A REVIEW ON SHEET EROSION MEASUREMENTS IN HUNGARY

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Abstract: Soil erosion has a significant role in ecology, economy and in environmental protection therefore its quantification and prediction are very important, particularly on a national level. Although some details can be described using physical equations, the entire soil erosion process is rather complicated and can be determined only empirically, which requires large measured datasets. Because plot measurement is the most convenient and therefore the most popular way of capturing erosion data, we used plot measurement to understand erosion in Hungary. The northern and the western parts of the country are endangered by sheet erosion, which is why the plots were carried out in those areas. Most of the plots were constructed to determine the "K" factor of the USLE (Universal Soil Loss Equation) under permanently tilled soils without vegetation cover. Additionally the soil protection effect of various field crops and the additional land use types (forest, pasture) was measured in the plots. Furthermore descriptive investigations, rainfall simulations and soil tracer detections were also used to quantify sheet erosion at different environmental conditions and scales. Despite the large amount of measured data collected, only a few of them have since been published. Due to a lack of available data, national erosion research, erosion prediction, and model calibration are less precise and effective Scaling problems among the measured levels also emphasized a definite need for a larger and more accessible national database. Finally, without the financial base of additional plot measurements, the publication of the previously gathered data is absolutely necessary to continue soil erosion studies in Hungary.

Introduction

Soil erosion is a global problem that affects—with varying intensity—most of the cultivated areas of the world. The pressures of an increasing population have led both to food that is produced intensively on existing farmland and to the involvement of new areas into intensive tillage operations (RHODES 2014). Consequently, since soil is a conditionally renewable resource, soil erosion hazards can be a ticking time bomb for a country's security.

The success of avoiding and remediating soil erosion depends on the detailed knowledge of the sub-processes involved in erosion. Useful models are accessible only when large amounts of measured results are available.

Since soil erosion is a rather complex phenomena contingent on the temporary interactions of various environmental parameters, even the basic processes vary within a particular area. To apply a general and adequate soil erosion model in the landscape and to gain the best results, it must be calibrated and validated with local data first. Accordingly the very best soil erosion model can present inadequate results because of the lack of previous calibration and validation. Therefore each country has almost a responsibility to gather as much and as high quality place-specific erosion data as it is possible.

The case of Hungary is very unique from this point of view because two thirds of the country is used agriculturally and widespread loose sediment parent material makes the soils especially prone to erosion. Although the area of the country (ca. 93,000 km^2) is smaller than the average traditionally agricultural country in the EU, a wide range of erosion processes can be found and often parallel to each other. The flatter, continental parts of Hungary are often afflicted by wind erosion and even by "berm erosion" on salt affected alkali flats (TÓTH et al. 2015), while the hilly parts are eroded by both sheet and gully erosion. The varying landscape and climate results in a rather complex mosaic pattern of soil erosion processes with very high

spatial diversity (CENTERI 2002c, KERTÉSZ and CENTERI 2006). This spatial diversity makes the up- and downscaling of the measured data considerably difficult both over time (DE VENTE and POESEN 2005) and among scales (STROOSNIJDER 2005).

The aim of this paper is to review the efforts of soil erosion measurements in Hungary and compare the published results. To do so, the focus is solely on sheet erosion, even though gully (JAKAB et al. 2009, KERTÉSZ and JAKAB 2011), wind (NÉGYESI et al. 2014) and fluvial (SZALAI et al. 2013) erosion also have a very important impact on recent landscape development of Hungary.

Measuring soil erosion

Most of Hungary's soil erosion history has occurred from natural phenomena and is of limited interest to this study. However anthropogenic soil erosion events and processes have increased in the last century due to intensive farming practices (SZILASSI et al. 2006). Therefore soil loss as a potential danger, rising in the 20th century, directed attention to erosion processes. From a theoretical standpoint the history of soil erosion research was divided to three main groups by the authors described below: (1) descriptive studies, (2) process oriented studies, (3) complex studies. This classification is subjective reflecting the progressive attitude of man to the nature over time.

Descriptive studies

In the first part of the 20th century soil erosion was considered more of a cause of recent landscape morphology rather than a process, which detaches soil particles and moves them elsewhere. Because of this common consideration, a detailed survey of the current status of soil erosion in Hungary seemed to be more prescient than investigations of the processes of its present soil erosion. Results of the survey were soil erosion maps constructed and produced at various scales from national (DUCK 1960, STEFANOVITS 1964) to larger scales (DUCK 1966, ÁDÁM 1967). Additionally, case studies were carried out in order to measure nutrient distributions along different slopes due to sheet erosion on various soil types (MATTYASOVSZKY and DUCK 1954).

