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MONITORING THE SANITARY BACTERIOLOGICAL QUALITY OF POTABLE WATER SUPPLIES

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ALASKA WATER LABORATORY
College, Alaska

MONITORING THE SANITARY BACTERIOLOGICAL QUALITY OF POTABLE WATER SUPPLIES

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The available information indicates that many public water supplies in Alaska do not comply with all the minimum public health standards which ensure a safe water supply. There are supplies that comply with none of the standards such as the use of raw water, and others that perhaps comply with all of them. One of the most neglected areas of compliance is adequate monitoring of the bacteriological quality.

Numerous pathogenic (disease causing) bacteria and viruses are potentially present in water. None of these microorganisms are found naturally in water and most of them enter the water as a result of the activities of man or other warm blooded animals and birds both domestic and wild (5). Fecal material, from individuals with an active disease or from persons called carriers, is generally the source of water borne pathogens. However, some pathogens such as leptospires may be shed only in the urine. Carriers are usually persons who have recovered from the disease but still harbor and excrete highly infective pathogens, such as the bacterium causing typhoid fever. The numbers and even the very presence of any specific pathogen in water varies with the geographic area, state of community health, nature and degree of waste treatment and other factors (5).

Regardless of whether communities obtain their public water supply from wells, surface water reservoirs or streams, they are potentially susceptable to fecal pollution. Wells may be contaminated from sources such as septic tank effluents which seep into the water table or from surface water runoff into the top or along the casing of poorly constructed or damaged wells.

Reservoirs and streams may be contaminated by surface pollution from humans, birds or animals within the watershed, seepage of contaminated ground water, or from sewage effluents upstream. Water distribution systems are also susceptable to contamination through cross connection and/or loss of pressure within the system. These are not necessarily all of the potential sources of contamination, but will serve to illustrate the many ways that fecal material may enter a potable water supply. One well documented case of a village having a polluted water supply occurred in 1969 when it became necessary for the old village of Minto to obtain its water supply from the Tanana River. A sampling station for a fecal indicator bacteria survival study being conducted at the Alaska Water Laboratory was located directly in front of the village. The river water at this station was found to contain more total colicorm bacteria than permitted in any water source to be used for drinking purposes (an average of 2,200 total coliforms per 100 ml throughout the two week period of the study).

The microorganisms which are significant from a public health viewpoint are the pathogens. They may be present only sporadically or at best in low numbers, and the methods for detecting the presence of many of the pathogenic bacteria and all viruses are still in a rather primitive state. However, the potential presence of pathogenic bacteria is routinely determined using indicator bacteria. It was pointed out previously that most pathogens which may be found in water are of fecal origin. Therefore, the bacteriological quality of water is determined routinely only in relation to fecal pollution.

The enteric (intestinal) bacteria which most nearly meet the requirements as indicators of the potential presence of pathogenic bacteria are divided into two general groups, total coliforms and enterococci. These bacteria, which are normal inhabitants of the intestinal tracts of warm blooded animals, are present in fecal material in large numbers and their presence is easily determined by routine examination of the water. These groups can be divided into additional subgroups for specific studies, but for routine monitoring no further division is used. Bacteria of the coliform group are present in the largest numbers in the intestinal tract of warm blooded animals, and are the easiest to work with for routine monitoring of the bacterial quality of potable water supplies and sewage treatment plant effluents.

The definition of the total coliform group is as follows: "The coliform group includes all aerobic and facultative anaerobic, gram-negative, nonsporeforming rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35° C" (3). This definition encompasses a large group of closely related bacteria most of which are normal inhabitants of the intestinal tract of warm blooded animals. The few members which are considered vegetative types (not of fecal origin) do not detract from the usefulness of this group of bacteria for monitoring the sanitary condition of water.

It should be obvious that the sanitary bacteriological quality of potable water requires regular monitoring if a safe public water supply is to be maintained. However, bacteriological quality is not the only consideration. The Alaska Administrative Code (4) sets forth two requirements for public water supplies:

(1) (A) "Such water shall be obtained from a source which is properly located, constructed and adequately protected against contamination."

(B) "Such water shall be properly and adequately purified."

(2) "All such water shall not show upon analysis a chemical content deleterious to the public health, as specified by the Alaska Drinking Water Standards."

If the source does not meet the physical requirements of location, construction and protection, the supply can not be considered safe even though analyses indicate that the water quality requirements are met (6, 7).

After the best possible water source has been selected and found to meet the chemical standards, either naturally or by treatment, then the sanitary bacteriological quality is considered. The density of total coliforms is used to establish the bacteriological quality of water for public health purposes. Total coliform density is reported as the number of total coliforms per 100 ml of water. Two coliform levels for raw water to be treated for public consumption are recognized by the State of Alaska Water Quality Standards (1). The first level is raw water which averages less than 50 total coliforms per 100 ml in any month. This water can be used after simple disinfection and removal of naturally occurring impurities. The second level is raw water which averages less than 2000 total coliforms per 100 ml. This water requires adequate treatment equal to coagulation, sedimentation, filtration, disinfection, and any additional treatment necessary to remove naturally present impurities.

