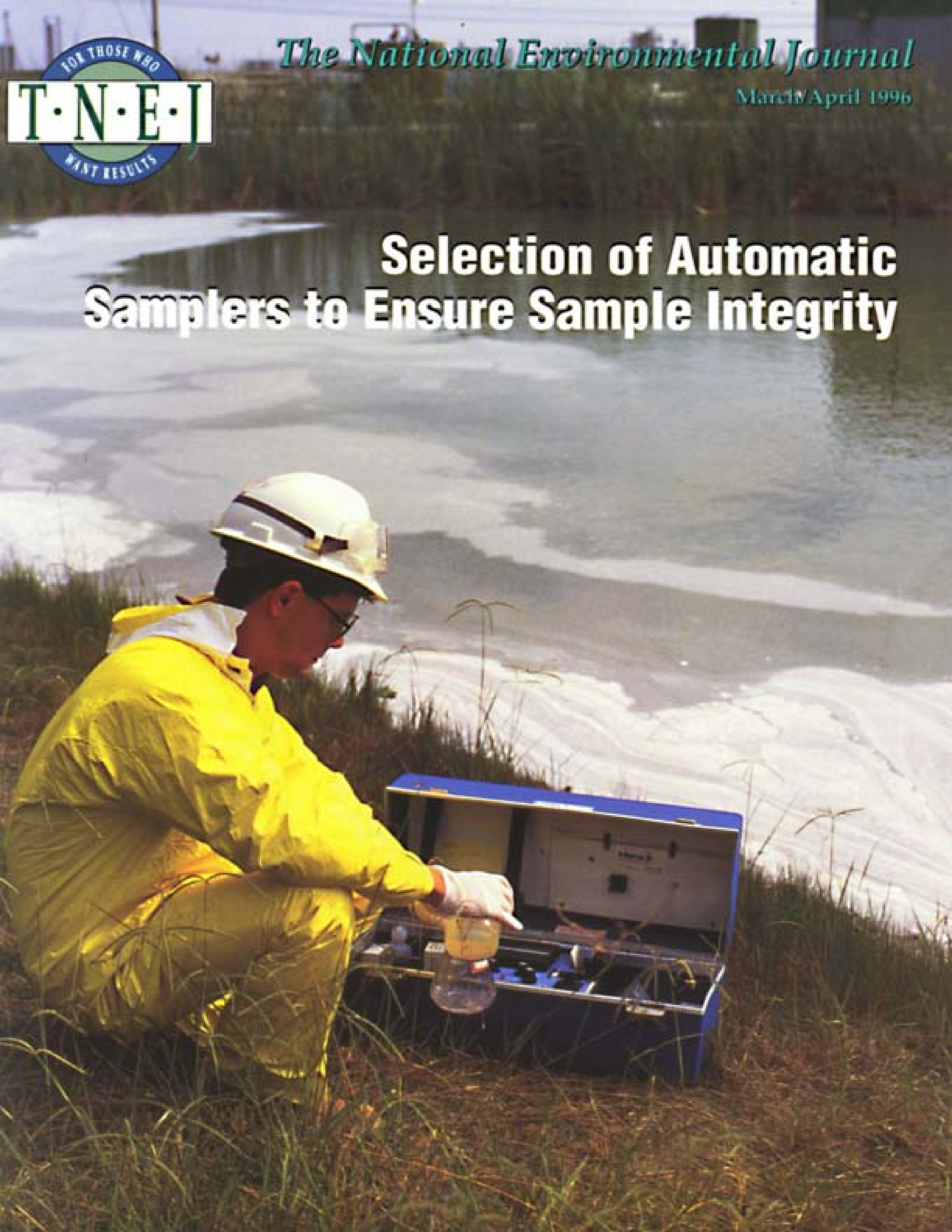
T·N·E·J

FOR THOSE WHO WANT RESULTS

The National Environmental Journal

March/April 1996

Selection of Automatic Samplers to Ensure Sample Integrity



Selection of Automatic Samplers to Ensure Sample Integrity

Traditional manual sampling techniques are often unacceptable for collecting wastewater samples for monitoring because of intricate routines required by permit or regulatory programs. Automatic samplers have resolved some issues about sample acceptability, but samplers offered in the marketplace differ in their ability to collect representative samples.

