3rd Workshop

Proficiency Testing for Water Testing Laboratories

Dar Es Salaam
10 – 11 November 2005

Report on the Workshop
Proficiency Testing for Water Testing Laboratories

Dar Es Salaam, Tanzania, 10 – 11 November 2005

Prepared by Dr.-Ing. Michael Koch

Summary

The workshop covered the evaluation of the second SADCMET water PT and all aspects that could be derived from the results. The results showed that there is a need for improvement in nearly all laboratories. It was shown how PT results could be used to find the weak points in the analysis and a link to the estimation of measurement uncertainty was given. Most of the participants were very enthusiastic. It is highly recommended to continue the PT system for chemical analyses and to extend it to microbiology. The structure of local coordinators was strengthened to minimize logistical problems for the next round and to increase the number of participants. The assessment procedure using limited standard deviations has proven to be very effective, the statistical methods used will be changed in the next round to be in accordance with the new ISO standard. As and Cd will be added to the list of parameters for the next PT round in June 2006. An additional PT system for microbiological analyses is highly recommended. Training of the potential PT provider essential for that.

The SADC ASSOCIATION OF WATER TESTING LABORATORIES (SADCWATERLAB) was established during the workshop. Chair, vice chair and a project management committee was elected. This association is a good chance to improve the quality of the involved laboratories by mutual help and harmonisation.

An initiative to support the SADC laboratories with instrumentation was started and will coordinated by SADCWATERLAB.

For the future development of the laboratories it is essential to keep up the spirit of these last three workshops and to continue on this way.

Introduction

The workshop reported here followed previous workshops held in Windhuk, Namibia in February 2004 and in Pretoria in November 2005 (the reports are available from http://www.sadcmet.org). As a result of these workshop two proficiency tests for water testing laboratories were organised by Umgeni Water (Pietermaritzburg, South Africa). The workshop in Pretoria was to evaluate and assess this first PT and to find ways forward to a regular PT system and other supportive measures. The aim of this workshop in Dar Es Salaam was the evaluation of the second PT and the establishment of a Water Laboratory Association to facilitate the mutual support between the water laboratories in the SADC region. The workshop was preceded by a training course on the estimation of measurement uncertainty, organised by CSIR.

Participants and Organisation

The workshop was attended by 23 participants from the following countries:

- Angola 2
- Botswana 2
- Ethiopia 1
- Kenya 2
- Lesotho 1
- Malawi 2
- Mauritius 1
- Mocambique 2
- Namibia 2
- Seychelles 2
- South Africa 1
- Swaziland 2
- Tanzania 14
- Uganda 2
- Zambia 2
- Zimbabwe

The Workshop was organised by
Dr. Mukayi Musarurwa, CSIR, South Africa
Dr. Michael Koch, Universität Stuttgart, Germany
and leaded by
Dr. Michael Koch, Universität Stuttgart, Germany
Additional presentations were given by
Merle Smuts, Umgeni Waters, Pietermaritzburg, South Africa

Measurement Uncertainty Training Course and PT Workshop

Opening on Saturday 5th November 2005

The Measurement Uncertainty Training Course and PT Workshop was opened by Mr. B.B. Matemba, acting Director of the Tanzania Bureau of Standards (TBS), with two local TV stations and four print newspapers being present.

Measurement Uncertainty Training Course

The training course started at 5th November 8:30 h. For details of this training course see separate report from CSIR. The training course ended at Wednesday 9th November 2005 with a presentation of Michael Koch on the new German “Guideline for the estimation of measurement uncertainty from validation data” for water testing laboratories (see Annex 1).

PT Workshop Programme

Day 1 – Evaluation of and experiences from the 2nd SADCMET Water PT

Morning-Session – 09:00 to 13:00 (with break from 11:00 to 11:15):

- ***M. Koch***: Opening
- ***M. Smuts***: Experiences of the PT provider – planning, sample preparation, sample distribution, problems
- ***All Participants***: Working group discussions - experiences of participants
- ***M. Smuts and M. Koch***: Evaluation and assessment – SADCMET PT round 2

Afternoon-Session – 14:00 to 17:30 (with break from 15:30 to 16:00):

- ***All Participants***: Working group discussions - evaluation and results
- ***All Participants***: Working group discussions - the way forward: chemistry PT and microbiology PT
- ***M. Koch:*** Summary

Thursday, 10 November 2005

Opening

The Workshop was opened at 9:00 h by Michael Koch.

M. Smuts: Experiences of the PT provider

Merle Smuts reported about her experiences in the 2nd PT (Annex 2). The number of participating laboratories increased from 22 to 44. There were 8 participants each from Tanzania as well as from Zimbabwe due to the strong commitment of the local coordinators. Five heavy metals (lead, copper, zinc, chromium and nickel) and phosphate were added to the list of parameters from the first PT round. The total list of parameters in this 2nd round is given in table 1.

Table 1: List of parameters in the 2nd PT round

Anions	Cations	
sulphate	calcium	aluminium
chloride	magnesium	lead
fluoride	sodium	copper
nitrate	potassium	zinc
phosphate	iron	chromium
	manganese	nickel

The provider produced 50 litres of each sample based on laboratory water spiked with known amounts of analyte. The samples were dispensed, labelled, packaged and shipped by DHL.
The cost of shipment could be reduced very much by sending all samples to the local coordinator.

The samples were all successfully delivered within one week after dispatch.
Apparently there were more leakage problems than in the 1st round. This has to be improved for the next round.
Problems occurred also with payment, which was made by bank drafts, transfers, cheques and also by cash. Some payments were made, but not (yet) received.
The results were generally received in time by fax or email. Only 2 out of 44 laboratories did not send results. So the participation again was very enthusiastic.
No transportation and custom problems were recognised.
The major problems in the results could be identified as:

- use of incorrect units (especially NO_3^--N instead of NO_3^- and PO_4^{3-}-P instead of PO_4^{3-}
- transcription, dilution and calculation errors
- parameters not analysed due to lack of chemicals
- lack of harmonisation of the methods used

In general the standard deviation of the analyses were found to be very high

Payment turned out to be one of biggest challenges. In some cases payment in foreign currency was a problem, in other cases the tracking of the payments made. The bank charges could be drastically reduced, if a bulk payment by the local coordinators would be possible.

All Participants: Working group discussions - experiences of participants
Seven questions were discussed in three working groups.
Results of the discussion:

Question 1 - Announcement of the scheme – did you receive enough information in good time?
Some participants received enough information, but others were surprised to receive samples. The role of the local coordinator as an information centre should be strengthened. Some laboratories did not get the call to nominate for participation. Some participants had problems with e-mail and would prefer communication via fax. The information between the call for participation and the dispatch of the samples were too less for some participants.

Question 2 - Registering – did you have any problems?
No serious problem was identified for the registering, but there should be more information for local coordinators to forward to potential participants. A flyer for the PT system and one for the respective PT round would be favourable. The local coordinator should have access to basic resources for networking. The local coordinator should be nominated within this group of participants (which in fact was done later). For some potential participants the participation fee (50 US-$) was an obstacle to register.

Question 3 - Local coordinators – did it work? - have all interested/relevant laboratories got all the information from local coordinators?
The idea to have local coordinators was beneficial. To improve the effectiveness it would be favourable to nominate an organisation as local coordinator and not a person. In the last round there was too less information about the local coordinators for the participants. In some cases it was not clear, whether the payment should go to the local coordinator or to the PT provider. The question who covers the costs for the local coordinator was discussed without finding a solution. At the moment these costs

have to be covered by the organisation being the local coordinator. The local coordinator were encouraged to increase the number of participants by spreading the information within the respective country.

Question 4 - Shipment – did you encounter any courier problems? - did everybody get the samples in time?
Leaking of samples was reported in some cases. Some bottles were reported to be empty (but almost all laboratories reported results and no laboratory mentioned empty bottles as a reason for not sending results). The custom procedure takes 2-3 days (but is completely managed by the courier). Again the question was raised, who pays for the local distribution from the local coordinator to the participants.

Question 5 - Reporting of results – any problems?
No problem was found here. The template for reporting is very clear. Some participants felt that the time period for reporting was too short.

Question 6 - Payment / costs? – Is the fee affordable? – Problems with money transfer?
The majority of the participants said that the fee is affordable. Some had local problems with money transfer. The invoice should be in Rand and in US-$.
Some participants criticized that there is not enough information on the proforma-invoice.

Question 7 - Are you, as a customer, satisfied with the organisation?
The answer was simply yes.

Agreements from the working group discussions:

- List of **local coordinators** to be prepared. These coordinators should be organisations (not persons) to improve the availability. Nevertheless contact persons (and deputies, if possible) should be nominated
- how to cover the **costs of local coordinators**?
  responsibility of the local coordinator:
  a. additional invoice to all participants with real costs
  b. additional invoice to all participants with average costs for all participants
  c. sponsoring
- Preparation of an **information leaflet for the PT system**
- Preparation of an **information letter for the specific PT** together with the announcement

Table 2: List of local coordinators

Local coordinators		
Country	**Organisation**	**Contact person**
Angola	The Environment and Chemistry Unit, Sonangol	Vanda Policarpo
Botswana	Water Utilities Corporation	Mr. Teddy Ditsabatho
Ethiopia	Quality and Standards Authority of Ethiopia	Theodros Zekarias
Kenya	Kenya Bureau of Standards	Tobias Ololo
Lesotho	Dept of Standards	Ms Polo Leboela
Malawi	Malawi Bureau of Standards	Patricia Nayeja
Mauritius	Mauritius Standards Bureau	Shabbir Hammad Ghoorun
Mocambique	Ministry Of Health	Ms Rhoda Nuvunga Luis.
Namibia	Namwater	Mrs M Conradie
Seychelles	Seychelles Bureau of Standards	Vivian Radegonde
South Africa	Umgeni Water	Merle Smuts
Swaziland	Rural Water Supply	Zanele S'gwane
Tanzania	TBS	Kezia Mwanga Mbwambo
Uganda	Uganda National Bureau of Standards	Hope Kamusiime
Zambia	Food and Drugs Control Labora	Margaret Sakala Mazhamo
Zimbabwe	Standards Association of Zimbabwe	Benson Gabi

M. Smuts and M. Koch: Evaluation and assessment – SADCMET PT round 2

Merle Smuts and Michael Koch presented the results of the evaluation of the 2nd PT round (Annex 3).
All participants received a preliminary evaluation of the PT round using the following methods:

- assigned value: calculated from the median of the participants results
- Z-scores: calculated using the standard deviation from the normalised inter-quartile range using the factor 0.7413
- gross outliers (values < ref.-value/8 and > ref.-value*8, where the ref.-value was calculated from the weighings during the preparation of the sample) were eliminated prior to the statistical calculations.

In order not to get to too high standard deviations for the assessment, these standard deviations were limited to the following values:

Table 3: Limits for the standard deviation used for assessment

Parameter	limit in %
Sulphate	10
Chloride	10
Fluoride	12
Nitrate	15
Phosphate	10
Calcium	10
Magnesium	10
Sodium	10
Potassium	10
Iron	<1 mg/l: 20, >1mg/l: 12
Manganese	<1 mg/l: 20, >1mg/l: 12
Aluminium	30
Lead	25
Copper	20
Zinc	20
Chrome	25
Nickel	25

For the performance assessments the following condition were used:

|z-Score| ≤ 2: Satisfactory
2 < |z-Score| ≤ 3: Questionable
|z-Score| > 3: Unsatisfactory

The laboratory was considered successful in analysing a parameter if two or more z-scores for this parameter were satisfactory
The participants analysed between 4 and 17 parameters. The frequencies are shown in figure 1.

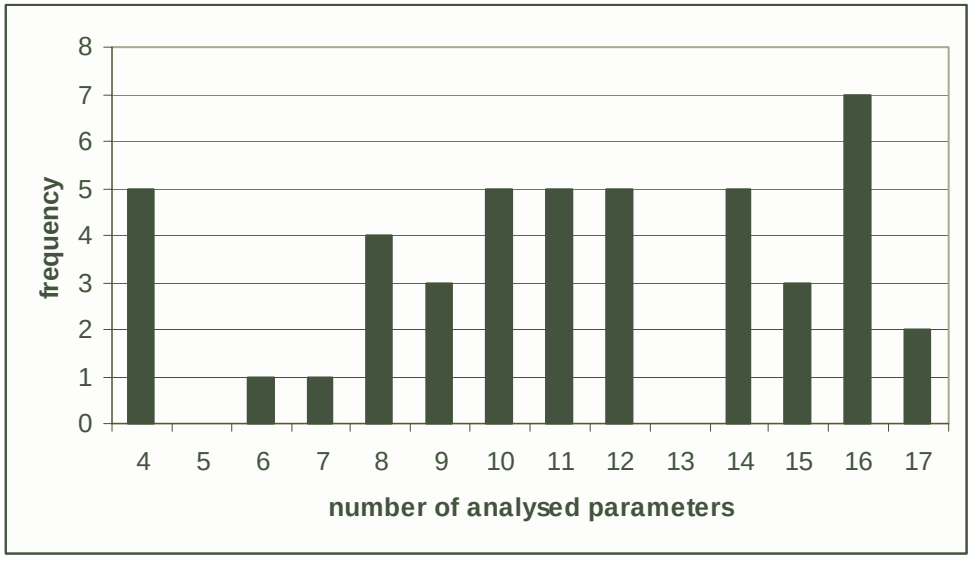

Figure 1: Frequencies of the number of analysed parameters

The percentage of successully analysed parameters varied between 13% and 100% (see figure 2)

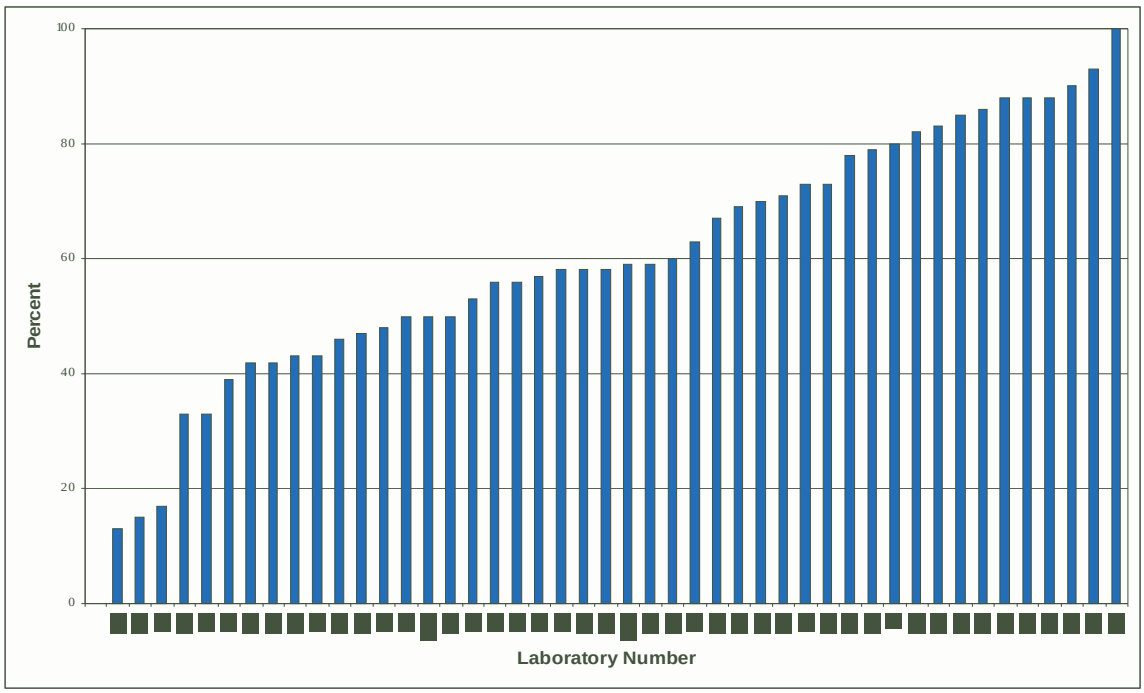

Figure 2: Percentage of successful results for the individual laboratories

The comparison of the parameters to be analysed in round 1 and round 2 showed that 61% of the participants analysed the same number of parameters (or more) in round 2.
Also 61 % of the participants showed (for these 11 parameters) the same or better performance with regard to the percentage of successfully analysed parameters (see figure 3.

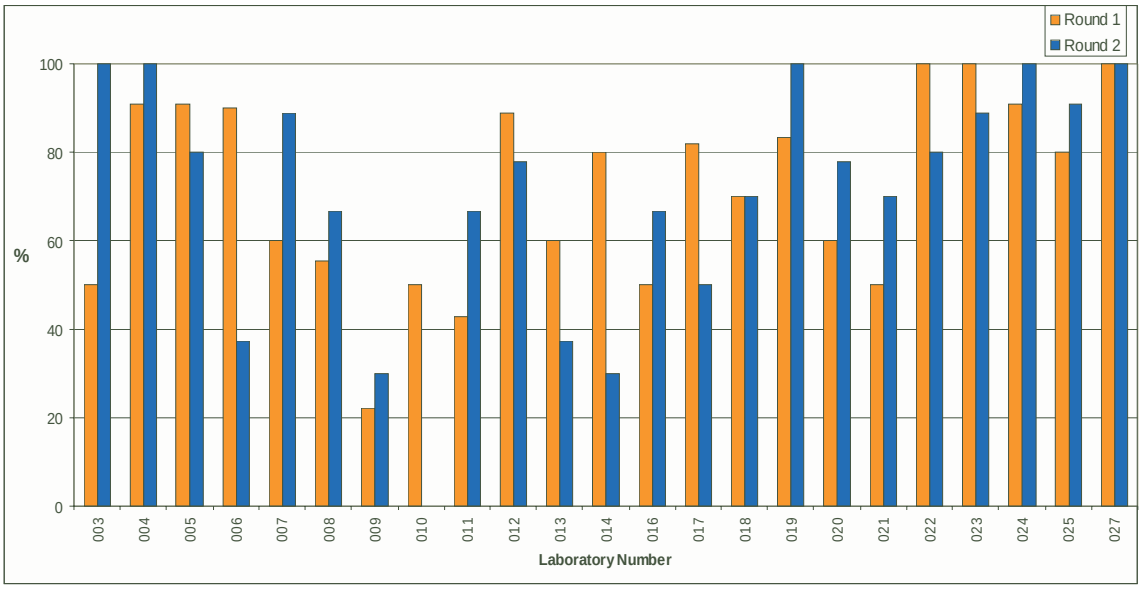

Figure 3: Percentage of successfully analysed parameters in round1 and in round 2 for the parameters included in both rounds.

A method specific evaluation was made (as far as possible). The figures for the frequency of the used methods and the performance evaluation can be found in the Annex.

M. Koch presented details of the evaluation and conclusions that could be drawn from these data (see also annex 3). He showed figures for all parameters with:

- a comparison between the calculated median (with its uncertainty) and the ref.-value calculated from the weighings
- a linear regression diagram for median vs. ref.-value, showing the mean recovery
- a graphical display of the relative standard deviation vs. the concentration together with the applied limit
- for each sample a graphical display of all data with the median, the ref.-value and the tolerance limits as well as in numbers:
    - number of values
    - number of removed values (gross outliers)
    - median
    - ref.-value
    - deviation of median from the ref.-value
    - the calculated standard deviation (absolute and relative)
    - the applied limit for the standard deviation
    - the tolerance limits
    - number and proportion of values outside the limits
- a classification of errors found for the respective parameter with the following classes:
    - ok (no serious error)
    - gross or indefinable errors
    - constant systematic errors
    - proportional systematic errors

  an explanation was given, how the type of error can be derived from the PT results of each lab

All details are included in annex 3.

For the evaluation in future M. Koch gave the following recommendations:

- Due to the development of a new international standard (ISO 13528) it is highly recommended to use the statistical methods from these standards
- But no statistical procedure can cope with datasets containing more than 50 % data not being fit for purpose
- In case of doubt the assigned value should be derived by calculation from the masses used (as recommended in ISO 13528, chapter 5.2.1)
- The setting of limits for standard deviation has proven to be very effective and therefore should be kept for the next rounds

The participants success is shown in the following figure:

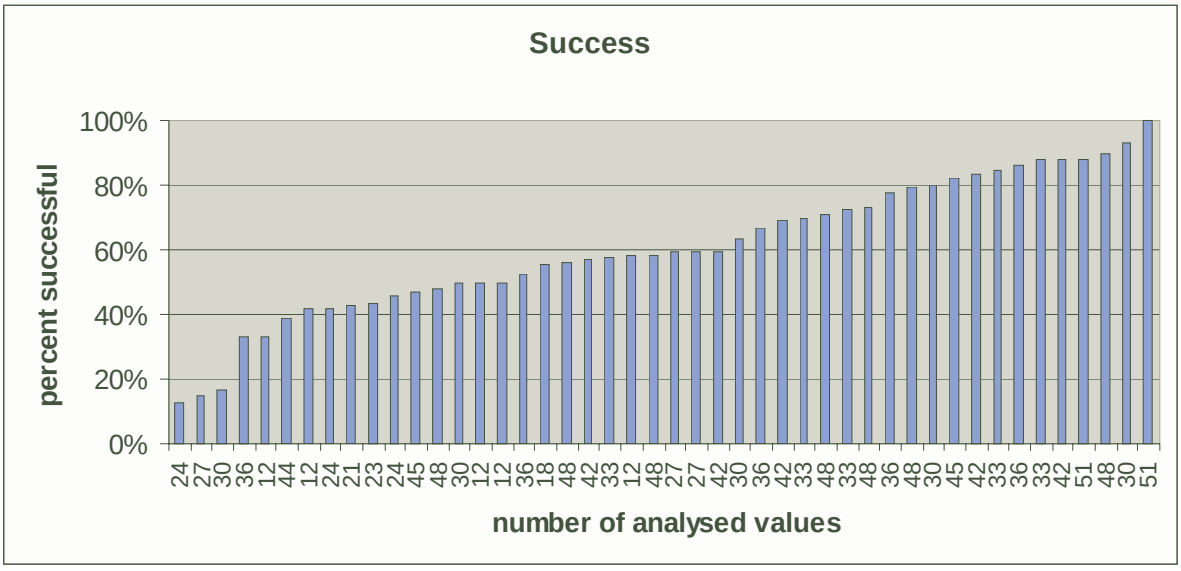

Figure 4: Percentage of successfully analysed parameters together with the number of analysed parameters

Only 12 participants were able to successfully analyse 80% or more of the parameters, which in Germany is the limit for a overall success.
From the evaluation the following conclusions were drawn:

- the PT Provider did a very good job
- the evaluation and assessment procedure needs only minor changes in the future
- the SADCMET Water PT is a good possibility for the participants to compare with peers and with stated fitness-for-purpose criteria
- the results of many laboratories are still not satisfactory and need improvement
- a SADCMET lab association could be a good platform for discussions, how to improve and for mutual help

All Participants: Working group discussions – evaluation and results
Five questions were discussed in three working groups.
Results of the discussion:

Question 1 - Are you satisfied with the method of evaluation? – what changes are necessary?
The comparison was difficult for the parameters, because they were not familiar with other methods. They would like to have a user-friendly presentation whichs provides help for corrective actions. They need help for the consequences that have to be drawn from the identification of the type of error. They would like to know how the PT results of their laboratory could be linked with the estimation of uncertainty.

Question 2 - Are the limitations of standard deviation for assessment fit for the purpose?
The limits are ok. Limit dependent on the concentration and technique used were discussed.

Question 3 - What should be done with results obviously reported in wrong units (N/NO_3^- and P/PO_4^{3-})?

All participants agreed that the values should be used as reported.

Question 4 - How do you judge the outcome of the PT regarding the quality of the laboratories?
The quality is unsatisfactory – there is room for improvement.

Question 5 - What do you want to be included in / excluded from the report?
The participants want to included everything covered in the workshop, especially more pictures. A list of methods would be very welcome.

Agreements from the working group discussions:

- method of evaluation
  - assigned value: use of reference value instead of median, calculation on uncertainty with the help of CSIR
  - statistical methods: median and norm. IQR for this PT, in the next PT use of Alg. A
- Assessment
  - limitation of STD: Pb to change to 40% for <0.5 mg/l (also for this PT)
- Values in wrong units: leave as they are, warning notice on the form in future rounds!
- Content of the report: to be revised

All Participants: Working group discussions – the way forward: chemistry PT
Five questions were discussed in three working groups.
Results of the discussion:

Question 1 - Which parameters should be eliminated?
All participants agreed that no parameter should be eliminated from the programme.

Question 2 - New parameters? (waste water parameters?)
The following parameters had been suggested: TOC and BOD (for waste waster) and Hg, Cd, As.

Question 3 - Is it necessary to include a real matrix?
(real drinking water? ground water? waste water?)
All participants agreed that it would be favourable to improve on the current samples and there stay at it is.

Question 4 - Payment/costs?
What would happen, if PTB would stop sponsoring?
All participants expressed their urgent appeal to PTB not to stop the sponsoring at this stage, because this would lead to a crash of the PT scheme. It was discussed, if the new SADC Lab Assoc. could look for another financing resource on a long term.

Question 5 - How to attract more participants?
The following suggestions were made during the discussions:

- include a brochure in the introductory letter
- use the influence of the bureaus of standards
- use the platform of national lab associations

- it’s a primary task for the local coordinators
- improve marketing with a booklet

Agreements from the working group discussions:

- As and Cd to be added to the PT programme
- No matrix in the sample for the next PT round
- next PT round in June 2006
- everybody tries to attract more participants
- regarding the payment problems in the actual PT round it was decided to recommend the PT provider to write a letter to the chief executive of the participant. If no payment is received, there will be no chance for participation of this laboratory in the next round

All Participants: Working group discussions – the way forward: microbiology PT

Two questions were discussed in three working groups.
Results of the discussion:

Question 1 - Which parameters should be included?
The following parameters were mentioned:

- total coliform
- E.Coli
- total counts
- standard plate counts
- faecal coliform, faecal streptococci
- clostridium
- pseudomonas
- cholera

Question 2 - Which problems are expected with respect to transport, customs/security, others?
Transport problems are expected because of the need to have a fast and cooled transport. Freeze-dried sample were discussed. It is difficult to predict if there will be problems with customs and/or security, but it is at least possible. Payments could also be a problem. It was recommended by the participants to have another PT provider for the microbiology PT.

Agreements from the working group discussions:

- Due to the lack of experience for a microbiological PT, it is recommended to have two people trained in Germany. Benson Gabi from Zimbabwe and one person from Tanzania were suggested
- The programme for a first microbiology PT should be arranged with the help of an expert.
- If possible the first PT should be already in 2006, organized by the Standards Association of Zimbabwe

Thursday, 10 November 2005

Laboratory Association

The main topic for this day was the establishment of a Laboratory Association. M. Musarurwa opened the discussion with a presentation: SADC ASSOCIATION OF WATER TESTING LABORATORIES (SAWATL) (see annex 4).

Based on this the following decisions were taken:

- The name of the organisation will be SADC ASSOCIATION OF WATER TESTING LABORATORIES (SADCWATERLAB)
- The objectives will be international cooperation between water testing laboratories
- The structure will be as follows:
    - general assembly
    - project management committee (PMC)
    - chair and vice chair
    - secretariat
- Kezia Mwanga Mbwambo (Tanzania Bureau of Standards) was elected as chair by acclamation
- Rhoda Nuvunga Luis (Mocambique Ministry of Health) was voted by ballot for vice chair
- The participants agreed to have the following organisations in the PMC:
    - Mauritius, MBS
    - Zambia, FDCL
    - Botswana, WUC
    - Zimbabwe, ZIMLAB
- The secretariat will be held by CSIR together with the SADCMET secretariat
- The term for the elections will be 2 years for the chair and the vice chairand 3 years for the PMC members. Only 2 terms are allowed, then position will then go to another country
- It was agreed to have for the time being no membership fee
- M. Musarurwa will prepare draft statutes for SADCWATERLAB

Used instruments

The discussions during the workshop showed, that quite often unsatisfactory instrumentation is one of the reasons for unsatisfactory participation in the PT. M. Koch proposed to look for used instruments in Germany. M. Musarurwa will circulate a form to the participants, where they can specify their special needs. PTB will be

asked for sponsoring the transport to Africa. The distribution of the instruments will be organized by the SADCWATERLAB PMC.

Harmonisation of methods

To find out the different methods used and to compare the used methods Merylinda Conradie (Namwater, Namibia) volunteered the collect information from the participants on the methods and results for Nitrate analysis in the last PT round. Other parameters should follow.

Evaluation questionnaire

All participants were requested to fill out an evaluation questionnaire (annex 11). Evaluation see below.

Closure of workshop

Dr. Musarurwa and Dr. Koch closed the workshop and thanked Mrs Merle Smuts for her excellent job in the preparation of the PT and all participants for their enthusiastic cooperation.

General recommendations from the consultant:

- The both PT rounds proved to be a very effective way for external quality control of the SADC water laboratories. It is highly recommended to further support this system.
- For an additional improvement of the PT system I recommend to have a 1-2 week training of the PT providers staff in Germany at the University of Stuttgart. Since there is also a local PT system in Tanzania, the training in Stuttgart extended to the responsible person for this PT also.
- A microbiological PT system is also essential. To be able to organise such a system a training of the responsible staff (one person form Zimbabwe and one from Tanzania) is indispensable.
- The participants need help for corrective actions resulting from the PT participation. A help system like an email-hotline is recommended.
- After the next PT round (chemistry and hopefully also microbiology) again a workshop is recommended to discuss the progress.
- To encourage the participants to take corrective actions it is recommended to oblige all participants (as soon as possible) to report about these corrective actions during the next workshop.
- Discussions with the participants showed that there is need for training on how to work with control charts. This therefore should also be a topic during the next workshop.
- Harmonisation of methods is still a big problem. The process of harmonisation should be encouraged wherever possible.
- If possible, a collection of used instruments and distribution to badly equipped laboratories should be supported.

Evaluation of the questionnaire

The judgement of the participants regarding

- **The venue of the workshop:**
  - Very good 10
  - Good 24
  - Fair 5

  Mean: 1.87 (1 for very good, 2 for good and 3 for fair)
- **The content of the presentations:**
  - Very good 14
  - Good 22
  - Fair 3

  Mean: 1.72 (1 for very good, 2 for good and 3 for fair)
- **The handout and documents:**
  - Very good 18
  - Good 18
  - Fair 3

  Mean: 1.62 (1 for very good, 2 for good and 3 for fair)
- **The working group discussions:**
  - Very good 23
  - Good 14
  - Fair 2

  Mean: 1.46 (1 for very good, 2 for good and 3 for fair)
- **Presenters skills and handling of the workshop:**
  - Very good 14
  - Good 23
  - Fair 1
  - no answer: 1

  Mean: 1.66 (1 for very good, 2 for good and 3 for fair)

Were all aspects of the pilot PT covered?

Yes: 35
No: 3
No answer: 1

The aspect not covered:

- How to evaluate PT – different approach
- statistical approaches
- statistical analysis not full covered

The most important topics (in brackets the number of participants mentioning this point):

- (Statistical) evaluation of PT (21)
- Measurement uncertainty using PT data (9)
- Water laboratory association (8)
- Methods used for evaluation (4)
- Experience of provider (3)
- Comparison of different methods used (2)
- Conclusions drawn out of the evaluation (2)
- Establishment of microbiology PT (2)
- Choosing of office bearers (1)
- Discussion of the evaluation (1)

- Discussion on the need of harmonisation of methods (1)
- Calculation of z-scores (1)
- The importance of measurement uncertainty (1)
- Performance levels (1)
- How to determine consensus / assigned value (1)
- How can a laboratory make use of PT evaluation report (1)
- Trouble shooting (1)

Did the workshop fulfil your expectations?

