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MEASUREMENTS OF SPLASH–SALTATION FLUXES UNDER OBLIQUE RAIN

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SUMMARY

This study deals with the problem of direct measurements of the net splash-saltation fluxes. On the base of theoretical considerations, a technique has been developed to measure the net splash-saltation flux under artificial oblique rains in laboratory conditions. This has been done for different slope inclinations, ranging from weather-side to lee-side conditions.

In most cases, the net splash saltation flux goes in the same sense as the velocity component of the raindrops, parallel to the soil surface, regardless its inclination.

Indirectly, the laboratory measurements show that splash-saltation can be considered as a pluvio-eolian process, except for the pure theoretical case of a vertical rain.

They also suggest that the measurement of splash-saltation fluxes in the field is a rather complex operation, because neither direction nor sense of the flux can be assumed beforehand on the base of the slope configuration alone. The design is made of a field set up enabling to measure an arbitrarily oriented splash-saltation flux.

RESUME

Cette étude traite le problème de la mesure directe du flux des particules de sol jaillissant sous l'effet des impacts des gouttes de pluie. Des considérations théoretiques ont mené au développement d'une technique pour mesurer le "flux de saltation", sous des pluies obliques artificielles, créées au laboratoire. Des pentes du côté du vent et du bas côté ont été simulées.

Dans la plupart des cas, le "flux de saltation" va dans le même sens que la composante de la vitesse des gouttes selon la surface du sol, quelle que soit la pente.

Indirectement, il découle des mesures que le jaillissement par le "splash" peut être considéré comme un processus pluvio-éolien, sauf pour le cas purement théorique d'une pluie verticale.

Les résultats indiquent que la mesure du "flux de saltation" sur le terrain est une opération compliquée, parce que la configuration seule de la pente ne permet pas d'estimer à l'avance ni sa direction ni son sens. Une installation de terrain, permettant de mesurer un flux quelconque, est proposée.

1. INTRODUCTION

The spatial redistribution of soil particles and aggregates as a result of saltation caused by raindrop impacts, has been recognized since a long time (ELLISON 1944). During the subsequent years the process of splash-saltation has been analysed in respect to factors as ejection angles, mean saltation distances, detachability and others. POESEN & SAVAT (1981) give an excellent review of this work, together with an extensive bibliography. With the years, there was a growing concern to provide means of measuring splash erosion and of finding mathematical equations for predictive or postdictive purposes. So, VAN HEERDEN

(1967), was the first to express splash-saltation erosion in the mathematical form:

$$E = \sum_{0}^{i} m_i \; x_i$$

where E = total splash-saltation erosion
m_i = elementary soil mass
x_i = vectorial distance travelled by m_i

Other authors as MEYER & WISHMEIER (1969) and ROWLINSON & MARTIN (1971) provided mathematical models of splash-saltation erosion. One of the pioneers in the study of the process of splash-saltation is certainly J. DE PLOEY (1969,1972). He succeeded to derive from his analytical work a practical and general formula, describing splash-saltation transport as:

$$a = k. (\sin \alpha)^{0.75}$$

where a = the discharge over a cross-section: m^2/year
k = a factor, function of rainfall and soil erodibility characteristics
α = slope angle in degrees,

whereby ranges of k-values are given (MOEYERSONS & DE PLOEY 1976). A further discussion of this formula can be found in SAVAT (1981). POESEN & SAVAT (1981) published experimental data which throw new light on the factors governing detachability and transportability. From these data they calculated mass distribution curves and saltation distances (SAVAT & POESEN 1981), on which they rely for the elaboration of a more sophisticated splash-saltation erosion formula, taking into account the granulometric composition of the sediment.

Thus, while analytical research has resulted in the elaboration of mathematical predictive formulae, the direct measurement of the net effect of splash-saltation seems still to be problematic. This is illustrated by MORGAN (1978), who correctly states that most methods to measure the net effect of splash erosion in the field have their disadvantages. He claims that the alternative method which he proposed provides a good indicator for splash erosion, but in the same time he admits that improvements in design are needed.

So, there seems to exist a certain need for a theoretically correct method of direct measurement of splash-saltation. Such a method could be used as a means of verification of the different splash-saltation erosion formulae. But more than a simple control is at stake. Recent investigations with artificial oblique rain have shown that the net resultant splash-saltation transport is highly influenced by the angle at which raindrops strike the inclined ground surface (MOEYERSONS 1982). This observation puts all formulae, proposed on the base of former experiments in their true perspective: they are correct for the theoretical case of a vertical rain. However, as vertical rain is a rather exceptional phenomenon, one can wonder to what extent they are usefull as tools of prediction or postdiction.

In the light of this observation there were two possibilities to continue the work. Experiments could be set up in order to evaluate the effect of the rainfall obliquity on ejection angles, projected saltation distances detachability and so on, to elaborate a mathematical equation. The objection was that this procedure would be very difficult and time consuming, leading to higher risks of errors. Therefore, we decided to develop a simple and theoretically correct method to measure directly the net splash-saltation flux.

2. THEORETICAL CONSIDERATION

The case can be considered of a bare slope with uniform soil cover, exposed to a uniform rain at constant intensity. When splash-saltation occurs, a snapshot should show the soil surface with a cloud of soil particles above, each particle situated on a point of its saltation trajectory. When the picture is moved forward, it should be seen that the cloud is permanently renewed: some particles jump in a direction with an upslope component, others in a direction with downward component. So, one can consider two fluxes over a cross-section: an upslope flux (φu) and a downslope flux (φd). Hereby a flux is simply defined as the amount of material passing within a unit time over the unit cross-section. The total net saltation flux can be defined as:

$$\varnothing = \varphi d - \varphi u. \qquad (1)$$

It should be emphasised that the flux-concept is not new. The downward splash-saltation flux φd corresponds, in fact, to the term S_a used by DE PLOEY (1969), while φu corresponds with the term E'_a for the same cross-section, used by the same author.

