Water Quality and Fecal Contamination on Mt. Aconcagua:
Implications for Human Health at High Altitude

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An expedition was conducted on Mt. Aconcagua, Argentina, in January 2002 to assess and reduce environmental damage and human health risks from fecal contamination of high-altitude water sources. Water samples and trash were collected at various high-altitude camps ranging in altitude from 2950 to 5950 meters. Water samples were tested for fecal contamination using a combined E. coli and total coliform test. Sample incubation near body-temperature was performed using a phase-change incubator that can be charged by heating in boiling water. Coliform organisms were found in several mountain water sources and both coliform and E. coli were found in one stream. Cold temperatures prevented testing of liquid water sources above 14 thousand feet and analysis of frozen samples above this altitude yielded negative results. The results suggest that both native and fecal coliform exist in Mt. Aconcagua water sources. Additional epidemiological evidence is required to evaluate the impact of current and future fecal contamination on human health.

Hypothesis: We hypothesized that fecal contamination of Mt. Aconcagua water sources is a significant and growing problem due to (a) the large number of trekkers and climbers that enter the park each year, and (b) the presence of significant quantities of fecal material near several high-altitude campsites.

Background: Mt. Aconcagua, at an elevation of 6962 m (22841 ft) above sea level, is the tallest mountain in the Americas, and is located in the Provincial Park of Aconcagua, entirely in Argentina, near the Argentina-Chile border at latitude 32 degrees 39 minutes. The high altitude of Aconcagua, combined with the availability of a non-technical climbing route to its highest peak (the Normal route – see Figure 1), draws thousands of mountaineers from all over the world each year from December to March.

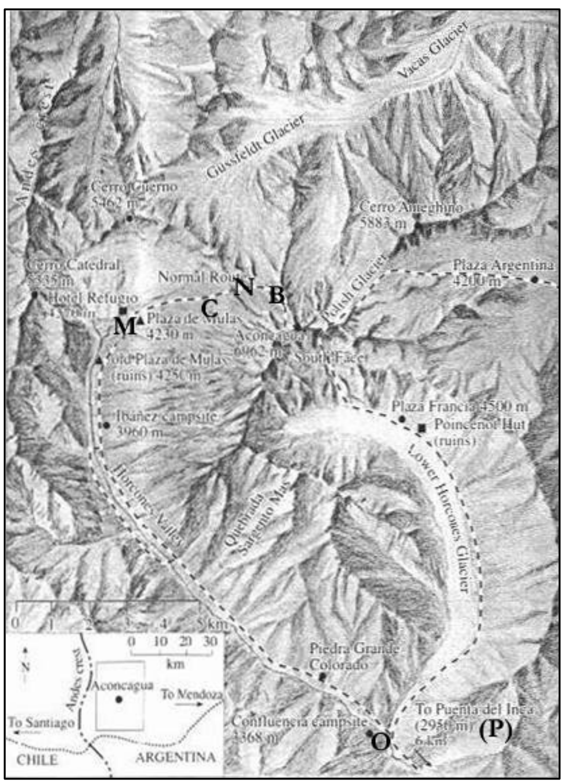

Figure 1 – The Normal route follows the Horcones valley from Puete del Inca (P, 2950m) through Confluencia (O, 3368m) to the base camp at Plaza de Mulas (M, 4380m). Above Plaza de Mulas, the most commonly used camps are Camp Canada (C, 5050m), Nido de Condores (N, 5545m), and Berlin Camp (B,5950) (adapted from [Secor, 1994]).

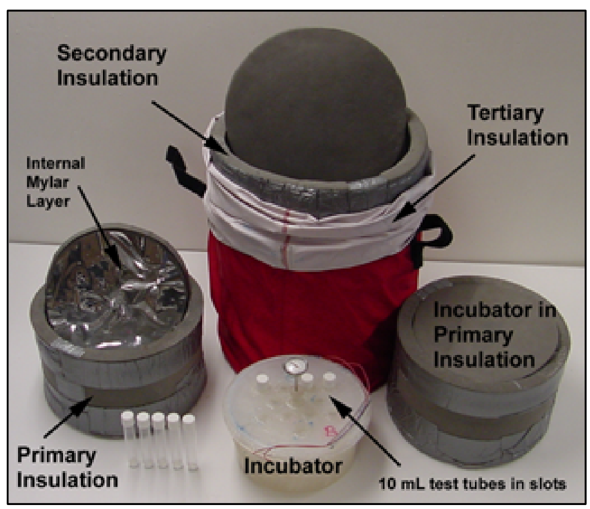

Figure 2 – A multi-layer insulation system was developed to reduce heat flux from the incubator during incubation in cold temperatures.

