PHYSICAL LABORATORY II

Exercise No. 2

Measurement of β type radioactive contamination in water and air samples

THE PURPOSE OF THE EXERCISE

The aim of this exercise is to determine the activity of β-emitting radioactive elements in the natural environment based on water and air samples analysis.

For the calibration of the measuring system we use the natural source of $\beta-$radiation, the ^{40}K isotope, out of which the chemical compound-KCl (salt) is built. The specific activity of KCl is 400 pCi/g.

The specific activity stands for the number of decays per unit of time and amount of substance of the sample at time set to zero ($t = 0$). "Amount of substance" can be the mass, volume or moles of the initial sample.

All the results should be written in Table. 1.

a)

b)

THE COURSE OF THE EXERCISE

1. Calibration of the measurement system by using the KCl.

   a) Weigh 1g of KCl (salt).

   b) Place a plate with salt in the proper drawer of scintillation counter and measure the number of counts emitted by the KCl source in time corresponding to measurement uncertainty $\sim 3\%$ (thus, $\frac{\sqrt{N}}{N}$=0.03). Write down the value of this time. Usually, $t \approx 1000$ s. In total, perform such measurements three times.

2. Measure the background (3 times, in total) in the time interval corresponding to the measurement done for KCl sample ($t \approx 1000$ s).

3. Measurement of the activity of air

   a) By using the air filtration kit, pump $\sim 5m^3$ of air through the paper filter. Write down the exact value of the volume of air that has been pumped. To start the measurement, place the filter in the part between the vacuum cleaner and the pump, then turn on the pump.

   b) Remove the filter carefully and put it on a special plate. In a next step, place it in the same drawer of the scintillation probe, as it was done for calibration KCl sample. Measure the number of counts emitted by the filter in the time interval corresponding to the measurement of salt (KCl). Do it 3 times.

4. Mesurement of the activity of water

   a) Pour 5l of water through the device for filtration of water. You can use a different volume of water . Remember, however, to measure its volume. In order to start the measurement, place the filter in the element above the water container and unscrew the tap carefully (water should flow into the container with a slow stream). When all the water flows through the filter, remove it and place it on a special plate.

   b) In analogy to step 3b, measure the number of counts emitted by the filter (do it 3 times).

EXPERIMENTAL RESULTS

No.	**Background** (N_{BG})	**KCl** ($N_{KCl,exp}$)	**Water** ($N_{w,exp}$)	**Air** ($N_{air,exp}$)
1				
2				
3				
Average				

Table 1: Number of counts for: background (N_{BG}), KCl ($N_{KCl,exp}$), water ($N_{w,exp}$) and air ($N_{air,exp}$).

ANALYSIS OF THE RESULTS

1. Calculate the number of counts N_{KCl}, N_w, N_{air} taking into account the intensity of the background:

$$N_x = \frac{N_{x,exp} - N_{BG}}{t}. \tag{1}$$

2. Express the specific activity of KCl (A_{KCl}) in units of $\frac{Bq}{g}$ (1Ci=$3.7 \cdot 10^{10} \frac{Bq}{g}$). When using a different than 1g mass of KCl, recalculate the activity corresponding to this mass.

3. Calculate the activity for:

   a) air (A_{air})

$$\frac{A_{air}}{A_{KCl}} = \frac{N_{air}}{N_{KCl}} \tag{2}$$

   b) water (A_w)

$$\frac{A_w}{A_{KCl}} = \frac{N_w}{N_{KCl}} \tag{3}$$

4. Calculate the activity for $1m^3$ of air and 1l of water.
5. Compare your results with applicable standards and comment on them.
6. Calculate the errors.