Erosion by Rain

its subprocesses and diagnostic microtopographic features

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Why is this video significant? Because it shows erosion-induced microtopographic features during rainfall that were not recognised in this detail before and these features appeared to have practical applications in rural extension and erosion research.

The use of microtopographic erosion features

Common approach of erosion evaluation is by amount per ha, measured or modelled.

Drawbacks of common approaches:
- erosion plots are expensive, and rare
- models are rarely calibrated for local conditions, have often unrealistic generalised assumptions (such as flow depth or velocity) and are in many cases over-extrapolated. Therefore they often produce unreliable results.

Present method:
- does not aim at quantifying soil loss, but uses erosion features of microtopography as indicator of actual erosion intensity in a field.
- compares the erosion intensity of sites in a local area
- can be applied quickly in other areas that have erosion conditions (such as rainfall, topography) different from the first area.

Advantages of present method:
- uses field evidence of erosion, not models and pedotransfer functions
- needs no equipment, little time, is easy to learn and can be applied for any land use and in any terrain that is accessible on foot
- gives results immediately after observation
- shows the comparative resistance to erosion of studied land use systems or conservation practices within a local area
- shows the spatial and temporal distribution of erosion subprocesses
- can be used for monitoring during a single rainstorm or over a rainy season.

The video shows the features of microtopography during erosion and rainfall. One can see their function in the erosion process. The video can be used in education, research and consulting (i.e. rural extension of selecting practices for soil conservation).

Contents of the video

The video shows erosion by rain at the land surface. Several types of subprocesses of rainwater erosion can be seen in operation:

- rainfall and splash erosion
- ponding
- overland flow
- the transport of soil particles
- the scour of soil by flowing water in combination with splash
- the deposition of soil material in certain places
- the formation of flow-steps in the prerills
- the afterflow: overland flow after the rain has stopped
- the effect of plant residue (maize) on the flow, erosion and deposition.

In the video one can see that the microtopography of the soil surface consists of different components or features. There is no random roughness but a composition of 7 different features. A short description of these seven features is the following:

Description of the microtopographic features

1) Original/Resistant clods, showing original forms that generally were created by tillage and are either resisting degradation or being recently formed.
Characteristics are:

- sharp edges
- overhanging sides
- former soil surface may be present on a side of the clod
- rocks and stones are included under this heading

2) Eroding clods/areas, formed by splash and disaggregation (from wetting and drying, etc.).
Characteristics are:

- dominantly convex surface
- micro-pedestals of coarse sand, gravel and vegetal matter may be present on the upper clod surface
- must be situated above the areas of flow

3) Flow surfaces, formed by shallow unconcentrated flow.
Characteristics are:

- developed on deposits that have smoothed the pre-existing micro-relief, or developed on parts that have been smoothed by erosion
- often have parallel linear flow patterns of lag sediment

4) Prerills, shallow channels of concentrations of flow, up to about 3-5 cm deep.
Characteristics are:

- shallow channel, slightly concave cross-section
- may have small scarps at the sides
- mostly discontinuous, not integrated in the micro-drainage system of the field.

5) Rills, micro-channels incised deeper than the prerills of 3-5 cm depth
Characteristics are:

- formed by incision into the soil, or formed originally by collapse of seepage tunnels
- may be depth-limited by a ploughpan or shallow B-horizon
- in case of a resistant subsoil have a distinct rill-bottom and U-shaped cross section
- micro-scarps occur at the sides when flow was recent
- function mostly as part of the micro-drainage system of the field
- occur often below a knickpoint in the gradient of flow

6) Depressions, areas without immediate drainage outlet where ponding occurs and eroded material can accumulate. Tillage as in land preparation leads to micro-depressions. Eventually these areas may be filled by deposits, or be removed by incision and headward erosion of micro-channel flow.
Characteristics are:

- no immediate outlet
- site for surface ponding and in-field deposition of eroded material.

7) Vegetative basal cover, the basal cover of living or dead plant material (or plastic), close to the surface and resistant against wash.
Characteristics are:

- low folial and other vegetal matter that cannot be removed easily, either because of intensive plant rooting, partly ploughed-in residues or otherwise stable in position.

