THE TREND ANALYSIS OF THREE YEAR BIO MONITORING RESULTS IN THE NEIGHBOURHOOD OF NPP TEMELIN

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Abstract

Bio-monitoring is conducted by employees of Czech Technical University (CVUT) in Prague based on requirements of Nuclear Power Plant Temelin. The year 2000 was designated as reference year before the start of the NPP operation and 2001 was the year of the initial operation. Research will continue in the following years. The bio monitoring consist of gamma spectrometric determination of contaminant ^{137}Cs (detection limit 2 Bq/kg) in the area of interest up to distance of 20 km from NPP and trend analysis of the acquired data. Forest humus, surface of pine bark, Schreiber's moss, edible mushrooms and forest berries were used as bio-indicators. In total 203 samples in 2000, 222 samples in 2001 and 223 samples in 2002 were collected. The bio monitoring for year 2000 and 2002 included assessment dosimetry and spectrometry characteristic of photon-fields (that is the determination of reference background). With the exception of the identified ^{137}Cs (from Chernobyl accident fallout) it was not possible to identify among the measured spectra any significant contribution of any other radionuclides. The trend analysis didn't establish any ^{137}Cs concentration increase at the measurement points.

Introduction

Atmospheric radionuclide deposits monitoring in the environment is often conducted using bioindicators [1,5]. Using ecological principes, the changes in environment quality are indicated by biological indicator changes. This could be entire living organism, its parts, its non living parts (tree bark, fallen leaves...) or decomposed organics matter. The part of the wide spectrum monitoring of the influence NPP Temelin on the environment within 20 km radius is following bio indicator values, in our case forest humus, surface of pine bark, Schreiber's moss, edible mushrooms and forest berries [1]. Monitored area contained 29 sampled locations along eight radial profiles intersecting the area of interest up to distance of 20 km from NPP Temelin (the points of measurement are located 2-5-10-20 km from NPP, distance of 20 km is a comparison area, where no real radioactive air pollution should occur). The gamma spectrometric method (with very good range of detection) was chosen to determine the presence of natural and manmade radionuclides. The pine bark and moss were sampled at the selected sites twice yearly, at spring and fall, forest humus once in spring months, mushrooms and berries once in a growing season. Top 3 mm of tree bark were taken in reference height of 1m above ground along the circumference of the trunk from 8-10 trees at a given point. To prevent contamination by soil the moss samples were cut by scissors. Forest humus was sampled by a small shovel with respect to resolution of surface layers, according to the degree of hummification.
Processing of measured spectra in the range up to 3 MeV provided mass related activity of naturally radioactive elements (^{40}K, ^{226}Ra, and ^{232}Th) and contaminant ^{137}Cs (resulting from nuclear weapon tests in the fifties of the last century and from Chernobyl accident fallout). With a sufficient amount of measurement samples collected, it will be feasible to compare the potential radionuclide accumulation, against the reference "zero level", obtained in the year 2000 (before the start of the NPP operation), using trend analysis. The bio monitoring for year 2000 and 2002 also included assessment dosimetry and spectrometry characteristic of photon-fields at 15 selected points. Research will continue in the following years. In total we have collected 203 samples in 2000, 222 samples in 2001 and 223 samples in 2002 [4].

Methods

For the determination of radionuclide presence and their activity in samples a laboratory gamma spectroscopy method was selected. The gamma spectrometric method enables to determine presence of many natural and artificial radionuclide emitted gamma rays with very good limits of detection. It is non-destructive method requiring relatively simple sample preparation and is based on the proportion between designated radionuclide peak area in the measured spectrum and its gamma activity. The measuring equipment consists of HPGe detector with built-in preamplifier (mfg. by EG&G Ortec), amplifiers 2022 Canberra, Source VN31060 Canberra, ADC built-in analyser, analyser model 4202 Canberra and a PC. After drying (for example on case of mushrooms the weight loss was 90%), samples were enclosed in Marinelli containers with a volume of 0.5 l, surrounding during the measurements coaxial HPG detector. Processing of measured spectra using the program SP DEMOS [7] in the range up to 3 MeV provided mass related activity of naturally radioactive elements ^{40}K, ^{226}Ra, and ^{232}Th in the first year and contaminant ^{137}Cs in all years [8,9,10].

