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An Intercomparison Exercise on Radionuclides in Sediment Samples

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Abstract
An intercomparison exercise on artificial and natural radionuclides in two sediment samples, one from the Baltic Sea and one from the Kattegat, has been carried out under the EKO-1 project of the Nordic Safety Research Programme (NKS) for the period 1996-97. The measurement techniques have included direct gamma-ray spectrometry with Ge and NaI detectors, and radiochemical procedures followed by beta counting and alpha spectrometry. The participants have comprised 21 laboratories. Results were submitted for Cs-137, Cs-134, Co-60, Sb-125, Pu-239,240, Pu-238, Am-241, Sr-90, Ra-226, Th-232 and K-40, Pb-210, Po-210 and U-235. The analytical performance of the participants was evaluated for those radionuclides where six or more data sets were received. Statistical tests were made to see if individual results agreed with overall average radionuclide concentrations in the two sediment materials within target standard deviations. The results of these tests show that for Cs-137, Cs-134, Ra-226, Th-232 and K-40 the analytical performance criteria were not met for 20-40% of the data sets. For plutonium isotopes the tests show that the performance criteria were not met for 13% of the data sets. Tests of overall analytical performance show that 61% of the data sets do not meet the combined performance criteria. This shows that there is room for considerable improvement of analytical quality for most of the laboratories that have participated in this intercomparison. The intercomparison exercise has furthermore demonstrated several elementary problems in analytical work such as interchange of samples, mistakes in calculations and correction of background levels.

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1. INTRODUCTION

Under the EKO-1 Project on marine radioecology which is organised by the Nordic Nuclear Safety Research Programme (NKS) for the period 1994-97 an intercomparison exercise on radionuclides in sediments was initiated in 1995 by Risø National Laboratory. Quality control and quality assurance of radioanalytical work has always been a key feature in Nordic projects on radioecology. The conclusions that may be drawn from intercomparison exercises depend on the number of participants for what reason it was decided to invite laboratories other than those from the EKO-1 project to participate. A total of 21 laboratories have participated in the present exercise: 14 from the Nordic countries, 6 from the Baltic republics, and one from Japan.

2. MATERIAL AND METHODS

2.1. Sediment samples

Two sediment samples were obtained: one from the Baltic Sea and one from the Kattegat. The Baltic Sea sediment sample was obtained from the German Federal Maritime and Hydrographic Agency (BSH) who collected the sample on 5 March 1994 in the Inner Lübeck Bight which is in the western Baltic Sea. The sample was surface sediment with a total mass of about 1.7 kg. The Kattegat sample was obtained from the Danish National Environmental Research Institute who collected the sample on 15 February 1995 in the central Kattegat. The sample was surface sediment with a total mass of about 5 kg. Both samples were homogenised by Risø National Laboratory and tested for homogeneity by gamma-spectrometric measurements on 9 sub-samples. Each set of sub-samples were measured in identical geometry on the same Ge detector. The counting rates from 8 prominent peaks in the spectra were compared and tested for variability. A χ^2-test was performed for each peak by calculating test values according to the following equation:

$$T = \sum_{i=1}^{9} \frac{(x_i - \bar{x}_w)^2}{s_i^2},$$

where x_i and σ_i are the individual counting rates and their associated uncertainties, and $\bar{x}_w$ the weighted average of the counting rates. The latter is calculated according to

$$\bar{x}_w = \frac{\sum_{i=1}^{9} \frac{x_i}{s_i^2}}{\sum_{i=1}^{9} \frac{1}{s_i^2}}.$$

The T-values are assumed to be χ^2-distributed with 8 degrees of freedom.

The peaks cover gamma-ray energies from 47 to 1461 keV and represent natural radionuclides and Cs-137. The results are shown in Appendix B, Tables B1 and B2, which also give the T-values and their statistical significance. One of the peaks (Cs-

137 in Baltic Sea sediment) gives a very high T-value of 44.3 corresponding to a highly significant test (P> 99.9%). This shows that the variability of Cs-137 in that sample is significantly larger than the precision of the measurements which is about one percent. For all the other peaks the tests were not significant indicating homogeneity within the counting uncertainties. In order to quantify the inhomogeneity of Cs-137 in the Baltic Sea sediment sample, an additional percentage of uncertainty was combined with the counting uncertainty for that peak. This showed that by including an extra 2% uncertainty, the T-value reduced to 13.3 which is not statistically significant for the 8 degrees of freedom. It may thus be concluded that homogeneity of the sediment samples has been demonstrated for Cs-137 and natural radionuclides to within a few percent.

The sample material was distributed in June 1995 by sending 100 g Baltic Sea sediment and 200 g Kattegat sediment to the participating laboratories. Some laboratories shared the same samples. One participant received a Kattegat sediment sample only. The participants were requested to report results on natural and artificial radionuclides to Risø by the end of 1995. This deadline was later extended to mid-March 1996. The 21 participating laboratories are listed in Appendix A sorted by country. During the intercomparison two of the participants submitted an extra set of results, so the number of results received per radionuclide varies from 1 to 23. Appendix C lists all data received from the participants. For anonymity the data sets are identified by numbers from 1 to 23.

2.2. Statistics

The data were evaluated by comparing the laboratory mean results of radionuclide concentrations in the sediment samples to the corresponding overall mean concentrations. The procedures were adopted from those used in a recent proficiency testing exercise on radionuclides in milk powder carried out by the Central Science Laboratory (CSL 1996). The overall mean concentrations were determined for those radionuclides where six or more sets of data were received and after exclusion of outliers determined on a subjective basis. No evaluation was carried out for radionuclides where less than six sets of data were received.

For each laboratory mean result a z-score was calculated according to

$$z = \frac{x - \bar{x}_{om}}{s_t},$$

where x is the laboratory mean value, $\bar{x}_{om}$ the overall mean value and σ_t a target value for the standard deviation around the overall mean value for the analysis in question. The target values were chosen to be 5%, 10%, 15% or 20% depending on the radionuclide and represented uncertainties typical of those reported by the participants. The z-score may be used as a test-value in the normal distribution such that values between -2.0 and 2.0 would be acceptable at the 5% level.

Values of z-scores may be combined into a rescaled sum of z-scores, a RSZ-value which is calculated according to

$$RSZ = \frac{\sum z}{\sqrt{n}},$$

where n is the number of z-scores being combined. The RSZ-value may be used for a test in the normal distribution. The value is an indicator of analytical bias.

Values of z-scores may furthermore be combined into a sum of squares of z-scores, SSZ, which is calculated according to

$$SSZ = \sum_{i=1}^{n} z_i^{\,2}.$$

This value may be used for a test in the χ^2-distribution with n degrees of freedom. The SSZ-value is an indicator of analytical accuracy.

Two-sided tests have been made for the normal distribution and the χ^2-distribution. The following levels and symbols of statistical significance have been used: probably significant (P>95%, *), significant (P>99%, **) and highly significant (P>99.9%, ***).

The scores were combined across the two sediment samples for each set of results to allow an evaluation of the laboratory performances for each radionuclide to be made. Additionally, the scores were combined across all radionuclides to permit an evaluation of the overall analytical performance for each participant.

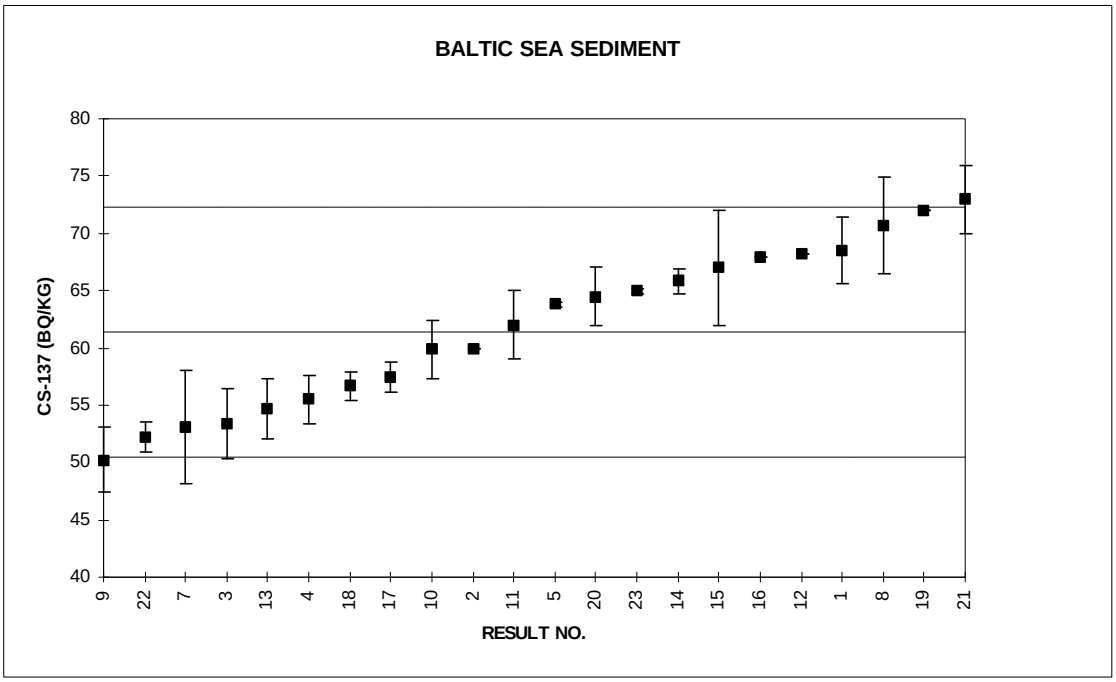
It is important to note the elements of subjectivity in the statistical tests. The overall mean values are in several cases determined after elimination of subjectively identified outliers (identified in Appendix D), and the target values of the standard deviations (σ_t) around the overall mean values are chosen on a subjective basis. For Cs-137 a σ_t-value of 5% has been used, for Pu-239,240, Ra-226, Th-232 and K-40 a σ_t-value of 10% has been used, for Co-60 a σ_t-value of 15% has been used and for Cs-134 and Pu-238 a σ_t-value of 20% has been used. Statistically significant tests demonstrate that the variabilities are greater (or smaller) than these σ_t-values.

3. RESULTS

Results were received on a wide range of radionuclides. The artificial radionuclides comprise Cs-137, Cs-134, Co-60, Sb-125, Pu-239,240, Pu-238, Am-241 and Sr-90. The natural radionuclides comprise Ra-226, Th-232, K-40, Pb-210, Po-210 and U-235. This section gives a graphical presentation of the results for each radionuclide and sediment sample where six or more data sets were received. The graphs show the sorted results and include an indication of the overall mean value and the 95% confidence interval for the data on which the overall mean is based. The results are shown with error bars that represent either standard errors of the mean in case of multiple determinations or reported uncertainties of single values. This covers the radionuclides Cs-137, Cs-134, Co-60, Pu-239,240, Pu-238, Ra-226, Th-232 and K-40. Furthermore, an evaluation of the laboratory scores is shown. The laboratory mean results including z-scores, overall mean values and corresponding 95% confidence intervals are given in Appendix D. For Cs-137 and K-40 the results are characterised by good statistical precision and many data for what reason additional graphs are given for these two radionuclides showing scatterplots of the laboratory ranking of the re-

sults for the two sediment samples. This helps identify laboratories with consistently high of low values compared with the overall mean values.

