Preparing a Full Length Paper with MS Word for Windows (Title font: Times New Roman: size 16 point)

Zhaoyin Wang (Times New Roman, 10 point)
Professor, Tsinghua University, Beijing 100084, China. Email: zywang@tsinghua.edu.cn

Charles Steven Melching,
Professor, Dept. of Civil and Environmental Engineering ,Marquette Univ., Milwaukee, WI 53201.
E-mail: charles.melching@marquette.edu

ABSTRACT: (Times New Roman, Bold, 10 point) (Body font: Times New Roman, 10 point) This article should be used as an instruction for authors to prepare the electronic versions of their papers for the Proceedings of the 35th IAHR World Congress. Only papers in accordance with this template will be considered for proceedings inclusion. The abstract is expected to state, no more than 500 words, research objectives, methods applied and results and conclusion, forming a rounded article. Enter 5 keywords and separate them by commas. A qualified paper is normally required to have an abstract with keywords, and a paper body that contains such chapters as introduction, research method, results, and conclusion. Each chapter is allowed to have consecutively numbered subdivisions. Put one blank line before you start a new subdivision. The first lines of paragraphs are indented by 7 mm. Divide your paper into clearly-defined sections and number them as: 1.1 (then 1.1.1, 1.1.2 ...), 1.2, etc. Subdivisions should be no more than 3 levels.

KEY WORDS: Bed load, Experiment, Step-pool system, Flow energy, Mountain stream.

1 INTRODUCTION

This template should be used as the sample for typing your paper. The whole text of your paper should be typed in Times New Roman (size 10 point), single spaced (12 point line spacing except for the lines with formulas), left and right justified. Page frame should be in one column of 160mm × 240mm. It is suggested to open your original file and this template file and switch between these two files with the Windows menu. Select the whole text of your original paper (with finalized content) and paste it onto the template file (with the new format). In order to avoid disruption of the text and frames, copy the text paragraph by paragraph without including the first word. It is better to type the first words manually and then paste the correct text behind. The electronic version of the complete paper should be submitted online in .doc form as well as .pdf form. If you are using a processing program rather than Word, the pdf file must be in the same format as the template.

Parameters in mathematics (not for log, sin, cos, ln, max., d (in d*x*), etc), Latin names of species and genera in botany and zoology should be in italics. Never underline any text. Use the small font (9 points on 10 points) for tables, figure captions and the references. Use the equation editor of the selected word processing program. Equations are put in the middle of the line. Number equations consecutively and place the number at the end of the line, between parentheses. Refer to equations by these numbers. Number figures consecutively in the order in which reference is made to them in the text. Figures should fit within the type area width of 160 mm. Figures, photographs, etc. can be in black/white or full color. A caption should comprise a brief title and a description of the illustration. Text in the illustrations are supposed to explain all symbols and abbreviations used with the fewest possible words. The captions of a figure must be in the same page with the figure. All letters in the figures and equations should not be larger than the text letter in size. Put one blank line between each figure and the text.

Tables should fit within the type area width of 160 mm. Locate tables close to the first reference to them in the text and number them consecutively. Avoid abbreviations in column headings. Indicate units in the line immediately below the heading. Explanations should be given at the foot of the table, not within the table itself. Put one blank line between each table and the text.

Literatures cited in the text should be in the form of (family name and first name of authors, year of publication) and must be listed in References. All papers listed in the references must be cited in the text. The format of the reference list is shown at the end of the template paper:

Journal paper

Strom K. B. and Papanicolaou A. N., 2007. ADV measurements around a cluster microform in a shallow mountain stream. Journal of Hydraulic Engineering, 133(12), 1379-1389.

Conference paper

Kuhl D., 1992. Fourteen years of artificial grain feeding in the Rhine downstream of the barrage Iffezheim. Proceedings 5th International Symposium on River Sedimentation, Karlsruhe, Germany, 1121-1129.

Book

Brookes A., 1988. Channelized Rivers: Perspectives for Environmental Management. John Wiley and Sons, Ltd., Chichester, U.K.

