ON THE POPULATION DOSE AROUND THE SEMIPALATINSK NUCLEAR TEST SITE

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1. INTRODUCTION

Since 1949 the Semipalatinsk Nuclear Test Site (NTS) was extensively used by the former Soviet government as a testing range for atomic weapons. Atmospheric and underground tests were finally stopped in 1962 and 1989, respectively. The Ministry of the Russian Federation of Atomic Energy officially counts a total of 456 tests, including 116 atmospheric tests [1]. The total yield of the nuclear explosions carried out was 6.3 Megatons equivalent with 6.7 PetaBq of ^{137}Cs and 3.7 PetaBq of ^{90}Sr being released into the athmosphere [2]. Some of the athmospheric radioactive tests shielded plumes, which extended far beyond the outer borders of the NTS (fig.1). Already the first Soviet atomic bomb test on August 29th, 1949 due to unfavourable meteorological conditions affected the villages of Dolon and Moistik.

Since 1995 joint investigations performed by the Research Centre Jülich in cooperation with the Kazakh National Nuclear Centre in the region of the former nuclear test site near Semipalatinsk besides environmental measurents also involve the assessment of the current dose of the population at and around the test site in addition to the important retrospective determination of the dose of persons affected by the atmospheric tests.

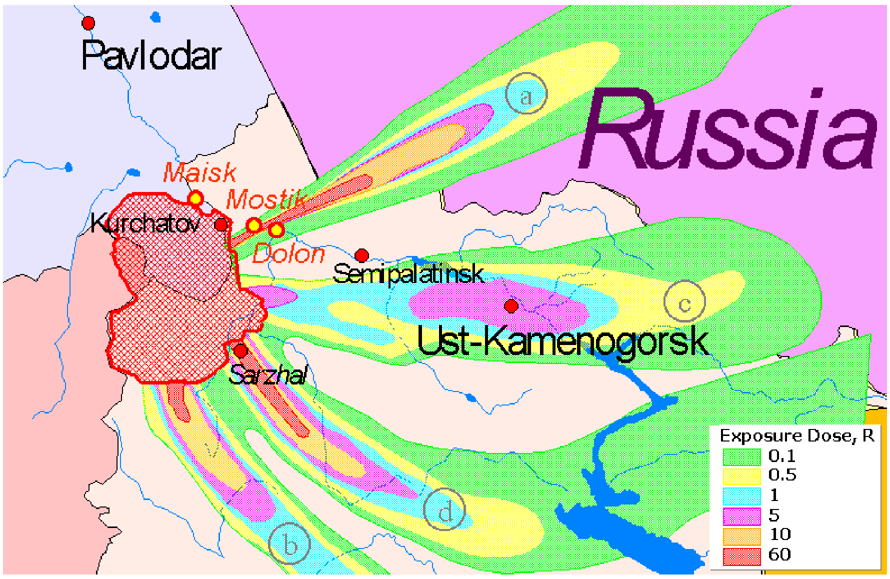

Fig. 1 : The Semipalatinsk Nuclear Test Site and its radioactive plumes [3]

An important aspect was to adress the need of the government and the local population to understand the present individual radiological situation and provide data as a reliable basis for health impact assessments. A first pilote study was restricted to collecting field data in two villages (Moistik and Maisk)and evaluating them. Detailed results are given in references [4,5].

Present investigations of the actual and retrospective dose include the assessment of external dose (area dose measurements, TLD-dosimetry), the assessment of soil and air samples, urinary excretion analysis as well as EPR-measurements of teeth. The three villages of Dolon, Maisk and Moistik are included in this study, as well as five small settlements and camps at the area of the test site itself. The evaluation of the data is not completely finished yet. Further results are to be expected.

2. AMBIENT DOSES

Ambient dose equivalent rates dH_x/dt resulting from this study correspond to mean doserates in normal environments. From in-situ gamma ray spectrometry measurements a very small anthropogenic contribution to the external dose to the extent of 2-5% (^{137}Cs) can be found in Maisk and in Moistik [4,5].

