Quantitative Large-Volume Sampling Technique

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A filtration technique for high-volume sampling of water has been developed that, when combined with the most probable number procedure, permits the quantitation of microorganisms present at very low densities.

Dutka and Bell (3) recently pointed out the need for quantitative techniques for the enumeration of small numbers of enteric pathogens and indicator organisms in large volumes of wastewater and receiving waters. Various qualitative techniques for the isolation of bacteria present in very low densities have been described (2, 4, 6, 8), but quantitative methods for their enumeration under such conditions have not been reported. This note describes a high-volume sampling (HVS) technique that can be used in conjunction with the most probable number (MPN) procedure to permit quantification of bacteria in those instances where an MPN procedure is available.

The HVS technique utilizes a Balston (Lexington, Mass.) type AA cartridge filter (2.5 by 6.4 cm) in conjunction with a type 90 filter holder. The filter is composed of borosilicate glass microfibers bonded with epoxy resin. The retention efficiency for liquids is 98% for 0.3-μm particles. The maximum recommended pressure differential for these filters is 69 kN/m² (outside to inside flow). The filters, filter holders, and associated vacuum tubing are sterilized by autoclaving at 121 C for 15 min.

The apparatus as used is represented in Fig. 1. The water sample was collected in or transferred to a sterile calibrated container, and a portion thereof was passed through the filter under vacuum. A manifold was used to provide the capability of filtering five portions simultaneously. A trap was inserted between the manifold and the vacuum pump to collect the filtered water. When the desired quantity of water had been filtered, the filter was aseptically removed from the holder and placed directly into a suitable culture medium for incubation. Another sterile filter was placed in the filter holder, and the procedure was repeated. Resterilization of the apparatus was required only when a new sample was examined.

The amount of time required to filter large volumes of water varied with the turbidity of the sample. With most samples, 10 liters could be filtered within 60 min (Fig. 2). If this is impossible due to excessive turbidity, several filters may be used successively on a single portion and placed in the same container of culture medium.

The HVS procedure was used to obtain MPN estimates of Salmonella densities in samples collected from marine waters in the vicinity of New York City (Table 1). All samples were assayed within 12 h of collection. Dulcitol-Sele

![Fig. 1. Sampling apparatus. Vacuum pump operates at 69 kN/m² to draw water through the filter into the trap. A calibrated container is used to permit direct measurement of the volume sampled.](http://aem.asm.org/Downloaded from May 8, 2020 by guest)
Table 1. Salmonella densities in water samples from New York City beaches

| Water source    | Date taken | MPN code | Organisms/100 liters |
|----------------|------------|----------|----------------------|
| W. 25th Street | 6-12-73    | 510      | 22.0                 |
| W. 25th Street | 7-7-73     | 200      | 4.0                  |
| Riis Park      | 7-7-73     | 010      | 1.8                  |
| W. 25th Street | 7-14-73    | 100      | 2.0                  |
| Riis Park      | 7-14-73    | 000      | <1.8                 |
| W. 25th Street | 7-15-73    | 110      | 4.0                  |
| Riis Park      | 7-15-73    | 210      | 6.8                  |
| W. 25th Street | 7-22-73    | 200      | 4.0                  |
| Riis Park      | 7-22-73    | 000      | <1.8                 |

* Five-tube MPN values were calculated for volumes filtered. The W. 25th Street sample taken 12 June 1973 was assayed using 15, 1.5, and 0.15 liters for each of three sets of five tubes. All other samples were assayed using 10-, 1.0-, and 0.1-liter volumes.

Table 2. Accuracy of HVS technique

| Trial | Water source* | Seeded with | Bacterial density/100 liters |
|-------|---------------|-------------|-----------------------------|
|       |               |             | Expected* | Observed* |
| 1     | Potable (sterilized) | Coliforms | 130          | 130        |
| 2     | Potable (sterilized) | Coliforms | 130          | 49         |
| 3     | Potable (sterilized) | Coliforms | 32           | 47         |
| 4     | Potable        | Coliforms | 440          | 240        |
| 5     | Potable        | Coliforms | 196          | 230        |
| 6     | Potable        | Coliforms | 9            | 10         |
| 7     | Estuary       | Salmonella | 810         | 920        |
| 8     | Estuary       | Salmonella | 810         | 350        |

* Potable water for trial 5 was obtained from the Westerly, R.I., water supply. All other water samples are from the Wakefield, R.I., water supply.

The expected coliform count is based on a Standard Methods (1) MPN. Samples of polluted water used as the inoculum were obtained from a polluted river. The expected Salmonella count is based on three replicate brain heart infusion spread plates from a suspension of S. enteritidis.

Trials 1, 2, 3, 4, 7, and 8 are based on sample volumes of 10, 1, and 0.1 liters. Trial 5 is based on 40, 4, and 0.4 liters, and trial 6 is based on 70, 7, and 0.7 liters.

This HVS technique can be applied to any situation where a selective-enrichment medium is available for use in conjunction with the MPN procedure. For each application, however, it must be determined whether factors characteristic of large-volume sampling, such as the adsorption of toxic metal ions and overgrowth by background organisms, may impose a bias. The accuracy of the HVS procedure when used to obtain Salmonella and coliform densities can be seen in Table 2. For the coliform analysis, potable water sterilized by autoclaving was seeded with predetermined quantities of polluted water; in the Salmonella trials, portions of S. enteritidis suspension held in sterile estuarine water for 24 h were added to estuarine water that contained less than 1 coliform per 100 ml and less than 1.8 salmonellae per 100 liters. The expected bacterial densities were determined from a five-tube, total coliform MPN (1) on the polluted water and on triplicate spread plates of brain heart infusion agar (Difco) for the stressed S. enteritidis suspension. The HVS procedure for coliform enumeration differed from the standard method in that 250 ml of lactose broth was used in each tube and all tubes that exhibited turbidity were transferred to the confirmatory broth. With both organisms, the observed HVS estimates were similar to the expected values (Table 2).
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