The bio-monitoring for year 2000 and 2002 included assessment dosimetry and spectrometry characteristic of photon-fields (that is determination of reference background) at 15 selected points. Two methods were selected with corresponding types of measurements:
1/ determination of air kerma rate (by direct measurement with device TESLA NB 3201 and by calculation based on spectrometry data)
2/ measurement of photon-spectra by use of scintillation spectrometer MCA μ NOMAD EG &G Ortec with scintillation detector NaI(Tl) diameter 3” by 3” in the energy range up to 3 MeV.
All measurements were conducted in reference altitude 1 meter above surface. Total of 99 (2000) and 134 (2001) measurements were conducted using device NB 3201 with integration interval of 100 seconds. The spectra during spectrometry measurements were collected for 2700 seconds [4].

The most important task of this project is to describe the influence of NPP Temelin on radioactivity increase in its neighbourhood. Two model situations have to be studied. *Firstly*, one fairly large accident leads to relative extensive radionuclide escape and contamination of the neighbourhood of NPP. In virtue of the environmental contamination, radionuclides are accumulating in organisms living in places, where the radionuclides are deposited. It means that the escape of radinuclides from NPP can be proved by identification of these radionuclides, especially fission products, in samples which were taken in the surrounding of NPP after accident. The method of gamma spectrometry can be successfully used for such survey. The measurements carried out in the year 2000, i.e. before fuel activation in the first block of the NPP Temelin, detect the presence of ^{137}Cs, ^{40}K and uranium and thorium decay products. Uranium a thorium decay products, as well as ^{40}K, are radionuclides of natural origin. Radionuclide ^{137}Cs is a fission product and its presents in nature is related to human activities. Testing of nuclear weapons in the atmosphere, which were performed in the fiftieth and sixtieth years of the twentieth century, and nuclear accident in NPP Cernobyl are obviously the most significant reasons for its occurrence in nature. With the exception of ^{137}Cs, other radionuclides created by fission cannot be detected due to their low activities. The cause of the low activities is their short half-life in comparison with time of creation. The measurements have been continued after the NPP Temelin was put into operation in the year 2001. Samples of Schreiber’s moss, pine barks, forest humus, mushrooms, and blueberries have been collected every year. The analysis results were identical with the ones that were obtained in the year 2000. The samples contain the same radionuclides as the samples that were taken in the year 2000. Also their activities are comparable. Short-lived radionuclides were identified neither in the year 2000 nor in the following ones. This shows that no accidents with significant radiation escape have occurred during the entire time the NPP Temelin has been operating.
The second model situation presumes that a small amount of radionuclides is continuously escaping and being deposited during the common operation of NPP. This long term continuous escape could be observed according to ^{137}Cs activity increase in the samples that are regularly collected for a long time. If the activity increase is not significant, the demonstration of the influence of NPP on environment presents a difficult task, due to a high fluctuation in the amount of radionuclides in live organisms. Therefore, if the activities in current sample are higher then in the samples that were taken in previous year, this phenomenon does not prove an actual increase. That can be proved only, if measurements are significantly higher then the activity fluctuation. The method of trend analysis has been used for result comparison and activity increase determination. Because ^{137}Cs is the only radionuclide in sample, whose presence is related to fission process in NPP, the trend analysis was performed only for this radionuclide [2,3].

Results

The results of ^{137}Cs mass activity were statistically processed. The groups of measured quantities of mass-activity in Bq/kg (further A_h) are characterized by minimum, maximum, median, average value and standard deviation (for normal deviation), arithmetic and geometric mean value, geometric standard deviation (for logarithmic-normal spread). All values have assigned 95% tolerance intervals.

