THE PRACTITIONER'S TOOL KIT

Practical Field Sampling Strategies

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Editor's Note: The National Environmental Health Association (NEHA) strives to provide relevant and useful information for environmental health practitioners. In a recent membership survey, we heard your request for information in the *Journal* that is more applicable to your daily work. We listened and are pleased to feature this column from a cadre of environmental health luminaries with over 300 years of combined experience in the environmental health field. This group will share their tricks of the trade to help you create a tool kit of resources for your daily work.

The conclusions of this column are those of the authors and do not necessarily represent the official position of NEHA, nor does it imply endorsement of any products, services, or resources mentioned.

As environmental health practitioners and sanitarians who have been there and done that, we can honestly say that of all the mistakes we made in our careers, poor field sampling techniques, bias, and misinterpretations were probably the worst—and the most embarrassing. So bear with us while we share a bit of insight into this thorny topic.

There are two definitions of sampling:

1. The first definition is the act, process, or technique of selecting a suitable sample. Specifically, selecting a representative part of something for the purpose of finding parameters or characteristics of the whole. Taking a single temperature reading of a pan of lasagna in no way represents the temperature of the whole pan. We know that we can make anything pass or fail, depending on where we stick the thermometer.
2. The second definition goes to the heart of what we do: a small part selected as a sample for inspection or analysis. Since sampling is a part of inspection, and inspection is checking or testing something against established standards, we are compelled to do it correctly and defend what we do when we sample. The goal of sampling is to define objective measurements and refine subjective observations without bias. In other words, making sense of statements like "clean to sight and touch," ensuring that temperature-sensitive foods are not held in the temperature danger zone for any longer than necessary, or measuring physical parameters for sanitation or safety such as ventilation, adequate lighting, and slip resistance, just to name a few.

Always keep in mind the cardinal rule of sampling: Garbage in equals garbage out. Samples that are not representative of the source are of little use. Furthermore, poor collection procedures can yield unrepresentative samples, contribute to the uncertainty of the analytical results, or worse yet, result in contamination of the samples.

Errors can be calculated and are easy to interpret if our sampling strategy focuses on probability. In other words, systematic or random sampling has the least bias. For example, in sampling that lasagna pan we referred to earlier, by taking several temperature measurements (remember, there is a thermocouple response time) diagonally across the pan and averaging the temperature readings, you are taking a systematic probability sample. This sampling strategy is defensible whereas the single, judgmental nonprobability sample is not. What you are doing by sampling in this manner is defining a gradient through a repeatable grid pattern. As an environmental health practitioner, it is important for you to understand the various types of sampling strategies available for use and to have a sense of where each type should be used.

To begin, the best strategy is to prepare a sampling plan as a standard operating procedure that can be referenced in field notes and is easily used by more than one person. Organizations and agencies, such as health departments, should have a set of standard operating procedures that cover field sampling, particularly when used in routine inspections.

Sampling plans that are similar to systematic sampling include stratified and cluster sampling. These variations are used depending on the size, configuration, and convenience of the things that are to be sampled but follow the same general pattern and have the same bias. Regardless of the plan used, always try to take five or more samples with each run. In this way, you are introducing statistical relevance.

For those of us in institutional practice or who work with commercial food preparation facilities such as dairies, bakeries, or the inner workings of any food manufacturing, the luxury of time and consistency in these operations allows us to use a random sampling plan. The *Military Standard for Sampling Procedures and Tables for Inspection by Attributes* (MIL-

STD-105E, https://bit.ly/3DNQzNJ) is both easy to use and easy to understand.

The random sampling plan, while it requires the most samples, is also the least biased and most accurate. It is an important tool when evaluating, auditing, or inspecting multiple suites, rooms, and living quarters. And we use it regularly to verify hazard analysis critical control point (HACCP) plans and evaluate sanitation, safety, and maintenance activities in correctional facilities, military bases, hospitals, schools, and hospitality venues. A simple random sampling plan works extremely well in institutional food service where there is a stable population that is served by a fixed or 5-week rotational menu, along with standard sized hotel pans and chafing dishes in kitchen preparation and serving operations.

