Comparison of the results of modelling soil loss with WEPP and USLE in the Koppány Valley, Hungary

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Abstract
Soil water erosion prediction is the backbone of outlining hot spots where soil and nutrient loss might reach the biggest proportion, causing yield loss thus deficit for the farmer; sedimentation on the farm – deficit again –; siltation (filling up) and pollution of waterways and lakes putting the task of cleaning the roadside on the shoulder of local communities etc. It is important to find the best solution, the most appropriate, close to natural reality calculation or modelling of soil and nutrient loss and runoff. In the present study WEPP and USLE model were used to prove their efficiency on a slope of intensive arable farmland, close to the Koppány Creek. Along the creek we can find a NATURA 2000 site so it is not only important for the sake of the clean water itself but there are high natural values to be considered. The results show that on the upper and middle slope sections WEPP calculates more soil loss than USLE while at the bottom of the slopes WEPP calculates much more than USLE. On site investigations proved that the lower part of the slope is sedimented so USLE is closer to reality at the bottom of the slope.

Key Words
Soil water erosion, modelling, soil loss, WEPP, USLE, natural values.

Introduction

Soil erosion is a serious problem on agricultural fields of Hungary. In the hilly areas precipitation is between 600 and 800 mm/year. Even the relatively low intensity rainfalls are causing gullying and rills. The crop rotation structure does not favour soil protection, contains a high percentage of medium or low soil protection crop (Centeri 2002, Szilassi *et al*. 2006). Soil and nutrient loss, runoff and sediment yield calculations (Jakab and Szalai 2005) are important in protecting our (still) valuable arable lands. Examination of soil parameters are essential to teach farmers for better management practices in order to save nutrients, soils, money, time and to protect the environment (Jordan *et al.* 2005). Soil and nutrient loss are calculated in erosion models all over the world (Gournellos *et al*. 2004), especially in connection with arable cultivation. The area suffers "rural exodus", all the young people have already left the region thus land use can be characterized by intensive farming on the areas of the former cooperative and quasi extensive use on the other part of the area thanks to the lack of local workers.

Methods

The well-known USLE (Wischmeier and Smith 1978) and WEPP (Flanagan *et al.* 2007) models were used for the analyses. The Water Erosion Prediction Project (WEPP) was started in 1985. Its purpose was to develop new-generation water erosion prediction technology, originally (as well as the USLE) for use in the USA. The WEPP model was developed by the USDA-ARS to replace empirically based erosion prediction technologies, such as USLE, RUSLE, MUSLE. The WEPP model simulates many of the formerly missing physical processes important in soil erosion (e.g. infiltration, runoff, raindrop and flow detachment, sediment transport, deposition, plant growth, and residue decomposition) as input parameters. The WEPP project is similar to USLE because it was constructed based on extensive field experimental program (on cropland, rangeland and disturbed forest sites). Sufficient amount of data was needed to parameterize and test the model. The model became functional with the cooperation of research locations, laboratories and universities. The WEPP model can be used on hill slopes and on smaller watersheds. The model can be used with Microsoft Windows operating system graphical interfaces, web-based interfaces, and integration with Geographic Information Systems since 1995. Watershed channel and impoundment components, CLIGEN weather generator, the daily water balance and evapotranspiration routines, and the prediction of subsurface lateral flow along low-permeability soil layers was developed and continuously improved (Chaves and

Nearing 1991; Risse *et al*. 1994; Flanagan *et al*. 2007; Deer-Ascough *et al*. 1995; Grismer 2007; Moffet *et al*. 2007; Kim *et al*. 2007; Bonilla *et al*. 2007; Moore *et al*. 2007).

WEPP is widely used for soil loss calculations (Pandey *et al*. 2008, Shen *et al*. 2009, Irvem *et al*. 2007, Baigorria and Romero 2007).

Input parameters for the WEPP model: rainfall (amount 16.50 mm, duration 48 min), normalized peak intensity (2.73), normalized time to peak (0.15). Land use was tilled fallow. Slope length and slope angle was calculated based on the topography map of the area and on in situ check with GPS. Input parameters for the USLE model were: R = E = 0.06934, K = 0.009, LS = 4.75 (slope length was 240m (first section's plane length was 44.16m, second section's plane length was 157.98m, third section's plane length was 37.85m; slope length was 8, 6 and 4%), C = 1 (for black fallow), P=1.

Results

The results of soil loss calculations with USLE model can be found in Table 1.

