

Welcome

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Statistical procedures for checking compliance with rules of conformity in the course of disposal of dredged material in the German Bight

Abstract

In the permits of the Federal State of Schleswig-Holstein for the disposal of dredged material from Hamburg to the North Sea, the necessity of assessing the effects of the disposal is formulated. These include, in addition to national and international guidelines, an assessment, by appropriate statistical tests, of the compliance with threshold values for the quality of sediment to be dredged and disposed.

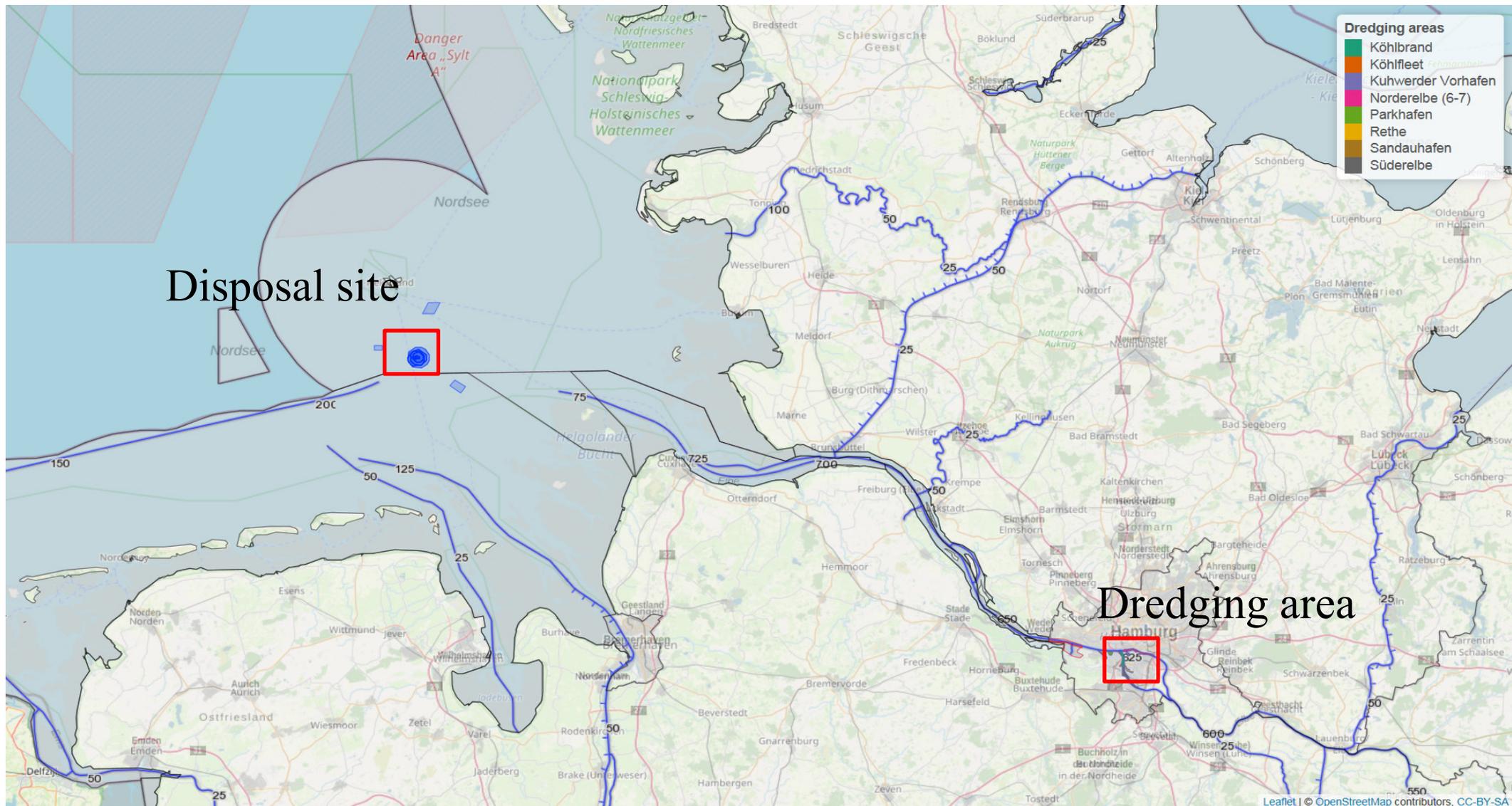
An approach for solving this question is presented

Topics

1. Framework for disposals
 - locations
 - regulations
2. Analysis of variance for **comparison of means**
3. Concept of measurement uncertainty for **comparison of single values to a threshold value**
4. Summary