At that time, soil erosion was considered as an effect, which mitigated soil fertility hence caused economical damages. Its role as an environmental hazard had not yet been recognized. On the other hand the role of human activity was identified as the main purpose of accelerated erosion increase. Consequently significant efforts were made for erosion prevention and soil protection theories and practices (FEKETE 1953).

Although process oriented investigations have become more popular since the 70s, descriptive studies were still popular. In that time KERÉNYI (1984a) introduced a new way of soil erosion surveying and mapping in which he took rill and gully erosion into account in order to determine the real rate of accumulated soil loss. Since this type of survey needed significantly more effort it did not become widespread.

Process oriented studies

While descriptive investigations increased a need arose to understand the processes involved in generating soil erosion. This led to increasing attention being paid to monitoring and modelling studies. Soil erosion monitoring was carried out with the construction of measuring equipment that could quantify runoff and soil loss values due to natural precipitation events. These techniques aimed at measuring soil losses at different spatial scales since it became

evident right away that the results of different scales are hardly comparable to each other (STROOSNIJDER 2005).

The small-scale investigations were based on monitoring sediment traps at catchment outlets (SZŰCS 2012), creeks or rivers (DEZSÉNY and LENDVAI 1986). In the 80s the water quality of Lake Balaton—because the lake was a very popular destination—decreased dramatically, becoming a major problem. Although water pollution was partly due to the lack of sewerage, attention was focused on the erosion processes in the Balaton watershed (DEZSÉNY and LENDVAI 1986). At this point in time measurements were concentrated on the surface water quality of the streams in the catchment in which phosphate received the primary interest (MÁTÉ 1987).

In the early 90s, a country wide catena scale monitoring program was designed and partly constructed by the National Soil Monitoring Network (TIM) (VÁRALLYAY 1994). In this study metal sheets of 1 m^2 were placed into the soil at exactly 60 cm from the surface parallel to various geomorphological positions—mainly on ridges, footslopes and midslopes. The changes of soil depth above the metal sheet referred the dynamics of erosion or deposition processes (NOVÁKY 2001). Although in this study the construction took the main part of the budget—maintenance being nearly negligible—monitoring stopped because of financial difficulties. Moreover there are very limited data published from the short monitoring period (18 stations, 3 slope positions and 3 recording times). These data partly reflect the obscurity of the first year results manifested in a few cm changes in both directions at the same place (NOVÁKY 2001).

Plot measurements

Measuring in situ soil erosion this method is currently the most widespread of the world. Many sites can be found in Europe with large amounts of published data (VACCA et al. 2000, JANKAUSKAS and JANKAUSKIENE 2003, CERDAN et al. 2006, GONZÁLEZ-HIDALGO et al. 2007) and many countries neighboring Hungary have well documented monitoring results such as Romania (IONITA et al. 2006), Slovakia (STANKOVIANSKY et al. 2006) and Slovenia (HRVATIN et al. 2006). Theoretically plot measurement can provide data on a wide variety of scales even though data is typically recorded at micro and smaller scaled investigations (STROOSNIJDER 2005).

Hungary is situated on the border of 3 climatic zones therefore the whole country cannot be described as one unit. The SE part (The Great Plain) is continental and has the least amount of precipitation (less than 500mm year^{-1}) and a high yearly mean temperature fluctuation (20°C). The Western part is the wettest while the SW has a slight Mediterranean influence (DÖVÉNYI 2010).