Table 1. Input parameters and results of the simulation with the USLE model, Gerézdpuszta, Hungary

Slope section	R factor*	K factor	L factor	S factor	Soil loss (kg/m^2)
Upper		0.38	1.42	0.85	0.543496
Middle	0.06934	0.009	1.83	0.57	0.011124
Lower		0.0001	1.31	0.35	0.000054

**in this special case, since the calculation is for one rainfall event, this is erosivity index, C and P factors = 1*

The results of soil loss calculations with WEPP model can be found in Tables 2-4.

Table 2. Results of the simulation with the WEPP model for the upper slope third, Gerézdpuszta, Hungary

PD (m)	**SOL**	**PD (m)**	**SOL**	**PD (m)**	**SOL**	**PD (m)**	**SOL**	**PD (m)**	**SOL**
(m)	(kg/m^2)	**(m)**	(kg/m^2)	**(m)**	(kg/m^2)	**(m)**	(kg/m^2)	**(m)**	(kg/m^2)
0.44	0.014	9.27	0.016	18.11	0.447	26.94	0.683	35.77	0.864
0.88	0.014	9.72	0.042	18.55	0.461	27.38	0.693	36.21	0.872
1.32	0.014	10.16	0.076	18.99	0.474	27.82	0.703	36.65	0.880
1.77	0.014	10.60	0.111	19.43	0.487	28.26	0.713	37.10	0.888
2.21	0.014	11.04	0.146	19.87	0.500	28.71	0.723	37.54	0.895
2.65	0.014	11.48	0.181	20.31	0.513	29.15	0.733	37.98	0.903
3.09	0.014	11.92	0.217	20.76	0.525	29.59	0.742	38.42	0.910
3.53	0.014	12.37	0.246	21.20	0.538	30.03	0.752	38.86	0.918
3.97	0.014	12.81	0.264	21.64	0.550	30.47	0.761	39.30	0.925
4.42	0.014	13.25	0.281	22.08	0.562	30.91	0.770	39.75	0.933
4.86	0.014	13.69	0.297	22.52	0.574	31.36	0.779	40.19	0.940
5.30	0.014	14.13	0.313	22.96	0.585	31.80	0.788	40.63	0.947
5.74	0.014	14.57	0.329	23.41	0.597	32.24	0.797	41.07	0.954
6.18	0.014	15.02	0.345	23.85	0.608	32.68	0.806	41.51	0.961
6.62	0.014	15.46	0.360	24.29	0.619	33.12	0.814	41.95	0.968
7.07	0.014	15.90	0.375	24.73	0.630	33.56	0.823	42.40	0.975
7.51	0.014	16.34	0.390	25.17	0.641	34.00	0.831	42.84	0.982
7.95	0.014	16.78	0.405	25.61	0.652	34.45	0.840	43.28	0.988
8.39	0.014	17.22	0.419	26.06	0.662	34.89	0.848	43.72	0.995
8.83	0.014	17.66	0.433	26.50	0.673	35.33	0.856	44.16	1.002

PD = Profile distances are from top to bottom of hillslope, SOL = Soil loss

Table 3. Results of the simulation with the WEPP model for the middle slope third, Gerézdpuszta, Hungary

PD (m)	SOL	PD (m)	SOL	PD (m)	SOL	PD (m)	SOL	PD (m)	SOL
(m)	(kg/m^2)	(m)	(kg/m^2)	(m)	(kg/m^2)	(m)	(kg/m^2)	(m)	(kg/m^2)
45.74	0.419	77.34	0.520	108.94	0.609	140.53	0.626	172.13	0.696
47.32	0.424	78.92	0.525	110.52	0.608	142.11	0.630	173.71	0.699
48.90	0.430	80.50	0.529	112.10	0.608	143.69	0.633	175.29	0.702
50.48	0.435	82.08	0.534	113.68	0.607	145.27	0.637	176.87	0.706
52.06	0.440	83.66	0.539	115.26	0.606	146.85	0.641	178.45	0.709
53.64	0.445	85.24	0.543	116.84	0.605	148.43	0.644	180.03	0.714
55.22	0.451	86.82	0.548	118.41	0.603	150.01	0.648	181.61	0.736
56.80	0.456	88.40	0.552	119.99	0.602	151.59	0.651	183.19	0.762
58.38	0.461	89.98	0.557	121.57	0.601	153.17	0.655	184.77	0.787
59.96	0.466	91.56	0.561	123.15	0.599	154.75	0.658	186.35	0.813
61.54	0.471	93.14	0.566	124.73	0.598	156.33	0.662	187.93	0.839
63.12	0.476	94.72	0.570	126.31	0.596	157.91	0.665	189.51	0.864
64.70	0.481	96.30	0.575	127.89	0.597	159.49	0.669	191.09	0.890
66.28	0.486	97.88	0.579	129.47	0.600	161.07	0.672	192.67	0.908
67.86	0.491	99.46	0.584	131.05	0.604	162.65	0.675	194.25	0.912
69.44	0.496	101.04	0.588	132.63	0.608	164.23	0.679	195.83	0.916
71.02	0.501	102.62	0.592	134.21	0.611	165.81	0.682	197.41	0.919
72.60	0.506	104.20	0.597	135.79	0.615	167.39	0.686	198.99	0.923
74.18	0.510	105.78	0.601	137.37	0.619	168.97	0.689	200.57	0.926
75.76	0.515	107.36	0.605	138.95	0.622	170.55	0.692	202.15	0.930

