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A Cheap and Rapidly Built Bottom Water Sampler for Shallow-water Environments

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Abstract: We present a bottom water sampler made of a plastic bottle, a weight, and four pieces of rope which can be operated by one person from any working platform in shallow-water environments. The measurements of our sampler were equal to those taken with a Niskin bottle. The water sampler was operational in tidal currents up to 0.6 ms^{-1} and may be used in water at least 10 m deep.

Key words: Bottom water sampler, shallow water, stratification.

Introduction

Water samplers are indispensable equipment in the study of shallow-water environments such as rivers, lakes, lagoons, or estuaries. Information on changes in water parameters in the vertical plane through time is crucial for understanding the dynamics of aquatic ecosystems, e.g., changes in stratification or hypoxia. However, there are numerous situations in limnological, riverine, estuarine and coastal studies in which professional water samplers such as the Niskin bottle are unavailable, e.g., risk of damage or loss, absence of equipment, or problems with customs. For researchers with restricted funding, professional water samplers may also be too expensive to purchase or maintain. Other types of bottom water samplers that are applicable in shallow waters are often relatively expensive, have sophisticated technical features or may require considerable time for assembly or repair (e.g., Jonasson, 1977; Kjensmo, 1967; Martin et al., 2004; Reed et al., 1997).

Here, we present a bottom water sampler for shallow waters that is comprised of a weight, four pieces of rope and a plastic bottle, and can be easily operated by a single person. The material of the water sampler is widely available, cheap, and first assembly and testing takes less than 30 min. Although virtually maintenance-free, damaged pieces of the water sampler can be easily substituted.

Material and Methods

Materials needed for the construction of an "Aying bottom water sampler" are as follows:

- Plastic bottle (e.g., 0.5 or 1 litre) with a relatively narrow opening
- Weight (should have at least 3-5 times the weight of the filled bottle)
- Four pieces of rope (a rope connecting bottle and weight, a holing rope, a rope to transfer the drag, and a rope to immerse the bottle).

Figure 1 shows the assembly and operation of the "Aying bottom water sampler". A plastic bottle (e.g., a cleaned soft drink bottle) without cap is tightened on its bottleneck to a weight (e.g., bricks) (rope 1 in Figure 1). The length of rope 1 should have at least the height of

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the bottle so that the bottle can completely turn around. The length of rope 1 and the height of the loop on the weight determine the height above the bottom from where the water sample is taken. A bowline knot is appropriate to make the loop on the weight.

Before the bottle is lowered, care should be taken that the ropes 1, 2 and 3 are free and not entangled. The empty bottle is lowered, bottleneck first, below the water surface (by hand or using rope 4 when immersing the bottle from an elevated platform; Figure 1A). The hauling rope 2 is held loosely and the bottle or rope 4 is let go (Figure 1A), allowing the bottle to sink upside down through the water column until the weight hits the bottom (Figure 1B).

Rope 2 (dashed line in Figure 1), which runs through a loop at the weight and is fixed to the lower part of bottle, is then carefully hauled so that the lower end of the bottle is drawn downwards towards the weight against the buoyancy of the air inside the bottle (Figure 1C). The weight should have three to five times the mass of the filled sample bottle to avoid lifting and seesawing of the weight when turned around. Once the bottom of the bottle is lower than the bottleneck, air bubbles can leak out and water flows into the bottle (Fig. 1D). Pulling rope 2 slightly further upward fully erects the bottle because rope 3 transfers the drag of rope 2 directly to the bottleneck (Figure 1D). The length of rope 3 should be slightly shorter than the height of the bottle. The position of the knot of rope 3 at rope 2 is important to ensure the drag transfer. When the bottle is hanging erect, the knot should be approximately one bottle length above the mouth of the bottle; when the bottle is upside down, the knot should be at approximately half the distance between the tip of the bottle and the loop. When air bubbles are no longer visible on the surface, the bottle is full and the bottle and the weight can be lifted using rope 2. The bottle should have a narrow bottleneck to minimize the mixing of sample water with ambient water when the bottle is lifted (Figure 1E).

