Assessment of Natural Conditions in Lithuania from the Point of View of Wind Erosion

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Wind erosion in Lithuania, as also the neighbouring Baltic countries, occurs mainly in areas where the natural plant cover has been replaced by agriculture. In the years of Soviet power, the formation of vast continuous tilled fields (up to 1000 ha) and extinction of agroplantations and individual farmsteads, contributed greatly to intensification of wind erosion. As a result of soil drainage and wind erosion (the wind no longer meets obstacles on its way) in some years up to several tons of light soils would be blown out in a few days (e.g.,1982, 1988, 1989).

A group of scientists from the Institute of Geography in Vilnius (R.Morkunaite, S.Paskauskas, M.Beconis, V.Minkevicius, headed by the author of the present article) investigated the processes of wind erosion in 1986-1991. The field investigations were carried out using various sediment samplers [2,3]. These investigations were supplemented by a physical modeling of wind erosion processes in the wind tunnel [1]. From the data obtained a mathematical model was worked out, which expresses the dependence of wind erosion on the major determining factors:

$$D = -1798 \pm 450v - 357g - 105h - 45m$$

where wind erosion coefficient (R) = 0.69, D is the volume of blown soil, t/ha/h; v = wind speed, m/s; g = diameter of equivalent soil aggregates, mm; h = humus, %; m = content of physical clay, %.

The structural analysis revealed that the character of wind erosion dependence on the indicated factors, determined by the mathematical model, is in good correlation with corresponding interrelations determined by other authors [4], who used theoretical and empirical methods.

Due to specific modeling conditions (dry soil, no vegetation cover, etc.) the intensity of wind erosion at similar wind speed in the wind tunnel is higher than under field conditions. For this reason the data obtained during the mentioned experiment can be accepted with reservation (the intensity of potential wind erosion determined by modeling would make 1000 h/year, estimated by one grade number).

In order to use this mathematical model of wind erosion we had to collect extensive data about the wind and soil characteristics to be included in the model.

Winds

The critical wind speed at which the wind erosion begins is 5-6 m/s in dry sand soils without vegetation and 7-9 m/s and more in loams. A particularly appreciable intensification of wind erosion is observed when the wind speed reaches 8-10 and 14-16 m/s respectively. In Lithuania the highest possibility of wind erosion occurs in spring and autumn (Table 1).

Table 1. Average long-term indices of erosion winds (>10 m/s) duration (h/ms)

Lithuanian regions	Spring (IV–V) h/ms	Summer (VI–VII–VIII) h/ms	Autumn (IX–X) h/ms
East Lithuania	108	68	100
Middle Lithuania	141	66	64
West Lithuania (Coastal area)	168	112	164

h – hours, ms – months

As can be seen from Table 1 the erosion winds of longest duration occur in the Lithuanian coastal area. This region is also distinguished for particularly strong winds (12-15 m/s) which recur 2-4 times more frequently than in other Lithuanian regions.

The best conditions for wind erosion occur in spring when the number of days with precipitation is the least, relative air humidity is low, and what is most important, 25-35% of tilled lands are either not sown and planted with summer and hoed cultures or the shoots of such cultures are so small and undeveloped that they are unable to protect the soil from blowing out. In autumn the conditions for wind erosion are not so favourable due to frequent rains and resulting soil saturation with the water which increases their resistance to blowing out.

The West and Southwest winds prevail (especially in the coastal area) in Lithuania. This should be taken into consideration while projecting the wind erosion-protective plantations.

Soils

Under otherwise similar conditions fine-grained wash-out sands are the least resistant to wind erosion. The volume of blown out soils from them is 30-50% larger than from the medium-grained sands and 60-120% than from the coarse-grained sands. Most resistant to wind erosion are the soils of heavy mechanical composition (loams and clays). However, it was recorded that in winters without snow during strong storms the frozen loam soils are very intensively blown out (up to some hundred tons from one ha).

Weak resistance of light soils to wind erosion is dependent also on their poor structure and small content (0.8-1.3%) of humus. These are the indices evaluated in our mathematical model of wind erosion. Their equivalent granulometric diameter is 0.05-0.1 mm; equivalent aggregate diameter – 0.2-0.35 mm.