3.1. Cs-137



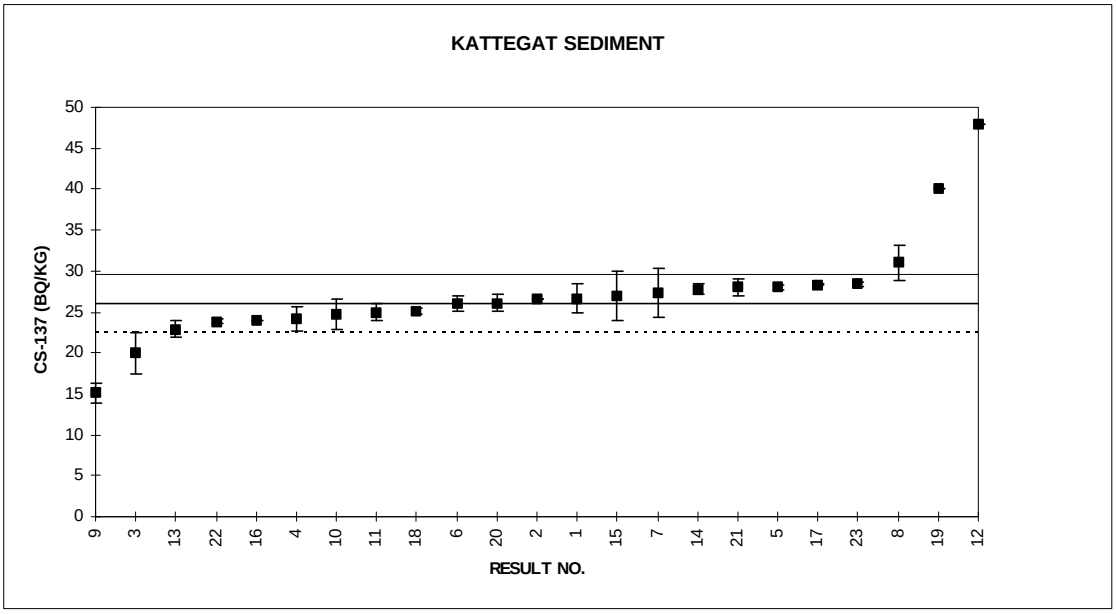


Table 3.1. Summary of combined z-scores for Cs-137 results showing rescaled sum of scores (RSZ), sum of squares of z-scores (SSZ) and the corresponding levels of statistical significance.

Res. No.	RSZ	Sign	SSZ	Sign	Res. No.	RSZ	Sign	SSZ	Sign
1	1.9	ns	5.6	ns	13	-3.3	**	10.7	**
2	-0.1	ns	0.3	ns	14	1.9	ns	3.8	ns
3	-5.1	***	28.7	***	15	1.8	ns	3.8	ns
4	-2.4	**	5.8	ns	16	0.4	ns	7.3	ns
5	1.6	ns	2.7	ns	17	0.3	ns	4.5	ns
6	-0.1	ns	0.0	ns	18	-1.7	ns	3.0	ns
7	-1.2	ns	8.2	*	19	10.0	***	125.1	***
8	4.8	***	23.2	***	20	0.7	ns	1.0	ns
9	-8.5	***	84.4	***	21	3.7	***	16.4	***
10	-1.1	ns	1.4	ns	22	-3.3	***	11.8	**
11	-0.5	ns	0.8	ns	23	2.1	*	4.4	ns
12	13.4	***	285.9	***					

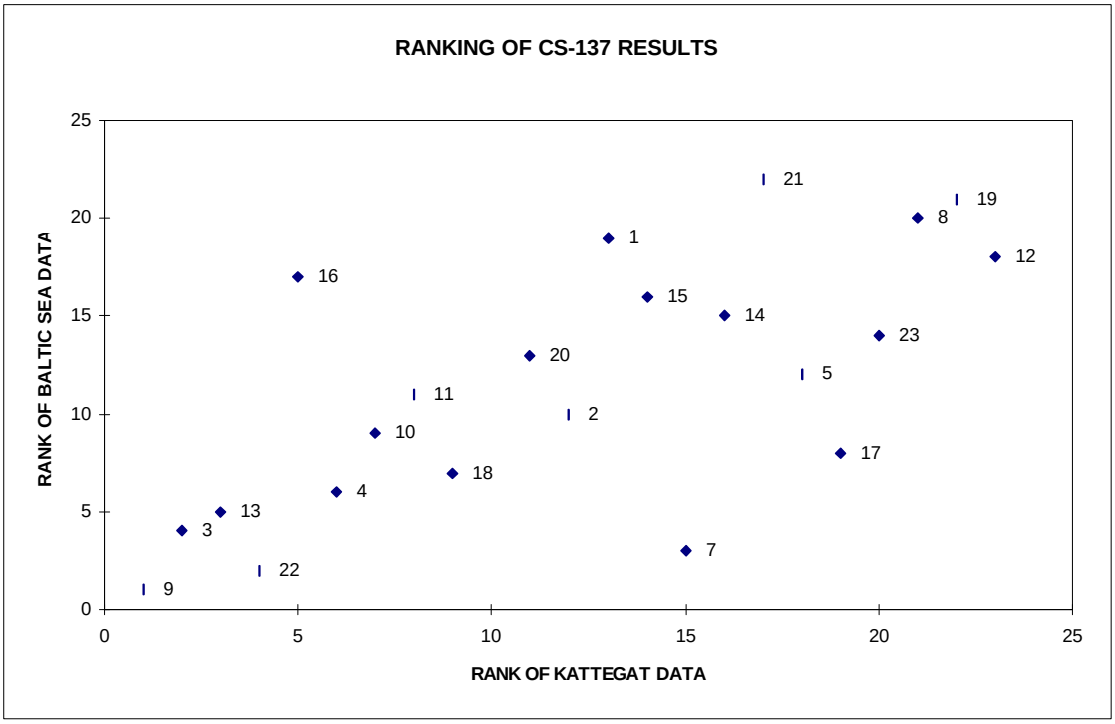


Figure 3.1. Scatterplot of ranking of Cs-137 results for the two sediment materials showing data-set labels with the marks.

The statistical tests in Table 3.1 show that 12 of the 23 data sets received on Cs-137 agree within 5% of the two overall mean values and that 9 of the data sets disagree significantly. Figure 3.1 shows that the data sets no. 3, 9, 13 and 22 show consistently low Cs-137 results compared to the other data sets, and that the data sets no. 8, 12 and 19 show consistently high values compared to the other data sets.

3.2. Cs-134

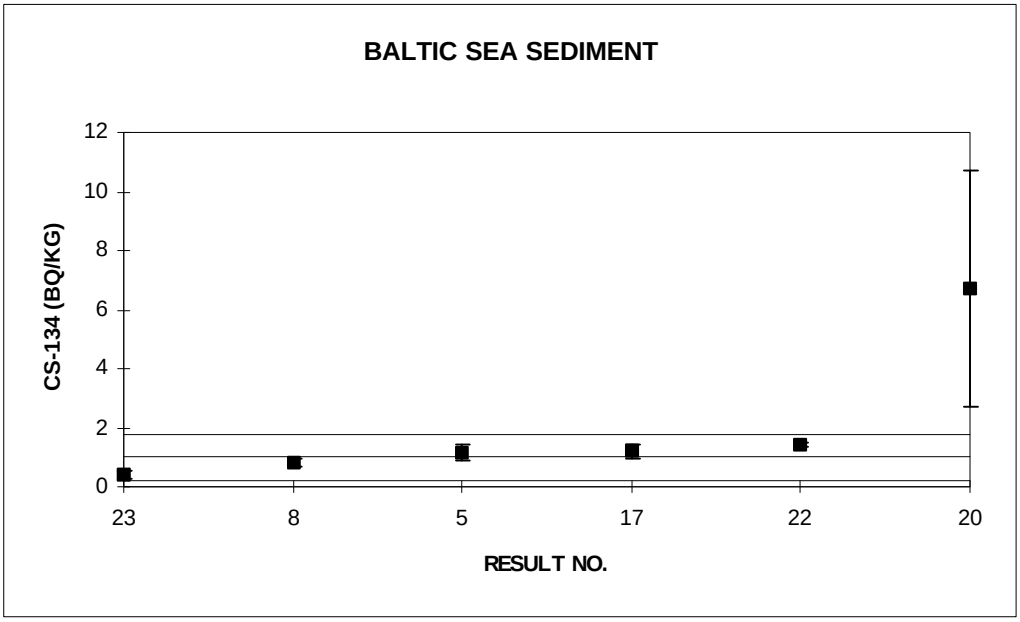


Table 3.2. Summary of combined z-scores for Cs-134 results showing rescaled sum of scores (RSZ), sum of squares of z-scores (SSZ) and the corresponding levels of statistical significance.

Res. No.	RSZ	Sign	SSZ	Sign	Res. No.	RSZ	Sign	SSZ	Sign
5	0.8	ns	0.6	ns	20	28.6	***	820	***
8	-0.8	ns	0.7	ns	22	2.0	*	4.1	*
17	1.0	ns	1.0	ns	23	-3.0	**	9.0	**

The statistical tests in Table 3.2 show that 3 of the 6 data sets received on Cs-134 agree within 20% of the overall mean value and that 2 of the data sets disagree significantly.

3.3. Co-60

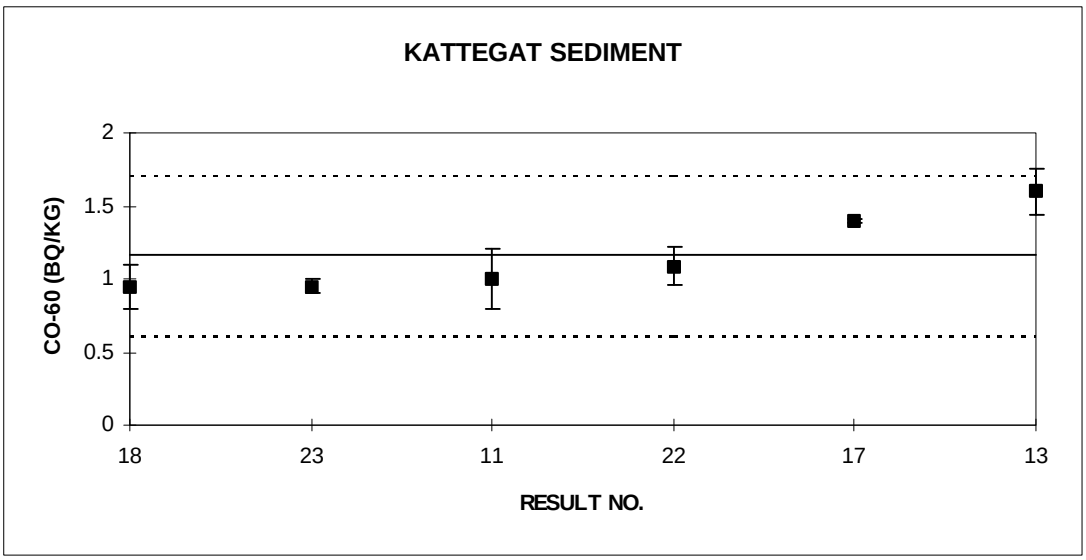


Table 3.3. Summary of combined z-scores for Co-60 results showing rescaled sum of scores (RSZ), sum of squares of z-scores (SSZ) and the corresponding levels of statistical significance.