These seven different features are each related to a different group of subprocesses of erosion. Some features represent a group of subprocesses that contribute more to soil loss; other features contribute less (Table 1).

Table 1. Relation between microtopographic features and erosion processes.

Dominant processes	**Microtopographic features**						
Splash	res	ero					
Splash, relative slow transport			flo				
Splash, some scour, relative fast transport				pre			
Scour, relative fast transport					ril		
Surface storage, deposition						dep	
Slow transport, no scour							veg

res = resistant / original clods; pre = prerills; dep = depressions
ero = eroding clods / surfaces; ril = rills; veg = vegetative basal cover
flo = flow paths and surfaces

The microtopography of the soil surface shows the accumulated effect of previous erosion. Recording the distribution of the microtopographic features allows calculating an indicator of the intensity of the erosion that has taken place over a period previous to observation. The indicator reflects the erosion hazard in that previous period. It gives the possibility to compare the resistance to erosion given by soil conservation practices or land use systems in a local area, on sites where other factors that determine erosion hazard are constant, such as rainfall, topography and soil. Several studies have been made in application of the method. An overview of references is given in Table 2.

Table 2. Studies using microtopographic features.

Author	Year	Language other than English	Contents
Bergsma	1992		*Method*
Bergsma & Kwaad	1992		Case study on loess in *southern Netherlands*, distinction between conservation practices, comparison with soil loss.
Bergsma	1997a	French	as 1992
Bergsma	1997b		Case study in *northern Thailand*, distinction between conservation practices, comparison with soil loss.
Bergsma	2001a		Case study in *middle northern Thailand*, distinction between conservation practices, the presence of fertiliser and the erosion development between contour hedges.
Bergsma	2001b	Spanish	as 1992 and 1994. Case studies in the Netherlands and northern Thailand, distinction between conservation practices, comparison with soil loss.
Kunwar, Bergsma, and Shrestha	2002		Case study in *Nepal*, distinction between types of land use.

It appeared from these studies (for instance Bergsma 2001a) that the indicator of erosion intensity correlates with measured soil loss. The method can in turn indicate erroneous soil loss measurements from irregular values of the erosion intensity indicator in replication soil loss plots. The correlation between measured soil loss and the indicator of erosion intensity derived from microtopographic features is of higher statistical significance when sites are numerous and there are 3-4 replications (Table 3).

Table 3: Measured soil loss and the indicator of erosion intensity.

Location and date	Number of treatments and replications of erosion plots	Spearman rank correlation coefficient		
		all plots	number of plots excluded †	plots grouped per treatment
Chiang Dao, Thailand August 1994	5 treatments with 4 replications and 1 bare fallow and 1 forest plot	0.39	3 plots: 0.76*** 4 plots: 0.79***	0.69 † 1 treatment: 0.85*
Doi Thung, Thailand, July 1997	5 treatments with 4 replications and 1 bare fallow, 1 forest and 1 upland rice plot	0.59	1 plot: 0.84*	0.90**

*** Significance level of 0.001
** Significance level of 0.01
* Significance level of 0.05
† Excluded for reasons of faulty plot management, deposition within-plot, and two derived but unlikely extreme erosion intensities in 1997

Field observations, though they are simple, have to be done accurately. Replication of observation lines and replication of experimental plots are helpful to obtain significant correlations of the indicator of erosion intensity and measured soil loss..

Guideline for recording the microtopographic features in the field and the calculation of the indicator of erosion intensity

A site is selected to represent important land use and management by characteristic slope steepness, slope form, erosion slope length, rainfall regime and soil.
Within the selected field the observation lines are set. They might be planned in the most eroded part, so as to avoid underprediction of erosion hazard.
An observation line of 12.5 meter long is set out along the contour, so as to meet flow features.
Two parallel lines for replication records are spaced above or below the first line, spaced 1-2 meter from each other.
A measuring tape with 10 coloured intervals of 25 cm is used for the observations. For each tape interval the dominant microtopographic feature is recorded. This gives 10 observations per tape. Thus over the distance of 12.5 m 50 observations are made. Each observation represents 2% of the surface of that part of the field. The recording is repeated for the (two) replication lines.

