Comparison: US P-61 and Delft Sediment Samplers

By Joseph P. Beverage[1] and David T. Williams[2]

Introduction

The Delft Bottle (DB) is a flow-through device (Fig. 1) designed by the Delft Hydraulic Laboratory (DHL), The Netherlands, to sample sand-sized sediment suspended in streams. Its original purpose was to collect material in motion near the beds of estuaries. However, it has been used increasingly in streams as well. It weighs about 20 kg.

The DB is suspended in the stream by the hanger bar H. Streamflow enters the nozzle N and follows a circuitous path (shown by the arrows) into the enlarged rear chamber, where coarse sediment is deposited before the flow emerges at the exit, E. Baffles prevent the flow from going directly from the rear of the nozzle to the exit orifice.

The US P-61 sampler (Fig. 2) was designed by the Federal Interagency Sedimentation Project (FISP) at the St. Anthony Falls Hydraulic Laboratory, Minneapolis, Minnesota, to collect suspended sediment from deep, swift rivers. It is a sampler commonly used in the United States and weighs about 45 kg.

The valve V controls the nozzle N and the air-equalization circuit. The valve is closed while the sampler is lowered to its operating location. The closed nozzle position provides a path for air from the sample container to the head cavity. During lowering, water flows into the compression chamber CC through openings in the bottom of the sampler, compressing the air and forcing it through a small tube into the head cavity. With the valve in the open, or sampling position, the nozzle passes water into the sample container, which is in the sample container chamber SC. Excess air leaves the sample container through the valve and an exhaust line (not shown). Aluminum ballast B is cast into the tail section for balance.

The performance of the two samplers was compared in 1975 and 1976, when a DB and a P-61 were used side by side as point samplers in the Rio Magdalena in Columbia, South America. The sediment-transport values determined from the P-61 were 2.5 times greater than the values from the DB sampler (Dijkman 1978). The disparity was so large that DHL and FISP decided to perform additional tests.

In 1979 a P-61 was loaned to DHL for comparative point-sampling tests on the Danube River (Dijkman and Milisic 1982). The sampler was used in conjunction with a DB and several other samplers. These tests showed the average of the P-61 and two other samplers collecting 1.5 times more than

[1]Hydro., U.S. Geological Survey, Fed. Interagency Sedimentation Proj., Minneapolis, MN 55414-2196.

[2]Hydr. Engr., West Consultants, San Diego, Calif.; formerly, Corps of Engrs., Waterways Experiment Station.

Note. Discussion open until May 1, 1990. To extend the closing date one month, a written request must be filed with the ASCE Manager of Journals. The manuscript for this paper was submitted for review and possible publication on May 14, 1987. This paper is part of the ***Journal of Hydraulic Engineering***, Vol. 115, No. 12, December, 1989. ©ASCE, ISSN 0733-9429/89/0012-1702/$1.00 + $.15 per page. Paper No. 24186.

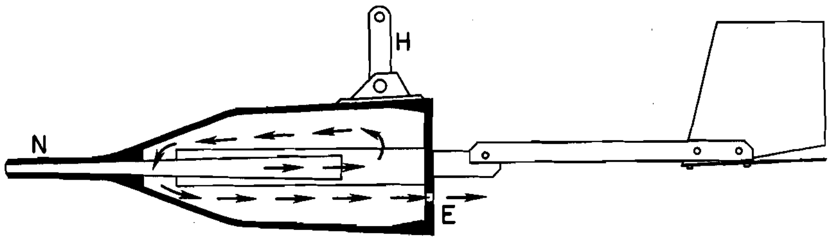

FIG. 1. Cutaway View of Delft Bottle Suspended-Sediment Sampler

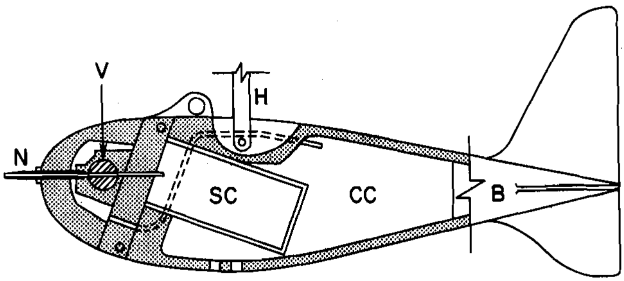

FIG. 2. Cutaway View of US P-61 Suspended-Sediment Sampler

the DB (Dijkman and Milisic 1982).