Rick Sueverkruepp,
lsco, Inc.

Automatic wastewater samplers are an important tool in monitoring discharges to receiving waters. More than 150 different automatic wastewater sample collection devices are available commercially. The samplers differ in several ways, including intake design, constituents in the flow stream, velocity of the flow stream, and transport velocity. Additionally, differences spring from devices custom designed and built for a single purpose or special sampling application. These applications include sampling sludges, high suspended solids, extreme depths, or difficult location equipment.

Because no single sampling instrument exists for every sampling application, instrument selection process is a critical part of any sampling and monitoring program. Automatic sampling devices must be able to:

Automatic wastewater sampler with a pump revolution counting system and liquid presence detector to deliver repeatable sample volumes.

- Collect and store aliquots that accurately reflect the composition of the source being sampled;
- Collect a sufficient volume to represent the source, but a small enough sample to be handled effectively in the laboratory;
- Collect samples in a way that properly reflects the concentrations of pertinent constituents in the total discharge; and
- Handle samples after collection in a way that does not significantly alter the samples before analysis.

The goal of water sampling is to collect samples that accurately represent the body of water being sampled. If the samples do not reflect actual flow stream conditions, laboratory procedures cannot compensate to obtain accurate data.

Automatic samplers today differ in their ability to collect representative samples. Of the many techniques used by automatic samplers today, some deliver samples that incorrectly represent certain pollutants in the flow stream.

These variations are due to many factors, including:

- Sample intake design,
- Intake position in the flow strcam.
- Velocity of the flow stream.
- Sample transport velocity,
- Simple transport method,
- Vertical distance to travel or lift,
- Constituents in the flow stream, and
- Materials in contact with the sample

Importance of Transport Velocity

One of the most important factors in accurate sample collection is the transport velocity. Of the many techniques used by automatic samplers today, some deliver samples that incorrectly represent certain pollutants in the flow stream. Many studies have attempted to evaluate various methodologies, but these studies have not been compiled in a single presentation. The following discussion reviews the findings of several studies on transport velocity and examines how sampling mechanism designs can affect the collected samples.

Table 1. Densities of Wastewater Pollutants

Material	Specific Gravity
Oils, other organics	0.95
Flocculated mud particles	1.03
Municipal EE Effluent	1.15
Municipal WW Influent	0.8-1.6
Grit	1.2-1.7
Aluminum Floc	1.18
Iron Floc	1.34
Sand	2.65
Calcium Carbonate Precipitate	2.70

The official publication on sampling [1] advises selection of a sample pump "capable of lifting a sample a vertical distance of 6.1 m and maintaining a

