Simple passive methods for the assessment of the directional and vertical distributions of wind-blown particulates

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ABSTRACT

We have designed and tested two types of passive collectors to study aeolian erosion in the field. The first passive sampler is a sticky pad that allows for directional particulate assessment by an automatic particle counting procedure. The second one features an omni-directional capture opening, and mass of retained particles is gravimetrically quantified. Vertical arrays of these passive collectors have been constructed to obtain vertical profiles of the horizontal particle flux as a function of soil properties, nearby sources and wind speed. We present some first results from field campaigns.

Palabras clave: passive samplers, aeolian erosion

INTRODUCTION

The vertical distribution of soil particulate transport produced by wind flow across the field has been studied by a number of authors using a variety of vertical array traps, some of them mounted on wind vanes to continuously align the traps parallel to the wind. To overcome disturbances to the wind field that affect the efficiency of the traps some collectors perform near isokinetic sampling. Passive collectors, however, are widely used in field experiments as they are inexpensive and require no power supply.

Directional assessment is complementary to such measures. The knowledge of the direction from which dust is coming provides useful information to identify differences in soil properties or local crustal sources, combining wind directions and the existence of specific dust sources around the study site.

We present a description of two new kinds of passive vertical array collectors and some related first results of our work in semi-arid SE Spain.

METHODS

The first passive sampler is a sticky pad that allows for directional particulate assessment. Particles are collected on a 7 cm high transparent adhesive film fixed completely around a vertically mounted cylinder. Following exposure, the samples are scanned and images are saved as BMP files on a computer for later image analysis. Then we count particles from the scanned images with an automatic procedure by recording the position and size (from the area of the two-dimensional projection) of individual coarse particles (greater than 20 microns); as a complement we also record the presence or absence of dust for each pixel. The colour of the particles is retained as well. Previous uses of sticky pads by other authors include dust quantification by percentage reduction in reflectance (Beaman & Kingsbury, 1981) and by the proportion of pixels that have been dusted (Farnfield & Birch, 1997).

We have constructed vertical arrays of this kind of sampler to estimate the vertical distribution of horizontal particle flux (Fig. 1). Collectors were mounted on masts at seven heights, sampling a combination of reptation, saltation and suspension. 48-hour measurement periods are considered.

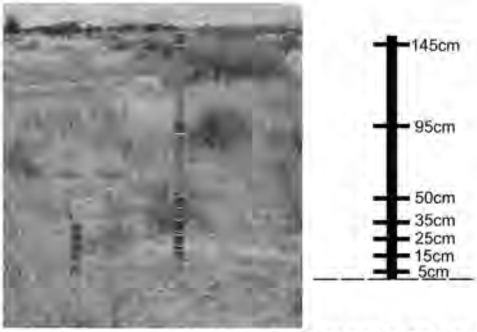

Figure 1. Vertical array collectors composed of sticky pads and schematic showing the middle height of each sticky pad.

The second sampler is a modified version of the Cox sand catcher (CSC), see *e.g.* (Ono, 2006), that features an omni-directional capture opening (1 cm height) located 15 cm above the ground where particles entering can impact on an inner cylinder. This sand catcher is far from being an isokinetic sampler, but its omnidirectional nature presents some advantages. The CSC has been calibrated against the BSNE sampler at Owens Lake in USA and to the Sensit piezoelectric saltation impactor (Ono, 2006). We have constructed stacked catchers with openings at five heights (Fig. 2). Particulate matter in each stage is collected after three/four weeks and is gravimetrically quantified.

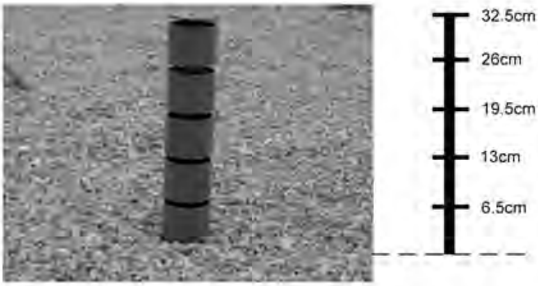

Figure 2. Vertical array collector composed of five omnidirectional sand catchers and schematic indicating the center of the capture openings.