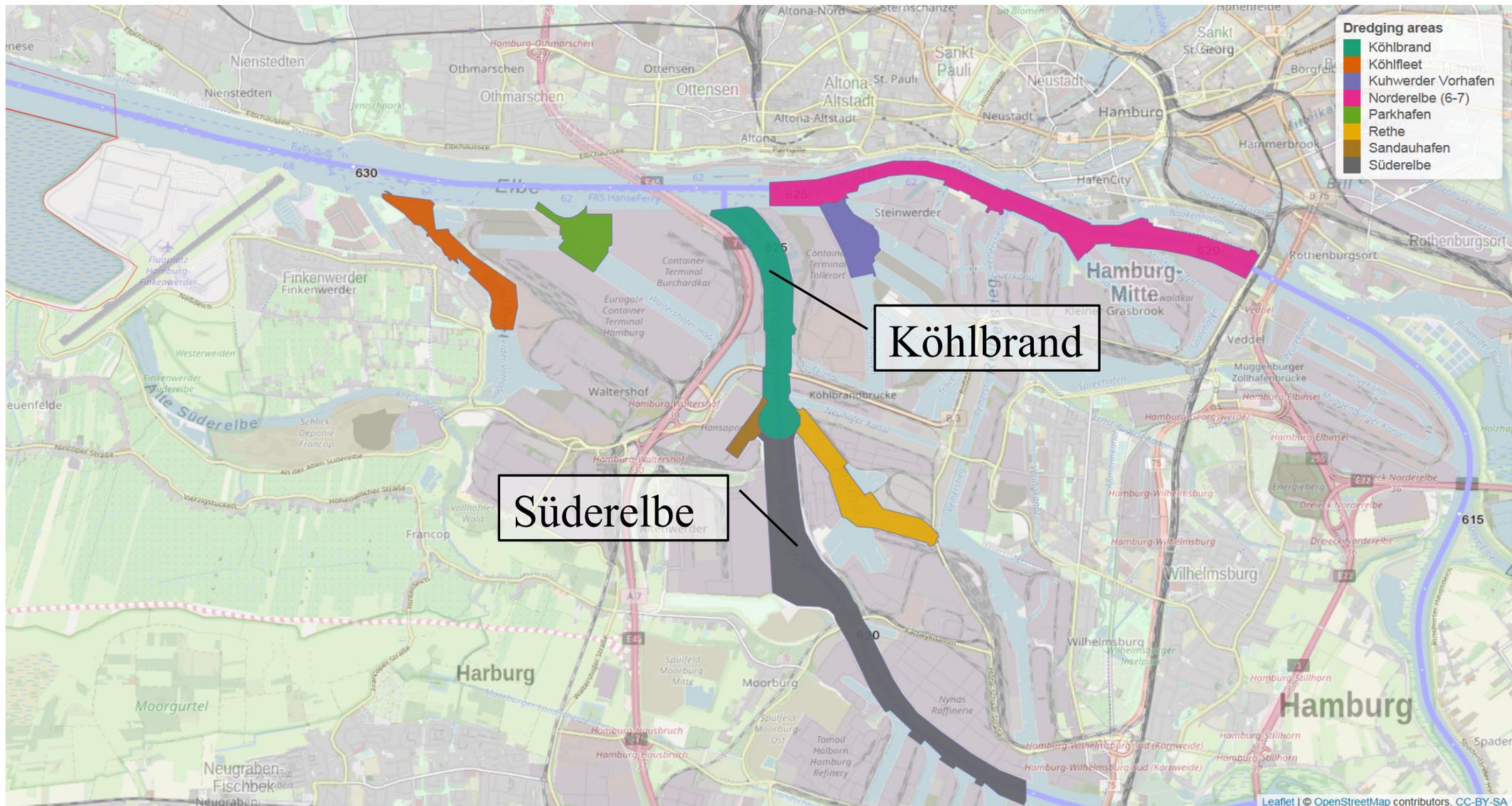
1. Framework for disposals

- locations of dredging areas and disposal site



1. Framework for disposals

- locations of dredging areas



1. Framework for disposals

- Location of disposal site



1. Framework for disposals

- regulations
 - International: OSPAR (EAC/ERL)
 - National: GÜBAK, EQS
 - Agreement with the Federal State of Schleswig-Holstein

Regulations for amount and quality of dredged material and its fate at the disposal site