Yes: 34
No: 3
No comment: 2

Why not:

- no field visits to labs
- would wish to know how I could individually handle the date evaluation
- time was too short to cover the course content

What benefits did you draw from the workshop?

- Knowledge of technique in PT evaluation
- Establishment of SADC Lab Association
- handling of PT process, i.e. sample analysis and evaluation when reporting the results
- I have learned the importance of PT as to support all participants. Continue with the same spirit so that they can be accredited.
- knowledge on how to evaluate results
- Ability to perform and evaluate PTs and hoping SADCMET will initiate PT for microbiology
- How to enhance SADCMET etc.
- A drive to work harder
- Establishment of lab association
- The discussions on the evaluation of the PT results were very useful to me
- Evaluation of lab performance
- Increase the performance
- A lot of interesting and different evaluations of the PT scheme
- I have learned new things
- Self evaluation is now possible
- The need to harmonise methods
- I have checked the performance of my lab
- I learned the estimation of measurement uncertainty from validation data
- I know how to evaluate the data
- How to evaluate the PT appropriately
- I would be able to use the PT result for my uncertainty estimation
- Improvement of analytical procedures
- Interaction with others
- Performance in PT
- Finding out capacity of the instrument
- Know more about PT evaluation, how it is being conducted and how to improve
- The use of uncertainty in writing reports

Any other comments:

- The allowance should be more, especially during weekend and holiday
- Keep up the spirit
- More training and workshop shall be conducted. Increase the sufficient time for workshop
- PTs are a good way of checking ones performance and water being one of the basic human resources, this has been an eye opener as regards the status of water testing equipment in my laboratory.
- It has been nice to interact with other member countries and exchange technical ideas
- The last two days we moved very fast and as a result I felt we should have extended more on methods for evaluating the PT results
- It was an excellent PT evaluation with a lot of detailed information
- The result was not very good of course, but – real the method and instrument used for matters unless more effort could have been used to at least sponsor us in instrumentation: especially the PTB take part in this modify our results anyway
- Accelerate the establishment of the association
- Members to be involved in selection of venues
- Participants to be allowed to describe problem areas to fellow participants
- Deliberate effort should be done to educate CEO on the newly established association
- Handouts should have been in colour to graphically illustrate performance/trend per multi-coloured powerpoint slides.
- We need to have South African laboratories participating in the SADCMET PT scheme

Summary of the evaluation

From the questionnaires the conclusion can be drawn, that almost all of the participants were very happy with the workshop. The expectations of the particpants have been fulfilled and most of them were quite enthusiastic. Almost all topics were mentioned in the list of most important topics, showing that there was constant interest throughout the whole workshop.

Dr.-Ing Michael Koch

Universität Stuttgart

Guideline for the estimation of measurement uncertainty from validation data

to be published in spring 2006
in the German standard methods for water analysis

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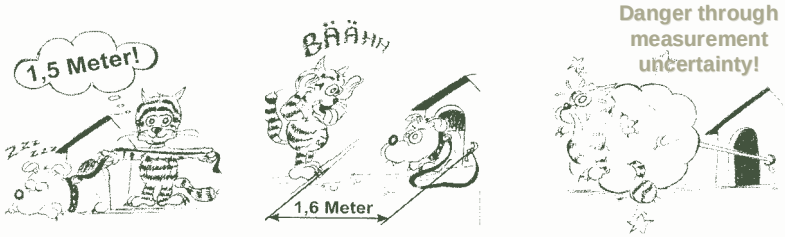
Measurement uncertainty is important!



Measurement results are informations.

Without knowledge, how they were achieved and what is the uncertainty, they are just rumours!

Albert Weckenmann

Universität Stuttgart

Quality requirements on analysis – fitness for purpose

- **Quality is the property of a product or a service to fulfil stipulated requirements**
- The quality of measurements can be assessed only, if the customers requirements are known
- Reporting the measurement uncertainty enables the customer to judge, if his requirements are fulfilled

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Quality of measurement uncertainty estimation

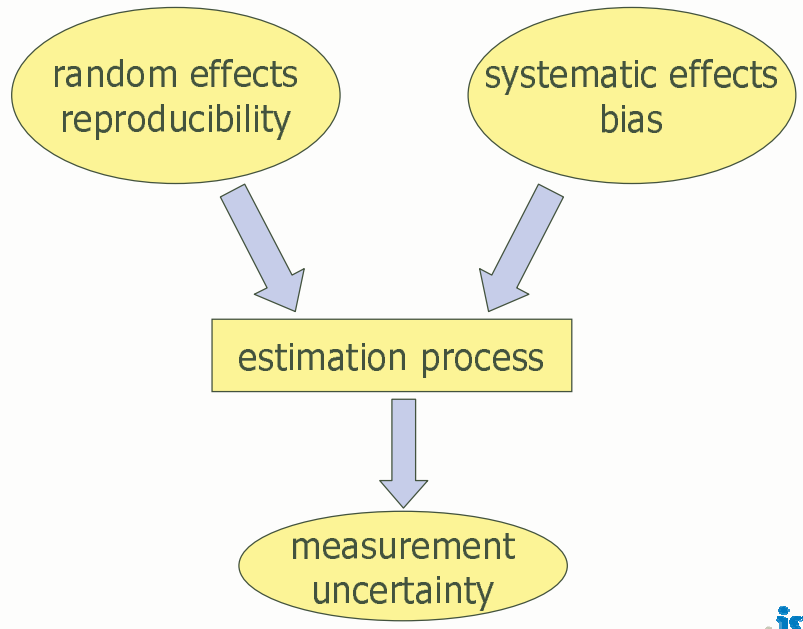
- The quality of mu estimation must be fit for the purpose – not more!
- The German Standardisation organisation DIN decided to publish a „Guideline for the Estimation of Measurement Uncertainty from Validation Data“ for water testing

Uncertainty budget vs. estimation from validation and QC data

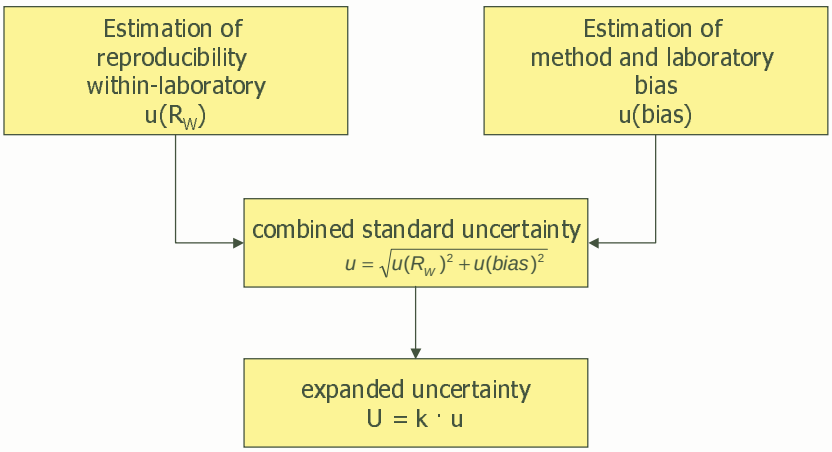
- Calculation of an uncertainty budget is very expensive, but enables the identification of the most important uncertainty components
- In many cases it is sufficient to estimate uncertainties form validation and QC data
- This procedure was first published by NORDTEST (Handbook for calculation of measurement uncertainty in environmental laboratories; www.nordtest.org)

Accuracy = Precision + Trueness

- The accuracy of an analytical results is characterised by its precision and its trueness
- In the same way the measurement uncertainty is caused by random and systematic deviations of the result



Overall flowchart



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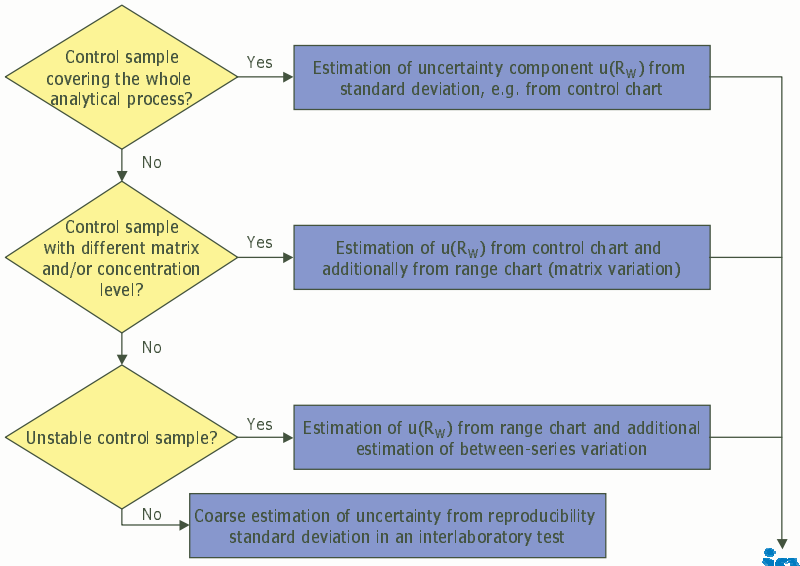
Flowchart reproducibility $u(R_W)$



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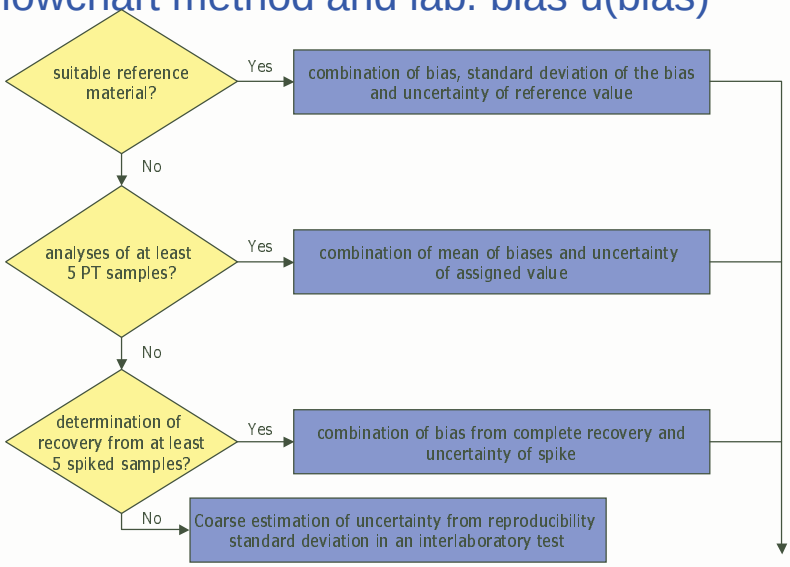
Flowchart method and lab. bias u(bias)



Reproducibility within-laboratory

- quantification of random variations has to be done under the same conditions as in routine analysis
- i.e.:
  - neither under repeatability conditions
  - nor under reproducibility conditions
  - but under between-series conditions
- this is called here „reproducibility within-laboratory“

Reproducibility within the laboratory R_w - method 1

Control sample covering the whole analytical process

- if
  - the control sample covers the whole analytical process and
  - has a matrix similar to the samples,
- the within-laboratory reproducibility at that concentration level can simply be estimated from the analyses of the control sample
- If the analyses performed cover a wide range of concentration levels, also control samples of other concentration levels should be used.

		value	rel. Uncertainty	Comments
Reproducibility within the lab R_w				
control sample 1 $\overline{X}$ = 20.01 µg/l	s_{Rw}	standard deviation 0.5 µg/l	2.5 %	from 75 measure-ments in 2002
control sample 1 $\overline{X}$ = 250.3 µg/l	s_{Rw}	standard deviation 3.7 µg/l	1.5 %	from 50 measure-ments in 2002
other components		---		

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Reproducibility within the laboratory R_w – method 2

Control samples for different matrices and concentrations

- if
  - a synthetic control solution is used for quality control, and
  - the matrix type of the control sample is **not** similar to the natural samples
- we have to take into consideration uncertainties arising from different matrices
- These can be estimated from the repeatability with different matrices (range control chart)

		value	u(x)	Comments
Reproducibility within the lab R_w				
low level (2-15 µg/l)	s_{Rw}	0.5 µg/l from the mean control chart 0.37 µg/l from the range control chart	0.6 µg/l	Absolute: $u(x) = \sqrt{0.5^2 + 0.37^2}$
high level (>15 µg/l)	s_{Rw}	1.5 % from the mean control chart 3.6 % from the range control chart	3.9 %	Relative: $u(x) = \sqrt{1.5\%^2 + 3.6\%^2}$

Note: The repeatability component is included two times!!

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Reproducibility within the laboratory R_w – method 3

Unstable control samples

- if
  - the laboratory does not have access to stable control samples (e.g. measurement of dissolved oxygen)
- it is possible only to estimate uncertainty components from repeatability via the range control chart
- the „long-term“ uncertainty component (from batch to batch) has to be estimated e.g. by a qualified guess

		value	u(x)	Comments
Reproducibility within the laboratory R_w				
Duplicate measurements of natural samples	s_r	s = 0.024 mg/l mean: 7.53 mg/l	0.32 %	from 50 measurements
Estimated variation from differences in calibration over time		s = 0.5 %	0.5 %	based on experience
Combined uncertainty for R_w Repeatability + Reproducibility in calibration		$\sqrt{0.32\%^2 + 0.5\%^2} = 0.59\%$		

Method and Laboratory bias

- can be estimated from
  - the analysis of certified reference materials
  - the participation in proficiency tests
  - from recovery experiments
- Sources of bias should always be eliminated if possible
- According to GUM a measurement result should always be corrected if the bias is significant and based on reliable data such as analysis of a CRM.
- In many cases the bias can vary depending on changes in matrix. This can be reflected when analysing several matrix CRMs

Method and Laboratory bias u(bias) Components of uncertainty

- the bias (as % difference from the nominal or certified value)
- the uncertainty of the bias determination
- the uncertainty of the nominal/certified value $u(C_{ref})$

Method and Laboratory bias u(bias) - method 1a
Use of one certified reference material

- The reference material should be analysed in at least 5 different analytical series
- Example: Certified value: 11.5 ± 0.5 (95% confidence interval)

Uncertainty component from the uncertainty of the certified value	
Convert the confidence interval	The confidence interval is ± 0.5. Divide this by 1.96 to convert it to standard uncertainty: 0.5/1.96=0.26
Convert to relative uncertainty $u(C_{ref})$	$100 \cdot (0.26/11.5) = 2.21\%$

Method and Laboratory bias u(bias) - method 1a
Use of one certified reference material

- Quantify the bias
  - the CRM was analysed 12 times. The mean is 11.9 with a standard deviation of 2.2%
  - This results in:

$$bias = 100 \cdot (11.9 - 11.5)/11.5 = 3.48\% \quad and$$

$$s_{bias} = 2.2\% \quad with \quad n = 12$$

- Therefore the standard uncertainty is:

$$u(bias) = \sqrt{(bias)^2 + \left(\frac{s_{bias}}{\sqrt{n}}\right)^2 + u(C_{ref})^2} =$$

$$\sqrt{(3.48\%)^2 + \left(\frac{2.2\%}{\sqrt{12}}\right)^2 + 2.21\%^2} = 4.2\%$$

Method and Laboratory bias u(bias) - method 1b
Use of several certified reference material

- Quantification of the bias
  - bias CRM1 is 3.48%, s=2.2% (n=12), u(C_{ref})=2.21%
  - bias CRM2 is –0.9%, s=2.0% (n=7), u(C_{ref})=1.8%
  - bias CRM3 is 2.4%, s=2.8% (n=10), u(C_{ref})=1.8%
  - RMS_{bias} then is:

$$RMS_{bias} = \sqrt{\frac{\sum (bias_i)^2}{n}} = \sqrt{\frac{3.48\%^2 + (-0.9\%)^2 + 2.4\%^2}{3}} = 2.5\%$$

  - and the mean uncertainty of the certified value u(C_{ref}): 1.9%
- This results in the total standard uncertainty of the bias:

$$u(bias) = \sqrt{RMS_{bias}^2 + u(C_{ref})^2} = \sqrt{2.5\%^2 + 1.9\%^2} = 3.1\%$$

Method and Laboratory bias u(bias) – method 2
Use of PT results

- In order to have a reasonably clear picture of the bias from interlaboratory comparison results, a laboratory should participate at least 6 times within a reasonable time interval

Uncertainty component from the uncertainty of the nominal value	
between laboratory standard deviations s_R	s_R has been on average 9% in the 6 exercises
Convert to relative uncertainty u(C_{ref})	Mean number of participants= 12 $u(C_{ref}) = \frac{s_R}{\sqrt{n}} = \frac{9\%}{\sqrt{12}} = 2.6\%$

In the German guideline changed to: $u(C_{ref}) = 1.25 \cdot \frac{s_R}{\sqrt{n}}$ for a robust mean to be in accordance with ISO 13528

Method and Laboratory bias u(bias) – method 2
Use of PT results

- Quantification of the bias
  - In the 6 participations the biases have been: 2%, 7%, -2%, 3%, 6% and 5%
  - Therefore RMS_{bias} is:

$$RMS_{bias} = \sqrt{\frac{\sum (bias_i)^2}{n}} = \sqrt{\frac{2\%^2 + 7\%^2 + (-2\%)^2 + 3\%^2 + 6\%^2 + 5\%^2}{6}} = 4.6\%$$

- and the total standard uncertainty of the bias:

$$u(bias) = \sqrt{RMS_{bias}^2 + u(C_{ref})^2} = \sqrt{4.6\%^2 + 2.6\%^2} = 5.3\%$$

Method and Laboratory bias u(bias) – method 3
From Recovery Tests

- Recovery tests, for example the recovery of a standard addition to a sample in the validation process, can be used to estimate the systematic error. In this way, validation data can provide a valuable input to the estimation of the uncertainty.
- Example: In an experiment the recoveries for an added spike were 95 %, 98 %, 97 %, 96 %, 99 % and 96 % for 6 different sample matrices. The spike of 0.5 mL was added with a micropipette.

uncertainty component from spiking	
uncertainty of the concentration of the spike u(conc)	from the certificate: 95% confidence intervall = ± 1.2 % u(conc) = 0.6 %
uncertainty of the added volume u(vol)	from the manufacturer of the micro pipette: max. bias: 1% (rectangular interval), repeatability: max. 0.5% (standard dev.) $u(vol) = \sqrt{\left(\frac{1\%}{\sqrt{3}}\right)^2 + 0.5\%^2} = 0.76\%$
uncertainty of the spike u($c_{recovery}$)	$\sqrt{u(conc)^2 + u(vol)^2} = \sqrt{0.6\%^2 + 0.76\%^2} = 1.0\%$

Method and Laboratory bias u(bias) – method 3 From Recovery Tests

- Quantification of the bias:
- RMS_{bias}:

$$RMS_{bias} = \sqrt{\frac{5\%^2 + 2\%^2 + 3\%^2 + 4\%^2 + 1\%^2 + 4\%^2}{6}} = 3.44\%$$

- Therefore the total standard uncertainty of the bias is:

$$u(bias) = \sqrt{RMS_{bias}^2 + u(C_{recovery})^2} = \sqrt{3.44\%^2 + 1.0\%^2} = 3.6\%$$

Combination of the uncertainties
(Reproducibility within-laboratory and bias)

- Reproducibility R_w (from control samples and other estimations)
- bias u(bias) (from CRM, PT or recovery tests)
- Combination:

$$u_c = \sqrt{u(R_w)^2 + u(bias)^2}$$

Calculation of the expanded uncertainty

- for the conversion to an approx. 95% confidence level

$$U = 2 \cdot u_c$$

Coarse estimation by direct use of reproducibility standard deviations

- If the demand on uncertainty is low: $u_c = s_R$
- The expanded uncertainty becomes: $U = 2 \cdot S_R$
- This may be an overestimate depending on the quality of the laboratory – worst-case scenario
- It may also be an underestimate due to sample inhomogeneity or matrix variations

Reproducibility standard deviation from a standard

- The laboratory must first prove that it is able to perform in accordance with the standard method
  - „no“ significant bias
  - verification of the repeatability
- The expanded uncertainty then is:

$$U = 2 \cdot s_R$$

Reproducibility standard deviation from a standard Example – Mercury according to EN 1483

Tabelle 2: Verfahrenskenndaten — reproducibility variation coefficient

	Alle Laboratorien										
	Probe	l	n	NAP %	Wahrer Wert µg/l	$\bar{\bar{x}}$ µg/l	σ_R µg/l	VC_R %	σ_r µg/l	VC_r %	Wieder-findungs-rate %
drinking water	A	21	62	9	0,819	0,831	0,2500	30,1	0,1310	15,8	101,5
surface water	B	20	59	13	1,474	1,459	0,3918	26,9	0,1855	12,7	99,0
waste water	C	21	68	0	5,732	5,799	1,3745	23,7	0,5746	9,9	101,2

- Expanded uncertainty for drinking water:
  $U = 2 \cdot VC_R \approx 60\ \%$

Reproducibility standard deviation from a PT

- The laboratory must have been successfully participating in the PT
- If the comparison covers all relevant uncertainty components and steps (matrix?)
- The expanded uncertainty then also is:

$$U = 2 \cdot s_R$$

Reproducibility standard deviation from a PT Example – Mercury in a Univ. Stuttgart PT

reproducibility variation coefficient

Niveau	Vorgabe [µg/l]	rob. Standardab	chung [µg/l]	chung [%]	ben [µg/l]	nten [µg/l]	ben [%]	Ausschlussgrenze unten [%]	Anzahl Werte	außerhalb unten	außerhalb oben	außerhalb [%]
1	0,584	0,133	22,86	0,889	0,341	52,25	-41,60	37	3	1	10,8
2	1,248	0,225	18,09	1,748	0,830	40,07	-33,46	39	3	1	10,3
3	1,982	0,3502	17,67	2,756	1,333	39,06	-32,75	39	1	0	2,6
4	3,238	0,4726	14,60	4,263	2,352	31,65	-27,36	41	2	2	9,8
5	3,822	0,4550	11,90	4,793	2,960	25,40	-22,55	38	0	1	2,6
6	4,355	0,7704	17,69	6,057	2,927	39,10	-32,78	40	1	0	2,5
7	5,421	0,7712	14,23	7,090	3,973	30,78	-26,71	41	1	1	4,9
8	6,360	0,7361	11,57	7,928	4,963	24,65	-21,96	38	5	1	15,8
9	6,553	0,9177	14,00	8,536	4,829	30,25	-26,31	39	2	0	5,1
10	7,361	0,9965	13,54	9,508	5,486	29,16	-25,48	40	1	3	10,0
11	8,063	1,0672	13,24	10,357	6,051	28,46	-24,94	38	5	2	18,4
12	9,359	0,9854	10,53	11,444	7,481	22,29	-20,06	40	2	2	10,0
							Summe	470	26	14	8,5

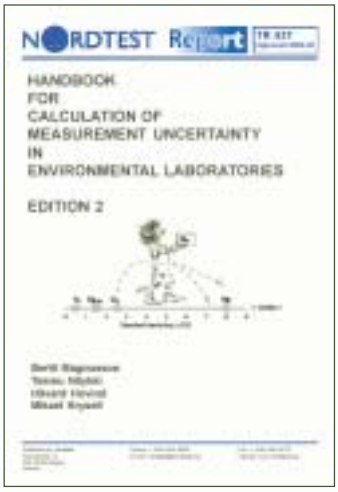
- $u_c = s_R \approx 20\%$
- $U \approx 40\%$

Conclusion

- The method described is an easy way to estimate measurement uncertainty from data that are already available in many cases
- Maybe it is not as accurate as the GUM
- But it is a holistic approach, you cannot forget an important uncertainty source
- It does not give you information about the source of the uncertainty
- If you want to know this, use the GUM approach

Where to get the NORDTEST-Handbook?

- The Handbook is available from http:\\www.nordtest.org as technical report No. 537



Experiences of the PT Provider

1

Introduction

- PT Round 2: Changes and Progress
- Preparation of Samples
- Shipment of Samples
- Payment
- Successes
- Challenges

2

PT Round 2: Changes and Progress : Participation

Country	Participation 2004	Participation 2005
Angola	1	1
Botswana	2	2
Ethiopia	1	1
Kenya	2	2
Lesotho	1	1
Malawi	2	2
Mauritius	1	3
Mozambique	2	3
Namibia	2	2
Seychelles	1	2
Swaziland	1	1
Tanzania	2	8
Uganda	1	3
Zambia	1	4
Zimbabwe	2	8
Number of Labs participating	22	44

3

PT Round 2: Changes and Progress : Analytes

2004	
ANIONS	CATIONS
SO4	Ca, Fe
Cl	Mg, Mn
F	Na, Al
NO3	K

2005	
ANIONS	CATIONS
SO4	Ca, Al
Cl	Mg, Pb
F	Na, Cu
NO3	K, Zn
PO4	Fe, Cr
	Mn, Ni

4

Preparation of Samples

- 50 litres of each sample prepared
  - Laboratory water spiked with parameter of interest
  - True value calculated from mass of spike
- Samples dispensed and labelled
- Packaged and travel documentation completed
- Courier

5

Shipment

- Bureaucratic issues with courier of choice
- Costs very much reduced by shipping all samples to one address for local distribution
- Samples all successfully delivered within one week after dispatch
- Apparently more leakage problems than PT 1

6

Payment

- Bank drafts, transfers, cheques and cash
- Some payments made, but not yet received
- Some payments not yet made at all

7

Results

- Results generally received timeously by fax or email
- Some laboratories submitted late results – holds up report for other Labs

8

Successes of 2nd PT

- Increased and continued enthusiastic participation
- No transport problems, including clearing Customs
- Local co-ordinators to be commended
- Only 2 (out of 44) labs did not submit results

9

Challenges: Results

- Reported results – incorrect units (eg as NO_3 and PO_4)
- Transcription/dilution/calculation errors
- Analytes not determined due to lack of chemicals
- Instrumentation/Method to be stipulated
- High standard deviations

10

Challenges: Administration

- Cost of transport – perhaps consider concentrated solutions
- Foreign currency payments
  - To date, approximately half the labs have paid
  - Tracking payments
  - Bank charges – bulk payment by local coordinators would reduce costs

Thank you

PTB
NML
GTZ
TBS
Dr Koch
Participants

Preliminary Evaluation and Assessment SADCMET PT Round 2

1

Introduction

- Evaluation of Round 2
- Comparison of Results with Round 1
- Evaluation of Methods used

2

Evaluation

- Robust statistics
- Assigned value = Median (central value)
- Std. Dev. = Normalized IQR
  - difference between 1st and 3rd quartile, normalised to a standard deviation using a factor (0.7413)
- Evaluation of performance using Z-scores

3

Parameters analysed: Round 2

Anions

	Ltd SD %
Sulphate	10
Chloride	10
Fluoride	12
Nitrate	15
Phosphate	10

Cations

	Ltd SD %
Calcium	10
Magnesium	10
Sodium	10
Potassium	10
Iron	<1 mg/l: 20, >1mg/l: 12
Manganese	<1 mg/l: 20, >1mg/l: 12
Aluminium	30
Lead	25
Copper	20
Zinc	20
Chrome	25
Nickel	25

Total of 17 parameters (51 analyses)

4

Evaluation

- Performance Assessment

  $|z\text{-Score}| \leq 2$: Satisfactory

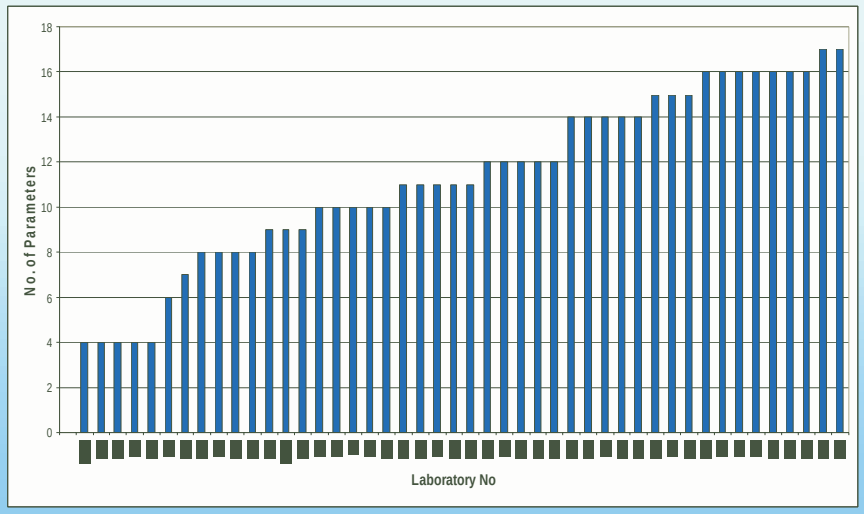
  $2 < |z\text{-Score}| \leq 3$: Questionable

  $|z\text{-Score}| > 3$: Unsatisfactory

- Laboratory considered successful in analysing a parameter if two or more z-scores for a parameter were satisfactory

5

Number Parameters analysed



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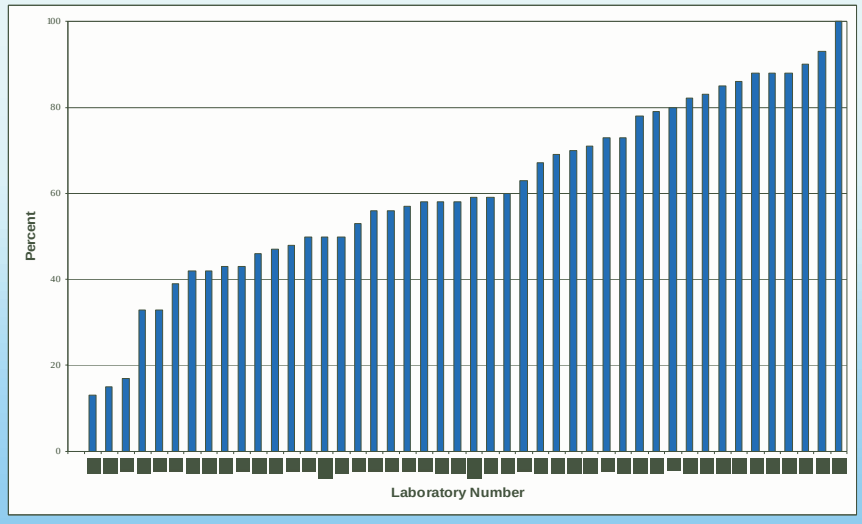
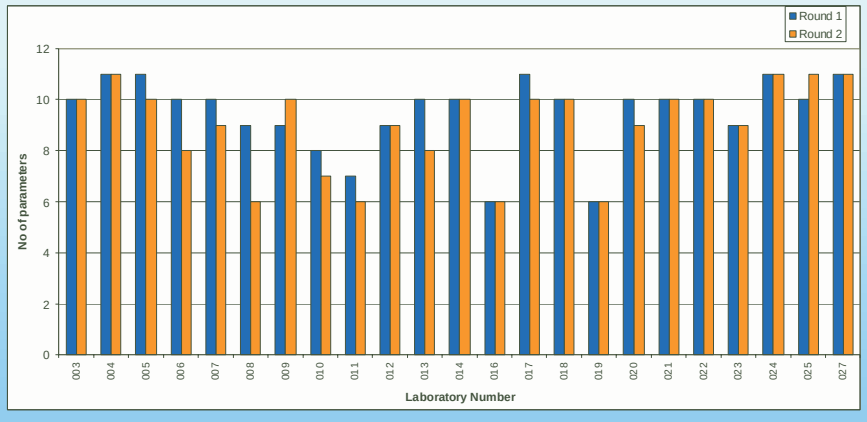
% Successful analyses



7

Comparison of Round 1 and Round 2 - Number of parameters analysed

61% of participants analysed at least the same number of parameters in Round 2.



