Estimating Suspended Sediment Transport through Transparency Tube in Vouraikos River, NW Peloponnese, Greece

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Introduction

Vouraikos River and its watershed has been the subject of an on-going Ph.D research (of the first author) initiated in 2012, and aimed at quantifying and modelling sediment transport. In this abstract we briefly present the results of a 5-year long measurements program, regarding suspended sediment transport. In particular, we discuss - and strongly encourage - the use of a transparency tube, a cheap and easy to use turbulometer (Anderson and Davic, 2004, Dahlgren et al.,2004), as a reliable alternative to more sophisticated and expensive instrumentation for monitoring sediment transport in rivers and streams.

Study Area

Vouraikos River is located in the northwestern Peloponnese and drains an area of 284 km^2. The southern part of its catchment consists of geological formations of Mesozoic age (mainly limestones, but also cherts and flysch layers which belong to the geotectonic zone of Olonos-Pindos. The northern part is dominated by Late Pliocene to Quaternary fluvial and lacustrine Gilbert type fan-delta conglomerates (Bornovas and Rondoyanni, 1983). The climate of the north Peloponnese is coastal Mediterranean (Köppen: Csb) with mean annual temperature 14.5 $^{\circ}$C. Rainfall exhibits a gradient ranging from 1500 mm of rain over the mountains to less than 450 mm at the seashore of the Gulf of Corinth. The drainage metwrk of Vouraikos directly drains extensive area of the Chelmos Mountain that retains snow for most of the year.

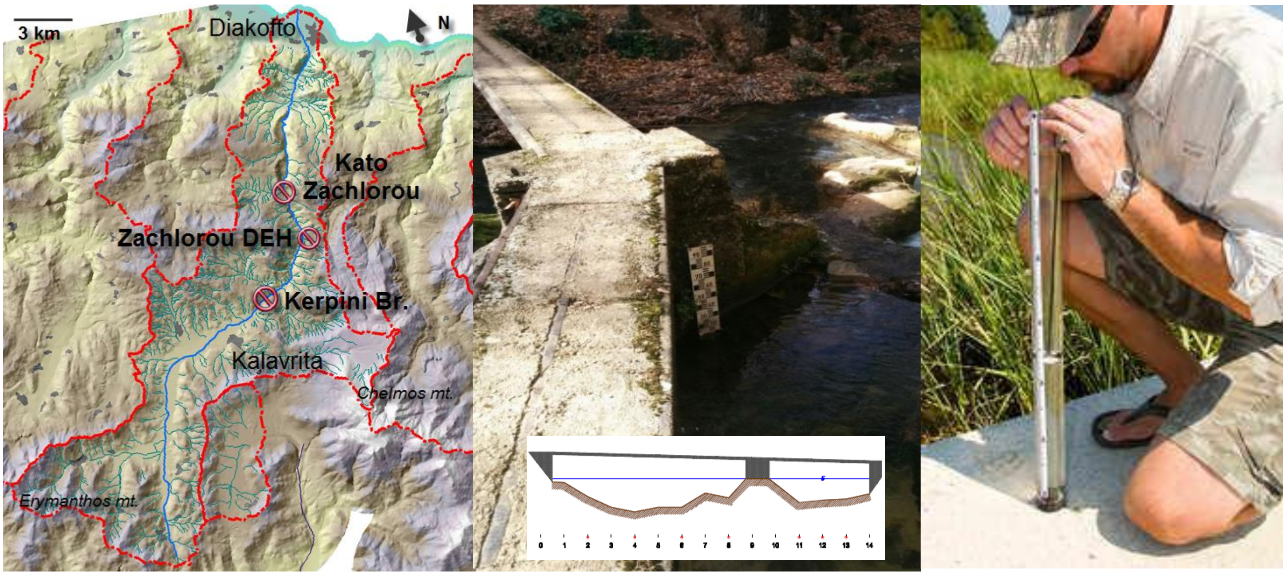

Figure 1.Left, a general map of the basin. Middle, the low bridge at Kato Zachlorou where measurements were conducted and (below) cross section of the channel. The stadia can be seen in the middle pier. Right, the use of the transparency tube is simple: one empties the tube until the mark in its bottom cup can be clearly seen, and then records the water height.

In the study site (Kato Zachlorou Bridge, Fig.1) the stream drains an area of 187 km^2 and it can be classified broadly as step – pool type. The stream is carved in the bedrock and the average slope is 2%. The principal sediment sources are fluvial and hillslope material while, due to the nature of the stream at the site, there is no sediment storage except from small sand pockets.

Methods and data

Two distinct periods of transparency tube daily measurements were conducted by a local collaborator, stretching about 2.5 months each. These periods were from 21/12/2015 to 26/02/2016 and from 25/2/2018 to 30/04/2018. Nine water samples were taken with a DH48 sampler lowered from the bridge, at high and low waters, which were later analyzed in the laboratory of Physical Geography of Harokopio University by drying in the oven and weighting the collected sediment. Discharge was estimated by the rating curve for the site. While the use of the transparency tube is rather simple, its main defect is the subjectivity of the observer when he decides that he "sees clearly" the black and white pattern at the cup. Because this point was not clearly agreed upon with the observer, the first period's measurements were not considered trustworthy. Due care was taken, stressing that point to the observer before the beginning of the second period of the measurements, that yielded much more reliable results (Fig.2). A turbulometer reading – SSC curve was constructed and was given an analytic expression (exponential) and extrapolated through the full range of the readings (0-60 centimeters).These measurements also yielded a sediment rating curve (Discharge – Suspended Sediment Concentration, SSC) for the site (Fig.2). In addition to the above, two ten-years period stage hydrographs (1980-1990 and 2004-2014) were made available to us, courtesy of the Public (once) Power Corporation (DEH), that has been monitoring the river through a hydrometric station (Zachlorou DEH), just 1.5 Km upstream. Rainfall and temperature data on a daily base were made available, also by DEH. We converted these stage hydrographs to discharge hydrographs with the use of our own rating curve for the site (10 points at Zachlorou DEH) and were thus able, using our sediment rating curve, to make a rough estimation of the suspended sediment load that had been transported during these periods. Another equation, developed by Ryan & Emmett (2002) for the Little Granite Creek, in Wyoming USA, was also considered, due to the fact that –regarding bedload - it gave results very close to our measurements, but also because these streams present significant similarities.

