Laboratory results of a portable wind and rainfall simulator

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Introduction

Soil degradation and desertification is often caused by wind and water erosion. For many years researchers have been studying both processes separately. Laboratory investigations with wind tunnels that include rainfall simulators have shown the existence of very complex interactions between wind and water erosion. These results were confirmed in recent field research, especially for semi-arid regions. For future quantification and prediction of soil desertification both processes need to be measured together.

Portable wind and rainfall simulator

Wind tunnel

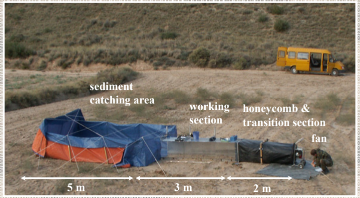


Fig. 1: Built up wind tunnel

Integrated rainfall simulator

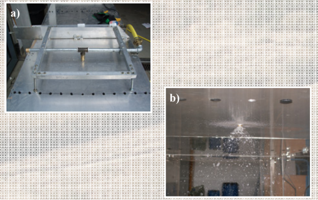


Fig. 2: a) Preliminary nozzle mounting b) Nozzle inside tunnel

Combined sediment trap

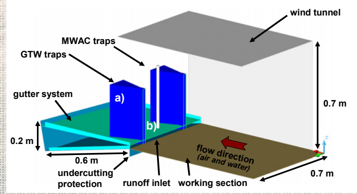


Fig. 3: Dimensional sketch of combined sediment catcher

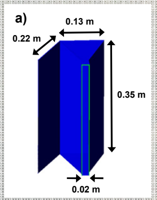


Fig. 4: Guelph-Trent Wedge Trap (GTW)
Nickling & McKenna-Neuman 1997

- passive trap, vertically integrating
- side can be opened for cleaning
- low cost
- good calibration results

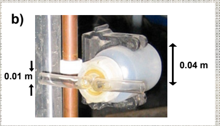


Fig. 5: Modif. Wilson and Cooke Sampler (MWAC)
Wilson & Cooke 1980

- passive trap
- horizontally installed
- low cost
- good calibration results

Main objectives

General objective of this study is to simultaneously measure erosion rates by wind and water erosion with a combined wind and rainfall simulator operational in the field. To reach this goal following calibration measurements were conducted:

(1) Homogeneity of airflow direction
(2) Homogeneity of wind speed
(3) Drop size distribution and drop fall velocity
(4) Spatial distribution of rainfall

Methodology

Fig. 6: Woolen wires
➡ airflow direction (1)

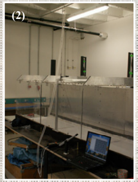


Fig. 7: Pietot tube
➡ wind speed (2)

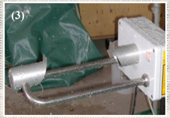


Fig. 8: Laser Disdrometer
➡ drop size/fall velocity (3)

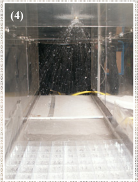


Fig.9: Collecting pans
➡ spatial distribution (4)

Calibration of wind tunnel

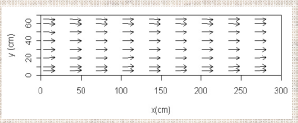


Fig. 10: Results of airflow direction measurement near surface (1); x-axis (tunnel length); y-axis (tunnel width)

- Deflection of airflow from parallel by sidewalls (maximum 3°)
- ➡ Homogeneous, parallel airflow between y=20 and y=50 cm

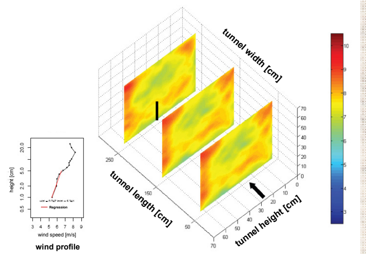


Fig. 11: Results of wind speed measurements above tarboard; 11x22 raster points; test duration 10 seconds, interval 1 second; black arrow (airflow direction); black line (position of profile)

- Wind speed variation between 6.5 and 9 m/s
- Lowest wind speeds near floor and between x = 40-60 cm and y = 10-50 cm
- Nearly logarithmical vertical wind profile until 18 cm height

Calibration of rainfall simulator

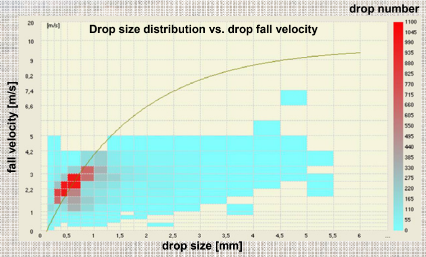
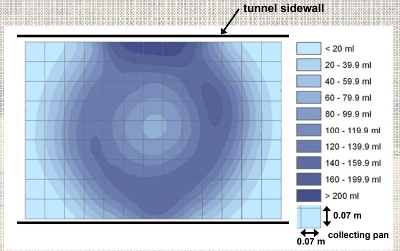


Figure 12: Drop size distribution and drop fall velocity measured by Thies Laser Disdrometer (3); test duration 1 min; intensity 130 mm/h; pressure 0.4 bar; fall heigth 0.7 m; Lechler full cone nozzle 460.608

- Complete naturally occuring drop spectra is covered
- Especially larger drops are too slow (max. fall velocity ~6 m/s) compared to natural rainfall droplets (green line)



- Concentric pattern of rainfall amount with high variations between center and rim (~50%)
- Runoff from upper sidewall increases water amount in collecting pans
- ➡ Spatial distribution of simulated rainfall is rather inhomogeneous

Figure 13: Spatial Distribution of rainfall test inside tunnel with a single nozzle (4); test duration 12 min; intensity 130 mm/h; pressure 0.4 bar; fall heigth 0.7 m; Lechler full cone nozzle 460.608

Conclusions

(1) Major limiting factors that prevent the development of a "natural" turbulent boundary layer and "natural" drop fall velocities are short tunnel length and low tunnel height.

(2) Due to the properties of full cone nozzles a homogeneous spatial drop distribution can only be created by using more than one nozzle.

Despite the problems to simulate "natural" wind and rainfall conditions we expect to be able to obtain valuable quantitative information regarding the relative impact of wind and water erosion on soil degradation. Especially the high mobility and reproducability make this device suitable for relative in-situ investigations

Literature

NICKLING, W. G. & MCKENNA-NEUMAN, C. (1997): Wind tunnel evaluation of a wedge-shaped aeolian sediment trap. – Geomorphology, 18, p. 333-345.

WILSON, S. J. & COOKE, R. U. (1980): Wind erosion. – In: Kirkby, M. J. & Morgan, R. P. C.: Soil erosion, Chichester.

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