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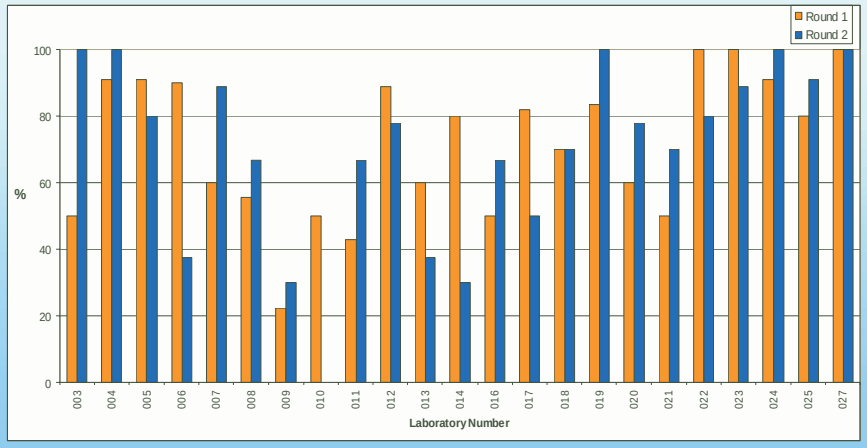
Comparison of Round 1 and Round 2 - Performance

61% of participants showed similar or improved performance in Round 2



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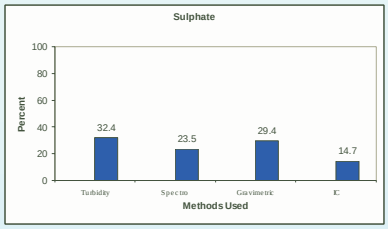
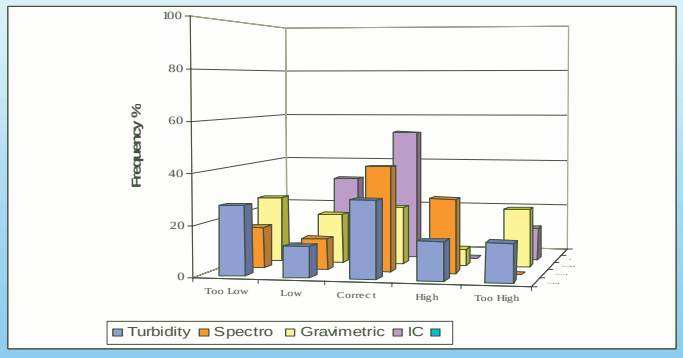
Evaluation of Methods Used

- Types and frequency of methods used
- Performance evaluation of methods used

10

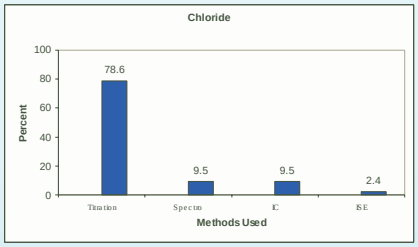
Sulphate

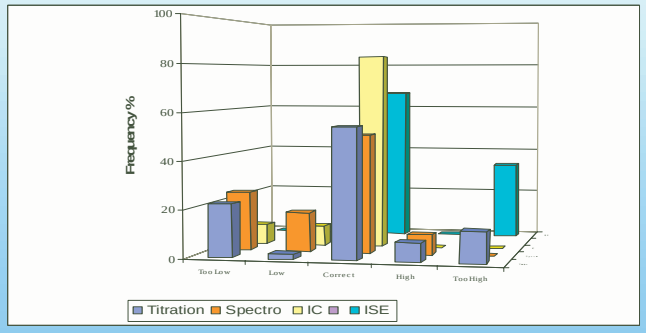




11

Chloride





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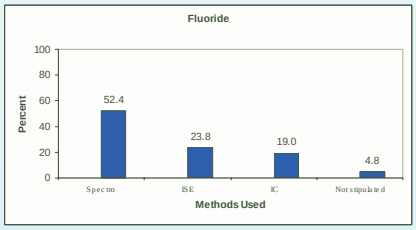
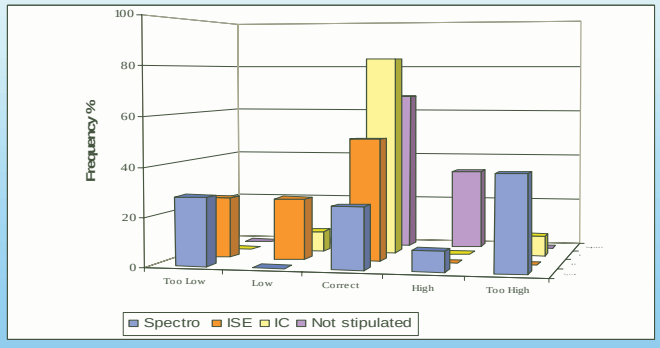
Fluoride





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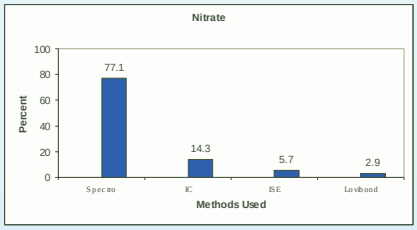
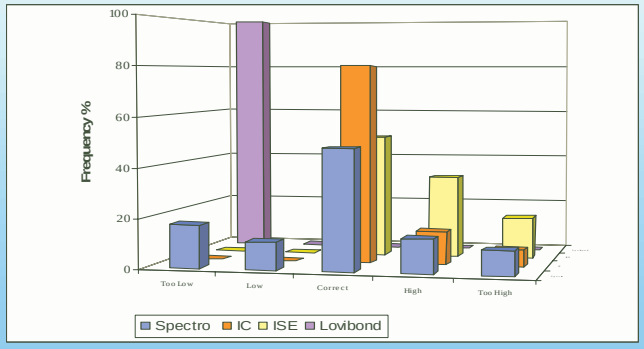
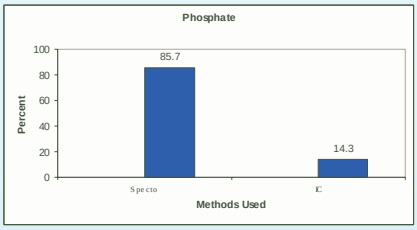
Nitrate

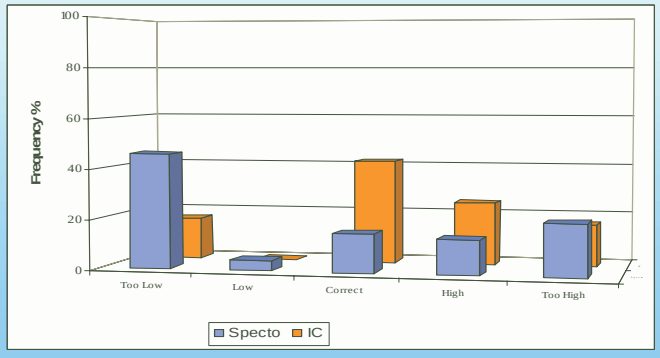




14

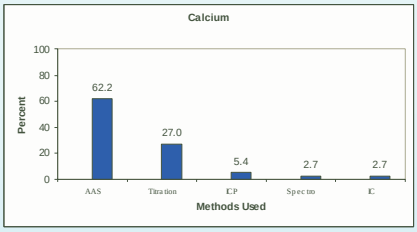
Phosphate

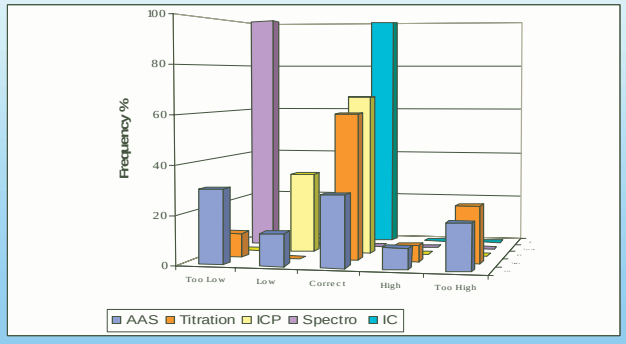




15

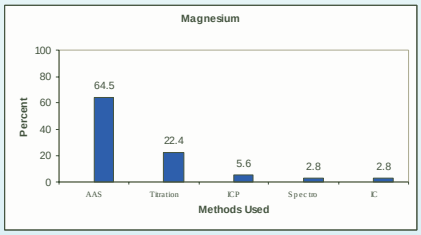
Calcium

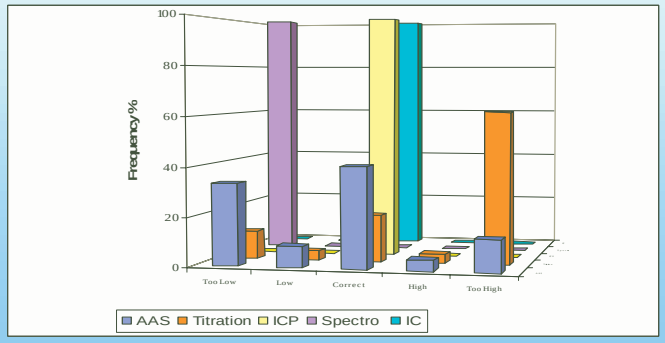




16

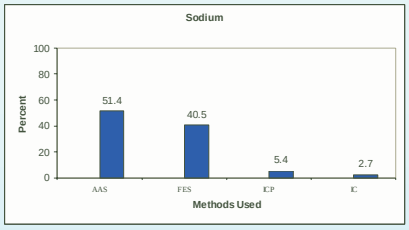
Magnesium

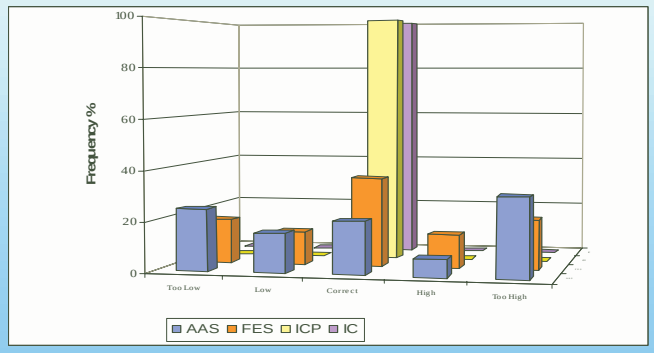




17

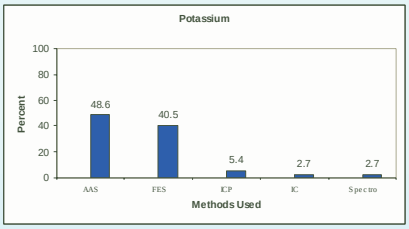
Sodium

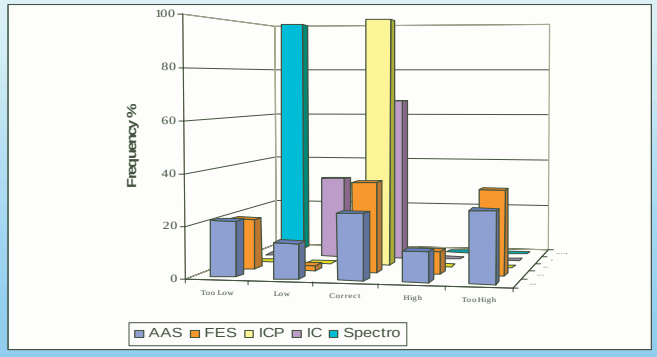




18

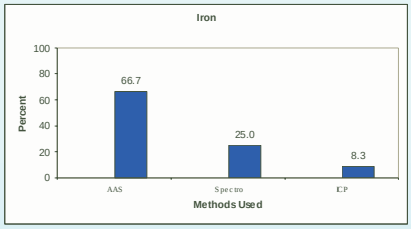
Potassium

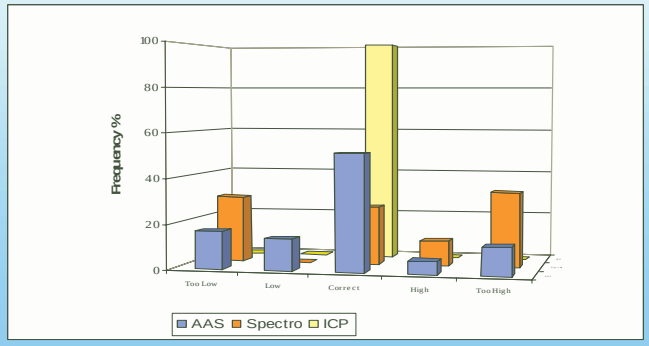




19

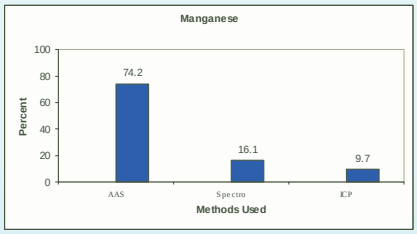
Iron

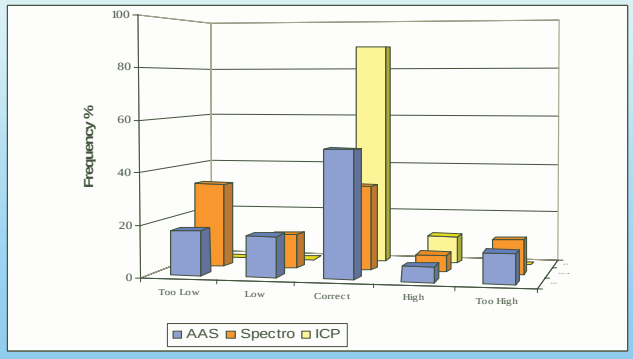




20

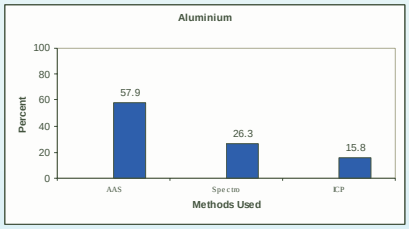
Manganese

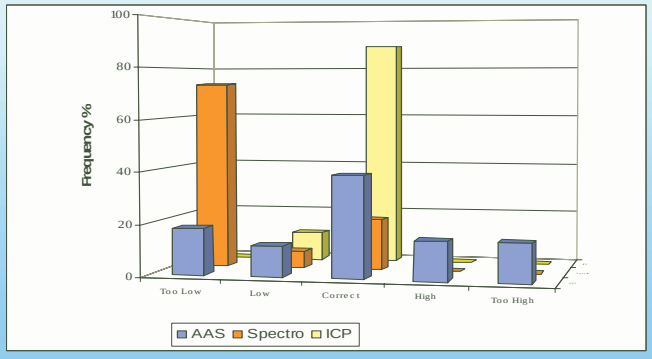




21

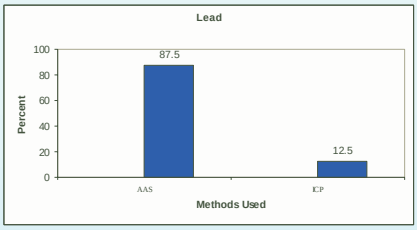
Aluminum

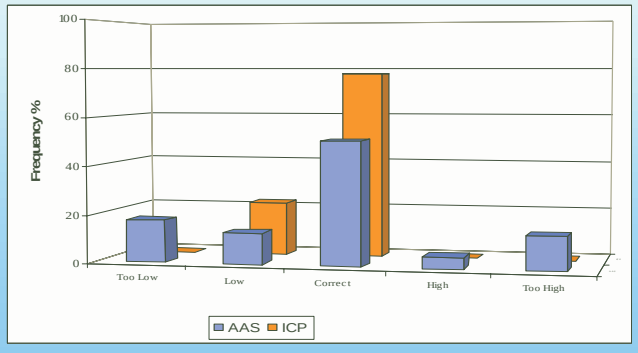




22

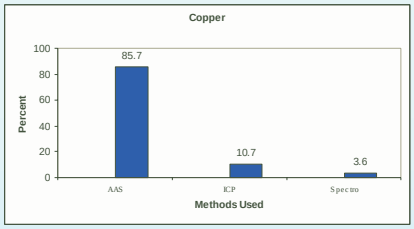
Lead

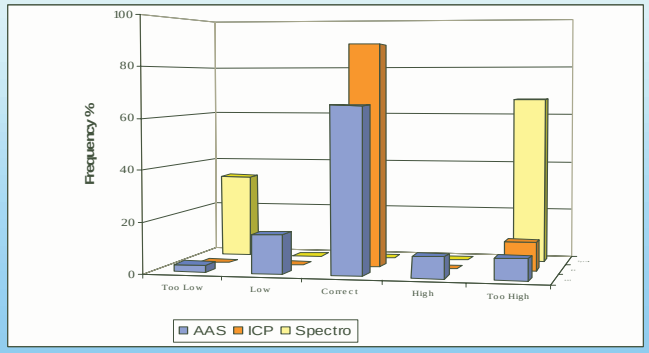




23

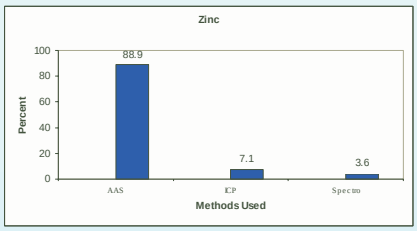
Copper

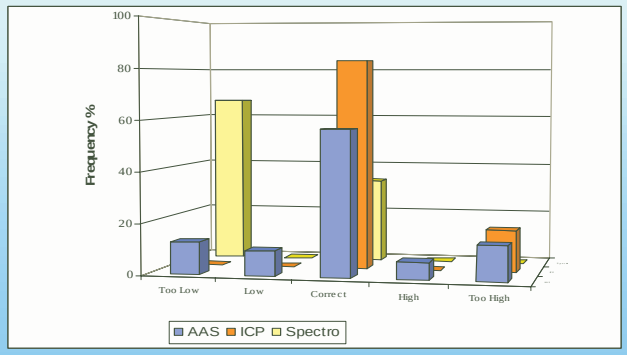




24

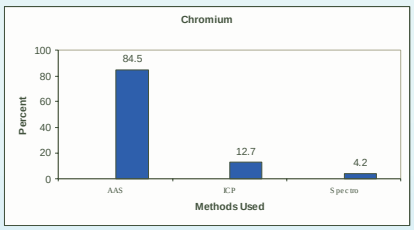
Zinc

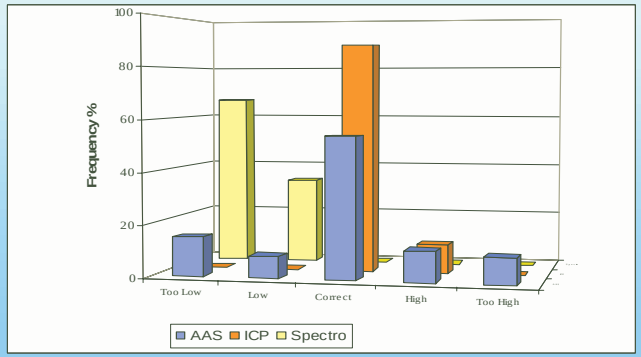




25

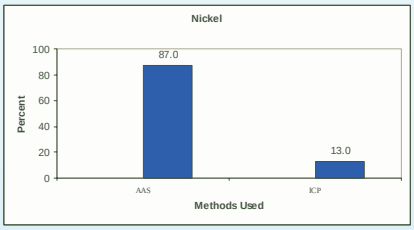
Chromium

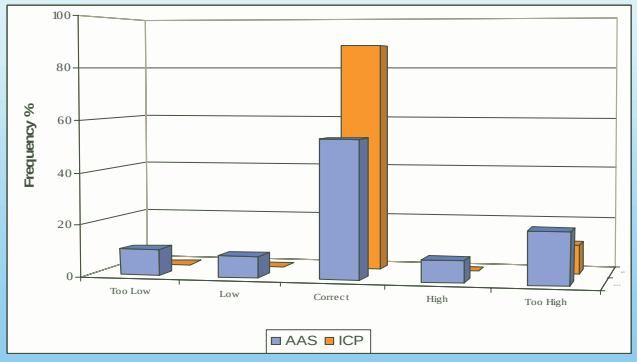




26

Nickel





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Thank you

PTB
NML
GTZ
TBS
Dr Koch
Participants

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Evaluation of the 2nd SADCMET Water PT

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Evaluation and Assessment

- according to the procedure agreed on in Pretoria
  - assigned value from median of participants results
  - calculation of standard deviation from normalized interquartile range
  - but! – limitation of the standard deviation (as 'fitness for purpose' requirement)

Limits for standard deviation

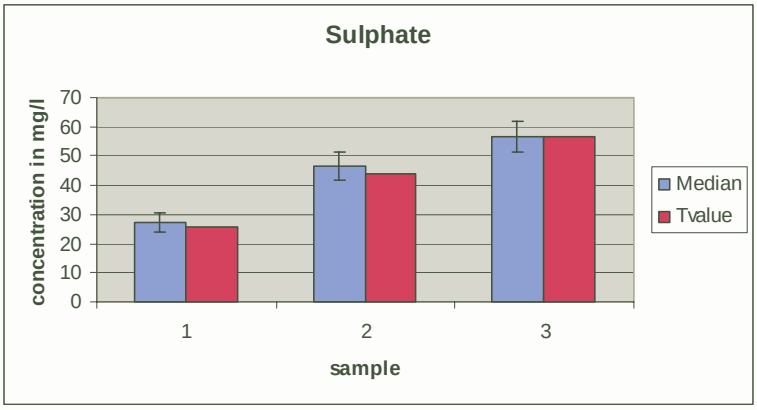
parameter	std limit
sulphate	10 %
chloride	10 %
fluoride	12 %
nitrate	15 %
phosphate	10 %
calcium	10 %
magnesium	10 %
sodium	10 %
potassium	10 %

parameter	std limit
iron	20 % / 12 %
manganese	20 % / 12 %
aluminium	30 %
lead	25 %
copper	20 %
zinc	20 %
chromium	25 %
nickel	25 %

Elimination of gross outliers

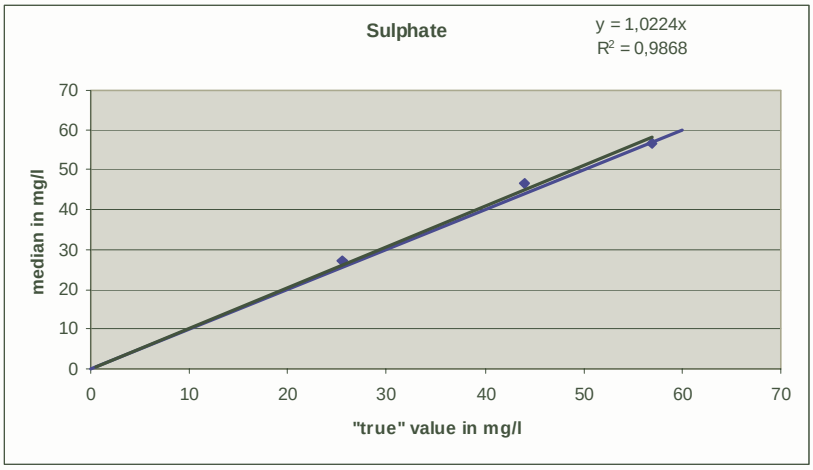
- Values < ref.-value/8 and > ref.-value*8 have been excluded before applying statistical procedures

Sulphate
median and ref.-value from weighings



Uncertainty of the assigned value is calculated according to ISO 13528: $U_{c_{ref}} = 2 \cdot u_{c_{ref}} = 2 \cdot 1{,}25 \cdot \frac{s_R}{\sqrt{n}}$

Sulphate
median vs. ref.-value



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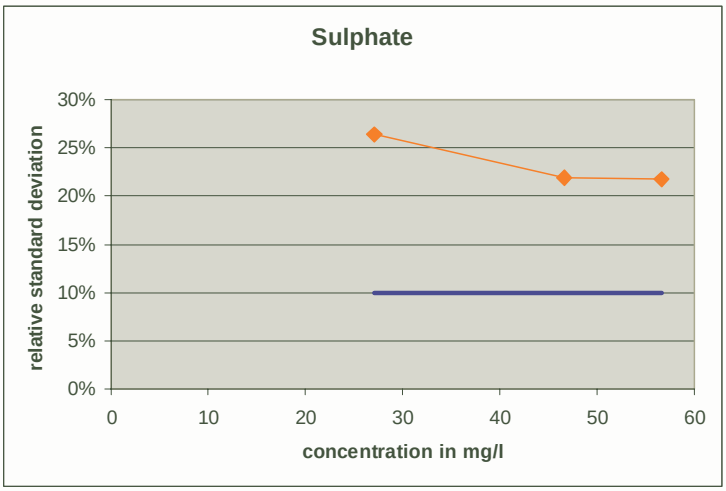
Sulphate
calculated standard deviation and limit



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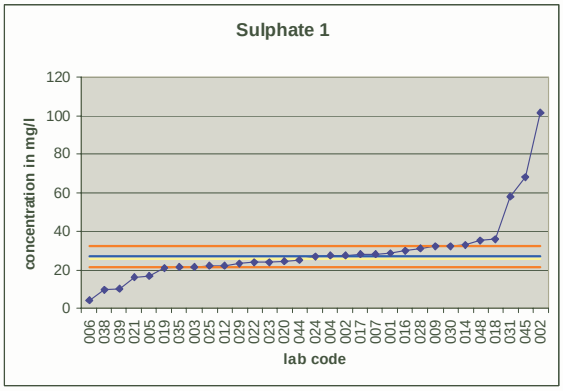
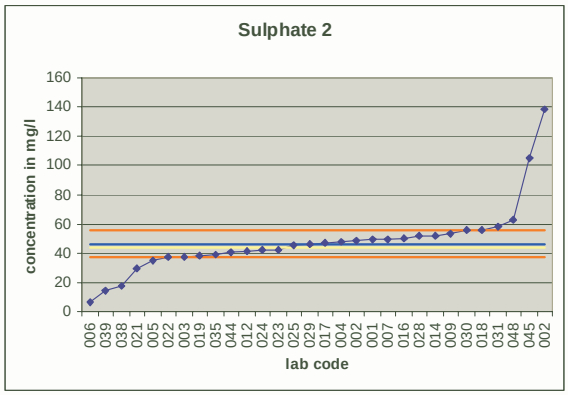
Sulphate 1



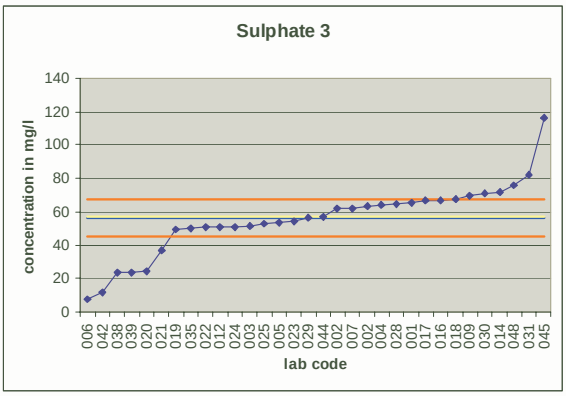
- values: 32
- removed: 1
- Median: 27 mg/l
- Weighing: 25,5 mg/l
- Deviation: +5,9 %
- Standard deviation: 7,15 mg/l; 26,5 %
- limit for St.-dev.: 10%
- Upper limit: 32,4 mg/l
- Lower limit: 21,6 mg/l
- too high: 6 values
- too low: 7 values
- outside tolerance limits: 43,8 %

Sulphate 2



- values: 32
- removed: 2
- Median: 46,55 mg/l
- Weighing: 44 mg/l
- Deviation: +5,8 %
- Standard deviation: 10,2 mg/l; 21,9 %
- limit for St.-dev.: 10%
- Upper limit: 55,86 mg/l
- Lower limit: 37,24 mg/l
- too high: 4 values
- too low: 5 values
- outside tolerance limits: 34,4 %

Sulphate 3



- values: 32
- removed: 0
- Median: 56,55 mg/l
- Weighing: 56,9 mg/l
- Deviation: -0,6 %
- Standard deviation: 12,3 mg/l; 21,7 %
- limit for St.-dev.: 10%
- Upper limit: 67,86 mg/l
- Lower limit: 45,24 mg/l
- too high: 6 values
- too low: 6 values
- outside tolerance limits: 37,5 %

Different kind of errors

- Constant systematic errors, due to
  - increased blank values
  - incomplete recovery
- Proportional systematic errors, due to
  - wrong calibration
  - dilution errors
  - wrong calculation / wrong unit
- Gross and indefinable errors, due to
  - anything

How to identify the kind of error?