The size of the published plots varies from 2 to 1200 m^2 due to different purposes (KAZÓ (1966a) reported about the advantages and disadvantages of in situ measurements on various plot sizes). In accordance with topography and pedology the most endangered spots can be found mainly in the western and the northern parts of the country (KERTÉSZ and CENTERI 2006) (Figure 1). In these areas the soils concerned are Luvisols and Lithosols on the higher parts and Cambisols on the hills. The most investigated land use type is arable land, especially black fallow or continuous seedbed conditions, however, forest cover has also been investigated (BÁNKY 1959b).
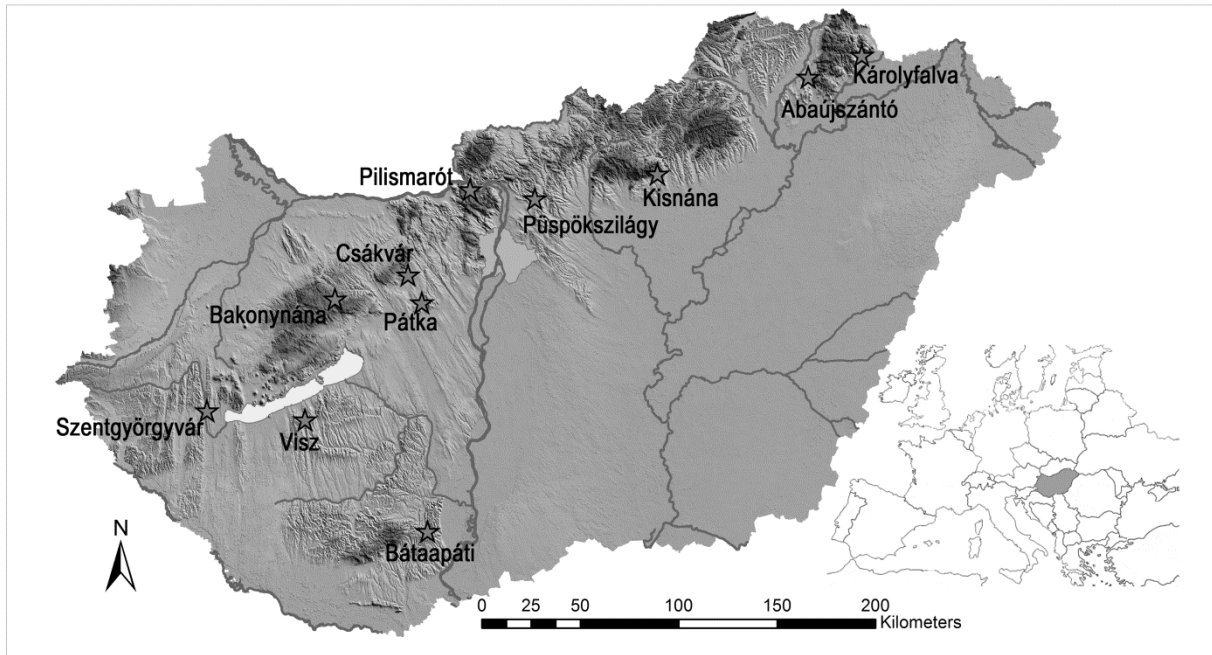
Figure 1. Location of plot measurements in Hungary
1. ábra A parcellás mérések elhelyezkedése hazánkban

The appearance of the USLE concept (Wischmeier and Smith 1978) provided a standard way for sheet erosion measurement. Its high efficiency was associated with easy applicability, which is why the USLE method became widely accepted even in Hungary behind the *iron curtain*. Although considerable more plot measurement data was registered and stored this study focuses on only ten locations on the basis of seventeen publications. Most of the measured data are still unavailable since they manifested only in manuscripts even though some of them contain data that covers long periods of time (more than 10 years continuous monitoring).

Some of the sources present single precipitation induced runoff and soil loss values, other reveal derived values (e.g. soil erodibility (K) factor from the USLE) (Table 1). A common problem in sources from former times was the exchangeability and comparability of the presented data due to the lack of certain precipitation parameters or soil bulk density. The bulk density of soil loss is generally much less than that of the in situ soil, hence soil loss values presented in bulk units are hardly comparable to those of weight units.

The most accepted calculation methods concern an annual period even though often a few precipitation events result almost in the total amount of annual soil loss. This phenomenon is typical for semiarid regions such as the Mediterranean but due to climate change it is becoming even more frequent even in Hungary. Accordingly the same sediment gathering infrastructure has to collect and store sediment and soil loss of various orders of magnitude. This is why there is no completely accepted and widespread sediment collector equipment in Hungary—even the most up to date devices can not handle extreme events, which causes data loss.

Table 1. Plot measurement properties in Hungary The presented values are means. (K: soil erodibility factor of the USLE; R: rain erosivity factor of the USLE; A: soil loss; RR: runoff rate; question mark refers to ambiguous data)

1. táblázat Magyarországi parcellás eróziómérések A pulikált eredmények átlagok. (K: USLE erodálhatósági tényező; R: USLE esőenergia tényező; A: talajveszteség; RR: lefolyási ráta; a kérdőjel kétes adatot jelöl)