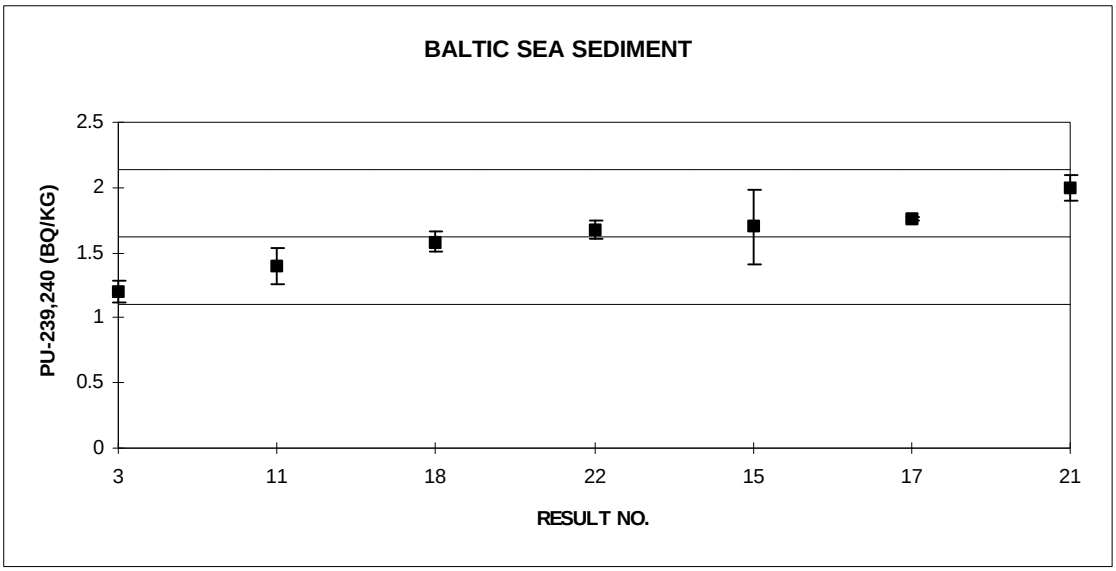
Res. No.	RSZ	Sign	SSZ	Sign	Res. No.	RSZ	Sign	SSZ	Sign
11	-0.9	ns	0.9	ns	18	-1.2	ns	1.5	ns
13	2.5	*	6.3	*	22	-0.5	ns	0.2	ns
17	1.3	ns	1.8	ns	23	-1.2	ns	1.5	ns

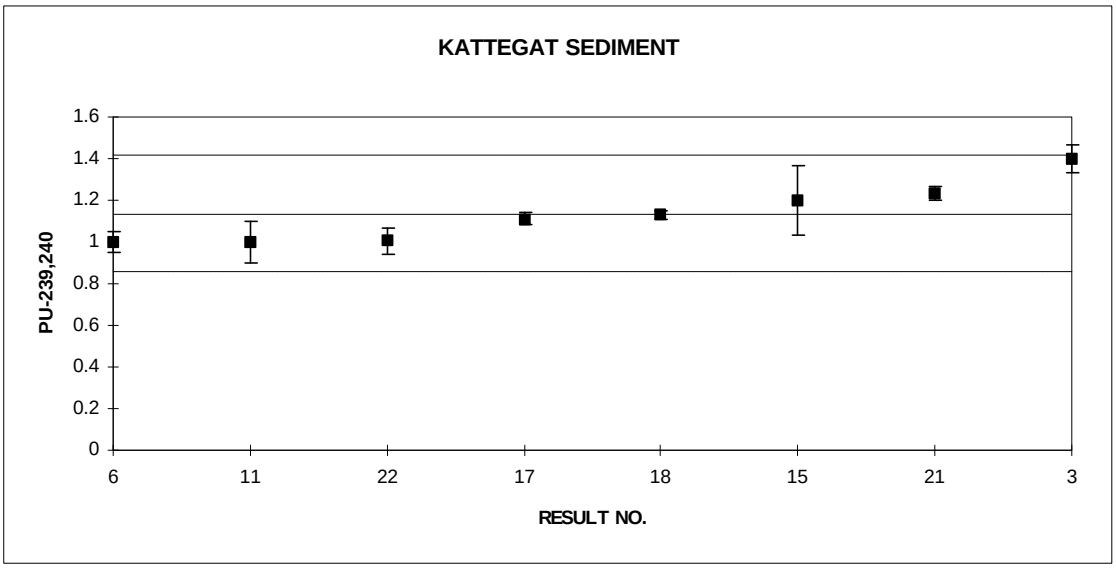
The statistical tests in Table 3.3 show that 5 of the 6 data sets received on Co-60 agree within 15% of the overall mean value and that none of the data sets disagree significantly.

3.4. Pu-239,240

Table 3.4. Summary of combined z-scores for Pu-239,240 results showing rescaled sum of scores (RSZ), sum of squares of z-scores (SSZ) and the corresponding levels of statistical significance.

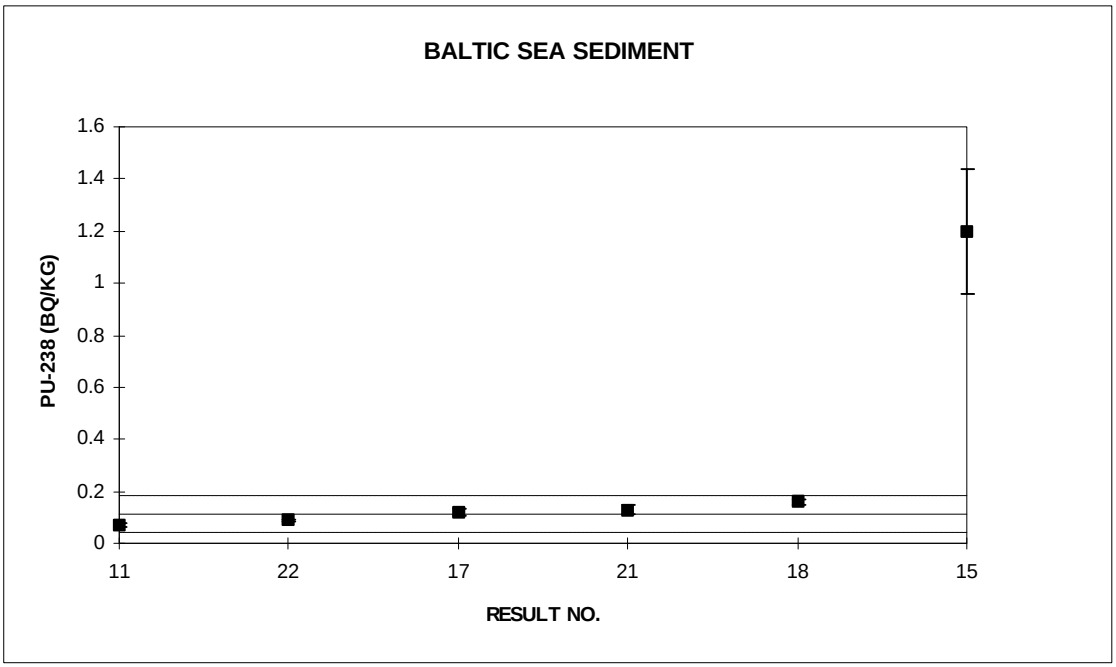
Res. No.	RSZ	Sign	SSZ	Sign	Res. No.	RSZ	Sign	SSZ	Sign
3	-0.2	ns	12.1	**	17	0.5	ns	0.8	ns
6	-1.2	ns	1.4	ns	18	-0.2	ns	0.04	*
11	-1.8	ns	3.2	ns	21	2.3	*	6.4	ns
15	0.8	ns	0.6	ns	22	-0.5	ns	1.4	ns





The statistical tests in Table 3.4 show that 5 of the 8 data sets received on Pu-239,240 agree within 10% of the two overall mean values and that one of the data sets disagrees significantly. It should be noted that the SSZ-value for result no. 18 is probably significant due to a very low value (two-sided test).

3.5. Pu-238



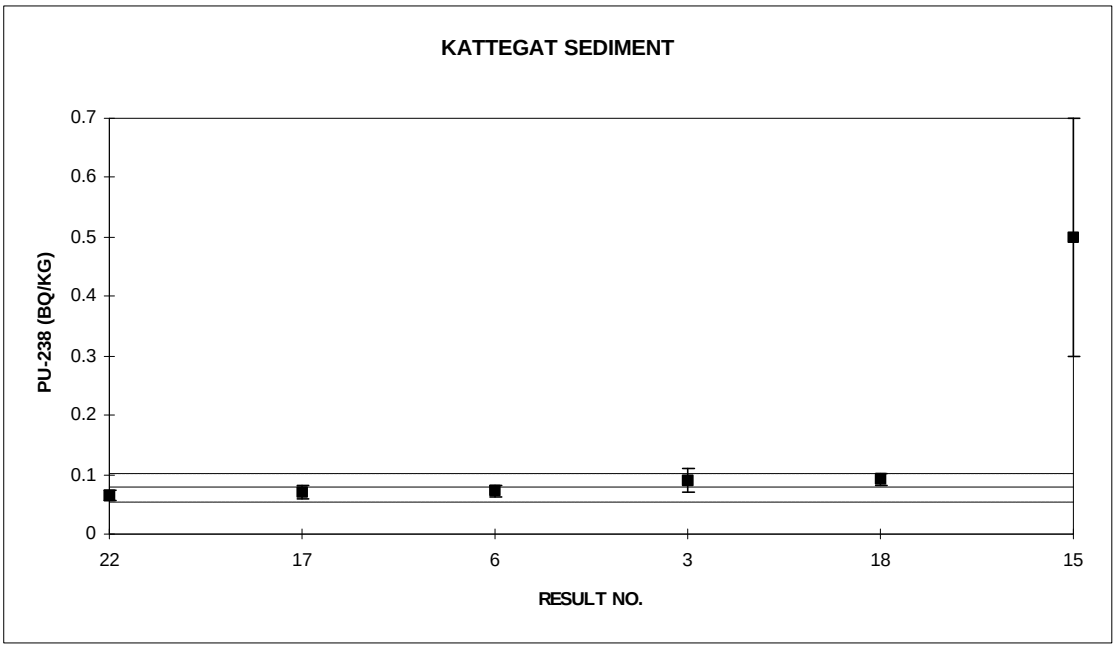
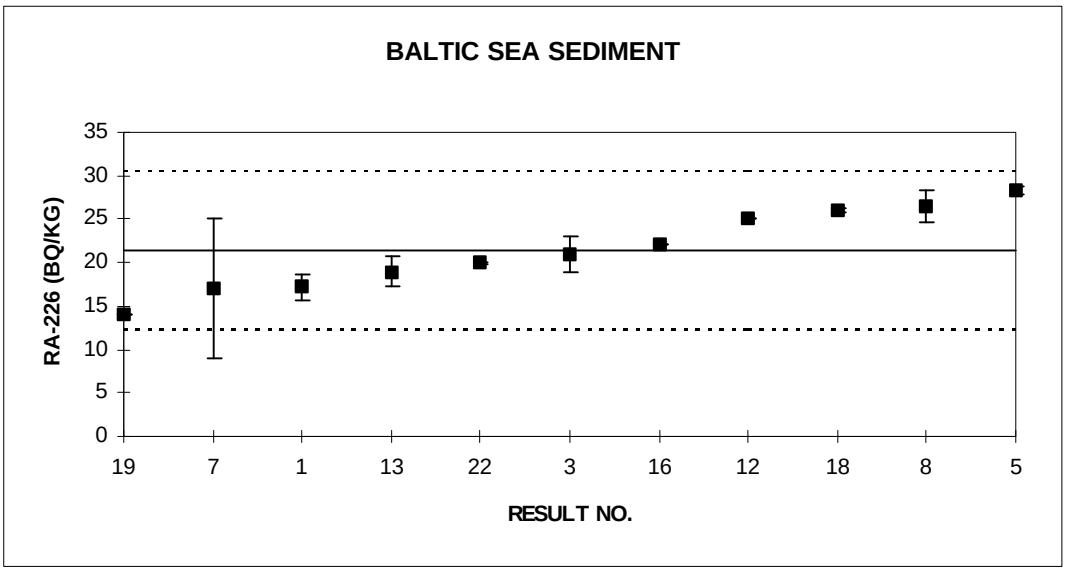