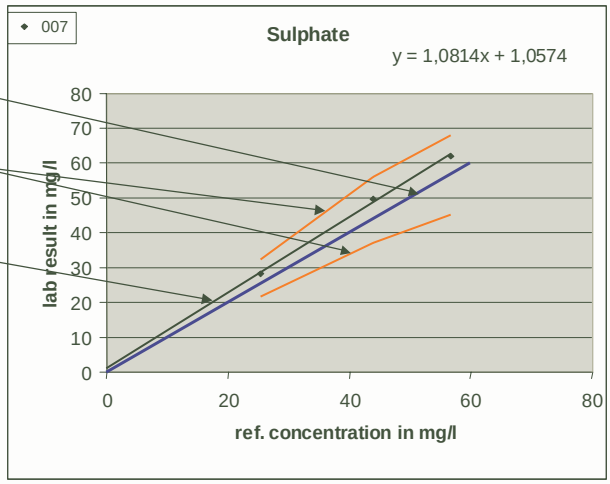
- Graphical display of analytical result vs. assigned value

100 % recovery

tolerance limits

linear regression line

good analysis!
No serious error



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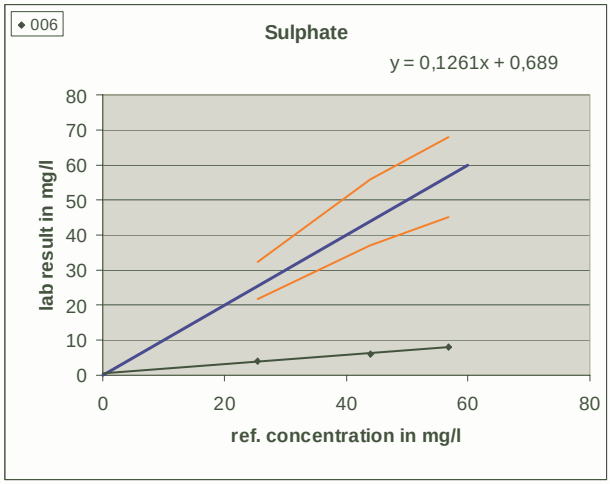
proportional systematic error! Dilution error, calibration error or gross calibration error



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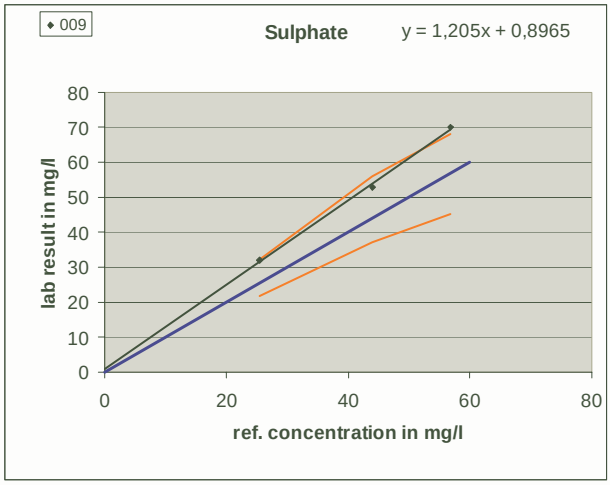
proportional systematic error! calibration error, leading to results just at the limit



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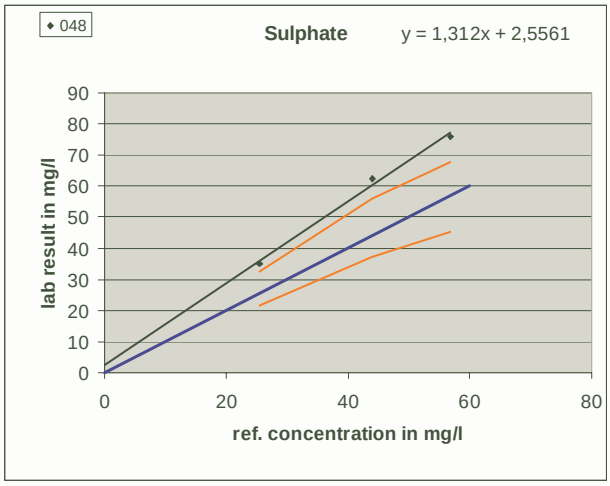
proportional systematic error! calibration error, leading to results beyond the limit



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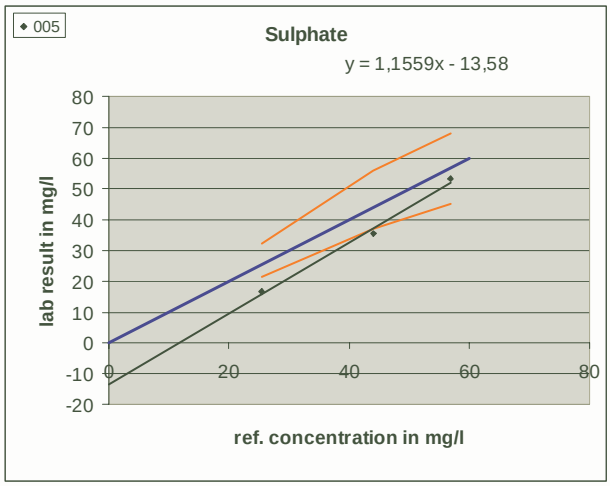
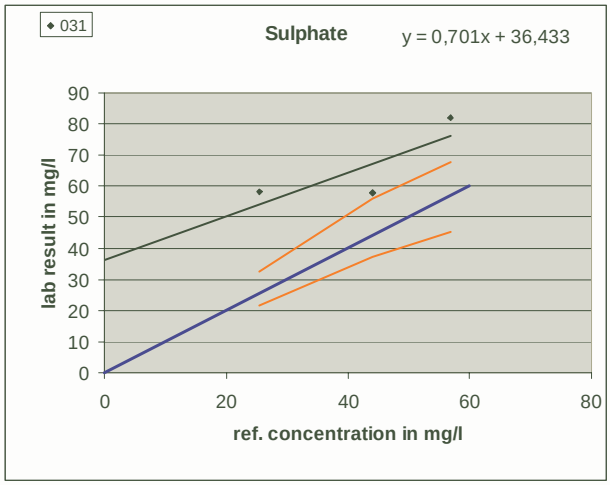
constant systematic error? recovery too low?



indefinable, gross error



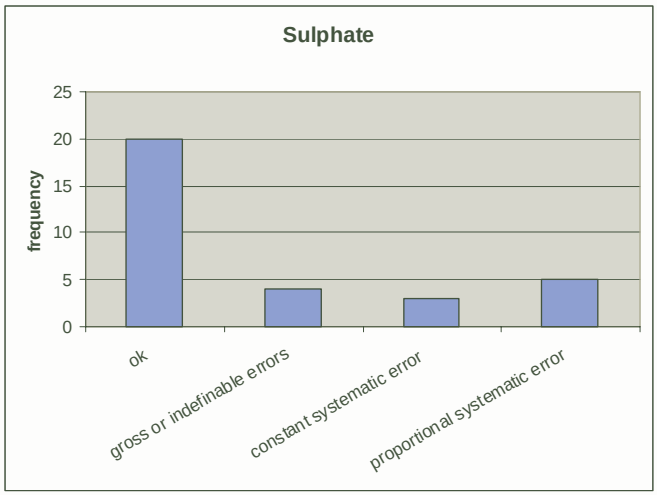
You want to look on your results?

- Excel-File will be available on the SADCMET-homepage after the workshop

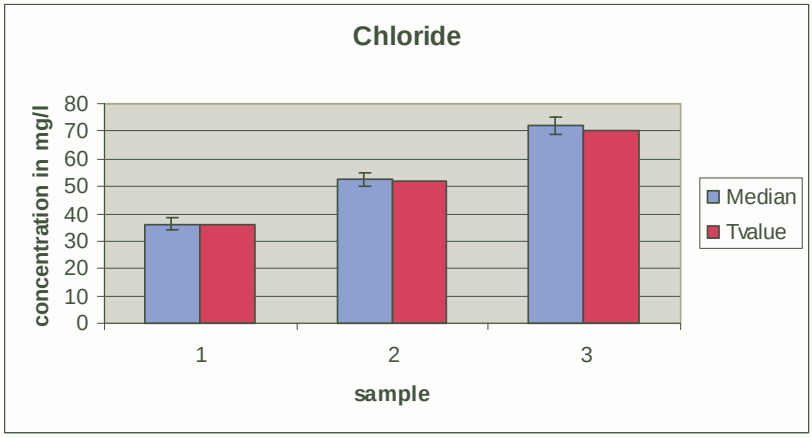
Classification of results

- On the basis of these graphs classification as
  - ok
  - gross or indefinable error
  - constant systematic error
  - proportional systematic error

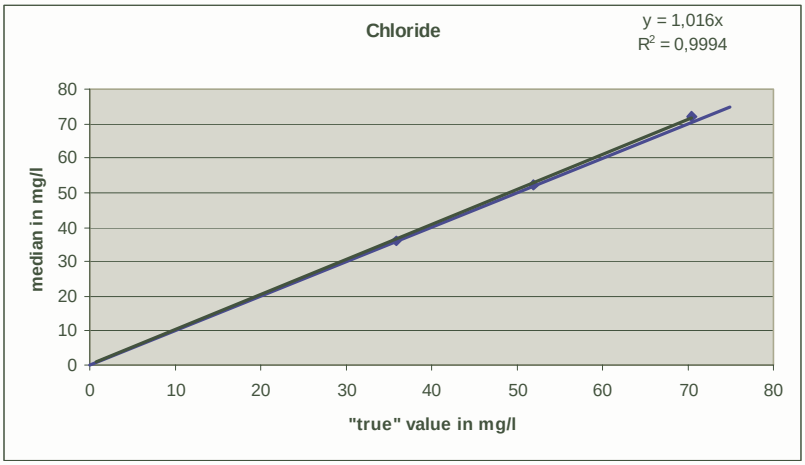
Sulphate
Classification of results



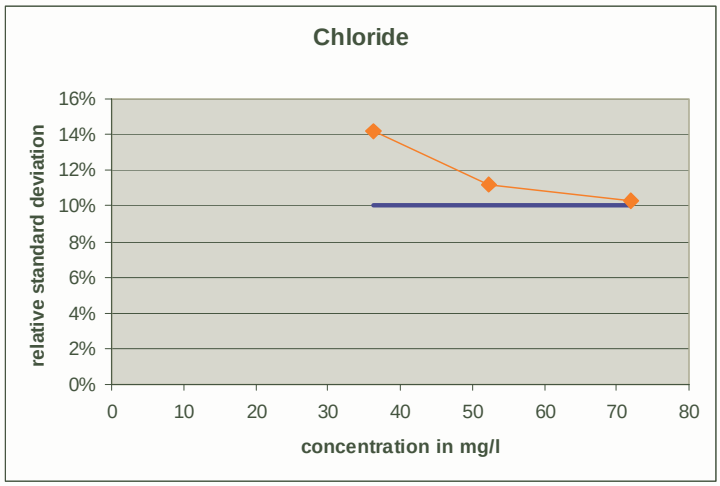
Chloride
median and ref.-value from weighing



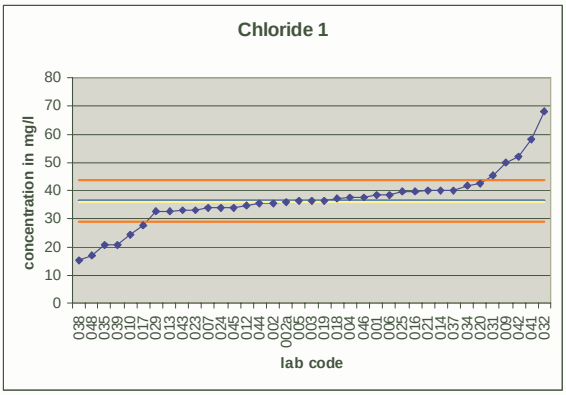
Chloride
median vs. ref.-value



Chloride
calculated standard deviation and limit



Chloride 1



- values: 39
- removed: 2
- Median: 36,3 mg/l
- Weighing: 35,8 mg/l
- Deviation: +1,4 %
- Standard deviation: 5,2 mg/l; 14,2 %
- limit for St.-dev.: 10 %
- Upper limit: 43,56 mg/l
- Lower limit: 29,04 mg/l
- too high: 5 values
- too low: 6 values
- outside tolerance limits: 33,3 %

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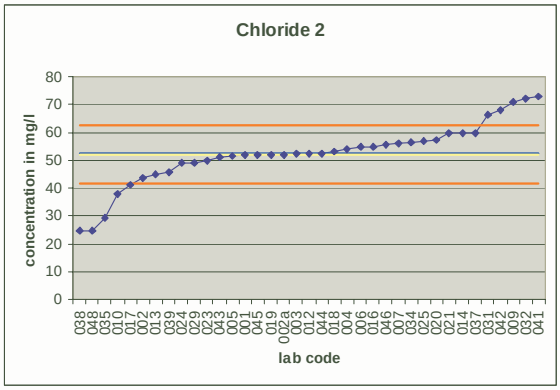
Chloride 2



- values: 39
- removed: 2
- Median: 52,3 mg/l
- Weighing: 51,9 mg/l
- Deviation: +0,8 %
- Standard deviation: 5,9 mg/l; 11,2 %
- limit for St.-dev.: 10 %
- Upper limit: 62,72 mg/l
- Lower limit: 41,81 mg/l
- too high: 5 values
- too low: 5 values
- outside tolerance limits: 30,8 %

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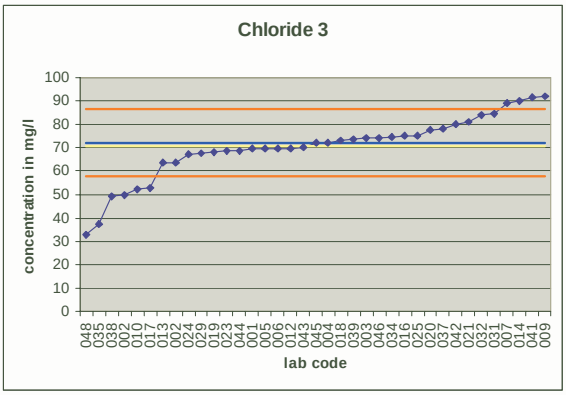
Chloride 3



- values: 39
- removed: 2
- Median: 72,0 mg/l
- Weighing: 70,5 mg/l
- Deviation: +2,1 %
- Standard deviation: 7,4 mg/l; 10,3 %
- limit for St.-dev.: 10 %
- Upper limit: 86,4 mg/l
- Lower limit: 57,6 mg/l
- too high: 4 values
- too low: 4 values
- outside tolerance limits: 25,6 %

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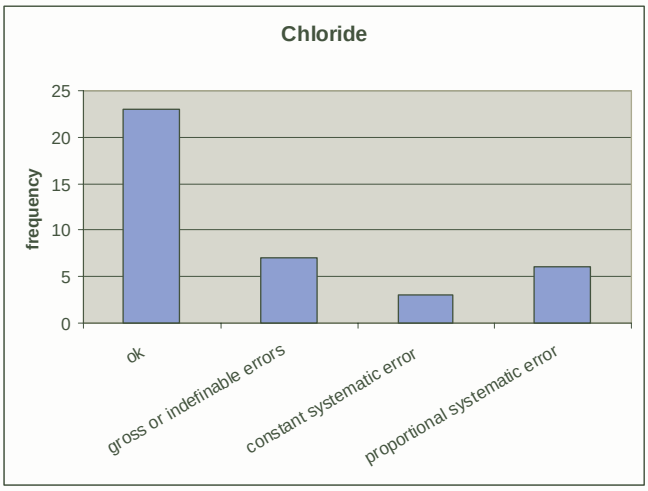
Chloride
Classification of results



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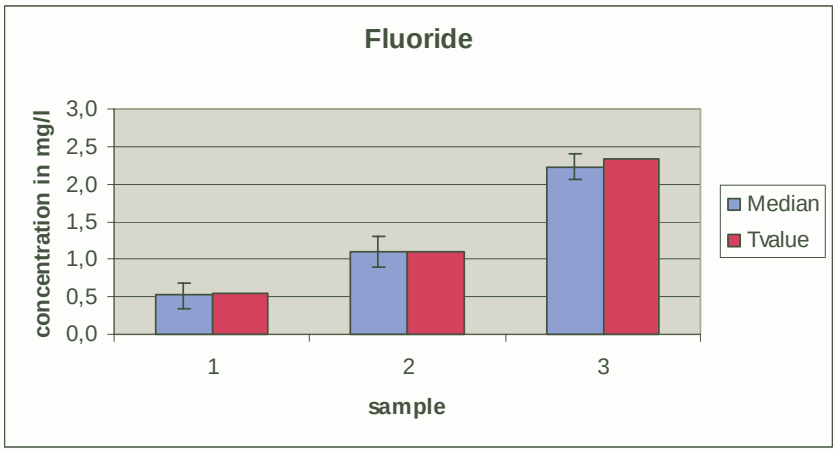
Fluoride
median and ref.-value from weighing



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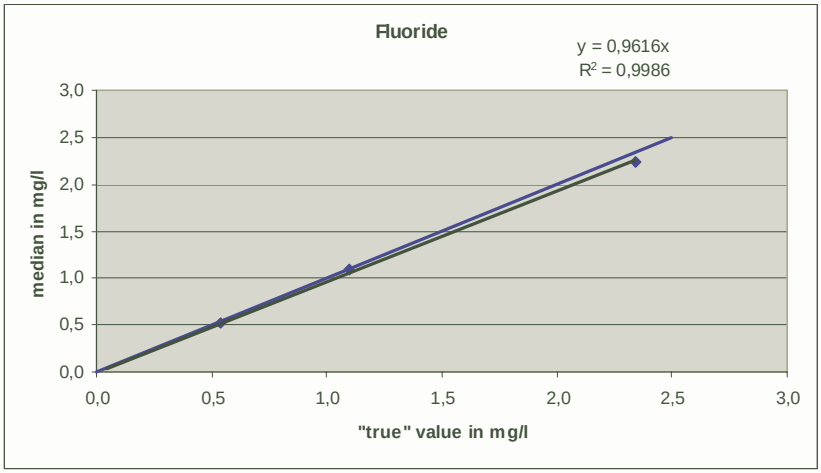
Fluoride
median vs. ref.-value



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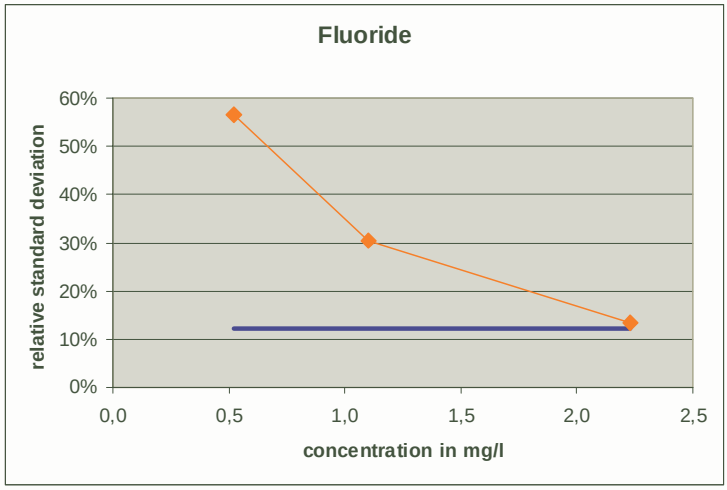
Fluoride
calculated standard deviation and limit



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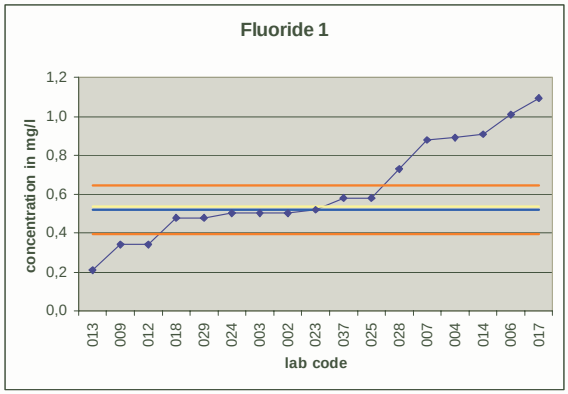
Fluoride 1



- values: 19
- removed: 2
- Median: 0,52 mg/l
- Weighing: 0,54 mg/l
- Deviation: -3,7 %
- Standard deviation: 0,29 mg/l; 56,5 %
- limit for St.-dev.: 12 %
- Upper limit: 0,645 mg/l
- Lower limit: 0,395 mg/l
- too high: 6 values
- too low: 3 values
- outside tolerance limits: 57,9 %

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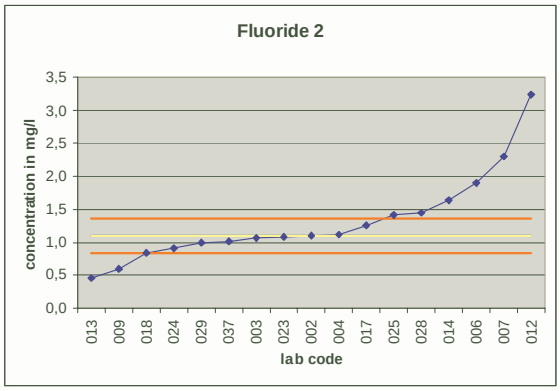
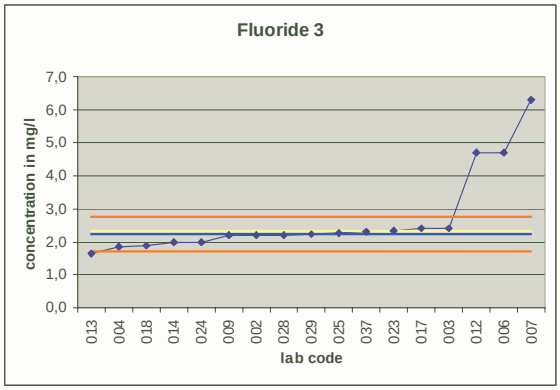
Fluoride 2



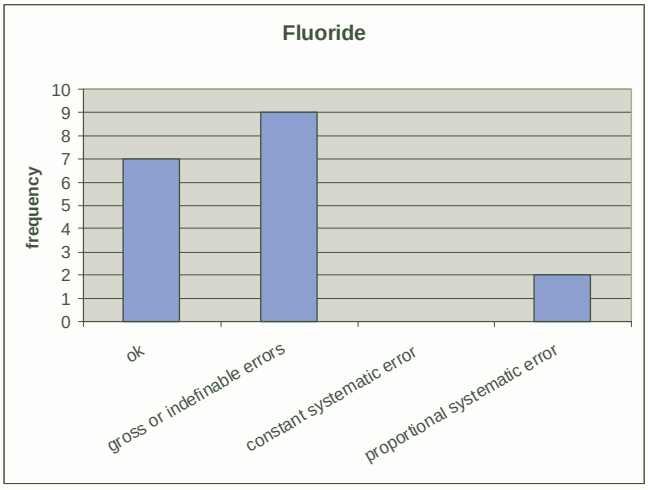
- values: 19
- removed: 2
- Median: 1,1 mg/l
- Weighing: 1,1 mg/l
- Deviation: 0 %
- Standard deviation: 0,33 mg/l; 30,3 %
- limit for St.-dev.: 12 %
- Upper limit: 1,364 mg/l
- Lower limit: 0,836 mg/l
- too high: 6 values
- too low: 3 values
- outside tolerance limits: 57,9 %

Fluoride 3

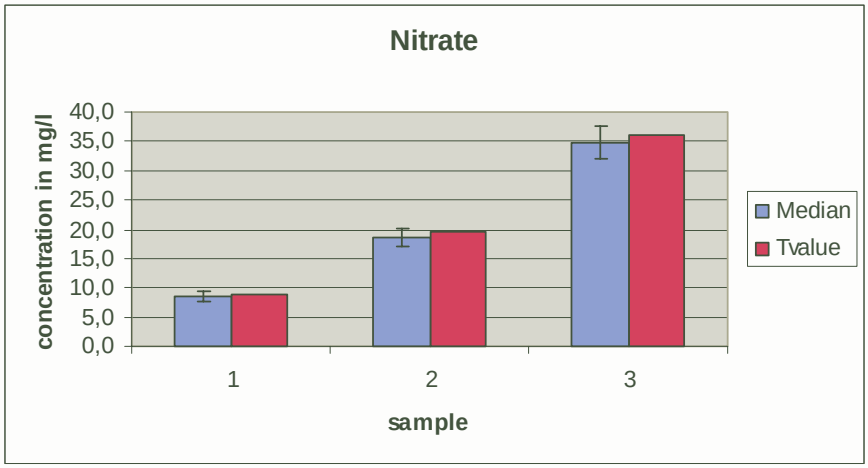


- values: 19
- removed: 2
- Median: 2,23 mg/l
- Weighing: 2,34 mg/l
- Deviation: -4,7 %
- Standard deviation: 0,3 mg/l; 13,3 %
- limit for St.-dev.: 12 %
- Upper limit: 2,765 mg/l
- Lower limit: 1,695 mg/l
- too high: 3 values
- too low: 1 values
- outside tolerance limits: 31,6 %

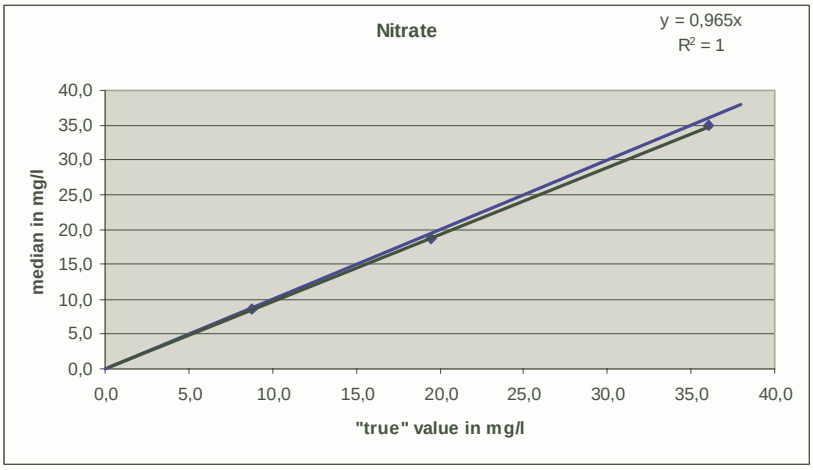
Fluoride
Classification of results



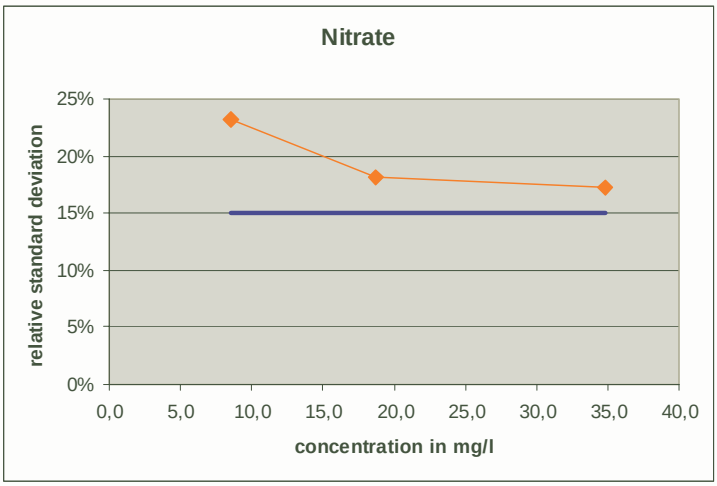
Nitrate
median and ref.-value from weighing



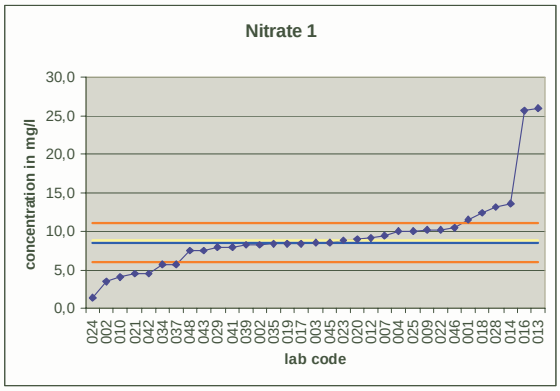
Nitrate
median vs. ref.-value



Nitrate
calculated standard deviation and limit

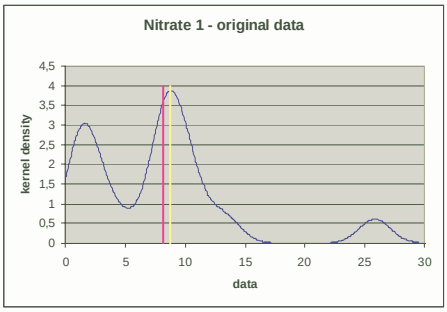


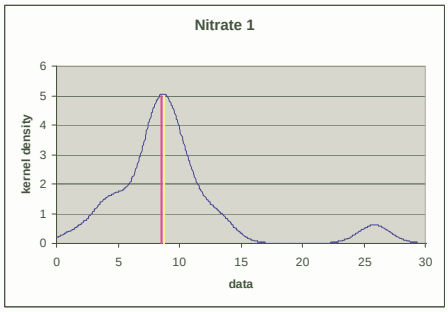
Nitrate 1



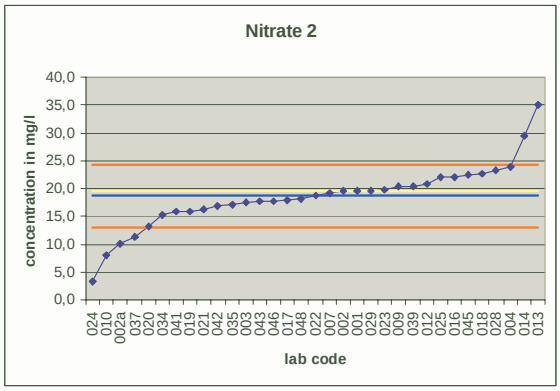
- values: 33
- removed: 0
- corrected N → NO_3^-: 9
- Median: 8,51 mg/l
- Weighing: 8,81 mg/l
- Deviation: -3,4 %
- Standard deviation: 1,97 mg/l; 23,1 %
- limit for St.-dev.: 15 %
- Upper limit: 11,06 mg/l
- Lower limit: 5,96 mg/l
- too high: 6 values
- too low: 7 values
- outside tolerance limits: 42,4 %

Nitrate 1



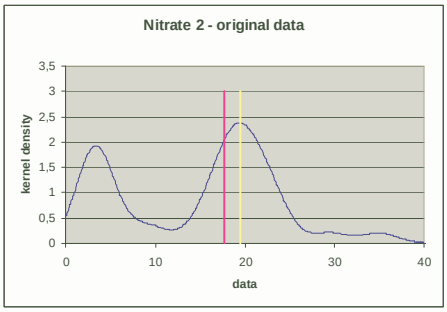


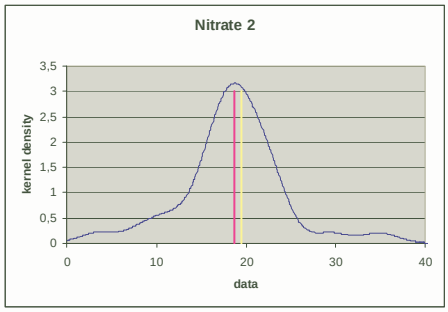
Nitrate 2



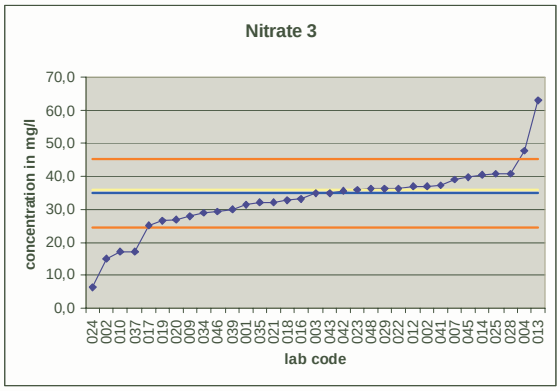
- values: 33
- removed: 0
- corrected N → NO_3^-: 9
- Median: 18,7 mg/l
- Weighing: 19,5 mg/l
- Deviation: -4,1 %
- Standard deviation: 3,4 mg/l; 18,2 %
- limit for St.-dev.: 15 %
- Upper limit: 24,31 mg/l
- Lower limit: 13,09 mg/l
- too high: 2 values
- too low: 4 values
- outside tolerance limits: 18,2 %

