Estimating Sediment Mobilisation from Torrent and Gully Deposits: Field Studies

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Introduction

The bed-load sediments that are found trapped in the depositional alluvial fans of ephemeral gullies and ravines are the remains of sediments mobilised by erosion in the catchment minus those sediments removed by flowing water. Erosion is selective; it removes different parts of the soil and regolith in different proportions and the least easily moved sediments dominate the sediments trapped in depositional fans. Although the rules which govern selective erosion are quite complicated, there remains the possibility of measuring the volume and particle size distribution of the sediments in an alluvial fan and use this information to calculate the total amount of sediment removed by the flows that created the fan.

In fact, this approach has been employed by generations of landslide researchers and by those who study debris flows, which can be 5-76% coarse sediment (>64 mm) (Haigh et al., 2004; Webb et al., 2000). This study explores some of the problems that emerge when an attempt is made to extend this logic to the analysis of deposits created by flows in first order torrents and gullies. Of course, if it were possible, easily, to perform this calculation, then it would be equally easy to determine how much sediment a particular ephemeral basin contributed to the general sediment load of an affected river basin during a particular extreme event. Unfortunately, the problem is not so simple (Walling, 1988). This article reviews some of the issues.
Particle Size Analysis

Particle size analysis, like Munsell Soil Colour scores and pH, is a soil property more frequently measured than put to good use. True, it has major applications in discussions of soil aggregate stability and also in soil loss prediction, where it is a factor in the USLE, WEPP and many other technologies. This article deploys particle size analysis in a study of the processes of selective erosion and considers the extent to which particle size data of mobilised sediment can be used to estimate sediment yield. It is founded in the simple laboratory techniques of wet sieve and hydrometer analysis (Loveland and Whalley, 1991). It reinvents an intuitively obvious but little heralded approach to soil loss estimation, here graced with the title: ‘The Lost Soil Method’. This is evaluated as a tool in studies of some intensively monitored micro-catchments in the USA and India.

Himalaya Case Study

First, India and a study based on measurements of the accumulation of alluvial sediments from four, parallel, adjacent, first-order, torrents on a steep, south-facing, ridge in the Lesser Himalaya. Two of these streams flow through areas that retain their forest cover and two through areas where the major trees have been removed and replaced by a goat-ruptured turf and thin scrub.

The site is at Landour, near Mussoorie, Uttarakhand (30.27°N, 78.60°E). The geology is Tal Formation shale and sandstones, which dip southwards (160-210° T.B.) at angles of 20-30° (Range: 8-52°). The hill-slope is very steep, ground-surveyed in 2 m unit lengths, 92% is steeper than 15° and 41% steeper than 35°. Forest covers 55%, agricultural terraces just 2% and housing and roads about 34% of the land area (Haigh, 1979). All four catchments include houses and are crossed by the two paved roads that run east-west along the contour. Annual rainfall is 2356 mm—but this study was undertaken after a twice-normal intensity monsoon and nearly all the rain fell in the period July-September. Frost action is slight. Winter snowfalls are short-lived.

The four micro-catchments explored for this study have similar physical characteristics. They have a local relief of approximately 300 m, their areas range between 0.8 and 1.1 km². Their single main channel is rock floored and slopes at about 40°. Channel walls of soil and weathered rock slope at 50-70° and are major sources of sediment. However, the two channels that drain the deforested slopes are much wider, deeper and show greater bed-load than those in the forest.

A bed-load sediment trap is an obstacle introduced into a stream channel’s long profile that causes a large portion of its sediment load to be retained. In this case, such a trap was created accidentally by road works on the lower of the roads that cross the catchment. Culverts were blocked, so in monsoon flood conditions, streams flowed right across the road-bed where, the abrupt