Introduction

Wind erosion poses a serious problem in many parts of the world and is a dominant issue in Hungary too, where there are wind-blown areas of a considerable size. These occupy nearly 23 per cent of the total surface of the country. Agricultural land most susceptible to wind erosion is situated in a large blown-sand area in the southern part of Hungary, between the Danube and Tisza river. Wind-blown sand areas play a considerable part in farming and their importance is ever growing. Thus it is apparent that conservation of a light sand soil against the wind erosion is vital. Geomorphologists and landscape ecologists have to get involved in this research. Due to the studies performed in the last 30 years the knowledge on wind erosion has expanded, however up-to-date methods should be increasingly involved to expand investigations to new test areas.

The Department of Physical Geography launched an intensive research project on wind erosion in 1994. To study deflation occurring in the Danube-Tisza Interfluve a research station was located for measurements of deflation and accumulation of sandy soils meteorological and climatic conditions of wind erosion. This detailed examination and analysis are the basis of our study, in which we examine the meteorological aspects of wind erosion and the results of the first year of the research. At the same time the change on land use and the connection between the land utilisation and wind erosion are also investigated.

Remote sensing is proved to be a possible source of data from which updated land cover information can be obtained effectively (Smara, et al., 1995). With the help of satellite images we can investigate the most important reasons of wind erosion, e.g. surface temperature, condition of vegetation and soil moisture. The larger accumulated and eroded resultant forms can be characterised. In order to characterise the surface state better: we must integrate data other than remotely sensed data, such as measured data derived from the field and laboratory work.

Geomorphology of the test site

The test site is situated near Kőmpőc in the Danube-Tisza Interfluve, at the border of Bács-Kiskun Country (fig. 1). The wind-blown sand areas can be investigated from the western border of the alluvial flood plain of the Tisza river. This area is the residue of the
Fig. 1. Geological map of the Danube-Tisza Interfluve and the occurrence of natron lakes (Molnár, 1980)

Legend: 1 – alluvium, 2 – flood-plain sediment of high carbonate content, 3 – solodised loess, clay and sand, 4 – wind-blown sand, 5 – loessic sand, 6 – typical loess, 7 – alluvial loess, 8 – argillaceous loess, 9 – carbonate-containing smallakes

large alluvial fan of the Danube river, which was mainly formed during the Pleistocene. The sand and sandy silt deposits of the alluvial fan ridge have not been shaped by fluvial since the middle of the Würm (up to the Interpleni-glacial epoch). In this period, due to structural motions, the Danube gradually abandoned its alluvial fan in the Interfluve and assumed an N-S direction of flow (Borsy, 1982). Particularly in Late Pleistocene and during the dry periods of the Holocene the loose fluvial deposits of the alluvial fan were reworked by wind.

The thickness of the transported and accumulated blown sands from 10 to 30 m in the eastern part of the area. The most characteristic landforms are windrift, residual ridges,
sand hills as well as sand dunes. From the aerial photos the long straight valleys, which are parallel to the most characteristic NW wind direction; there are small lakes or sometimes-smaller streams. On the bottom of these valleys, silty-sodic sediments are being formed containing dolomite silt and clay (fig 1). The valleys with infrequent ponds are not only parallel with the dominant wind direction, but indicate the general slope of the area. The lake basins should be regarded as depressions produced by wind erosion – in the periods of spring snowmelt and rain weather – of surface workflow and ground water percolation (Jakucs, 1990).

Climate

The average annual precipitation for this area is lower than 550 mm. The average monthly and annual precipitation figures show the presence of a dry period in early spring, middle summer, late summer and early autumn. In the second half of the summer the probability of a rainless period is much higher here than in other regions of Hungary.

The investigated area has a continental climate and may be characterised as a warm sand steppe with hot summers. In warm years mean annual temperature is above 11.5°C. July mean temperature is above 22°C. The largest number of summer days (85-90) is found here and hot days are more than 30 annually. A long, warm autumn is typical; the daily temperature sinks below 10°C after October 25th. Winter is moderately cold, the mean temperature for January is -1.5°C. In spring the daily mean temperature rises above 10°C as early as April 5th.

The potential and actual evapotranspiration show considerable water deficit in the area from May (10 mm) to September (in August 48,8 mm). Consequently, the soil surface totally dries up during this period, the grains of the upper sandy soils lose water content which is necessary for bonding. In this way, wind erosion can remove, blow out, transfer and accumulate sand (Mucsi, 1993).

The prevailing wind is the NW, while the second most frequent direction is the SE, with higher frequencies in the spring and autumn months (Tar, 1991). The strong NW and NNW (above 5°B) winds are most frequent between June and September (Jakucs, 1990).

Based on the data series of measurement between 1963 and 1973 (source: Molnár, 1974), the weekly frequencies of wind higher than 3 m/s (daily averages) and the averages of dry soil state (Bodolay, 1965) were compared. The values clearly indicate that the months of April, October and November are critical from the aspect of wind erosion.

Comparing relationships between the frequency of different wind velocity with the frequency of values of soil moisture, the correlation coefficients show significant relationship between the winds, which are stronger than 3-4 m/s with the dry soil state (0.6-0.7). There was a weaker correlation (0.4) in the case of weekly frequencies of winds with the winds higher than 6 m/s, suggesting that the strongest occurrences of wind (February-April, November) do not coincide with the dry periods of soil state in the area (July-August).