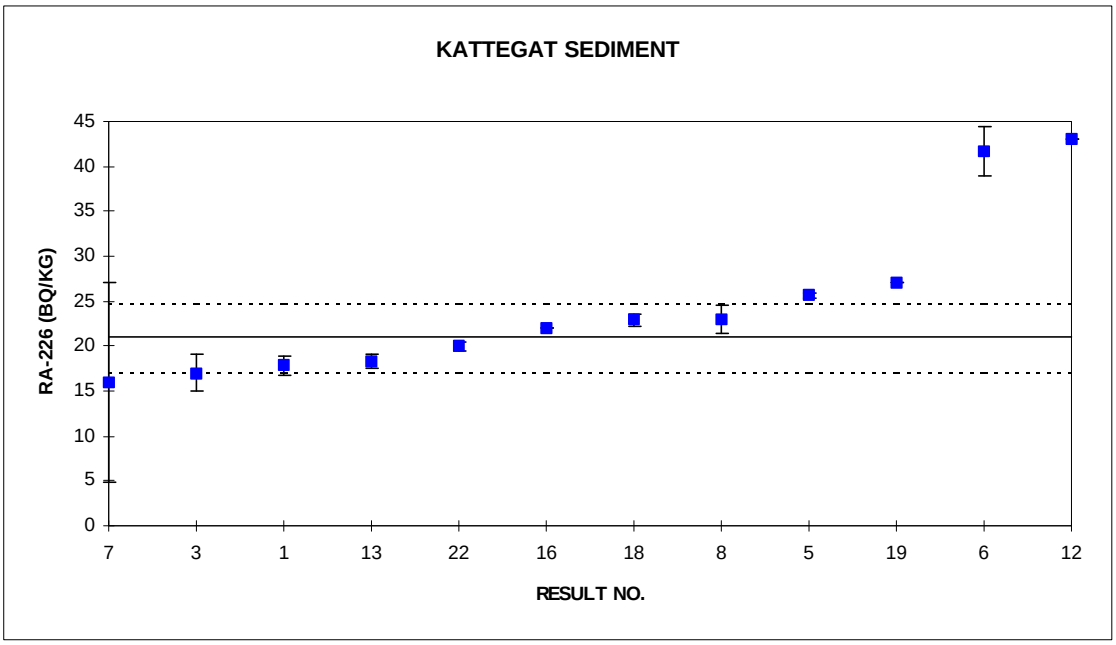
Table 3.5. Summary of combined z-scores for Pu-238 results showing rescaled sum of scores (RSZ), sum of squares of z-scores (SSZ) and the corresponding levels of statistical significance.

Res. No.	RSZ	Sign	SSZ	Sign	Res. No.	RSZ	Sign	SSZ	Sign
3	0.8	ns	0.6	ns	17	-0.2	ns	0.3	ns
6	-0.4	ns	0.1	ns	18	2.1	*	4.9	ns
11	-1.9	ns	3.7	ns	21	0.7	ns	0.5	ns
15	53.0	***	3024	***	22	-1.4	ns	1.9	ns

The statistical tests in Table 3.5 show that 6 of the 8 data sets received on Pu-238 agree within 20% of the two overall mean values and that one of the data sets disagrees significantly.

3.6. Ra-226





For the Kattegat sediment, result no. 6 is based on a radiochemical analysis of Ra-226 while the other results are based on direct gamma-ray spectrometry.

Table 3.6. Summary of combined z-scores for Ra-226 results showing rescaled sum of scores (RSZ), sum of squares of z-scores (SSZ) and the corresponding levels of statistical significance.

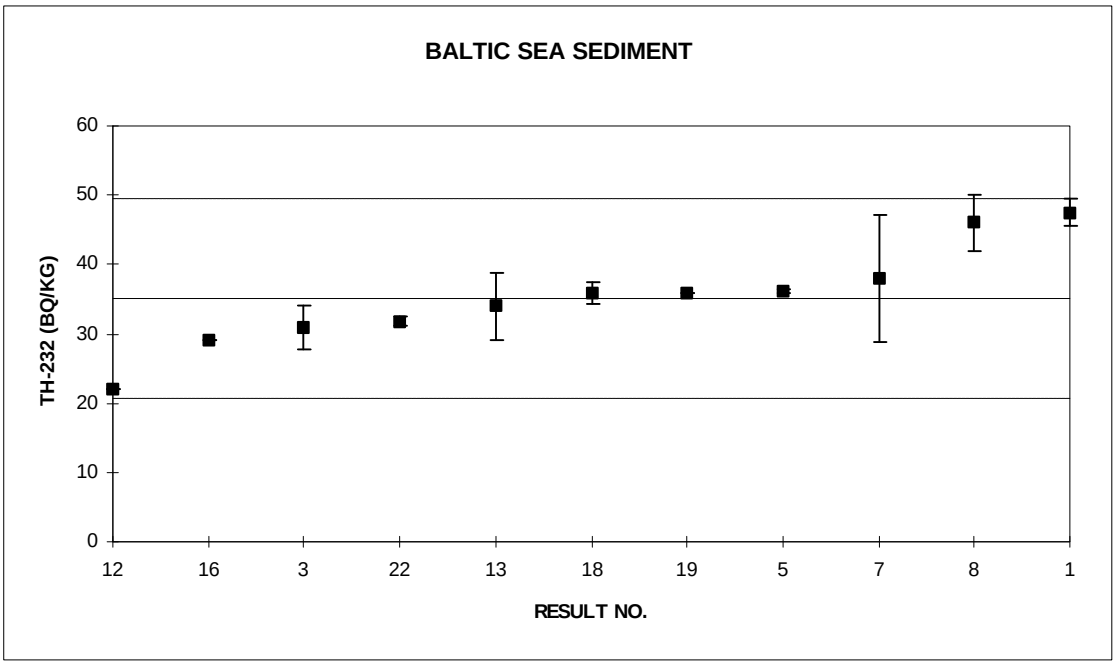
Res. No.	RSZ	Sign	SSZ	Sign	Res. No.	RSZ	Sign	SSZ	Sign
1	-2.5	*	6.2	ns	12	8.6	***	112.9	***
3	-1.5	ns	3.6	ns	13	-1.7	ns	2.9	**
5	3.8	***	15.1	**	16	0.5	ns	0.3	ns
6	9.9	***	97.2	***	18	2.2	*	5.4	ns
7	-3.1	**	9.9	**	19	-0.4	ns	20.3	***
8	2.3	*	6.5	ns	22	-0.8	ns	0.7	ns

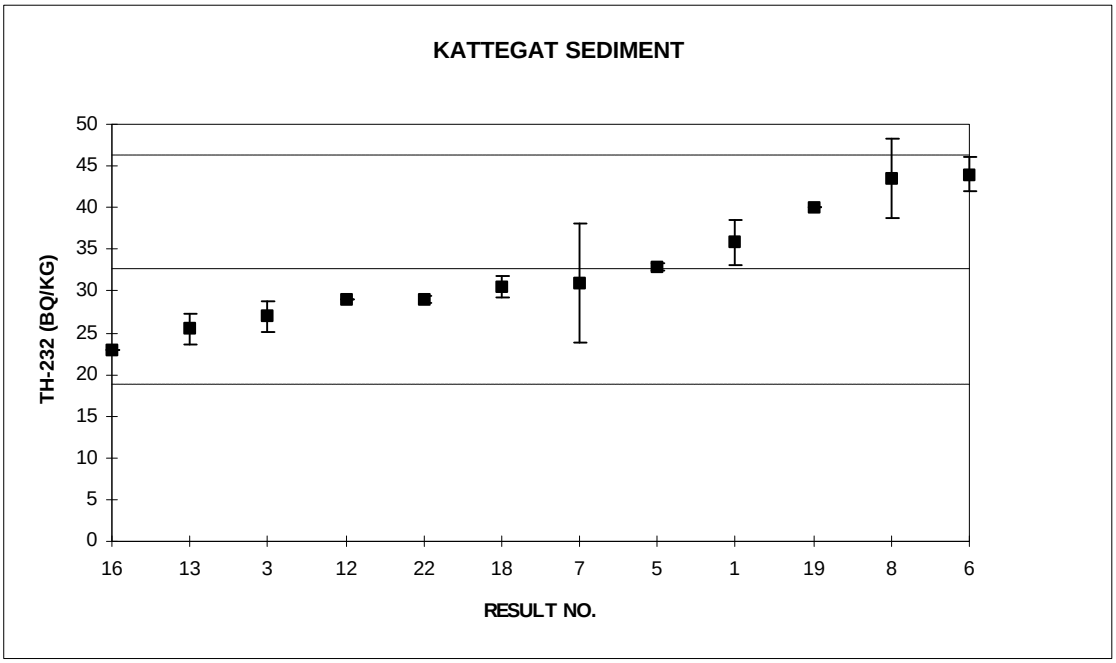
The statistical tests in Table 3.6 show that 3 of the 12 data sets received on Ra-226 agree within 10% of the two overall mean values and that 5 of the data sets disagree significantly.

3.7. Th-232

Table 3.7. Summary of combined z-scores for Th-232 results showing rescaled sum of scores (RSZ), sum of squares of z-scores (SSZ) and the corresponding levels of statistical significance.

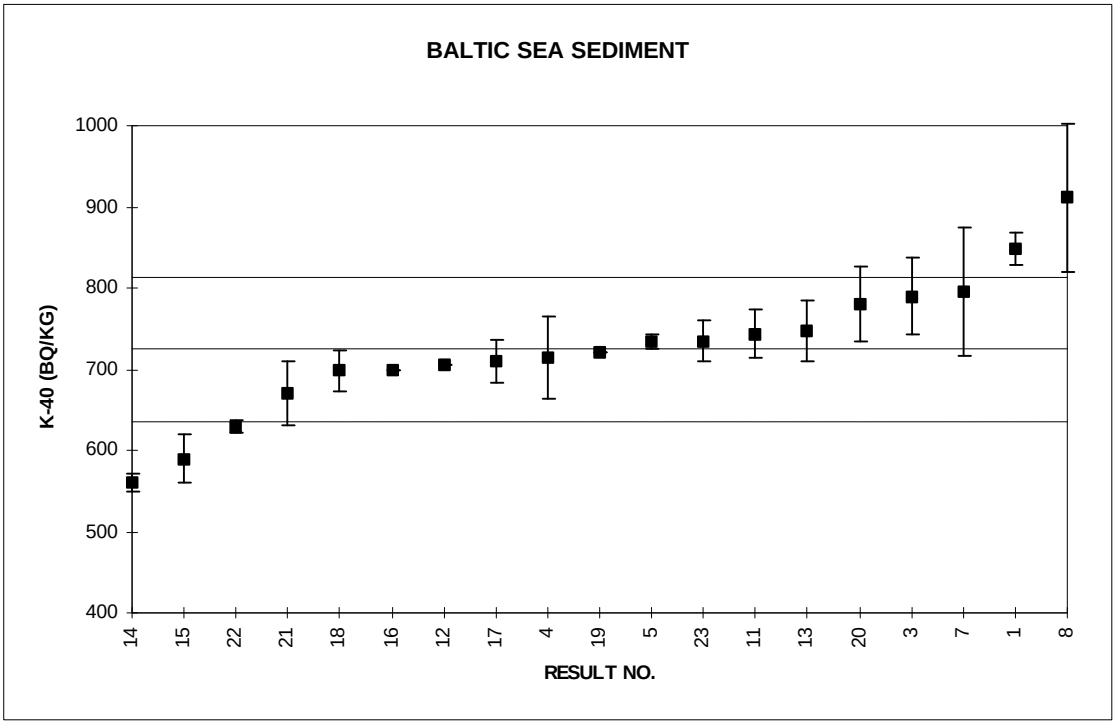
Res. No.	RSZ	Sign	SSZ	Sign	Res. No.	RSZ	Sign	SSZ	Sign
1	3.2	**	13.2	**	12	-3.4	***	15.3	***
3	-2.1	*	4.4	ns	13	-1.8	ns	5.0	ns
5	0.2	ns	0.1	ns	16	-3.3	***	11.8	**
6	3.5	***	12.2	**	18	-0.3	ns	0.5	ns
7	0.2	ns	0.9	ns	19	1.8	ns	5.2	ns
8	4.5	***	20.6	***	22	-1.5	ns	2.1	ns

