

A Tale Of Two Samplers - Part 1
comparison of bailer and peristaltic pump groundwater sampling protocols.

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Bailers are routinely used to obtain groundwater samples from wells. As such, bailers are an important component of the currently available groundwater sampling "toolkit" that may also include suction-pump devices. The combination of bailers and suction pumps allows the sampler extreme versatility in addressing a wide variety of sampling situations.

Recently, bailer-based sampling protocols have come under scrutiny from various regulatory groups, including both state and federal (e.g., EPA) agencies. Accusations of poor accuracy and reliability have lead many regulatory jurisdictions to greatly restrict the use of bailers in groundwater sampling, preferring pump-based procedures instead. For most shallow well applications, i.e., where depth to groundwater is maybe 5 to 25 feet (1.5 to 7.6 m), the most common pump-based technique involves a peristaltic pump in conjunction with flexible tubing.

This article is the first in a two-part series that presents a critical comparison of bailers and peristaltic pump/tubing groundwater sampling. This part examines more general issues, including overall sampling accuracy, sensitivity to operator skill, sampling costs, remote location applicability, and the solid waste issue. Part II will explore other more specific issues, including sample aeration, analyte volatilization, organic sorption, fluid flow aspects, applicability to light non-aqueous phase liquids (LNAPLs) and turbidity issues.

Bailers (when properly used) are indeed an acceptable sampling tool. Some of the criticism currently being levied against bailers reflects an incomplete awareness of current bailer "science" and the extent that bailer technology has actually been positively reviewed in the literature.

Bailer basics

As described in ASTM D4448-85a (1992), bailers are down-hole sample collection devices that can be constructed in various designs employing various materials of construction. The basic components are: 1) the bailer tube that holds the obtained water sample; 2) a check-valve-type device at the filling (bottom) end that prevents emptying of the bailer after filling; and 3) a device at the top of the bailer for connection to a line (lanyard) for raising/lowering. Most current bailers are about 1.6 inches (4.1 cm) outer diameter for application to the sampling of 2-inch (5.1 cm) or larger diameter monitoring wells. Bailer lengths are typically from about 2 feet (0.61 m) to about 4 feet (1.2 m) in length. Materials of construction include stainless steel, Teflon, PVC, acrylic, polypropylene and polyethylene; the polymer materials currently dominate the industry.

Bailer sampling techniques typically involve the gentle lowering of the bailer into the water column of the well, using care not to introduce contamination related to the bailer lanyard contacting water or other materials. Specific steps are also followed to properly transfer water from the bailer to sample containers; most protocols are moving in the direction of requiring sample container transfer from the bottom of the bailer. Transfer from the top of the bailer was a common technique that is still used by some samplers. Peristaltic pumps are suction lift pumps that are widely employed in sampling shallow aquifers. The basic peristaltic pump is a self-priming unit consisting of a variable-speed motor and a rotor

with ball-bearing rollers that basically "squeezes" water contained within flexible tubing. Normally, the flexible tubing ("delivery tube" or "drop tube") is introduced directly into the groundwater to be sampled, with the pump located at ground level in very close proximity of the well top. The most popular tubing is 1/4-inch (0.64 cm) inner diameter and 3/8-inch (0.95 cm) outer diameter Teflon, although other polymers are occasionally employed.

Peristaltic pump/tubing protocols have several attractive features, including: 1) general ease of operation; 2) efficient use in both the well flushing (purging) and sampling phases; and 3) the fact that the water being sampled is always contained within the polymer tubing, minimizing initial decontamination requirements and also eliminating contamination problems related to water-pump mechanism materials contact.

Many regulatory procedures recommend "low-flow" conditions for the sampling phase, typically in the range 0.1 to 0.5 liters per minute (EPA, 1995). Specific steps are usually followed regarding the proper transfer of water contained within the drop tube into sample containers. It is generally regarded as poor technique to fill sample containers directly from the tubing on the discharge side of the pump with the pump running.