1. Framework for disposals

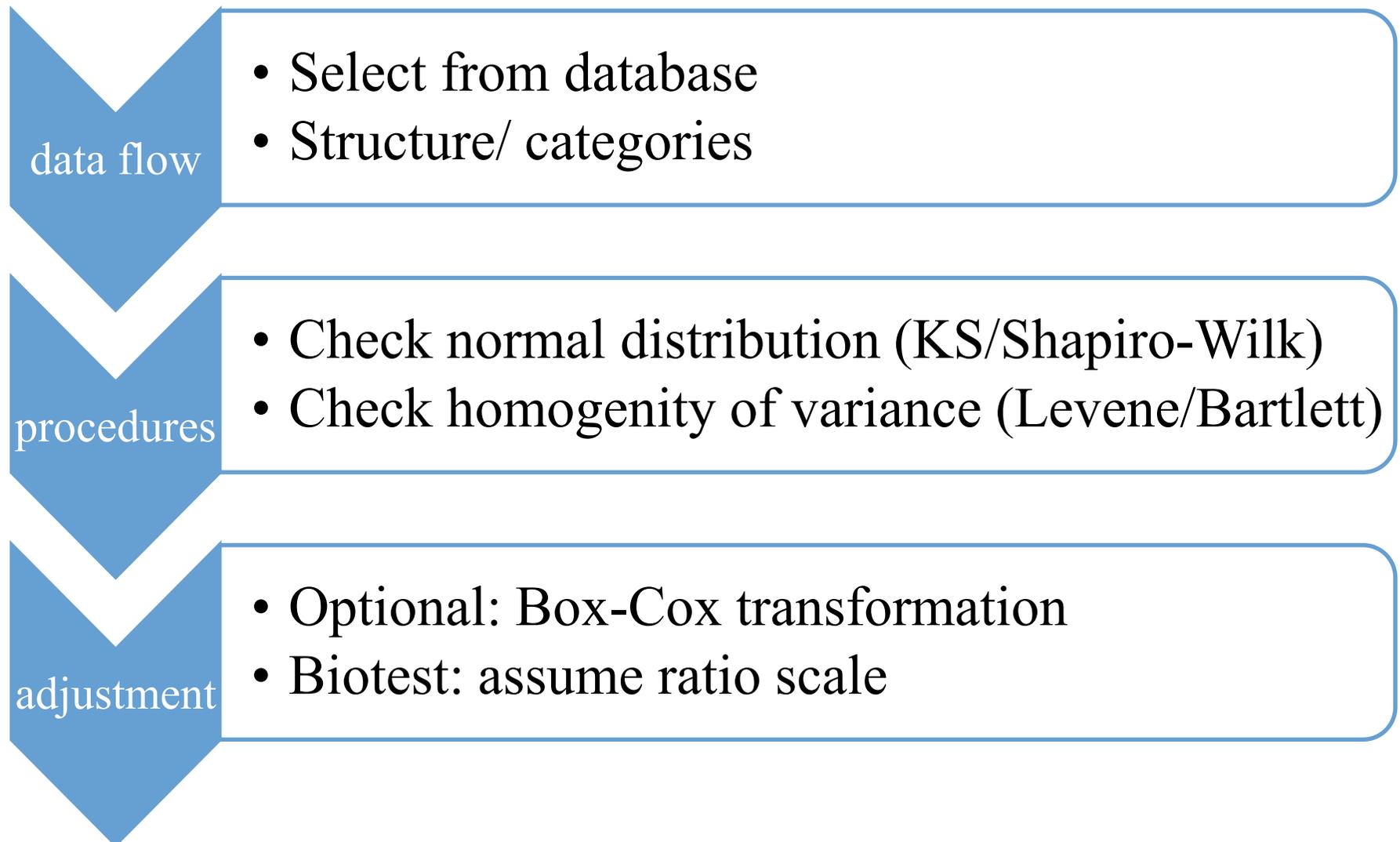
- agreement

approved *October 2019* and limited to *31. Dezember 2024*

- ✓ 5.0 Mio t DS from the fairway and the entrance to the terminals
- ✓ Quality status of the sediments

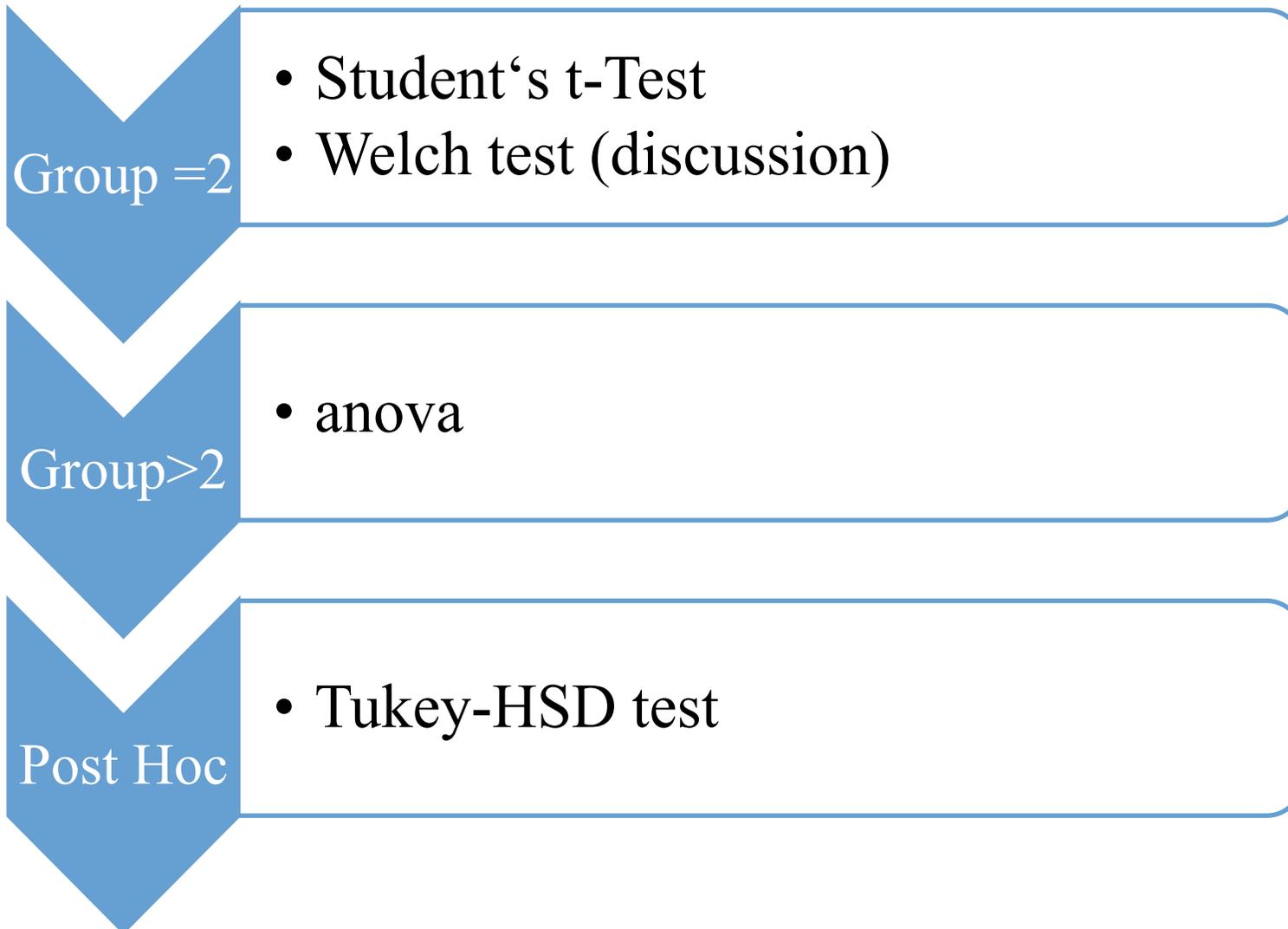
1. The arithmetic mean (**threshold value 1**) of their respective chemical parameters as well as the respective ecotoxicological effects must not be statistically **significantly** higher than the corresponding arithmetic mean values of the same sub-areas from the years 2005 to 2015.
2. In case for HCB, TBT, Sum 6 DDX: the P_{90} (**threshold value 2**) of the reference period 2005-2015 may not **significantly** exceed.

