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Pollution Study in the Boundary Waters Canoe Area

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Abstract. Bacteriological quality of water along commonly used canoe routes in the Boundary Waters Canoe Area along the Minnesota-Canadian border was checked by estimating the most probable number (MPN) of coliforms and total plate counts of samples collected over a wide geographic area. Results show that much of the water used for drinking purposes does not meet United States Public Health Service standards for potability. Additional study is needed to determine (1) whether USPHS standards have any validity as applied to wilderness waters where high counts probably do not indicate human fecal contamination and (2) whether animals contributing to high counts of coliforms are or might become carriers of water borne organisms pathogenic for man.

A preliminary bacteriological study of waters in the Boundary Waters Canoe Area along the Minnesota-Canadian border near Ely, Minnesota, was undertaken between July 27 and August 17, 1967. Much of this area is remote and people traveling by canoe customarily drink untreated water directly from lakes and streams. Disposal of excreta is primitive. Poisonings by algal toxins have been reported from time to time and fatal poisoning of two dogs during the summer of 1967 was confirmed as having been caused by the accumulation and decomposition of blue-green algae at the outlet of Shagawa Lake at Ely (personal communications from Mr. Robert Sharp, St. Louis County Health Department, and Mr. Robert Brice, Federal Water Pollution Control Administration). Dysenteries of varying severities are fairly common and fungus infections acquired by swimming in contaminated waters have been reported.

Estimates prepared by the U. S. Forest Service indicate that the number of persons using the BWCA tripled from 1961 to 1966 for a total of 632,000 visitor-days of use in 1966. Residents of 45 states visited the Superior National Forest and one of five of these also visited Canada. Certain areas are subjected to a major portion of this traffic, with 30 percent of the total entering through Moose Lake and 16.6 percent entering through Fall Lake. For these reasons, knowledge of the water quality becomes increasingly important from a public health point of view.

Major pollution is suspected to occur at Ely, Minnesota, and to follow lake and stream currents through Shagawa Lake and the Shagawa River into Fall Lake, thence into Newton, Basswood and a

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series of lakes and rivers along the United States-Canadian border. At times of heavy load, untreated domestic sewage is by-passed at the Ely sewage treatment plant and enters Shagawa Lake approximately 200 feet from the city's main swimming beach. Coliform counts of 500 to 900 organisms per 100 ml. of water have been found in samples taken at this beach by the St. Louis County sanitarian. The main bulk of sewage effluent has undergone secondary treatment and chlorination but contains sufficient nutrients to support a heavy and continuous bloom of algae on Shagawa Lake and the lakes immediately below it.

In 1946 the United States Public Health Service established bacteriological standards for drinking water(1). A most probable number (MPN) of 2 coliforms organisms per 100 ml. and a total plate count of 100 organisms per ml. is considered as acceptable.

The genera *Salmonella* and *Shigella* include most of the important causative agents of intestinal diseases in man. These pathogens are transmitted almost exclusively by fecal contamination of water, food and milk, and transmission by water is by far the gravest source of infections such as typhoid, paratyphoid and dysenteries. These pathogens are difficult to isolate and identify and it has long been public health practice to ascertain the occurrence of fecal contamination by demonstrating the presence of *Escherichia coli,* a nonpathogenic but constant inhabitant of the intestines of man and other warm-blooded animals. A relatively high bacterial population in water is also a suspicious but not a specific indicator of fecal pollution.

Procedures

Facilities of the Associated Colleges of the Midwest Wilderness Field Station were made available for this study. Water samples were collected on several short trips made by motorboat and on two canoe trips into less accessible areas.

Field adaptations of the methods given for enumeration of coliforms and total plate count in *Standard Methods for the Examination of Water and Waste Water*(2) were employed. The only variation from the standard method of determining most probable number of coliform organisms was incubation time and temperature. A 35° incubator was available in the laboratory, but electricity is not provided at the station from 10:30 P.M. to 6:00 A.M., and during the night the temperature dropped to 25-28°. Some tubes were inoculated in the field and carried at ambient temperature until returned to the laboratory. To compensate for reduced temperature, incubation time was extended to 72 hours. Plate counts made at the station utilized a standard pour plate technique using 1, 0.5 and 0.1 ml. aliquots, or 0.1 ml. was spread over the surface of a previously poured plate with a sterile bent glass rod. They were incubated immediately and examined after two and three days. Plate counts made in the field on the long canoe trip (8/10 through 8/16) were made on previously poured plates, using three 0.1 ml. aliquots spread over the surface with the sterile pipette used to measure the sample. These were carried at ambient temperature until 8/16, at which time they were placed in the station incubator.

Plate counts of a known pure culture of *Escherichia coli* on violet red bile agar and standard plate count agar were made in the laboratory at Coe 7/19. Triplicate plates of duplicate samples were incubated at 35° (standard incubation temperature) and room temperature (variable near 25°) to determine the reliability of counts made using non-standard incubation. Counting after 24 and 48 hours incubation showed no difference between the two temperatures, although colony size was greater at 35°. *Escherichia coli* grew well at both temperatures.

Data and Results

A total of 68 samples of water were examined, with MPN of coliforms ranging from 0 to infinity and plate counts from 40/ml. to TNTC (too numerous to count). A series of nine samples collected in geographical sequence from Ely along the flow through lakes and rivers downstream failed to show a pattern of high pollution followed by diminishing counts, but none of the sample was of potable quality. Since this is a heavily travelled route, pollution may be contributed by additional sources below Ely. (Table 1.)