In the theoretical case, presented here, detachability and transportability are constant over the entire slope. So, if the slope is considered infinite and rectilinear, $\varnothing$ is constant for the entire slope. In case the slope is delimited by cross-sections m and n (fig. 1A), then $\varnothing$ = -φu at n and $\varnothing$ = φd at m. The upward flux φu will attain its maximum value at a distance l upslope from m and remain the same higher up. In the same way φd reaches its maximum value at a distance L from n and remains constant till the foot of the slope. L stands for the maximum downward saltation distance and l for the maximum upward saltation distance. The net saltation flux $\varnothing$ takes the number of ejections per unit area and the mean saltation distances implicitly into account. This can intuitively be demonstrated on fig. 1A. There, φd through cross-section A clearly depends on the number of particle ejections in belt L. If it is assumed that a certain proportion of the total amount of ejections passes through A, a decrease of ejections per time unit, which means a decrease in detachability, will cause a lower flux φd in A. If, on the other hand, the detachability would remain constant with an increase of the mean saltation distance, φd in A will increase because more particles from zone L will pass. Moreover, in that case φd is not at its maximum value in A. This should be reached at a point situated downwards from A, at the maximum downward saltation distance from the crest.

From equation (1) it follows that $\varnothing$ can be defined by measuring φu and φd.

On fig. 1A, φd can be measured in m, φu in n. If we consider the case of φd measured in m, it will be shown that for a cross-section of limited length (a) in m, φd equals the amount of sediment caught in a rectangular recipient R, with length (L) and width (a) (fig. 1B).

Let φd through cross-section (a) be determinated first. The lower part of the slope can arbitrary be subdivided in slope sections of the same dimensions as catching tray R. In the same time other catching trays, S, T ... are added. The total amount of material ejected within a certain time out of r over the line m can be called Ar. If the maximum lateral saltation distance equals s, Ar will then pass over cross-sections a, b, c, d and e.

Let us consider the case of a rain with a horizontal velocity component whose projection on the soil surface coincides with the slope line. As in the case of a vertical rain, the redistribution of particles from one impact point will become symmetric to a slope line passing through the impact point, if time is taken into account.

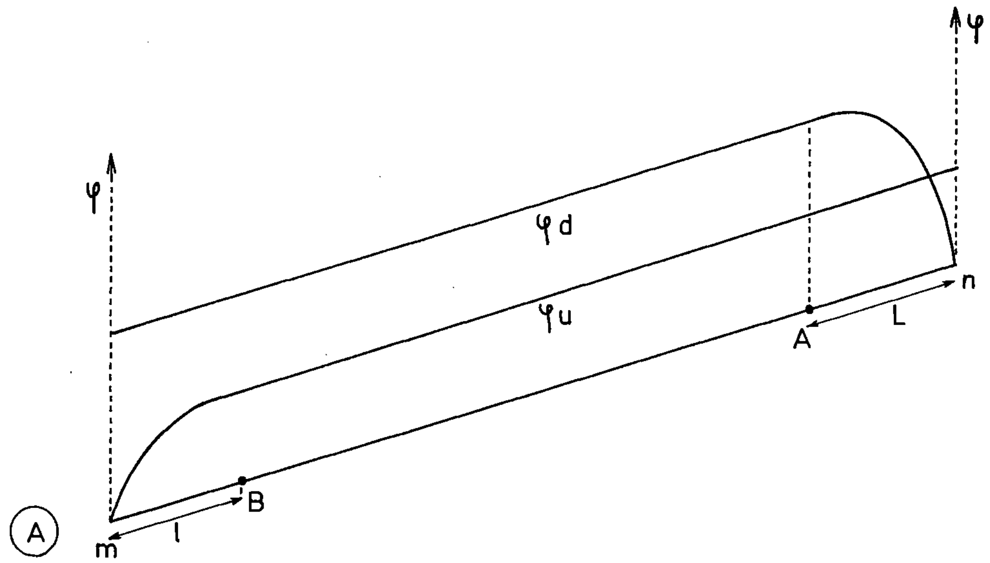


Fig. 1A: Rectilinear slope section m-n and the distribution of upward and downward oriented splash-saltation fluxes. L: maximum downward saltation distance; l: maximum upward saltation distance.