The climatological prognostics suggest 1-mm annual precipitation loss for the next decades and the predicted rise in temperature is 0.5°C in twenty years and 1.0°C rise in fifty years in the Danube-Tisza Interfluve. All these mean that the annual rainfall will drop below 500 mm and that will not cover the water demand of the region. They result in a growing aridification and in dropping of the ground water table, which is to mobilise the sand
movement in the region. Due to the changing climatic conditions 30-50 percent increase of the wind erosion rate may be predicted (Mezősi, 1996).

Environmental degradation caused by man

Anthropogenic effects also caused sand movement at smaller spots as early as the first part of the subboreal phase. These however resulted in hardly any morphological changes. Neither did deforestation in the Middle Ages exert any significant influence on the surface. The situation completely changed from the 16th century, when deforestation extended to larger and larger areas. Deforestation in 18th century was extended to dune surfaces with higher relief energy, in order to conquer newer and newer territories for agriculture. However, these newly acquired lands produced good yield only for a few years, since the soil eroded easily from the higher parts of the dunes. Thereafter eolian erosion was accelerated and the sand began to move again in some places (Borys, 1982).

The most attractive interference's within the agricultural landscape, however, were those of modern times in which the territories most threatened by wind erosion were, the most intensively used agricultural lands with the highest production (Hradek, Svehlik, 1995). The largest interventions within the structure of farm plots, however, was that on the collectivisation period which features the agriculture of this country between 1960-1989. Large areas of fields on which there was no vegetation in repeated seasons have been now exposed to the wind erosion.

Due to the spreading of plant cultivation technologies over larger and larger fields, a lot of factors affected the soil deterioration caused by wind blowout the length of affected area. From these unobstructed distances of action must be considered to be the main factor intensifying danger as this has undergone the biggest changes along with the creation of gigantic fields. The structure of land use in the early 1960s with much smaller fields and with a dense tanya (grange) network and rows of trees (shelter belts) approached the optimal organisation of plough-fields. We compared the topographic maps (scale 1:100000) of the test area mapped before the collectivisation and mapped much later, in the 1980s. The number of grange on this area was 340 in the early 1960s whereas this number is nowadays 190 (fig. 2). The disappearance of the granges was accompanied with significantly decreasing length of rows of trees and shelterbelts. A way to improve the spatial organisation, which is unfavourable today, is to form a complex shelterbelt system in all the areas sensitive to wind erosion (Baukó, Beregszászi, 1990).

Methods for monitoring of wind erosion

The purpose of our research is to work out the wind erosion model of the Danube-Tisza Interfluve: to mark the territories endangered by wind erosion and also to define the size of these areas and the mass of sandy soil removed by the wind. Between 1995-1998 we have been drawing up the methods of wind erosion monitoring on a test area at Kömpóc.

We started this job by having a parcel formed out next to the Hydro-meteorological Station at Kömpóc, where we measured the intensity of wind erosion and also the quantity of the soil transported by wind. On the 50 meters by 100 meters parcel we set 1-metre-high stakes, beside which we weekly measure the eroded and the accumulated quantity of sand. One part of the parcel is agriculturally cultivated where we plant different
Fig. 2. Topographic maps of the test area from 1960s (upper) and from the 1990s (lower)
types of crops each year. The other part is an uncultivated control area, where we can measure erosion arisen on strongly erodible soil surface. Next we marked out an 8-km² large test area, which has the parcel within its centre. We propose to make the geomorphological, soil and land use mapping of this area. These data will form the basis of the remote sensing analysis.

We collected airborne photos (1988, 1992), LANDSAT TM satellite images (1985, 1992) and SPOT image made in 1995 is already available which lets us start the monitoring of the area as we already have the field data of this year too.

Continuous observation was carried out on the parcel between May 31 and November 29, 1995. These data were computerised by Surfer software (fig. 3). Figure 4 shows that within each two-week-long observation interval, sand was accumulated on the parcel except for some shorter deflational periods. Data series of six months makes us assume that this surface is a depositional area of the sediment removed by wind, which supposition must be supported by further sedimentological analysis. At the border of the control and the cultivated areas, a deep, deflational zone was founded which proves that the densely planed wheat has wind driving effect. We have calculated the mass of accumulated and eroded sand on the 2750 m² large uncultivated plot. In 1995, the cultivated part of the parcel was sown by wheat and sand movement practically was not learnt here. This year, we are going to plant clover area, which may raise less difficulty for wind erosion.

The monitoring methods of the test area were partly elaborated. We have produced the photo map of 1:10000 scale using ERDAS IMAGINE 8.2 software. On several areas the photographs showed spots with unstabilised surface liable to be transported by wind which proved to be semistabilised or grassed surfaces. The introduction of digital images has expanded the techniques of the change detection. According to the NDVI, it can be deduced that there are significant and sharp differences in plant cover. The ploughed land and the vineyard are very dry and hot. This can be seen on the images of TM5 band and on the image of Soil Wetness Index, which relates to canopy and soil moisture (Mucsi, 1993):

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SWI = 0.1509(TM1) + 0.1973(TM2) + 0.3279(TM3) + 0.3406(TM4) - 0.7112(TM5) - 0.4572(TM7)
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By using the SWI-index image we have classified the driest areas which are exposed to wind erosion to a greater extent (Szatmári, 1996). The total size of these areas covers 22 km² of the 64-km² large test site (34%).

Our research on wind erosion has mainly aimed at drawing up the methods of effective and successful monitoring. These methods will hopefully serve as a basis of our research scheduled for the next years.
Fig. 3. The difference of the measured values at the end of the first observation interval in 1995. The dark patches show the areas of the intensive deflation.

Fig. 4. Area of accumulation and deflation of sand on the experimental parcel (m²) and mass of the accumulated and eroded soil (ton) between May and November 1995.
References


