

Name of research institute or organization:

Environmental Radioactivity Section (SUER), Radiation Protection Division, Swiss Federal Office of Public Health

Title of project:

Monitoring of Air Radioactivity at the Jungfrauoch Research Station:
Test of a new High Volume Aerosol Sampler

Project leader and team:

Prof. Dr. Hansruedi Völkle, projet leader, and Thomas Flury (Master Student)

Project description:

Switzerland started Environmental monitoring of radioactivity in 1956 with the appointment by the Swiss Federal Council of the Federal Commission for Radioactivity Surveillance (KUER). Already in 1959 a first automatic aerosol sampling station with an on-line measurement of the gross beta radioactivity of the aerosols was installed at the Jungfrauoch research station at 3454 meters. In order to improve the present radioactivity monitoring network, in particular to increase the sensibility of the surveillance and to allow individual radionuclide determination by gamma spectrometry instead of only gross beta activity, a new high volume DIGITEL DHA-80 aerosol sampler, manufactured by DIGITEL Elektronik AG CH-8604 Hegnau (Switzerland) was first tested in Fribourg (630 meters) and then installed at the Jungfrauoch High Altitude Research Station at 3454 meters. This sampler collects aerosol particles on glass fiber filters manufactured by Ederol, Binzer & Munktell Filter GmbH, D-35088 Battenberg (Germany) of 150 mm in diameter. The sampler is controlled remotely through an Internet connection. The air flow rate can be set between 6 and 60 m³/h and the instrument is maintaining a constant flow rate over the whole sampling period. Air is sucked from outside the building and heated. The filters are changed automatically twice a week. For the analysis by gamma spectrometry the filters are pressed to a tablet of 6 cm in diameter and 3 mm height by means of a hydraulic press at 15 tons. Normally 4 filters are measured together (corresponding to approximately 16'000 m³ air at normal conditions T = 288 K, p = 1013 hPa) by a gamma ray spectrometry in the Fribourg Laboratory of SUER (Radiation Protection Division of the Federal Office of Public Health) using a high purity coaxial germanium detector. Counting time is 2 days. The activities were back calculated to the middle of the sampling period. ¹⁰Be is determined by Accelerator Mass Spectrometry (AMS) by the EAWAG in CH-8600 Dübendorf in collaboration with the Institute for Particle Physics at the ETH CH-8092 Zurich.

The radio nuclides measured are the natural ⁷Be, ²¹⁰Pb, ⁴⁰K and traces of the artificial ¹³⁷Cs, the later due to resuspension of fallout from the Chernobyl reactor accident in April 26th 1986. The short lived daughter nuclides of the uranium and thorium series are not detected for two reasons. First, the activity is very low because of snow and ice at Jungfrauoch preventing the noble gas Radon (²²²Rn) to escape into the atmosphere, and secondly, the measurement of the filters starts at the earliest 3 days, after filter change, enough time for those nuclides to decay significantly. ⁷Be and ¹⁰Be are spallation products due to interactions of cosmic rays with atmospheric nitrogen and oxygen. They soon attach to aerosols. 67% of the production takes place in the

stratosphere whilst only 33%, are produced in the troposphere. Together, ^7Be and ^{10}Be are sensitive tracers of atmospheric transport and stratosphere-troposphere exchange because of their very different half-lives of 53.3 days and 1.5×10^6 years respectively. The production ratio $^{10}\text{Be}/^7\text{Be}$ is constant with the altitude, but the concentration increases in the stratosphere due to the longer residence time of aerosols of 1 - 2 years compared to 10 - 35 days in the troposphere. High values of the $^{10}\text{Be}/^7\text{Be}$ ratios therefore indicate the presence of stratospheric air.

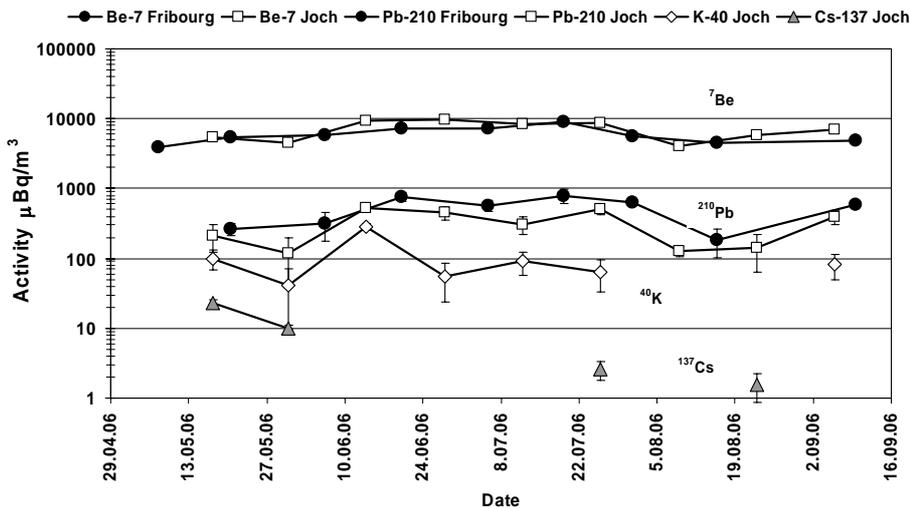


Figure 1. Natural (^7Be , ^{40}K , ^{210}Pb) and artificial (^{137}Cs) radionuclides measured at Jungfrauoch (3454 meters) and comparison with the ^7Be and ^{210}Pb values from Fribourg (630 meters).