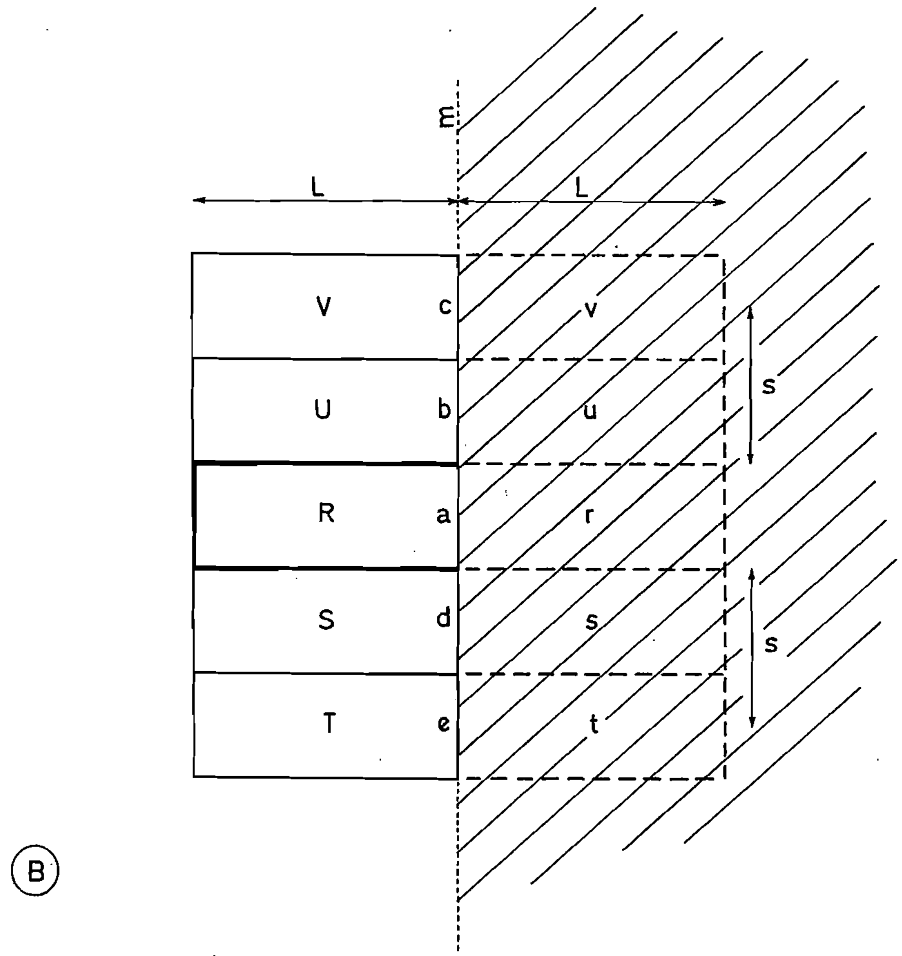


Fig. 1B: View in plan of the lower part of slope section m-n. R, S, T, U, V are sediment traps below the slope section, with cross-sections a = b = c = d = e. r, s, t, u, v are parts of the slope section, all of the same surface area as the traps. L: maximum downward saltation distance; s: maximum lateral saltation distance.

It can, therefore, be understood that the splash balance will be zero in the direction perpendicular to the slope. So, if an amount of material Ar/x from r traverses cross-section d, it should be compensated by the same amount passing within the same time through cross-section b. In the same time, an amount of material Ar/y will saltate through cross-sections c and e. In this case

$$Ar = 2\frac{Ar}{x} + 2\frac{Ar}{y} + \frac{Ar}{z} \qquad (2)$$

Where Ar/z equals the amount of material saltated out of r through cross-section a. For the same reason of symmetry, it should be accepted that the amount of material Ar/x, passing over cross-section d, will be compensated by the same amount of material ejected out of s, As/x, saltating within the same time over cross-section a.

Consequently, the amount of material (X), traversing cross-section (a) within a certain time can be defined as:

$$X = \frac{Ar}{z} + \frac{As}{x} + \frac{Au}{x} + \frac{At}{y} + \frac{Av}{y}$$

Because $\frac{As}{x} = \frac{Ar}{x}, \frac{Au}{x} = \frac{Ar}{x}, \frac{At}{y} = \frac{Ar}{y}, \frac{Av}{y} = \frac{Ar}{y}$

and because of (2),
X = Ar.

The very same reasoning can be made concerning the amount of material caught in tray R during the same time.

Consider Ar divided over $\frac{Ar}{p}$, going to R
$\frac{Ar}{q}$, going to S and to U
$\frac{Ar}{t}$, going to T and to V

than R will receive:

$$\frac{Ar}{p} + \frac{As}{q} + \frac{Au}{q} + \frac{At}{t} + \frac{Av}{t} = Ar$$

where As and Au stand for the material respectively ejected out of s and u, assuming that Ar = As = Au. So, it can be seen that, during the time considered, the amount of material collected in R, and the amount of the material traversing cross-section (a) equal both the amount of material splashed out of r over m. Hence, in fig. 1B, φd is defined by the amount of material collected in R divided by the time considered and by the width (a) of R.

It is needless to show that φu can be measured in the same way at the crest of the slope.

3. THE MEASUREMENT OF SPLASH–SALTATION FLUXES IN THE LABORATORY

3.1. PRINCIPLES

On the occasion of geomorphological research in Rwanda (MOEYERSONS 1978), it was decided to study the splash-saltation phenomenon under artificial oblique rain by means of the recently developed S.T.O.R.M.-1 rain simulator (MOEYERSONS 1982). This was done on small slope sections, representing weather-side and lee-side situations with respectively slope inward and slope outward rains.

The usable part of the impluvium of S.T.O.R.M.-1 is rather small. This makes direct measurements of the total splash-saltation fluxes impossible. So, a technique has been developed to measure saltation fluxes by fractions. Fig. 2A illustrates the principe of the experimental set up. The arrow represents the horizontal raindrop velocity component. The particles, ejected out of the source area S (22,5 × 15 cm), fall within the elliptic area as indicated by the dashed line. This area is filled up by sediment traps, with the same surface dimensions as the source recipient (22,5 × 15 cm) and arranged as indicated. Now, the case is considered of φl, in the opposite sense of the horizontal velocity component of the rain. Fig. 2B represents the end of a long rectilinar slope. A sediment trap, 22,5 cm wide and at least as long as the maximum saltation distance in the sense of φl can be imagined at the end of the slope. So, the splash saltation flux can be defined as: φl = material collected in T (gram)/22,5 cm · time.