Location	Purpose	Plot size (m)	No of plots	Soil	Land use	Monitoring period	Slope steepness (%)	Published results	Source
Csákvár	USLE K factor	1×8	10	Regosols Leptosols	Black fallow	1990-1997	14	K values for five soils	KERTÉSZ and RICHTER 1997; KERTÉSZ et al. 2004,
Visz	USLE K, C factors	2×22	4	Cambisol	Black fallow Pasture	1999	9	K=0.034	TÓTH et al. 2001.
Kisnána	Erodibility	various	6?	Luvisol	Forest	1958-2009	?	Results of single events	BÁNKY 1959a
Szent-györgyvár	Tillage comparison	24×50	4	Luvisol	Arable land	2003-2009	9	Annual runoff and soil loss values	BÁDONYI et al. 2008; KERTÉSZ et al. 2007; KERTÉSZ et al. 2010 Madarász et al. 2011
Püspök-szilágy	USLE K factor	2×22	4	Cambisol & Luvisol	Black fallow	2000	9	Results of single events	BALOGH et al. 2003
Bátaapáti	USLE K factor	2×22	2	Leptosol	Black fallow	2006	9	K=0.2, A=30 t ha^{-1}, R=140 kJ m^{-2} mm h^{-1}	BALOGH et al. 2008
Pilismarót	Erodibility	various	6	Luvisol	Arable land	1982-1985	14-23	RR=0.04, A= 10.2 g m^{-2}	GÓCZÁN & KERTÉSZ 1988, 1990; KERTÉSZ 1987
Bakonynána	Erodibility	various	6	Luvisol	Arable land	1976-1984	18-29	RR=5.6	KERTÉSZ and GÓCZÁN 1990; GÓCZÁN and KERTÉSZ 1988
Abaújszántó	Geotextil effect	2×10	16	Cambisols	Vineyard Orchard	2007-2008	10-20	K=0.002; 0.004; 0.035	KERTÉSZ et al. 2007b,c
Károlyfalva	Erodibility	0.8×2.5	4	Cambisol	Black fallow	1986	18	Results of single events	KERÉNYI 1991, 2006
Pátka	Model calibration	2×20 1.8×60	3	Cambisol Chernozem	Arable field Vineyard Orchard	1999-2002	4-13	Results of single events	BARTA 2004

The most adequate database among the investigated sources is based on the Csákvár experimental station (Figure 2). The K factor for five representative soils of the Lake Balaton catchment was determined over several years. Four soil types were transported to the station in order to equalize climatic conditions. Each investigated soil was originally shallow, therefore after the settlement of the replaced soil the circumstances were the same as in the in situ locations (Kertész and Richter 1997). Eight years of measurement was calculated into eight separate K factor values for each of the five investigated soils (Kertész et al. 2004).
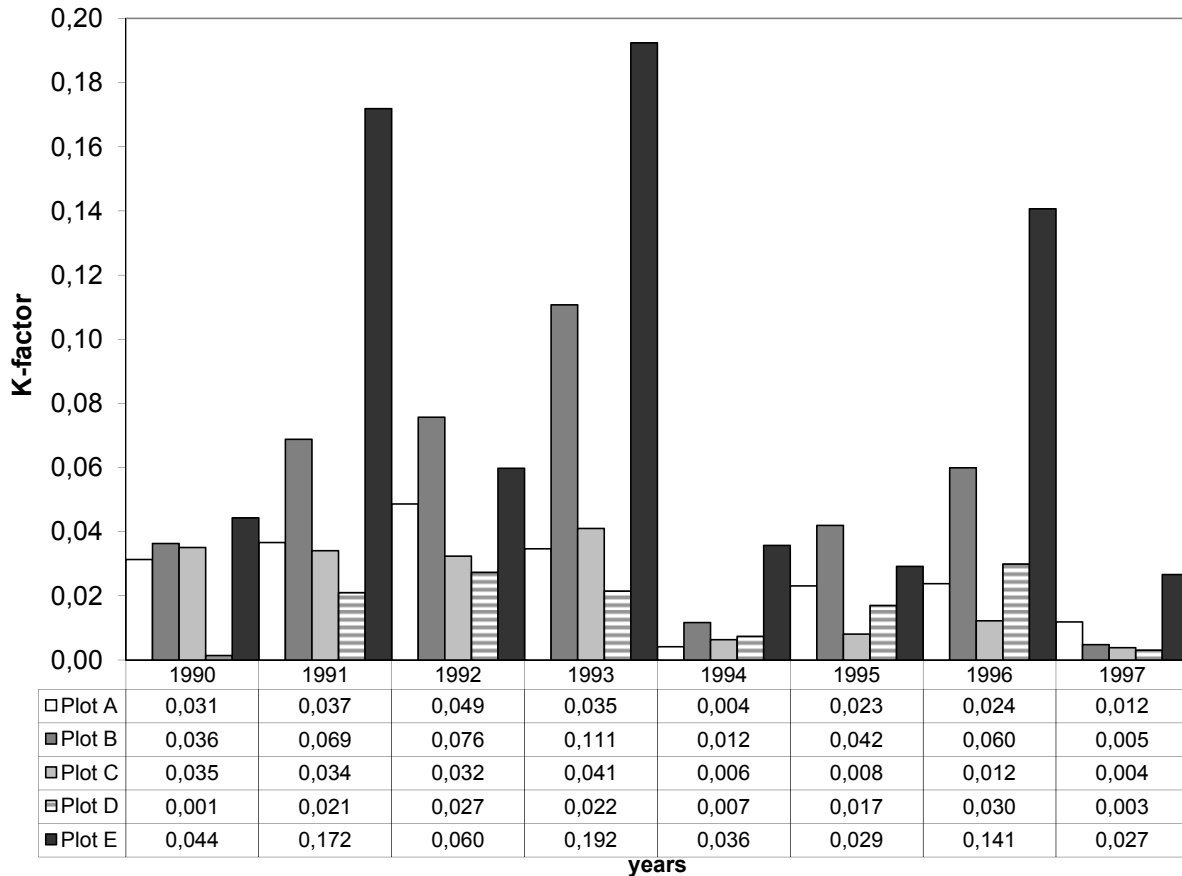