RESULTS

The passive collectors have been used in a number of sites with different soil coverage and affected by emissions coming either from wind flow across the field or from vehicular traffic along a dusted paved road.

Vertical profiles obtained with the arrays of sticky pads are complex, as in addition to saltation they collect reptating (at the lowest stage) and (above 50 cm) suspended particulates. A large number of particles is mobilized by reptation in non-vegetated loose soils. The fraction of the smallest particles is larger at higher heights and is associated to suspension. Close sites with distinct soil types show different vertical profiles; moreover, the terrain topography strongly modifies the profile.

The directional assessment allows differentiating between particulate sources. In the example of Fig. 3 it can be seen that there is contribution of (fine) particles coming from NE and another contribution of (coarser) particles arriving from SE. A brick manufacturing industry located 1.5 km to the NE of the sampling site and a dusted paved road 30 m to the SE may account for the measured values.

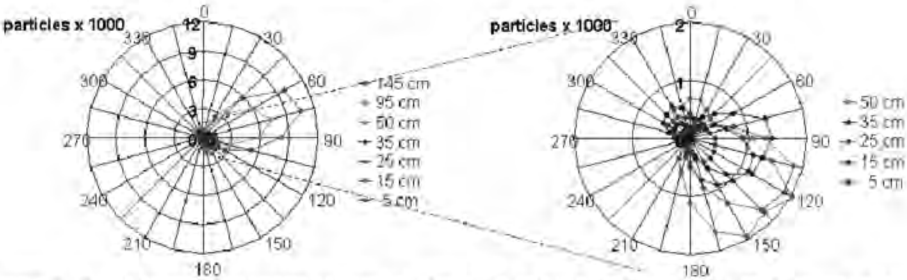

Figure 3. Particle number roses computed for all 7 heights (left) and for the 5 lowest stages (right) of an array of sticky pads placed at a bare soil site. NE and SE winds prevailed in the 48-h sampling period and specific particle sources are related to those directions.

The vertical profile of the mass collected in the omni-directional stacked sand catchers follows an exponential function with respect to height (Fig. 4), showing strong differences according to the soil and sources close to the sampling site. The determination coefficient of the fits is greater than 0.99 in all cases.

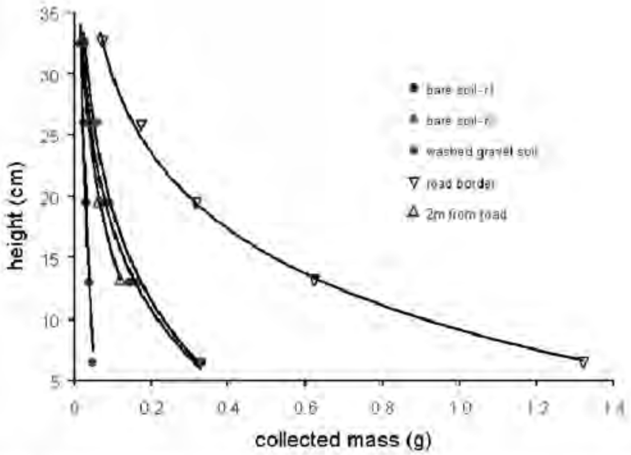

Figure 4. Typical vertical profiles of the mass collected on the stacked sand catchers for different soils (circles): washed graved soil, bare soil (two replications), and proximity to a dusted road (triangles).

CONCLUSIONS

We have designed and tested two types of passive collectors to study aeolian erosion in the field. The use of the vertical arrays of collectors in many locations seems promising and it is proposed as appropriate for research. Further scrutiny of the methods in comparison with others and the assessment of the capture efficiency of each stage may be desirable.

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