From the weight of sediment, collected in the recipients on fig. 2A, the amount of material which should fall in sediment trap (T) in fig. 2B can easily be calculated. For convenience, the lower part of the slope is subdivided into imaginary rectangular sections, a to o, 22,5 cm long and 15 cm wide and arranged as indicated in fig. 2B. So, in the particular case of fig. 2, (T) in fig. 2B will receive the following amounts of sediment:

- from partial area a: the sediment caught in recipients 6, 7 and 8 in fig. 2A.
- from b: the sediment in 6 and 7.
- from c: the sediment in 6.

The enumeration can be further completed and the additional result will be: 22,5 cm × time xφl = the amount of material caught in I in fig. 2A (2, 5, 8, 11, 13)

+ 2 × (sediment in II)
+ 3 × (sediment in III)

In the same way φr, in the sense of horizontal velocity component of the rain is expressed as:

$$\varphi r = (\mathrm{IV} + 2\,\mathrm{V} + 3\,\mathrm{VI})\ \mathrm{time}^{-1} \cdot 22{,}5\ \mathrm{cm}^{-1}.$$
$$\text{and } \Phi \doteq \varphi l - \varphi r$$

From the theoretical point of view, the dimensions of the source area are of no importance. Nevertheless, the smaller they are, the bigger the "edge"–effects will be because the circumference of the source grows proportionally with decreasing area.

For reasons of symmetry, explained above, the elliptic field in fig. 2A possesses a symmetry axis, indicated by AB. Every sediment trap will receive the same amount of material as the corresponding trap on the other site of the axes (e.g. traps 5 and 11). This practical con-

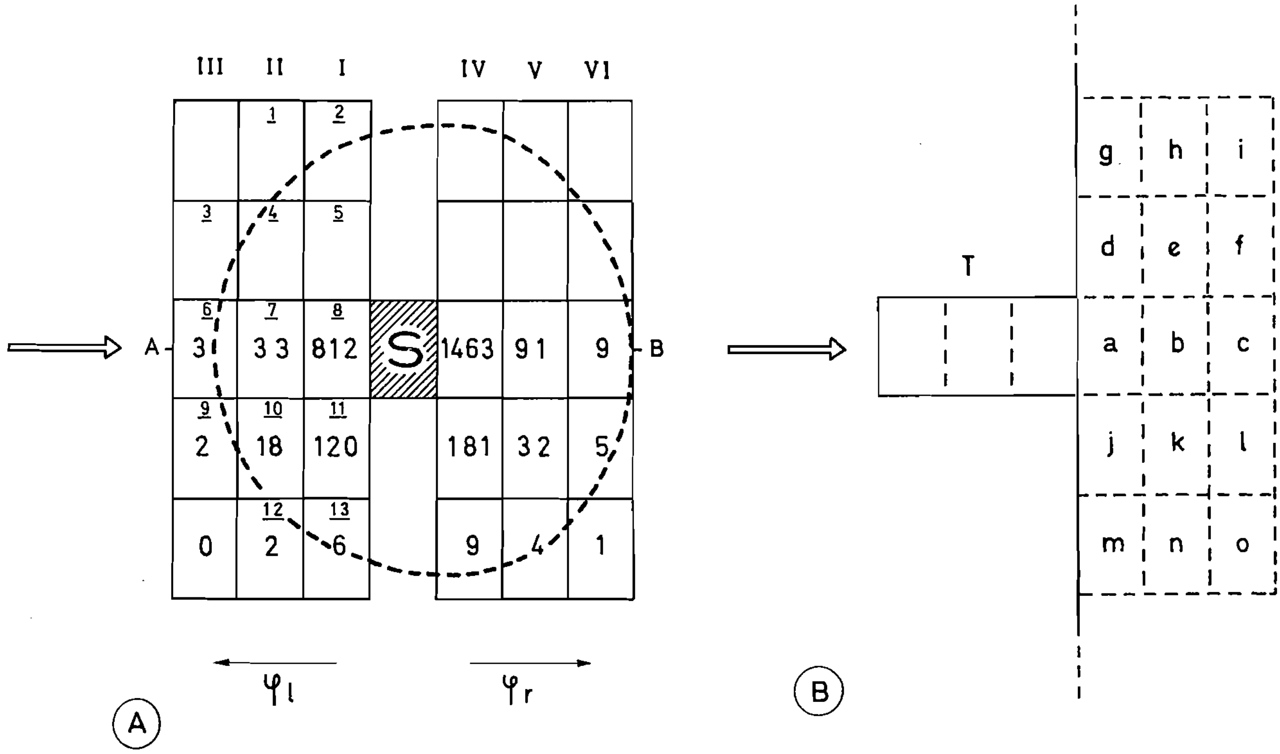


Fig. 2A: View in plan of experimental set-up. S = source area; other compartments are sediment traps. Double arrow: horizontal velocity component of the raindrops. φ and φ : saltation flux respectively to the left and the right. Further explanation: see text.

Fig. 2B: View in plan of the theoretical case of a sediment trap, T installed at the limit of a slope, a, b ... subdivisions of part of the slope surface in partial areas, with the same dimensions as in fig. 2A.