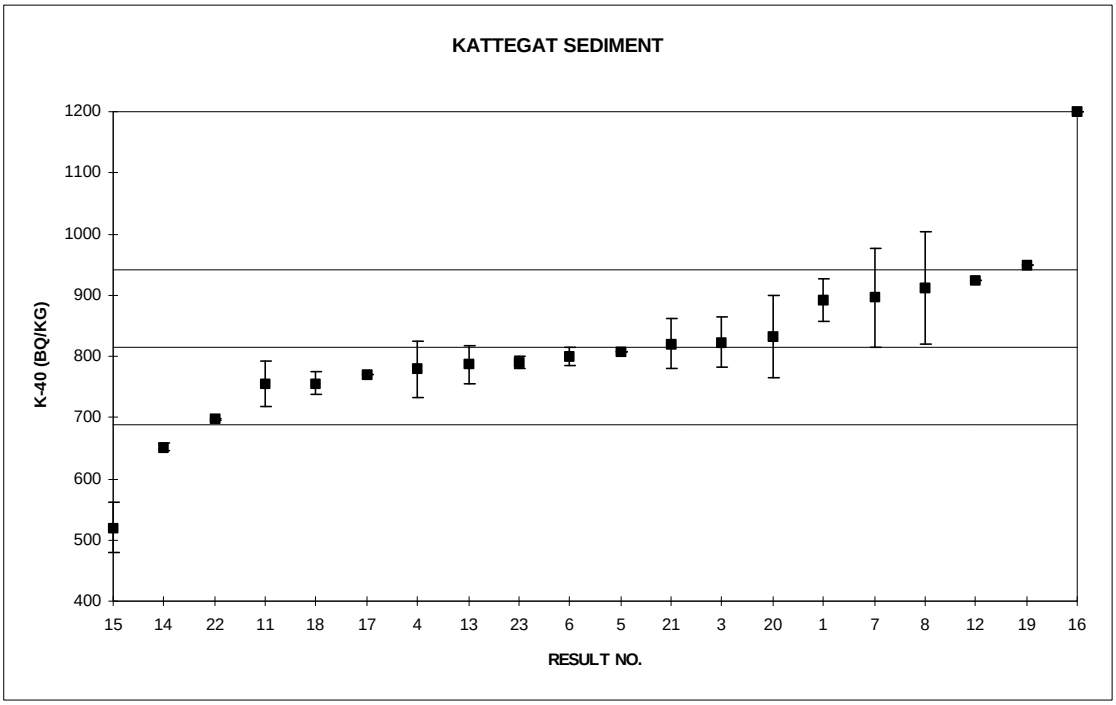




The statistical tests in Table 3.7 show that 6 of the 12 data sets received on Th-232 agree within 10% of the two overall mean values and that 5 of the data sets disagree significantly.

3.8. K-40


BALTIC SEA SEDIMENT
K-40 (BQ/KG)
1000
900
800
700
600
500
400
14 15 22 21 18 16 12 17 4 19 5 23 11 13 20 3 7 1 8
RESULT NO.


KATTEGAT SEDIMENT
K-40 (BQ/KG)
1200
1100
1000
900
800
700
600
500
400
15 14 22 11 18 17 4 13 23 6 5 21 3 20 1 7 8 12 19 16
RESULT NO.

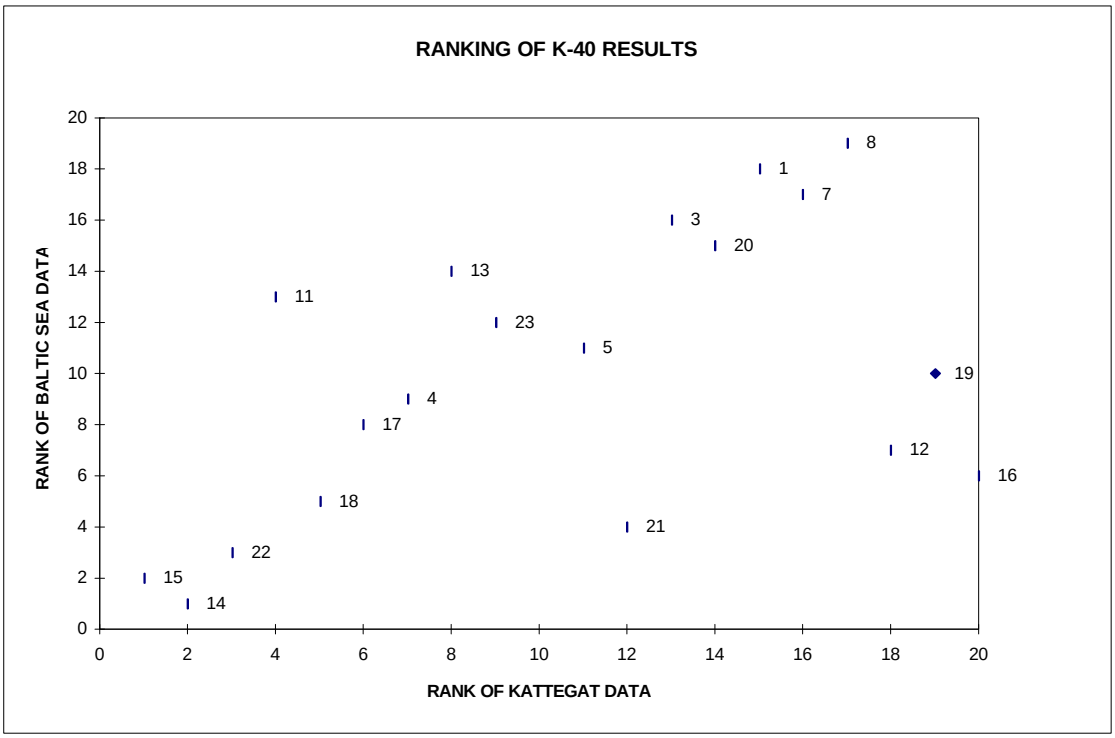


Figure 3.8. Scatterplot of ranking of K-40 results for the two sediment materials showing data-set labels with the marks.

Table 3.8. Summary of combined z-scores for K-40 results showing rescaled sum of scores (RSZ), sum of squares of z-scores (SSZ) and the corresponding levels of statistical significance.

Res. No.	RSZ	Sign	SSZ	Sign	Res. No.	RSZ	Sign	SSZ	Sign
1	1.9	ns	3.8	ns	14	-3.0	**	9.2	*
3	0.7	ns	0.8	ns	15	-3.9	***	16.6	***
4	-0.4	ns	0.2	ns	16	3.1	**	22.4	***
5	0.0	ns	0.0	ns	17	-0.5	ns	0.3	ns
6	-0.2	ns	0.0	ns	18	-0.8	ns	0.7	ns
7	1.4	ns	2.0	ns	19	1.1	ns	2.8	ns
8	2.7	**	8.0	*	20	0.7	ns	0.6	ns
11	-0.3	ns	0.6	ns	21	-0.5	ns	0.6	ns
12	0.7	ns	1.8	ns	22	-2.0	ns	3.8	ns
13	0.0	ns	0.2	ns	23	-0.1	ns	0.1	ns

The statistical tests in Table 3.8 show that 16 of the 20 data sets received on K-40 agree within 10% of the two overall mean values and that 4 of the data sets disagree significantly. Figure 3.8 shows that the data sets no. 14, 15 and 22 show consistently low K-40 results compared to the other data sets, and that the data set no. 8 shows consistently high values compared to the other data sets.

3.9. Radionuclides combined

Table 3.9. Summary of combined z-scores for Cs-137, Cs-134, Co-60, Pu-239,240, Pu-238, Ra-226, Th-232 and K-40 showing rescaled sum of scores (RSZ), sum of squares of z-scores (SSZ) and the corresponding levels of statistical significance. The number of z-scores combined is given as n.

Res. No.	n	RSZ	Sign.	SSZ	Sign.	Res. No.	n	RSZ	Sign.	SSZ	Sign.
1	8	2.3	*	28.8	***	13	9	-2.4	*	25.1	**
2	2	-0.1	ns	0.3	ns	14	4	-0.8	ns	13.0	*
3	11	-3.2	**	50.2	***	15	8	25.8	***	3044.7	***
4	4	-2.0	*	6.0	ns	16	8	0.3	ns	41.8	***
5	9	2.9	**	18.5	ns	17	10	0.8	ns	8.8	ns
6	6	4.7	***	111.0	***	18	13	0.2	ns	16.0	ns
7	8	-1.4	ns	21.0	*	19	8	6.2	***	153.3	***
8	9	6.5	***	59.0	***	20	5	13.7	***	821.6	***
9	2	-8.5	***	84.4	***	21	7	3.2	**	23.9	**
10	2	-1.1	ns	1.4	ns	22	14	-3.2	**	26.1	*
11	8	-2.3	*	9.1	ns	23	6	-0.6	ns	15.0	*
12	8	9.7	***	416.0	***						

The overall analytical performance for Cs-137, Cs-134, Co-60, Pu-239,240, Pu-238, Ra-226, Th-232 and K-40 of each participant may be evaluated from the data in Table 3.9. The statistical tests show that 4 of the 23 data sets agree within target standard deviations of the overall mean values and that 14 of the data sets disagree significantly. It should be noted, however, that the number of results submitted by the participants vary considerably, from 2 to 14.

3.10. Other observations

During the course of the intercomparison some details of the communication of results from participant to evaluator is worth mentioning, particularly since these are believed to be typical of what may happen when data are analysed and communicated to other laboratories.

Two participants on their own initiative sent new results to the intercomparison. It was decided to retain both old and new sets of results for the evaluation. For one participant these are the data sets numbered 9 (old) and 10 (new) and they cover Cs-137 only. Clearly the quality of the two sets of results improved significantly with the new data as can be seen from the z-scores from the Tables D1 and D2 in Appendix D. These measurements were made with a NaI-detector system and the motivation for the change was that a more realistic background correction (marine sediments) had been applied for the new set of results than for the old (lake sediments). For the other participant the old data set was no. 7 and the new no. 8 and the reason for the change was stated to be due to a mistake in the old data. However, the overall performance shows that the change was to the worse. Data set no. 7 is one of the few that agrees with the overall performance criteria, while data set no. 8 does not (Table 3.9). Only one nu-

clide (Ra-226) shows some improvement going from data set no. 7 to no. 8 (Table 3.6), for all the other nuclides the performances deteriorate.

One participant submitting results from gamma-spectrometric analyses was asked to check his results since they were all found to be higher than those from the other participants with the same factor of about an order of magnitude. New results were received and the old ones discarded.

One participant was asked to check if he had accidentally interchanged the results for the two sediment samples. This was confirmed by the participant and the results were changed accordingly before the evaluation.

4. CONCLUSIONS

An intercomparison exercise has been carried out under the EKO-1 project of the Nordic Safety Research Programme (NKS) for the period 1996-97. The exercise has dealt with the analysis of artificial and natural radionuclides in two sediment samples, one from the Baltic Sea and one from the Kattegat. The measurement techniques have included direct gamma-ray spectrometry with Ge and NaI detectors, and radiochemical procedures followed by beta counting and alpha spectrometry. The participants have comprised 21 laboratories of which 14 are from the Nordic countries, 6 from the Baltic republics and one from Japan.

Results were submitted for a large number of radionuclides comprising Cs-137, Cs-134, Co-60, Sb-125, Pu-239,240, Pu-238, Am-241, Sr-90, Ra-226, Th-232 and K-40, Pb-210, Po-210 and U-235. The analytical performance of the participants has been evaluated for those radionuclides where six or more data sets were received. Statistical tests were made to see if individual results agreed with overall average radionuclide concentrations in the two sediment materials within target standard deviations. The results of these tests are summarised in Table 4 which shows the radionuclides, the selected target standard deviations, the number of data sets submitted and the number of data sets which disagree significantly with the overall mean values.

