TECHNICAL GUIDANCE DOCUMENT
INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

Groundwater Sampling with Peristaltic Pumps

Office of Land Quality

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Notice

The IDEM Technology Evaluation Group (TEG) reviewed the items listed in the "References" section of this document to clarify guidance for determining when peristaltic pumps are acceptable for groundwater sampling projects on a site-specific basis.

Background

Peristaltic pumps (also called suction-lift pumps) are commonly used to collect groundwater samples from monitoring wells, piezometers, and direct-push subsurface soil boreholes. They utilize a series of rotating wheels that compress a length of tubing to create a vacuum that lifts water to the surface. Peristaltic pumps mainly operate outside of the well since only the pump tubing is lowered into the well.

Section 3.3 of the IDEM *Remediation Closure Guide* states: *Bailers, **peristaltic pumps*** [emphasis added]*, high-speed submersible pumps, and inertial lift pumps may cause excessive agitation of ground water samples, and IDEM does not recommend their use when collecting samples for VOC analysis*. Studies have shown that a peristaltic pump under certain conditions can cause degassing and VOC loss to the sample, although this effect is not likely in every case. Moreover, depending on the project data quality objectives (DQOs) the advantages of using a peristaltic pump may far outweigh the limitations even if some VOC loss does occur.

Advantages

When compared to other types of groundwater sampling pumps, peristaltic pumps offer the following potential advantages:

- Monitoring wells, piezometers, and boreholes with internal diameter of less than 2 inches cannot be sampled using many standard size pumps or bailers. However, a peristaltic pump may be used in these small diameter wells, since only the pump tubing is lowered into the well.
- Since the groundwater sample does not contact the pump and only touches the pump tubing, decontamination of the peristaltic pump is not needed between

sampling locations. All tubing is changed between locations; tubing is typically disposed of instead of decontaminated for re-use.
- Peristaltic pumps are typically easy to operate.
- Most peristaltic pumps offer variable speed control, and are capable of low flow rates (< 100 mL/min) often needed for low-flow (minimal drawdown) groundwater sampling.
- Peristaltic pumps are available from numerous equipment suppliers and typically cost less than submersible pumps.
- Peristaltic pumps have few moving parts, easily replaceable tubing and heads, and are portable.
- A peristaltic pump may be used for other sampling activities such as sample filtration and surface water collection. In-line sample filtration is possible with most pumps.

Limitations

When compared to other types of groundwater sampling pumps, limitations of sampling depth (typically less than 25 ft.) and potential for the pumps to cause degassing of certain compounds may cause the pumps to be inappropriate for contaminant specific groundwater sampling projects.

These limitations, and consequential use restrictions due to the limitations, are further described in the following citations:

- Suction-lift pumps may be unacceptable for some groundwater sampling applications. Exertion of a reduced pressure on the sample can cause volatilization or may result in degassing, which can cause changes in the pH, redox potential, and other gas-sensitive parameters. [US EPA 2005, ASTM 2001]
- The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and some volatiles loss. [US EPA 1996]
- Suction-lift pumps create a vacuum in the intake line that draws the sample up to land surface ... The vacuum can result in the loss of dissolved gases and VOCs … Use of a peristaltic pump (1- to 2-L/min pumping rate) is limited to wells in which depth to water is less than about 25 ft. (~9 m). The operation lift may be as small as 20 ft. [USGS 2014]
- Suction pumps are limited by practical suction limits, which restricts their use to wells with water levels less than 25 feet below ground. [OH EPA 2006]
- The major drawback is that the application of strong negative pressures promotes degassing; therefore, these devices [peristaltic pumps] are not recommended for collecting samples to be analyzed for volatile, semi-volatile, pH, Eh, dissolved metals, dissolved gasses, and other gas-sensitive parameters. [OH EPA 2006]
- Several studies have shown that there can be significant changes in the solution chemistry of samples collected with a peristaltic pump. These include changes from degassing and loss of oxidizable and volatile organic constituents. [Parker 1994]

- Based on previous studies, if this pump is operated at conventional flow rates, it should not be used for monitoring volatile constituents and constituents subject to oxidation and precipitation reactions. [Parker 1994]
- Due to the undesirable effects of negative pressure, which this pump continuously imparts to a sample, accurate and reproducible measurement of air sensitive parameters cannot be obtained … As a result, this device is restricted from the collection of surface and ground water samples for volatile and semi-volatile organic analysis. [NJ DEP 2005]
- As demonstrated in this study, disadvantages of the peristaltic pump are excessive degassing of the water and its limitation to shallow wells. [Paul and Puls 1992]

Sampling Method Variations

Soda Straw Method

Variations of the "soda straw method" have been proposed for groundwater sampling projects in Indiana. The basic steps of the soda straw method include:

- Lower the peristaltic pump tubing to the desired sampling depth in the monitoring well, piezometer, or borehole (just called "the well" hereafter).
- Turn on the pump and purge the well according to the site sampling plan.
- Collect all groundwater samples except the samples for VOC analysis directly from the pump output.
- When ready to collect the groundwater sample for VOC analysis, use the pump to slowly draw water up into the pump tubing, and then stop the pump.
- Carefully remove the tubing from the well, and fill the VOC vials at the removed end of the tubing by reversing the direction of the pump rotation and turning pump on at a very slow rate. Avoid completely emptying the tubing when filling the sample vials to prevent introducing water that was in contact with the flexible pump head tubing. (Note: This step assumes there is sufficient vacuum to prevent water from draining back into well during tubing removal.)
- Return tubing to well and repeat steps if needed to fill all VOC vials.