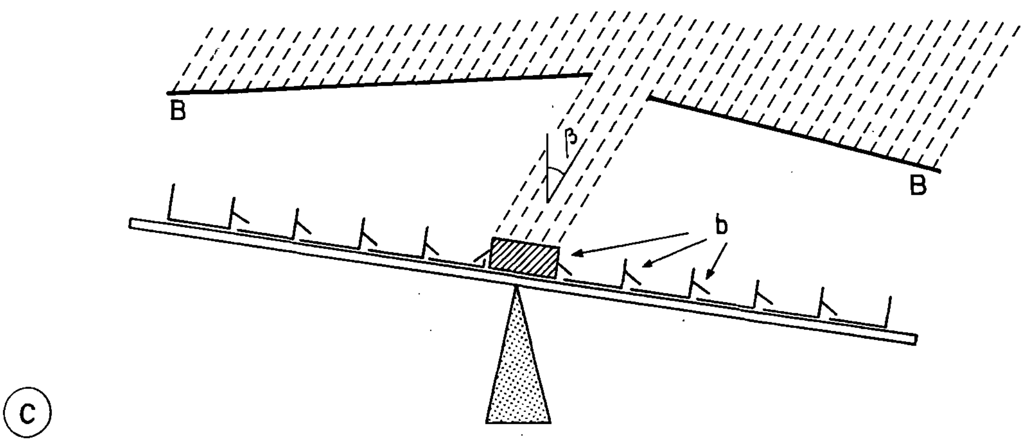


Fig. 2C: Lateral view of the experimental set-up with the source area and sediment traps, arranged on inclined screen. α: slope inclination in degrees, β: angle between vertical line and raindrop trajectory, in degrees; B: protection boards.

sideration allowed to use in the experiment only those sediment traps, which were in line with the source area and the horizontal raindrop velocity component together with the remaining traps on one side of the axis. It is clear that the dimensions of the elliptic area vary in function of slope inclination and rainfall obliquity. The number of recipients was therefore, adapted to every particular case, so that all or nearly all particles could be intercepted in that part of the elliptic catchment area considered.

3.2. SET UP, PROCEDURES AND RESULTS

Cardboard boxes, 22.5 cm long, 15 cm wide and 5 cm deep were varnished in order to make them water resistent. One of them, destinated to contain the sediment, was fortified at its inner side by small wooden boards, to avoid deformation when filled with sediment. The wooden boards remain 2 cm below the rim of the box, so that, when filled to the rim, only the 1 mm thick cardboard side remained visible. Perforations in the bottom permitted eventual drainage of the sediment. The soil material used, comes from the 50 cm thick humic A-horizon from Rwaza hill in Southern Rwanda. It is a dark-brown stony earth, containing about 4% of humic material. It is badly sorted and contains up to 20% of clay (less than 2 micron and colloids), about 40% of silt (63-2 micron) and about 30% of sand sized particles (2000-63 micron). A variable amount of coarser particles is also present. Most of them are angular quartz grains between 2 and 3 mm diameter, but quartzite stones and iron nodules can occur.

For every measurement new sediment was used with an initial water content of about 3%. This sediment was manually compacted till a dry bulk density of about 1.30 gr/cm^3 was reached.

The source box with the sediment, together with the boxes used as sediment traps were fixed on a screen by means of thumbnails as shown in fig. 2A. Fig. 2C shows how the screen could be rotated, the rotation axis of the screen being in horizontal position and perpendicular to the horizontal velocity component of the rain drops. The slope inclination is given by the symbol α. In the case of fig. 2C, α is arbitrarily considered as negative, because the slope is exposed to the rain, called a slope inward rain. When the screen is inclined to the other side, α is considered positive and the rain is slope outwards. The sediment traps were made from the cardboard boxes as indicated above. According to every particular position on the screen (fig. 2C), sides were cut off so that only one vertical face was left between every sediment trap. This was done to avoid splashed particles to fall between two boxes. Furthermore, the sides of the sediment traps were provided with small boards (b) for the same purpose. As shown on fig. 2C, the rainfall obliquity is expressed by the angle β between a vertical line and the raindrop trajectory. Protection boards were suspended above the set up, so that the sediment traps could only receive material and water, splashed out of source S.

The experiment has been carried out for $\beta = 5°$ and $\beta = 20°$ with various slope inclinations and a variable number of sediment traps, according to the size of the elliptic catchment area. Every rain shower took 30′ at a constant rainfall intensity of 50 mm/h. The mean drop diameter was close to 2.5 mm and the vertical velocity component of the drops was close to their natural vertical fall velocity. More technical information concerning the measurement of β, the mean drop diameter and the vertical velocity component of the drops, is given by MOEYERSONS (1982).

As an example, the net splash saltation flux is calculated for the first measurement for rain with $\beta = 5°$ on a horizontal surface ($\alpha = 0°$). Fig. 2A gives the set up of the source box and the sediment traps. The weight of sediment, caught by every individual sediment ttrap is indicated (in milligrams). The splash flux in opposite sense to the horizontal velocity component of the rain ($\varphi.l$) can be defined as:

$$\varphi l = \frac{2(6+120)+812+2[2(2+18)+33]+3[2(0+2)53]}{22.5 \text{ cm} \times 30'}$$

$$= \frac{1.231\text{g}}{22.5 \text{ cm} \times 30'}$$

The opposite splash flux can be written as:

$$\varphi r = \frac{2(181+9)+1463+2[2(4+32)+91]+3[2(1+5)+9]}{22.5\ \text{cm} \times 30'}$$

$$= \frac{2.232\text{g}}{22.5\ \text{cm} \times 30'}$$

$$\text{and } \Phi = \varphi r - \varphi l = \frac{1.001\text{g}}{22.5\ \text{cm} \times 30'}$$

what indicates that there is a net splash-saltation flux in the sense of the horizontal velocity component of the rain.