3. PERSONAL DOSE ASSESSMENT

Individual personal doses have been obtained for a group of geologists and a group of herdsmen at the test site [6]. Five small settlements and camps have been selected for investigation: three settlements (Algabas, Tulpar, Tortduk) served as a basecamp for shepherds, 2 camps were used by geologists working in the field for exploration. Although in all five locations area dose rates are in the range of worldwide normal values both professional groups nonetheless roam the test site in persueing their work. Thus working in areas of a more highly contamination might lead to additional (occupational) doses. Highly sensitive thermoluminescence dosemeters (TLD) were hence used to measure for the first time the individual personal dose directly for these population groups. Detection limits of about one µSv permitted wearing times of less than a fortnight. Personal doses where obtained for 28 individuals. The measurement results do not stand out significantly from the local variation of natural background radiation. A more conservative assessment from the aspect of practical health physics was yielded a mean personal dose of 0.55 µSv per day in case of the shepherds, whereas geologists received a mean personal dose of 0.45 µSv per day. For an annual exposure period of typically about three months, the radiation dose received by the persons investigated in addition to the natural radiation exposure is thus below 0.1 mSv/a.

4. ENVIRONMENTAL MEASUREMENTS

By γ-spectrometric and radioanalytical methods the artificial isotopes ^{137}Cs, ^{60}Co, ^{90}Sr and ^{241}Am were identified in soil samples the latter being an indicator for the deposition of plutonium. The content of the premordial nuclide ^{40}K in soil from Moistik and Maisk is within the range of global values. The content of ^{90}Sr in soil was found to be enhanced above global background values. In both villages the soil contaminations from ^{137}Cs are comparable with values in Germany and Switzerland (e.g.[7]). The ratio of ^{137}Cs and ^{134}Cs in environmental samples excludes global Chernobyl fall-out as a unique source [4,5].

Possible health effects can not only be caused by radioactive contamination, but also by other types of environmental contamination. Soil samples have been digested and analyzed with a PE SCIEX ELAN 5000 ICP-MS system. Details on the digesting procedure and measurement methods are given elsewhere. [8].

Element concentrations found in analysed soil samples from Maisk and Moistik are presented in Fig. 2. Both samples are a deep profile (5-10 cm-1; 10-15 cm-2; 15-20 cm-3) of soil in pasture areas. It is obvious that in the sample collected in Maisk the concentration of five of these elements (Cu, Zn, Cd, Hg and Pb) are significantly higher than in sample collected in Moistik. Observed concentration levels in Maisk for these elements indicated a medium environmental pollution [8]. Values found in Mostik are similar to that observed in non polluted areas [8]. The concentration decreases with the depth (e.g. Hg) indicating that this elevated concentration levels are men made. To explain the sources of environmental pollution in Maisk more work should be done. In both villages the concentration of all other elements is nearly identical and not significantly different from levels observed in other countries [9].

