RECONSTRUCTING FALLOUT EXPOSURES TO THE U.S. POPULATION FROM WEAPONS TESTING IN NEVADA DURING THE 1950's

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ABSTRACT

Techniques used to reconstruct fallout depositions which included re-analyses of gummed-film and other monitoring data, retrospective soil and sediment sampling, and analyses of recent airborne gamma spectrometric survey data to locate fallout "hotspots" are discussed. Based on the resulting estimates of cumulative fallout deposition, external radiation exposure probably resulted in whole-body doses on the order of only 1 mSv to most of the U.S. population.

INTRODUCTION

During the years 1951 to 1958, over 100 above-ground weapons tests were carried out at the U.S. government's Nevada Test Site (NTS), located ~150 km NW of Las Vegas, Nevada. In recent years, considerable public concern has surfaced regarding possible radiation exposures to the population of states downwind from the NTS. This concern has manifested itself in a number of lawsuits filed against the U.S government. In response, a number of major reassessment efforts were begun, starting in 1979. These include: the U.S. Department of Energy-sponsored Offsite Radiation Exposure Review Project (ORERP), whose goal is to reconstruct both external and internal radiation exposures to the populations of states downwind from the NTS (Church et al. 1987); a Congressionally-mandated U.S. National Cancer Institute (NCI) study to estimate the thyroid exposure of the entire U.S. population to ^{131}I from NTS tests (Wachholz 1987; Bouville et al. 1987); and two NCI sponsored epidemiology studies being carried out by the University of Utah attempting to correlate the incidence of leukemia and thyroid cancer in certain downwind populations with exposure to NTS fallout (Rallison and Lotz 1987; Lloyd et al. 1987).

All of these studies have one common requirement, namely, estimates of fallout deposition from each weapons test. These deposition estimates are then incorporated into various food-chain models, structure-shielding models, etc., to estimate either external population doses or doses to particular organs. Most of the deposition estimates have been inferred from one of three major data sources: a) extensive survey meter monitoring in the region within a few hundred km of the NTS after each shot, b) estimates of daily fallout deposition at about 100 sites monitored throughout the U.S. using gummed-film, and c) retrospective estimates of cumulative fallout deposition from all NTS detonations inferred from residual amounts of ^{137}Cs and plutonium present in soil samples from undisturbed sites. Since the latter two resulted from the efforts of the Environmental Measurements Laboratory (EML) and represent the only comprehensive sources of actual data on deposition beyond the immediate downwind vicinity of the NTS, we have been closely involved, either directly or in an advisory capacity, in all the reconstruction efforts mentioned above. In addition, we have also developed and utilized several other innovative methods to supplement and corroborate the soil sampling, survey meter, and gummed-film data.

METHODS

In order to corroborate the deposition estimates, and corresponding radiation exposures inferred from survey meter monitoring, as well as to extend the estimates further downwind to areas where no monitoring was done, we developed a method of estimating cumulative fallout deposition from measurements of ^{137}Cs and plutonium isotopes in undisturbed soils (Beck and Krey 1983). The NTS ^{137}Cs contribution is distinguished from the generally greater "global" fallout contribution from the large thermonuclear explosions, conducted external to the continental U.S. during the early 1960's, by the greatly different ratio of $^{240}Pu/^{239}Pu$ for the two sources. Using this technique, we corroborated earlier fallout exposure estimates for close-in sites, and also showed that significant deposition occurred in areas as far away as the Salt Lake valley in northern Utah (Beck and Krey 1983). This finding led the ORERP to extend the scope of their study from the area immediately downwind from the NTS to as far east as western Colorado and northern New Mexico, utilizing the EML soil analysis technique.