Our “Aying bottom water sampler” was designed in 2007 and tested during the wet season 2008 in the low and middle salinity zone of the Wenchang/Wenjiao River Estuary on the east coast of Hainan, China, South China Sea (N 19°35 E 110°48). The mixed semidiurnal tide has a tidal range of 1.5-2.0 m at spring tides. Maximum spring ebb current speeds were 0.6 ms^{-1}. Water depth at low water in the low and middle salinity zone was 2 m and 3 m, respectively. Despite shallow water, the estuary

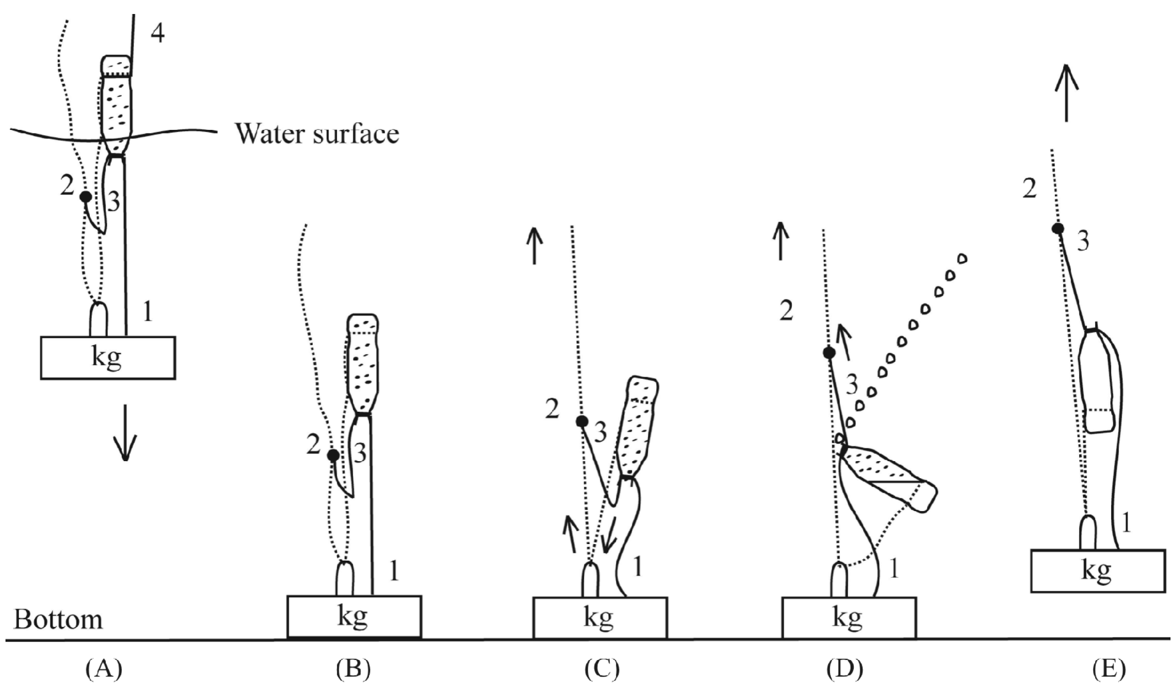

Figure 1: Schematic drawing of the “Aying bottom water sampler” construction and operation. The sampler is made of a weight, a plastic bottle and four ropes (1-4). The length of rope 1 and the height of the loop at the weight determine the sample depth. Rope 2 (dotted) is the hauling rope. The bottle is lowered with the bottleneck first (A). Dots inside the bottle indicate air which holds the bottle upside down until touch-down (B). Once rope 2 has pulled the bottom of the bottle below the level of the bottleneck via the loop (C), air can escape (D) and rope 3 transfers the drag to the bottleneck and the sample can be hauled (E). Arrows indicate the direction of the drag. Loose and tight ropes are indicated by curvy and straight lines, respectively. Rope 4 is only shown in (A). See text for further details.

is subject to strong stratification. For instance, during high tide the surface and bottom water salinities in the low and middle salinity zone can differ by >15 and >10 salinity units (psu), respectively. The strong stratification allowed for the testing of the Aying bottom water sampler's accuracy in taking samples at a specific target depth (as compared to samples taken using a Niskin bottle).

