Surface erosion of Alpine watersheds (1994-1998)

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Introduction

Most Swiss dams were built thirty to sixty years ago. Their dead storage, designed to accumulate the sediment yield, is in some particular cases nearly filled. This can present problems for the exploitation or even affect the safe operation of the bottom outlet devices. In order to improve the knowledge on the sediment yield to the alpine reservoirs, the importance of surface erosion in the Swiss Alps is studied.
The first part of the research consists of an inventory of the reservoirs, where the annual volume of sediments is measured (Figure 1). The characteristics of the reservoir's watersheds are discussed and analysed in order to explain the annual soil loss. Finally some particular watersheds (coloured in green on figure 1) are submitted to a more detailed analysis using laboratory tests on soil samples. Soil properties influencing surface erosion are grain size distribution, organic matter content, soil density and permeability.

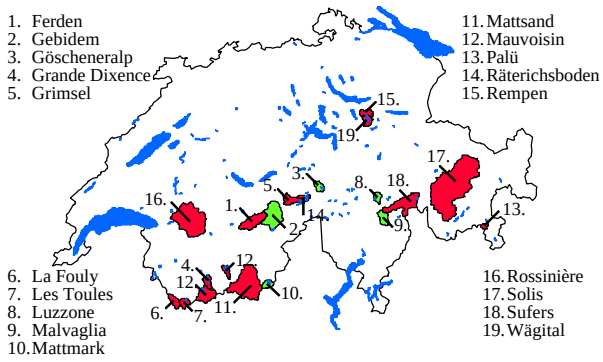

Fig. 1. Map of Switzerland with the studied watersheds. Basis : Lakes of Switzerland, OFS GEOSTAT.

Laboratory tests with a rainfall simulator were then performed on a typical Alpine soil, in order to evaluate the individual influence of the most important parameters like slope steepness, rainfall, grain size distribution and density of the soil. The test results are analysed in order to establish a simple erosion model for alpine watersheds.

Inventory of watersheds

Nineteen reservoirs in Switzerland could be documented where the annual sediment yield was determined either by measuring the sediment transport during flushes or by surveying the sediment deposits. These data could be collected in collaboration with the owners of hydropower facilities and with specialised surveyors. The geographical situation of the related watersheds is shown on Figure 1.
Most characteristics influencing surface erosion could be easily determined with maps for the considered watersheds. They concern information about :

- slope steepness ;
- rock type (Figure 2);
- soil cover;
- annual rainfall.

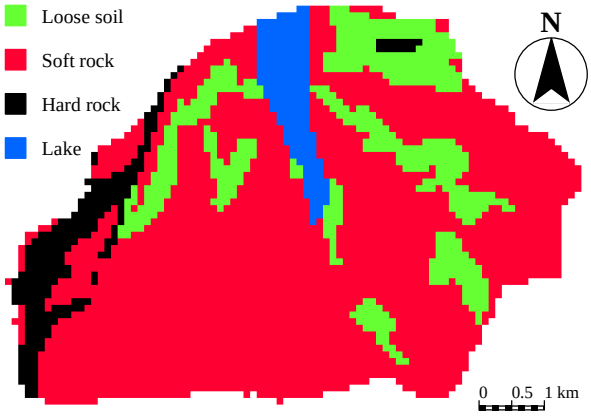

Fig. 2. Rock types in the watershed of Mattmark. Basis: Simplified geotechnical map of Switzerland, OFS GEOSTAT.

A statistical analysis of these data allowed to establish an erosion model for alpine watersheds. The mean annual sediment yield is increasing with the surface without vegetal cover, with the surface of soil of high erodiblity and with the mean annual rainfall during the summer months.

Laboratory tests and preliminary results

The laboratory tests were performed with four different slopes, three different rainfall intensities and four different runoff discharges. The soil has been chosen based on the grain size distributions of the soil samples collected in five different watersheds (coloured in green on figure 1).
The results reveal the great influence of the initial soil surface conditions and the runoff discharge. Soil loss increases with slope stepness, rainfall intensity and runoff discharge as shown on figure 3 where the soil loss measured during the tests is plotted against the erosivity. The erosivity describes the aggression of the soil surface by rainfall and runoff and depends on the rainfall intensity, the cinematic energy of the drops, the maximum runoff discharge and the total volume of runoff.
Three different existing erosion models, developed for agricultural land, could be calibrated with the results of the laboratory tests. These models must know be tested with the watershed data in order to approve their applicability to the Alpine environment.

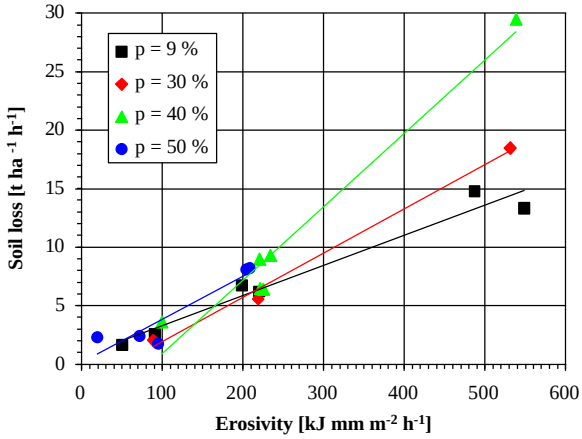

Fig. 3. Results of the laboratory test. Soil loss as a function of rainfall and runoff erosivity.