One could assume from fig. 2A that a small amount of soil has been splashed over a wider area than is occupied by the sediment traps. From the calculation above, it can easily be seen that this apparently small loss of sediment can hardly modify the result.

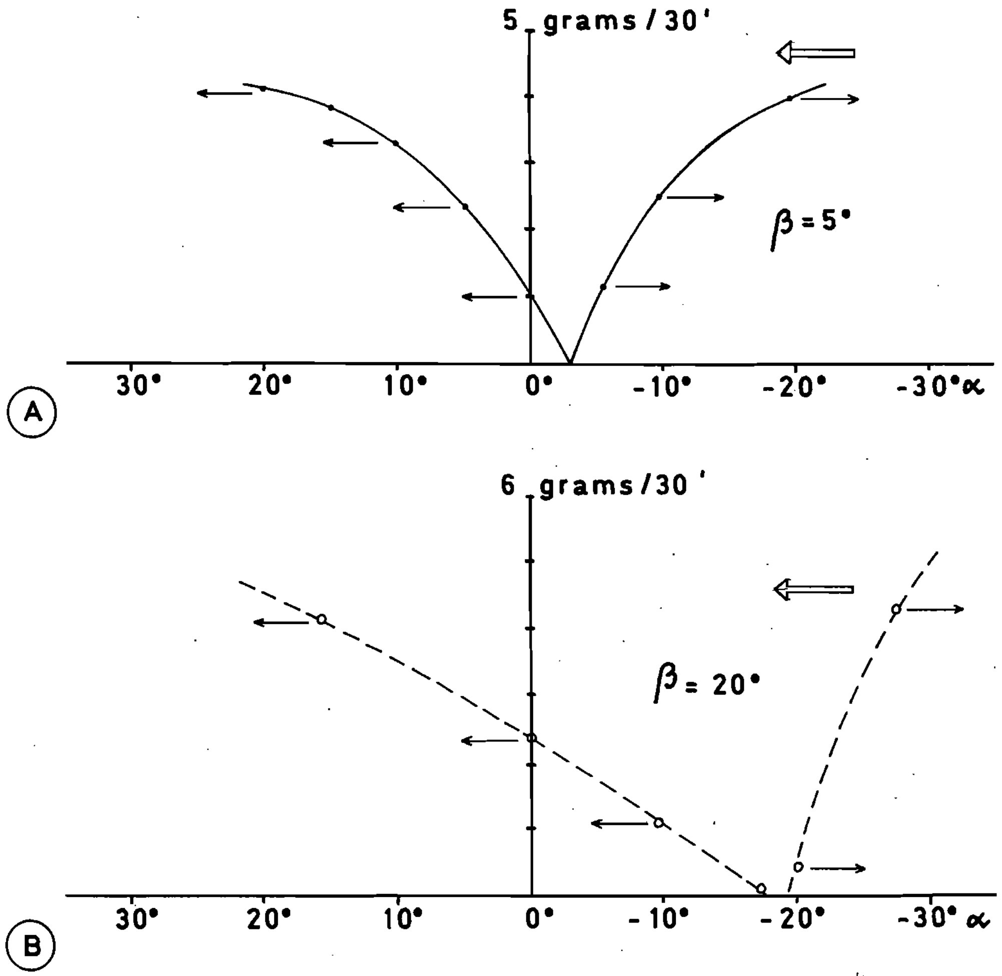


Fig. 3: Graphs, representing 22.5 cm × ø, expressed in grams/30′, in function of slope inclination. Double arrows indicate the sense of the horizontal velocity component of the rain. Single arrows indicate the sense of ø parallel to the slope lines. A: $\beta = 5°$, B: $\beta = 20°$.

The graphs on fig. 3 show the splash-saltation fluxes as calculated for the other cases of α and β. The results are significant and convincing: the net splash-saltation flux depends not only on slope inclination but also on slope orientation, when it concerns oblique rain.

One should be aware of the fact that the water content of the source sediment necessarilly changes during every experiment. According to POESEN & SAVAT (1981), this might have resulted in changes in the detachability. Moreover as the degree of rainfall obliquity probably influences the infiltration capacity of the sediment in function of slope angle, it can be expected that the evolution of the surface water content of the sediment in time was different for every particular set up.

This situation is considered as opportune because it probably imitates the natural condition more closely than an imaginary experiment where the sediment water content would have been manipulated. On the other hand, the initial soil water content, the thickness of the source and the duration and intensity of the natural rain were calculated beforehand as in order to avoid percolation during the experiment and hence to maintain a realistic soil tension. This tension apparently sufficed to prevent noteworthy runoff.

