Wind erosion in loess soils of the Semiarid Argentinian Pampas
Erosion éolienne des loess des pampas semiarides argentines

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ABSTRACT

This study is the first effort to measure wind erosion in the field in South America. Wind erosion of two bare soils, a Typic Ustipsamment and an Entic Haplustoll of the Semiarid Argentinian Pampas, was measured in the field during wind storms that occurred on June 16 (mean wind speed = 14km/h and storm duration 103h), and June 30 of 1995 (mean wind speed = 21.4km/h and storm duration 25h). Measurements were made with BSNE dust samplers placed at heights of 0.135, 0.54, and 1.47 m within a 1 ha field. 

Mass flux (amount of eroded material within a given time) was larger in the sandy Ustipsamment than in the loamy sand Haplustoll in both storms. A maximum amount of transported dust was found within the limits of the studied field (100 meters) during the June 16 wind storm and outside the studied field during June 30 wind storm. This was attributed to the variation in wind direction on June 16.

The total amount of eroded material from the field at each storm reached 1.82 Ton/ha in the Ustipsamment and 0.29 Ton/ha in the Haplustoll on June 16, and 0.98 Ton/ha in the Ustipsamment and 0.75 Ton/ha in the Haplustoll on June 30. Wind velocity was large enough to erode the loosened Ustipsamment but not the better structured Haplustoll on June 16. On June 30, wind velocity was high enough to erode both soils but a shorter storm duration did not allow the erosion of large amounts of soil.

INTRODUCTION

Wind erosion is an important soil degradation process in the Semiarid Argentinean Pampas and has a great negative impact on the ecosystem in this region. Large amounts of soil are eroded annually as a consequence of inadequate tillage systems used on highly erodible soils. Buschiazzo and Taylor (1993) demonstrated for soils of the Semiarid Pampas that wind erosion decreases the thickness of A-horizons, modifies its textural composition
and decreases its organic matter contents to an extent that it transforms Entic Haplustolls into Typic Ustorthents. Silenzi et al. (1993) showed that the erosion of 1cm of soil by wind produces a decrease of 22 kg/ha on yields of wheat in this region. Though wind erosion has a significant impact on the environment and human life in this region, there is a lack of information about its characteristics and amounts.

Some attempts to measure wind erosion in the southern semiarid Pampas were made by Bravo (1994) who calculated the length of wind strips for Entic Hapludolls using the Wind Erosion Equation (Woodruff and Siddoway, 1965). However these calculations only predict annual erosion but not the seasonal or daily erosion events and are based on estimated erosion values.

Few studies have measured wind erosion under natural conditions in agricultural fields. Fryrear (1995) measured soil loss ranging from 3 to 70 mt ha\(^{-1}\) on 5 agricultural fields in the US using dust samplers installed on fine sandy loam, silt loam and loam soils. Soil loss varied from 2 to 26 mt ha\(^{-1}\) for four different storms measured on a sandy agricultural soil located in the Sahel of Niger (Sterk and Stein, 1997). No studies measuring field wind erosion have been made in Argentina or in all of South America.

As a first step to understand wind erosion processes in the semiarid Argentinian Pampas, the objective of this research was to measure erosion on two soils with contrasting soil textures under differing wind velocities.

**MATERIALS AND METHODS**

Wind erosion was measured at two sites of the semiarid Pampas: Santa Rosa (36º 37’ S latitude and 64º17’W longitude) and Anguil (36º 31’ S latitude and 64º01’W longitude). These sites were located 30km apart and differed on edaphic but not on climatic conditions. The soils were both developed on Holocene eolian sediments and classified as an Entic Haplustoll at Santa Rosa and a Typic Ustipsamment at Anguil. Main physical and chemical characteristics of the soils are detailed in Table 1. Annual temperature averages 16°C and annual rainfall 550 mm in both sites.

Erosion measurements were made during two wind storms that occurred on June 16 and June 30 1995. On June 16 the mean wind speed at 3 meters height was 14 km/h (+/- 25%) and storm duration was 103 h. The June 30 storm had a mean wind speed of 21.5 km/h (+/-52.3%) and storm duration was 25h. Wind speed and direction were measured with an automatic climatological station placed at Santa Rosa.

Soils at both sites were planted with *Eragrostis curvula* grass for 30 years before wind erosion measurements started. Erosion was measured under bare soil conditions, obtained by mouldboard ploughing and disking. The soil surface was smooth and level during erosion measurements.

Airborne sediment measurements were collected using BSNE dust samplers developed by Fryrear (1986). Dust samplers were placed at three heights (0.135, 0.54 and 1.47 m) on 12 points (clusters) within a 1ha field. The points consisted of 3 rows parallel to the prevailing N-S wind direction. Each row had 4 samplers separated by 33 m. The plot was surrounded by nonerodible permanent pasture and the first wind facing rows were at approximately 5 meters from plot edge.
The amount of material collected by each sampler was calculated using the equation [1], developed by Zingg (1953) and recently modified by Stout and Zobeck (1996), which describes the mass as a function of height at each sampling point.

\[ \frac{f(z)}{f_0} = (1 + z/\delta)^2 \]  

[1]

where \( f(z) \) is horizontal mass flux at height \( z \), \( f_0 \) is the mass flux at the surface (\( z=0 \)), and \( \delta \) a scale height.