It is noteworthy that with the exception of Co-60 the performance criteria are not met in about 20-40% of the data sets for the relatively straight forward gamma-spectrometric analyses of Cs-137, Cs-134, Ra-226, Th-232 and K-40. For the more complicated radiochemical analyses of plutonium isotopes only 13% of the data sets do not meet the performance criteria. The test of the overall analytical performance shows that 61% of the data sets do not meet the combined performance criteria. This shows that there is room for considerable improvement of analytical quality for most of the laboratories that have participated in this intercomparison.

Table 4. Summary of analytical performance across all data sets.

Nuclide	Target standard deviation (%)	Number of data sets	Number of data sets that disagree significantly with performance criteria
Cs-137	5	23	9 (39%)
Cs-134	20	6	2 (33%)
Co-60	15	6	0 (0%)
Pu-239,240	10	8	1 (13%)
Pu-238	20	8	1 (13%)
Ra-226	10	12	5 (42%)
Th-232	10	12	5 (42%)
K-40	10	20	4 (20%)
Nuclides combined		23	14 (61%)

The intercomparison exercise has furthermore demonstrated several elementary problems in analytical work such as interchange of samples, mistakes in calculations and correction of background levels. High-quality analytical performance requires careful and dedicated staff using well-established laboratory procedures and frequent participation in international intercomparison exercises.

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APPENDIX B, TEST OF SAMPLE HOMOGENEITY

This appendix gives the detailed data in the Tables B1 and B2 of the Ge detector measurements on sub-samples of the two sediment materials for the investigation of sample homogeneity.

The tables on the two following pages are missing in this version of the report. For further information, please contact the author.

Table B1. Nine sub-samples of Baltic Sea sediment of identical weight (125 g) and geometry analysed by gamma-ray spectrometry on a Ge detector. Counting rates (counts per 1000 s, c/ks) and associated uncertainties (1 SD, %) of prominent gamma-ray peaks from the spectra are shown. The weighted mean counting rates and corresponding relative uncertainties are given for the peaks, as well as T-values for χ^2-tests of homogeneity.

Sample	47 keV		295 keV		352 keV		583 keV		609 keV		662 keV		911 keV		1461 keV	
No.	(c/ks)	(%)	(c/ks)	(%)	(c/ks)	(%)	(c/ks)	(%)	(c/ks)	(%)	(c/ks)	(%)	(c/ks)	(%)	(c/ks)	(%)
1	30.5	6.2	19.5	6.2	33.7	3.7	25.0	4.1	20.7	5.3	121.8	1.3	15.3	5.6	91.8	1.4
2	32.0	5.8	19.0	5.8	33.3	3.4	23.5	3.9	22.5	4.2	119.4	1.1	14.6	5.3	92.1	1.2
3	27.8	6.9	20.6	5.6	33.9	3.4	23.0	4.1	21.1	4.8	110.5	1.2	14.5	5.6	90.8	1.3
4	29.1	5.6	17.4	6.5	33.1	3.4	23.1	4.1	22.9	4.3	116.4	1.2	14.3	5.5	93.6	1.3
5	26.9	6.3	20.6	5.5	31.0	3.7	22.2	4.3	22.9	4.3	115.9	1.2	14.5	5.6	93.3	1.3
6	26.3	11.4	19.2	10.3	33.3	6.0	26.0	7.8	22.9	7.8	111.2	2.2	14.8	9.3	92.9	2.3
7	31.3	6.1	20.0	6.5	31.6	4.2	21.9	5.0	22.6	4.9	118.0	1.4	14.4	6.0	94.9	1.4
8	25.6	6.2	20.2	5.4	33.9	3.3	24.9	3.7	21.3	4.6	114.5	1.2	15.0	5.2	95.5	1.2
9	28.1	10.8	18.5	11.5	33.7	6.3	23.9	7.1	21.2	8.7	117.9	2.3	16.1	8.9	93.4	2.4
Mean	28.6	2.2	19.5	2.1	33.0	1.3	23.5	1.5	22.0	1.7	116.2	0.4	14.7	2.0	93.1	0.5
T	11.8		6.1		5.9		10.5		5.4		44.3		2.1		12.0	
Significance	ns		ns		ns		ns		ns		***		ns		ns	

ns not significant, *** highly significant (P> 99.9%)

Table B2. Nine sub-samples of Kattegat sediment of identical weight (260 g) and geometry analysed by gamma-ray spectrometry on a Ge detector. Counting rates (counts per 1000 s, c/ks) and associated uncertainties (1 SD, %) of prominent gamma-ray peaks from the spectra are shown. The weighted mean counting rates and corresponding relative uncertainties are given for the peaks, as well as T-values for χ^2-tests of homogeneity.

Sample	47 keV		295 keV		352 keV		583 keV		609 keV		662 keV		911 keV		1461 keV	
No.	(c/ks)	(%)	(c/ks)	(%)	(c/ks)	(%)	(c/ks)	(%)	(c/ks)	(%)	(c/ks)	(%)	(c/ks)	(%)	(c/ks)	(%)
1	30.5	12.0	26.6	10.5	43.2	6.2	35.0	6.7	29.9	7.7	77.6	3.6	19.8	9.4	151.7	2.1
2	31.0	6.3	26.4	5.8	42.4	3.5	33.6	3.8	31.4	4.1	75.1	2.0	18.4	5.6	151.5	1.1
3	34.8	9.5	26.0	9.6	43.7	5.7	34.3	6.4	31.5	7.1	75.7	3.4	19.8	8.7	148.6	1.9
4	29.5	3.4	23.4	3.4	41.6	1.9			30.9	2.2	75.3	1.0			148.5	0.6
5	31.1	6.0	24.4	5.7	41.7	3.4	32.5	3.7	29.8	4.1	76.0	1.9	20.2	4.9	149.7	1.1
6	29.1	5.8	23.8	5.4	43.2	3.0	32.8	3.4	30.0	3.7	75.7	1.7	18.8	4.8	153.5	0.9
7	29.0	5.9	23.8	5.5	42.9	3.0	34.0	3.3	28.9	4.0	75.0	1.7	20.5	4.4	150.4	1.0
8	29.2	6.0	25.7	5.2	42.4	3.1	35.6	3.2	30.9	3.7	74.7	1.8	19.6	4.8	150.6	1.0
9	30.3	4.2	23.8	3.7	41.4	2.1	33.7	2.2	30.0	2.6	77.1	1.1	19.3	3.2	149.9	0.6
Mean	30.0	1.8	24.2	1.7	42.1	1.0	33.8	1.2	30.4	1.2	75.7	0.5	19.5	1.7	150.1	0.3
T	3.89		8.08		2.83		4.85		3.79		4.35		3.66		10.61	
Significance	ns		ns		ns		ns		ns		ns		ns		ns	

ns - not significant

APPENDIX C, ALL DATA

This appendix shows the individual results of radionuclide concentrations in the two sediment materials reported by the participants.

Table C1. Results reported on Cs-137 (Bq kg^{-1} and percent uncertainty, 1 SD) in Baltic Sea sediment samples.

Res. No.	Bq/kg	%	Res. No.	Bq/kg	%	Res. No.	Bq/kg	%	Res. No.	Bq/kg	%
1	74	20.3	9	42		10	60		18	53.9	6.0
1	64	20.3	9	43		10	62		18	53.6	4.0
1	72	20.8	9	44		10	67		18	55.2	2.0
1	78	20.5	9	47		10	69		18	57.4	4.0
1	59	20.3	9	49		10	71		18	58.4	2.0
1	64	20.3	9	55		11	62	4.8	18	61.6	2.2
2	60		9	59		12	68.2		19	72	
3	53.4	5.8	9	61		13	54.6	4.8	20	64.5	4.0
4	55.5	3.8	9	64		14	65.8	1.7	21	73	4.1
5	63.6	4.1	10	45		15	67	7.5	22	54.2	3.0
5	64	3.1	10	51		16	68		22	52.8	3.0
7	53.1	9.4	10	56		17	59.1	4.1	22	49.7	3.0
8	70.7	6.0	10	58		17	54.8	4.0	23	65.1	4.0
9	38		10	60		17	58.3	3.9	23	64.8	4.0

Table C2. Results reported on Cs-137 (Bq kg^{-1} and percent uncertainty, 1 SD) in Kattegat sediment samples.

Res. No.	Bq/kg	%	Res. No.	Bq/kg	%	Res. No.	Bq/kg	%	Res. No.	Bq/kg	%
1	30	20.0	9	7		10	24		18	26.11	5.0
1	25	20.0	9	12		10	26		18	23.45	6.0
1	29	20.7	9	14		10	27		18	25.34	5.0
1	32	21.9	9	15		10	29		18	25.13	1.0
1	22	22.7	9	15		10	30		18	25.31	3.0
1	22	22.7	9	16		10	35		19	40	
2	26.6		9	16		11	25	4.0	20	26.1	4.0
3	20	12.5	9	17		12	48		21	28	3.6
4	24.2	6.2	9	18		13	22.94	4.2	22	23.8	2.9
5	27.7	4.7	9	21		14	27.8	2.2	22	23.5	3.0
5	28.3	3.5	10	14		15	27	11.1	22	24.3	2.9
6	26	3.5	10	19		16	24		23	28.7	5.0
7	27.4	10.9	10	20		17	28.4	3.9	23	28.1	4.0
8	31	7.0	10	23		17	28.2	3.9			

Table C3. Results reported on Cs-134 (Bq kg^{-1} and percent uncertainty, 1 SD) in Baltic Sea sediment samples.

Res. No.	Cs-134	%	Res. No.	Cs-134	%	Res. No.	Cs-134	%	Res. No.	Cs-134	%	%
3	< 2.5		8	0.83	18	17	1.5	27	22	1.3	15	
4	< 4.5		13	< 3.2		17	nd		22	1.4	36	
5	1.4	64	15	< 2		20	6.7	60	23	0.4	37	
5	0.9	56	17	0.9	33	22	1.5	13				

Table C4. Results reported on Cs-134 (Bq kg^{-1} and percent uncertainty, 1 SD) in Kattegat sediment samples.

Res. No.	Cs-134	%	Res. No.	Cs-134	%	Res. No.	Cs-134	%	Res. No.	Cs-134	%
3	< 1.0		5	0.3	167	13	< 0.83		20	2.2	40
4	3.4	44	5	0.5	20	15	< 2				

Table C5. Results reported on Co-60 (Bq kg^{-1} and percent uncertainty, 1 SD) in Kattegat sediment samples.

Res. No.	Co-60	%	Res. No.	Co-60	%	Res. No.	Co-60	%	Res. No.	Co-60	%
3	< 1.5		17	1.41	8	22	1.3	15	23	0.9	19
11	1	20	17	1.38	7	22	0.85	15	23	1	18
13	1.6	10	18	0.95	16	22	1.1	18			

Table C6. Results reported on Sb-125 (Bq kg^{-1} and percent uncertainty, 1 SD) in Kattegat sediment sample.

Res. No.	Sb-125	%
17	2.0	20
17	1.7	18

Table C7. Results reported on Pu-239,240 (Bq kg^{-1} and percent uncertainty, 1 SD) in Baltic Sea sediment samples.

Res. No.	Pu-239,240	%	Res. No.	Pu-239,240	%	Res. No.	Pu-239,240	%	Res. No.	Pu-239,240	%
3	1.20	8	17	1.76	7	18	1.51	8	22	1.65	5
11	1.40	7	17	1.76	6	21	2.10	5	22	1.81	8
15	1.70	18	17	1.80	8	21	1.90	5			
17	1.71	9	18	1.66	8	22	1.57	6			

Table C8. Results reported on Pu-239,240 (Bq kg^{-1} and percent uncertainty, 1 SD) in Kattegat sediment samples.

