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Assessing Bedload 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, with emphasis in bedload transport. In this abstract we briefly present the results of a 5-year long measurements program, regarding bedload transport.

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 and. 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 °C, mean temperature of the coldest month 10.6 °C and mean temperature of the warmest month 26.4 °C (Katsafados et al., 2012). Rainfall exhibits a gradient ranging from more than 1500 mm of rain over the mountains of central Peloponnese to less than 450 mm at the seashore of the Gulf of Corinth. The main channel of Vouraikos river is made up, in general, by two distinct parts; It is characterised by a tranquil, slow flow in the valley of Kalavryta (gentle slope), while, after its exit from the valley (approximately downstream of the bridge of Kerpini), its slope increases and it becomes a roaring watercourse within a v-shaped, steep valley, until almost the village of Zachlorou. About 1 km upstream of the village of Zachlorou, the v-shaped, steep valley becomes a gorge, for which this river is widely known.

Figure 1.Panoramic view of the stream, downstream of the Pliatsikouras bridge station. The piles of gravels that can be seen in the left bank are supplied by a tributary. Occasionally, this sediment is shovelled and piled overbank.

In the study site (Pliatsikouras Bridge) the stream can be classified broadly as plain bed type. Not far downstream, as its slope increases, it becomes a step – pool type. The average slope is 1.5%. The principal sediment sources are fluvial, hillslope and debris flows while sediment storage is mainly overbank. These features can be seen in Fig. 1.

Methods and data

Bedload samplings were carried out with the use of a Helley-Smith sampler with a 15cm square opening. Sediments traps were also employed, but were abandoned at a later stage since their operation is very problematic under large discharges. On the contrary, the existence of the low bridge gave us the opportunity to use the Helley-Smith sampler, even in near-bankfull discharges. Sediment transport measurements were concurrent with flow velocity and water discharge measurements that, inter alia, revealed the at-a-station hydraulic geometry. Grainsize distributions (GSD) of surface bed material and the substrate were acquired from such gravelometric surveys as pebble counts and shovel (bulk) samplings (Karalis et al., 2016). Main geometric features of the river reach, such as slope, width and plan course were made available from a complete topographical survey of the reach that we performed, stretching about 400 m. upstream of the station. Two ten-years period 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 from a station(Zachlorou) just 2 Km downstream of Pliatsikouras Bridge. Rainfall and temperature data on a daily base were made available to us also by DEH.

Results

We compared our measurements against the outcome of some of the bedload equations included in B.A.G.S. (Bedload Assessment for Gravel-bed Streams) software, made by the United States Forest Service (Wilcock et al., 2009). Three equations were chosen from BAGS, in particular the ones that employ surface material distributions (Parker 1990, Wilcock 2001, Wilcock – Crowe 2003). Another equation, that has been developed for the Little Granite Creek, in Wyoming, USA, by Ryan & Emmett (2002) was also considered, due to the fact that it gave results very close to our measurements. Finally, we developed a site-calibrated equation -Wclb2- based on the procedure outlined by Wilcock (2001).

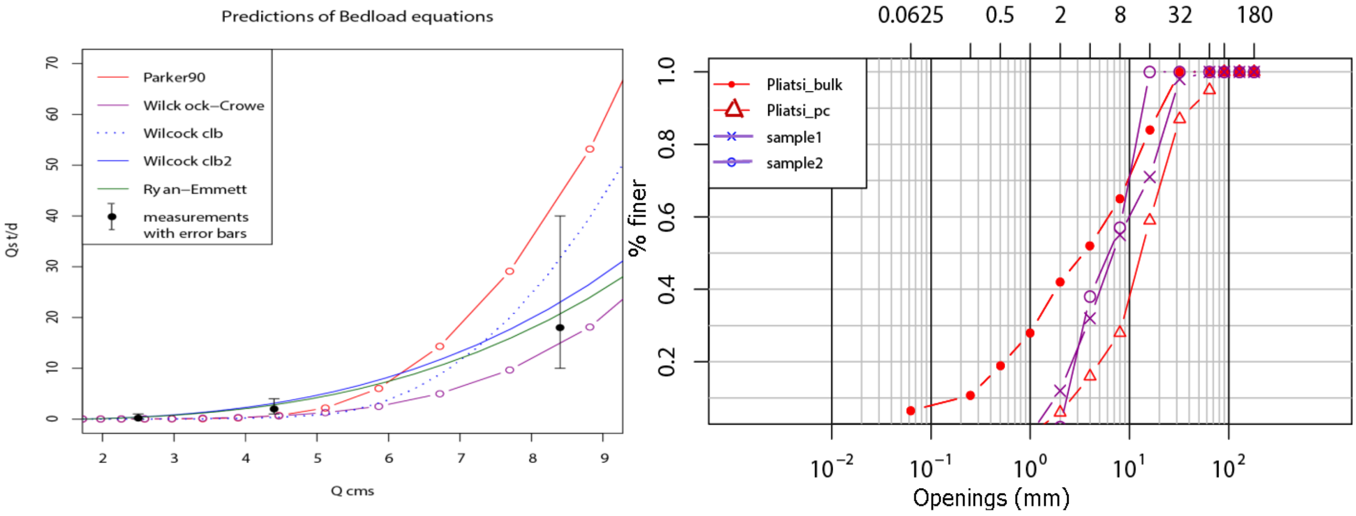

Figure 2. Left: predictions of 5 bedload equations against measurements. Right: GSD's of two different sampling methods of bed material (pebble count and bulk sample) along with GSD of two bedload samples, at the site. Error bars in measurements span from twice to half of the measured quantity.

Other well-known equations like Meyer – Peter & Muller, Kalinske, Einstein – Brown, Karim – Kennedy, Engelund & Hansen and Ackers – White were also tried. Only Ackers – White gave results close to our measurements, while all others seriously overestimated sediment load, by as much as 4-5 times.

Conclusions

As we can see (Fig.2, Left), with the exception of Parker90 equation, all others fall within a relatively short distance from our measurements. Another important point to note is the discharge at which the curve lifts above the x-axis, that is, the discharge above which we have some noticeable bedload transport. All equations are sensitive mainly in the size of surface material that will be used for the calculations (D50). As we see in Fig.2 (Right), bedload samples are somehow closer to the GSD obtained by pebble counts, but this is also due to the fact that Helley-Smith cannot trap sediments smaller than a few millimeters. The fact that we were able to sample near bankfull discharge (~8cms) was very favorable to the integrity of our estimations. An encouraging fact though, is that in the long term (a decade), all equations (except Parker90) predict the same mass of dislocated material, as we can see in Table 1, below.

Table 1. Mean annual bedload discharge from 5 equations in metric tonnes, for two periods

Q mean daily (cms)	*Ryan-Emmet*	*Wilcockclb*	*Wilcockclb2*	*Parker 90*	*Wilcock-Crowe*
A period 1980-1990:2,57	2229	2008	2223	4862	2090
B period 2004-2014:1,66	693	882	1393	1958	1030

The above values represent a percentage of 8-10% of the total load and happen mainly in the 4-month period from December to March of each year (unpublished Ph.D. results). Overall, our results seem reasonable. We can conclude that, given good quality hydrological, topographic and sedimentological data, these three equations from BAGS can give credible results. The most critical point is the choice of D50.

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