

# Radioactivity measurements in ‘negative ion’ consumer products

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## Introduction

In August 2020 and February 2021, the Authority for Nuclear Safety and Radiation Protection (ANVS) received reports from private citizens of possible radioactivity in necklaces, pendants and other consumer products, sold on the Internet. It was claimed that the products emitted so-called ‘negative ions’. On the websites selling the products, a health claim was made that these ions would have a positive effect on the health of the wearer.

In response to these reports, the ANVS inspectorate ordered 10 of these types of products, which were then presented to RIVM for further investigation. The following investigation into these ‘negative ion’ consumer products was performed:

- Identification of the radionuclides present in the items
- Specification of the activity concentration and the total activity of the radionuclides in the products, based on the components that contain radioactive substances;
- Investigation into the risks for individual citizens resulting from the radiation dose (also from alpha and beta radiation) in the use of the products.

## Methods

10 items were supplied by the ANVS. The items were photographed and weighed:



The entire products were measured using high-resolution gamma spectrometry, in an n-type germanium semiconductor detector (Mirion; 40%; BE type), a pulse sorter (DSA-1000, Mirion) with 8,192 channels and the APEX gamma and Genie-2000 software packages (Mirion). The counting efficiency of each measurement was calculated using Mirion’s ISOCs software package, with a model of the measurement geometry being created for each measurement, including the dimensions, elemental composition and density of the objects.

The beta and gamma radiation contribute to the local skin equivalent dose applicable to the most exposed cm<sup>2</sup> of skin. This skin dose is calculated using the dose conversion coefficients (DCCs) from Table 7.1 in the document *Berechnungsgrundlage für die Ermittlung von Körper-Äquivalentdosen bei äußerer Strahlenexposition* [SSK17].

Since the items in this investigation have a certain thickness, we also need to correct for self-absorption of beta particles in the items themselves using a method inspired by Dalton and Kunaish [Dalton64]. Self-shielding leads to a reduction in counting efficiency, and we have assumed that the counting efficiency is the same as the dose efficiency. It was assumed that all of the gamma radiation would pass through the items.

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## Results

Nuclides from the natural chains of Th-232, U-238 and U-235 were found in the items.

**Table 1.** Highest found activity concentrations and activities for the radioactive components of the items

Sample No.	Chain/nuclide	Activity concentration [Bq/g] <sup>a</sup>	Activity [Bq] <sup>a,b</sup>
1	Ra-224 <sup>d</sup>	12.4 ± 1.3	113 ± 12
2	Ra-224 <sup>d</sup>	12.3 ± 1.3	220 ± 20
3	Ra-224 <sup>d</sup>	14.7 ± 1.5	83 ± 9
4	Ra-224 <sup>d</sup>	16.0 ± 1.7	79 ± 8
5	Th-232sec <sup>c</sup>	21 ± 2	116 ± 12
6	Th-232sec <sup>c</sup>	18.7 ± 1.9	24 ± 2
7	Ra-224 <sup>d</sup>	7.5 ± 0.8	69 ± 7
8	Th-232sec <sup>c</sup>	74 ± 8	780 ± 80
9	Th-232sec <sup>c</sup>	16.2 ± 1.1	5.9 ± 0.4
10	Th-232sec <sup>c</sup>	8.0 ± 0.4	153 ± 8

<sup>a</sup> The stated uncertainties are based on one standard uncertainty.

<sup>b</sup> Total activity based on the weight of the radioactive part of the item.

<sup>c</sup> Chain in equilibrium (assumed) based on the daughter nuclide results.

<sup>d</sup> Nuclides from the Th-232 chain. In these samples this chain was not in equilibrium.

Since a number of assumptions were made (such as the length of time for which the items would be worn) to calculate the dose, the results specify the order of magnitude of the actual skin dose. The actual dose may deviate by up to several dozen percent from the reported value.

**Table 2.** The total local skin equivalent dose for the most exposed cm<sup>2</sup> of skin, and the contributions from the beta and gamma radiation to this skin dose, from wearing the items 24 h/day. Corrections were made for self-shielding and for any shielding from fabric covers.

Sample No.	Total (mSv)	Beta contribution (mSv)	Gamma contribution (mSv)
1	19	14	6
2	34	25	9
3	34	30	5
4	18	17	2
5	13	10	2
6	50	44	6
7	20	17	3
8 <sup>a</sup>	47	44	3
9	25	22	4
10	32	20	12

<sup>a</sup> Worn for 8 h/day

By way of comparison, normal average radiation exposure in the Netherlands is 2.6 mSv per year [RIVM18]. The associated expected local skin equivalent dose is also 2.6 mSv per year. The Dutch legal limit for the local skin equivalent dose is 50 mSv per year.

## Conclusions

- The examined ‘negative ion’ consumer products contain daughter nuclides from the natural chains of Th-232, U-238 and U-235
- Th-232 daughter activity concentrations between 8.0 ± 0.4 and 74 ± 8 Bq/g, with total activities between 5.9 ± 0.4 and 780 ± 80 Bq per item
- Local skin equivalent dose resulting from wearing the items 24 hours per day between 12 and 50 mSv per year. The Dutch legal limit is 50 mSv

## Acknowledgements & References

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