Water samples were taken simultaneously with our water sampler and a Niskin bottle about 1 m above the bottom at different tidal stages, at day and night, during two spring tide cycles from a small ferry boat. Water temperature, salinity, pH (WTW – Wissenschaftlich-Technische Werkstätten, sonde tretracon 320), and oxygen content (Hach Lange HQ40D) were instantaneously measured. We used the Passing-Bablok regression to evaluate the equality of measurements from the two methods (Passing and Bablok, 1983; EVAPAK for Windows, version 3.1, © Roche Diagnostics GmbH 1999). This is a linear regression procedure which calculates confidence intervals of the slope *b* and the intercept *a*. These are used to determine whether *b* differs from 1 and *a* from 0.

Results and Discussion

The water sampler operated well, even at ebb current speeds of 0.6 ms^{-1}. Interestingly, in the field, our water sampler was preferred over the Niskin bottle by all crew members due to its simple use. Table 1 shows that our water sampler performed equal to the Niskin bottle. However, at lower water temperatures our water sampler produced slightly higher values than the Niskin bottle. This may be due to the fact that the smaller water volume of our sampler heated faster; but this trend was not significant. Given the strong stratification in the estuary, the equality between the two methods indicates that the samples were taken from the same depth and that the equality was not due to a homogenous water column.

Our water sampler should not substitute a professional water sampler developed to meet highest standards. It may, however, be considered a useful alternative method for researchers in "emergencies" when professional equipment is not on-hand and for scientists who have to study shallow water bodies on low budgets. Our water sampler can be used to sample standard parameters of bottom water such as temperature, salinity, pH, oxygen, dissolved nutrients and phytoplankton. Sampling of total suspended matter particles, however, should be done with caution by waiting several minutes before turning the bottle so that bottom sediment suspended during touch-down is allowed time to be flushed away from the sampler by the current.

Our sampler can be used in shallow water (at least 10 m water depth) of lakes, rivers, lagoons, estuaries and the coastal ocean where it produces reliable samples when currents are weak to medium strength and when purity requirements of the water samples are not too high. Rougher conditions may result in the intrusion of surface water during the initial lowering of the inverted sampling bottle or while the upright bottle is pulled up to the surface. The latter effect inevitably increases with increased sampling depth. This effect may be reduced by using a large sample volume (e.g. one litre bottle) with a small bottleneck, careful immersion of the inverted bottle below the surface, and uninterrupted hauling of the filled bottle.

At greater depths, especially at greater current speeds, operating the hauling rope 2 may become difficult. The weight should be adapted to the maximum current speed to avoid unwanted displacement of the equipment while lowering and hauling it. Rope size should be adapted to the mass of the weight and to facilitate the hauling. Different depth strata can be sampled when a set of Aying water samplers with different sample depths (determined by the lengths of rope 1 and of the loop) is assembled.

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Table 1: Results of the Passing-Bablok regression of four bottom water parameters taken with our Aying sampler and a Niskin bottle during wet season spring tide cycles in a stratified estuary in East Hainan, China

Parameter	*n*	*Range*	*Slope b (LCL; UCL)*	*Intercept a (LCL; UCL)*	*r*
Water temperature (°C)	21	29.2-32.2	1.167 (1.000; 1.308)	-5.150 (-9.508; 0.000)	0.966
Salinity	20	0-32	1.004 (0.982; 1.035)	0.000 (-0.111; -0.078)	0.998
pH	21	6.41-8.75	0.953 (0.807; 1.087)	0.366 (-0.715; 1.555)	0.906
Oxygen (mg/L)	21	5.36-10.94	0.930 (0.838; 1.041)	0.439 (-0.274; 1.148)	0.984

n: number of pairs for comparison; Range: range of values; LCL: lower 95% confidence limit; UCL: upper 95% confidence limit; *r*: coefficient of correlation.

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