2 STUDY METHODS

Field investigation and field experiments were conducted in 15 tributaries of the Xiaojiang River from May 2006 to July 2010 (Yu et al, 2009, Zhang et al., 2010). The Xiaojiang River is a tributary of the upper Yangtze River. The upper reaches of the river are divided into two stem rivers: the Dabai River and Kuaihe River, with numerous tributary mountain streams. Figure 1 shows the Xiaojiang River basin, the tributaries and measurement and experiment sections. The streams in the basin can be classified into three groups: 1) streams that are currently experiencing channel bed incision; 2) streams that were incised but at present the riverbed is stable because incision has been stopped by step-pool systems; 3) streams that were incised but at present no incision is occurring but instead slow aggradation is occurring because of sufficient bed load supply. For the third case, bed incision had propagated to the upstream reach and tributary gullies, which resulted in gully erosion and plenty of bed load.

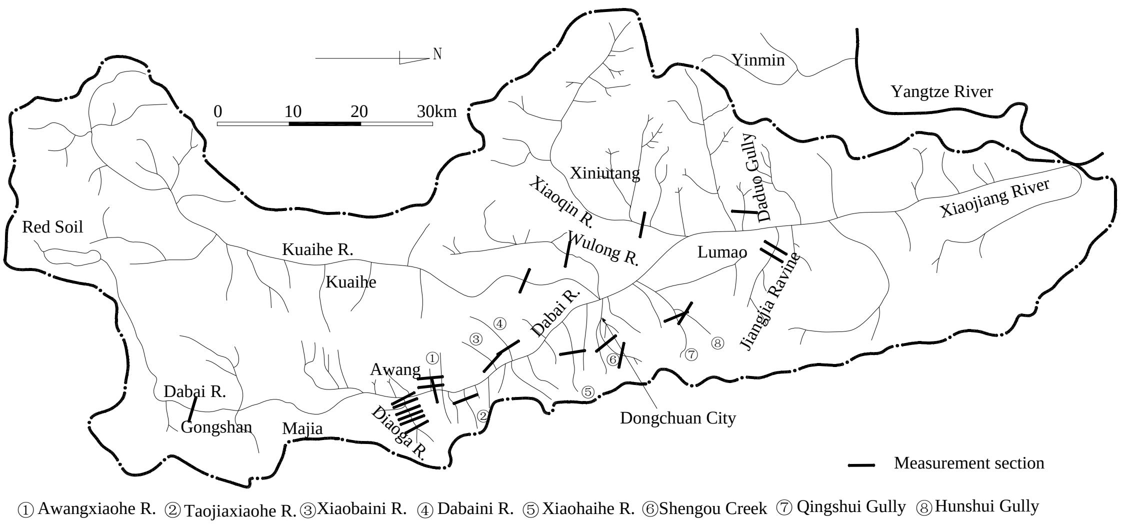


Figure 1 Measurement and experiment sections on the tributary streams of the Xiaojiang River

The rate of bed load transport per width, g_b, the stream power p, and the development degree of the step-pool system, S_P, were measured at the measurement sections on 15 streams. The rate of bed load transport was measured with a double box sampler, as shown in Figure 2. The outer box was installed into the stream bed with its top edges even with the local bed surface. The size of the inner box was

0.5m×0.2m×0.2m. A steel-wire mesh was used at the bottom of the box to drain the water rapidly when the box was lifted out of the river. The weight of the collected bed load sediment was measured and the rate of bed load transport was calculated.

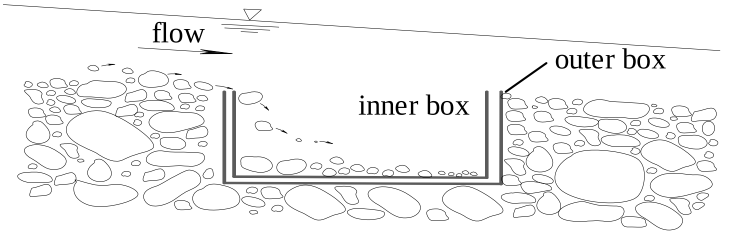


Figure 2 Double box sampler of bed load

The development degree of a step-pool system, S_P, was measured with a specially designed instrument. The instrument has thirty measuring rods spaced 5 cm apart, on a horizontally placed aluminum steel frame. Each rod is able to slide down onto the bed surface. The upper ends of the rods describe the bed profile. By moving the frame along the thalweg of the stream and taking pictures at different segments the bed profile along the thalweg can be measured. The S_P value is then calculated by the following formula (Wang et al., 2009):

$$S_P = \frac{\sum_{i=1}^{m} \sqrt{(R_{i+1} - R_i)^2 + 5^2}}{\sqrt{[5(m-1)]^2 + (R_m - R_1)^2}} - 1 \tag{1}$$

in which R_i is the reading of the upper end of the measuring rods on the screen in cm, and m is the total number of readings.