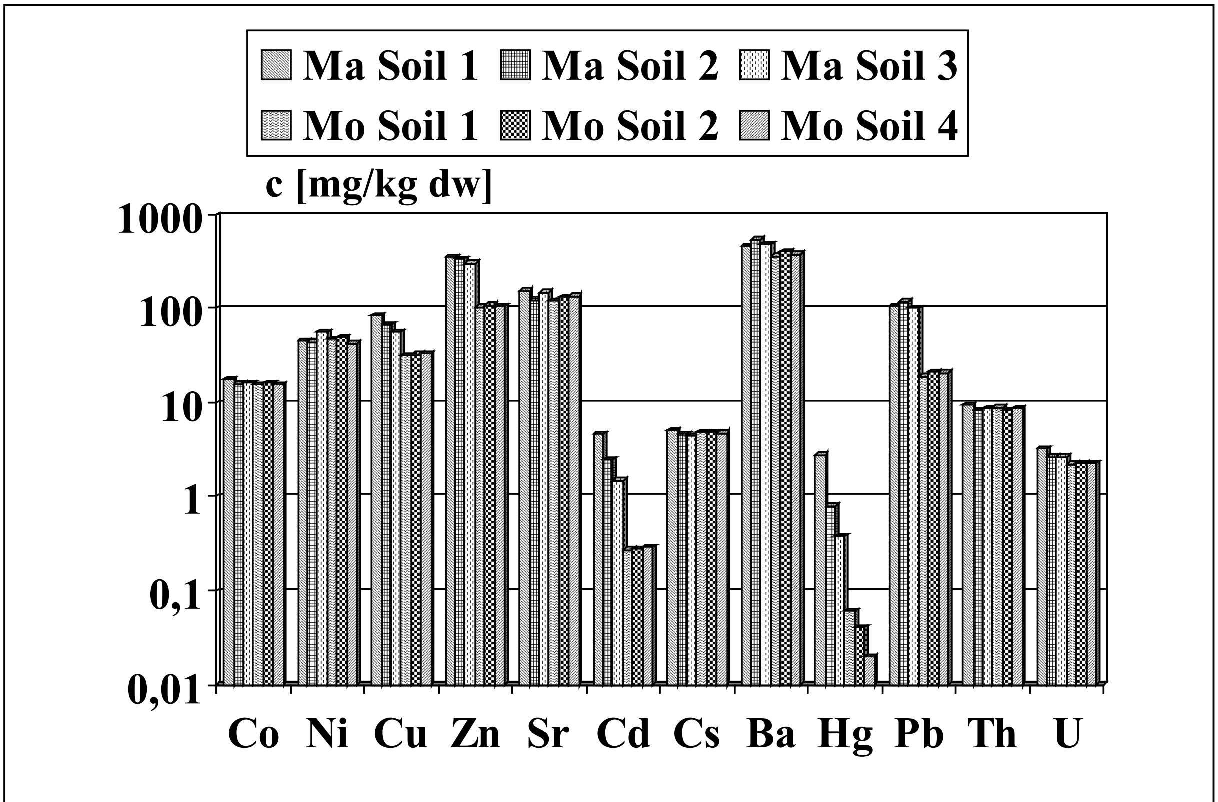

Fig. 2: Comparison of element concentration in soil samples from Maisk (Ma) and Moistik (Mo)[8]

5. INCORPORATION OF RADIONUCLIDES

Body burdens of the inhabitants of Moistik and Maisk were assessed by means of whole-body counting and analysis of urine samples.

5.1 Mobile in-vivo monitoring

A mobile whole-body counter designed especially for this field mission was used to assess the incorporation of γ-emitters. Its design as a chair configuration allowed it to fit into a VW van [4]. The γ-rays wer detected with two large steel-shielded NaI(Tl) detectors pointing from the back towards the person examined. The measuring time was one minute.

Fig. 3 : Mobile in-vivo measurement at Moistik/Kazakstan

5.1.1 Cesium

In Mostik 293 persons were examined by whole-body counting and 476 in Maisk. All measurement results for ^{137}Cs were below the minimum detectable whole body activity of 300 Bq for standard man (70 kg).

5.1.2 Other γ-emitting nuclides

No indication of other man-made γ-emitting nuclides has been observed in the measured spectra.

