Erosion and sediment transport measurement
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QUANTITATIVE GEOMORPHOLOGY IN EROSION PROCESS INVESTIGATION

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ABSTRACT

This paper summarizes the different approaches in erosion processes investigation. The authors consider the quantitative geomorphologic approach as a supply of data for erosion mathematical models. The main parameters are briefly described and some thematic maps are produced by using a computer.

The methods for evaluating erosion are different and depend on the different approaches.

As soil results from the various synthesis of physical factors which interact with the landscape and from the balance between constructive (biological activity) and destructive (erosion) processes, the pedologic data survey is certainly a great help for the knowledge in space of the intensity of erosion processes on slopes, even if it is not sufficient to express them quantitatively.

Moreover the pedologic survey requires a large committment of men and resources, so it can be used only in small areas.

Another method can also be the management of dissolved and solid matter transport in a cross section at the outlet of a river basin.

This system does not give data of areal distribution of erosion in the basin, but a total value.

The precision of such measurements is generally low and long periods of observation are necessary for the measurements to become statistically significant.

This measurement however allows the quantitative evaluation of sediment yield.

The geomorphologic survey of the landscape is another approach for the study of erosion processes.

Such survey is, moreover, an indispensable support for the pedologic survey.

Geomorphology studies the genesis of forms and classifies them in function of the different erosion processes, but does not express quantitatively the erosion rate.

The study of the forms of the landscape remains however of particular interest because these are, in a humid climate, the result of erosion in that landscape.

The final approach for the erosion evaluation is by means of mathematical models.

This line of research is extending greatly and researchers of various cultures are involved in it.

The essential parameters most commonly used in the literature refer to some climatic, pedologic, vegetative, crop management and geomorphological characteristics.

This paper is intended as a contribution to the survey of those geomorphological elements used as parameters in hydrology and erosion models.

Quantitative geomorphology analyses the landscape forms and expresses some significant elements in numerical terms.

The geomorphological elements which can be considered are, of course, many and various in relation to the processes with which they are correlated.

The elements considered important by the authors are:

1. drainage density
2. length

3. incline
4. orientation
5. exposure to sunlight

Drainage density expresses in km/km^2 the total length of the river network for unit surface area.

The reliability of such parameters varies in relation to the method used for the drainage network survey.

In fact, such a parameter is highly reliable only if the whole natural drainage network is considered including particularly the first-order streams.

Such a precision is possible only by means of ad hoc survey using aerial photographs on a suitable scale.

The drainage network derived from topographic maps is not reliable because, as is known, a topographic map represents the surface and some particulars of the terrain by symbols.

The particulars represented on a topographic map must be those most suited to the identification of every point of the surface, and in quantity such as to maintain the graphic density of the symbols homogeneouosly and sufficiently low for a good understanding.

The map-maker chooses between the various particulars to be represented (drainage network, contour lines, roads, buildings, vegetation, etc.) eliminating those he thinks superfluous.

Does it happen that drainage network is represented in great detail when the network is part of a wooded and inhabited region where the only elements to be represented are contour lines and drainage network.

Viceversa, in a region which in reality has the same drainage density but which on the contrary is densely populated and urbanized, the large number of elements to be represented on the map demands a drastic reduction of detail of the drainage network design.

The drainage density surveyed in this way is one of the most significant parameters influencing hydrological processes in general and in particular erosion processes (CICCACCI et al.,1977).

Slope length is the distance measured along the lines of maximum incline from every point of the divide to the intersection of these with the stream.

Naturally, the distance varies from point to point on every slope.

In practice it is impossible to measure this parameter.

If instead we consider the average slope length defined as the average length of the projection of the trajectory on the horizontal plane from the divide to the related stream, also considered horizontal, this can be calculated as a function of drainage density (BILLI et al.,1979).

Slope length is the morphometric parameter used in all the erosion models and it is probably the one most easily correlated to sediment yield.