Nitrate 2



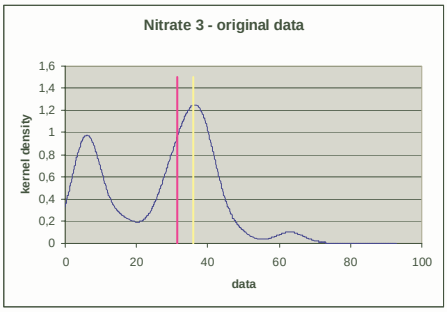


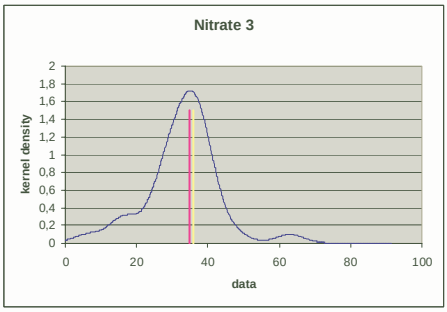
Nitrate 3



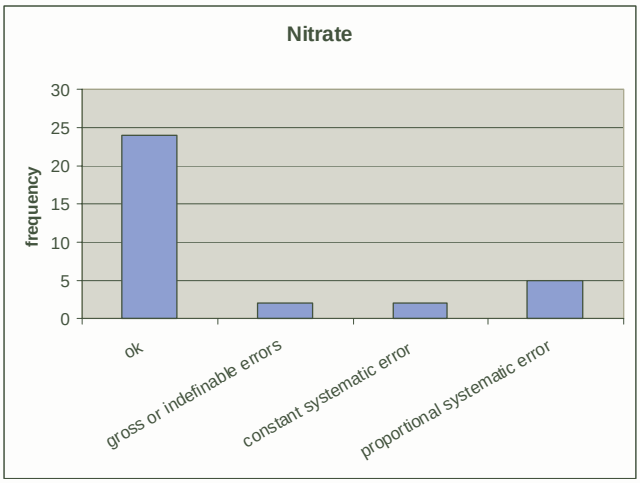
- values: 33
- removed: 0
- corrected N → NO_3^-: 9
- Median: 34,8 mg/l
- Weighing: 36 mg/l
- Deviation: -3,3 %
- Standard deviation: 6,0 mg/l; 17,3 %
- limit for St.-dev.: 10 %
- Upper limit: 45,24 mg/l
- Lower limit: 24,36 mg/l
- too high: 2 values
- too low: 4 values
- outside tolerance limits: 18,2 %

Nitrate 3

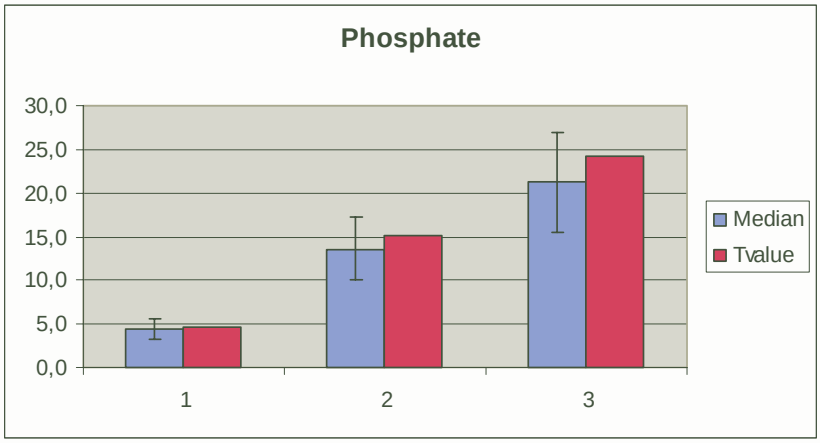




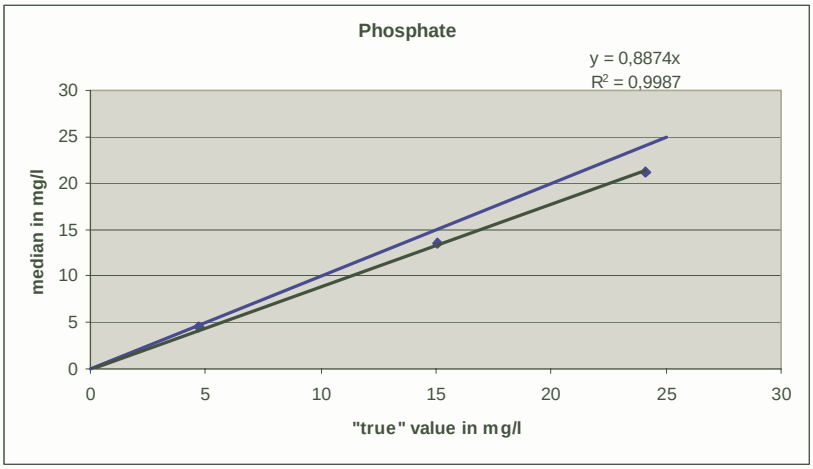
Nitrate
Classification of results



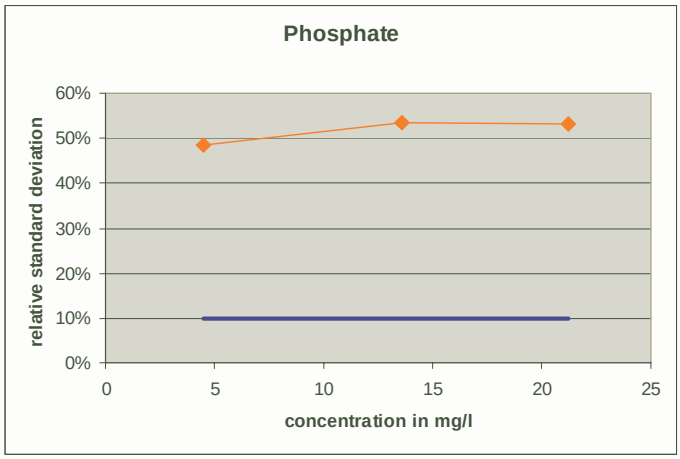
Phosphate
median and ref.-value from weighing



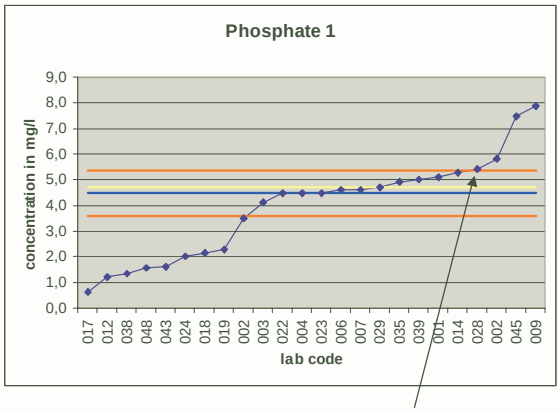
Phosphate
median vs. ref.-value



Phosphate
calculated standard deviation and limit

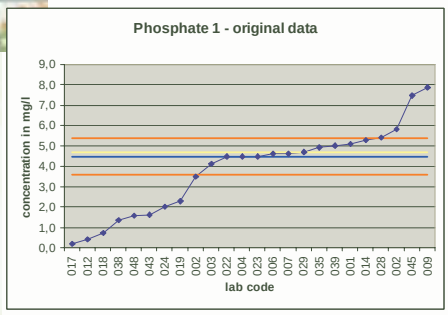


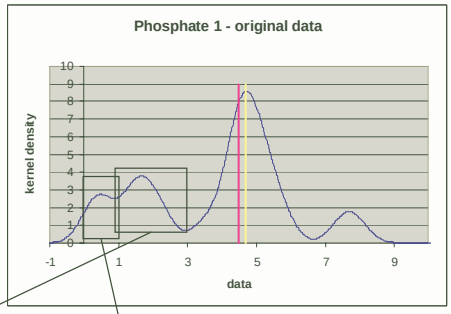
Phosphate 1

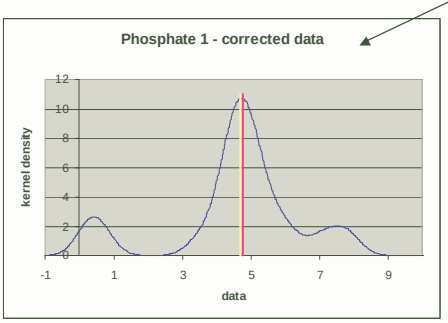


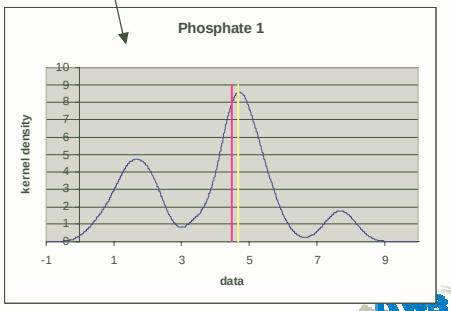
Assessment would be changed, if reference value would be used

- values: 26
- removed: 2
- corrected P → PO_4^{3-}: 3
- Median: 4,48 mg/l
- Weighing: 4,68 mg/l
- Deviation: -4,3 %
- Standard deviation: 2,17 mg/l; 48,4 %
- limit for St.-dev.: 10 %
- Upper limit: 5,37 mg/l
- Lower limit: 3,58 mg/l
- too high: 4 (3) values
- too low: 9 values
- outside tolerance limits: 57,7 (53,8) %

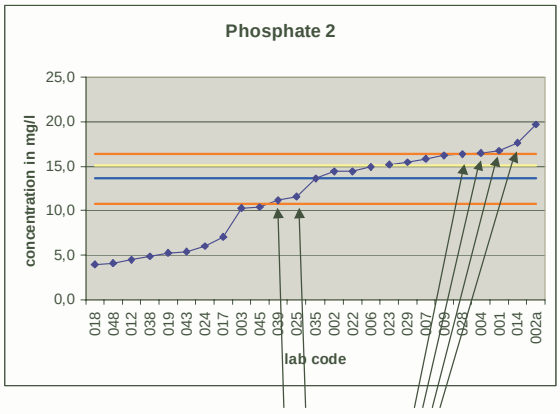






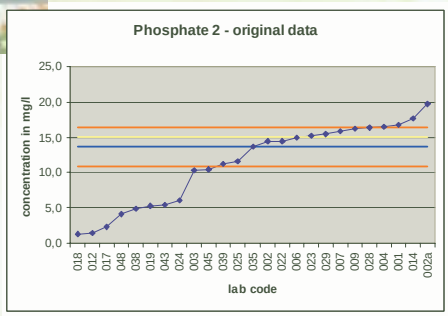


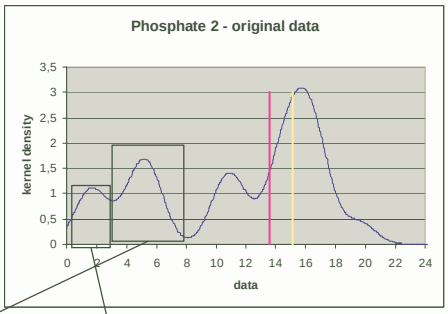
Phosphate 2

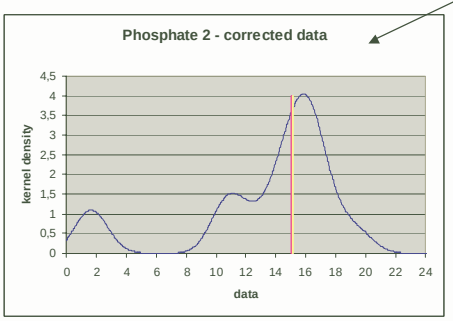


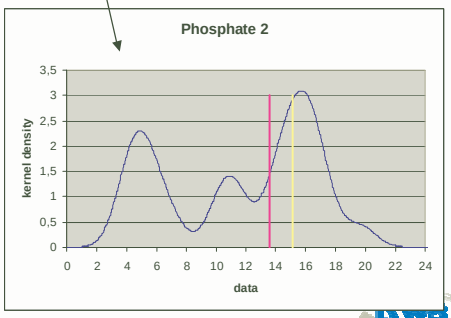
Assessment would be changed, if reference value would be used

- values: 26
- removed: 1
- corrected P → PO_4^{3-}: 3
- Median: 13,6 mg/l
- Weighing: 15,1 mg/l
- Deviation: -9,9 %
- Standard deviation: 7,26 mg/l; 53,4 %
- limit for St.-dev.: 10 %
- Upper limit: 16,32 mg/l
- Lower limit: 10,88 mg/l
- too high: 5 (1) values
- too low: 10 (12) values
- outside tolerance limits: 61,5 (53,8) %

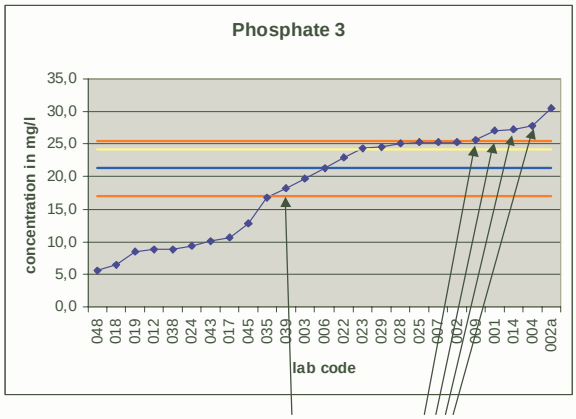






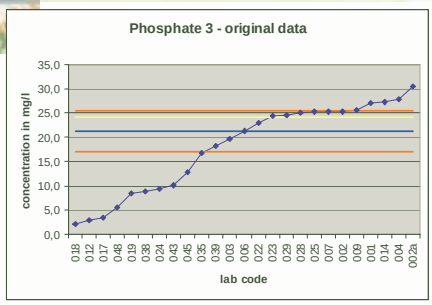


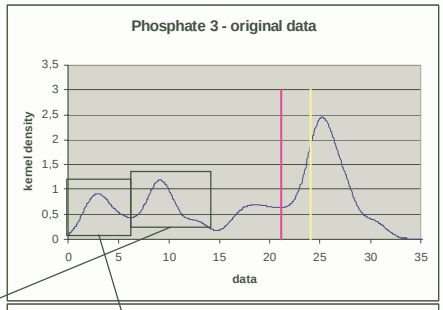
Phosphate 3

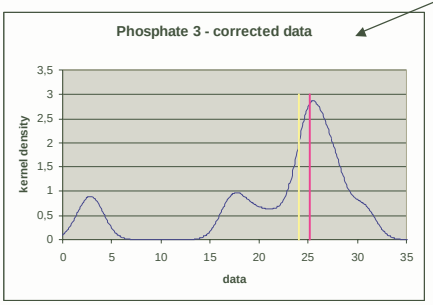


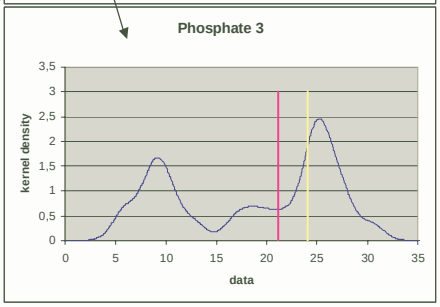
Assessment would be changed, if reference value would be used

- values: 26
- removed: 1
- corrected P → PO_4^{3-}: 3
- Median: 21,2 mg/l
- Weighing: 24,1 mg/l
- Deviation: -12,0 %
- Standard deviation: 11,25 mg/l; 53,1 %
- limit for St.-dev.: 10 %
- Upper limit: 25,44 mg/l
- Lower limit: 16,96 mg/l
- too high: 5 (1) values
- too low: 10 (11) values
- outside tolerance limits: 61,5 (50) %

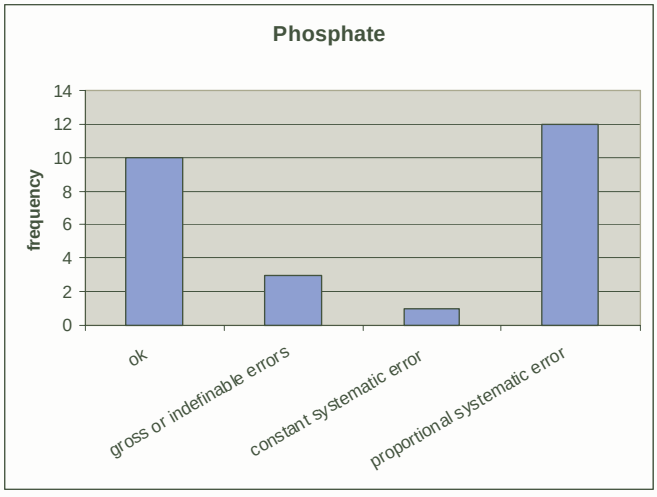








Phosphate
Classification of results



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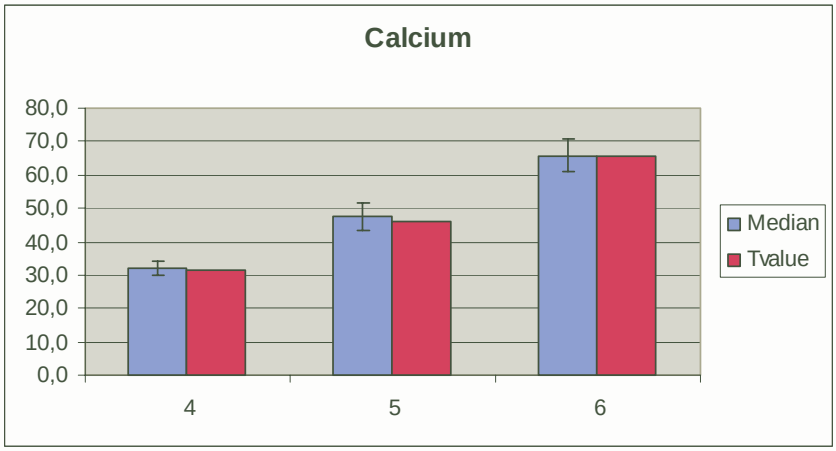
Calcium
median and ref.-value from weighing



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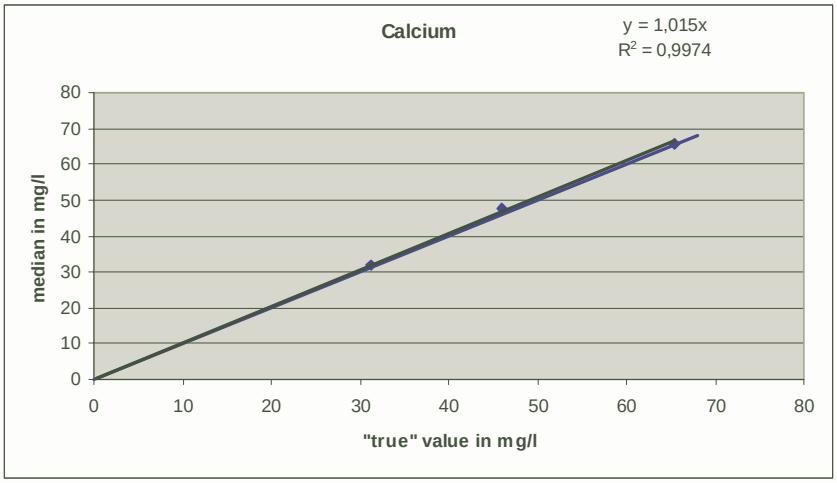
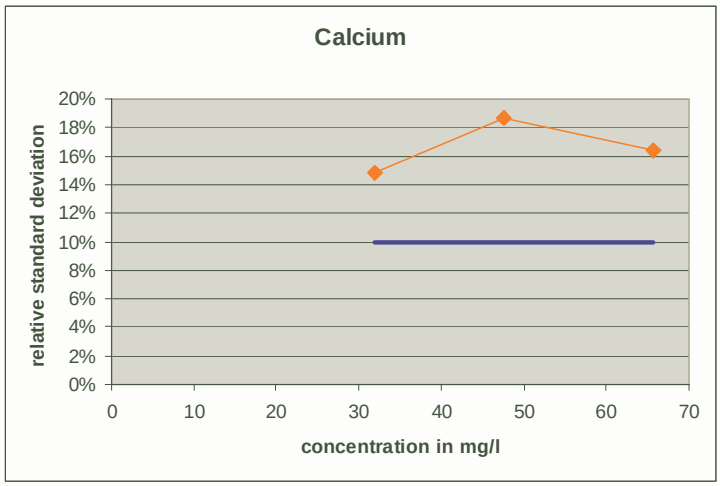
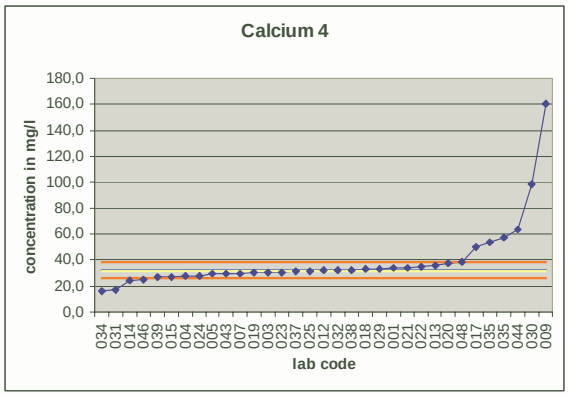
Calcium
median vs. ref.-value



Calcium
calculated standard deviation and limit



Calcium 4



- values: 36
- removed: 3
- Median: 32,0 mg/l
- Weighing: 31,3 mg/l
- Deviation: 3,2 %
- Standard deviation: 4,74 mg/l; 14,8 %
- limit for St.-dev.: 10 %
- Upper limit: 38,4 mg/l
- Lower limit: 25,6 mg/l
- too high: 6 values
- too low: 4 values
- outside tolerance limits: 25,6 %

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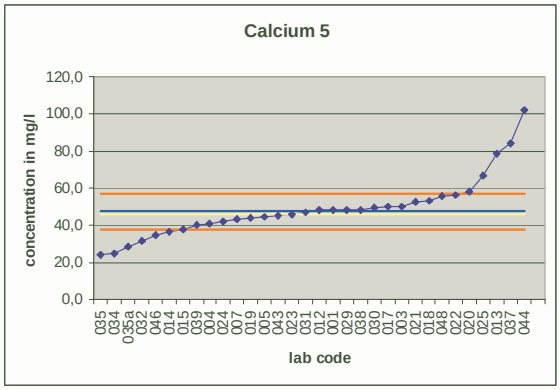
Calcium 5



- values: 36
- removed: 4
- Median: 47,5 mg/l
- Weighing: 45,9 mg/l
- Deviation: + 3,5 %
- Standard deviation: 8,87 mg/l; 18,7 %
- limit for St.-dev.: 10 %
- Upper limit: 57,0 mg/l
- Lower limit: 38,0 mg/l
- too high: 5 values
- too low: 7 values
- outside tolerance limits: 44,4 %

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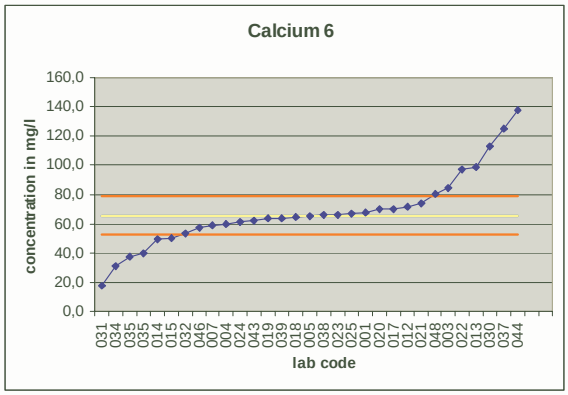
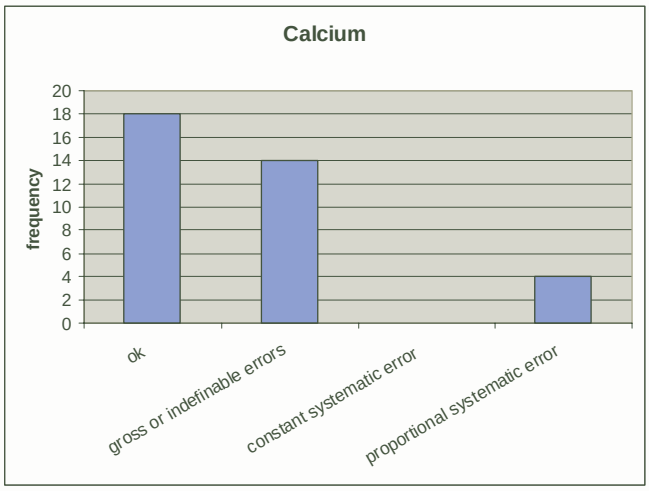
Calcium 6

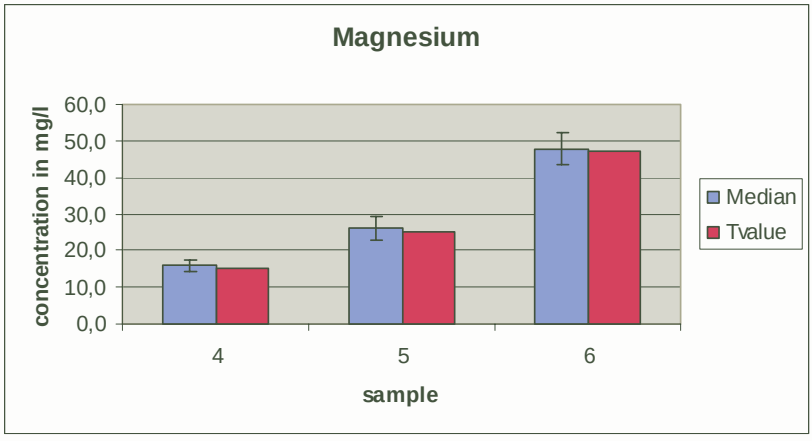


- values: 35
- removed: 4
- Median: 65,63 mg/l
- Weighing: 65,4 mg/l
- Deviation: +0,4 %
- Standard deviation: 10,76 mg/l; 16,4 %
- limit for St.-dev.: 10 %
- Upper limit: 78,76 mg/l
- Lower limit: 52,50 mg/l
- too high: 7 values
- too low: 6 values
- outside tolerance limits: 48,6 %

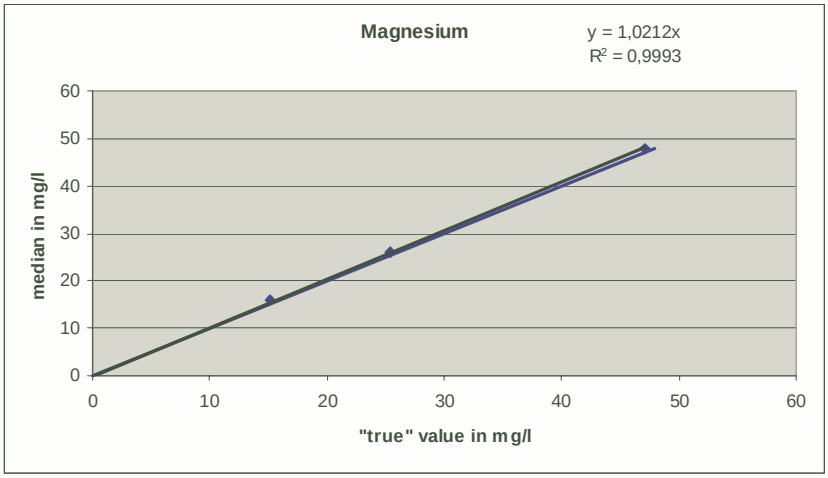
Calcium
Classification of results



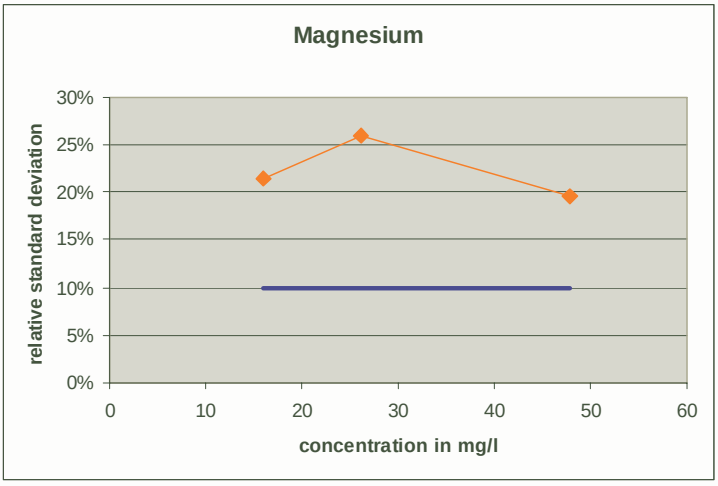
Magnesium
median and ref.-value from weighing



Magnesium
median vs. ref.-value



Magnesium
calculated standard deviation and limit



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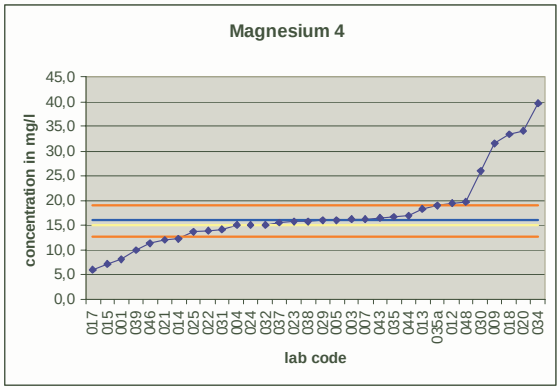
Magnesium 4



- values: 35
- removed: 3
- Median: 15,93 mg/l
- Weighing: 15,1 mg/l
- Deviation: +5,5 %
- Standard deviation: 3,43 mg/l; 21,5 %
- limit for St.-dev.: 10 %
- Upper limit: 19,12 mg/l
- Lower limit: 12,75 mg/l
- too high: 7 values
- too low: 7 values
- outside tolerance limits: 48,6 %

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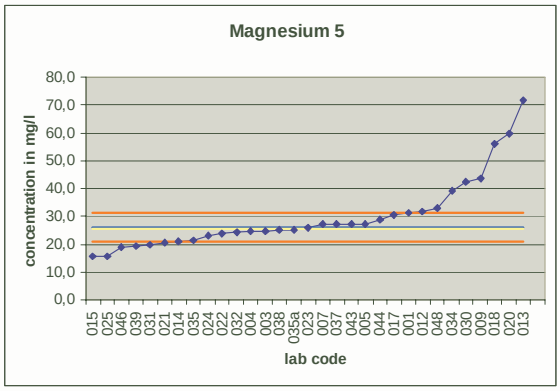
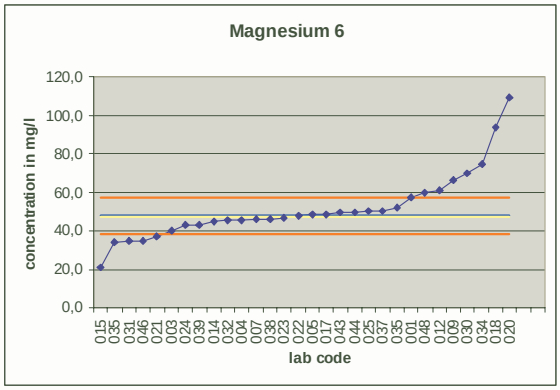
Magnesium 5



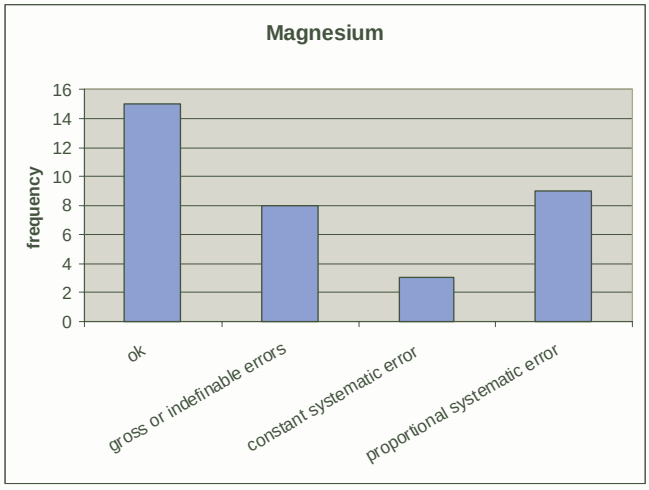
- values: 34
- removed: 3
- Median: 26,14 mg/l
- Weighing: 25,4 mg/l
- Deviation: +2,9 %
- Standard deviation: 6,79 mg/l; 26,0 %
- limit for St.-dev.: 10 %
- Upper limit: 31,37 mg/l
- Lower limit: 20,32 mg/l
- too high: 8 values
- too low: 6 values
- outside tolerance limits: 50,0 %