Res. No.	Pu-239,240	%	Res. No.	Pu-239,240	%	Res. No.	Pu-239,240	%	Res. No.	Pu-239,240	%
3	1.40	7	17	1.17	8	18	1.15	9	21	1.20	17
6	1.00	5	17	1.11	6	18	1.11	8	22	1.03	5
11	1.00	10	17	1.03	7	21	1.20	8	22	1.10	6
15	1.20	17	17	1.13	7	21	1.30	8	22	0.89	8

Table C9. Results reported on Pu-238 (Bq kg^{-1} and percent uncertainty, 1 SD) in Baltic Sea sediment samples.

Res. No.	Pu-238	%	Res. No.	Pu-238	%	Res. No.	Pu-238	%	Res. No.	Pu-238	%
3	< 0.06		17	0.09	11	18	0.168	11	22	0.081	30
11	0.07	14	17	0.13	8	21	0.13	15			
15	1.2	20	17	0.12	17	22	0.10	25			
17	0.14	21	18	0.151	14	22	0.084	24			

Table C10. Results reported on Pu-238 (Bq kg^{-1} and percent uncertainty, 1 SD) in Kattegat sediment samples.

Res. No.	Pu-238	%	Res. No.	Pu-238	%	Res. No.	Pu-238	%	Res. No.	Pu-238	%
3	0.09	22	17	0.10	20	18	0.082	25	22	0.05	40
6	0.072	13	17	0.07	14	18	0.102	14			
11	nd		17	0.05	20	22	0.076	16			
15	0.50	40	17	0.06	17	22	0.069	22			

Table C11. Results reported on Am-241 (Bq kg^{-1} and percent uncertainty, 1 SD) in Baltic Sea sediment samples.

Res. No.	Am-241	%	Res. No.	Am-241	%	Res. No.	Am-241	%
17	0.69	12	17	0.75	8	18	0.97	9
17	0.83	8	17	0.53	13	18	0.90	9

Table C12. Results reported on Am-241 (Bq kg^{-1} and percent uncertainty, 1 SD) in Kattegat sediment samples.

Res. No.	Am-241	%	Res. No.	Am-241	%	Res. No.	Am-241	%	Res. No.	Am-241	%
6	0.37	9	17	0.50	12	17	0.41	10	18	0.37	10
17	0.44	27	17	0.47	15	18	0.41	10			

Table C13. Results reported on Sr-90 (Bq kg^{-1} and percent uncertainty, 1 SD) in Baltic Sea sediment samples.

Res. No.	Sr-90	%	Res. No.	Sr-90	%	Res. No.	Sr-90	%	Res. No.	Sr-90	%
3	0.39	5	15	15.7	4	18	0.21	10	18	0.21	9

Table C14. Results reported on Sr-90 (Bq kg^{-1} and percent uncertainty, 1 SD) in Kattegat sediment samples.

Res. No.	Sr-90	%	Res. No.	Sr-90	%	Res. No.	Sr-90	%	Res. No.	Sr-90	%
3	0.2	10	15	32	13	18	0.11	19	18	0.18	5

Table C15. Results reported on Ra-226 (Bq kg^{-1} and percent uncertainty, 1 SD) in Baltic Sea sediment samples.

Res. No.	Ra-226	%	Res. No.	Ra-226	%	Res. No.	Ra-226	%	Res. No.	Ra-226	%
1	13	54	3	21	10	13	19.0	9	18	26.4	6
1	15	47	5	27.8	4	16	22		18	27.1	11
1	16	44	5	28.7	10	18	25.1	12	19	14	
1	18	50	7	17	47	18	25.4	6	22	19.7	
1	18	50	8	26.5	7	18	25.7	3	22	20.1	
1	23	35	12	25		18	26.2	22	22	20.1	

Table C16. Results reported on Ra-226 (Bq kg^{-1} and percent uncertainty, 1 SD) in Kattegat sediment samples.

Res. No.	Ra-226	%	Res. No.	Ra-226	%	Res. No.	Ra-226	%	Res. No.	Ra-226	%
1	15	40	5	25.4	4	12	43		18	24.9	5
1	16	38	5	26	6	13	18.3	4	19	27	
1	16	38	6	38	5	16	22		22	19.3	4
1	18	50	6	40	5	18	21.2	10	22	19.8	6
1	20	50	6	47	4	18	21.9	1	22	21	5
1	22	32	7	16	69	18	23.1	8			
3	17	12	8	23	7	18	23.5	9			

Table C17. Results reported on Th-232 (Bq kg^{-1} and percent uncertainty, 1 SD) in Baltic Sea sediment samples.

Res. No.	Th-232	%	Res. No.	Th-232	%	Res. No.	Th-232	%	Res. No.	Th-232	%
1	38	24	3	31	10	13	34.0	14	18	39.1	24
1	46	28	5	35.8	4	16	29		18	42.1	32
1	50	26	5	36.3	5	18	32.4	18	19	36	
1	50	28	7	38	24	18	32.9	11	22	30.7	10
1	50	26	8	46	9	18	33.1	6	22	31.8	6
1	51	25	12	22		18	36.2	9	22	32.9	5

Table C18. Results reported on Th-232 (Bq kg^{-1} and percent uncertainty, 1 SD) in Kattegat sediment samples.

Res. No.	Th-232	%	Res. No.	Th-232	%	Res. No.	Th-232	%	Res. No.	Th-232	%
1	30	27	5	32.5	4	13	25.4	7	19	40	
1	30	27	5	33.3	3	16	23		22	28.2	6
1	30	27	6	42	5	18	27.2	29	22	29.2	6
1	40	25	6	46	5	18	28.6	2	22	29.7	5
1	40	25	7	31	23	18	29.6	13			
1	45	28	8	43.5	11	18	33.0	12			
3	27	7	12	29		18	34.3	7			

Table C19. Results reported on K-40 (Bq kg^{-1} and percent uncertainty, 1 SD) in Baltic Sea sediment samples.

Res. No.	K-40	%	Res. No.	K-40	%	Res. No.	K-40	%	Res. No.	K-40	%
1	800	35	5	742	5	17	670	4	19	720	
1	810	36	7	796	10	17	700	6	20	780	6
1	810	36	8	911	10	17	760	5	21	670	6
1	880	38	11	743	4	18	599	5	22	620	4
1	890	3	12	705		18	676	2	22	622	3
1	900	30	13	748	5	18	696	2	22	645	5
3	790	6	14	560	2	18	706	6	23	710	4
4	714	7	15	590	5	18	725	5	23	760	4
5	726	3	16	700		18	787	3			

Table C20. Results reported on K-40 (Bq kg^{-1} and percent uncertainty, 1 SD) in Kattegat sediment samples.

Res. No.	K-40	%	Res. No.	K-40	%	Res. No.	K-40	%	Res. No.	K-40	%
1	810	31	5	809	4	16	1200		20	832	8
1	820	30	6	800	2	17	770	5	21	820	5
1	850	31	7	896	9	17	770	5	22	695	4
1	920	29	8	912	10	18	710	3	22	697	3
1	920	29	11	755	5	18	744	3	22	699	3
1	1030	28	12	923		18	750	2	23	780	4
3	823	5	13	787	4	18	751	1	23	800	4
4	779	6	14	652	1	18	824	3			
5	807	3	15	520	8	19	950				

Table C21. Results reported on Pb-210 (Bq kg^{-1} and percent uncertainty, 1 SD) in Baltic Sea sediment samples.

Res. No.	Pb-210	%	Res. No.	Pb-210	%	Res. No.	Pb-210	%	Res. No.	Pb-210	%
5	110	12	18	99.5	13	18	91.7	5	22	86	15
5	96	11	18	83.3	9	22	98	15			
18	99.7	21	18	99.1	8	22	95	15			

Table C22. Results reported on Pb-210 (Bq kg^{-1} and percent uncertainty, 1 SD) in Kattegat sediment samples.

Res. No.	Pb-210	%	Res. No.	Pb-210	%	Res. No.	Pb-210	%	Res. No.	Pb-210	%
5	117	11	6	120	18	18	83.5	11	22	87	15
5	101	11	6	120	18	18	86.4	5	22	88	15
6	120	18	18	93.2	10	18	95.0	4	22	82	15

Table C23. Results reported on Po-210 (Bq kg^{-1} and percent uncertainty, 1 SD) in Kattegat sediment sample.

Res. No.	Po-210	%	Res. No.	Po-210	%	Res. No.	Po-210	%
22	89.6	3	22	92.4	7	22	88.8	7
22	87.0	3	22	85.5	7	22	86.3	11

Table C24. Result reported on U-235 (Bq kg^{-1} and percent uncertainty, 1 SD) in Baltic Sea sediment sample.

Res. No.	U-235	%
13	2.6	18

Table C25. Result reported on U-235 (Bq kg^{-1} and percent uncertainty, 1 SD) in Kattegat sediment sample.

Res. No.	U-235	%
13	0.85	18

APPENDIX D, AVERAGE DATA

This appendix shows averages of results on radionuclides in the two sediment samples. For each radionuclide and sample for which six or more sets of results were received, an overall mean concentration and corresponding 95% confidence interval were calculated after subjective removal of outliers. An indicator (z-score) of analytical bias with respect to the overall mean is given for each average result. The uncertainties are given as standard errors of the mean value which in cases where multiple results were submitted were calculated directly from these, not considering possible uncertainties on individual results. The uncertainties were carried over in case of submission of single results .

Table D1. Average results on Cs-137 in Baltic Sea sediment samples, uncertainties, numbers of individual determinations (n) and z-scores. The overall mean sample concentration is 61.4 Bq/kg with a 95% confidence interval of [50.5; 72.3]. The results numbered 8, 9, 19, 21, 22 were not included in the calculation of the overall mean. A relative uncertainty of 5% was used for the calculation of the z-scores.

Res. No.	Cs-137 (Bq/kg)	1 SE (Bq/kg)	n	z-score
1	68.5	3.0	6	2.3
2	60.0		1	-0.4
3	53.4	3.1	1	-2.6
4	55.5	2.1	1	-1.9
5	63.8	0.2	2	0.8
7	53.1	5.0	1	-2.7
8	70.7	4.2	1	3.0
9	50.2	2.8	10	-3.6
10	59.9	2.5	10	-0.5
11	62.0	3.0	1	0.2
12	68.2		1	2.2
13	54.6	2.6	1	-2.2
14	65.8	1.1	1	1.4
15	67.0	5.0	1	1.8
16	68.0		1	2.2
17	57.4	1.3	3	-1.3
18	56.7	1.3	6	-1.5
19	72.0		1	3.5
20	64.5	2.6	1	1.0
21	73.0	3.0	1	3.8
22	52.2	1.3	3	-3.0
23	65.0	0.2	2	1.2

Table D2. Average results on Cs-137 in Kattegat sediment samples, uncertainties, numbers of individual determinations and z-scores. The overall mean sample concentration is 26.1 Bq/kg with a 95% confidence interval of [22.7; 29.6]. The results numbered 3, 8, 9, 12, 19 were not included in the calculation of the overall mean. A relative uncertainty of 5% was used for the calculation of the z-scores.