Methods: We chose the Colilert™ system from IDEXX to simultaneously detect total coliform and E. coli. Samples were aseptically collected and transferred to five prefilled 10 mL Colilert™ tubes, incubated for 24 hours at 35°C and then assessed for bacterial growth using a phase-change incubator, designed by Amy Smith of the MIT Edgerton Center (Figure 2). Two incubators each with 12 tube slots were used, allowing four samples and four tubes serving as negative controls (prepared using sterile water) to be analyzed concurrently. Incubator and ambient air temperatures were monitored before and after incubation using a thermometer and during incubation by a data logger (Figure 3).

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A comparator solution was used to perform color comparison to determine coliform-positive (yellow) or E. coli-positive (fluorescent) results.

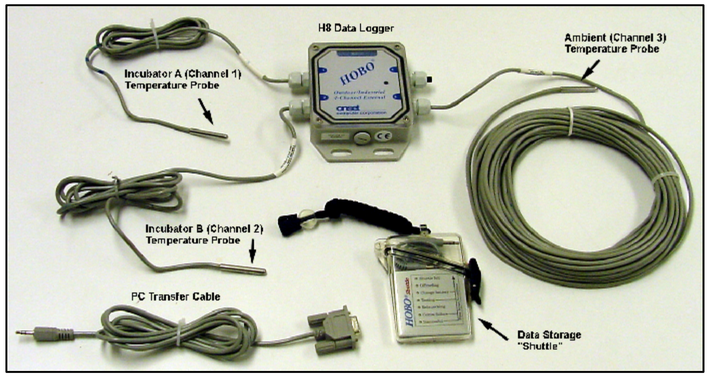

Figure 3 – A HOBO data logger system was used to record temperature data every four seconds. The temperature sensors have a resolution and accuracy of 0.41°C and 0.5°C respectively at a temperature of 20°C.

Results: Samples were collected at 17 sites between January 14-22, 2002, and four incubations of four samples each were performed. All incubations maintained temperatures of 35 ± 1°C as verified by data logger measurements and manual temperature measurements (Figure 4). The drinking water source of Confluencia tested positive for coliform, and a river sample at the old Confluencia campsite tested positive for coliform and E. coli. The Plaza de Mulas stream tested negative upstream of the camp and strongly positive downstream of the camp. Samples from two Plaza de Mulas small lagunas tested weakly positive (one tube of each sample), as did a snow sample near Camp Canada.

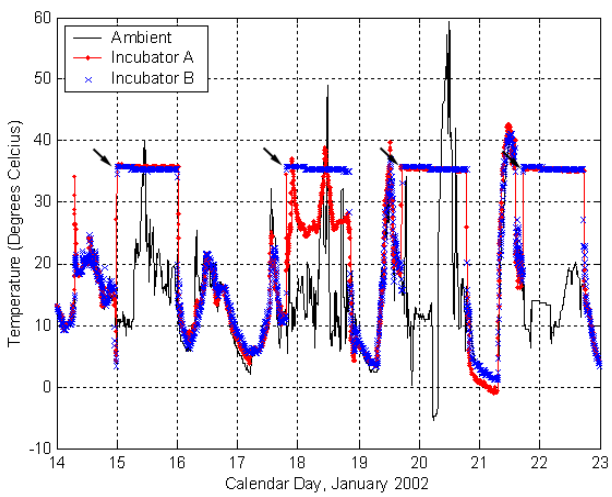

Figure 4 – Data logger-measured incubator and ambient air temperatures during the expedition. An arrow indicates the start of each incubation.

Discussion: The Confluencia water source coliform is likely to be native, but the proximity of the old Confluencia camp to the E. coli-positive sample suggests that longstanding contamination may be a problem. In addition, the Plaza de Mulas stream results are strong evidence of coliform contamination caused by human fecal waste.

Approximately one to two people are diagnosed with a water-borne illness each week by the Plaza de Mulas medical staff during the climbing season [8]. While many more people seek medical attention each week due to altitude-related illness, many who contract water-borne illnesses or parasites due to direct fecal contact or poor hygiene likely fail to report their illnesses, choosing to self-treat problems such as occasional or recurrent diarrhea, intestinal cramps, nausea, and dehydration. Some of these symptoms can also be confused with symptoms of acute mountain sickness, and may therefore go unrecognized. While evaluation of water quality is an important first step in understanding the health implications of fecal contamination of high-altitude water sources, additional epidemiological work is needed to determine fecal material disposal practices, hygiene standards, and standards of water purification actually in use on Mt. Aconcagua and on other mountains. Cases of water-borne illness requiring medical attention may be rare, but the effects can be acute and can seriously aggravate existing health problems at altitude.

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