PD = Profile distances are from top to bottom of hillslope, SOL = Soil loss

Table 4. Results of the simulation with the WEPP model for the lower slope third, Gerézdpuszta, Hungary

PD (m)	SOL	PD (m)	SOL	PD (m)	SOL	PD (m)	SOL	PD (m)	SOL
(m)	(kg/m^2)	(m)	(kg/m^2)	(m)	(kg/m^2)	(m)	(kg/m^2)	(m)	(kg/m^2)
202.53	1.191	210.10	1.184	217.67	1.176	225.24	1.169	232.81	1.161
202.90	1.191	210.47	1.183	218.05	1.176	225.62	1.168	233.19	1.161
203.28	1.191	210.85	1.183	218.42	1.175	225.99	1.168	233.56	1.160
203.66	1.190	211.23	1.183	218.80	1.175	226.37	1.168	233.94	1.160
204.04	1.190	211.61	1.182	219.18	1.175	226.75	1.167	234.32	1.160
204.42	1.189	211.99	1.182	219.56	1.174	227.13	1.167	234.70	1.158
204.80	1.189	212.37	1.181	219.94	1.174	227.51	1.166	235.08	1.127
205.18	1.189	212.75	1.181	220.32	1.173	227.89	1.166	235.46	1.083
205.55	1.188	213.12	1.181	220.69	1.173	228.27	1.166	235.84	1.040
205.93	1.188	213.50	1.180	221.07	1.173	228.64	1.165	236.21	0.995
206.31	1.187	213.88	1.180	221.45	1.172	229.02	1.165	236.59	0.951
206.69	1.187	214.26	1.180	221.83	1.172	229.40	1.165	236.97	0.905
207.07	1.187	214.64	1.179	222.21	1.172	229.78	1.164	237.35	0.859
207.45	1.186	215.02	1.179	222.59	1.171	230.16	1.164	237.73	0.812
207.82	1.186	215.40	1.178	222.97	1.171	230.54	1.163	238.11	0.764
208.20	1.186	215.77	1.178	223.34	1.170	230.92	1.163	238.49	0.716
208.58	1.185	216.15	1.178	223.72	1.170	231.29	1.163	238.86	0.667
208.96	1.185	216.53	1.177	224.10	1.170	231.67	1.162	239.24	0.617
209.34	1.184	216.91	1.177	224.48	1.169	232.05	1.162	239.62	0.566
209.72	1.184	217.29	1.176	224.86	1.169	232.43	1.162	240.00	0.514

PD = Profile distances are from top to bottom of hillslope, SOL = Soil loss

Tables 2-4. show that a not too big rainfall event, arriving on the area with bad timing (no surface cover) can cause 10 t ha^{-1} soil loss.

Conclusion

It has always been emphasized that local measurements have very high importance so we do not wish to conclude this well-known fact again but we would like to call attention on carefully choosing the input parameters. In the present case a very simple method proved that the high amount of calculated soil loss is not proper since parent material was found at the depth of 180-200cm below surface.
On the other hand, it is important information for local farmers that a relatively small (45mm h^{-1}) intensity precipitation can cause very high amount of soil loss. The only way to protect the land against it is to have

some soil loss measure, plant residues on the surface, another crop or some technical improvements. Furthermore detailed local knowledge from the soils can save energy, fertilizer, time and money for the farmers.

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