2. Analysis of variance for comparison of means



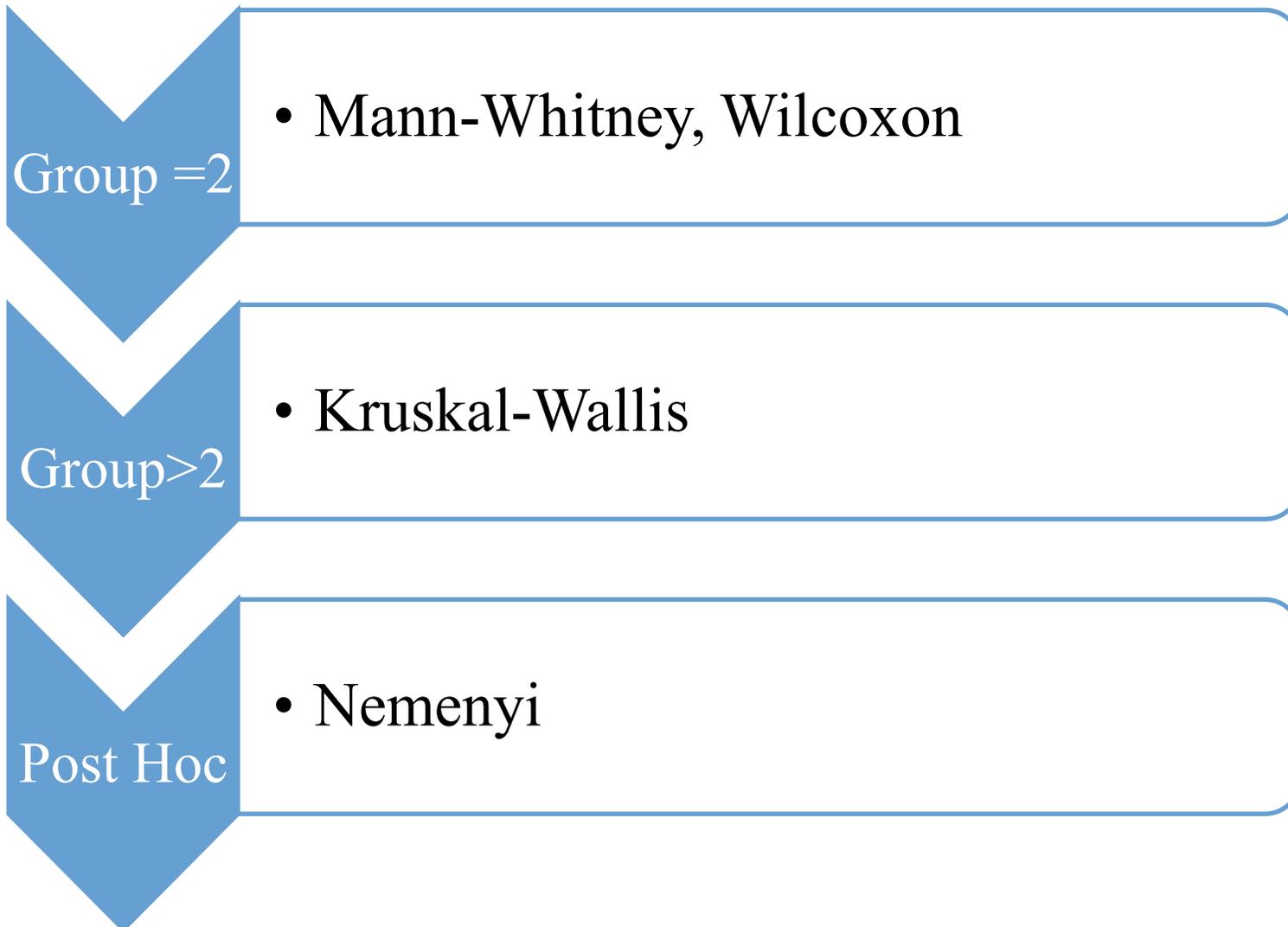
2. Analysis of variance for comparison of means: parametric tests

✓ Normal distribution, homogeneity of variance =TRUE



2. Analysis of variance for comparison of means: non-parametric tests

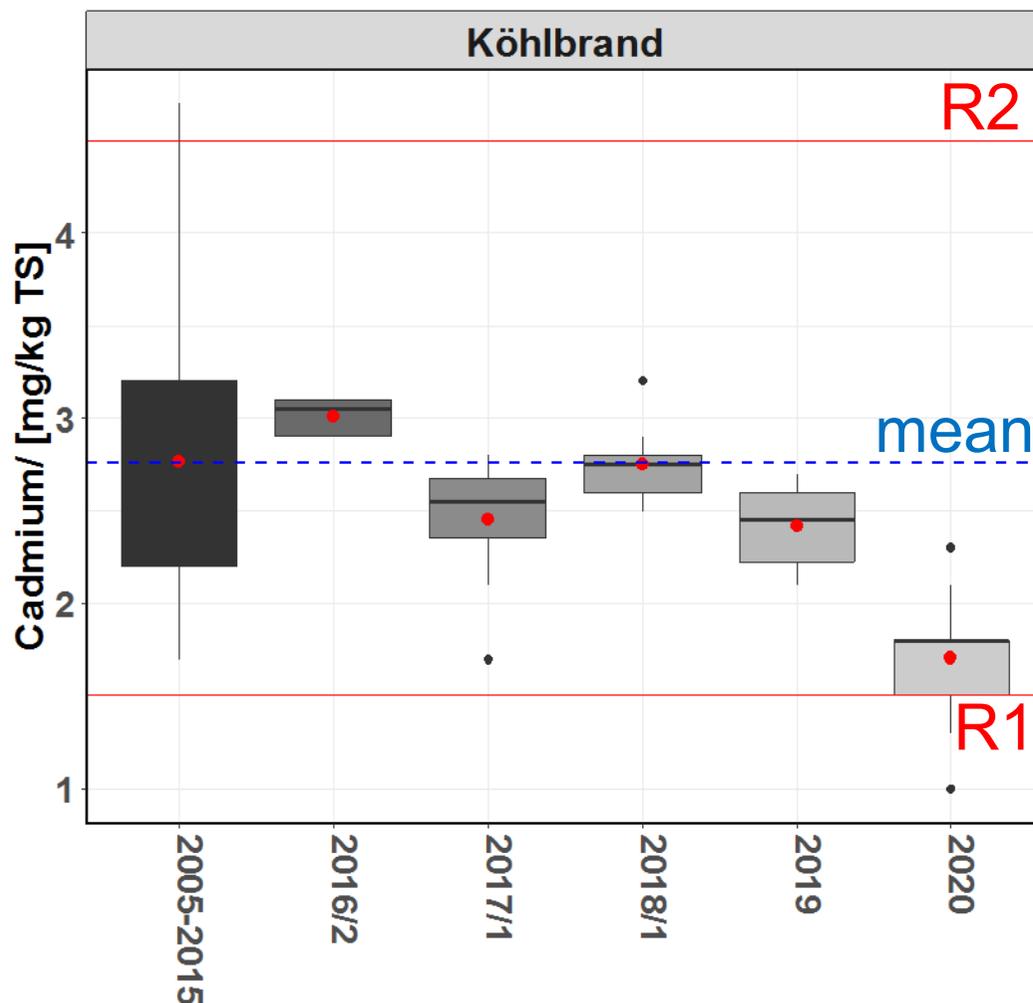
- Normal distribution, homogeneity of variance =FALSE