The results of two point-sampling tests in the United States, the Mississippi River near Vicksburg, Mississippi, in 1983 and the Colorado River near Blythe, California, in 1984, are provided in this report. These studies compare sand-transport rates, rather than total sediment-transport rates, because fine material washes through the DB sampler. In the United States, the commonly used limits for sand-sized material are 0.062 mm to 2.00 mm (Vanoni 1975).

Test Results

Fig. 3 shows the relation between the total sand-transport (sediment > 0.062 mm) rates measured by the P-61 and the DB samplers for the U.S. tests. The data cluster about the least-squares regression line which shows the P-61 collecting roughly twice the sand-transport of the DB. This conclusion supports observations determined in previous studies (2.5:1 ratio, Dijkman 1978; 1.5:1 ratio, Dijkman and Milisic 1982).

Fig. 4 compares the fine-sand fraction (0.062–0.125 mm) rates of the two samplers. This figure also shows that the DB is collecting less transport than the P-61, reflecting the "inefficient trapping of particles smaller than 0.100 mm" (Van Rijn and Schaafsma 1986).

Fig. 5 compares transport rates for the next coarser fraction (0.125–0.250 mm sediment). The figure shows fair agreement for transport rates <200 g/m^{2}s measured by the two samplers. However, only one of the four transport rates >200 g/m^{2}s is near agreement. The plot of the next coarser fraction

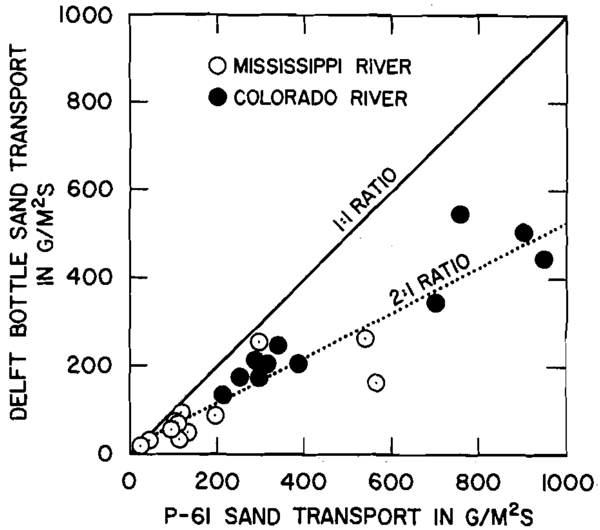

FIG. 3. Relation between Sand Transport (>0.062 mm) Measured by P-61 and Delft Bottle Samplers

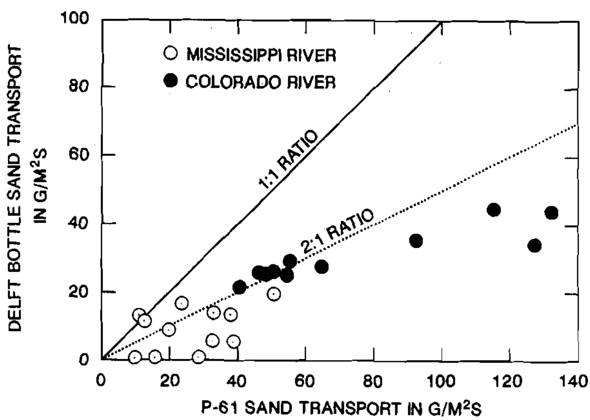

FIG. 4. Relation between Sand Transport (0.062–0.125 mm) Measured by P-61 and Delft Bottle Samplers

(0.250–0.500 mm) shows fairly good agreement except for one point. That plot is not shown because of space limitations.

