A BACTERIAL WATER QUALITY INVESTIGATION OF CANYON LAKE

by

W. F. Horak and G. S. Lehman

During the summer of 1972, personnel of the Tonto National Forest regularly sampled waters of major recreation areas on the Salt River reservoir system. These samples were assayed for fecal coliform bacteria, the presently accepted indicator of recreational bacterial water quality. The anaylses indicated the periodic occurrence of fecal coliform counts in excess of the 200 counts per 100 ml level recommended by the Committee on Water Quality Criteria, Federal Water Pollution Control Administration. Concern over the possibility of health hazards attending the bacterial counts prompted the Forest Service, in conjunction with the University of Arizona, to initiate an intensive study of the fecal contamination problem in order that criteria for corrective measures might be formulated.

Canyon Lake was chosen for the study inasmuch as samples from Acacia and Laguna swimming areas of the lake, on three occasions each during the summer of 1972, contained greater than 200 fecal coliforms per 100 ml of water. Initially, eight sampling stations were established in locations where a pollution potential was believed to exist and a ninth point was located near the dam. Data collected during the first sampling period, the weekend prior to the fourth of July, 1973, showed that only in the Acacia swimming area did the coliform count reach significant levels. It was, therefore, decided to delete all other locations from the sampling network and to add two more points in the Acacia area so that efforts could be concentrated where the probability of pollution was greatest. The stations at the east and west extremes of the swimming area, numbered 6 and 7, respectively, were retained and two more, numbered 10 and 11, were added approximately 100 and 300 feet east of the swimming area (figure 1). The latter two stations were so located in order to monitor the eastward migration of coliforms under the influence of the prevailing westerly winds. Also, leakage from the pit privy near the east end of Acacia beach, which could have contributed to contamination, could be detected at these stations.

The authors are Graduate Research Assistant and Associate Professor of Watershed Management, respectively, Department of Watershed Management, The University of Arizona, Tucson.
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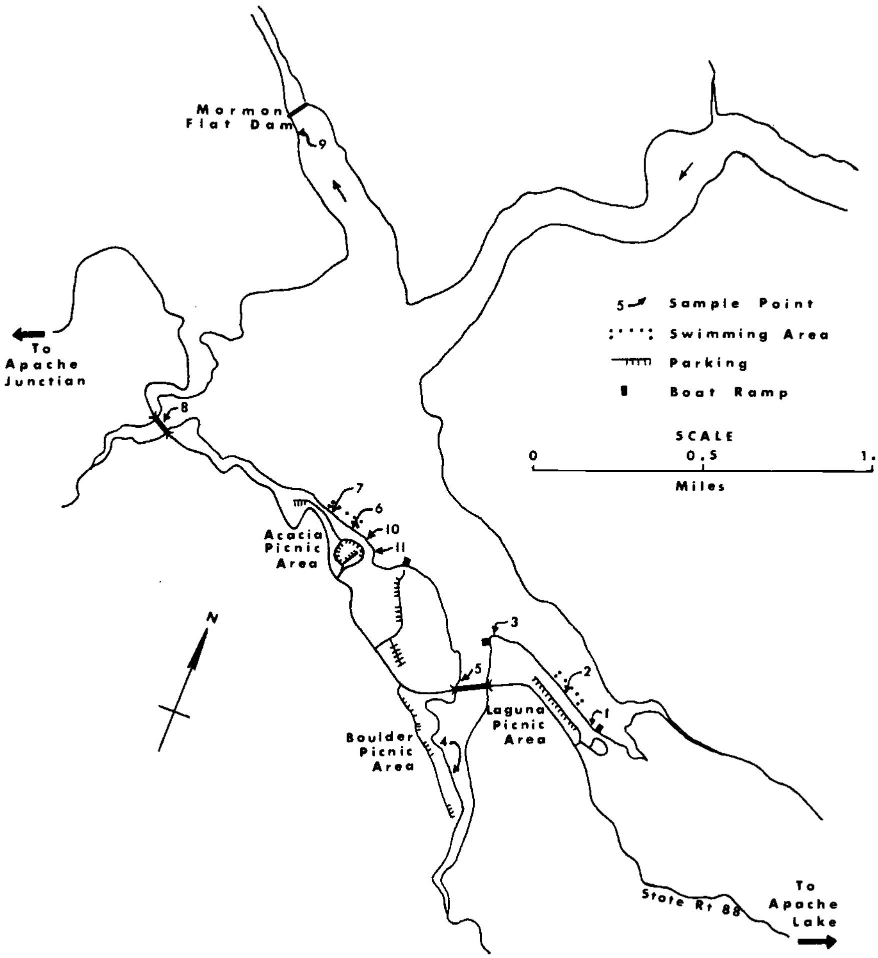

Figure 1. Canyon Lake, Tonto National Forest, Arizona

In addition to fecal coliform analyses, other recorded data included user car count in the Acacia parking area (as an indication of the number of users of the swimming area), water temperature, turbidity, and dissolved solids. Wind direction and relative velocity were also noted at each sampling time. The only parameter showing a significant correlation with fecal coliform count was the car count. Figure 2 shows the relationship between fecal coliform count and car count at the west and east ends of the swimming area, respectively, for the weekend preceeding the fourth of July, 1973. A fairly brisk wind prevailed from the west during this period. The data for station 7 indicate an excellent correlation between coliform count and car count. Station 6 data show a lesser correlation possibly due to the effect of the wind. It is believed the increase in coliform count at station 6 on the morning of July 2 was the result of strong westerly winds during the previous evening. This increase in organism count occurred during a period when visitor use decreased.