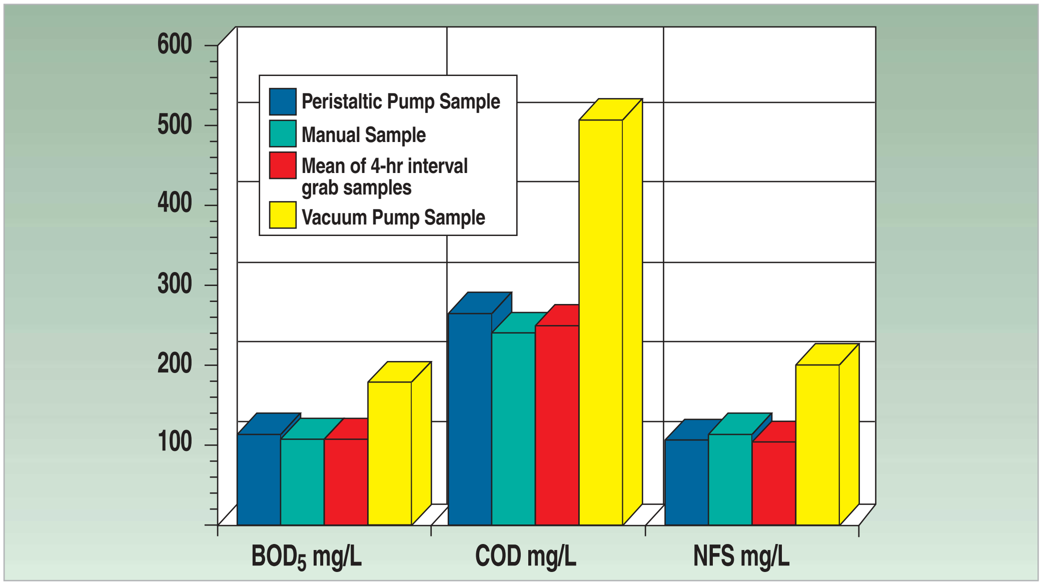


Figure 1.

line velocity of 0.6 to 3.0 m/sec. (2 to 10 fps)." A publication of the US. Environmental Protection Agency [2] explains that "sample train velocities should exceed 2 fps" Both statements are based on studies made by EPA's Harris and Keffer [3]. who suggest several features of an ideal sampler, including that the sampler should have an intake hose velocity adjustable from 0.61 to 3 m/sec with a dial setting."

The suggestion, in turn, is based on earlier recommendations by Shelley and Kirkpatrick [4] that "minimum (suction line transport) velocities of 2 to 3 feet per second would appear warranted." It is based upon a formula that shows "a velocity of 2 feet per second is required to adequately transport a 0.09 mm particle with a specific gravity of 2.65 and a friction factor of 0.025." This particle is sand.

In a 6-meter suction line suspended vertically, this particle would fall 0.61 m during transport. If the suction line used is nominally 3/8-inch in diameter, this would mean that the first 43.4 ml of the sample collected would be devoid of particles with these characteristics. If a 1000 ml sample is being collected, this would result in an understatement of the sand concentration by 4.3%. If the transport velocity were raised to 3.0 fps, the error would be 2.9%. At 1 fps, the error would be 8.7%.

These calculations seem to indicate that achieving accurate samples of a flow stream containing particles with these concentrations requires a transport velocity of 2 fps, and preferably 3 fps. However, professionals who have studied samplers agree that it is very difficult — even under experimental conditions — to duplicate results to within ±15%. This means that the error introduced by variations in transport velocity are not significant. In general, only researchers studying sedimentation in rivers and streams are concerned about solids with these characteristics.

The most important application for automatic wastewater samplers is collecting representative samples for analysis of loading effects These typically are analyzed for BOD, COD, TSS and other factors. The type of solids encountered that contribute to these factors are almost always organic in nature and therefore have densities nearly equal to that of water. Table 1 lists densities for some typical wastewater pollutants.

With densities nearly equal to water, there would be less settling of solids during transport to the storage containers. The transport velocity would not be a significant factor in obtaining a representative sample. Transport velocity is also not a factor when dissolved materials are concerned. In actual application, it has been found that differences in sampling technique and technology do produce varying results.

The differences in the sampler's ability to take a representative sample was most clearly pointed out in Harris and Keffer's study. They noticed significant differences in the results obtained from using different types of samplers to sample the influent at treatment plants. Their experiment used two automatic samplers, a vacuum pump and a lower speed peristaltic pump. These units were installed so they could collect samples from the same point in the flow stream. The intakes were tied together and placed at the midpoint of the influent stream. The collected samples were analyzed for BOD_5, COD and NFS and the results are listed in Table 2, with averages shown in Figure 1.

The differences in the automatic samples are clearly because of the different techniques used to automatically collect these samples. The data for the samples collected with peristaltic pump sampler more closely reflect the values that are generated collecting samples manually. The manual sample is used as a control.