2. Analysis of variance for comparison of means: Example

Pairwise comparisons of means using Nemenyi-test with Chi-squared approximation for independent samples

GSF <20µm



	2005-2015	2016/2	2017/1	2018/1	2019
2016/2	0,839	-	-	-	-
2017/1	0,778	0,050	-	-	-
2018/1	1,000	0,686	0,784	-	-
2019	0,625	0,021	1,000	0,614	-
2020	0,007	0,000	0,243	0,003	0,408

high significant
 significant
 low significant

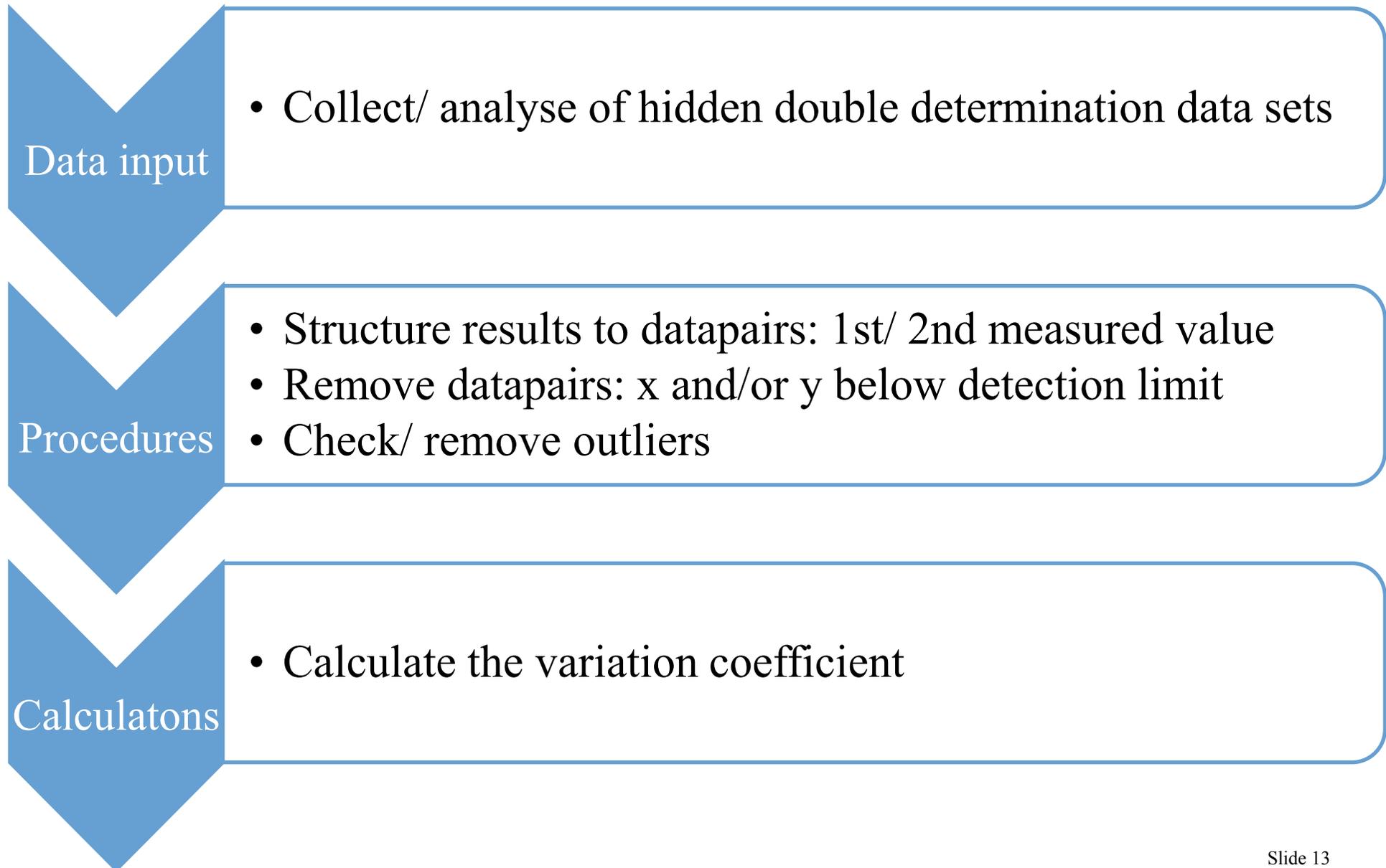
Red points: weighted, arithmetic means

Solid line in box: median value

Whisker: 1,5*IQR, depending on data

Result: Mean of sampling campaign 2020 is significant **lower** compared to reference