Magnesium 6

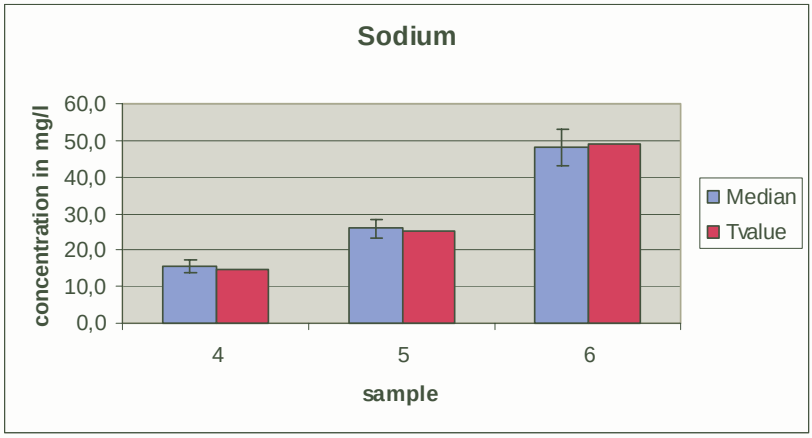


- values: 30
- removed: 3
- Median: 47,82 mg/l
- Weighing: 47,1 mg/l
- Deviation: +1,5 %
- Standard deviation: 9,35 mg/l; 19,5 %
- limit for St.-dev.: 10 %
- Upper limit: 57,39 mg/l
- Lower limit: 38,26 mg/l
- too high: 8 values
- too low: 5 values
- outside tolerance limits: 53,3 %

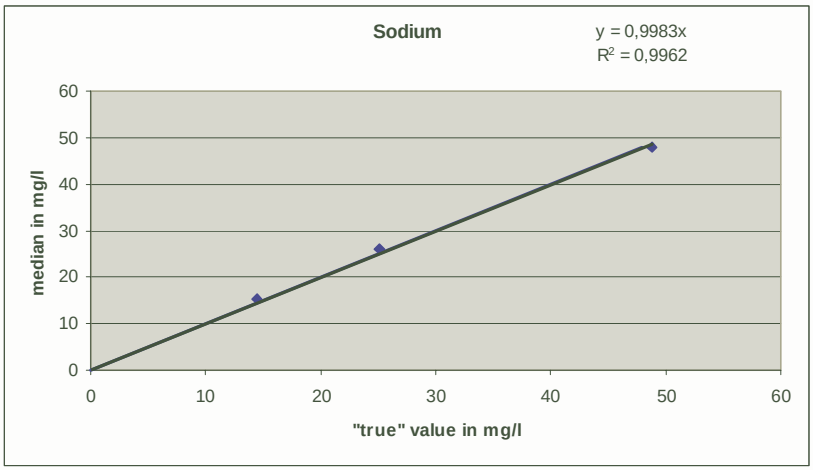
Magnesium
Classification of results



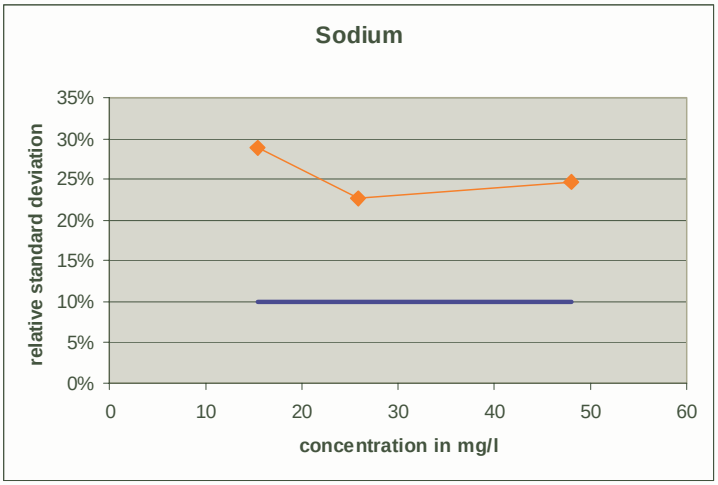
Sodium
median and ref.-value from weighing



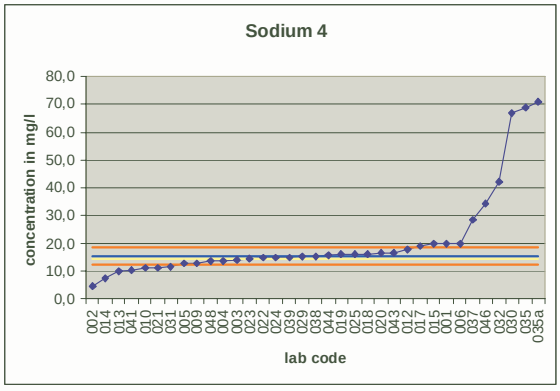
Sodium
median vs. ref.-value



Sodium
calculated standard deviation and limit

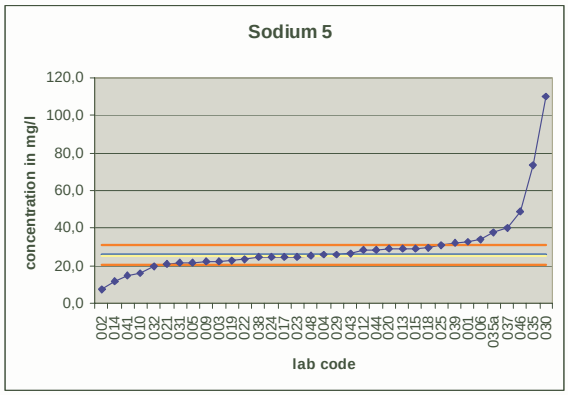


Sodium 4



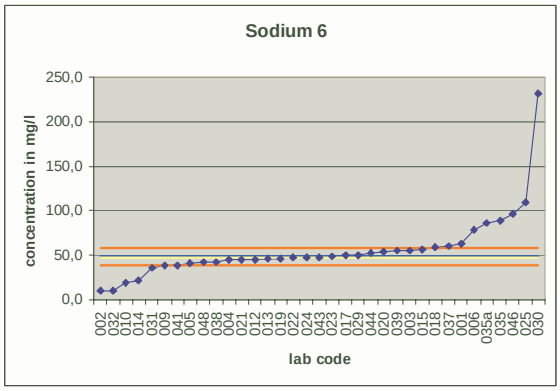
- values: 36
- removed: 1
- Median: 15,42 mg/l
- Weighing: 14,5 mg/l
- Deviation: +6,3 %
- Standard deviation: 4,46 mg/l; 28,9 %
- limit for St.-dev.: 10 %
- Upper limit: 18,51 mg/l
- Lower limit: 12,34 mg/l
- too high: 10 values
- too low: 7 values
- outside tolerance limits: 50 %

Sodium 5



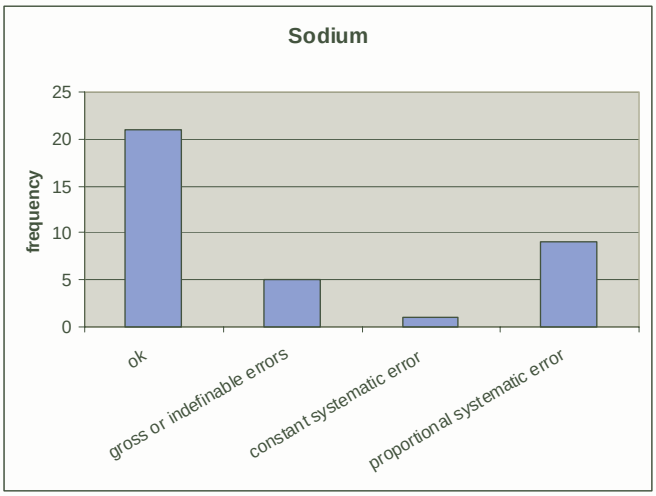
- values: 36
- removed: 1
- Median: 25,9 mg/l
- Weighing: 25,1 mg/l
- Deviation: +3,2 %
- Standard deviation: 5,86 mg/l; 22,6 %
- limit for St.-dev.: 10 %
- Upper limit: 31,08 mg/l
- Lower limit: 20,72 mg/l
- too high: 8 values
- too low: 5 values
- outside tolerance limits: 38,9 %

Sodium 6

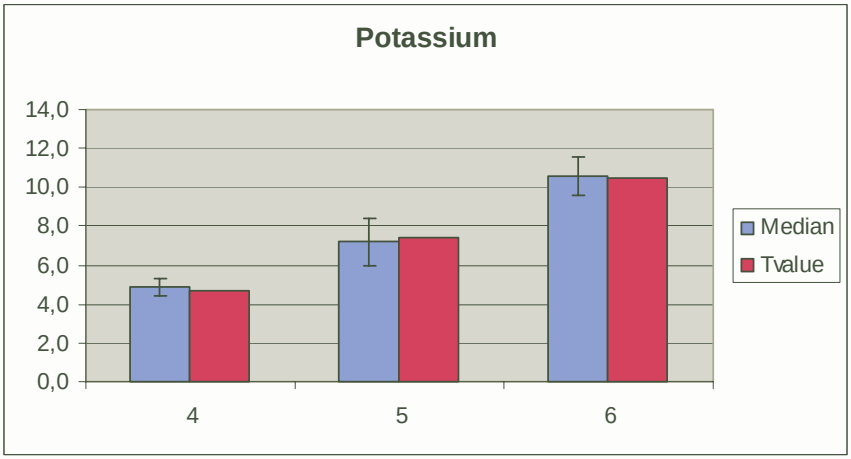


- values: 36
- removed: 1
- Median: 48,8 mg/l
- Weighing: 48 mg/l
- Deviation: -1,64 %
- Standard deviation: 11,83 mg/l; 24,6 %
- limit for St.-dev.: 10 %
- Upper limit: 57,6 mg/l
- Lower limit: 38,4 mg/l
- too high: 9 values
- too low: 5 values
- outside tolerance limits: 41,7 %

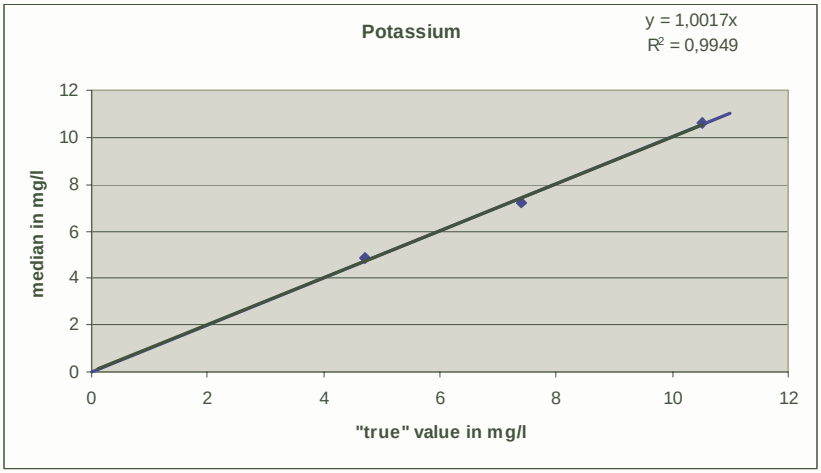
Sodium
Classification of results



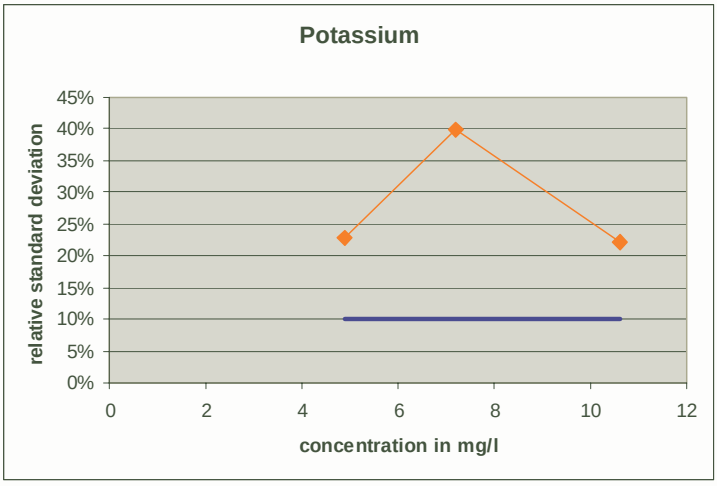
Potassium
median and ref.-value from weighing



Potassium
median vs. ref.-value



Potassium
calculated standard deviation and limit



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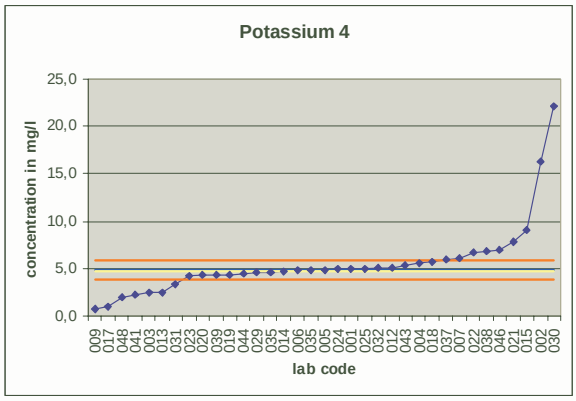
Potassium 4



- values: 36
- removed: 1
- Median: 4,88 mg/l
- Weighing: 4,71 mg/l
- Deviation: +3,69 %
- Standard deviation: 1,12 mg/l; 22,8 %
- limit for St.-dev.: 10 %
- Upper limit: 5,86 mg/l
- Lower limit: 3,91 mg/l
- too high: 9 values
- too low: 7 values
- outside tolerance limits: 47,2 %

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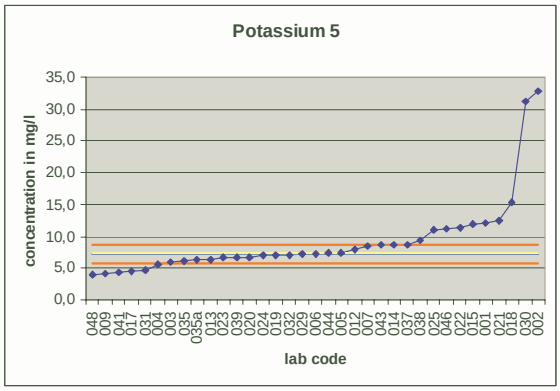
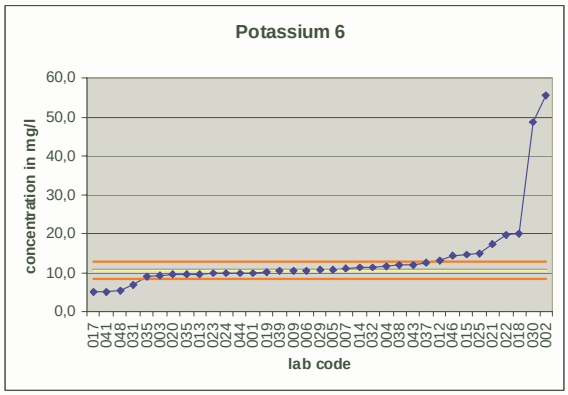
Potassium 5



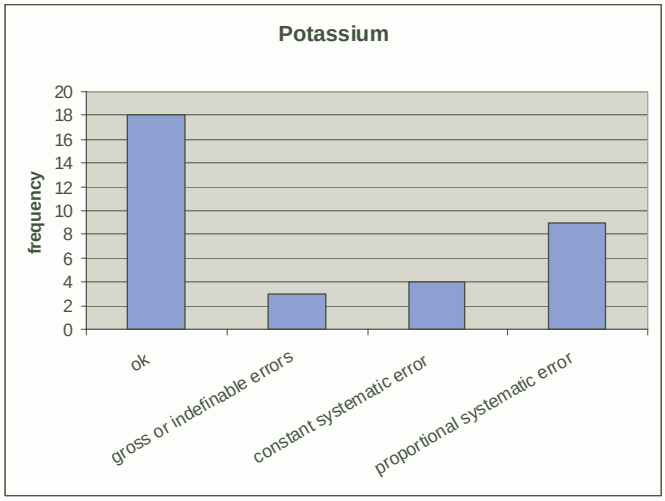
- values: 36
- removed: 1
- Median: 7,2 mg/l
- Weighing: 7,41 mg/l
- Deviation: -2,83 %
- Standard deviation: 2,87 mg/l; 39,9 %
- limit for St.-dev.: 10 %
- Upper limit: 8,64 mg/l
- Lower limit: 5,76 mg/l
- too high: 11 values
- too low: 6 values
- outside tolerance limits: 50,0 %

Potassium 6

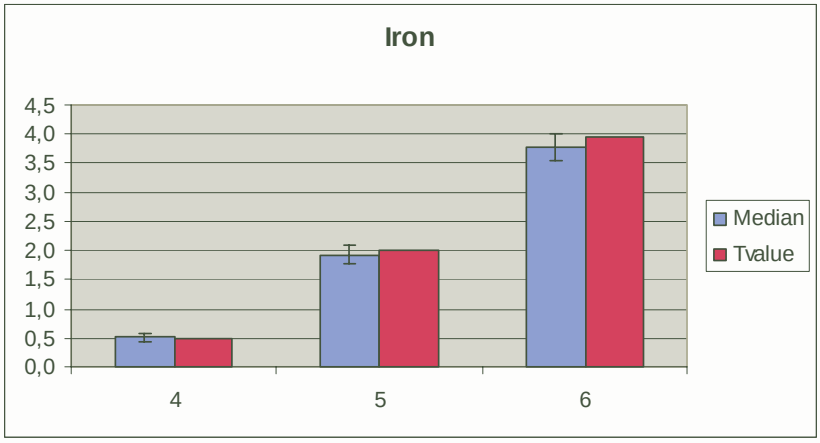


- values: 36
- removed: 1
- Median: 10,6 mg/l
- Weighing: 10,5 mg/l
- Deviation: +0,95 %
- Standard deviation: 2,35 mg/l; 22,2 %
- limit for St.-dev.: 10 %
- Upper limit: 12,72 mg/l
- Lower limit: 8,4 mg/l
- too high: 9 values
- too low: 4 values
- outside tolerance limits: 38,9 %

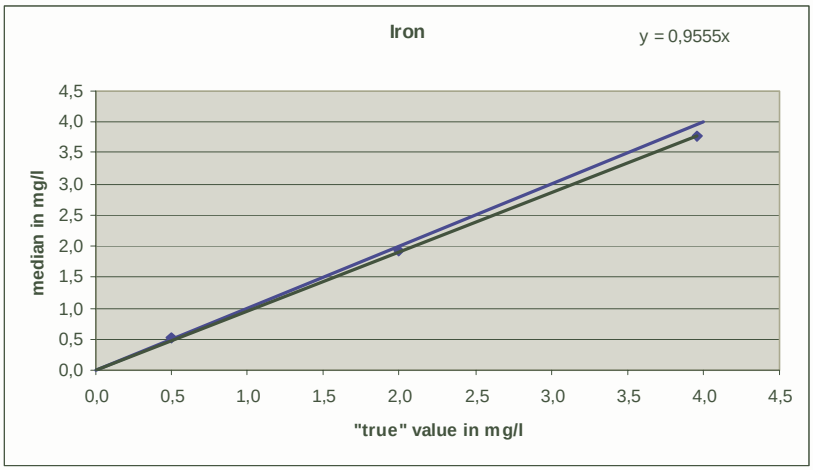
Potassium
Classification of results



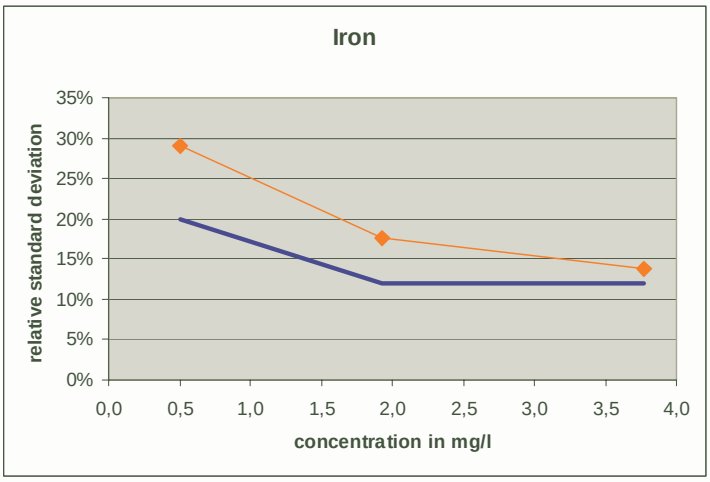
Iron
median and ref.-value from weighing



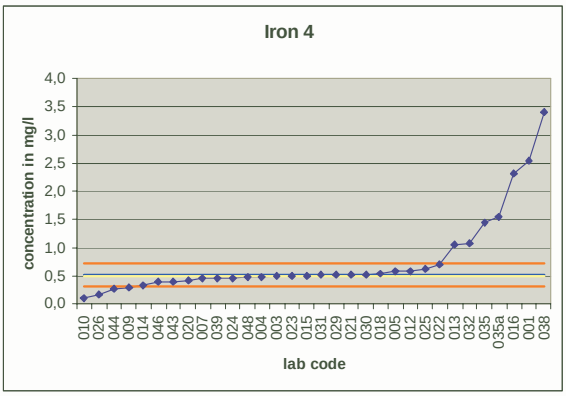
Iron
median vs. ref.-value



Iron
calculated standard deviation and limit



Iron 4



- values: 33
- removed: 1
- Median: 0,51 mg/l
- Weighing: 0,50 mg/l
- Deviation: +2,0 %
- Standard deviation: 0,15 mg/l; 29,0 %
- limit for St.-dev.: 20 %
- Upper limit: 0,714 mg/l
- Lower limit: 0,306 mg/l
- too high: 7 values
- too low: 4 values
- outside tolerance limits: 36,4 %

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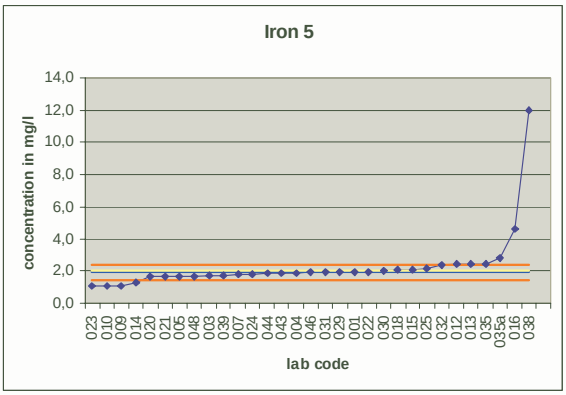
Iron 5



- values: 33
- removed: 2
- Median: 1,93 mg/l
- Weighing: 2,00 mg/l
- Deviation: -3,5 %
- Standard deviation: 0,34 mg/l; 17,7 %
- limit for St.-dev.: 12 %
- Upper limit: 2,39 mg/l
- Lower limit: 1,47 mg/l
- too high: 6 values
- too low: 4 values
- outside tolerance limits: 36,4 %

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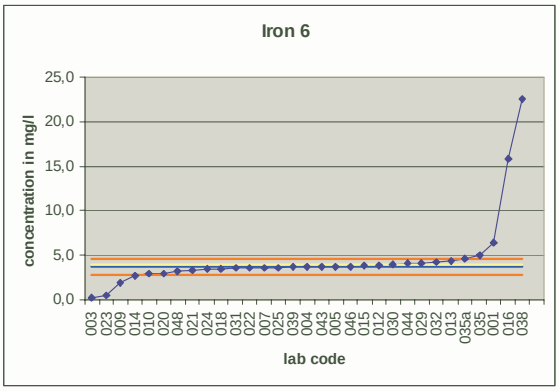
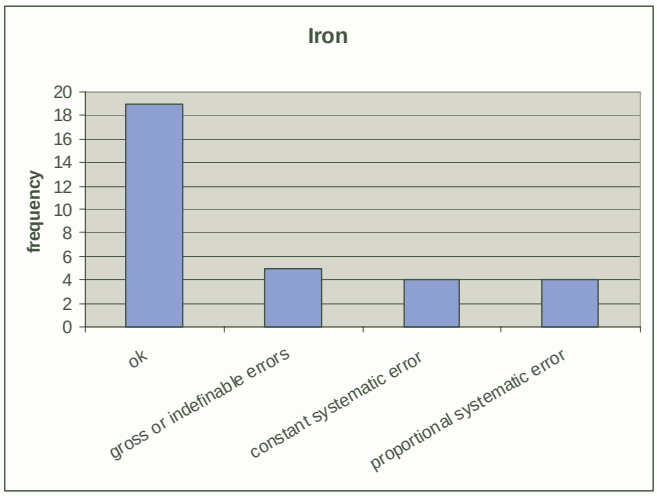
Iron 6

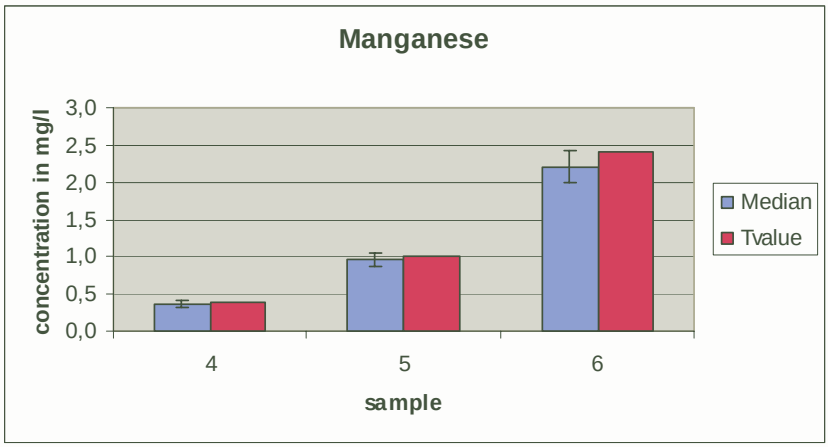


- values: 33
- removed: 2
- Median: 3,77 mg/l
- Weighing: 3,96 mg/l
- Deviation: -4,80 %
- Standard deviation: 0,52 mg/l; 13,9 %
- limit for St.-dev.: 12 %
- Upper limit: 4,67 mg/l
- Lower limit: 2,87 mg/l
- too high: 4 values
- too low: 4 values
- outside tolerance limits: 30,3 %

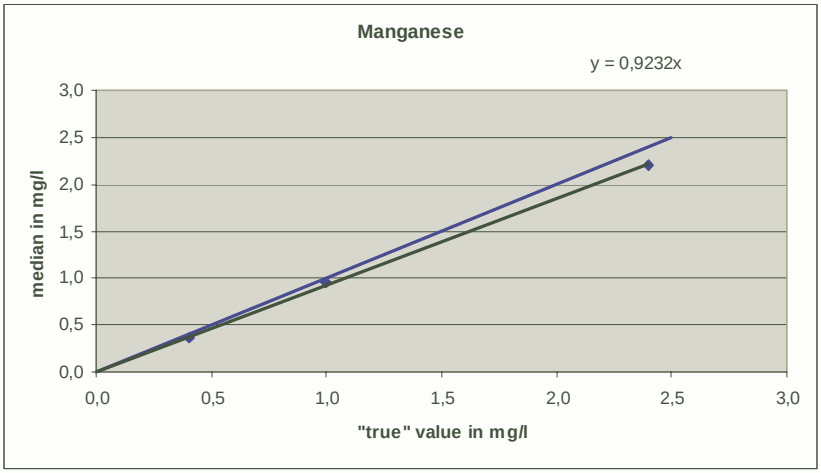
Iron
Classification of results



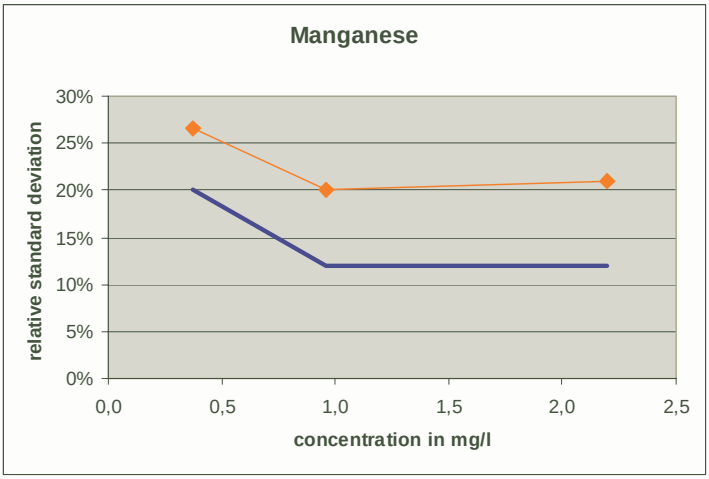
Manganese
median and ref.-value from weighing



Manganese
median vs. ref.-value



Manganese
calculated standard deviation and limit



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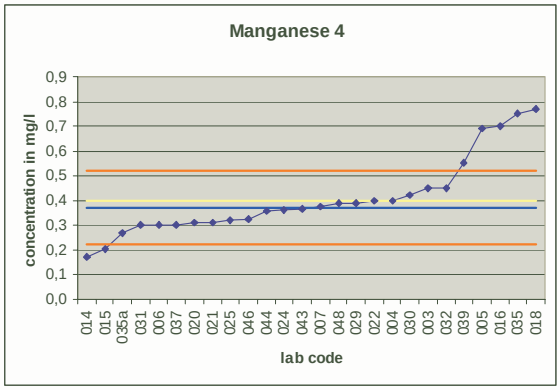
Manganese 4



- values: 29
- removed: 3
- Median: 0,37 mg/l
- Weighing: 0,40 mg/l
- Deviation: -7,38 %
- Standard deviation: 0,1 mg/l; 26,5 %
- limit for St.-dev.: 20 %
- Upper limit: 0,519 mg/l
- Lower limit: 0,222 mg/l
- too high: 5 values
- too low: 2 values
- outside tolerance limits: 34,5 %

