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Interpreting the Presence of Coliform Bacteria in Drinking Water

Determining the bacterial quality of drinking water is the single most important water quality test. Why? Because one glass of water containing just a few disease organisms can cause illness. When minimal exposure creates an immediate health risk, that contaminant is known as an acute contaminant. Bacterial contaminants such as *E. coli* and fecal coliform in drinking water represent an acute health risk. In contrast, meaningful health risk from most chemical contaminants, such as arsenic, radon, or benzene, requires a long period of exposure. Consequently, these contaminants are considered chronic.

The total coliform test is the starting point for determining the biological quality of drinking water. This test is performed frequently because of the acute risk that disease-causing organisms pose to the users of that water supply. The test is easy to perform and inexpensive.

Total Coliform as an Indicator

The total coliform test is considered an indicator, since the presence of bacteria in this group indicates the possibility, but not the certainty, that disease organisms may also be present in the water. When total coliforms are absent there is a very low probability of disease organisms being present in the water. The ability of the total coliform test to reliably predict the bacterial safety of drinking water relative to the hundreds of possible diseases is critical since it is impossible, in a practical sense, to frequently check for every type of disease-causing organism.

Important exceptions to this generalization include protozoa such as *Giardia* and *Cryptosporidium*, which can be present in water even when the total coliform test shows an absence of organisms. Under such circumstances illness could occur. Nevertheless, the total coliform test remains the most commonly used standard for determining the bacterial quality of drinking water in the US and the world.

Risk Associated with Coliform Types

There are a number of subsets within the coliform group. The presence of bacteria from each progressively smaller subset heightens the concern that disease-causing organisms may also be present in the water. These groups and their relative risk implications are discussed below.

Total Coliform. These organisms are prolific in the soil. Their presence does not necessarily imply contamination from wastewater nor the presence of other sanitation-based health risks. The presence of total coliform by itself does not imply an imminent health risk but does indicate the need for an analysis of all water system facilities and their operations to determine how these organisms entered the water system. Public notice to water system users is required since a properly constructed and maintained water system should not have total coliform present. When only total coliform are present, the water system is allowed 30 days to give public notice to customers that the water has violated a drinking water standard. This lengthy period indicates regulatory agencies' perception of a low degree of immediacy to the risk.

Fecal Coliform. This is a subset of the total coliform group. Fecal coliform bacteria generally originate in the intestines of mammals. They have a relatively short life span compared to other coliform bacteria. Their presence could be related to improper disposal of sanitary waste. Immediate public notice and a boil order to the users (within 24 hours) are required due to the higher likelihood of disease organisms also being present in water.

Escherichia coli (E. coli). This is a species within the fecal coliform group. *E. coli* originate only in the intestines of animals including humans. As with other fecal coliform, they have a relatively short life span compared to non-fecal coliform bacteria. Their presence indicates a strong likelihood that human or animal wastes are entering the water system. Immediate public notice and a boil order (within 24 hours) are required due to a higher likelihood of disease organisms also being present in the water.

Non-Coliform Bacterial Results

The membrane filter test produces a result for non-coliform organisms. High non-coliform results are generally interpreted in two ways:

Invalidation of the Total Coliform Test

When the number of non-coliform organisms is high, their presence may inhibit the growth of organisms in the total coliform group. When present in numbers over 200 colony forming units (CFUs) in a 100 milliliter sample, non-coliforms will invalidate a total coliform test.

Non-coliform as an Indicator of Inadequate Filtration

One expects to find a small number of non-coliform organisms in a properly constructed well. Thus when non-coliforms are numerous in groundwater samples, there is concern that the water in the well is not being adequately filtered. Reasons for a lack of adequate filtration include: the well is not properly constructed, or the soil/rock layering is not adequately filtering the rainfall or runoff that is percolating down from above to the well.

CONFLICTING COLIFORM DATA

Sometimes bacterial tests from the same public water system, under the same conditions, are not consistent.

Samples Taken at Different Times

In an inadequately filtered well, bacteria are expected to be present. Organisms that gain access to a

well can be there one day and die off before a second sample is taken a few days or a week later.

Samples Taken at the Same Time

This is a somewhat unlikely but possible event. One explanation is the diversity of coliform test methods. Some bacterial tests use a filtration step while others do not. Each test uses a different proprietary media to incubate the organisms. Sometimes the bacteria themselves are counted while in other cases enzyme byproducts are measured. Some methods will better detect coliform species that have been stressed by chlorine or other harsh environmental conditions while others will not. Finally, fully representative samples are hard to obtain since bacteria often congregate together in clumps in pipes and in the sample container. Thus, in cases where there are few organisms, they may not be evenly distributed in the water.

Laboratory Methods for Total Coliform Identification

All methods of total coliform identification require culturing of the sample in the presence of a special food source. The culturing process requires approximately one to two days of culture growth before interpreting the bacterial data. There are three laboratory procedures that can be used for determining the presence of total coliform in a water sample:

Multiple Tubes. This method was developed in the early 1900s. It uses a number of test tubes and measures the amount of gas production during two days of incubation. Results are stated in terms of most probable number of organisms (MPN) per 100 milliliters of sample. Advantages include being the first reliable bacterial method for drinking water; disadvantages include significant glassware use and required laboratory cleanup.

Membrane Filter. This method was developed in early 1950s. It filters organisms from the water onto a paper surface and then incubates the initial parent organisms to produce visible colonies. A minimum of 22 hours incubation time is required. Resultant growths are counted by the laboratory staff. Results are identified as “counts” of CFUs per 100 milliliters. The advantage of this method is that it is much simpler than test tubes; the disadvantage is that it can't be used on muddy water.

MMO Chromogenic Fluorogenic Method. This method was developed in the late 1980s. It consists of culturing the organisms in the sample bottle. An incubation time of 18-28 hours is required. A yellow color indicates the presence of total coliform and the presence of a fluorescent condition under black light indicates *E. coli*. Results are stated as the presence or absence of coliform organisms per 100 milliliters. Non-coliform organisms are not produced.

FOR MORE INFORMATION

Please contact the Drinking Water and Groundwater Bureau and the New Hampshire Water Well Board at (603) 271-2513 or dwgbinfo@des.nh.gov or visit our website at <http://des.nh.gov/organization/divisions/water/dwgb/index.htm> . All of the bureau's fact sheets are online at <http://des.nh.gov/organization/commissioner/pip/factsheets/dwgb/index.htm>.

Note: This fact sheet is accurate as of September 2010. Statutory or regulatory changes or the availability of additional information after this date may render this information inaccurate or incomplete.