	1990	1991	1992	1993	1994	1995	1996	1997
▫ Plot A	0,031	0,037	0,049	0,035	0,004	0,023	0,024	0,012
▪ Plot B	0,036	0,069	0,076	0,111	0,012	0,042	0,060	0,005
▫ Plot C	0,035	0,034	0,032	0,041	0,006	0,008	0,012	0,004
▫ Plot D	0,001	0,021	0,027	0,022	0,007	0,017	0,030	0,003
■ Plot E	0,044	0,172	0,060	0,192	0,036	0,029	0,141	0,027

Figure 2. Measured K values on Csákvár station (A: Lithosol, sandy silt; B: Cambisol, silty sand; C: Cambisol silty clay; D: Rendzina silty clay; E: Cambisol silty clay) After Kertész et al. (2004)
2. ábra Mért K értékek a Csákvári Állomásról (A: Köves sziklás váztalaj, homokos vályog; B: Váztalaj homok; C: Földes kopár agyag; D: Lejtőhordalék agyag; E: Rendzina silty clay) Kertész et al. (2004)

Presumably the database measured at the Kisnána station contains the highest amount of data, however it has yet to be published. On the basis of the available data here, no valuable calculations or comparisons can be made.

Some parts of the data measured at Szentgyörgyvár are published both in a detailed rough format and in a summarized format (Table 2), hence they are not particularly applicable for further calculations or comparisons (Bádonyi et al. 2008, Kertész et al. 2007, Kertész et al. 2010). Moreover the main parts of the database are still unavailable for the scientific community.

Table 2. Main measured parameters on the Szentgyörgyvár site. (R: USLE erosivity factor; Dep: deposited soil loss; Susp: suspended soil loss) After BÁDONYI et al. 2008 and MADARÁSZ et al. 2011
2. táblázat Szentgyörgyvári Állomás által mért főbb adatok . (R: USLE esőenergia tényező; Dep: ülepedő talaj-veszteség; Susp: lebegtetett talajveszteség) BÁDONYI et al. 2008 és MADARÁSZ et al. 2011 alapján

Year	R	Tillage	Runoff	Runoff rate	Dep.	Susp.	Total Soil loss
	$kJ\ m^{-2}\ mm\ h^{-1}$		$m^3\ ha^{-1}$		$kg\ ha^{-1}$	$kg\ ha^{-1}$	$kg\ ha^{-1}$
2004	51.34	Conventional	15.458	0.010	57	9	67
		Minimum	2.708	0.002	3	2	5
		M/C %	17.5	17.5	5.3	20.9	7.5
2005	173.35	Conventional	892.127	0.290	4542	264	4806
		Minimum	342.531	0.111	101	74	175
		M/C %	38.4	38.4	2.2	28	3.6
2006	40.24	Conventional	448.631	0.015	7331	591	7922
		Minimum	110.44	0.005	1.1	64	165
		M/C %	24.6	35.9	1.4	10.8	2.1
Mean for 2007-2009	n.a.	Conventional	26.2	0.04	n.a.	n.a.	1540
		Minimum	9.4	0.014	n.a.	n.a.	580
		M/C %	35.9	35	n.a.	n.a.	37.7

The published parts of the erosion measurements carried out at Bátaapáti and Püspökszilágy are short-term case studies. Since the data issued are separated and point scale, both in time and space, the usage of these measurements are limited.