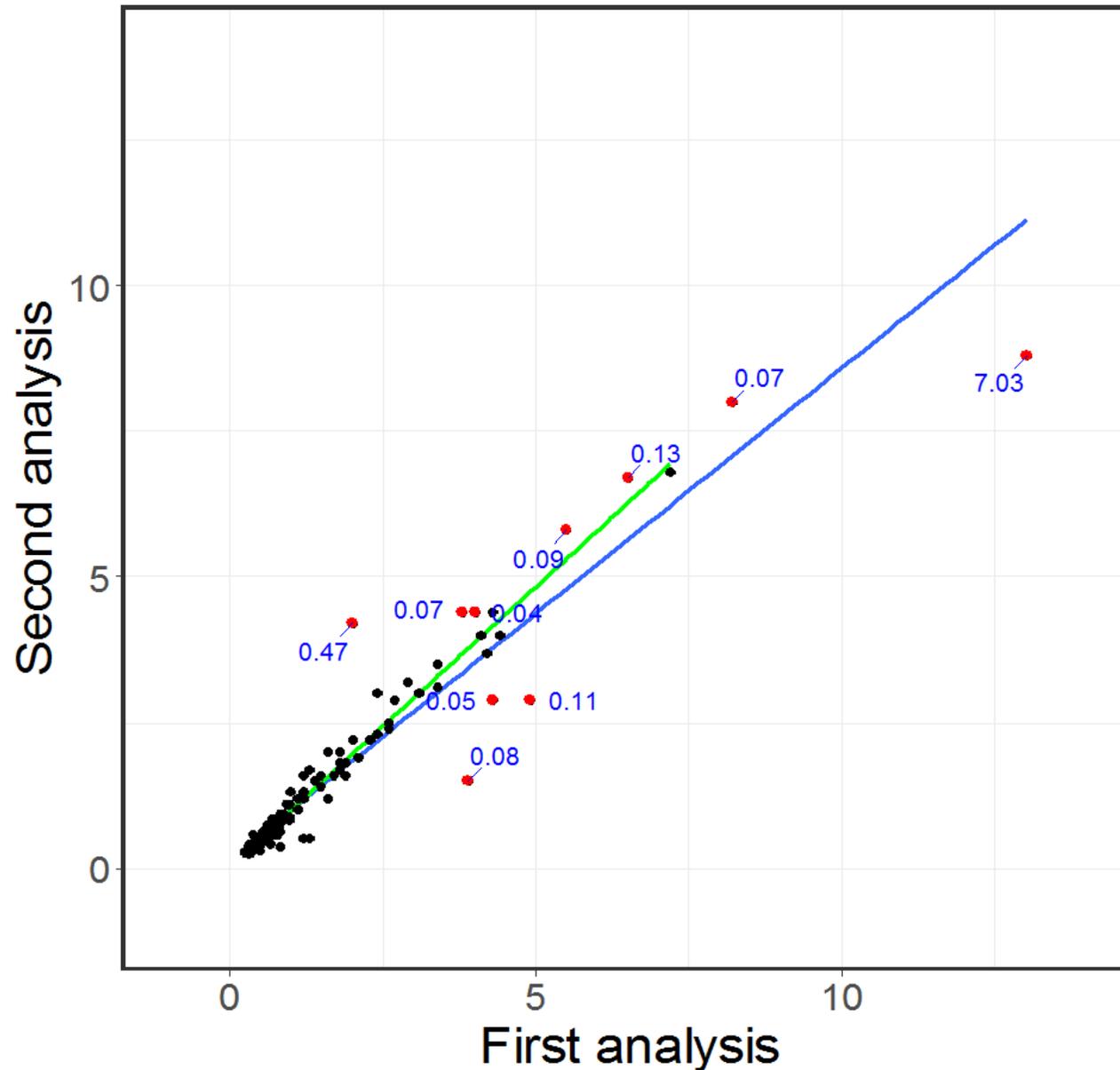
3. Concept of measurement uncertainty for **comparison of single values to a threshold value**



Outlier Determination

-according to Cook's distance method-

Example data set of hidden double determinations for Cadmium mg/kg DS GSF <20µm



Fit:

Blue : Inclusive outliers

Green : Exclusive outliers

Points:

Red : outliers

Labeling: Cook's dist. res.

the data set was supplemented with
old data from contaminated areas
to increase the span

Detection of outliers

-Cook's Distance-

Cadmium mg/kg DS GSF <20µm

First value	Second value	Mean value	Difference of mean	Diff/Mean	cooks distance	outlier
8,8	13	10,9	-4,2	-0,39	7,03	delete
4,2	2	3,1	2,2	0,71	0,47	delete
6,7	6,5	6,6	0,2	0,03	0,13	delete
2,9	4,9	3,9	-2	-0,51	0,11	delete
5,8	5,5	5,65	0,3	0,05	0,09	delete
1,5	3,9	2,7	-2,4	-0,89	0,08	delete
8	8,2	8,1	-0,2	-0,02	0,07	delete
4,4	3,8	4,1	0,6	0,15	0,07	delete
2,9	4,3	3,6	-1,4	-0,39	0,05	delete
4,4	4	4,2	0,4	0,10	0,04	delete
3	2,4	2,7	0,6	0,22	0,02	keep
4,4	4,3	4,35	0,1	0,02	0,01	keep
0,51	1,3	0,905	-0,79	-0,87	0,01	keep
3,2	2,9	3,05	0,3	0,10	0,01	keep

