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Evaluation of erosion in mountain basins by the suspended sediment monitoring programme in three Apennines rivers

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Introduction A suspended sediment monitoring campaign has started on 1997 on the Sillaro watershed and it has been extended to Savena's. Lavino's and river Reno's basins. The project addresses the sampling of river water and the monitoring of river stages in order to estimate suspended sediment load and analyse watershed dynamics. The measuring stations are set up at the outlet of the mountain basin for the three torrents (Sillaro, Lavino and Savena) and at the outlet of the Reno watershed, few kilometres from the Adriatic Sea. Each monitoring station is equipped with an ultrasonic flow meter and an automatic water sample. This study shows the results of a detailed analysis of suspended sediment yield and river flow for the three torrents in order to estimate soil erosion from their respective watershed. The monitoring program is sponsored by the Reno Basin Authority and by A.R.P.A. Site description The monitored watersheds are similar in size, position and geological setting, but different in lithological setting and anthropic pressure. The Sillaro (137.6 Km2), the Lavino (82.6 Km2) and the Savena (168.9 Km2) basins, all are narrow shaped and develop along their longitudinal axis (south-west to north-east); the morphology of the watersheds enhances the character of flashiness of the floods. Average annual rainfall over the portion of the Apennines covered by the three watersheds (389 Km2) is of 1000 mm. Lithology is mainly of sedimentary origin; hillsides of the main trunk for the Sillaro and the Lavino are mildly sloped and locally highly eroded; badlands ("calanchi") are a very common feature for these watersheds, besides mud flows and landslides. Savena basin instead, characterized by loamy sandrock and stratified sandrock, allows the presence of steep slopes and is less subjected to surface erosion. The most anthropised basin of the three is the Lavino watershed, for its vicinity to Bologna, the presence of intensive agriculture and the new urban settlements. Analysis methods The monitoring

stations consist in an ultrasonic flow meter and an automatic water sampler and are sited on a check dam at the outlet from the mountain basin. The flow meter signals the water sampler to collect a water specimen every 100.000 m3 of water crossing the section, thus to have samples concentrated during storm events. We considered this sampling strategy as suitable to perform a correct analysis of suspended load and of the rainfall-induced erosive processes. On the basis of the data collected for several years (since year 1997, 1998 and 2000 respectively for the Sillaro. the Lavino and the Savena torrent):Qs=kE(CiQi) where Qs is the annual suspended sediment yield (Tons/Km2). Ci is the monthly average concentration (g/l). Qi is the monthly average discharge (m3/s). Results Almost 90% of samples derive from flood events. Over the 1352 samples collected on the Sillaro torrent since 1997, the average suspended sediment concentration is 3.7 g/l, while 80% of the samples collected on the Lavino and the Savena torrents had a suspended sediment concentration lower to 2 g/l. The average suspended sediment concentration over the 1258 river water specimens from the Savena torrent is 2.17 g/l. In the Lavino torrent the average suspended sediment is of 1.1 g/l (1051 samples), with a standard deviation of 1.87 g/l. Average soil loss from the Sillaro resulted of 10.4 Tons/ha (1998-2003), corresponding to a loss of 0.69 mm of soil eroded (averaged over the entire basin; sediment density 1.5 Tons/m3). Highest soil loss has been recorded over the year 2002, with an estimate of 306۠,700 Tons of material transported, corresponding to 1.49 mm of soil eroded. Over the monitoring period (2000-2003), the mountain basin of the Savena torrent discharged, on average, 9.8 Tons/ha of suspended sediment a year; soil loss maximum has been reached during 2003 with 18 Tons/ha, corresponding to 1.2 mm of surface eroded. A less severe surface erosion has been monitored over the Lavino watershed: average annual suspended sediment 2.5 Tons/ha, corresponding to a 0.16 mm of surface soil loss. Final considerations From a first comparison of the estimates of surface soil loss from the three basins, it is evident the severity of soil erosion for the Sillaro basin. Referring to the Fournier classification, the annual average soil loss estimated for the Sillaro watershed belongs to the severe class and moreover to the strong erosion class for the year 2002. Savena torrent shows an average soil loss belonging to the medium erosion class and the Lavino to the low erosion class. These results are confirmed by the lithological conditions and by the erosive processes in the basins, which favour the strong erosion in the Sillaro basin. The estimate method of the suspended sediment yield, using the sum of the products of the monthly average discharge by the monthly average suspended sediment concentration, is fairly rapid; however it might be biased by the sampling strategy employed. Sampling according to water discharge leads to a heavier sampling during high river stage and during floods: this might result in a overestimation of the monthly suspended sediment yield. This sampling strategy, however, allows to strictly monitor flood events, during which the greatest fraction of the total

suspended sediment is transported, and therefore it is suitable to the study of overland flow and of stream bank erosion. Erosion rate estimates for the Sillaro Torrent are as follows:year 1998 429 T/Km2 (corresponding to 0.29mm);year 1999 1167 T/Km2 (corresponding to 0.78mm),year 2000 684 T/Km2 (corresponding to 0.46mm),year 2001 875 T/Km2 (corresponding to 0.58mm),year 2002 2229 T/Km2 (corresponding to 1.49mm),year 2003 863 T/Km2 (corresponding to 0.58mm);Mean(1998-03) 1041 T/Km2 (corresponding to 0.69mm) Erosion rate estimates for the Lavino Torrent are as follows:year 1999 481 T/Km2 (corresponding to 0.32mm),year 2000 44 T/Km2 (corresponding to 0.03mm),year 2001 146 T/Km2 (corresponding to 0.10mm),year 2002 295 T/Km2 (corresponding to 0.20mm),year 2003 262 T/Km2 (corresponding to 0.17mm);Mean(1999-03) 246 T/Km2 (corresponding to 0.16mm) Erosion rate estimates for the Savena Torrent are as follows: year 2001 520 T/Km2 (corresponding to 0.35mm),year 2002 614 T/Km2 (corresponding to 0.41mm),year 2003 1800 T/Km2 (corresponding to 1.20mm);Mean(2001-03) 978 T/Km2 (corresponding to 0.65mm).