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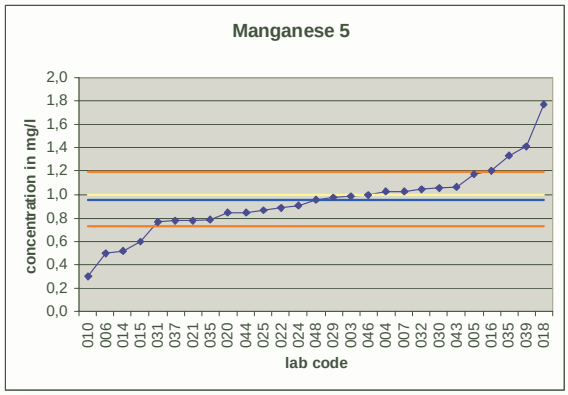
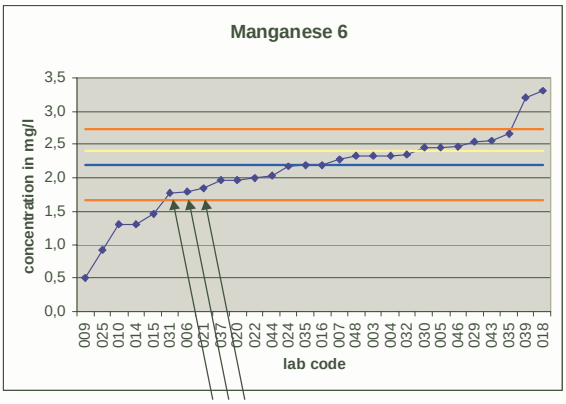
Manganese 5



- values: 29
- removed: 2
- Median: 0,96 mg/l
- Weighing: 1.0 mg/l
- Deviation: -4,0 %
- Standard deviation: 0,19 mg/l; 20,1 %
- limit for St.-dev.: 12 %
- Upper limit: 1,19 mg/l
- Lower limit: 0,73 mg/l
- too high: 4 values
- too low: 4 values
- outside tolerance limits: 34,5 %

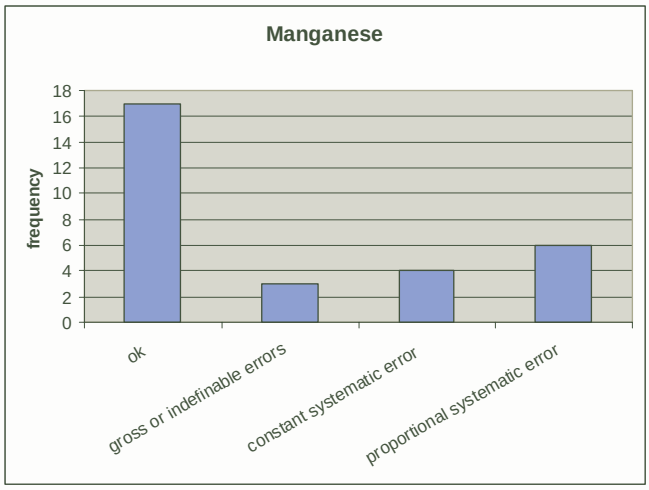
Manganese 6



Assessment would be changed, if reference value would be used

- values: 29
- removed: 1
- Median: 2,2 mg/l
- Weighing: 2,4 mg/l
- Deviation: -8,3 %
- Standard deviation: 0,46 mg/l; 21,0 %
- limit for St.-dev.: 12 %
- Upper limit: 2,73 mg/l
- Lower limit: 1,67 mg/l
- too high: 2 values
- too low: 5 values
- outside tolerance limits: 27,6 %

Manganese
Classification of results



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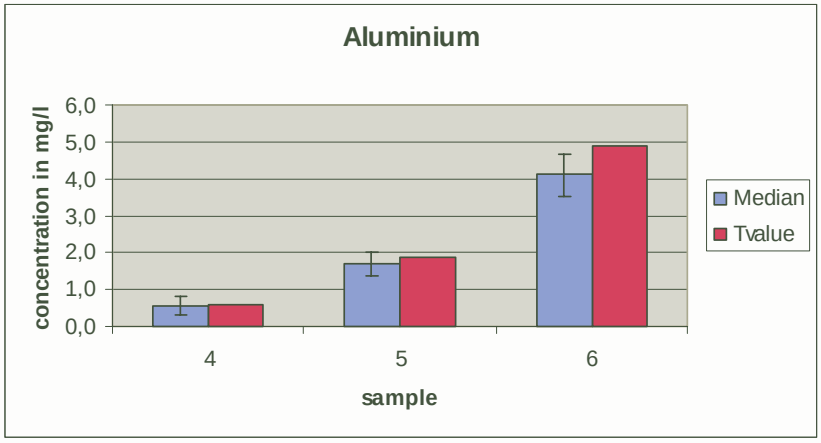
Aluminium
median and ref.-value from weighing



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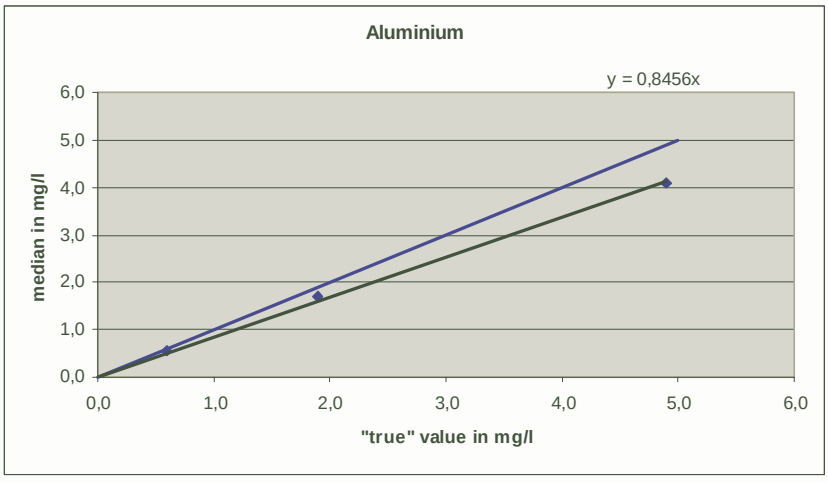
Aluminium
median vs. ref.-value



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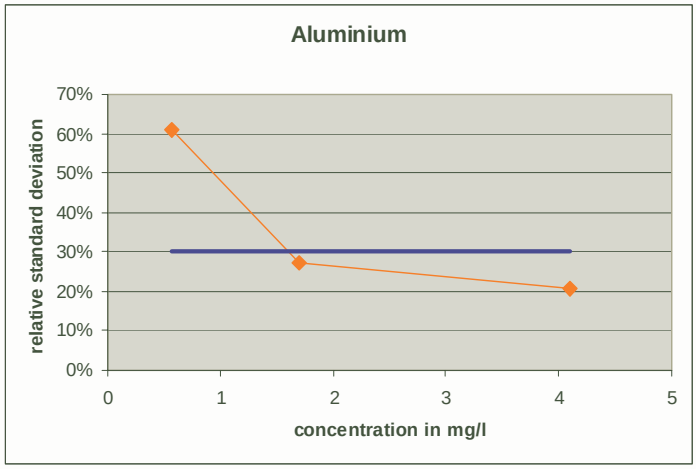
Aluminium
calculated standard deviation and limit



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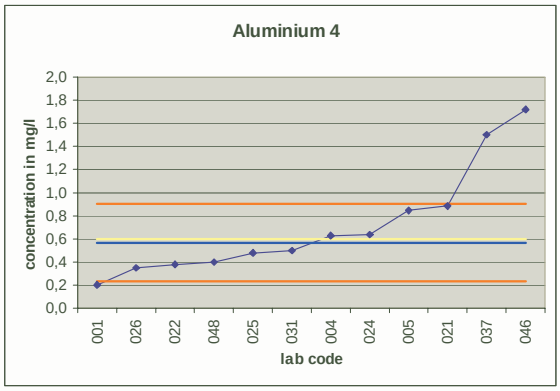
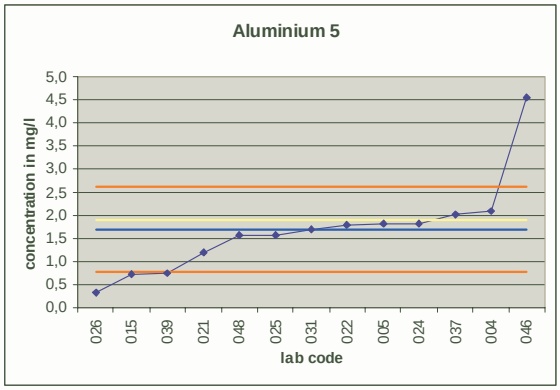
Aluminium 4



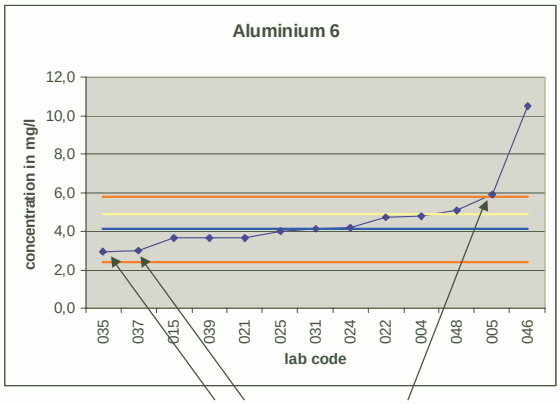
- values: 14
- removed: 2
- Median: 0,57 mg/l
- Weighing: 0,60 mg/l
- Deviation: -5,8 %
- Standard deviation: 0,35 mg/l; 61,1 %
- limit for St.-dev.: 30 %
- Upper limit: 0,90 mg/l
- Lower limit: 0,23 mg/l
- too high: 2 values
- too low: 1 value
- outside tolerance limits: 33,3 %

Aluminium 5



- values: 14
- removed: 1
- Median: 1,70 mg/l
- Weighing: 1,90 mg/l
- Deviation: -10,5 %
- Standard deviation: 0,46 mg/l; 27,0 %
- limit for St.-dev.: 30 %
- Upper limit: 2,62 mg/l
- Lower limit: 0,78 mg/l
- too high: 1 value
- too low: 3 values
- outside tolerance limits: 33,3 %

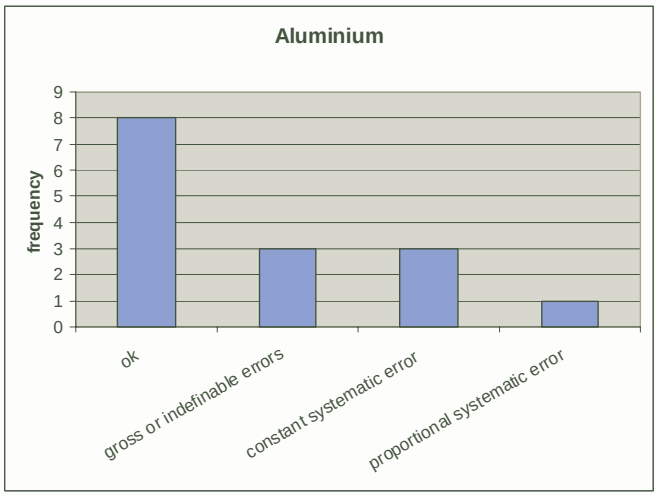
Aluminium 6



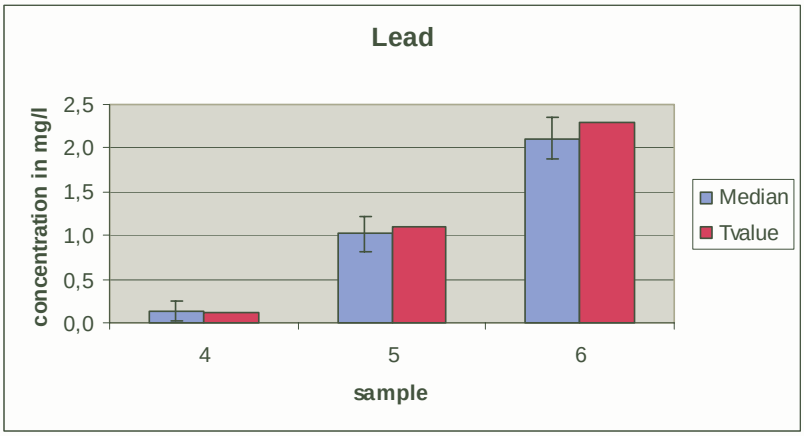
Assessment would be changed, if reference value would be used

- values: 15
- removed: 2
- Median: 4,1 mg/l
- Weighing: 4,9 mg/l
- Deviation: -16,3 %
- Standard deviation: 0,85 mg/l; 20,8 %
- limit for St.-dev.: 30 %
- Upper limit: 5,80 mg/l
- Lower limit: 2,40 mg/l
- too high: 2 (1) values
- too low: 0 (2) values
- outside tolerance limits: 26,7 (33,3) %

Aluminium
Classification of results



Lead
median and ref.-value from weighing



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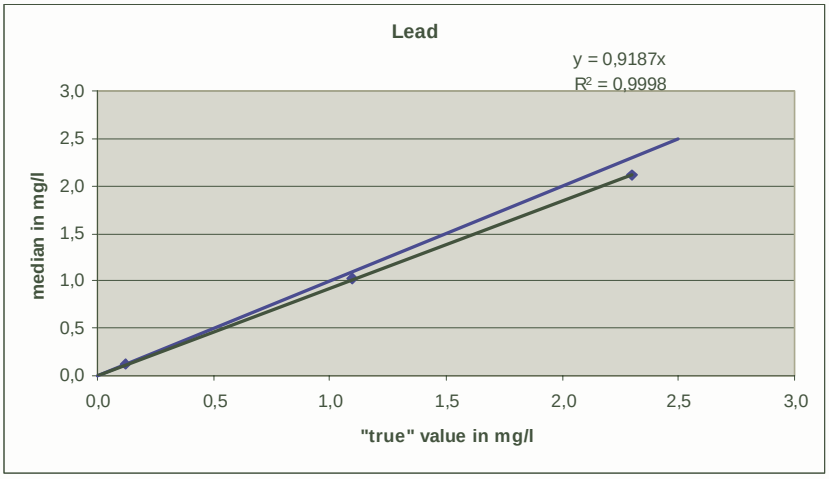
Lead
median vs. ref.-value



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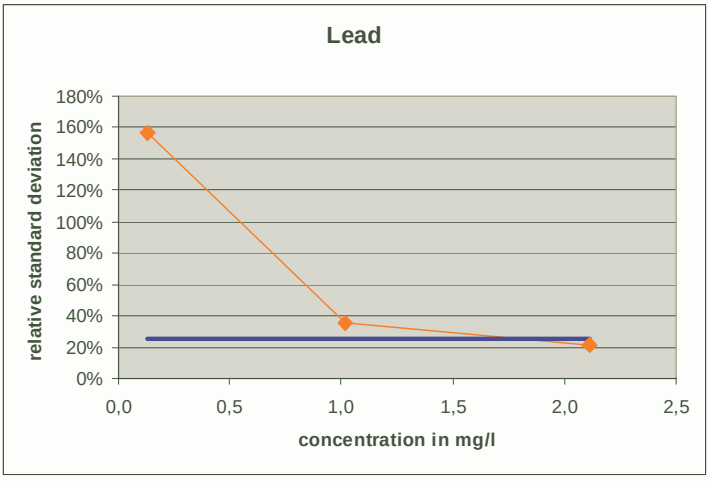
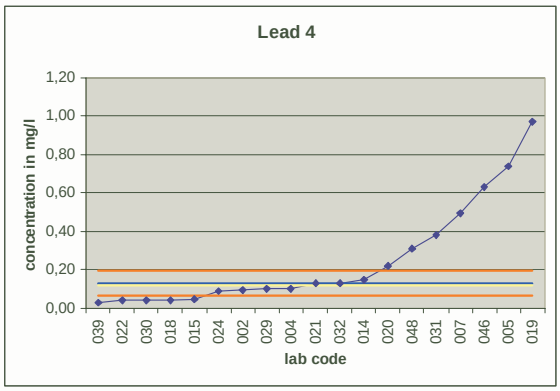
Lead
calculated standard deviation and limit

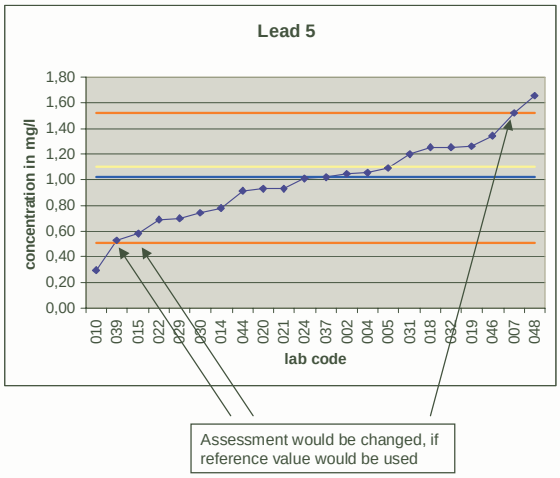


Lead 4



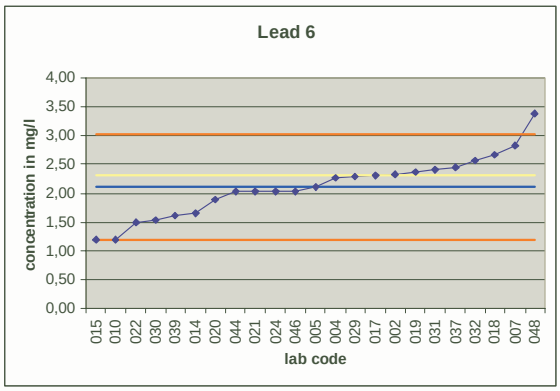
- values: 21
- removed: 2
- Median: 0,13 mg/l
- Weighing: 0,12 mg/l
- Deviation: 8,33 %
- Standard deviation: 0,2 mg/l; 157 %
- limit for St.-dev.: 25 %
- Upper limit: 0,195 mg/l
- Lower limit: 0,065 mg/l
- too high: 7 values
- too low: 5 values
- outside tolerance limits: 66,7 %

Lead 5



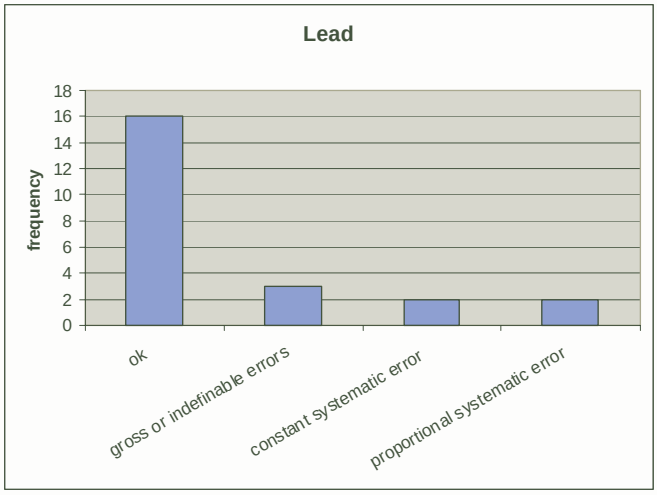
- values: 22
- removed: 0
- Median: 1,02 mg/l
- Weighing: 1,10 mg/l
- Deviation: -7,73 %
- Standard deviation: 0,36 mg/l; 35,6 %
- limit for St.-dev.: 25 %
- Upper limit: 1,52 mg/l
- Lower limit: 0,51 mg/l
- too high: 2 (1) values
- too low: 1 (3) values
- outside tolerance limits: 13,6 (18,2) %

Lead 6



- values: 23
- removed: 0
- Median: 2,11 mg/l
- Weighing: 2,30 mg/l
- Deviation: -8,3 %
- Standard deviation: 0,45 mg/l; 21,6 %
- limit for St.-dev.: 25 %
- Upper limit: 3,02 mg/l
- Lower limit: 1,20 mg/l
- too high: 1 value
- too low: 0 (2) values
- outside tolerance limits: 4,3 (13,0) %

Lead
Classification of results



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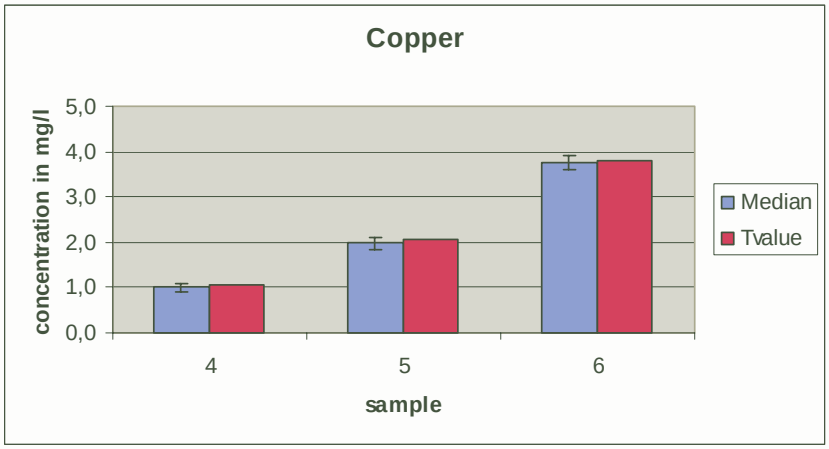
Copper
median and ref.-value from weighing



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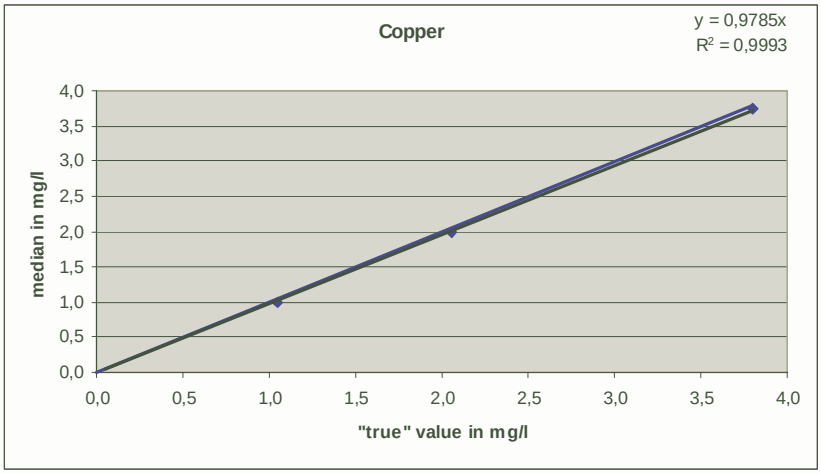
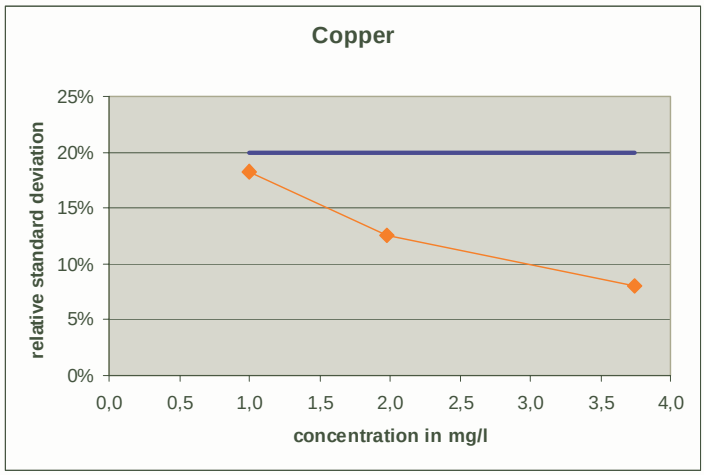
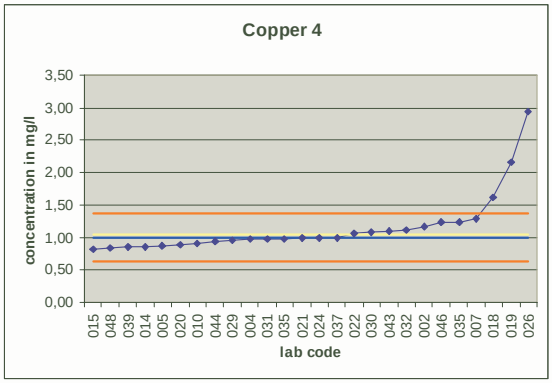
Copper
median vs. ref.-value



Copper
calculated standard deviation and limit

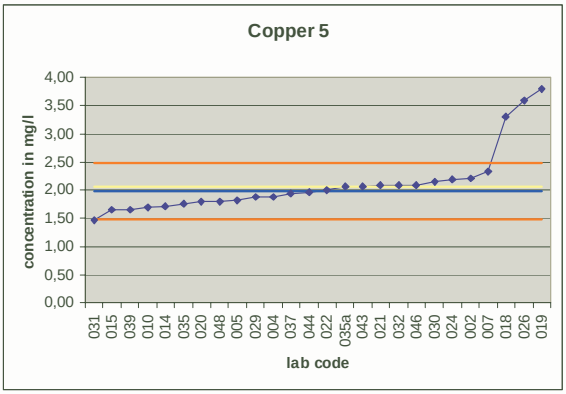


Copper 4



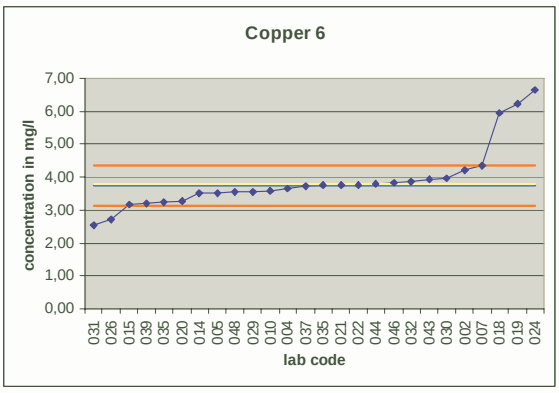
- values: 26
- removed: 0
- Median: 1,00 mg/l
- Weighing: 1,05 mg/l
- Deviation: -4,76 %
- Standard deviation: 0,18 mg/l; 18,3 %
- limit for St.-dev.: 20 %
- Upper limit: 1,37 mg/l
- Lower limit: 0,63 mg/l
- too high: 3 values
- too low: 0 values
- outside tolerance limits: 11,5 %

Copper 5



- values: 26
- removed: 0
- Median: 1,98 mg/l
- Weighing: 2,06 mg/l
- Deviation: -3,9 %
- Standard deviation: 0,25 mg/l; 12,5 %
- limit for St.-dev.: 20 %
- Upper limit: 2,48 mg/l
- Lower limit: 1,48 mg/l
- too high: 3 values
- too low: 1 values
- outside tolerance limits: 15,4 %

Copper 6



- values: 26
- removed: 0
- Median: 3,75 mg/l
- Weighing: 3,8 mg/l
- Deviation: -1,5 %
- Standard deviation: 0,3 mg/l; 8,1 %
- limit for St.-dev.: 20 %
- Upper limit: 4,35 mg/l
- Lower limit: 3,14 mg/l
- too high: 3 values
- too low: 2 values
- outside tolerance limits: 19,2 %

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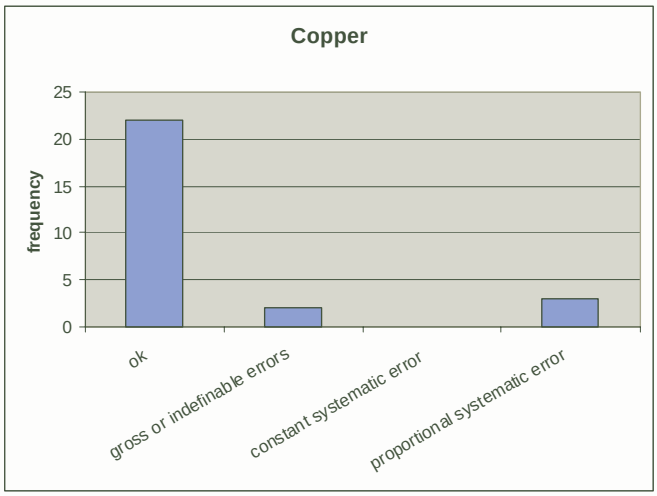
Copper
Classification of results



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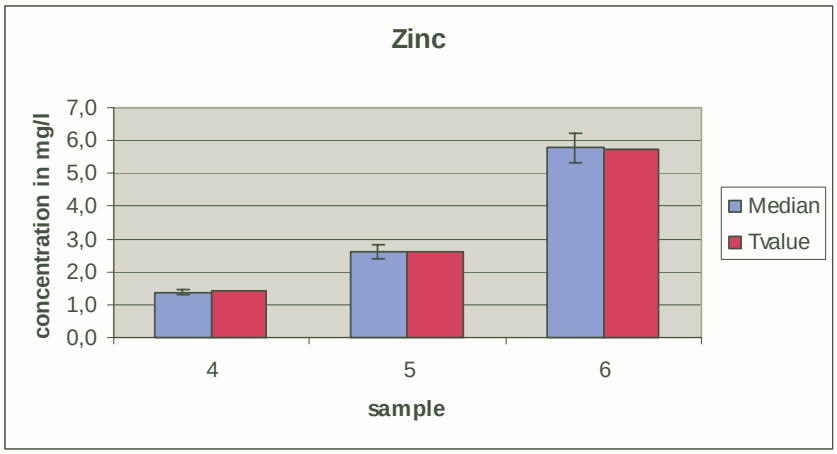
Zinc
median and ref.-value from weighing



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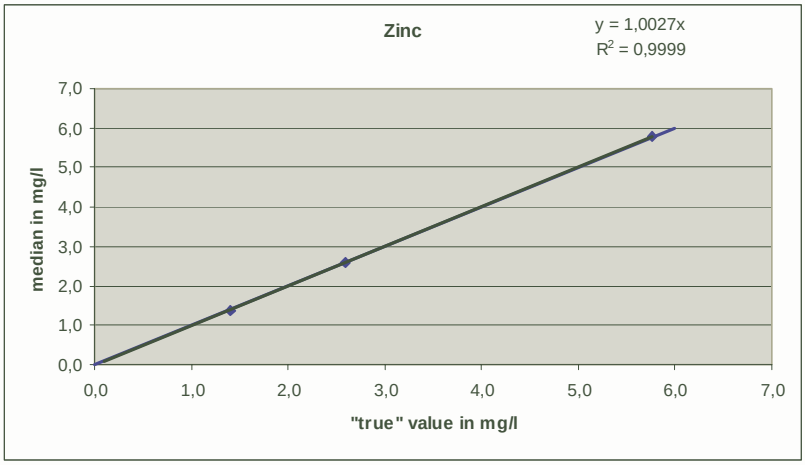
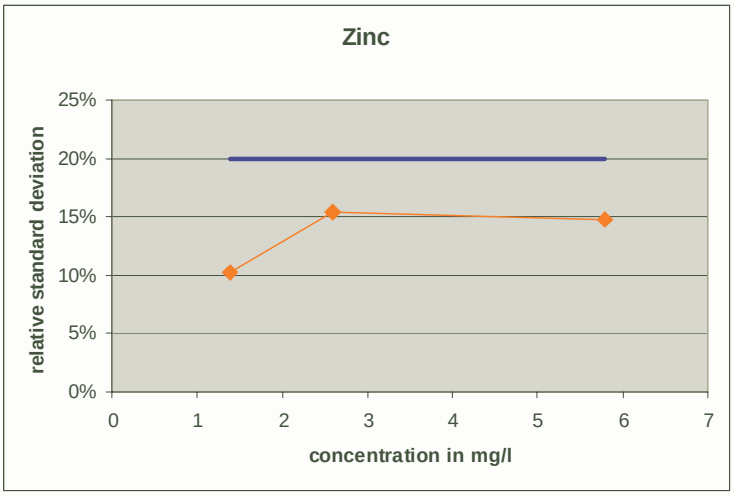
Zinc
median vs. ref.-value