The unit stream power p is given by

$$p = \gamma q J = \gamma q s \tag{2}$$

in which γ is the specific weight of water and is constant; q is the discharge of water per width and is measured by using a Pitot tube velocimeter; and J is the energy slope of the flow, which is equal to the average bed gradient s for uniform and steady flows. Two kinds of experiments were done on the streams. The first kind of experiment was conducted on a huge debris flow deposit on the left side of the Jiangjia Ravine channel. The surface of the experimental plot was smooth but the initial slope was about 0.06. Water and sediment was diverted from the Jiangjia Ravine into a narrow and shallow channel, which was dug on the debris flow deposit floodplain. Bed load motion was controlled with a pit (3 m in diameter and 1.5 m deep) and an artificial step-pool system was built on the channel bed. After an intensive fluvial process the channel gradually became stable and reached equilibrium. The results with and without bed load motion, and with and without a step-pool system were compared. The second kind experiment was conducted on the Diaoga, Xiaobaini and Hunshui rivers, in which low strength bed structures developed under some circumstances. The second kind of experiment involved removing the key stones to destroy the bed structures from a stream section of several tens of meters and measuring the bed load transportation, the unit stream power p and Sp value.

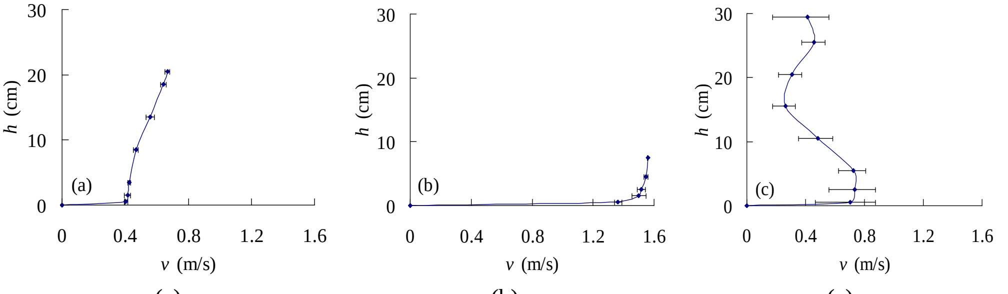
3 RESULTS AND DISCUSSION

3.1 Field Investigations

Figure 4 shows Shengou Creek and Hunshui Gully; both creeks flow into the Dabai River from the river's right side. The measured stream power per width for the two streams were almost equal (p = 10.34 kg/ms for Shengou Creek and p = 10.16 kg/ms for Hunshui Gully) and the sediment in the two rivers was from debris flow deposits; each creek's sediment had very similar size distributions. Nevertheless, the rates of bed load transport in the two streams were extremely different. A step-pool system developed in Shengou Creek and the value of S_P was 0.285. The energy consumed by the step-pool system was quite high and the flow had no energy to carry bed load. Therefore, the rate of bed load transport was very low (g_b = 0.002 kg/ms). Conversely, in Hunshui Gully where there was no step-pool system the measured value of S_p was very small with a value of only 0.04. The flow energy was consumed mainly through bed load motion and the measured rate of bed load transport was g_b = 18.9 kg/ms, which was about ten thousand times higher than the value in Shengou Creek.

The step-pools function like flow energy dissipation structures. At each step-pool, the flow energy is transformed into turbulence, and finally into heat. Thus, the average flow velocity is reduced through a step-pool and strong turbulence occurs in the pools. The velocity profiles in the Shengou Creek were measured with a Pitot tube velocimeter. Measurements were done in a section upstream of a step, at the step-lip, and in the pool below the step. Roller eddies occurred immediately downstream of the step making it difficult to measure the velocity profile. The velocity profiles in the pools were measured at a distance of 1.5 m from the steps. Figure 6 shows the velocity profiles measured at a step-lip, 0.5 m downstream of the step in the pool section, and 1.5 m above the step where the flow was almost in a normal run. The step was about 0.8 m high. The points in the figure are the mean value of velocity and the range of the lines are from the minimum to maximum values of velocity. The results support the conclusions of Wohl and Thompson (2000) that the bed-generated turbulence predominates at step lips and upstream from steps and in runs. The pool section was dominated by wake-generated turbulence.