Zonation of Lithuanian territory from the point of view of wind erosion

Wind erosion zones were distinguished taking into consideration, first of all, the mentioned soil properties. As geomorphologic regions of various types and genesis are characterized by specific soil complexes, their wind-erosion properties also differ. Great wind erosion potential of the coastal area is, for the most part, conditioned by greater probability of strong winds.

The mapping was done on scale 1:300 000. For the regions with very intensive wind erosion (Silute, Klaipeda, Kretinga, Vilnius, Varena) the mapping was done on scale 1:50 000. Areas susceptible to wind erosion were grouped into several susceptibility categories expressed by scale numbers (<0.5, 0.5-3, 3-6, 6-10, 10-20,>20). In the coastal area the zones of extreme susceptibility to erosion were distinguished additionally: 20-40, 40-60,>60.

On the ground of the abundant database and soil investigation data collected by the authors, as well as wind speed data from 11 meteorological stations collected in the months favourable for wind erosion (IV-V, VIII-X), the mathematical model was applied, which allowed the evaluation of the resistance to wind erosion of sand and sandy loam soils (by scale numbers) in different types of relief (Table 2). According to the data of Table 2, the major wind erosion index of Lithuanian soil complexes was computed, which served as the basis for mapping the areas susceptible to wind erosion.

Table 2. Evaluation of soils susceptible to wind erosion (scale numbers) in Lithuania

Type of relief	Mechanical composition	
	Sand	Loamy sand
1. Hilly morainic uplands		
a) with small hills	8.7	3.8
b) with large hills	9.5	4.9
c) effected by limnoglacial processes	9.6	5.8
2. Morainic plain	7.6	1.2
a) with small hills	15.0	3.7
b) with large hills	7.5	4.4
3. Fluvioglacial plain		
a) with small hills	44.0*	15.2*
b) with medium hills	9.5	5.4
c) with large hills	4.7	2.0
4. Limnoglacial plain		
a) with small hills	16.8(50*)	4.8(6.6*)
b) with medium hills	9.8(31.5*)	5.1(9.0*)
5. Bog-lake plains	10.9	2.0
6. Flood terrace plains	30.0(82.0*)	6.2(6.4*)
7. River valleys	13.1	5.2

From the point of view of wind erosion, the most susceptible soils are spread in the sandy Southeast Plain and Coastal plain.

The areas of the highest susceptibility to wind erosion (scale number 20) are situated in the sites of former shallow lakes (Svencionys, Trakai districts), confluence of large rivers (Neris-Zeimena, Neris-Sventoji) and higher terraces of the rivers Neris and Merkys. Dunes are frequent in such areas and buried soils in their trenches.

Areas with soils of lower susceptibility to erosion (scale number 10-20) are spread all over the country. They are found in the Baltic Sea terraces (Klaipeda, Kretinga districts), sites covered with sediments of former glacial basins (Zarasai, Trakai, Lazdijai districts) and sandy archaic deltas (vicinities of Kazlu Ruda and Salininkai-Viesvile).

Most areas with soil susceptibility to wind erosion scale number 6-10 are situated in the Southeast sandy plain. They are found in the Zarasai, Ignalina, and Varena regions on higher and lower outwash plain terraces. In the West and Middle Lithuania such areas are found in sites of former shallow water reservoirs and archaic deltas. They are also found on higher terraces of the rivers Sventoji, Neris, and Nemunas.

Soils with the scale numbers 3-5 are more frequent within the limits of the former glacial basins (Taurage, Trakai, Jonava, Silute and other districts) and the alluvial terraces of larger and smaller rivers.

Higher South-Lithuanian flood plains are characterized by soils with the scale number 0.5-3 (Vilnius, Salcininkai districts). Such soils are also found in the Zemaitija plateau in the sites of former shallow lakes, as well as between the ridges of the Baltic Upland and bottom of old vales.

The influence of meteorological conditions on wind erosion processes manifests itself through the duration of certain wind speeds in periods favourable for wind erosion. The longest duration of such winds was found in the Coastal Plain. Strong winds and large areas of sandy soils create favourable conditions for wind erosion. The Silute district is typical in this respect, where the scale number of 50% of soils susceptible to wind erosion is 20. This makes about 42% of all areas of this category in Lithuania (Tables 1,2).

References

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