Figure 3 represents the coliform and car count data obtained the weekend of August 10 to 14. The coliform peak levels were higher each day at the eastern end of the beach. This, again, shows the effect of the westerly wind in carrying the organisms to the east. The figures show that for station 7 the coliform count peaks during or slightly after the peak use period and then falls off sharply. The duration of the high count seems to be only a few hours and is probably a function of the wind speed.

Neither station 10 nor 11 to the east of Acacia beach produced samples with coliform counts in excess of 16 organisms per 100 ml, except following the rain on August 13. Station 10 had counts equal to or greater than those obtained at the more easterly station 11 at all times. Peaks in coliform counts for these two stations lagged 3 to 6 hours behind the peak at station 6 at the east end of the swimming area. The lower counts in these areas receiving little user contact was attributed to the dilution factor and to the settling of sediments and attached organisms with distance away from the swimming area.

Note the effect of a light rain shower at 4:00 p.m., August 13. At the 3:00 p.m. sampling time, the coliform counts were 18 and 3 per 100 ml. By 7:00 p.m. coliform colonies in the culture dishes were too numerous to count, but certainly were in excess of 400 per 100 ml. Judging from the paucity of rainfall and the short response time of the high count, the bacterial source was probably near-shore or beach contamination.

The over-all correlation between coliform count and car count was about 50%. Assuming car counts are an accurate indication of the number of swimmers at any given time, this modest correlation indicates a pollutional regime influenced by factors

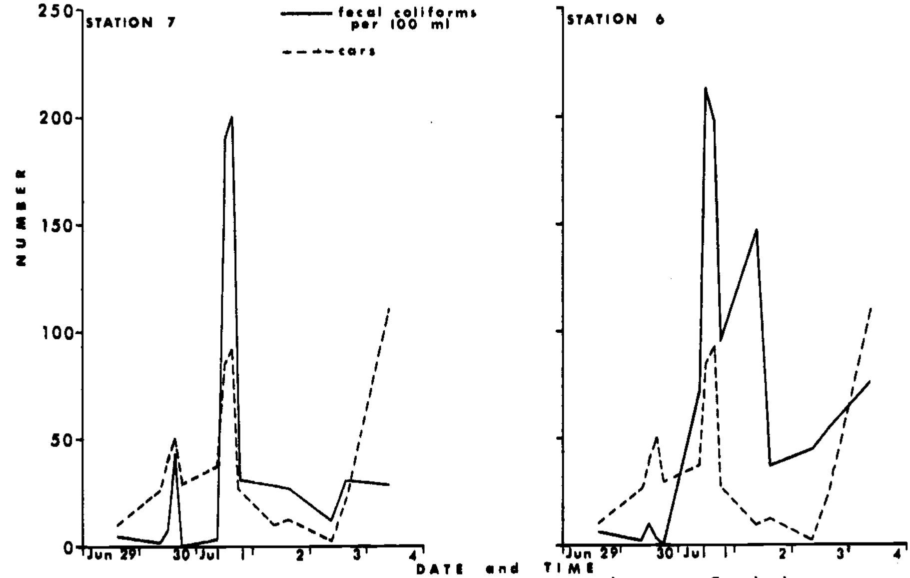

Figure 2. Relationship of car counts as an index of visitor use and fecal coliform counts for sampling stations 6 and 7, June 29 to July 4, 1973.

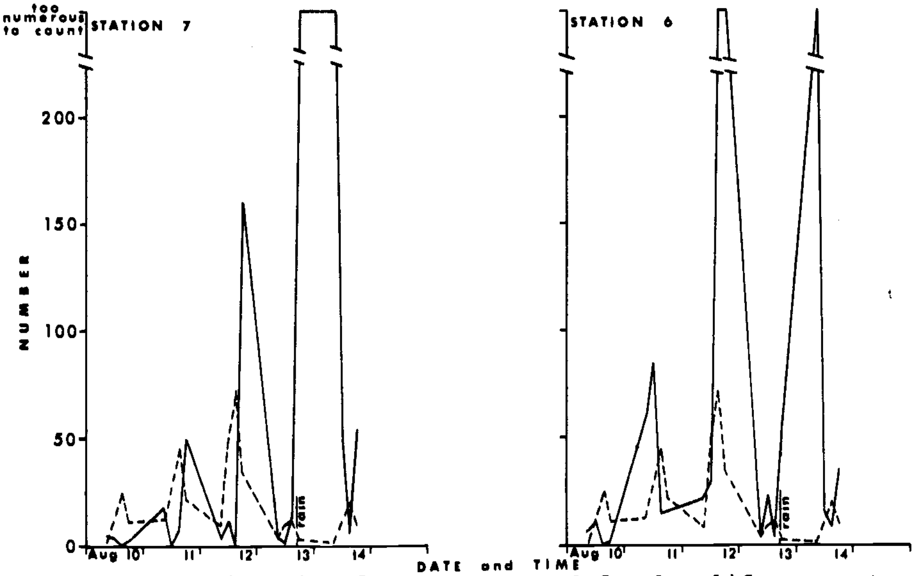

Figure 3. Relationship of car counts and fecal coliform counts for sampling stations 6 and 7, August 10 to August 14, 1973.