Table 1

Description	MPN	Plate Count
Effluent from Ely Sewage Plant	11	590
Shagawa Lake, 500 yards from Sewage Plant	2	1,360
Source of Shagawa River	33	1,920
Shagawa River at Winton	11	2,120
Above Pipestone Falls	6	760
Below Pipestone Falls	41	1,430
Off Pipestone—Jackfish Gauging Station	46	100
Basswood Falls	2	640
Crooked Lake off Table Rocks	39	300

A comparison of samples taken along the direct flow with samples taken from the same geographic area but away from the main flow shows the effect of heavy use or direct flow from a polluted area. It is probable that these differences in coliform counts represent human pollution, as animal populations would be likely to be greater away from the most-used canoe routes. (Table 2.)

The major inflows into Basswood Lake are (1) at Prairie Portage where water enters from the Moose Lake chain, a very heavily travelled waterway, (2) at the Pipestone-Jackfish inlet, also heavily travelled, and (3) at South Creek into North Bay. Samples taken at these points show a relationship between heavy use and fecal contamination

Table 2

Description of Sample	MPN	Plate Count
Portage, Back Bay to Pipestone, Back Bay side, NOT on direct flow or heavily travelled route	9.2	65
Portage, Back Bay to Pipestone, Pipestone side, on direct flow	Infinity	203
Basswood, between King's Point and small island, NOT on direct flow	0	180
Off Gauging Station where Pipestone and Jackfish enter Basswood	46	100
Jackfish Inlet into Pipestone	5	640
Jackfish Bay, NOT on direct flow	2	40
Pipestone Inlet into Jackfish, small bay, NOT on direct flow	2	120
Off Gauging Station where Pipestone and Jackfish enter Basswood	46	100

and dimunition of coliform counts as the water from these areas is diluted in the lake. As shown in Table 3, the highest coliform count was obtained from the point of greatest use, Prairie Portage, while the lowest count from an inlet was at South Creek, which drains a remote area.

Table 3

Description	MPN
Prairie Portage	Infinity
Basswood Lake between Prairie Portage and Canadian Customs	Infinity
Basswood Lake off Canadian Customs	9.2
South Creek into North Bay	9.2
Basswood Lake, Entrance to North Bay	0
Off Gauging Station where Pipestone and Jackfish enter Basswood	46
Basswood Falls, Main Outlet from the Lake	2

Twelve samples taken near habitations, houseboats or campsites on Basswood Lake showed MPNs ranging from 9.2 to infinity with plate counts of 90 to 2,800 per ml. Thre samples taken away from the shore of the same lake showed no coliforms. Samples taken near a campsite and away from shore on Brent Lake showed MPN of 345 and 172, respectively, and plate counts of 300 and 50.

Results from ten samples taken in remote areas appears to indicate that high numbers of coliforms are not always associated with *human* fecal contamination, but may be correlated with populations of beaver. Samples taken in beaver ponds and near beaver lodges consistently gave counts from 200 to infinity.

Discussion

Very few lakes can be considered to be "of drinking water quality" if USPHS standards are applicable to wilderness waters. The enumeration of *Escherichia coli* in wilderness waters is of questionable value unless some relationship has been or can be established between beaver feces and human disorders. In isolated lakes, not on portage routes, high MPN is not likely to be associated with human fecal pollution. Some organism more specific to the human intestinal tract than is *E. coli* should be used as an indicator of pollution.

Plate counts of total bacteria vary widely, as would be expected, with location of sample site, time of sampling (after heavy rain in contrast to prolonged fair weather, or following a weekend of heavy use of a particular area), presence of beaver, etc. To give a single count for a large lake such as Basswood is obviously nonsense. The U. S. Forest Service has recorded a plate count for *E. coli* of 8/100 ml. for "Basswood Lake" on 6/29/67. Samples obtained from various parts of Basswood Lake between 7/27 and 8/7 showed a range in MPN of 0 to infinity and total plate count of 40 to 2,800. Plate counts may correlate with organic matter. Many bays and lakes are full of dead and decaying trees. It is difficult to assign any public health significance to a high plate count under these conditions.

From a public health viewpoint, USPHS standards for drinking water probably do not apply to many of the lakes. On the other hand, the high MPN and plat count in areas of heavy human use where animals are comparatively few does mean something. For example, water from Pipestone Bay, Pipestone Falls, Basswood River, Crooked Lake, etc., is probably unsafe to drink, while water from other lakes with the same or higher MPN and plate count may be quite safe.

Canoeists are not going to be bothered to boil and portage water. They might be persuaded to carry and use Halozone tablets. They should be warned about areas where the water may be unsafe.

Conclusions

Basic research is needed on methods of evaluating public health hazards of bacterial and other contaminants present in wilderness waters. An organism more specific to the human intestinal tract than *E. coli* is needed as an indicator of pollution. Isolation and identification of organisms in the genera *Salmonella* and *Shigella* from beaver or from water in the vicinity of beaver houses might or might not show species of known human pathogenicity.

References

1. Public Health Service Drinking Water Standards. U. S. Department of Health, Education and Welfare. Public Health Service Publication No. 956, 1962.
2. Standard Methods for the Examination of Water and Wastewater (12th ed.). New York: American Public Health Association, 1965.