The measurement results confirm that in monitoring of biological plant samples a larger spread of measurement values is normal (for example due to impossibility of taking a sample exactly on the same place every year). For a reason of low values of bio indicators gamma activity, the measurement times are very long: from 14 000 sec (humus) to 30 000 sec (moss) – except dry mushrooms samples where the mass activity of ^{137}Cs is higher. The detection limit of ^{137}Cs was assigned 2 Bq/kg. From the year 2001 the surface area activity of the ^{137}Cs in forest humus is counted.
The measured values of the dosimetry and spectrometry characteristic of photon-fields corresponded to nominal values on natural background, depending mainly on geological substrata (soil contents), concentration of radon in soil or air etc. The methodology selected enables identification of individual contaminants and their contribution or occurrence. With the exception of the identified ^{137}Cs it is not possible to identify among the measured spectra any significant contribution of any other radionuclides (see Fig 1 and 2).

Fig. 1: The comparison the background measument results (spectrometer NaI(Tl) 3"x3") in the choice points 11.-12.7.2000 and 16.-17.7.2002

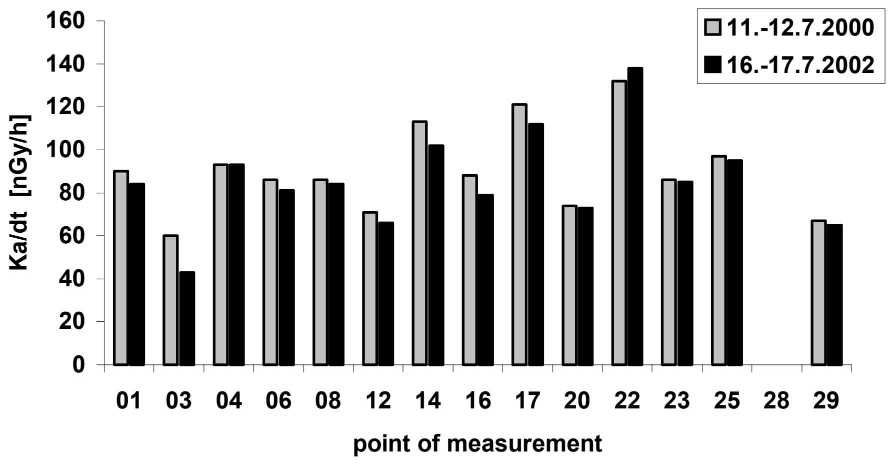
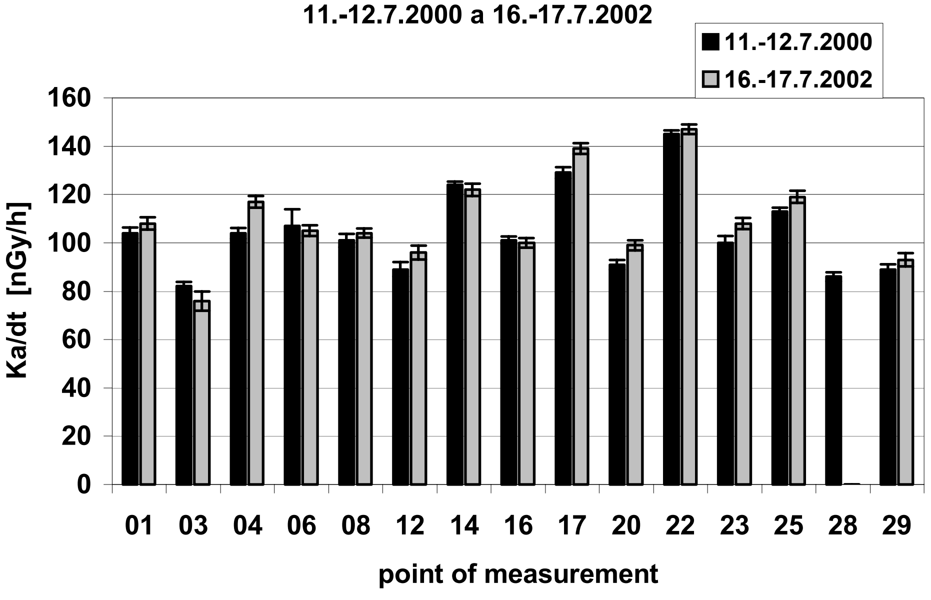


Fig 2: The comparison of the background measurement results (device Tesla NB 3201) in the selected points 11.-12.7.2000 a 16.-17.7.2002