Figure 4 Comparison of Shengou Creek (left) and Hunshui Gully (right) (Shengou: p = 10.34 kg/ms, S_p = 0.285, g_b = 0.002 kg/ms; Hunshui: p = 10.16 kg/ms, S_p = 0.04, g_b = 18.9 kg/ms)



(a) (b) (c)

Figure 5 (a) Velocity profile upstream from a step, where flow depth was 0.22 m; (b) Velocity profile at the step lip, where the step was 0.8 m high and the flow depth was only 0.08 m; (c) Velocity profile in a pool at 0.5 m downstream of the step with a flow depth of 0.3 m.

3.2 Results of Experiments

3.2.1 Model experiment

Two kinds of experiments were done in the streams of the Xiaojiang Basin. The first kind of experiments was conducted in the Jiangjia Ravine (Liu and Wang, 2009, Liu et al., 2010). Figure 8 shows the experimental plot (left), which was on a debris flow deposit on the left side of the Jiangjia Ravine channel. The surface of the experimental plot was smooth but the initial slope was about 0.06. A 100 m long, 0.5 m deep and 1 m wide channel was dug on the deposit before the experiment and stream water was diverted into the channel to scour the channel. Figure 8 also shows that the water flowed in the experimental channel and scoured the bed sediment (right). After an intensive fluvial process the channel gradually became stable and reached equilibrium.

Figure 9(a) shows the original sediment size distribution of the experimental plot. The plot had various types of sediment including: silt, sand, gravel, cobbles, and boulders. Fine materials were mixed with cobbles and boulders, and, thus, the surface of the experimental plot looked smooth. The discharge was controlled by a small dam on the Jiangjia Ravine which consisted of boulders, cobbles and gravel. The flow discharge diverted into the experimental channel is shown in Figure 9(b) (dashed line). The fluctuating discharge simulated the flood-low flow season cycles. The duration of flood flow lasted generally 1-2 hours in the experiment. The rate of bed load transport was measured, which is also shown in Figure 9 (b) (black pyramids). The total rate of bed load transport was very high during flood flow but low during low flow. The width of the channel varied in a range of 1-3 m along the course with an average of about 2 m. Therefore, the rate of bed load transport per width was about 3 kg/ms during flood flow, which was extremely high. The fluvial process and the bed deformation were very fast and generally reached a primary equilibrium in 3-4 hydro-cycles.

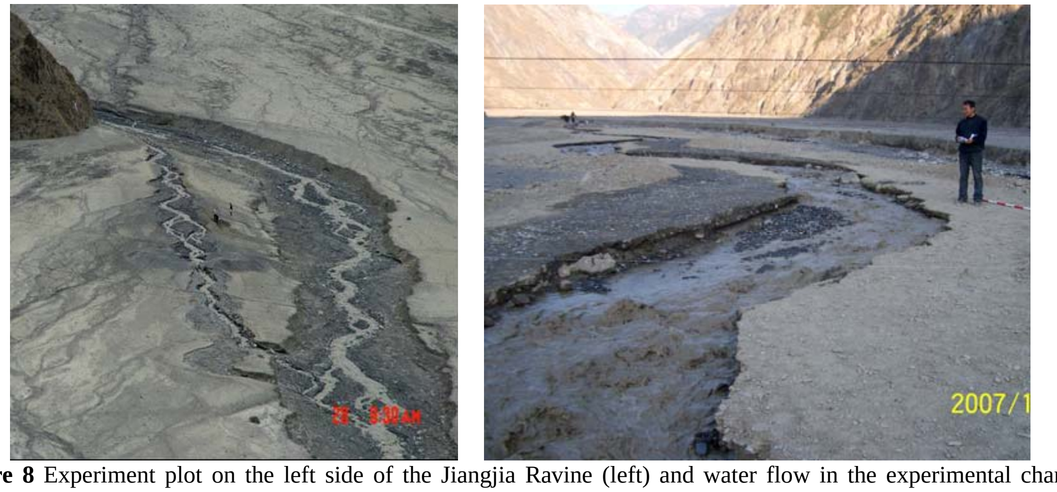
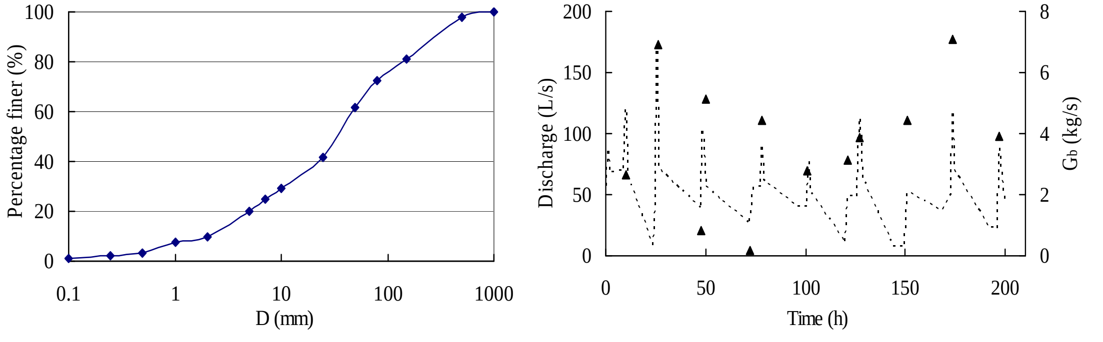