The activities of ^7Be and ^{210}Pb correlate and tend to a common maximum in July and decrease again in August due to precipitation in agreement with measurements from 2000 and 2001 by Tobler et al. (2001). The comparison of the results from Jungfrauoch to those of Fribourg shows the same trends in ^7Be and ^{210}Pb . Higher concentrations of ^7Be at Jungfrauoch match the higher concentrations of ^{210}Pb in Fribourg. Both results arise from the fact that the production of ^7Be augments with increasing altitude to reach a maximum between 17 and 20 km. Descending the troposphere a part of the ^7Be decays (Residence time 10 to 30 days). For the ^{210}Pb it is exactly the opposite: ^{210}Pb , as a long lived daughter nuclide of ^{222}Rn , ascends from the soil into the atmosphere. Even if ^{210}Pb can reach appreciable altitudes, it comes down by the same sedimentation and precipitation mechanisms as ^7Be .

Apart from the natural radioisotopes ^7Be , ^{210}Pb and ^{40}K in four out of nine samples, ^{137}Cs (half-life 30 years) was detected with up to 23 micro-Bq/m³ on May 17th. This higher activity was confirmed by measurements of the Physikalisch-Technische Bundesanstalt in Braunschweig, Germany (Personal communication by H. Wershofen, PTB Braunschweig), the Deutscher Wetterdienst in Offenbach and Berlin (Personal communication by Th. Steinkopff, DWD, Offenbach) and the Central Laboratory for Radiological Protection in Warsaw Poland (Personal communication by K. Isajenko and I. Kwiatkowska, Central Laboratory for Radiological Protection). ^{137}Cs concentrations were significantly higher at Jungfrauoch than in Fribourg.

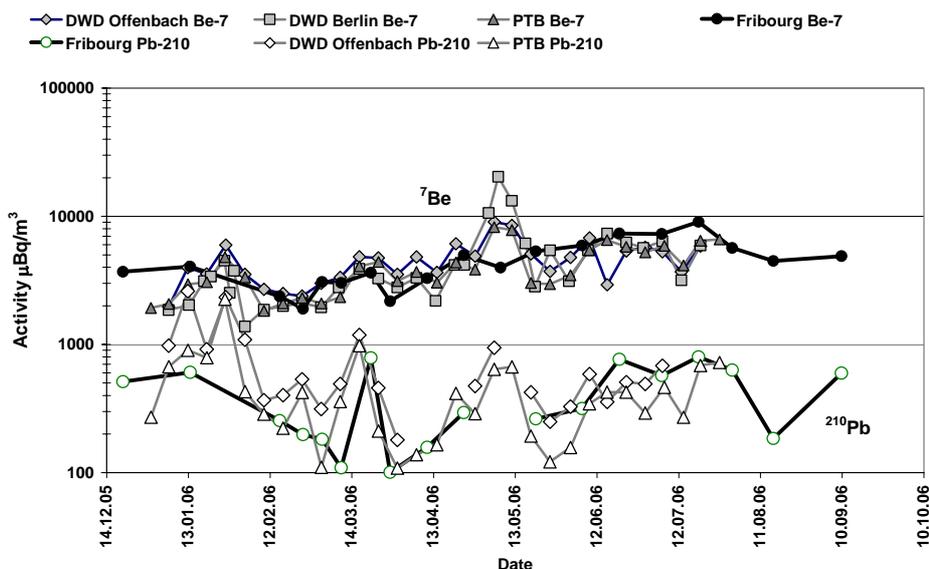


Figure 4: Comparison of the ^7Be and ^{210}Pb concentrations of the air at the Jungfrauoch (3454 meters) to data from the Physikalisch-Technische Bundesanstalt (Personal communication by H. Wershofen, PTB Braunschweig - Germany, 2006) and the Deutscher Wetterdienst in Offenbach and Berlin (Personal communication by Th. Steinkopff, DWD, Offenbach - Germany, 2006).

The DIGITEL aerosol sampler proved to be sufficiently reliable to work at the extreme meteorological conditions at the Jungfrauoch at 3454 meters and the remote control by an Internet connection is very useful. For two-week samples a detection limit for ^{137}Cs of 2 micro-Bq/m³ is obtained. Natural ^7Be and ^{210}Pb show a good correlation, although their different origins. Convection brings ^{210}Pb in the upper troposphere, where the sedimentation mechanisms are the same for both nuclides. In the future, the radionuclide data of the Jungfrauoch will be introduced into the Global Atmosphere Watch network of the World Meteorological Organization (WMO).

Key words:

Radioactivity, Nuclear Test Fallout

Collaborating partners/networks:

University of Fribourg

Scientific publications and public outreach 2006:

Thesis

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