

## Calculation of z-score

The performance of participants in proficiency tests is often evaluated using standardized values or z-scores. The z-score is a measure of the relative deviation from the assigned value and is as such independent of concentration and type of matrix.

The general formula to calculate the z-score is

$$z = \frac{x - \mu}{\sigma}$$

where  $x$  is the participant's laboratory measurement,  $\mu$  the assigned or "true" value, and  $\sigma$  the standard deviation.

ITMs interlaboratory comparisons often use samples with unknown composition and there are no target criteria for the standard deviation. Under such circumstances consensus values are typically used, meaning that the assigned values and standard deviation are based on the participants' results using the formula

$$z = \frac{x - \bar{x}}{s}$$

where  $\bar{x}$  is the sample mean and  $s$  the sample standard deviation. It is important that obvious errors and outliers are excluded before calculation of these metrics.

In ITMs reports  $\bar{x}$  and  $s$  (outliers excluded) are provided for all parameters in a summary table. These values can be transferred to e.g. MS Excel for calculation of z-scores for your laboratory's results. See screen shot at right for an example.

	A	B	C	D	E	F
1	Parameter	Sample	XBAR	Stdev	My result	z-score
2	AOX	2008-4,1	776.1	87.6	784	= (E2-C2)/D2
3	AOX	2008-4,2	782.1	82.5	870	1.06
4	BOD7	2008-4,1	16.68	1.92	15.9	-0.43
5	BOD8	2008-4,2	15.56	2.45	11.7	-1.56
6	CODCr Hg	2008-4,1	152.8	6.1	153	0.01
7	CODCr Hg	2008-4,2	150.4	5.5	150	-0.09
8	CODC noHg	2008-4,1	169.9	4.3	173	0.66
9	CODC noHg	2008-4,2	166.1	5.5	171	0.89
10	CODMn	2008-4,1	56.93	5.6	53	-0.72
11	CODMn	2008-4,2	56.87	5.83	55	-0.27
12	CorgT/TOC	2008-4,1	50.33	5.61	51	0.04
13	CorgT/TOC	2008-4,2	49.68	5.48	54	0.87
14	Kond	2008-4,1	79.79	2.41	80	0.04
15	Kond	2008-4,2	80.51	2.57	80	-0.34
16	pH	2008-4,1	7.005	0.129	6.9	-0.92
17	pH	2008-4,2	6.979	0.115	6.9	-0.77
18	pH	2008-4,3	10.18	0.13	9.8	-2.87
19	pH	2008-4,4	10.14	0.12	9.7	-3.67

### Calculation of z-score using Excel (Example from 2008-4 AOX).

Transfer means (XBAR) and standard deviations (Stdev) from the report into separate columns and enter corresponding measurements from your laboratory. The z-score formula can be entered as shown above. Alternatively, the Excel function "STANDARDIZE" can be used.

Evaluation of z-scores is identified as:

- $|z| \leq 2$  Satisfactory
- $2 < |z| \leq 3$  Questionable
- $|z| > 3$  Unsatisfactory

In the above example all analyses are satisfactory except that for alkaline pH that is far too low. There is likely a problem with the used method that need to be investigated.

Z-scores are less useful when there are few participants because the estimates of the assigned value and standard deviation then will be uncertain.