3.3. DISCUSSION OF THE RESULTS AND THEIR IMPLICATIONS

The results, presented here, cover only cases where the horizontal velocity component of the rain is perpendicular to the slope contours. In both cases of $\beta = 5°$ and $\beta = 20°$, the net splash-saltation flux equals zero for conditions of slope inward rains where the slope inclinations are a few degrees below the β-value. For $\beta = 20°$, the net flux $\varnothing$ equals zero for a slope inclination between 19° and 17°. For $\beta = 5°$, $\varnothing$ equals zero on a slope of about 3°. This result is important for two reasons. First, it shows that the splash-saltation flux can be oriented upslope in cases of slope inward rains for slopes between 0° and $(\beta - \pm 2)°$. This implicates that considerations concerning the effect of splash-saltation on the form of a hill are complex because the divide between upslope and downslope transport does not coincide with the hill summit. One can even go further and suppose a rather flat area where the steepest slopes are somewhat lower than the prevailing rainfall obliquity expressed by the angle β. The experiment indicates that in such landscape splash transport can become a meaningfull mechanism for long distance transport, if no natural barriers as rivers are involed and if there is a prevailing wind direction and hence a prevailing rainfall obliquity. Secund, the results are certainly an underestimation because S.T.O.R.M.-1 produces oblique rain without wind. As in nature oblique rain results from wind action, it is believed that the experimental results underestimate the fluxes in the sense of the horizontal velocity component of the rain and overestimate the opposite fluxes. So, the dissymmetry of the graphs, presented here, should still be more pronounced in nature. The point is that splash-saltation can be considered as a pluvio-eolian process, whereby the role of wind and water drops cannot be clearly distinguished. Indeed, even the detachment of particles from the ground under the impuls of raindrop impacts is function of wind direction and velocity, because this is the prime factor, determining the rain obliquity. So, pure rain splash-saltation only occurs under the rare, or maybe non existent, condition of rain without wind.

The experiment, described above, has been carried out as part of a program of erosion studies in Southern Rwanda. While it can be admitted as a general rule that splash-saltation erosion in that area is unimportant compared to other processes such as runoff erosion and even creep, it is probably of much more significance in the particular case of freshly cultivated field plots. Rain simulation on cultivated fields as well as simple observations during rain

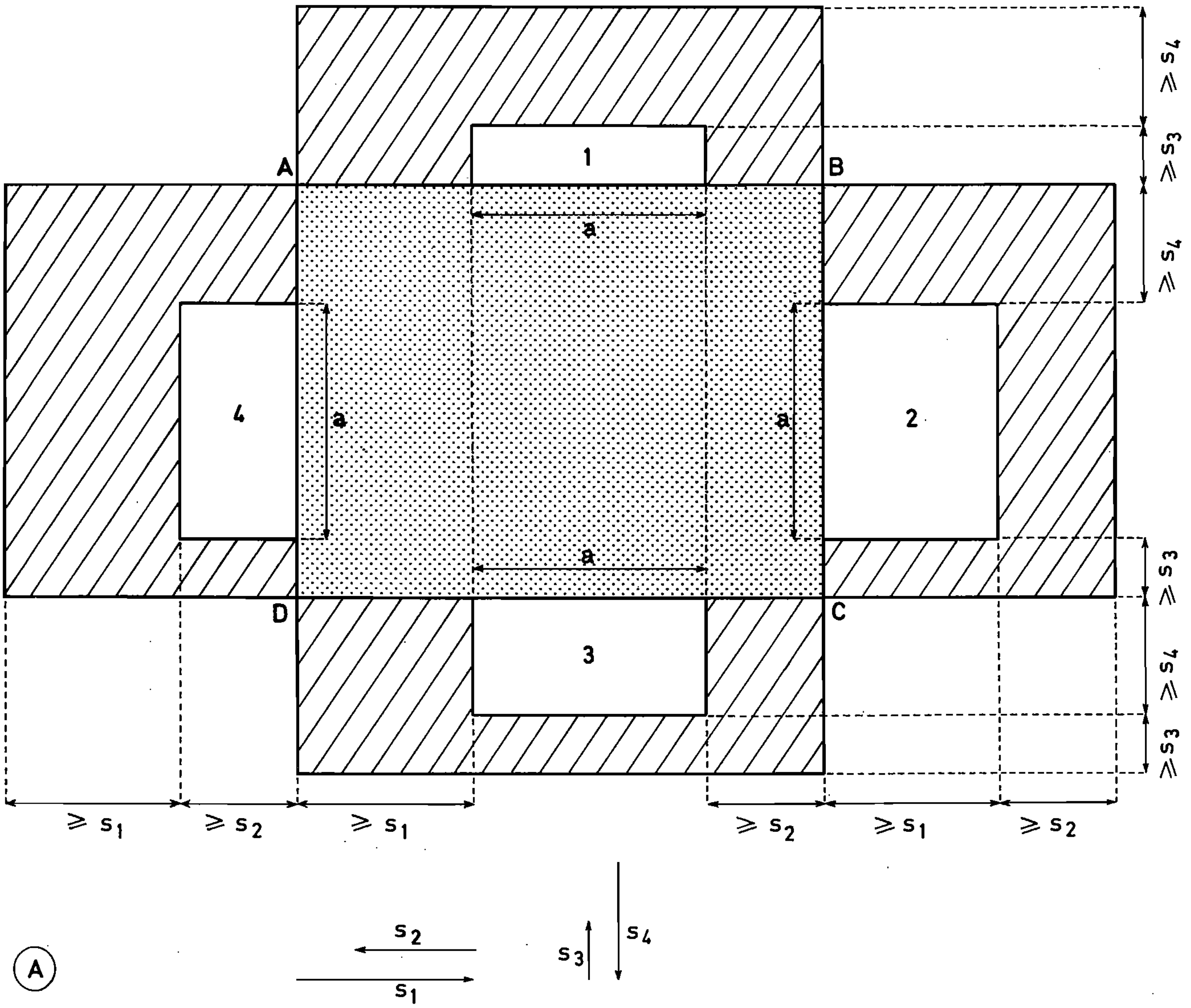
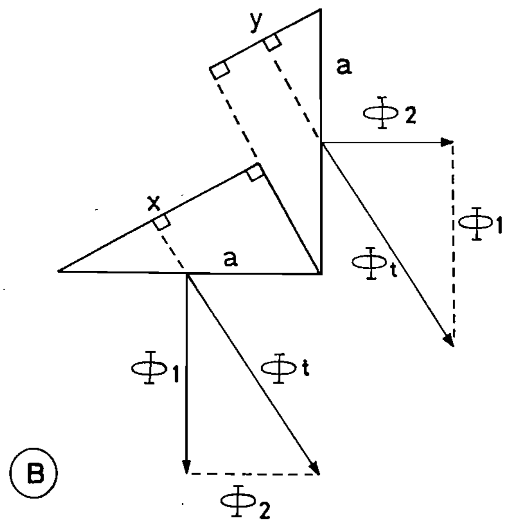