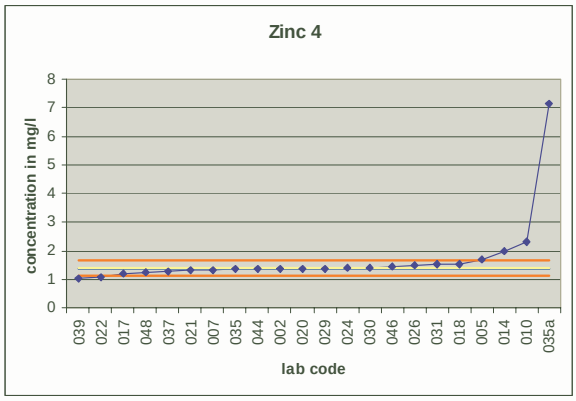


Universität Stuttgart

Zinc
calculated standard deviation and limit

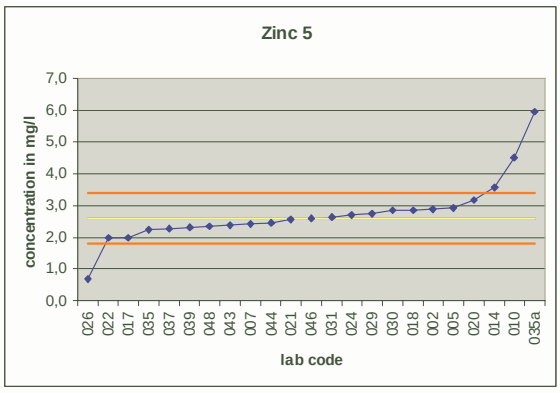


Zinc 4



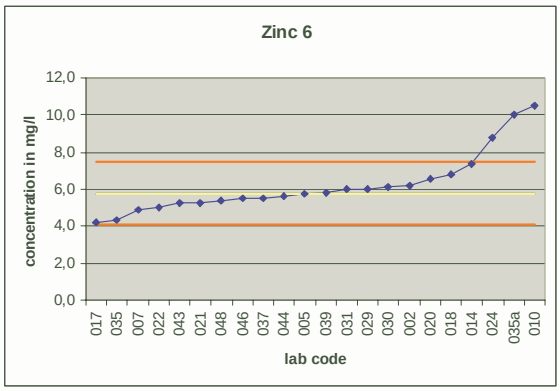
- values: 25
- removed: 3
- Median: 1,38 mg/l
- Weighing: 1,40 mg/l
- Deviation: -1,4 %
- Standard deviation: 0,14 mg/l; 10,3 %
- limit for St.-dev.: 20 %
- Upper limit: 1,66 mg/l
- Lower limit: 1,10 mg/l
- too high: 4 values
- too low: 2 values
- outside tolerance limits: 36,0 %

Zinc 5



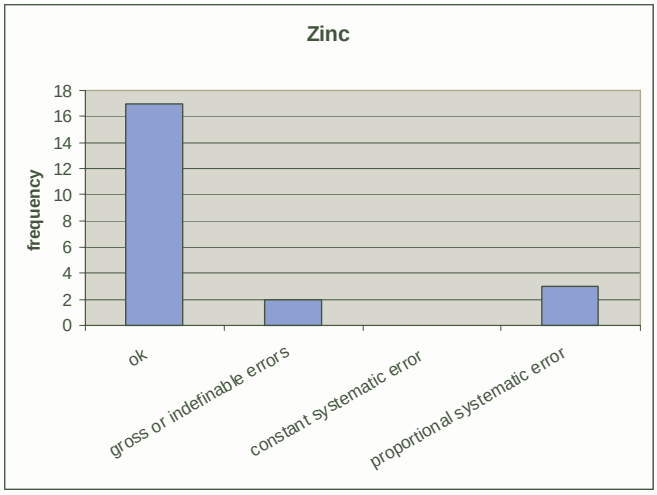
- values: 25
- removed: 2
- Median: 2,60 mg/l
- Weighing: 2,60 mg/l
- Deviation: 0,0 %
- Standard deviation: 0,4 mg/l; 15,4 %
- limit for St.-dev.: 20 %
- Upper limit: 3,4 mg/l
- Lower limit: 1,8 mg/l
- too high: 3 values
- too low: 1 values
- outside tolerance limits: 24,0 %

Zinc 6

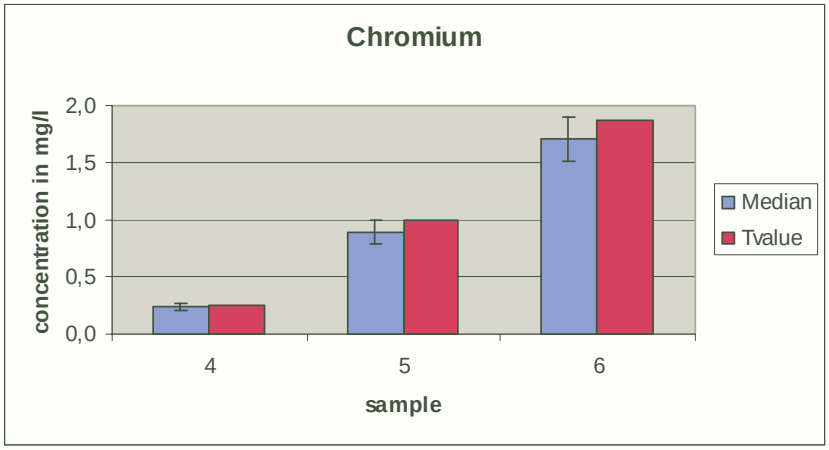


- values: 25
- removed: 3
- Median: 5,78 mg/l
- Weighing: 5,76 mg/l
- Deviation: +0,43 %
- Standard deviation: 0,85 mg/l; 14,8 %
- limit for St.-dev.: 20 %
- Upper limit: 7,49 mg/l
- Lower limit: 4,08 mg/l
- too high: 3 values
- too low: 0 values
- outside tolerance limits: 24,0 %

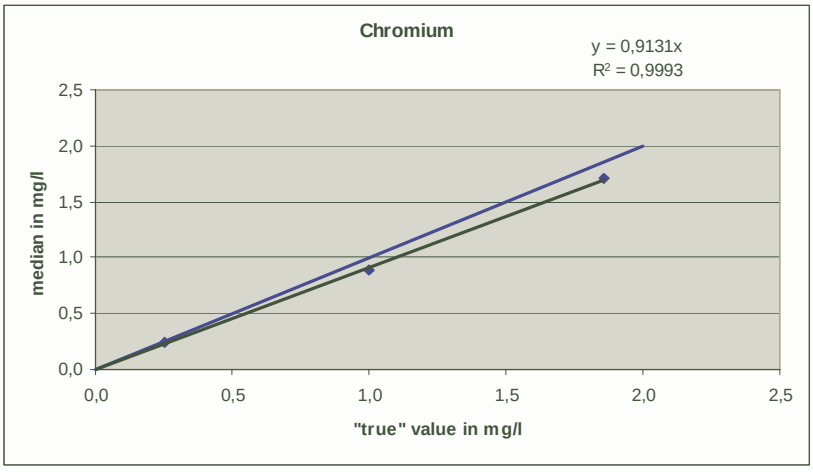
Zinc
Classification of results



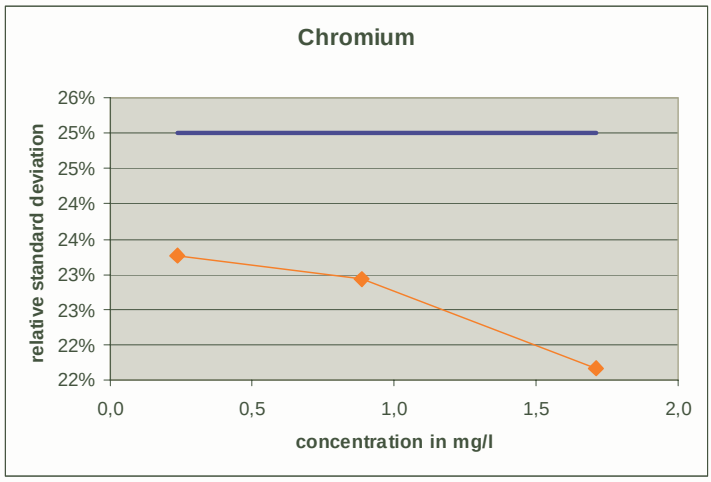
Chromium
median and ref.-value from weighing



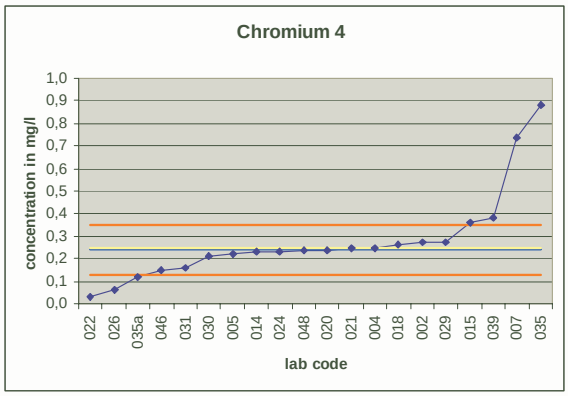
Chromium
median vs. ref.-value



Chromium
calculated standard deviation and limit

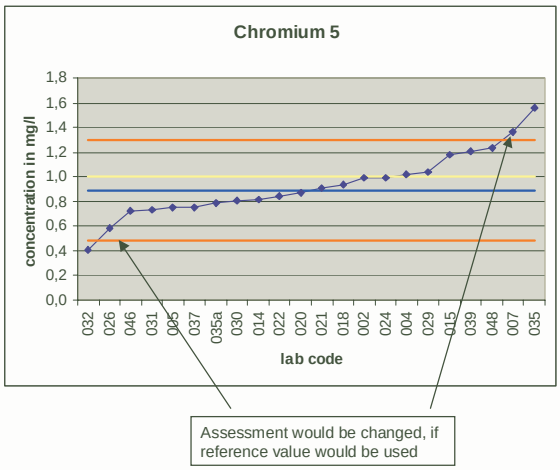


Chromium 4



- values: 21
- removed: 1
- Median: 0,24 mg/l
- Weighing: 0,25 mg/l
- Deviation: -5,0 %
- Standard deviation: 0,06 mg/l; 23,3 %
- limit for St.-dev.: 25 %
- Upper limit: 0,35 mg/l
- Lower limit: 0,13 mg/l
- too high: 4 values
- too low: 3 values
- outside tolerance limits: 38,1 %

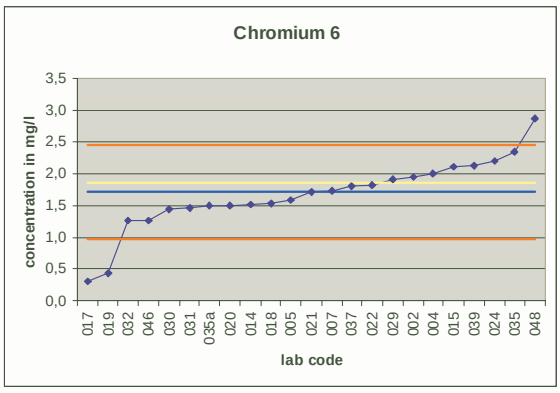
Chromium 5



Assessment would be changed, if reference value would be used

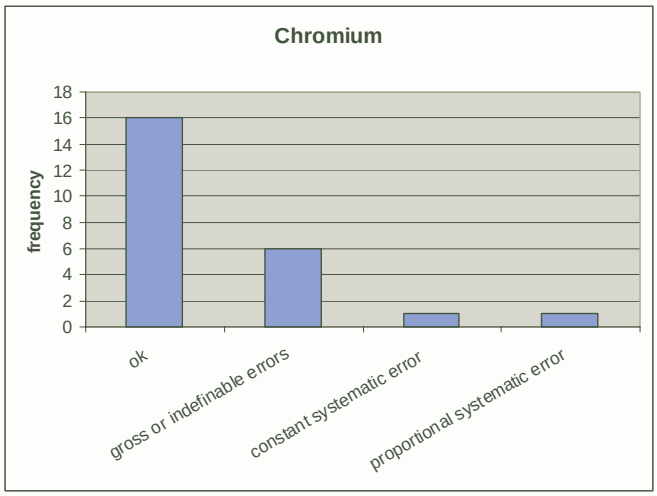
- values: 23
- removed: 1
- Median: 0,89 mg/l
- Weighing: 1,0 mg/l
- Deviation: -11,1 %
- Standard deviation: 0,2 mg/l; 22,9 %
- limit for St.-dev.: 25 %
- Upper limit: 1,30 mg/l
- Lower limit: 0,48 mg/l
- too high: 2 (1) values
- too low: 1 (2) values
- outside tolerance limits: 17,4 %

Chromium 6

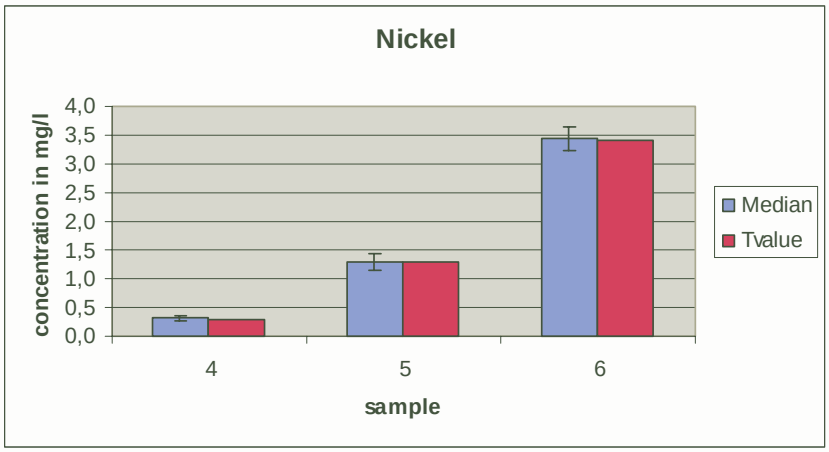


- values: 24
- removed: 1
- Median: 1,71 mg/l
- Weighing: 1,86 mg/l
- Deviation: -8,1 %
- Standard deviation: 0,37 mg/l; 21,7 %
- limit for St.-dev.: 25 %
- Upper limit: 2,45 mg/l
- Lower limit: 0,97 mg/l
- too high: 1 value
- too low: 2 values
- outside tolerance limits: 16,7 %

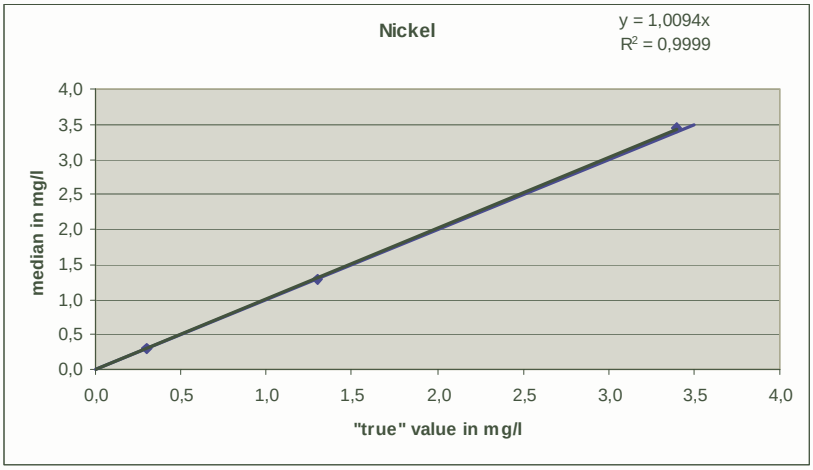
Chromium
Classification of results



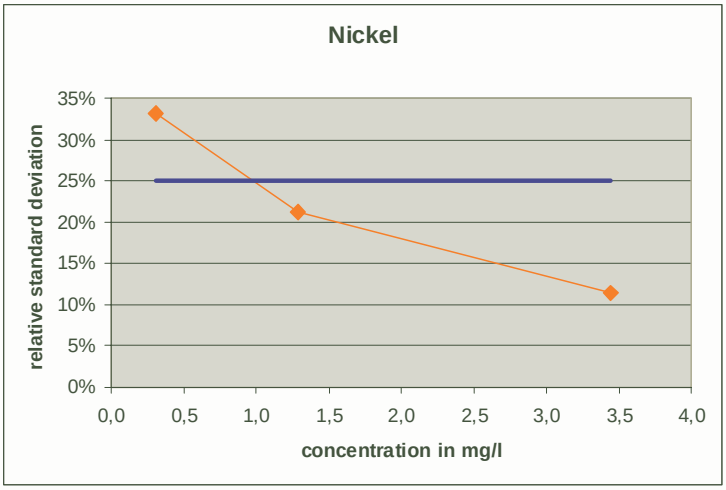
Nickel
median and ref.-value from weighing



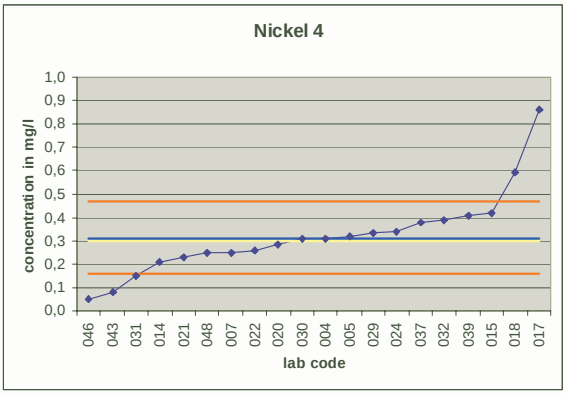
Nickel
median vs. ref.-value



Nickel
calculated standard deviation and limit

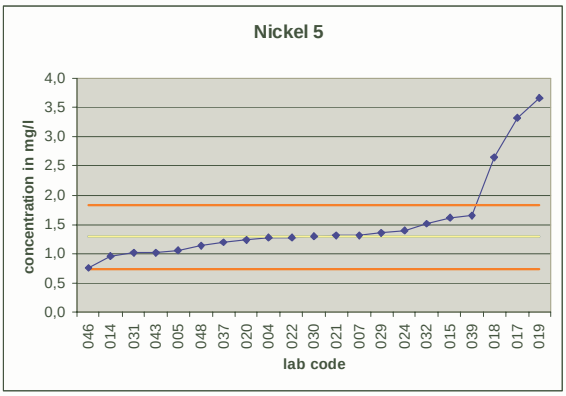


Nickel 4



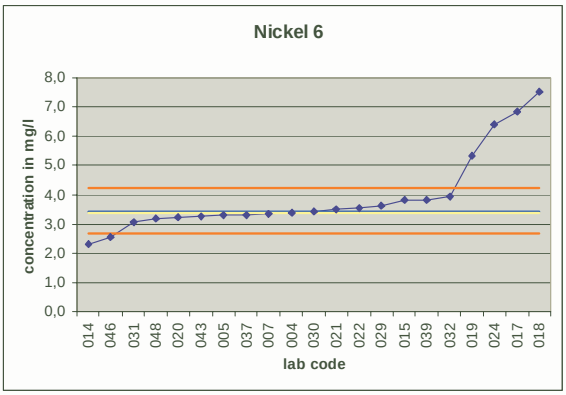
- values: 22
- removed: 2
- Median: 0,31 mg/l
- Weighing: 0,3 mg/l
- Deviation: +3,3 %
- Standard deviation: 0,1 mg/l; 33,2 %
- limit for St.-dev.: 25 %
- Upper limit: 0,47 mg/l
- Lower limit: 0,16 mg/l
- too high: 2 values
- too low: 3 values
- outside tolerance limits: 31,8 %

Nickel 5



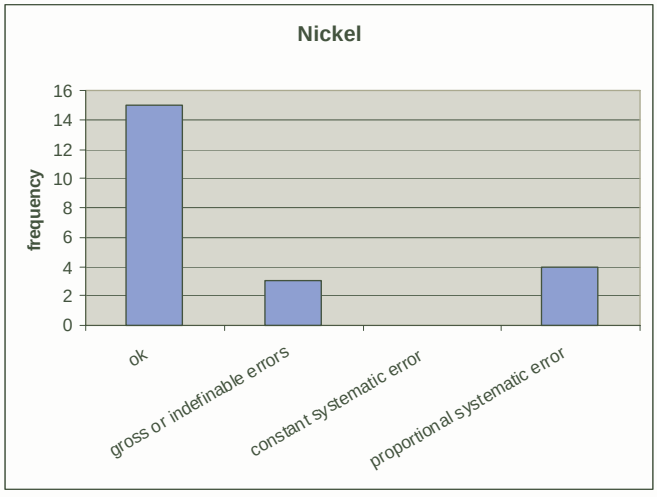
- values: 22
- removed: 1
- Median: 1,29 mg/l
- Weighing: 1,30 mg/l
- Deviation: -0,8 %
- Standard deviation: 0,27 mg/l; 21,3 %
- limit for St.-dev.: 25 %
- Upper limit: 1,84 mg/l
- Lower limit: 0,74 mg/l
- too high: 3 values
- too low: 0 values
- outside tolerance limits: 18,2 %

Nickel 6



- values: 22
- removed: 1
- Median: 3,44 mg/l
- Weighing: 3,40 mg/l
- Deviation: +1,2 %
- Standard deviation: 0,39 mg/l; 11,4 %
- limit for St.-dev.: 25 %
- Upper limit: 4,23 mg/l
- Lower limit: 2,65 mg/l
- too high: 4 values
- too low: 2 values
- outside tolerance limits: 31,8 %

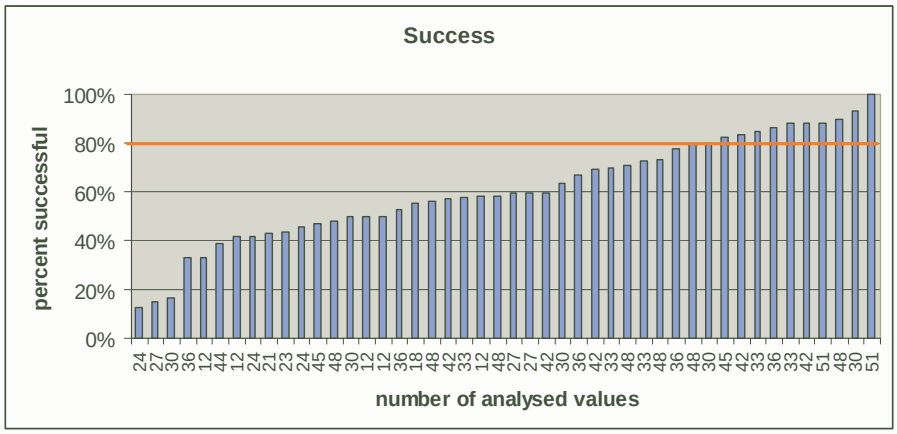
Nickel
Classification of results



Evaluation in future

- Due to development of new international standards it is highly recommended to use the statistical methods from these standards
- But no statistical procedure can cope with datasets containing more than 50 % data not being fit for purpose
- In case of doubt the assigned value should be derived by calculation from the masses used (ISO 13528, 5.2.1)
- The setting of limits for standard deviation has proven to be very effective

Overview on participants success



Conclusion

- The PT Provider did a very good job
- the evaluation and assessment procedure needs only minor changes in the future
- the SADCMET Water PT is a good possibility for the participants to compare with peers and with stated fitness-for-purpose criteria
- The results of many laboratories are still not satisfactory and need improvement
- A SADCMET lab association could be a good platform for discussions, how to improve and for mutual help

SADC ASSOCIATION OF WATER TESTING LABORATORIES (SAWATL)

Guidelines Towards its Establishment and Operational Framework.

11 November 2005
Dar es Salaam, Tanzania

Framework/Context

SOUTHERN AFRICAN DEVELOPMENT COMMUNITY

MEMORANDUM OF UNDERSTANDING

ON

COOPERATION IN STANDARDISATION, QUALITY ASSURANCE, ACCREDITATION AND METROLOGY

Context

ARTICLE 2
OBJECTIVE

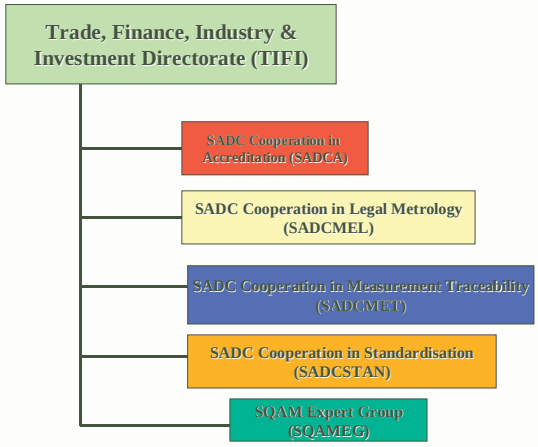
The objective of this Memorandum of Understanding (MOU) shall be to establish the formal framework in which the cooperation amongst the national institutions in Standardisation, Quality Assurance, Accreditation and Metrology (SQAM) shall take place in the Region and this framework shall be referred to as the SADC SQAM Programme.

ARTICLE 3
ESTABLISHMENT

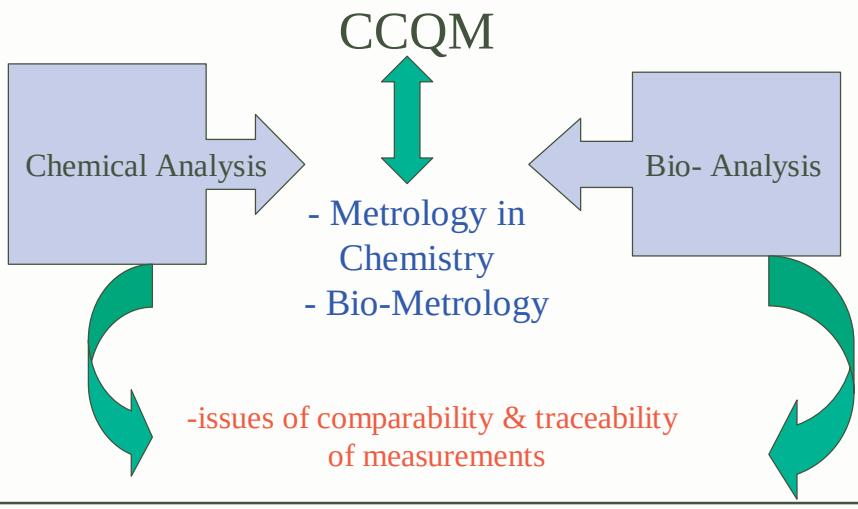
1. The SADC Programme in Standardisation, Quality Assurance, Accreditation and Metrology is hereby established.

2. The SADC SQAM Programme shall encompass standardisation, accreditation, certification, conformity assessment, testing, inspection, metrology and related matters.

Context



Conceptual Approach



Proposed Structure

- Preamble
- Name
- Location
- Scope
- Objectives
- Tasks
- Membership
- Administration
- Codes of procedure
- Amendment of Constitution

Preamble

- Reference to SADC MOU/Annex to Trade Protocol

Name

- The Association is named: SADC Association of Water Testing Laboratories, acronym “SADCWATERLAB”
- Or ‘SAWATL’
- SAWATL is hereby established

Location

- Interim location – dependent on interim Secretariat.

Scope

- The proposed constitution applies to SAWATL's:-
- Objectives
- Tasks
- Membership
- Committees and working groups
- Where necessary, SAWATL constituent bodies (Councils, committees, working groups) may establish their own supplementary rules of procedure in harmony with this draft constitution.

Objectives

- The Association is a regional not-for-profit association.
- Its major aims are:
- to facilitate technical cooperation and collaboration amongst regional laboratories involved in water testing.
- to provide an organised interface at the regional level between these laboratories and other SQAM structures involved in conformity assessment issues
- to accelerate the development and harmonization of measurement, test and analytical methods.

Tasks

- Organisation of inter-laboratory test comparisons and proficiency testing schemes
- Promotion of quality management and assurance in laboratories
- Identification of areas of priority for development of technical cooperation in the areas of testing, measurement and analyses
- Establishment of a forum for exchange of information
- Cooperation on the training of staff (staff exchange etc)
- Cooperation on development and interpretation of test methods, especially those relevant to regional technical regulations
- Cooperation between the laboratories and accreditation bodies on matters of common interest relating to accreditation

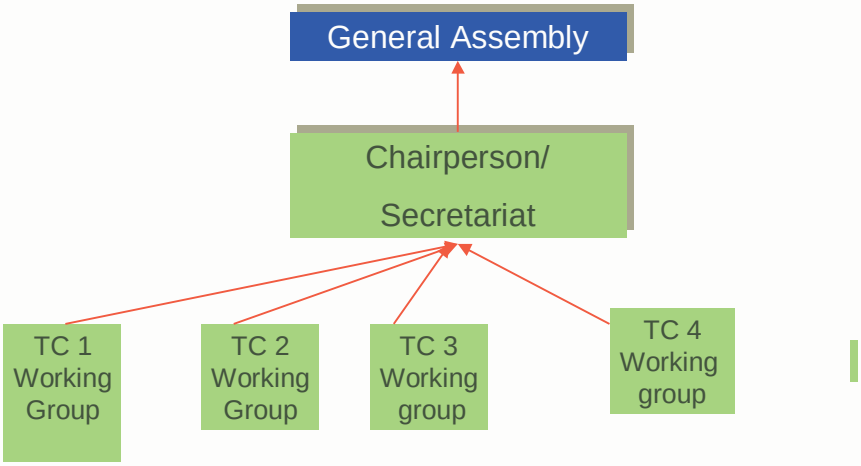
Membership

- 2 categories:
- Ordinary members: laboratories and lab. associations in SADC countries involved in water testing and analyses
- Associate members: laboratories and lab associations in non-SADC countries involved in water testing and analyses
- Membership fees

Management/Admin

- General Assembly
- Council
- Chair
- Vice Chair
- Secretariat
- Project Management Committee

STRUCTURE



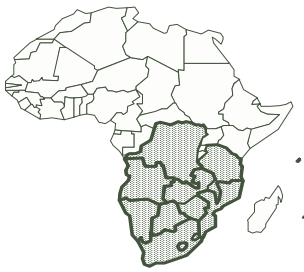
Finance

- Income – subscriptions, fees, donations

Rules of Procedure

- Elections of office bearers
- Convocation of meetings
- Voting rights
- Meeting procedures
- Technical committees and working groups

Amendments/Revision



SADCMET

Southern African Development Community (SADC) Cooperation in Measurement Traceability
Angola, Botswana, Democratic Republic of Congo, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, Zimbabwe

SADCMET Water PT Evaluation Workshop

10 – 11 November 2005, Protea Courtyard Hotel, Dar es Salaam, Tanzania

Evaluation Questionnaire

In order to evaluate the success of this training workshop, please kindly spare a few minutes to answer the following questions:

How do you judge:	Very good	good	fair	poor	very poor
The venue of the workshop (Accommodation, food, conference room)	☐	☐	☐	☐	☐
The content of the presentations	☐	☐	☐	☐	☐
The handouts and documents	☐	☐	☐	☐	☐
The working group discussions	☐	☐	☐	☐	☐
Presenters skills & handling of the workshop	☐	☐	☐	☐	☐

Were all aspects of the PT system covered? ☐ Yes ☐ No

If Not, which aspects were not covered ?……..

The most important topics for me have been:

1)……

2)……

3)……

Did the workshop fulfill your expectations? ☐ Yes ☐ No

If Not, explain .....

What benefits did you draw from the workshop?.....

Any other comments: .....

……