Figure 8 Experiment plot on the left side of the Jiangjia Ravine (left) and water flow in the experimental channel scouring the sediment (right).

In the experiment, water was diverted from the Jiangjia Ravine and flowed back into the same ravine through a 100 m long experimental channel. The experiment was conducted in a 60 m long lower section of the channel, on which 15 measurement cross sections were set. Between the experimental section and the upper section a 2 m long concrete flume was constructed for measurement of flow discharge with a velocimeter, which also acted as a base point for the measurement of the bed profiles. The bed structures, channel width and depth, erosion, sedimentation, and migration of the channel were measured at the 15 measurement cross sections.



(a) **(b)**

Figure 9 (a) Original sediment size distribution of the materials in the experimental plot (debris flow deposit); (b) Flow discharge (dashed line) diverted into the experimental channel and measured rate of bed load transport (black pyramids) varying with time.

3.2.2 Prototype experiment

Many existing studies about the influence of antecedent rainfall on soil and water erosion, however, are primarily focus on laboratory simulation tests, while only a few of them are based on field surveying data, especially in Rock area of Northern China. Related researches had shown that the effect of the rainfall within 8 days on soil water content is most significant (Cai et al, 1998), which can be used as the judgment standard of antecedent rainfall. And the same time, since the runoff plots were built at the beginning of 2003, the degree of damage for slope surface is severer; casual factors have more effect on the runoff and soil erosion in this year, so the hydrological data is eliminated firstly in this year. In order to understand the effect of antecedent rainfall on soil and water loss under the same rainfall condition, we selected four rainfall events in the years of 2004 to 2005 basing on the judgment standard of antecedent rainfall, that is two rainfall events which occurred separately on June 6th and July 1st 2004, and another two rainfall events which occurred separately on July 23 and August 12 2005, which are used for Compared study whether or not having antecedent rainfall. On the basis of field surveying data, there was no rainfall event within 10 days before June 6, 2004, while rainfall event took place within 2 days before July 1 2004. Therefore, two rainfall events occurring separately on June 6 and July 1 2004 fulfill compared study condition. Another two rainfall events occurring separately on July 23 and August 12 2005 also fulfill the compared condition (Table 2).

Table 2 Rainfall events for the compared study

Group	Year/month/day	P (m)	I_m (mm/h)	I_{10} (mm)	I_{30} (mm)	Time of antecedent rainfall	P_a (mm)	Antecedent rainfall	Note
I	2004/6/6	7.6	7	6	7.5	-		No	Having rainfall event within 8 days before next rainfall
	2004/7/1	5.8	8.7	2.7	5.1	2004/6/29-30	32	Yes	
II	2005/7/23	13.6	1.6	1.7	3.5	2005/7/22	31	Yes	
	2005/8/12	18	1.7	3.5	4.6	-		No	

P, I_m, I_{10}, I_{30} and P_a represent rainfall depth, mean rainfall intensity, the maximum rainfall intensity in 10 minutes, the maximum rainfall intensity in 30 minutes and antecedent rainfall depth.