Plot measurements taken place next to Abaújszántó were aimed to quantify the role of organic geotextiles in soil protection (JAKAB et al. 2012), moisture conservation (KERTÉSZ et al. 2011) and erosion control (Table 3).

Table 3. Main result of biological geotextiles covered plot measurements at Abaújszántó 2006-2008
3. táblázat Geotextillel fedett parcellák mért értékei Abaújszántón 2006-2008

	Orchard		Espalier vineyard				Traditional vine-yard	
	Jute	Un-covered	Jute	Borassus	Buriti	Un-covered	Jute	Un-covered
Soil loss ($t\ ha^{-1}\ year^{-1}$)	0.56	2.63	5.29	2.83	6.67	24.83	0.12	0.13
K ($t\ h\ MJ^{-1}\ mm^{-1}$)	n.a.	0.0045	n.a.	n.a.	n.a.	0.0427	n.a.	0.0002
P	0.21	n.a.	0.21	0.11	0.27	n.a.	0.98	n.a.
Runoff $mm\ year^{-1}$	7.1	9.5	13.7	17.2	11.2	29.0	7.5	6.3
Runoff rate	0.013	0.017	0.025	0.036	0.023	0.053	0.014	0.011

Some of data measured next to Pilismarót and Bakonynána are published in a single storm resolution, however the database seems to be incomplete in terms of the lengths of the measuring period. The presented values are often difficult to compare due to the lack or insufficiency of certain parameters such as surface coverage. The annual summaries have not yet been calculated and because of the length of the elapsed time it is unlikely they will ever be. Although runoff and soil loss results measured at Pátka were of high quality, even for soil erosion prediction model building (BARTA 2004), they were not available for further calculations. Similarly the database built at Károlyfalva seems to contain very useful data but neither the literature, the rough database or the calculated values are available.

Rainfall simulation studies

Plot measurement results hardly depend on recent climatic conditions. In the absence or abundance of some certain types of precipitation that occurred under a special soil condition, the measured annual values can differ remarkably from each other. Hence the gained results are comparable only with limitations. To ensure the possibility of a better comparison artificial precipitation forming devices were needed. Reflecting this need the first rainfall simulator was designed and constructed parallel to the global trend and the first plot constructions in Hungary by MATTYASOVSZKY (1953) in the 50s and KAZÓ (1967) in the 60s.

Table 4. Rainfall simulator studies in Hungary
4. táblázat Eső-szimulátoros vizsálatok Magyarországon

Type of simulator	Plot size	Purpose of using a rainfall simulator	Source
Rotating Drop former, field	0.25 m²	Infiltration, water management	KAZÓ 1966b
Rotating Drop former, field	0.25 m²	Soil erodibility	KAZÓ 1967
Rotating Drop former, lab	0.25 m²	Splash erosion	KERÉNYI 1982, 1984b, 1986
Individual drop former, field	8 m²	Soil erodibility	KERTÉSZ and RICHTER 1997
Alternating Nozzle type, field	12 m²	Soil erodibility	CSEPINSZKY et al. 1998
Alternating Nozzle type, field	12 m²	Soil erodibility, infiltration	CSEPINSZKY et al. 1999a-b
Alternating Nozzle type, field	12 m²	Soil erodibility, infiltration	CSEPINSZKY and JAKAB 1999
Alternating Nozzle type, field	12 m²	Soil erodibility	CENTERI et al. 2001
Alternating Nozzle type, field	12 m²	Soil erodibility, soil loss prediction	CENTERI 2002a
Alternating Nozzle type, field	12 m²	Soil erodibility, crop rotation	CENTERI 2002b
Alternating Nozzle type, field	12 m²	Soil erodibility	CENTERI 2002c
Alternating Nozzle type, field	12 m²	Soil erodibility	CENTERI et al. 2002
Alternating Nozzle type, field	12 m²	Soil erodibility, crusting impact	KERTÉSZ et al. 2002
Fix Nozzle type, field	10 m²	Phosphorus loss, erodibility	AZAZOGLU et al. 2003a,b
Alternating Nozzle type, field	12 m²	Soil erodibility	CENTERI 2003
Alternating Nozzle type, field	12 m²	Soil erodibility	CENTERI and PATAKI 2003
Alternating Nozzle type, field	12 m²	Soil erodibility, infiltration	SCHWEITZER et al. 2003
Alternating Nozzle type, field	12 m²	Model comparison	CENTERI et al. 2004
Alternating Nozzle type, field	12 m²	Soil erodibility, infiltration	JAKAB 2004
Fix Nozzle type, field	10 m²	Phosphorus loss, comparison of simulators	SISÁK et al. 2004a,b
Alternating Nozzle type, field	12 m²	Soil erodibility	CENTERI et al. 2005
Alternating Nozzle type, field	12 m²	Soil erodibility, infiltration	JAKAB and SZALAI 2005
Alternating Nozzle type, field	12 m²	Soil erodibility, Canopy effect	SZŰCS et al. 2006
Individual drop former, lab.	0.5 m²	Karst corrosion	ZÁMBÓ and WEIDINGER 2006
Fix Nozzle type, field	0.25 m²	Soil erodibility, tillage effect	KERTÉSZ et al. 2007
Fix Nozzle type, field	10 m²	Phosphorus loss	STRAUSS et al. 2007.
Alternating Nozzle type, field	12 m²	Soil erosion, canopy effect	BALOGH et al. 2008
Alternating Nozzle type, field	12 m²	Model comparison	CENTERI et al. 2009
Fix Nozzle type, field	10 m²	Rill initiation	HAUSNER and SISÁK 2009a,b
Fix Nozzle type, field	10 m²	Model calibration	HAUSNER 2010
Alternating Nozzle type, field	12 m²	Crusting, SOC erosion	JAKAB et al. 2013
Fix Nozzle type, lab.	0.5 m²	Aggregate erosion, crusting	SZABÓ et al. 2015