The mass of the entire sampler cluster (\( Q_{ij} \)) was obtained by integrating equation [1]. The solution of this integration was obtained by multiplication of \( f_0 \) and \( \delta \) (Stout and Zobeck, 1996). Mass flux of the total field was calculated by averaging the dust collected at each one of the three cluster rows. The total amount of eroded material from the one hectar field was equal to the dust collected by the samplers placed at the end of the field.

RESULTS AND DISCUSSION

Mean mass flux, the amount of eroded material within a given time, for 3 samplers by height is presented in Fig. 1. Results show that the Ustipsamment had higher erosion values than the Haplustoll, at all three heights for both storms. This was due to the higher susceptibility of the Ustipsamment to wind erosion. The Ustipsamment had over 60% more erodible aggregates (smaller than 0.84mm) than the Haplustoll (Table 1). Similar results were found by Chepil (1953), who showed that coarse textured soils are more susceptible to be eroded by wind than fine textured soils.

Close examination of wind direction data suggests the apparent transport capacity distance of 70 m for the Ustipsamment found in this study may be the result of an accumulation of dust near the center of the plot produced by changes in wind direction during the study. As it can be deduced from wind direction data of Fig. 2, on June 16 the wind blew 40% of the time from SW and 60% of the time from the N, while wind speeds were relatively similar on both periods. On June 30 the wind blew from the N more than 80% of the time, with higher speeds than when it blew from the SW. This indicates that N oriented winds produced most of soil erosion on June 30, while N and SW oriented winds produced similar soil erosion rates on June 16, which might explain larger accumulation of dust at middle plot positions.

The total amount of eroded material was higher for the Ustipsamment than for the Haplustoll for both storms. On June 16 the Ustipsamment lost 1.82 Ton/ha and the Haplustoll 0.29 Ton/ha, and on June 30 the Ustipsamment lost 0.98 Ton/ha and the Haplustoll 0.75 Ton/ha. Variation of differences between soils may have been produced by the combined effect of wind speed, direction and storm duration. On June 16 mean wind
velocity (14 Km/h) and velocity variation (25%) was lower but storm duration longer (103 h) than on June 30, when mean wind velocity was 21.6 km/h, wind velocity variation 52.3% and storm duration 24 h. Probably wind velocity on June 16 was large enough to erode the loosened Ustipsamment but not the better structured Haplustoll (see amount of loose erodible material of both soils in Table 1). On June 30 wind speed was high enough to erode both soils but storm duration did not allow the erosion of large amounts.

CONCLUSIONS

Results show that the Ustipsamment produced larger mass flux values and total sediment losses than the Haplustoll. This demonstrated that the loosened sandier soil is more susceptible to erosion by wind than the better-structured sandy loam soil.

The combined effect of wind speed and storm duration on mass flux and total sediment loss was deduced. In general, the lower velocity but longer lasting storm noticeably eroded the loosened Ustipsamment but not the structured Haplustoll. On the other hand the higher velocity and shorter duration storm eroded both soils to about the same low extents.

The maximum of transported dust within central portion of the fields during the 16 June storm were attributed to changes in wind direction during erosion measurements. Thus, caution should be used when analyzing wind erosion data to ensure that variations of wind direction during the study do not lead to errors in calculations of the amounts of transported material.

REFERENCES


Key Words: Wind Erosion; Semiarid Regions; Wind Direction, Argentina
Mots clés : érosion éolienne, région semiaride, direction du vent, Argentine

LEGENDE OF FIGURES:
Figure 1. Horizontal variation of sediment flux at heights of 0.135m, 0.54m and 1.47m. $V_m$ = mean wind velocity of the storm.

Figure 2. Wind direction plotted as a function of time on storms occurred on June 16 and June 30 1995. Numbers below points are mean wind velocities.

Table 1. Main characteristics of the studied soils

<table>
<thead>
<tr>
<th>Soil Great Group</th>
<th>Clay</th>
<th>Silt</th>
<th>Sand</th>
<th>Aggregates &lt; 0.84 mm</th>
<th>OM</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haplustoll</td>
<td>12.5</td>
<td>16</td>
<td>71.5</td>
<td>18.5</td>
<td>1.64</td>
<td>6.4</td>
</tr>
<tr>
<td>Ustipsamment</td>
<td>5.2</td>
<td>11.1</td>
<td>83.7</td>
<td>30.4</td>
<td>1.14</td>
<td>6.6</td>
</tr>
</tbody>
</table>

Table 1 continued...

<table>
<thead>
<tr>
<th>Height = 13.5 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.30</td>
</tr>
<tr>
<td>0.25</td>
</tr>
<tr>
<td>0.20</td>
</tr>
<tr>
<td>0.15</td>
</tr>
<tr>
<td>0.10</td>
</tr>
<tr>
<td>0.05</td>
</tr>
<tr>
<td>0.00</td>
</tr>
</tbody>
</table>

Meters | Mass Flux (g/m².s) |
--------|--------------------|
0       | 0.00               |
33      | 0.05               |
66      | 0.10               |
99      | 0.15               |

0       | 0.20               |
33      | 0.25               |
66      | 0.30               |
99      | 0.35               |

16 Jun 95 $V_m = 14$ km/h
30 Jun 95 $V_m = 21.8$ km/h
Height = 54 cm

Height = 147 cm