For one observation line of 50 intervals of 25 cm, the results may be as follows:

res	ero	flo	pre	ril	dep	veg	
5	13	14	9	8	1	0	Total number of observations is 50
10	26	28	18	16	2	0	Numbers expressed as percentages.

The indicator of erosion intensity is calculated as % flo + 2 (% pre + % ril). That is in the example: 28 + 2(18+16) = 96.

The indicator value helps to find which type of land use and management resists erosion most in a local area among representative sites that have other erosion conditions sufficiently similar. And of course, the conclusion is only part of the considerations for advice in rural extension, where there are many other aspects, such as acceptability for the land user.

An example of monitoring results

A case of monitoring microtopographic features during some weeks is shown in Figure 1 (mostly 3 repetitions on each date) and Table 4 (Hagos Woldu 1998). The case shows tendencies of change of features that are commonly observed.

Table 4: Data of Site 1A (Hagos Woldu 1998). Averages of 3 replications.

Date	res	ero	flo	pre	ril	dep	veg	Ind
03-06-97	13	51	6	0	0	1	29	6
16-06-97	4	47	15	3	0	1	30	21
17-06-97	4	43	20	2	0	1	30	24
26-06-97	4	39	20	2	2	1	32	30
02-07-97	3	42	22	0	2	0	31	28
08-08-97	3	26	31	18	0	0	22	67

res = resistant clods; ril = rills
ero = eroding clods; dep = depressions
flo = flow paths; veg = vegetative basal cover
pre = prerills; Ind = indicator of erosion intensity

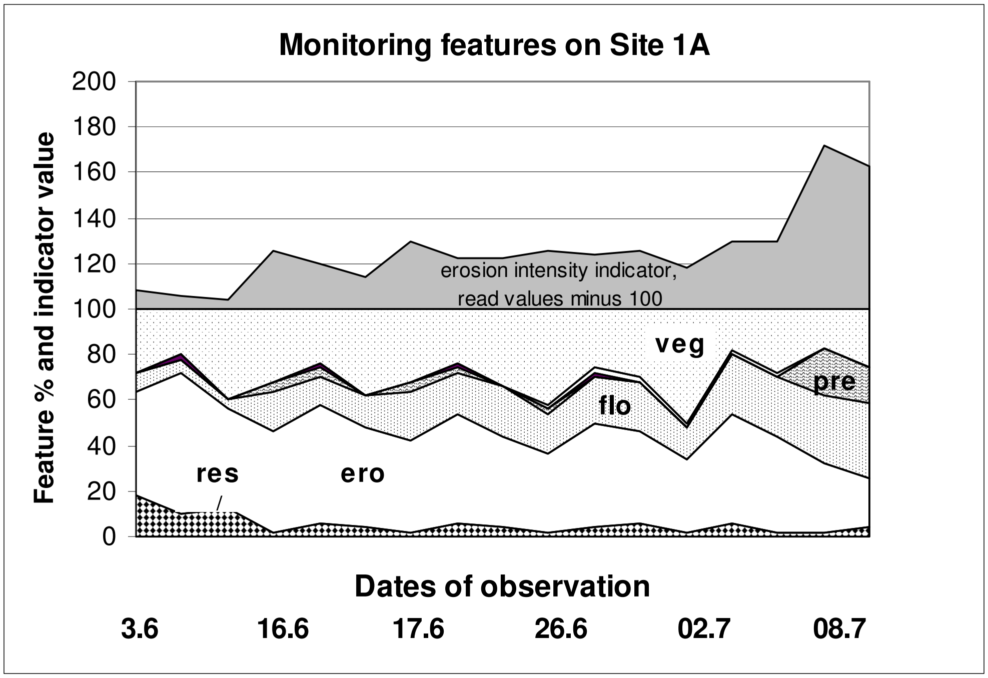

Figure 1: **Example of development of microtopographic features.**

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