By its very nature, nonprobability sampling has the most bias and is the most vulnerable for questioning and contradiction. Nonprobability sampling plans include judgmental, snowball, and convenience sampling:

- **Judgmental sampling** should be reserved for verifying two conditions. The first condition is where there is an obvious problem. These problems can include when off temperatures are encountered, obvious spoilage and contamination such as mouse dropping in food are found, poor or absent ventilation is noted, no lighting is present, and obvious inadequate sanitation is noted, just to name a few. The second condition is when the sample is homogeneous. For instance, sampling potable tap water, recreational waters, soups and other pumpable foods in larger preparation and serving containers, or where a single sample (if properly documented) is acceptable. We advise caution.
- **Snowball sampling** (i.e., a nonrandom sampling technique) is used to identify problems to trace the possibility of organisms such as *Campylobacter*, *Listeria*, *Salmonella*, *Vibrio*, or *E. coli* in food production from raw to finished product or to identify misuse or overuse of disinfectants in living environments. Snowball sampling relies on your professional judgment to determine where a problem might exist and tracing it throughout its path to find a practical solution for remediation. The more information you provide in describing your efforts with this sampling procedure, the more cost-effective and cost-efficient are the corrective actions.
- **Convenience sampling** is used when we are interested in getting an inexpensive approximation of the truth. As the name implies, the samples are selected because they are convenient. This strategy is quite acceptable as a screening tool. It is used to get a gross estimate of the results and to design a more comprehensive sampling scheme. Unfortunately, it is often erroneously used as the final arbiter in regulatory inspections.

There are two other factors we need to consider in selecting a sampling scheme:

1. The first factor is **repeatability**, which is the ability of the measurement system to provide consistent readings when used by a single inspector at a given location. It requires the following conditions to be in place: the same location, the same measurement procedure, the same observer, and the same measuring instrument all used under the same conditions.
2. The second factor is **reproducibility**, which is the ability for multiple environmental health practitioners to achieve consistent results. Reproducibility refers to the degree of agreement between the results of inspections (including re-inspections) conducted by different individuals, at different locations, and with different but similar instruments. Simply put, it measures our ability to replicate the findings of others.

In either case, the sampling strategy needs to be concisely documented. For example, "The lasagna pan in the kitchen bain-marie was systematically sampled on the diagonal, taking five readings, using the validated needle K-probe on the thermocouple. Sampling was completed at 1320 hours." This type of documentation makes it both repeatable and reproducible.

A good sampling strategy also helps us define observations. So much of what we do is subjective, where the information or observation is ill-suited and based on opinion, interpretations, points of view, emotions, and judgment. Sampling, whenever possible and practical, gives us information that is fact-based, measurable, and observable. Objective data are usually suitable for decision-making and are less likely to be disputed or challenged on an inspection report. By presenting objective measurements, accurate data are collected, presented, and compared on repeated inspections.

The best sampling strategy and the most careful sampling technique are worthless if the field documentation of the strategy and the sampling is not carefully done. Recording the technique, times, data, and conditions are necessary to get an accurate interpretation of those data and to allow reproducible results. All data should be recorded in a bound field sampling book with numbered pages (waterproof is best).

Included in the discussion of this topic is where are the best sampling locations? The selection of the sampling location is as much an art form as it is a science. This question is best answered using common sense and a good knowledge of the mechanisms of cross-contamination. What set us on a course of forensics was watching an individual "aseptically" sample food while touching everything but the sample. The act of sampling should be carefully choreographed so not to contaminate other foods, critical surfaces, or put yourself at risk of injury. While we are considering location, we must also consider sample sequence, particularly if we are to validate a HACCP plan. The sampling locations should always be selected in sequential order from processed to raw, cleaned to soiled, and sanitized to contaminated.

Finally, the interpretation of sampling results brings us back to the sampling objective. In presenting the collected data, consider five data quality indicators:

1. Precision
2. Bias
3. Representativeness
4. Completeness
5. Comparability

Each of these indicators is sensitive to the way sampling is done, and each is a reflection on the thoroughness of the answers we provide to the questions posed by the sampling objective. The variability of monitoring data should also be interpreted to reflect consideration of the possible sources of sampling error. These errors include sampling design, sampling implementation, and data analysis. This consideration is particularly significant when decisions are made that result from regulatory inspections. Now you know. Make your next inspection a stellar professional model.

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