Including outliers

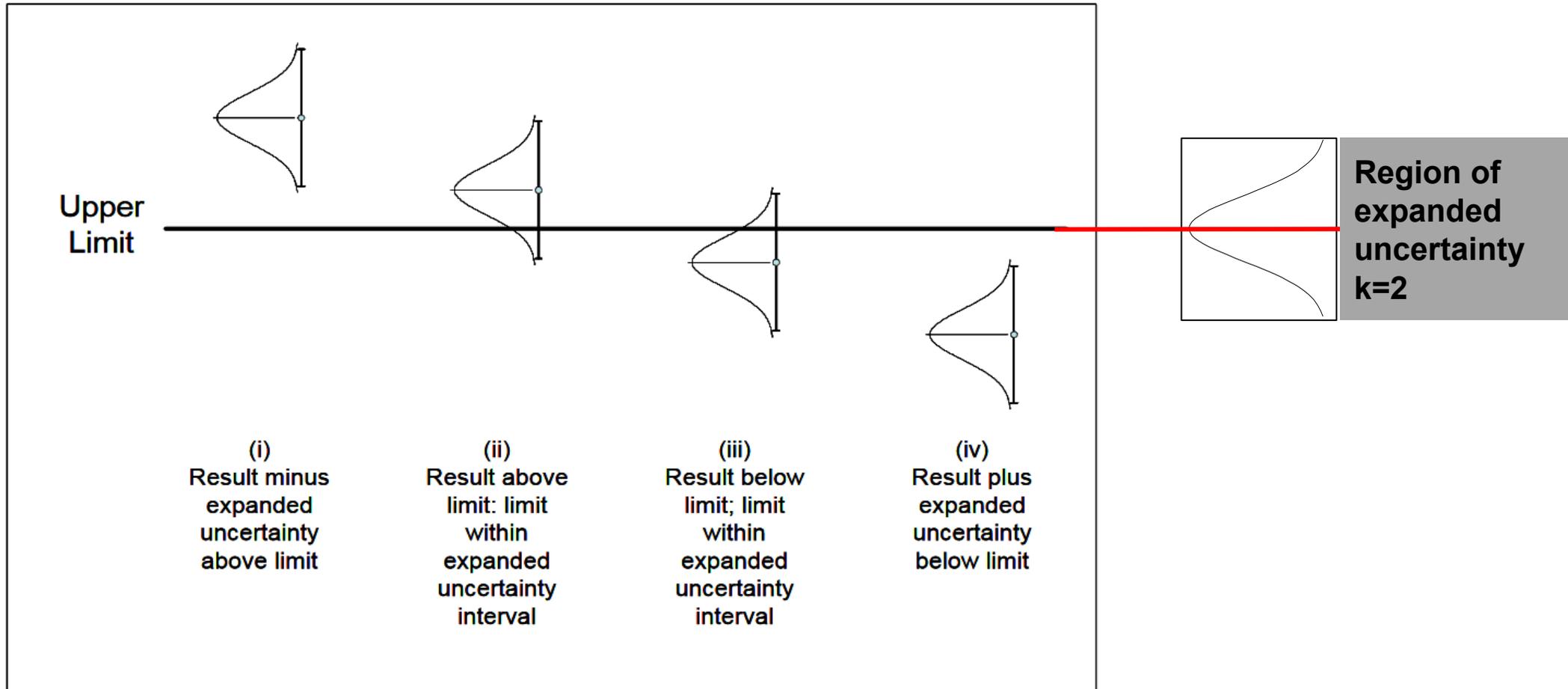
stdev	percent	count	r	p
0,201	14,21	162	0,957	5,72E-88

Excluding outliers

stdev	percent	count	r	p
0,18	12,37	152	0,986	1,80E-117

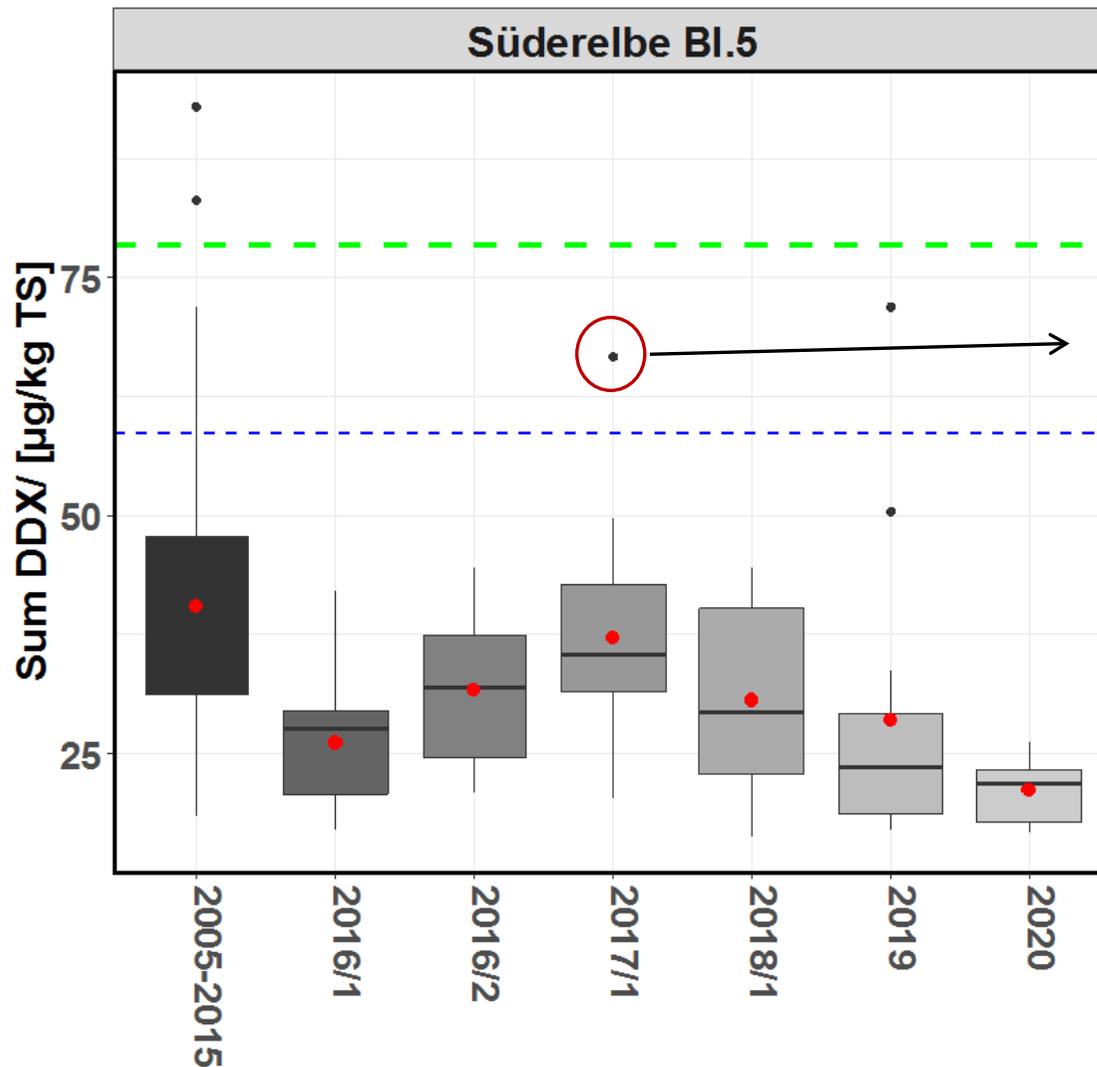
Coefficient of variation in percent= $\text{stdev}(\text{Diff}/\text{Mean})/\text{SQRT}(2)$