The goal of this method appears to avoid the loss of VOCs from the sample which may occur as the water flows through the tubing at the rotating pump head and then exits the tubing and into the sample container. However, the IDEM TEG is not aware of data showing that this method significantly reduces loss of sample VOCs when compared to simply collecting the VOC samples directly from the tubing at the pump head.

Switch to Bailer Method

The following method has been proposed for groundwater sampling projects in Indiana:

- Purge the well with the peristaltic pump according to the site sampling plan.
- Collect all groundwater samples except the samples for VOC analysis directly from the pump output.
- When sampling is complete, stop the pump and remove tubing from the well.
- Use a bailer or similar device to collect samples for VOC analysis from well.

As with the soda straw method, the goal is to avoid sample VOC loss at the pump head during sampling. However, the activities of removing pump tubing, lowering bailer into well, removing bailer, and pouring water from the bailer into sample container may also cause loss of VOCs. The IDEM TEG is not aware of data showing that this method significantly reduces loss of sample VOCs when compared to simply collecting the VOC samples directly from the tubing at the pump head.

Vacuum Jug Method

US EPA 2013, Section 4.3.1.2 includes detailed instructions for placing a vacuum jug between the pump and the intake tubing in the well when collecting samples for "organic compound analyses" but not for VOC analysis (see below). The pump draws sample water up into the vacuum jug, but the sample water does not come in contact with the tubing in the rotating pump head. When nearly full, the vacuum jug is disconnected from the pump and the groundwater samples poured from the jug into sample containers.

The IDEM TEG is not aware of Indiana sites currently using this method. US EPA 2013 notes that samples for VOC analysis cannot be collected using this method and instead requires collection using a bailer or by "other approved methods, such as the 'soda straw' method." As explained above, the IDEM TEG is not aware of data showing that the bailer or soda straw methods significantly reduce loss of sample VOCs when compared to simply collecting the VOC samples directly from the tubing at the pump head.

Pump Tubing

USGS 2014, Section 2.2.4 includes descriptions of types of pump tubing and tube connectors. The following cited comments suggest the choice of tubing may affect the potential loss of VOCs when using a peristaltic pump.

- *To minimize the bias, thick-walled, non-porous tubing should be used, except for a small section in the pump heads, which require a greater degree of flexibility.* [US EPA 2002]
- *Several types of elastomeric material can be used for the tubing, although flexible PVC and silicone rubber are most common ... The flexible tubing required for use in a peristaltic pump mechanism may also cause sample bias.* [ASTM 2001]
- *Intake tubing could diffuse atmospheric gases sufficiently to affect some target analytes unless thick-walled low-diffusion tubing is used.* [USGS 2014]
- *The type of tubing used in these pumps has a significant effect on the recovery of VOCs, even in shallow wells. They* [two studies cited] *found that VOCs were significantly reduced by silicone rubber tubing and that these losses could be reduced or eliminated by using more rigid PTFE lines for all sample lines except in the head of the pump.* [Parker 1994]

Groundwater sampling projects in Indiana have proposed methods for using a short piece of flexible tubing in the peristaltic pump head and then connecting this tubing to a more rigid, less porous tubing for lowering into the well. These methods have an added benefit in that the rigid tubing may be dedicated or designated to a particular well and

reused. However, most projects use one piece of flexible tubing throughout the system and dispose of this tubing after each use.

Safety Issues

The IDEM TEG did not identify any significant safety issues associated with peristaltic pumps.

Conclusion

Based on review of the documents listed in the References section of this document, the IDEM technical staff can use the following criteria when determining whether peristaltic pumps are acceptable for groundwater sampling at a specific site:

- Consider the DQOs for the groundwater sampling project. If precise measurement of low concentrations of VOCs or other gas-sensitive parameters in groundwater is needed for the project, then a peristaltic pump may not be appropriate for sampling.
- If groundwater will be sampled at depths of 25 ft. bgs or greater, it may not be possible to utilize a peristaltic pump for sampling.
- Peristaltic pumps may be appropriate when sampling monitoring wells, piezometers, and boreholes with an internal diameter of less than 2 inches. Standard size pumps and bailers will not fit in these narrow wells, and a peristaltic pump operated at a low flow rate may allow for minimal disturbance and volatilization of the sample when compared to other sampling devices.
- Reference documents reviewed for this guidance did not include data showing that the “soda straw” or “switch to bailer” methods described above significantly reduce loss of sample VOCs when compared to simply collecting VOC samples directly from the tubing at the pump head. Therefore, the IDEM TEG does not recommend using these methods.
- Studies have shown that the flexible tubing used with a peristaltic pump may play a part in the loss of VOCs during sampling. Reducing the length of flexible tubing used with the pump by connecting to rigid, less porous tubing in the well may improve retention of VOCs in the sample. Therefore, this sampling variation should be considered when using a peristaltic pump.

Further Information

If you have any additional information regarding peristaltic pumps or any questions about the evaluation, please contact the Office of Land Quality, Science Services Branch at (317) 232-3215. The IDEM TEG will update this technical guidance document periodically or on receipt of new information.

References

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