The slope gradient also strongly influences the intensity of erosion processes.

The extreme spatial variability of this data does not allow its survey point by point.

The slope surface is thus generally subdivided into areas inside which the gradient values are contained in a defined range.

The slope exposure is the intersection of projection of the normal onto the slope on the horizontal plane.

Naturally, also this parameter varies in the same way as gradient.

This parameter is important because combined with the slope gradient and the latitude it leads to the measurement of the exposure to sunlight which is expressed in hours of sunlight perpendicular to the slope (hn). This is in function to the quantity of solar energy potentially available in rock weathering processes.

Thematic maps are produced which describe numerically the essential features in relation to erosion processes.

Such maps are obtained by digitalising three main elements: contour lines; drainage network; divide network.

With successive numerical elaboration by computer it is possible to reconstruct the perimeter of every slope.

After associating every point of this perimeter to an elevation it is possible to reconstruct morphological data and to represent them graphically.

It is, moreover, possible to program the computer to produce the separation of colours necessary for the final printing of the map.

BIBLIOGRAPHY

BECCHI I.,BILLI P., TACCONI P.,(1978) "Trasporto solido e parametri fisici di un bacino idrografico. Ricerche sperimentali nei bacini dei tt. Virginio e Pesciola". Atti del 69° Congr.Soc. Geol.It., Perugia.

BECCHI I., BILLI P., TACCONI P.,(1979) "Field research on sediment production in small basins with different land use". Proc. IAHS Symp., Camberra, Publ. No.128.

BILLI P., MONTANI C., TACCONI P.,(1979) "Problemi di gestione del territorio: esperienze di cartografia tematica - assolazione e morfologia dei versanti". Atti Incontro CNR P.F., Ist. di Ingegneria Civile, Firenze.

CARLSTON C.W.,(1963) "Drainage density and streamflow". Geol.Surv. Prof.Paper No.422-C.

CANUTI P., TACCONI P., (1971) "Cartografia idrogeologica: le unità idrogeologiche". Boll.Soc.Geol.It. No.90.

CICCACCI S., FREDI P., LUPIA PALMIERI E.,(1977) " Rapporti fra trasporto solido e parametri climatici e geomorfici in alcuni bacini idrografici italiani". Atti Seminario "Misura del

Trasporto Solido al Fondo nei Corsi d'Acqua", Istituto di Ingegneria Civile, Firenze.

GREGORY K.S., WALLING D.E.,(1973) "Drainage Basin Form and Process". Edward Arnold, London.

HORTON R.E.,(1945) "Erosional development of streams and their drainage basins; hydrological approach to quantitative morphology". Geol.Soc.Am.Bull. LVI.

MONTANI C., MORANDI CECCHI M.(1980) "Sulla generazione automatica di carte tematiche per bacino idrografico". Atti Soc.Toscana di Scienze Matematiche, Memoria Serie A, 87.

MONTANI C., MORANDI CECCHI M.,(1980) "Studio informatico della morfometria di un piccolo bacino in Val d'Era (Toscana)". Atti Soc. Tosc.Sc.Matem. Mem. Serie A,87.

RAMBERT B.,(1973) "Recherches sur la signification hydrogéologique de la densité du drainage". Dept.Géologie de l'amenagement. 73 SGN 422 AME, Orléans Cédex.

SFALANGA M., CANUTI P., TACCONI P.,(1972) "Ricerche di geomorfologia applicata nel bacino dell'Era". Ann.Ist.Sper.Studio e Difesa del Suolo, III, Firenze.

TACCONI P.,(1973) "Problemi di gestione del territorio: esperienze di cartografia tematica - uso del suolo e sistemi di agricoltura". Atti Incontro CNR P.F., Istituto di Ingegneria Civile, Firenze.

WILSON L.,(1977) "Sediment yield as a function of climate". In: U.S. Rivers, IAHS, Publ. No.122, Paris.