available water capacity were variable among the three soil depths. These preliminary results suggest that spatial variability exists in the experimental plots.

5.0 **Tasks to be performed in the next Quarter (October - December 2005)**

We will continue to perform laboratory analysis on determining:

1. Assessment of C Pool in Aggregate Size Fractions for Different Land Use and Management Systems
2. Statistical Analysis of Data on Soil Physical and Chemical Properties

6.0 **References**

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1 F(II)	2 M	3 C	4 F(I) + C	5 C + M	6 No
7 C	8 F(II)	9 C + M	10 No	11 M	12 F(I) + C
13 M	14 No	15 F(I) + C	16 F(II)	17 C	18 C + M

Fig. 1. Treatments at experimental plots of reclaimed minesoils at Cumberland, Switch Grass and Tilton's Run. F(I)- fertilization (N:P:K = 179:40:74 kg/plot); F(II)- fertilization (N:P:K = 358:80:147 kg/plot); M- manure (27 kg/plot); C- compost (24 kg/plot).

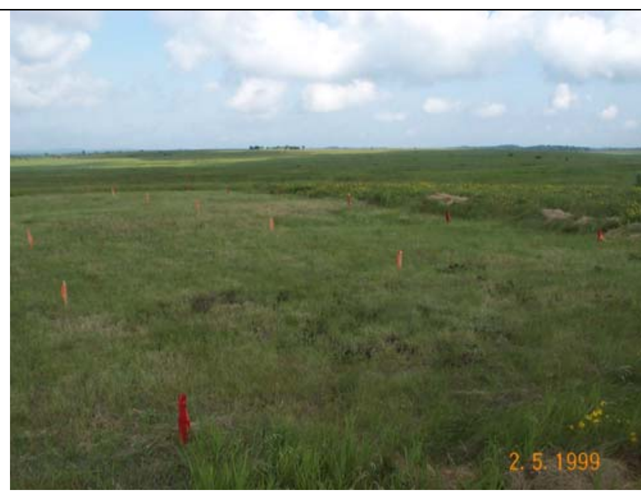
(A) Cumberland	
(B) Switch Grass	
(C) Tilton’s Run	

Fig. 2. Pictures of the experimental plots at Cumberland reclaimed in 1978, Switch Grass reclaimed in 1987, and Tilton’s Run reclaimed in 1994.

Table 1. Summary statistics for infiltration rate after 5 min (i5), steady state infiltration rate (i_c) after 2 h, and cumulative infiltration (I) for the experimental plots at Cumberland, Switch Grass and Tilton's Run. Cumberland was reclaimed in 1978, Switch Grass in 1987, and Tilton's Run in 1994. Note: i_5 and i_c are expressed in cm min^{-1} and I in cm.

	Cumberland			Switch Grass			Tilton's Run		
	i_5	i_c	I	i_5	i_c	I	i_5	i_c	I
Mean	1.36	0.27	57.89	2.93	0.63	113.07	1.76	0.40	73.68
Median	1.03	0.25	49.4	2.7	0.61	112.15	1.38	0.39	72.5
Std Error	0.20	0.05	7.52	0.48	0.08	9.28	0.33	0.04	6.11
Std Dev	0.84	0.19	31.00	2.05	0.34	39.37	1.42	0.18	25.94
CV	**0.62**	**0.71**	**0.54**	**0.70**	**0.54**	**0.35**	**0.80**	**0.45**	**0.35**
Skewness	0.33	2.65	1.58	1.07	1.61	0.28	2.43	0.45	-0.03
Kurtosis	-1.68	8.53	2.83	1.13	3.18	-0.64	7.23	0.01	-1.00
Minimum	0.3	0.07	23.64	0.3	0.15	49.5	0.37	0.12	31
Maximum	2.63	0.9	145	8.17	1.6	187.2	6.5	0.8	116.2

Table 2. Volume of transport and storage pores (VTP and VSP), and available water capacity (AWC) for the experimental plots at Cumberland, Switch Grass and Tilton's Run for 0-15 cm, 15-30 cm, and 30-50 cm depth. Cumberland was reclaimed in 1978, Switch Grass in 1987, and Tilton's Run in 1994. Note: VTP and VSP are expressed as % and AWC as cm.

	Cumberland			Switch Grass			Tilton's Run		
	VTP	VSP	AWC	VTP	VSP	AWC	VTP	VSP	AWC
				0-15 cm depth					
Mean	0.08	0.27	3.83	0.07	0.26	3.31	0.06	0.31	4.21
Std Dev	0.01	0.05	0.77	0.01	0.01	0.10	0.00	0.12	1.75
				15-30 cm depth					
Mean	0.05	0.20	2.78	0.05	0.24	3.15	0.03	0.21	3.00
Std Dev	0.02	0.02	0.34	0.02	0.05	0.70	0.00	0.03	0.43
				30-50 cm depth					
Mean	0.07	0.16	2.95	0.05	0.19	3.18	0.03	0.23	4.31
Std Dev	0.03	0.05	1.07	0.01	0.04	0.70	0.02	0.06	1.25