The trend analysis (the first test) was performed at the end of the year 2002, when there was a sufficient amount of data available (six point per all type of samples).The trend analysis was used for all 29 points in the neighbourhood of NPP Temelin for following samples:

1) Schreiber's moss – spring
2) Schreiber's moss – autumn
3) Pine bark – spring
4) Pine bark – autumn
5) Humus A
6) Humus B

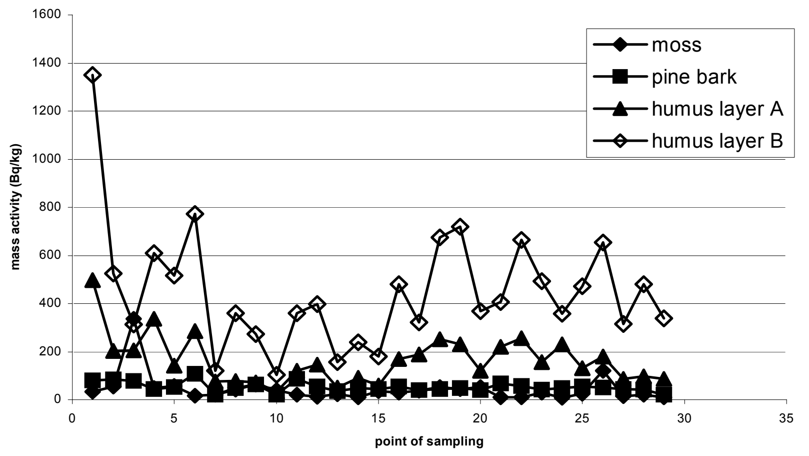
All these types of samples must be solved separately, because they differ in mass activities and the ways of income and accumulation of ^{137}Cs are not same as well. Due to different contamination in each point, that is probably caused by the accident in NPP Cernobyl, all points must be also solved separately. Therefore, the trend analysis was performed for all types of samples and all points, i.e. 174 calculations (6 samples multiplied by 29 points). Three values of mass activity corresponding to the measurements in the years 2000, 2001, and 2002 were available for each calculation. Trend analysis is based on fitting of measured valued with a suitable curve. Since the steady escape of radionuclides from NPP is presumed, the ^{137}Cs activities are fitted with a line curve. After the line is constructed, activity growth per year and its uncertainty is calculated. The uncertainty is derived from the difference between measured and fitted values. If the measured values lie close to the fitted line, the uncertainty is low and the activity growth can be simply proven or refused. The ratio of the activity growth per year and its uncertainty is related to Student t-distribution. If this ratio exceeds certain value, the activity growth is confirmed with the probability corresponding to a given confident interval of t-distribution. For a confident interval of 95%, the activity growth was proven only in four cases out of 174 calculations. According to these numbers, it seems that these four calculations represent rather statistical fluctuation than true growth. Table 1 shows the types of samples and the points where the activities of ^{137}Cs seem to be rising.

Although the assessment of the radiation growth is complicated due to fluctuations, that are typical for most of environmental measurements, this method seems to be appropriate for such an investigation. The higher number of years the activities are examined, the more accurate results can be obtained. Relative frequency of the wind direction (Weather station Temelín 1989-1999) – does not correspond with location of three points where increased activity was indicated [6].

Tab. 1: Samples and points where the activities of ^{137}Cs seem to be rising

Sample	Point
Schreiber's moss - spring	3
Schreiber's moss - autumn	10
Pine bark - spring	17
Pine bark - autumn	no
Humus A	3
Humus B	no

Fig 3: The three years average values of 137Cs mass activity



Discussion

With the exception of the identified ^{137}Cs (from Chernobyl accident fallout) it is not possible to identify among the measured spectra any significant contribution of any other radionuclides. The trend analysis didn't establish ^{137}Cs concentration increase on the measurement points. The concentration differences among constituent point in the research area are caused by different amount of rainfall after the Cernobyl accident. Although the assessment of the radiation growth is complicated due to fluctuations, that are typical for most of environmental measurements, this method seems to be appropriate for such investigation. The more years the activities are examined the more accurate results can be obtained. To increase the precision of the trend analysis results, the first step in the year 2003 will be to determine the variation coefficient for every bio-indicator due to larger set of samples collected from every point.

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