The Aloha Sampler™: concept, objective, design and implementation

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The *Aloha Sampler* is an innovative new sampling tool to effectively collect and combine increments from dynamic, liquid, one-phase and two-phase systems. It is extremely inexpensive and very cost effective to implement and produces more representative samples than any other conventional techniques. *TOS forum* has asked EnviroStat to present the *Aloha Sampler* for its readers.

Background

The Theory of Sampling (TOS) provides a comprehensive approach to representative sampling. Sampling tools are an important component of designing reliable sampling protocols; optimal sample mass and the appropriate number of increments for a composite sample will not provide a representative sampling if the tools are incorrectly designed or utilised. It has been estimated that 75% of all sampling tools are incorrectly designed with the result that: "enormous research is mandatory in order to develop correct sampling systems for monitoring the environment".[1] Correct sampling tools must enable an equi-probabilistic selection of all particles (molecules) at the randomly chosen increment location. Another important role of correct sampling tools is the ability to "reach" into the material being sampled, thus making all the material "available." Full availability is a critical success factor to make inferences from the analytical result back to the material in question (in TOS called the lot, and called the "decision unit" in EnviroStat's approach). This criterion has been formulated as the Fundamental Sampling Principle (FSP), see, for example, DS 3077 (2013).[2]

These two aspects, sampling tool correctness and FSP, are not the only design considerations. Some other important considerations for sampling tools are:

- durability
- easy to clean or decontaminate (if the tool is not disposable)
- easy to use (eliminate operator-induced errors)
- easy to maintain
- inert (does not interact with or contaminate the sampled media)
- maintain analyte integrity (eliminate adsorption, oxidation, leaching)
- efficient to collect and combine increments (to form composite samples)

The potential list of design criteria is too large to address here in full—it is always a function of the material sampled, environmental conditions and the analyte of interest.

Sampling of surface waters

There is a lack of sampling tools that meet the requirements of TOS for sampling of surface waters. Most surface water samplers are discrete point samplers (hand-held or weighted container samplers) and are typically some type of bottle that is opened and filled at one discrete point. These include dippers, lathes, using the sample container as the sampling device, and Van Dorn/Kemmerer type (Figure 1). All of these types of samplers do not adequately address the inherent distributional heterogeneity of the lot.

Sampling of surface water is always problematic due to its dynamic nature, especially since the composition changes with respect to both time and space. Examples of dynamic systems are industrial conduits, canals, lakes, rivers and oceans. The difficulty of sampling these systems is well recognised, alas very little has been done to develop tools and techniques to better represent such dynamic systems. The New Jersey Field Sampling Manual states: "Liquids, by their aqueous nature, are a relatively easy substance to collect. Obtaining representative samples, however, is more difficult. Density, solubility, temperature, currents and a wealth of other mechanisms cause changes in the composition of a liquid with respect to both time and space. Accurate sampling must be responsive to these dynamics and reflect their actions."[3]

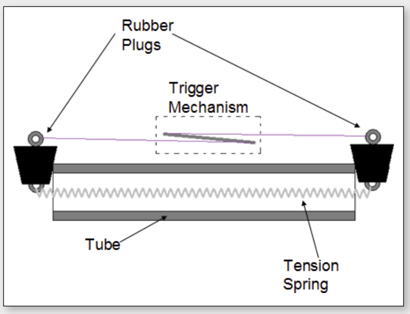

Figure 1. Generic design of Van Dorn/Kemmerer type sampler.

In one surface water study,[4] it was concluded that for individual samples drawn at 10-minute intervals (grab samples), the average variability (change in concentration between consecutive samples) was 60%—and as high as 700% for an individual result. This large variation on such a short time scale makes characterisation of surface waters virtually impossible if based on grab sampling. In the same report it was also stated that the misclassification rate of water quality was: 33%, 64% and 71% for each of three study years, respectively (% estimates are relative sampling variability (*RSV*) measures, as described in *DS 3077*).

The *Aloha Sampler* (Liquid Sampler Patent 7571657) was developed to address these concerns by an operational mode that will allow more representative liquid sampling.

The basic parts of the *Aloha Sampler* are an aperture cover (lid), and a receptacle for the liquid. The aperture cover has two holes, located along a diameter, that allow the liquid to flow into the receptacle when the sampler is submerged into liquid (Figures 2 and 3). The placement and size of holes allow for an approximate one minute fill rate if the holes are vertically aligned. If the Aloha Sampler is rotated slightly the fill rate increases to approximately two minutes. This gives the

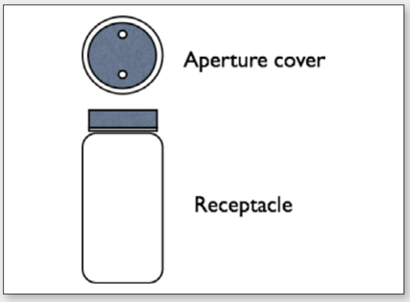

Figure 2. *Aloha Sampler* side and top view (Liquid Sampler Patent 7571657).

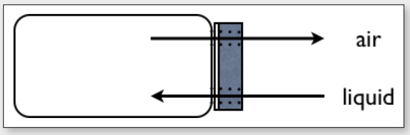

Figure 3. Basic operation of *Aloha Sampler* (Liquid Sampler Patent 7571657).

Figure 6. The *Aloha Sampler* in operation. Note air bubble leaving the upper hole in the aperture cover.

sampler flexibility to control the rate of liquid uptake.