Interpretation

The P-61 collects a true sample—a representative aliquot of the water-sediment mixture passing the nozzle during the sampling interval. The sampling interval is short relative to that of the DB, and samples often show the short-term variability typical of sediment-laden streams. The DB collects

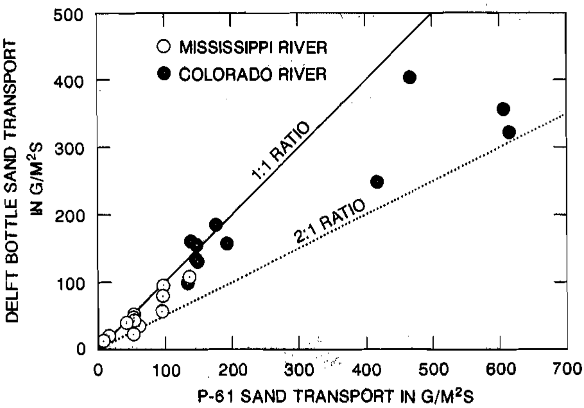

FIG. 5. Relation between Sand Transport (0.125–0.250 mm) Measured by P-61 and Delft Bottle Samplers

most of the coarse sediment (>0.100 mm) during a much longer interval, which averages out short-term variations. Strictly speaking, however, the DB does not collect a sample. The collected sediment mass must be corrected for various factors, but principally stream velocity (Dijkman 1978). Essentially, the DB is a large expansion chamber providing a low-velocity region for deposition of sediments coarser than 0.100 mm (Van Rijn and Schaafsma 1986). At high velocities, larger sediments are flushed through the device. Sampling at velocities above 2.5 m/s is not recommended (Dijkman and Milisic 1982).

The P-61 collects isokinetically the entire mass of water and sediment entering its nozzle. It is more than twice the weight of the DB and thus needs more rugged handling equipment, but it is more stable than the DB in fast water. The P-61 has a valve and solenoid that occasionally require servicing.

The DB, on the other hand, has no valve. A large amount of sediment can be collected (because the water is not retained), which allows a quick volumetric estimation of the coarse sediment mass. The conversion from volume to mass, of course, can add further error to those inherent in sampling nonisokinetically.

Acknowledgments

The Mississippi River test was conducted by personnel of the U.S. Army Corps of Engineers, Vicksburg, Miss. David Williams (Corps of Engr.) led the expedition in consultation with Peter Kerssens (DHL). Laboratory analyses were provided by the U.S. Army Corps of Engineers Laboratory at Vicksburg.

The Colorado River test was conducted by personnel from the U.S. Bureau of Reclamation in Boulder City, Nev., and Blythe, California. They were supervised by Curtis Orvis (Bureau Reclamation, Denver, Colo.) in consultation with the senior writer. Laboratory analyses were performed at the U.S. Bureau of Reclamation Laboratory in Yuma, Ariz.

M. de Vries and J. P. M. Dijkman represented DHL in discussions leading to these tests as well as the earlier Danube River test. De Vries arranged the loan of the DB sampler and the assistance of P. Kerssens for the Mississippi River test. Dijkman computed the DB transport rates for both tests. Their help is gratefully acknowledged.

Appendix. References

Dijkman, J. P. M. (1978). "Some characteristics of US P-61 and Delft Bottle suspended sediment samplers," thesis presented to the Delft University of Technology Civil Engineering, Delft, The Netherlands, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Dijkman, J. P. M., and Milisic, V. (1982). *Investigations on suspended sediment samplers based on measurements in the Danube River, May 1979*. Delft Hydraulics Laboratory and Jaroslav Cerni Institute, Belgrade, Yugoslavia.

Vanoni, V. A., ed. (1975). "Sedimentation engineering." *ASCE manual on engineering practice no. 54*, ASCE, New York, N.Y.

Van Rijn, L. C., and Schaafsma, A. S. (1986). "Evaluation of measuring instruments for suspended sediment." *Delft Hydraulics Communication no. 368*, Delft Hydraulics Laboratory, Delft, The Netherlands.