Untreated (raw) water is used extensively for drinking purposes in Alaska. It should be noted that there is no provision in the Water Quality Standards which establishes the quality of water to be used without any form of treatment.

The 1962 Public Health Service Drinking Water Standards (6) are used by the State of Alaska to establish the minimum quality for public water supplies. These standards state that samples for bacteriological examination shall be collected at representative points throughout the distribution system. The frequency of sampling and the location of sampling points shall be established jointly by the reporting agency and the certifying authority after investigation of the source, method of treatment and protection of the water concerned. The presence of coliform bacteria in the samples of treated water shall not exceed the following limits when the membrane filter technique is used:

"The arithmetic mean coliform density of all standard samples examined per month shall not exceed one per 100 ml. Coliform colonies per standard sample shall not exceed 3 per 50 ml, 4 per 100 ml, 7 per 200 ml or 13 per 500 ml in

(a) two consecutive samples;

(b) more than one standard sample when less than 20 are examined per month;

or (c) more than five percent of the standard samples when 20 or more are examined per month.

When coliform colonies in a single standard sample exceed the above values, daily samples from the same sampling point shall be collected promptly and examined until the results obtained from at least two consecutive samples show the water to be of satisfactory quality."

Samples for water quality analysis (from both public and private water supplies) are examined in laboratories maintained in Fairbanks, Anchorage and Juneau by the Alaska Department of Health and Welfare. The procedure for submitting samples for analysis is quite straight-forward and details can be obtained by contacting one of these offices. The personnel in these laboratories can provide satisfactory analyses only if the local operator submits valid samples. Valid samples are collected using proper sampling techniques, from representative locations in the system at pre-established intervals, and reach the laboratory promptly for analysis.

Even if the local operator obtains valid samples, the time loss between sample collection and laboratory analysis leaves room for considerable doubt concerning the value of the results. A.P.H.A. Recommended Procedures for the Examination of Seawater and Shellfish (2) states that bacteriological analysis should be started within one hour after sample collection. However, if a delay is necessary the samples should be kept at a temperature below 10° C, but not frozen, until examined, and samples should not be held more than 30 hours. Less than 30 hour delivery of any mailed parcel from a remote area is highly improbable and temperature control is even less likely. Extensive delays in analysis may result in the death of coliform bacteria in the samples and thus give a false indication of the water quality. In the event that a water supply has become contaminated, there is a minimum two day lapse between sampling and return of results to the operator, and the time span may well be much longer. If contamination of a water supply had occurred, an outbreak of a water-borne disease could occur during this delay if the operator waits for the results before initiating corrective action.

It is possible to shorten the elapsed time between sampling and receiving of results to 24 hours. The methodology and equipment are available and the basic procedure is quite simple. However, the persons responsible for providing and maintaining public water supplies must show a continuing interest before the details of the procedure can be worked out in a useable form. The essence of the procedure is for the operator to conduct routine bacteriological analyses on site. This requires a small outlay of funds for equipment and operator training.

The membrane filter procedure has received wide acceptance for analyzing the bacteriological quality of water. This procedure is relatively simple and produces reliable results in the hands of an operator who has acquired the minimum but essential training. The Federal Water Quality Administration has the capability of providing the necessary training. A five day course, offered periodically throughout the country, is open to attendance by all interested persons. If there is sufficient demand, the course can be scheduled for presentation in Alaska, preferably at the Alaska Water Laboratory in Fairbanks where laboratory space and equipment are available. Perhaps, when the details of the operational procedure are established, it may be found that the requirements for training differ sufficiently from the existing course to warrant the development of a three or four day course specifically for the Alaska need. The FWQA is available to help fill the need on request.

The equipment for bacteriological analysis of water can be obtained for a fairly low initial investment. A great deal of money can be invested in equipment, but this is not necessary unless extensive studies, where a large number of samples must be handled in a short time, are planned. In addition to on site requirements, there is a very important role for a central support laboratory. This role includes logistic support and, probably the most important, technical advice for the local operator in maintaining the quality of his work, finding the source and eliminating contamination when it occurs, and other support which may be desirable or appropriate.

The author feels strongly that the bacteriological monitoring of water supplies must be improved. It is hoped that this paper will stimulate further discussions and that a workable system can be developed with the participation of all concerned groups.

Of course, along with maintaining and improving the water supply, another means of reducing the potential hazard of contamination is to improve sewage collection, treatment, and disposal systems.

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