Uncertainty= $\text{value} * \text{coeff_var} * k(=2)$



3. Concept of measurement uncertainty for comparison of single values to a threshold value

Example



$P_{90} + MU = (58.7 + 19.8) \mu\text{g/kg}$, var=16.9, k=2

Sediment: 66,8 $\mu\text{g/kg}$

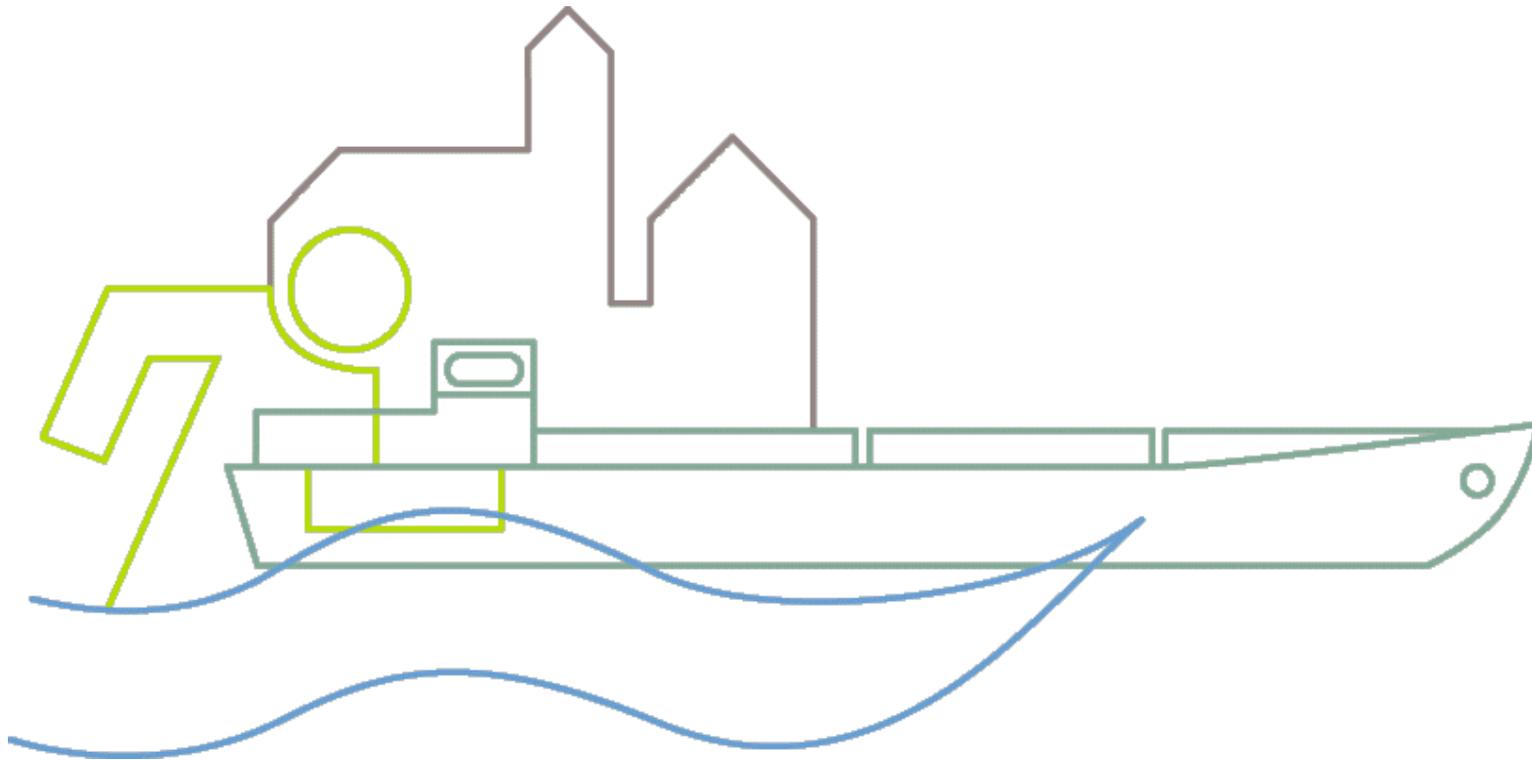
$P_{90} = 58,7 \mu\text{g/kg}$

Result:

Value not significant above P_{90} ,

4. Summary

- Two Statistical test designs are presented to ensure compliance with conformity regulations
 - **Comparison of means:** Univariate analysis of variance
 - Biotest: adjustment to a ratio scale
 - **Comparison of single values to a threshold:** Concept for determining the measurement uncertainty



Thank you for your attention

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