A comparison of bailers and peristaltic pumps

General accuracy—Most studies reported in the literature that compare several sampling procedures (usually including a bailer and a peristaltic pump) have reported: 1) there are small sampling errors associated with all methods; and 2) when proper techniques are employed, bailers do not perform any better or worse than pumping methods. Representative studies include Barcelona (1984), Yeskis, et al. (1988), Imbrigiotta et al. (1988), Schalla et al. (1988), Pohlmann et al (1990), Tai et al. (1991), Snow et al. (1992), and Parker (1994). In addition, various regulatory groups that have conducted internal studies, reaching similar conclusions. Some controversy exists in regards to metals sampling; inaccuracies are sometimes reported when bailers are used to obtain groundwater samples. This issue will be addressed in Part II.

Operator skill level—Operator skill level does have some influence on the ability to obtain representative groundwater samples.

Bailers, pumps and other sampling devices usually have detailed approved procedures that must be followed in order to obtain good samples. All such methods can be "defeated" in the field by operators who either are not properly trained or who purposely decide to ignore standard operating procedures, often in the interest of saving time. Given this, bailers may be more prone to operator variability in that there are more potential factors that are under operator control. For example, operators may simply drop a bailer into a well rather than slowly lowering the device. Also, operators may transfer samples by pouring out of the top of the bailer rather than using the bottom-discharge procedure (which takes more time).

New bailer designs have sought to eliminate top discharge, a process that was easy to do with many older designs. Peristaltic pump procedures have fewer variables that the operator can manipulate; pump speed is probably the most important one. Therefore, operator variability issues are usually not significant.

Applicability to deep aquifers—many monitoring wells are installed to allow sampling of "shallow" or near-surface aquifers, where depth to groundwater may only be a few feet. However, deep aquifers are found throughout the country. This is often the case for water supply aquifers, which may be located 100 or more feet below ground surface. Sampling of deeper wells can be very challenging to even an experienced technician.

Suction lift pumps simply do not function when the depth to water is 25 feet (7.6 m) or more. The theoretical limit is actually about 34

feet (10.4 m), but most suction pumps can only operate to a depth of about 25 feet. Thus, suction pumps are not usable at groundwater depths greater than 25 feet. On the other hand, bailers theoretically have no limitation in regards to the sample depth. Thus, bailers provide a means of sampling deeper wells, certainly beyond the depth limit applicable to suction pumps.

Sampling costs—Bailers are inexpensive sampling devices. The cost for bailer-based groundwater sampling per well is basically the bailer itself (assuming a disposable bailer) and any additional costs associated with bailer preparation such as decontamination. Peristaltic pump/tubing method costs are basically the tubing itself, any costs associated with tubing preparation, power supply costs and the pump itself. The pump purchase price and any associated maintenance are normally spread out over many sampling events. In general, peristaltic pump-based methods are also not particularly expensive. This would no longer be true when site-sampling plans propose or require well-dedicated pumps. Also, any pump device that establishes direct contact between the fluid and the pump internal surfaces (for example, bladder pumps) would require decontamination between sampling events, adding to the pump method costs.

Remote location issues—wells may be located in remote areas, often in an environment where access may be very difficult. Common examples include wetlands, swamps and other undeveloped “natural” areas. Power-requiring sampling procedures may therefore be challenging and difficult. Bailers definitely enjoy an advantage in such applications since there are no power requirements. Also, bailers can easily be transported to remote locations, only requiring sample site accessibility by individuals on foot. Any procedures requiring a vehicle or other apparatus (for example, portable power sources) would obviously demand more defined accessibility.

Solid waste issues—Some question the contribution of disposable bailers to the solid waste stream. Bailers are manufactured using nontoxic materials that normally would not be expected to pose an environmental threat. This would be true of either landfill disposal or incineration. The mass per volume of bailers is rather low; if totally compressed, the amount of material present in a typical bailer is rather small. Peristaltic pump tubing is usually treated as a single use disposable material. The same general comments also apply to this tubing, although the mass of tubing per mass of water sampled may actually be higher for tubing versus a bailer.

It should be clear from this discussion that bailers are definitely capable of obtaining representative water samples as long as proper sampling procedures are followed. It may be true that bailers (relative to peristaltic pump/tubing methods) are more vulnerable to operator-related problems, but such problems can be largely eliminated when operators closely adhere to proper procedures. New bailer designs reduce the possibility of sampling inaccuracies by improving bailer performance parameters and elimination of design characteristics that sometimes lead to operator-associated improper procedures.

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