Results

The results can be seen in Figure 2. In the right panel we can see the time series of the second period of turbulometer measurements. Along with the discharge line we can see two lines of SSC, one from the turbulometer readings and the other from the sediment rating curve. It is clear that the turbulometer SSC is much more sensitive to the sediment load, since it depicts the peak in SSC caused by the flood of the 26th of February, while the next day, when the available sediment has been depleted, the SSC returns to low values even though the discharge is still high. An encouraging fact is that these two curves, despite their differences, yield the same, more or less, amount of sediment for the given period.

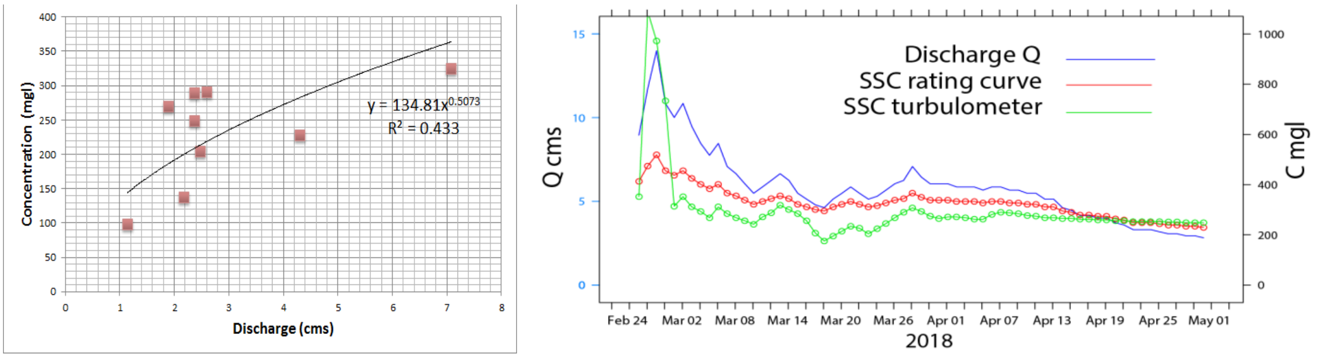

Figure 2.Left: the sediment rating curve used. Right: Time series of second period's measurements.

When applied over the two ten-year periods, the rating curve gives values of suspended sediment transport that range from 27 thousand metric tonnes per year for the first period (1980-1990) to about 13 thousand tonnes for the second period (2004-2014), with an average of 22 thousand tonnes. The maximum annual transport is estimated to be about 68 thousand tonnes for the hydrologic year of 1983. Ryan & Emmets' equation predicts much lower values, an average of 7 thousand tonnes. The bulk of the transport takes place mainly in the 4-month period from December to March. If we set on to calculate the transported material per km^2 based on the above values, we are faced with the difficulty of estimating the contributing basin area. Morphologically Vouraikos river is made up, in general, by four distinct parts (Sabot and Maroukian, 1989); The *mountainous* part that drains into the valley of Kalavryta (*upper*), while, after its exit from the valley (bridge of Kerpini), its slope increases and it becomes a roaring watercourse within a v-shaped, steep valley (*lower*), which, then, finally reaches the sea (*beachfront*) creating a fan. So, if we accept only the area downstream of Kerpini as contributing area (17 km^2) we come up with 1300 t/y/km^2. If we accept the whole of the basin at the site (187 km^2), we come up with just 120 t/y/km^2.

Conclusions

The use of a simple transparency tube turbulometer, is able, if locally calibrated, to assess total suspended solids and turbulence in rivers with acceptable accuracy. This method should be adopted by our governmental agencies as a cheap alternative for assessing sediment transport and even water quality, especially these days when the budgets for monitoring and research are dramatically reduced.

References

Anderson P. and Davic R.,(2004). Use of Transparency Tubes for Rapid Assessment of total suspended solids and turbulence in Rivers.Lake and Reserv. Manage. 20(2):110-120.

Bornovas, I.& Rondoyanni, Th. (1983) Geological Map of Greece,. Scale 1:500,000. Institute of Geology and Mineral Exploration.

Dahlgren R., V.Niewenhuyse E. and Litton G., 2004. Transparency tube provides reliable water quality measurements.http://CaliforniaAgriculture.ucop.edu.

Ryan, S., & Emmett, W. (2002). The Nature of Flow and Sediment Movement in Little Granite Creek Near Bondurant, Wyoming. United States Department of Agriculture Forest Service Rocky Mountain Research Station General Technical Report

Sabot V. and Maroukian H. (1989). River discharge and Stream Channel Changes Along a Torrent in Northern Peloponnesus, Greece. 2nd International Conference on Geomorphology. Frankfurt, Main.