Artificial rainfall simulation has many advantages. It makes the investigations cost-effective, thus theoretically any type of rainfall characteristic can be applied at any time and any place. The purpose of usage also widely varies. In addition to soil loss, runoff and infiltra-

tion studies, the device is also perfect for measurements on splash erosion, nutrient movements, contamination leaching, sealing, crusting, organic carbon degradation, and karst corrosion (Table 4). Rainfall simulation studies in Hungary were reviewed in detail by CENTERI et al. (2010).

Descriptive investigations for process estimations

A detailed survey of an area can provide much more information than simply the degree of soil erosion at various spots. The spatial distribution can be compared to other databases such as (1) to other areas comparing the missing or deposited soil values at definite geomorphologic sites; or (2) to the same area from another time. Additionally, if they are well documented, spatial comparisons can be done by applying individual studies from a wide range of published investigations. On the other hand, for temporal comparisons, repeated surveys or standardized estimated initial conditions are needed on the same location, which are generally created by the same research staff.

Tracer detections

Tracers are very useful tools for soil redistribution investigations. Most of the materials can act as a tracer in soil replacement detection, however some artificial materials are more suitable than others. Since Hungary is located close to the Ukraine fallout from the nuclear accident at Chernobyl nearly contaminated the whole territory of the country as much. Cs-137 detection in soil redistribution therefore can provide soil loss and landscape evolution data both in hillslope (CSEPINSZKY et al. 1999c) and catchment scale (DEZSŐ et al. 2004; KERTÉSZ and JAKAB 2011). Results demonstrated that soil loss of an ordinary transdanubian catchment of 100 km^2 originated partly from subsoil due to gully erosion (~50%) and partly from topsoil due to sheet erosion (50%) (JAKAB et al. 2009).

Retrospective estimates of deposition processes show that many chemical soil parameters can be used such as high phosphate content (CENTERI 2010), mineralogical composition (NAGY et al. 2012), $CaCO_3$ or soil organic matter (JAKAB et al. 2014). These studies report a relatively high deposition rate at the footslope position (generally more than two meters), however the exact volume of soil loss along the investigated hillslope could only be estimated.

For detailed analytical investigations the in situ, real time artificial contamination methods are more applicable than the retrospective ones. For tracers rear earth oxides are used to determine the effects of erosion and tillage. This technique is not widespread in Hungary, however TÓTH (2015) presented preliminary results from rear earth oxide distribution results due to erosion under various tillage systems in Zala county.

