BACKGROUND RADIATION SPECTRUM AND ITS INFLUENCE ON LOW LEVEL ACTIVITY MEASUREMENTS IN THE ENVIRONMENTAL SAMPLES

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ABSTRACT

The paper discusses the variations in the background gamma radiation spectrum as an important parameter in low level activity measurements. The background radiation spectrum has been recored from 1993 to 1995 on two HPGe detectors under equival environmental conditions but placed in differently constructed Pb cages. The results indicate that when one estimates low level activities of natural radionuclides in the environmental samples, background radiation can be a significant source of error, due to unadequate shielding or long counting time intervals. Special attention should be paid to the seasonal variations of the lines of Bi-214 and Pb-214, while errors due to intensity variations in K-40, U-235 and Th-232 lines in the spectrum are within the total eror of the method. Errors in intensity estimations in low and high energy range of the background spectrum should not be neglected , too.

INTRODUCTION

Background radiation spectrum is one of the basic Quality Assurance and Quality Control parameters in the evaluation of natural and man made radionuclides' activities in the environmental samples, especially when estimating low level activities of natural radionuclides. Intensity and stability of the spectrum are due to the technical characteristics of the detector itself, materials and design of the shielding, environmental conditions (ventilation ecc), construction of "low level chamber",ecc (1,2). Regular control of background radiation can point to the possible contamination of the detector or the environment (3). Some of the lines in the background spectrum can interfere with some of the lines in fission radionuclides spectrum or other complex spectra making the evaluation of the activities less reliable (4).

MATERIALS AND METHOD

Background gamma radiation spectrum has been recorded from 1993-1995 on two HPGe vertical detectors D1 and D2, relative efficiency 23% and 20% respectively, both placed in a ground floor laboratory, with ventilation. Both detectors have Pb shieldings (10 cm) with layers of Cu (3mm) and Fe (10 mm D1, 6mm D2) on the inner wall of the cages (45cmx45cmx45cm). The cages differ in construction: the upper surface of D2 cage is covered with additional Pb movable plates, so there is no free space between Pb bricks. Detectors are used for radioactivity measurements in the environmental samples (soil, grass, food, building materials) in different geometries (standard Marinelli beakers, plastic bottles, planshettes).

Background has been recorded monthly and the means of count rates (imp/1000s) over the counting interval (250.000-400.000s) have been calculated. Energy calibration was performed with a standard set of point sources (COFFRET d'etalon gamma ECGS-2,Saclay with Ba-133,Co-57,60 & Cs-137).

RESULTS AND DISCUSSION

The results of the background radiation recordings on D1 and D2 detectors have been presented in Table 1. The data present the means ($\bar{X}$) of monthly counts rates (imp/1000s) for the three years and the coefficients of variation CV(%) for the 1993-1995 period (T) and for each year (93,94,95).

Table 1. Mean count rates $\bar{X}$(imp/1000s) and variations CV(%) in the background radiation spectrum for detectors D1 and D2 from 1993 to 1995

		Detector D1					Detector D2				
			CV(%)					CV(%)			
Radio-nuclide	E(KeV)	$\bar{X}$	93	94	95	T	$\bar{X}$	93	94	95	T
Th-234	63.3	5.2	4	11	4	3	1.9	11	11	5	8
PbX	74.8+77.1	11.5	47	29	52	6	6.3	22	42	58	16
PbX	89.7	18.2	10	10	16	3	8.7	7	17	19	7
U-235	185.7	8.2	19	24	19	11	3.6	8	7	16	8
Pb-212 +214	238.6 +241.5	8.6	28	14	36	5	6.4	9	24	26	9
Pb-214	295.2	11.6	49	48	57	7	7.1	24	52	60	16
Pb-214	351.9	18.9	51	30	54	10	11.5	25	52	61	18
anih.	511.0	15.0	4	9	3	1	10.9	2	4	1	4
Tl-208	583.1	1.1	17	22	24	11	0.8	22	20	8	6
Bi-214	609.3	14.2	47	29	54	10	8.7	27	48	59	19
Cs-137	661.6	1.5	12	10	10	3	2.7	32	18	5	12
Ac-228	911.1	0.6	24	24	31	17	0.5	17	20	20	2
Bi-214	1120.3	2.5	27	28	81	17	1.7	27	54	56	13
Co-60	1173.2	1.8	4	12	12	15	0.4	16	21	20	22
Bi-214	1238.1	1.2	35	36	55	13	0.7	30	46	44	19
Co-60	1332.5	1.6	12	17	8	14	0.4	27	17	22	22
K-40	1460.8	1.9	8	6	10	5	1.4	10	11	4	4
Bi-214	1764.5	2.3	23	27	51	13	1.4	25	44	54	16

The mean background peak rates counts recorded on D1 are generally higher than those recorded on D2 with better shielding construction (on the average the means of D1 are 1.5 time higher than the means of D2 and for energies up to 200 keV twice as high). Co-60 lines in both spectra are due to the amounts of Co in the shielding material, the shilding of D2 being much less contaminated. The presence of Cs-137 in the background spectra is due to the Chernobyl nuclear plant accident in 1986. However, higher peak counts on 661.6 keV of D2 point to the contamination of the detector while used for environmental samples activity measurements.

As for natural radionuclides, special attention should be paid to the unstable lines of Bi-214 and Pb-214 as their high seasonal variations within a year (due to variations of radon concentrations in air) could be a significant source of error when estimating low level activities of natural radionuclides in the environmental samples. Long counting time intervals (up to 400.000 s) can cause an additional error in activity estimation as some variations of the background radiation could occur in the interval. Averiging the background count rates over long counting time intervals can be another source of error, too. On the other hand, the lines of K-40, U-235 and Th-234 are relatively stable and their variations are within the total error of the method.

Relatively low variations (T<20%) over three years period for both detectors confirm the stability of the systems and of the environmental and measuring conditions.

Higher variations for lower values of the mean peak counts can be asigned to the errors in intensity estimation.

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