A SCREENING ASSESSMENT OF EXTERNAL RADIATION LEVELS ON THE SHORE OF LAKE ISSYK-KYOL IN THE KYRGHYZ REPUBLIC

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ABSTRACT

The Kyrghyz Republic, located in the southeastern region of the former Soviet Union, holds a long history of atomic weapons development activities. Historical surveys, conducted primarily for geological exploration, have indicated that areas of shoreline on Lake Issyk-Kyol in the Kyrghyz Republic have relative radiation levels in excess of background by as much as a factor of ten. Nuclear testing in China and uranium mining operations in the mountains surrounding the lake may have resulted in the contamination of a number of areas on the lake's southern shore. The valley region maintains a population of more than one-half-million persons and is heavily dependent on the lake to draw tourists to the area and its utilization by some as a food and recreation source. In this paper, we show the results of a screening assessment of relative radiation levels along the shoreline of Lake Issyk-Kyol to pin-point areas of relatively high exposure rate.

INTRODUCTION

Lake Issyk-Kyol is situated in the northeast region of the Kyrghyz Republic, one of the newly independent states of the former Soviet Union, and bordered by China, Kazakstan, Uzbekistan, and Tajikistan (Fig. 1). The lake is one of the largest in Central Asia, having a depth of 668 m and a surface area of 6,240 km^2. It covers a significant portion of the valley lying between the Terskei mountains to the north and the Kungei mountains to the south, at a surface elevation of 1,550 m (CAGC 1987). Mountain runoff flows into the briny lake through about 80 small rivers and creeks. Lake Issyk-Kyol contains various types of edible fish including sea trout, sheatfish, pike, and perch. In addition to recreational fishing, it is used for swimming and boating, but because of its salt content, it is not a direct source of drinking water. During the Soviet era, Lake Issyk-Kyol was a well known vacation spot for the Soviet elite, but remained in virtual isolation from the outside world until the early 1990’s. Today, the lake attracts tourists from all over Central Asia.

Historical measurements suggest the presence of a few areas on the lake’s southern shore where radiation levels are in excess of ambient background. The radiological impact on Lake Issyk-Kyol has been primarily the result of local industrial mining and international nuclear weapons testing. Mining activities, primarily to obtain uranium ore, have since ceased, but were prevalent during the cold-war era. Operations at several uranium mines near the southern shore of Lake Issyk-Kyol were conducted in the 1940's and 1950's. Large amounts of soil were unearthed from these uranium-rich areas. Years of rainfall and mountain runoff have moved uranium tailings, thus introducing a concentrated source of radioactivity into the lake's ecosystem. Events leading to the introduction of man-made radionuclides into the environment of Lake Issyk-Kyol include world-wide nuclear weapons tests, particularly those in China. Approximately 400 kilometers to the east, over the Tian-Shan mountains is an active nuclear weapons test site in Lop-Nor, China. Above- and below-ground testing has occurred at the site for many years. Omuraliev et al. (1995) report that during the mid-to-late 1970’s, fallout beta radiation was detectable, but that levels have been near background since 1987.

Although abandoned for a number of years, a heavy water plant was operated by the Soviets on the lake's southern shore near Bokonbaevo (Fig. 2). This facility extracted deuterium, used to moderate Soviet nuclear reactors, from lake water. There are no radionuclides generated from the operation of a heavy water facility and, therefore, the plant should not have been a source of radioactivity to the environment. Measurements have shown, however, that isolated locations in, and in the vicinity of, the heavy-water plant have elevated radiation levels compared to outlying areas.

An investigation of radiation levels along the shoreline of Lake Issyk-Kyol was conducted previously by Kyrghyz scientists (SCSC 1990). Likewise, the Kyrghyz Department of Geology has collected data to prepare radioecological maps of gamma exposure levels in the region (Karpachov 1996), primarily for uranium and oil exploration. The SCSC (1990) survey resulted in nearly 400 measurements taken with a 1960's vintage Soviet-made NaI detector coupled to an analog ratemeter. At each location, relative radiation levels were determined at 1 m and 0.1 m from the surface. Measurement locations were recorded by hand and were based on prominent landmarks in the area. Sampling locations included both the southern and northern shore of the lake, starting at the town of Karakol to the east (see Fig. 2), moving west around the southern shore to Balykchy, then moving east along the northern shore, ending again near Karakol. The results of these historical measurements are shown in Fig. 3 (SCSC 1990). Sampling locations in Genish, Kadji-Sai, Bokonbaevo, and Cholpon-Ata indicate radiation levels in excess of ten times ambient levels (SCSC 1990).

A government commission in Kyrghyzstan was established from 1994 to 1996 to assess the radiation situation at Lake Issyk-Kyol and determine whether radioactivity in areas with elevated radiation levels was natural or man-made. To corroborate their data, we have completed an independent radiological assessment of the shoreline of Lake Issyk-Kyol with more sophisticated radiation survey instrumentation and global-positioning equipment than used in the earlier surveys.