Remote sensing

The use of aerial photographs for surveying soil erosion in Hungary dates back to 1966. MIKE (1966) tried to emphasize the advantages of this method compared to the traditional field survey, however, she focused mainly on gully erosion. As the calculation capacity of computers increased, remote sensing image interpretations became generally available even for sheet erosion surveys. VERŐNÉ WOJTASZEK (1996) compared calculated USLE soil loss categories to those interpreted from landsat images for a tilled sample field of 200 ha. The highest differences (37% both) were found in the soil loss categories of 5-10 t ha^{-1} and 15< t ha^{-1}, while the ratio of the area classified to the same category was only 11%. The difficulties mentioned were the disturbing influence of differences in plant coverage. A few years later VERŐNÉ

Wojtaszek and Balázsik (2008) published soil erosion map results derived from remote sensing images for a whole catchment (~ 120 km^2). These results were validated using field samples. The authors reported that changes in soil quality were detected even under vegetation coverage. Nevertheless this method cannot be automatized as the identification of learning areas is valid for only one image, hence changes in soil moisture content, soil status or vegetation cover can change soil radiation dramatically.

Complex studies

In complex studies the descriptive investigation is generally completed with analytical and/or historical data describing the complex process that formed the present landscape. Szilassi et al. (2006) investigated the role of land use change in the fluctuating intensity of soil erosion at a small catchment in the Balaton region and concluded that land use patterns have a unique importance in soil loss values.

Conclusions

Sheet erosion measuring methods used in Hungary have always been in accordance with the methods used by the rest of the world. The level of the designed experiments and equipment in Hungary has also increased with international standards. The country spent significant resources to construct and maintain their erosion measuring facilities that resulted in valuable databases at several locations. The most notable weakness of these efforts has been the poor publicity of these results due to the majority of the cases data stored in paper-based raw format without having gone through analysis.

Presently almost all the monitoring activities have been halted mainly due to financial problems. The existing raw data are unavailable for the scientific community, however with minimal additional investment they would become important resources for model calibrations and other soil science purpose. This course of action would be much more inexpensive than beginning new monitoring activities.

Conversely, some may say that it would be sufficient to use the erosion data measured by neighboring countries and there is no need to spend additional money for such costly business. Moreover, the existing correlations are losing their relevance due to the increasingly acute influences of climate change. However, Hungary has very diverse patterns of soil types, land use, climatic conditions and parent rock material that makes the expansion of the results difficult. Additionally the question of up- and downscaling among scales proves problematic without measured data.

Regardless, soil erosion is a rather serious problem—also in Hungary—that requires action. According to the opinion of the authors the increasing quantity of available data on soil erosion provides a higher level of security for the country.

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LEPELERÓZIÓS VIZSGÁLATOK EREDMÉNYEI MAGYARORSZÁGON

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Kulcsszavak: talajveszteség, léptékfüggés, módszertani különbség, országos adatbázis

Absztrakt: A talajpusztulás Magyarországon mind ökológiai, mind környezetvédelmi és gazdasági értelemben meghatározó szerepet játszik ezért mérése és modellezése elsődleges fontosságú, különösen országos léptékben. Az erózió néhány alapfolyamata jól közelíthető pusztán fizikai összefüggések használatával, azonban a holisztikus megjelenítés - a folyamat meglehetősen összetett volta miatt - csak empirikusan történhet, ami nagymennyiségű mért adat nélkül elképzelhetetlen. A lepelerózió in situ vizsgálatának legalkalmasabb és ezért a leginkább elterjedt módszere a parcellás mérés, következésképp hazánkban is e mérésekből származik a legtöbb adat. Magyarország északi és nyugati területei a leginkább veszélyeztetettek a lepelerózió által, ezért a mérések is e területekre koncentráltak. A legtöbb parcellás mérés a USLE Universal Soil Loss Equation "K" tényezőjének meghatározását célozta ezért növényborítás nélküli, folyamatosan magágy állapotban tartott talajt vizsgált. A későbbiekben aztán egyes szántóföldi növények illetve eltérő területhasználati típusok (erdő, kaszáló) talajvédő hatását is számszerűsítették a mérések során. Ezeken túlmenően eltérő környezeti feltételek és változó lépék mellett a területet leíró vizsgálatok, mesterséges esőztetések és a talajmozgás detektálása egészítette ki a lepeleróziós vizsgálatokat. A nagymennyiségű mért adatnak csak egy részét publikálták ezért jelentős részük nem elérhető a szakemberek számára. A hiányos adatok jelentős csökkenést okoznak a hazai erózióbecslés talajvédelem és modellezés pontosságában és hatékonyságában. Az egyes területi léptékben mért adatok kiterjeszthetősége más léptékekre korlátozott ezért a különböző léptékekben mért adatok megléte és használata nélkülözhetetlen. Az eróziómérésre fordítható források szűkülésével, újabb mért adatok hiányában a meglévő értékek közzététele létszükséglet.