4 CONCLUSIONS

Bed structures, such as step-pool systems, maximize the flow resistance and consume flow energy, thus protect the riverbed from erosion. Bed load motion has a similar function in that it consumes flow energy and protects the bed from erosion. The collisions of bed load particles with the bed result in the dispersive force, which balances the lift force and controls the initiation of motion of bed sediment. In mountain streams strong bed structures are associated with low bed load transportation. Mountain streams with sediment bed can be found in four different states: 1) Strong bed structures (step-pool system) have been established, most of the flow energy is consumed by the extremely high resistance created by the structure and there is almost no bed load motion; 2) There are no, or very weak, bed structures and intensive bed load motion occurs. The flow energy is consumed mainly by the bed load motion and the rate of bed load transportation increases with the flow discharge and bed gradient; 3) There are no bed structures and very low bed load transportation (because of lack of bed load supply from the upstream). Continual riverbed incision occurs, especially during flood season; 4) There are no bed structures and too much bed load is transported from high gradient upstream section. Bed load deposits on the river bed and aggradation occurs. Mountain streams in state 1) and 2) are mutually transformable. A stream in state 2) may transform into state 1) if a step-pool system develops. For streams in state 1), destruction of the bed structure may result in riverbed incision and intensive bed load motion, and the stream transforms into state 2).

The principle of equivalence is as follows: the functions of bed structures and bed load motion are equivalent and the bed structures and bed load motion are maturely replaceable for flow energy consumption and streambed incision control. The principle can be applied to control riverbed incision. The middle reaches of the Yangtze River has been incised down by more than 10 m since the impoundment of the Three Gorges Reservoir, which resulted in the cut off of flow in the channels between the river and the Tongting Lake and high stresses on the complex river-lake connected ecosystem. According to the principle of equivalency the bed incision can be controlled by placing a significant amount of tetrahedral frames onto the riverbed. The velocity may be reduced by at least 50% around a tetrahedral frame near the riverbed. Thus, river bed incision may be controlled and flood stage may rise to the level before the impoundment of the dam. Therefore, the water diversion from the river into the Tongting Lake may be regained and fish can freely migrate between the river and the lake.

ACKNOWLEDGEMENT

The study is supported by the Ministry of Science and Technology of China (2008CB425803) and State Key Lab of Water Science and Engineering (2009-ZY-2).

References

Abrahams A.D., Li G., and Atkinson J. F., 1995. Step-pool stream: Adjustment to maximum flow resistance. Water Resources Research, 31(10), 2593-2602.

Bagnold R.A., 1954. Experiments on a gravity free dispersion of large solid spheres in a Newtonian fluid under shear, Proceedings of the Royal Society London, 225A, 49-63.

Bathurst J.C., Graf W.H. and Cao H. H., 1987. Bed load discharge equations for steep mountain rivers, in Sediment Transport in Gravel Bed Rivers, edited by C. R. Thorne, J. C. Bathurst and R. D. Hey, pp. 453–491, John Wiley and Sons, Ltd., New York.

Brookes A., 1988. Channelized Rivers: Perspectives for Environmental Management. John Wiley and Sons, Ltd., Chichester, U.K.

Chien N., Wan, Z.H. and McNown J., 1998. Mechanics of Sediment Movement. ASCE Press, New York.

De Jong C., 1991. A re-appraisal of the significance of obstacle clasts in the cluster bedform dispersal. Earth Surface Processes and Landforms, 16(8), 737–744.

Kuhl D., 1992. Fourteen years of artificial grain feeding in the Rhine downstream of the barrage Iffezheim. Proceedings 5th International Symposium on River Sedimentation, Karlsruhe, Germany, 1121-1129.

Lane E.W., 1955. The importance of fluvial morphology in hydraulic engineering. Proceedings of the American Society of Civil Engineers, 81(7), 1-17.

Strom K. B. and Papanicolaou A. N., 2007. ADV measurements around a cluster microform in a shallow mountain stream. Journal of Hydraulic Engineering, 133(12), 1379-1389.

Wang Z.Y., 1999. Experimental study on scour rate and channel bed inertia. Journal of Hydraulic Research, IAHR, 37(1), 17-38.

Wang Z.Y., Melching C.S., Duan X.H. and Yu G.A., 2009. Ecological and hydraulic studies of step-pool systems. ASCE Journal of Hydraulic Engineering, 134(9), 705-717.

Yu G. A., Wang Z.Y., Zhang K., Duan X. H. and Chang T.C., 2010. Restoration of an incised mountain stream using artificial step-pool system. Journal of Hydraulic Research, 48(2), 178-187. doi:10.1080/00221681003704186