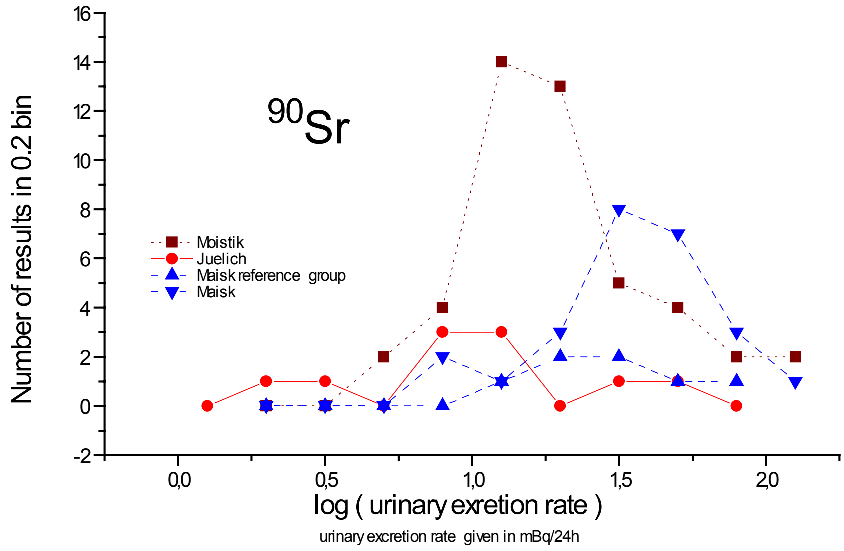

Fig 4 : Log-normal distributions of urinary excretion rates for different groups compared to urinary excretion rates in Jülich Germany [4]

5.2 Analysis of urine samples

A total of 105 urine samples were collected in Moistik and Maisk in the 1995 field mission. They were mainly from older persons who had still been in their growth phase during the above-ground atomic bomb tests. During this phase ^{90}Sr is particularly readily incorporated into the bones with long retention times. A control group of nine young persons born after 1960 served to identify incorporations attributable to the uptake by food. Further samples were taken in 2000.

5.2.1 Strontium

The urinary excretion rate of ^{90}Sr had a log-normal distribution (Fig.4) for all three groups. As judged from standard statistical tests, it was significantly higher than the excretion rate of a reference group in Jülich (Germany). The excretion rate in Mostik was also significantly lower than in Maisk. There was no significant difference between the excretion rates of older and younger inhabitants of Maisk. This can be taken as an indication of present body burdens being due to continuous ingestion. On the basis of present data long-term retention of old systemic depositions can not be proofed so far.

Also a few urine samples have been taken in Dolon in the year 2000. Preliminary results indicate excretion rates comparable to those observed in Moistik or Maisk. However excretion rates of shepherds at the Nuclear test site are much higher than those of most residents of the villages, which might be due to their special diet.

5.2.2 Uranium

No indication of U depositions from atomic bomb fallout was found in looking for the isotope ratio ^{234}U:^{238}U as an indicator. The ratios were well within the normal range of values given by UNSCEAR [10].

5.2.3 Plutonium

In urinary samples collected in 1995 no Pu was detected. However, detection limits of Pu have been lowered for samples taken in 2000. It appears that some of the latter samples do contain traces of Pu (fig. 6). The complete analysis is however still in progress. Especially the isotopic ratios between ^{238}Pu and ^{239}Pu are not fully understood so far.

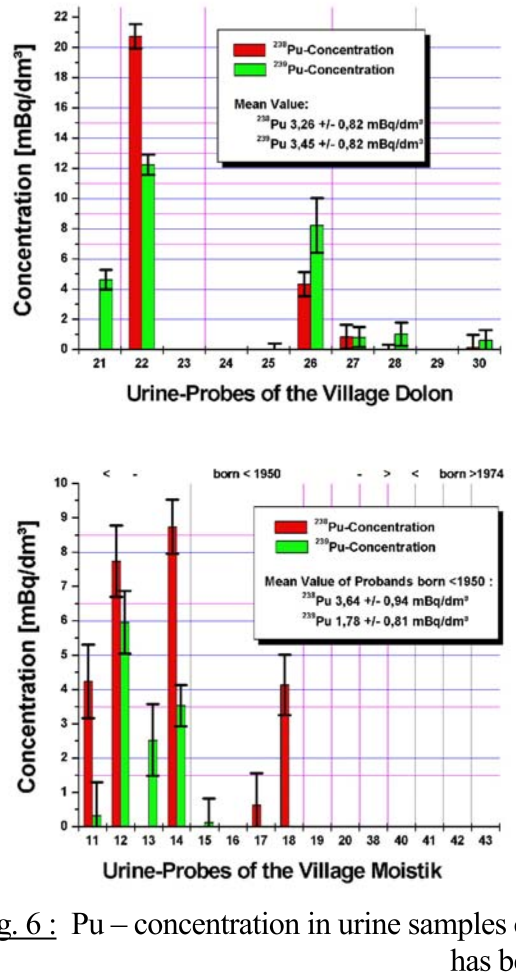

Fig. 6 : Pu – concentration in urine samples collected in Dolon and Moistik. Chemical background has been subtracted.