Res. No.	Cs-137 (Bq/kg)	1 SE (Bq/kg)	n	z-score
1	26.7	1.7	6	0.4
2	26.6		1	0.4
3	20.0	2.5	1	-4.7
4	24.2	1.5	1	-1.5
5	28.0	0.3	2	1.4
6	26.0	0.9	1	-0.1
7	27.4	3.0	1	1.0
8	31.0	2.2	1	3.7
9	15.1	1.2	10	-8.4
10	24.7	1.9	10	-1.1
11	25.0	1.0	1	-0.9
12	48.0		1	16.8
13	22.9	1.0	1	-2.4
14	27.8	0.6	1	1.3
15	27.0	3.0	1	0.7
16	24.0		1	-1.6
17	28.3	0.1	2	1.7
18	25.1	0.4	5	-0.8
19	40.0		1	10.6
20	26.1	1.0	1	0.0
21	28.0	1.0	1	1.4
22	23.9	0.2	3	-1.7
23	28.4	0.3	2	1.8

Table D3. Average results on Cs-134 in Baltic Sea sediment samples, uncertainties, numbers of individual determinations and z-scores. The overall mean sample concentration is 1.0 Bq/kg with a 95% confidence interval of [0.2; 1.8]. The result numbered 20 was not included in the calculation of the overall mean. A relative uncertainty of 20% was used for the calculation of the z-scores.

Res. No.	Cs-134 (Bq/kg)	1 SE (Bq/kg)	n	z-score
5	1.2	0.3	2	0.8
8	0.8	0.1	1	-0.8
17	1.2	0.2	3	1.0
20	6.7	4.0	1	28.6
22	1.4	0.1	3	2.0
23	0.4	0.1	1	-3.0

Table D4. Average results on Co-60 in Kattegat sediment samples, uncertainties, numbers of individual determinations and z-scores. The overall mean sample concentration is 1.2 Bq/kg with a 95% confidence interval of [0.6; 1.7]. A relative uncertainty of 15% was used for the calculation of the z-scores.

Res. No.	Co-60 (Bq/kg)	1 SE (Bq/kg)	n	z-scores
3	< 1.5		1	
11	1.0	0.2	1	-0.9
13	1.6	0.2	1	2.5
17	1.4	0.0	2	1.3
18	0.9	0.2	1	-1.2
22	1.1	0.1	3	-0.5
23	1.0	0.1	2	-1.2

Table D5. Average results on Pu-239,240 in Baltic Sea sediment samples, uncertainties, numbers of individual determinations and z-scores. The overall mean sample concentration is 1.6 Bq/kg with a 95% confidence interval of [1.1; 2.1]. A relative uncertainty of 10% was used for the calculation of the z-scores.

Res. No.	Pu-239,240 (Bq/kg)	1 SE (Bq/kg)	n	z-score
3	1.20	0.08	1	-2.6
11	1.40	0.14	1	-1.3
15	1.70	0.29	1	0.5
17	1.76	0.02	4	0.9
18	1.59	0.08	2	-0.2
21	2.00	0.10	2	2.4
22	1.68	0.07	3	0.4

Table D6. Average results on Pu-239,240 in Kattegat sediment samples, uncertainties, numbers of individual determinations and z-scores. The overall mean sample concentration is 1.1 Bq/kg with a 95% confidence interval of [0.9; 1.4]. A relative uncertainty of 10% was used for the calculation of the z-scores.

Res. No.	Pu-239,240 (Bq/kg)	1 SE (Bq/kg)	n	z-score
3	1.40	0.07	1	2.3
6	1.00	0.05	1	-1.2
11	1.00	0.10	1	-1.2
15	1.20	0.17	1	0.6
17	1.11	0.03	4	-0.2
18	1.13	0.02	2	0.0
21	1.23	0.03	3	0.9
22	1.01	0.06	3	-1.1

Table D7. Average results on Pu-238 in Baltic Sea sediment samples, uncertainties, numbers of individual determinations and z-scores. The overall mean sample concentration is 0.11 Bq/kg with a 95% confidence interval of [0.04; 0.18]. The result numbered 15 was not included in the calculation of the overall mean. A relative uncertainty of 15% was used for the calculation of the z-scores.

Res. No.	Pu-238 (Bq/kg)	1 SE (Bq/kg)	n	z-score
11	0.07	0.01	1	-2.6
15	1.20	0.24	1	63.8
17	0.12	0.01	4	0.4
18	0.16	0.01	2	2.7
21	0.13	0.02	1	1.0
22	0.09	0.01	3	-1.5

Table D8. Average results on Pu-238 in Kattegat sediment samples, uncertainties, numbers of individual determinations and z-scores. The overall mean sample concentration is 0.08 Bq/kg with a 95% confidence interval of [0.05; 0.10]. The result numbered 15 was not included in the calculation of the overall mean. A relative uncertainty of 15% was used for the calculation of the z-scores.

Res. No.	Pu-238 (Bq/kg)	1 SE (Bq/kg)	n	z-score
3	0.09	0.02	1	1.0
6	0.07	0.01	1	-0.5
15	0.50	0.20	1	36.2
17	0.07	0.01	4	-0.7
18	0.09	0.01	2	1.2
22	0.07	0.01	3	-1.1

Table D9. Average results on Am-241 in Baltic Sea sediment samples, uncertainties and numbers of individual determinations.

Res. No.	Am-241 (Bq/kg)	1 SE (Bq/kg)	n
17	0.70	0.06	4
18	0.94	0.04	2

Table D10. Average results on Am-241 in Kattegat sediment samples, uncertainties and numbers of individual determinations.

Res. No.	Am-241 (Bq/kg)	1 SE (Bq/kg)	n
6	0.37	0.03	1
17	0.46	0.02	4
18	0.39	0.02	2

Table D11. Average results on Sr-90 in Baltic Sea sediment samples, uncertainties and numbers of individual determinations.

Res. No.	Sr-90 (Bq/kg)	1 SE (Bq/kg)	n
3	0.39	0.02	1
15	15.7	0.6	1
18	0.21	0.004	2

Table D12. Average results on Sr-90 in Kattegat sediment samples, uncertainties and numbers of individual determinations.

Res. No.	Sr-90 (Bq/kg)	1 SE (Bq/kg)	n
3	0.20	0.02	1
15	32	4.2	1
18	0.15	0.04	2

Table D13. Average results on Ra-226 in Baltic Sea sediment samples, uncertainties, numbers of individual determinations and z-scores. The overall mean sample concentration is 21.4 Bq/kg with a 95% confidence interval of [12.3; 30.5]. A relative uncertainty of 10% was used for the calculation of the z-scores.

Res. No.	Ra-226 (Bq/kg)	1 SE (Bq/kg)	n	z-score
1	17.2	1.4	6	-2.0
3	21.0	2.1	1	-0.2
5	28.3	0.4	2	3.2
7	17.0	8.0	1	-2.1
8	26.5	1.9	1	2.4
12	25.0		1	1.7
13	19.0	1.7	1	-1.1
16	22.0		1	0.3
18	26.0	0.3	6	2.1
19	14.0		1	-3.5
22	20.0	0.1	3	-0.7

Table D14. Average results on Ra-226 in Kattegat sediment samples, uncertainties, numbers of individual determinations and z-scores. The overall mean sample concentration is 21.0 Bq/kg with a 95% confidence interval of [17.2; 24.7]. The results numbered 6 and 12 were not included in the calculation of the overall mean. A relative uncertainty of 10% was used for the calculation of the z-scores.

Res. No.	Ra-226 (Bq/kg)	1 SE (Bq/kg)	n	z-score
1	17.8	1.1	6	-1.5
3	17.0	2.0	1	-1.9
5	25.7	0.3	2	2.2
6	41.7	2.7	3	9.9
7	16.0	11.0	1	-2.4
8	23.0	1.6	1	1.0
12	43.0		1	10.5
13	18.3	0.7	1	-1.3
16	22.0		1	0.5
18	22.9	0.6	5	0.9
19	27.0		1	2.9
22	20.0	0.5	3	-0.5

Table D15. Average results on Th-232 in Baltic Sea sediment samples, uncertainties, numbers of individual determinations and z-scores. The overall mean sample concentration is 35.2 Bq/kg with a 95% confidence interval of [20.8; 49.6]. A relative uncertainty of 10% was used for the calculation of the z-scores.

Res. No.	Th-232 (Bq/kg)	1 SE (Bq/kg)	n	z-score
1	47.5	2.0	6	3.5
3	31.0	3.1	1	-1.2
5	36.1	0.3	2	0.2
7	38.0	9.1	1	0.8
8	46.0	4.1	1	3.1
12	22.0		1	-3.8
13	34.0	4.8	1	-0.4
16	29.0		1	-1.8
18	36.0	1.6	6	0.2
19	36.0		1	0.2
22	31.8	0.6	3	-1.0

Table D16. Average results on Th-232 in Kattegat sediment samples, uncertainties, numbers of individual determinations and z-scores. The overall mean sample concentration is 32.6 Bq/kg with a 95% confidence interval of [18.8; 46.4]. A relative uncertainty of 10% was used for the calculation of the z-scores.

Res. No.	Th-232 (Bq/kg)	1 SE (Bq/kg)	n	z-score
1	35.8	2.7	6	1.0
3	27.0	1.9	1	-1.7
5	32.9	0.4	2	0.1
6	44.0	2.0	2	3.5
7	31.0	7.1	1	-0.5
8	43.5	4.8	1	3.3
12	29.0		1	-1.1
13	25.4	1.8	1	-2.2
16	23.0		1	-2.9
18	30.5	1.3	5	-0.6
19	40.0		1	2.3
22	29.0	0.4	3	-1.1

Table D17. Average results on K-40 in Baltic Sea sediment samples, uncertainties, numbers of individual determinations and z-scores. The overall mean sample concentration is 725 Bq/kg with a 95% confidence interval of [636; 814]. The results numbered 1, 8, 14 and 15 were not included in the calculation of the overall mean. A relative uncertainty of 10% was used for the calculation of the z-scores.

Res. No.	K-40 (Bq/kg)	1 SE (Bq/kg)	n	z-score
1	848	19	6	1.7
3	790	47	1	0.9
4	714	50	1	-0.1
5	734	8	2	0.1
7	796	80	1	1.0
8	911	91	1	2.6
11	743	30	1	0.3
12	705		1	-0.3
13	748	37	1	0.3
14	560	11	1	-2.3
15	590	30	1	-1.9
16	700		1	-0.3
17	710	26	3	-0.2
18	698	25	6	-0.4
19	720		1	-0.1
20	780	47	1	0.8
21	670	40	1	-0.8
22	629	8	3	-1.3
23	735	25	2	0.1

Table D18. Average results on K-40 in Kattegat sediment samples, uncertainties, numbers of individual determinations and z-scores. The overall mean sample concentration is 815 Bq/kg with a 95% confidence interval of [688; 941]. The results numbered 14, 15, 16 and 19 were not included in the calculation of the overall mean. A relative uncertainty of 10% was used for the calculation of the z-scores.

Res. No.	K-40 (Bq/kg)	1 SE (Bq/kg)	n	z-score
1	892	34	6	0.9
3	823	41	1	0.1
4	779	47	1	-0.4
5	808	1	2	-0.1
6	800	16	1	-0.2
7	896	81	1	1.0
8	912	91	1	1.2
11	755	38	1	-0.7
12	923		1	1.3
13	787	31	1	-0.3
14	652	7	1	-2.0
15	520	42	1	-3.6
16	1200		1	4.7
17	770	0	2	-0.6
18	756	19	5	-0.7
19	950		1	1.7
20	832	67	1	0.2
21	820	41	1	0.1
22	697	1	3	-1.4
23	790	10	2	-0.3

Table D19. Average results on Pb-210 in Baltic Sea sediment samples, uncertainties and numbers of individual determinations.

Res. No.	Pb-210 (Bq/kg)	1 SE (Bq/kg)	n
5	103	7	2
18	95	3	5
22	93	4	3

Table D20. Average results on Pb-210 in Kattegat sediment samples, uncertainties and numbers of individual determinations.

Res. No.	Pb-210 (Bq/kg)	1 SE (Bq/kg)	n
5	109	8	2
6	120	0	3
18	90	3	4
22	86	2	3