The retrospective soil analysis technique, however, provides information on the cumulative NTS fallout deposition only. Its sensitivity is also limited due to the large "global" fallout "background" signal. Since most of the reconstruction efforts required more detailed information on exactly when fallout occurred at a given site as input to their dose pathway models, it was necessary to utilize the only other source of extensive data on fallout during this period, namely, the results of the EML gummed-film fallout monitoring network. Originally, these measurements of total beta activity deposited on gummed-film were intended only to give a gross indication of where significant fallout occurred after each shot. Quantitative deposition estimates based on these data were highly suspect due to uncertainties in collection efficiency, calibration, and other factors. An extensive re-analysis of the original data, however, has resulted in much more accurate estimates of individual radionuclide deposits from individual shots on a daily basis (Beck 1984; Beck et al. 1987). As a result, these gummed-film data are now being utilized as a prime source of deposition estimates for regions outside the area of survey meter monitoring in all the ongoing reconstruction studies.

Both the gummed-film deposition estimates and retrospective soil estimates have been shown to provide comparable results where data are available from both methods. Additional corroboration of both the temporal variation and the cumulative deposition has also been obtained for a few areas by examining the activity of ^{137}Cs and Pu as a function of depth in sediment cores taken from reservoirs and/or lakes in areas downwind from the NTS. The activity and isotopic composition in the various sediment segments can be related to deposits on the watershed occurring during particular time intervals, utilizing certain fiducial time markers. Comparison of the total inventory in the core with that on the shoreline then allows an independent estimate to be made of the average NTS and global fallout depositions over the watershed. The results obtained for two such watersheds in the state of Utah tended to corroborate the NTS fallout depositions inferred by other methods, providing an additional source of confidence in our total deposition estimates (Krey et al. 1987).

The retrospective soil sampling technique described earlier, while powerful in its ability to distinguish the source of the soil activity, is not an efficient method for surveying large areas. The total number of sites sampled by either EML or ORERP was only about 200, mostly in the more populated towns and cities. The survey meter monitoring which was carried out during the testing period was also limited in geographical extent. Thus concern continued to be expressed regarding the possibility of isolated undetected "hotspots" having occurred, perhaps as a result of washout by thundershowers or other localized meteorological phenomena. An additional retrospective survey technique was therefore utilized to search for these "potential hotspots". Fortunately, during the 1970's most of the U.S. had been systematically surveyed for possible sources of uranium ore by the National Uranium Resource Exploration Project (NURE), utilizing airborne gamma spectrometry. By carefully reexamining the gamma spectra so obtained over regions downwind from the NTS for indications of extraordinary high fluxes of 662 kev ^{137}Cs gamma rays, i.e., well above that which would be expected in that area from global fallout ^{137}Cs soil inventories, we were able to conclude that no NTS fallout "hotspots" of any significant extent or magnitude were likely to have occurred (Beck 1983).

In addition to the major sources of information on deposition discussed above, other less extensive sources also were utilized to supplement and confirm the data input into the various reconstruction programs. These sources included results of reanalyses of soil samples collected in various areas during the 1950's, meteorological modeling of cloud tracks for particular shots (Cederwall and Peterson 1987; Hoecker and Machta 1987), and data on fallout monitored in air and rain by the U.S. Public Health Service beginning in 1956.

DISCUSSION

Except for areas just outside the NTS, the cumulative depositions of fallout from Nevada weapons tests, and the resultant radiation exposures to populations, were quite small. Although detailed results for particular populations and pathways must await the publication of the final reports for the various reconstruction programs, the rough geographic variation in cumulative fallout deposition and resultant doses from external radiation exposure can be estimated from the gummed-film network data (Beck et al. 1987). For persons living in the eastern and midwestern U.S., cumulative whole body and bone marrow doses were on the order of 1 mSv, or of the same order as the external radiation dose ascribed to "global" fallout in these areas (UNSCEAR 1982), and also about the same order as that received by this population in a single year from natural background exposure. Corresponding cumulative ^{131}I depositions ranged from about 50,000 to 150,000 Bq m^{-2}. Even in states just downwind from the NTS, fallout depositions, and resulting external exposures, were only about 3 to 4 times higher, although some small towns just downwind from the NTS received fallout and hence doses about an order of magnitude higher (Beck and Krey 1983).

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