The *Aloha Sampler* can be used in a continuous mode (sampler not removed from the liquid during sampling) (Figure 4), or non-continuous/intermittent mode (sampler removed from the liquid between increment sampling deployment locations) (Figure 5). An example of a continuous operation would be sampling from a point on the shore of a river, out ten feet from the shore, from the surface to the bottom *in one continuous motion*, never breaking the surface of the water during collection. An example of a non-continuous operation would be sampling the length of a river where the *Aloha Sampler* is inserted in and removed from the river at each increment location (partially filling receptacle at each increment location). Both modes result in a reliable sample. The *Aloha Sampler* can be used to collect spatially and/or temporally

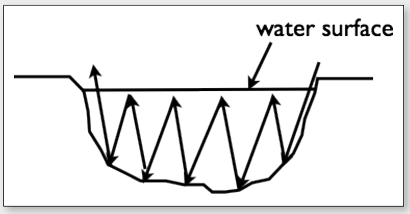

Figure 4. Continuous sampling path to represent a stream section without interrupting the sampling operation.

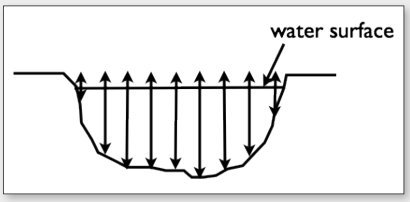

Figure 5. Collection of multiple vertical increments to form an integrated sample (composite sample).

Figure 7. Use of the *Aloha Sampler* with an extension pole.

Table 1. Lihue Mill Bridge, Kauai, Hawaii, 5 November 2013. Owen Environmental, Kalaheo, HI.

	Time	pH	Dissolved oxygen (%)	Total suspended solids ($mg\,L^{-1}$)
Rep. 1	9:11	7.07	76.0	12
Rep. 2	9:14	6.96	75.5	13
Rep. 3	9:16	6.95	75.8	12
Mean		—	75.8	12.3
RSV (%CV)			0.3	4.7

Total suspended solids by Method SM 2540 D
Dissolved oxygen and pH by YSI ProPlus Multi-parameter WQ Meter

Table 2. Lihue Mill Bridge, Kauai, Hawaii. 31 October 2013. Owen Environmental, Kalaheo, HI.

	Time	pH	Dissolved oxygen (%)	Total suspended solids ($mg\,L^{-1}$)
Rep. 1	11:11	7.07	73.9	13
Rep. 2	11:13	7.15	74.7	12
Rep. 3	11:19	7.08	72.9	14
Mean		—	73.8	13
RSV (%CV)			1.2	7.7

Total suspended solids by Method SM 2540 D
Dissolved oxygen and pH by YSI ProPlus Multi-parameter WQ Meter

integrated samples.[5] This allows great flexibility for either type of deployment. If the decision unit is small enough, a continuous sample can be easily collected. For larger decision units, a non-continuous sampling method may be desired due to the fixed filling time of the *Aloha Sampler*. Continuous sampling of liquids typically provides a more representative sample if the logistics allow integration of the entire decision unit.

To use the *Aloha Sampler*, simply submerge the device horizontally with the two holes aligned vertically (one above the other) to the desired depth of the liquid at a constant transit rate. The liquid will flow in the lower hole, and the air will escape through the upper hole (Figures 3 and 6). Once a vertically integrated increment is collected at a single location, move to the next location and take another increment etc. The transit rate, depth of liquid, fill rate and number of vertically integrated increments must be considered individually for each case, but it will always be possible to obtain a meaningful, optimised sample. Some pilot experimentation may be necessary to determine the ideal timing for specific cases—nothing could be easier, however.

The *Aloha Sampler* can also be attached to a pole to access hard to reach areas, Figure 7.

Once the sample is collected, the *Aloha Sampler* aperture cover is removed and a solid cover is placed on the sample bottle. The sample is then prepared and stored in the same way as any other type of liquid sample. The *Aloha Sampler* can be sterilised for the collection of bacteria.

The *Aloha Sampler* has been used in Hawaii to collect data from construction activities to determine impact to nearby streams. Multiple samples (replicate sampling) were collected for a specific project to determine the *reproducibility* of the Aloha sampling approach. *RSV* (%CV) is quite satisfactorily low for this type of sample collection (Table 1 and 2). These samples were collected using the *Aloha Sampler* on a pole (Figure 7).

Conclusion

The *Aloha Sampler* is a promising new tool to effectively collect and combine increments in a dynamic liquid system, producing highly flexible, problem dependent samples with very low sampling variability. It is extremely inexpensive in fixed capital outlay and very cost effective to implement and use. The *Aloha Sampler* produces fit-for-purpose samples over a wide range of hitherto difficult-to-sample lot and decision units. The *Aloha Sampler* is a significant improvement over commonly used sampling approaches and equipment targeting surface waters in a wide range of situations.

References

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2. DS 3077, *DS 3077. Representative sampling—Horizontal Standard*. Danish Standards (2013). www.ds.dk
3. *Field Sampling Procedures Manual*. New Jersey Department of Environmental Protection (August 2005).
4. *Sampling and Consideration of Variability (Temporal and Spatial) for Monitoring of Recreational Waters*. US Environmental Protection Agency, Office of Water. EPA-823-R-10–005 (December 2010).
5. C.A. Ramsey, W. Okubo, T. Teruya and M. Heskett, "Application of sampling theory to the measurement of bacteria at ocean beaches", *Proceedings 6th World Conference of Sampling and Blending*, pp. 445–456 (2013).

Chuck Ramsey is the founder of the company EnviroStat, Inc. (www.envirostat.org). EnviroStat provides specialised training in the areas of field (bulk) sampling, laboratory subsampling, statistics and quality control. EnviroStat's approach integrates all facets of sample plan design, implementation and data interpretation. EnviroStat's methodology has been used by various state and federal government agencies as well as private industry for over 20 years to improve sample representativeness and defensible decisions.