Some areas that may account for differences in the sample values could be:

- Cross contamination of samples. The peristaltic pump samples are put directly into the sample container. The portion of the suction line can be purged and rinsed before each sample to ensure that the sample collected is free from cross contamination from previous samples. With a vacuum pump sampler, all samples collected must pass and then be retained in a metering chamber. This metering chamber is unable to be adequately rinsed and cleaned between samples.
- Intake velocities. The intake velocity of the peristaltic pump sampler is closer to the intake velocity of the actual flow stream. This helps to approach the concept of "iso-kinetic sampling" that has been suggested by some researchers. This is where the intake velocity of the sampler and the flow stream velocity are equal. It is theorized that this will produce a more representative sample because the flow will not be forced into the intake line. A vacuum pump sampler typically has a

Table 1. Comparison of Results from Two Samplers on the Same Flow Stream

Test 1	BOD$_5$ mg/L	COD mg/L	NFS mg/L	Test 2	BOD$_5$ mg/L	COD mg/L	NFS mg/L
Peristaltic Pump	95	330	120	Peristaltic Pump	84	165	47
Vacuum Pump	215	588	254	Vacuum Pump	140	388	126
Manual	113	279	121	Manual	99	223	109
Mean of 4-hr interval grab sample	124	356	148	Mean of 4-hr interval grab sample	97	177	74
Grab Sample Standard Deviation	63	163	88	Grab Sample Standard Deviation	44	95	37

Test 3	BOD$_5$ mg/L	COD mg/L	NFS mg/L	Average	BOD$_5$ mg/L	COD mg/L	NFS mg/L
Peristaltic Pump	153	306	149	Peristaltic Pump	110.7	267	105.3
Vacuum Pump	153	526	186	Vacuum Pump	169.3	500.7	188.7
Manual	107	252	106	Manual	106.3	251.3	112
Mean of 4-hr interval grab sample	98	236	87	Mean of 4-hr interval grab sample	106.3	256.3	103
Grab Sample Standard Deviation	43	94	38	Grab Sample Standard Deviation	50	117.3	54.33

line velocity well above the flow stream velocity at lower head heights. This can cause a "scouring" of the channel floor and dislodging solids that have been settled out when the sampler performs a prepurge of the suction line. When the sampler then reverses that sample is collected from a "cloud" of settled out material that artificially enriches the sample for suspended solids content and renders the sample unrepresentative. Figure 1 shows average results of the sample analysis data.

- Operational differences in the samplers. The peristaltic pump sampler places samples directly into the sample container, and meters the volumes through a series of optical switches. Recent developments, including the use of liquid detectors and optical sensors, have improved the delivered volume accuracy and repeatability. The operator simply selects the volume for each sample to be collected and this volume is then metered through a direct path to the sample container. The vacuum pump sampler must collect a fixed volume of sample, dependent on the metering chamber size. Volumes are then adjusted with the use of a mechanical device inside the chamber to deliver a fixed volume to the sample container. After the fixed volume is inside the metering chamber, the liquid is held in the chamber. This allow solids to settle to the lower part of the chamber. The volume passed to the sample container then consists of a enriched solids sample because of this settling action.

Conclusions

In all cases of the data shown in the charts, the NFS data was always higher than present in the manual sample. In one case it rendered a number more than 100% higher than the manual sample. The samples collected by the peristaltic pump sampler more clearly and consistently reflects the results observed in the manually collected samples. The peristaltic pump samples data are shown to be within 5 to 6% of the manually collected samples data. Variations in the vacuum pump samples can vary as much as 50% of the manually collected samples.

This test shows the consistency and accuracy of samples collected using the peristaltic pump sampling technique. Current peristaltic pumps samplers are using new techniques and technology to continue to improve the accuracy and repeatability of the techniques so that samples are truly representative of the flow stream. This results in better and reliable data being generated about a specific site, and proper informed decisions be made about the treatment and control measures needed for a specific site.

References

1. "Wastewater Sampling for Process and Quality Control," Water Environment Federation, Alexandria, VA, 1980.
2. National Pollutant Discharge Elimination System (NPDES) Compliance Sampling Inspection Manual, U.S. Environmental Protection Agency, Section 5, September 1994.
3. Harris and Keffer, "Wastewater Sampling Methodologies and Flow Measurement Techniques," U.S. Environmental Protection Agency, EPA 907/9-74-005, 1974.
4. Shelley, P., "Automatic Sewage Samplers: What to Look for When Buying," October 1980.

For more information, contact the author, Rick Sueverkruepp, Isco, Inc., P.O. Box 82531, Lincoln, NE, 68501-2351; phone: (402) 464-0231.