5.3 Doses due to internal contamination

Annual internal doses determined so far from this study are in the range of a few µSv and hence this additional dose is only a small fraction of the doses observed worldwide for incorporation from natural sources (areas of normal background : 1.5 mSv [11]).

6. RETROSPECTIVE DOSIMETRY

EPR-Dosimetry has been used for a retrospective dose analysis measuring teeth enamel. Teeth collected in the vicinity of the NTS. Enamel samples were measured at Almaty in a Bruker EPS300E EPR-spectrometer. To obtain reliable data even in cases of small quantities of tooth enamel the method of rotation was applied using a goniometer. Such the anisotropy effect was leveled out.

Spectra processing for dose reconstruction requries essentially the following operations:

- Preliminary correlation of a zero line; substraction of a native signal;
- Substraction of a background spectrum from cavity and tube; smoothing of noises.
- Normalizing of a signal to 100 mg, 200 scans, the reference conditions of registration,
- Reconstruction of a dose using the allocated radiation signal by matching with dose standards.

Preliminary reconstructed dose values for six tooth samples obtained from residents at Maisk are mostly in the dose range of 390-490 mGy (age of donors being 24, 48, 53, 54 and 68 years). In the case of a 72-year old a value of 1700 mGy has been found. Some more teeth enamel samples are still under evaluation, part of them being measured also at GSF Munich for validation purposes.

Our preliminary results might be compared to the work of Romanyukha et al. [12] , who found an average reconstructed gamma dose of 390±70 mGy for nine tooth enamel samples of eight Kainar residents prepared from teeth extracted in 1964.

7. SUMMARY AND CONCLUSIONS

Since 1995 investigations funded by NATO have been jointly performed by the Research Centre Jülich and the Kazakh National Nuclear Centre in the region of the former nuclear test site near Semipalatinsk, which was used as a testing range for atomic weapons since August 1949. The studies involve an assessment of the current dose loads of the population at and around the test site, mainly in the villages of Moistik and Maisk, as well as some work on retrospective dose evaluation. Though the data analysis is not completed yet a review on lessons learned so far can be given:

- Concerning the radiological situation life in Dolon, Moistik and Maisk, although situated close to the site border, is presently safe. Ambient doses are comparable to global background.
- Cesium was found in environmental samples but not in the body of men. The ratio of ^{137}Cs and ^{134}Cs in environmental samples excludes global Chernobyl fall-out as unique source.
- The Sr-content in soil samples as well as in urine samples is slightly enhanced. Excretion observed is essentially due to present intake from environmental contamination. Long-term retention of old depositions could not be proofed so far.
- The Sr-content in soil and urine samples is higher Maisk is than in Moistik, which is quite surprisingly for a village not situated in the obvious traces of atomic bomb explosions. Hence

any comprehensive assessment of the radiological situation at and around the nuclear test site ought to include also those areas not being obviously downwind of atomic bomb tests.

- Urinary excretion of ^{234}U and ^{238}U has been studied. There is no indication of uranium originating from artificial origin.
- Pu decay product ^{241}Am was found in environmental samples. Urinary excretion of Pu is under evaluation.
- Besides the radiological assessment, an assessment of other environmental contaminants needs to be performed. In some soil samples enhanced values of heavy metals were found.
- None of the current sources of radiation observed so far is strong enough to result in adversible health effects. Retrospective dose assessment is in progress.

Though dose reconstruction for those inhabitants directly affected by the above ground atomic weapons tests will remain difficult, the assessment of individual doses has a high potential in linking the results of environmental and medical research. To get a comprehensive dose assessment, in which also the other highly contaminated villages (Dolon, Sarzhal, Kainar etc.) near the Semipalatinsk Nuclear Test Site are included, further research work is needed and would fit nicely in UN's efforts to assist Kazakhstan in working up the consequences of atomic bomb tests. For epidemiological studies it will also be essential to consider in the future besides the effects of radiation the influence of man-made contaminations by heavy metals.

8. ACKNOWLEDGEMENTS

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