METHODS

Data collection. Our screening measurements were taken during the spring and summer of 1997 and 1998. Approximately 2,200 radiation measurements were collected at more than 400 locations near the mouths of streams emptying into Lake Issyk-Kyol, along the shoreline of the lake, and, based on earlier assessments, at specific locations believed to have elevated radiation levels. During this survey, relative exposure was recorded using an E600 Portable Radiation Monitor[*] coupled with a SPA-8 NaI (1" x 1") probe maintained at 1 m above the ground surface. At a few locations where exposure rates were elevated, additional measurements were taken at 10 cm above the surface to determine whether radiation contributions were from localized sources. Calibration of the E600 was conducted by the manufacturer and confirmed with a 27-mCi ^{137}Cs source at the University of Michigan prior to obtaining field measurements. The active energy range of the SPA-8 is from 40 keV to 1.3 MeV. Energy response, however, is not linear at energies less than about 100 keV (Fig. 4) and energy spectroscopic information was not available, therefore, radiation levels presented herein are "relative to background" for the active energy range of the detector.

Measurements with the E600 were recorded at regular intervals in its internal memory, along with time and date, while the surveyor walked predetermined paths around the lake's perimeter and along selected river inlets. A recording global positioning satellite (GPSR) receiver[†] was used to log positional data. The GPSR is a small, self-contained unit that automatically records date, time, latitude, longitude, course, and speed on a removable PCMCIA memory card. Data were stored at 10-second intervals during our investigations. Because of the physical size of Lake Issyk-Kyol, more than a dozen separate expeditions were required to gather data. Expeditions were scheduled during the spring and summer months because of the large amounts of snowfall covering the shoreline during winter.

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[*] Eberline Instruments, P.O. Box 2108, Santa Fe, NM 87504.
[†] Control Trac, Inc., 903 Main Street, New Ellenton, SC 29809.

Data reduction. Data stored in the E600 and the GPSR were downloaded to a PC at the end of each expedition. The synchronized time and date stamps of data points from each instrument were used to match measured radiation levels with shoreline location. Because of the uncertainties associated with the GPS unit (positional accuracy of approximately 20-70 meters), average exposure rates were determined by reducing the data to a resolution of six one-hundredths of one minute in both latitude and longitude. This resolution is approximately equal to the resolution of the GPS receiver. Averaged and hot-spot data were compiled separately to present large-area averages and localized areas of elevated exposure levels. At times, the radiation level at the hot-spots exceeded 10 times background. The hot-spots have great importance because these areas are very localized and in some instances, comprise areas only a few meters in diameter, much smaller than the resolution of the GPS unit.

RESULTS AND CONCLUSIONS

The results of our survey are similar to historical measurements in that they corroborate Kyrghyz data as to the locations of elevated radiation levels. A few areas on the shore of Lake Issyk-Kyol have relative exposure rates signficantly above ambient levels (Fig. 5). We have located three areas on the southern shore where localized radiation levels are appreciably higher than the surrounding region. The data at Location 1, although near the former heavy water facility, are associated with very small areas that contain coal ash from Kadji-Sai. At Location 2, the data show no elevated levels inside the village of Kadji-Sai, however, about 1 km to the northeast there are radiation levels 2-3 times higher than background. The measurements approximately 2-km NE of Kadji-Sai leading from the lake shore, south along a dried stream bed indicate that activity from the uranium tailings site has not migrated appreciably to Lake Issyk-Kyol. Because of the appearance of black sands at the sampling location, elevated radiation levels near Genish (Location 3) appear to be associated with monazite deposits.

Measurements by our international team of scientists confirm the existence of areas with elevated levels of radiation exposure on the southern shore of Lake Issyk-Kyol, in the Kyrghyz Republic.

Historical evidence provides insight into the possible sources of the radioactivity, however, we have not seen results that would suggest contamination from man-made sources. On the contrary, at this early stage, our investigations indicate that the source of elevated radiation levels are from natural deposits of radioactivity.

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FIGURE CAPTIONS

Fig. 1. Location in Central Asia of the Kyrghyz Republic and Lake Issyk-Kyol.

Fig. 2. The Lake Issyk-Kyol region with detail of major population areas, roadways, and in-flowing streams.

Fig. 3. Historical relative radiation levels on the shore of Lake Issyk-Kyol (beginning at Karakol, moving west along the southern shore to Balykchy, and then east along the northern shore to Tup, and back to Karakol). Quotes describing the terrain near high-radiation areas are translated from the original Russian documents. Solid lines under the names of villages depict the extent of the number of measurements collected within the limits of that village. Adapted from the data of SCSC (1990).

Fig. 4. Relative response as a function of energy for a 1 x 1" NaI detector (from Eberline, Santa Fe, NM).

Fig. 5. Relative radiation levels at specific locations on the shoreline of Lake Issyk-Kyol.