Fig. 4A: Schematic representation of field set up for the measurement of the splash-saltation flux. Dotted area: undisturbed slope section. 1, 2, 3, 4: sediment traps. Arched area: fixed soil surface s_1, s_2, s_3, s_4: maximum saltation distances, taken in the directions of the sides of the rectangular slope section.



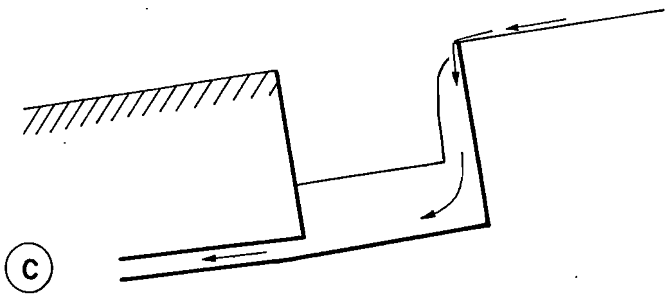


Fig. 4B: Geomtrical construction of vector ø t and the cross-section (x + y) to which it is related.

Fig. 4C: Lateral view of sediment trap with false side and false bottom. The arrow indicates runoff.

storms have shown that runoff is not very important and often discontinuous. This follows from the high soil infiltration capacity as a result of hoeing. It seems therefore, that net upward oriented splash fluxes on fields upon the weather-side of a hill (where $\beta > \alpha$), might compensate for the restricted downward transport by runoff. So, as long as the soil infiltration capacity can be maintained high by reworking the field at regular times, the fields in question may have an advantage over other fields, where the net splash flux and runoff erosion both act in downslope direction.

Finally, the experimental results show that eventual direct measurements in the field are rather complicated, because the direction and sense of the splash-saltation flux are unknown. Indeed, while the experiments are only related to situations of slope inward and slope outward rain, in nature there exist also situations where the horizontal rain velocity component might be more or less parallel to the slope contours. There is no reason why such rains, called transverse rains, should not cause fluxes oblique to the local slope line. As it is stated above that there is a need for good field measurements, we present here a possible field set up. It consists of 4 sediment traps, with a width (a). They should be placed, one at every side of a square or rectangular undisturbed slope section, the orientation of which has no importance. Some dimensions, however, should be respected. This can be illustrated on fig. 4A. If the maximum saltation distances in the direction of the two pairs of sides of the slope section are known (s_1,s_2,s_3,s_4), trap 1 should be situated at a distance from A, at last equal to s_1 and at a distance from B equal or more than s_2. The length of the trap should at least be equal to distance s_3. In this way, the material, collected within a certain time in trap 1, will be the same as the amount of material passing over its side (a) out of the slope section, provided that the trap is protected against all material coming from the other parts of the slope around the trap. This last condition can be realized by fixing the soil surface in the shaded area (fig. 4A) by means of chemical fixatives, used as soil stabilizers (GABRIELS, HARTMAN & DE BOODT 1974) or lacquers used to take negatives from soil profiles. So, two splash fluxes can be defined. The first flux (ø 1) is determined on the base of the material collected in sediment traps 1 and 3. The secund flux (ø 2) can be calculated from the amount of material collected in sediment traps 2 and 4. The vectorial summation of ø 1 and ø 2 gives the total flux ø t. On fig. 4B it can be seen that ø t is not related to a cross-section (a) but to a cross-section, perpendicular to t, composed of line sections x and y. If t has to be known, the length of the cross-section should be calculated. In the case of fig. 4B

$$x + y = a. \cos (\text{arc tg } \frac{\varnothing 1}{\varnothing 2}) + a. \cos (\text{arc tg } \frac{\varnothing 2}{\varnothing 1})$$

The field set up, presented here, is theoretically correct in respect to the calculation of the total net splash-saltation flux over a section perpendicular to it. Two practical problems, however, remain to be resolved. First of all, there is the problem of runoff water which may fill the traps and add not splashed material, and/or may cause overflow of the traps and disappearance of collected material. More solutions exist for this problem, but the type of solution depends on local field factors as slope and type of soil material. Anyway, runoff coming from the sealed surface around the traps can be deviated by small gutters. Runoff, coming out of the slope section on which splash-saltation is masured can be collcted by the traps if they have a false side and false bottom as shown in fig. 4C. Enough perforations should be provided to permit the collected water to infiltrate quickly into the soil. If runoff is too high, the lower chamber of the trap could be provided with an outlet, coming at the surface downslope the installation. The second problem is the possibility that material should be splashed out of the trap. This simply can be avoided by making the trap deep enough.

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