other than just the immediate user load. No doubt a substantial portion of the organisms are shed from the swimmers. That this source may be of importance has been proven in controlled experimentation (Robinton and Mood, 1966, and Hanes and Fassa, 1970).

Swimmers also agitate the bottom sediments, consequently dispersing much of the bacteria contained in the benthos into the overlying water. The literature indicates that fecal coliform densities are commonly 100 to 1000 times greater in mud than in the overlying water and that bottom sediments serve as a protective medium accessory to extended microbial survival (Van Donsel and Geldreich, 1971). As the lake bottom over much of the Acacia swimming area is quite silty and is easily dispersed, sediment-stored bacteria probably are a substantial portion of the observed coliform count. Since little remedy exists to relieve the problem of direct contamination from swimmers short of chlorination or a reduction of usage, the most promising means of alleviating the bacterial pollution appears to be the identification and elimination of the sedimentary bacteria source.

In order to determine the contribution from livestock waste on adjacent rangeland to the contamination of the swimming area, fecal streptococci analyses were made for two days of the sampling period in August. It has been demonstrated that the ratio of fecal coliform to fecal strep is greater than four when the source of contamination is solely human feces and less than 0.7 when the source is only animal waste (Geldreich and Kenner, 1969). The few Acacia swimming area samples for which this ratio was determined implicate livestock waste as the primary source of pollution. However, this interpretation could be misleading in light of the data available from bacteria survival studies. Assuming that a large portion of the bacteria cultured from the water samples are derived from disturbed sediments, figure 4 illustrates how the fecal coliform-fecal strep ratio will continually lessen with storage time. Within seven days after deposition more than three times as many fecal streptococci will have survived as fecal coliform organisms. This differential survival characteristic attests to the importance of sampling close to the point of contamination, both temporally and spatially, to assure accurate interpretation of the results. In a still water body with a high capacity for sediment storage it is very difficult, if not impossible, to sample only a fresh bacterial population.

Future investigative efforts will be designed to identify the major source of contamination, whether it be from swimmers or from nearby livestock waste which is carried to the lake with storm runoff. Fecal coliform-fecal strep ratios will be determined and benthos bacterial populations will be monitored in an attempt to establish the water pollution contribution from sediment-stored bacteria. An attempt will be made to correlate the degree of bottom disturbance with coliform count in water samples.

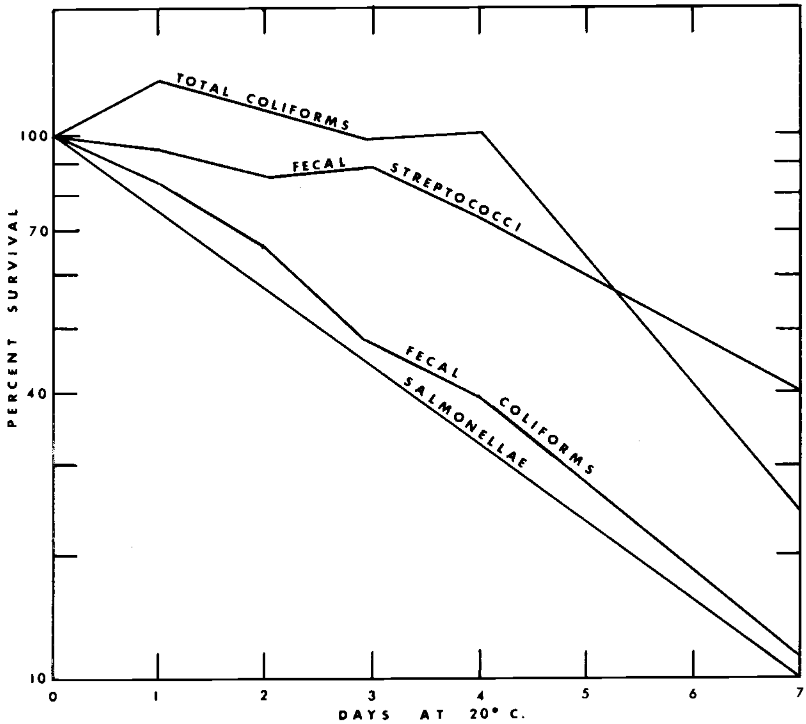

Figure 4. Averaged survival of salmonellae and indicator bacteria in 3 mud samples stored at 20° C. (from VanDonsel and Geldreich, 1971, p. 1083)

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