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Automated system programmed in R for performance evaluation in proficiency testing

according to ISO 17043:2023 and ISO 13528:2022

By Chemical Metrology Unit:

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Introduction

IBMETRO is the National Metrology Institute of Bolivia. It provides services of calibration, testing, and proficiency tests (PT) in Bolivia. IBMETRO offered PT services for many years. However, IBMETRO had the pending task of obtaining recognition from the Quality System Task Force of the SIM. One challenge for the QMS was the systematization of the documentation generated for each PT. For this reason, there was a need to carry out the performance evaluation of participants in an efficient and reliable manner. As a result, a system based on the R programming language was designed, developed, and implemented to fulfill this task.

Methodology

The entire statistical treatment of participants performance evaluation was divided into 5 forms, each with its respective program developed in the R programming language using the R-Studio IDE. First, the participants' data are collected from a Excel format to a .csv format adequate to work with de R program. Then, the programs are executed, generating the respective reports for the evaluation of test item such as homogeneity, stability of test items, evaluation of outlier data, determination of the assigned value and its uncertainty (eq. 1), standard deviation for proficiency evaluation, comparison of uncertainty and the performance evaluation criterion (eq. 2), and performance evaluation of participants using z-score (eq. 3) or another criteria as required. In all cases, the guidelines of ISO 17043:2023 and ISO 13528:2022 standards are followed.
In the next section an example of the performance evaluation of zinc in drinking water carried out in December 2024 is shown. In this example, the standard deviation for proficiency evaluation was calculated using the Horwitz model (Eq. 4).

Eq.1 $$u(x_{pt}) = \sqrt{u_{char}^2 + u_{hom}^2 + u_{trans}^2 + u_{stab}^2}$$

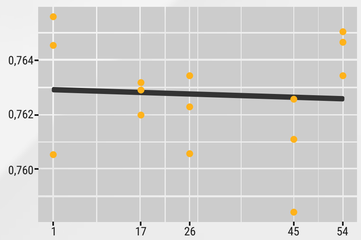
Eq.2 $$z_i = \frac{x_i - x_{pt}}{\sigma_{pt}}$$

Eq.3 $$u(x_{pt}) > 0{,}3 * \sigma_{pt}$$

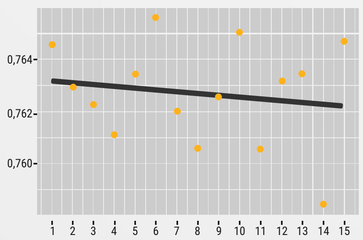
Eq.4 $$\sigma_{pt} = \begin{cases} 0{,}22c & : c < 1{,}2 * 10^{-7} \\ 0{,}02c^{0{,}8495} & : 1{,}2 * 10^{-7} \le c \le 0{,}138 \\ 0{,}01c^{0{,}5} & : c > 0{,}138 \end{cases}$$

Results

The effect of preparation order and measurement order was analyzed in the homogeneity study for the parameter of concentration of zinc (mg/L) in water.



Order of preparation



Order of measurment

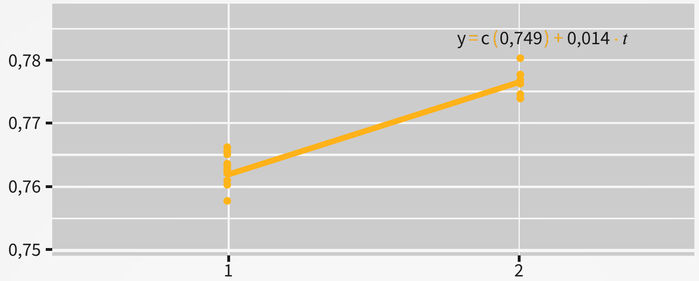
Type of order	Incerpt	Slope	p-value
Preparation	0.7629	0.0000	0.8123
Measurment	0.7633	-0.0001	0.5365

s_w^2	s_x^2	s_s	$0{,}3\ \sigma_{pt}$
0	0	0,001	0,03881

$$\sigma_{allow}^2 = (0{,}3\ \sigma_{pt})^2$$
$$c = F_1\ \sigma_{allow} + F_2\ s_w^2$$
$$c \le s_s^2$$

s_s^2	c	F_1	F_2
0	0,00036	2,3719	0,826

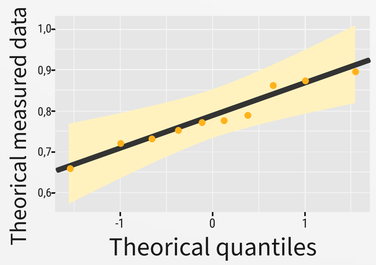
The effect of stability and transportation on the test items was evaluated according to the criteria of ISO 13528:2022.

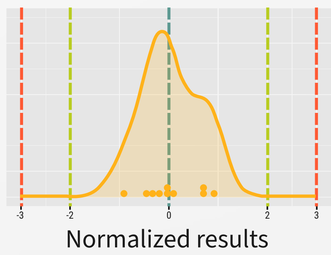


Variation before and after the proficiency test

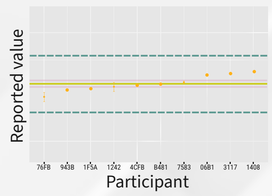
$\bar{x}_{hom}$	$\bar{x}_{est}$	$\lvert\bar{x}_{hom} - \bar{x}_{est}\rvert$	$0{,}3\ \sigma_{pt}$	$u(\bar{y}_1)$	$u(\bar{y}_2)$	$0{,}3\sigma_{pt} + 2 * \sqrt{u^2(\bar{y}_1) + u^2(\bar{y}_2)}$
0,76269	0,77635	0,01366	0,03881	$5{,}1 \times 10^{-4}$	0,00121	0,132

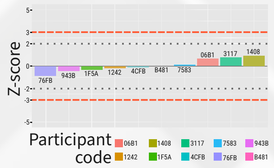
The presence of outliers was evaluated, and all possible assigned values were calculated along with their respective uncertainties and standard deviations for proficiency evaluation in accordance with ISO 13528:2022.
Once the assigned value was chosen, the performance evaluation of the participants was carried out, assessing firstly the behavior of the population to evaluate the assumptions of normality and unicity (or unimodality) of the population for the parameter of concentration of zinc (mg/L) in water.





Finally, with the statistical data obtained and supported, the performance evaluation of each participant is carried out with the assigned value, the standard deviation for the proficiency assessment and verifiying if the uncertainty is considerable.





x_{pt}	σ_{pt}	$U(x_{pt})$
0,778	0,1293	0,027

Participant	Reported result	Z-score	Result of evaluation
76FB	0,660	-0,91	acceptable
943B	0,720	-0,45	acceptable
1F5A	0,735	-0,34	acceptable
1242	0,752	-0,20	acceptable
4CFB	0,771	-0,06	acceptable
B481	0,776	-0,01	acceptable
7583	0,790	0,09	acceptable
06B1	0,863	0,65	acceptable
3117	0,875	0,74	acceptable
1408	0,896	0,91	acceptable

Conclusions

Due to the implementation using the R programming language, significant improvements were achieved in efficiency for data processing in the proficiency evaluation of participants.
The systematic approach presented was audited and approved by the Quality System Task Force of the Inter-American Metrology System, thus obtaining recognition for the quality management system.

APPROVAL OF QUALITY MANAGEMENT SYSTEM
APROBACIÓN DEL SISTEMA DE GESTIÓN DE LA CALIDAD
Instituto Boliviano de Metrología (IBMETRO) – Bolivia
Proficiency Testing in Chemical Quantities: Water and Minerals

https://ibmetro.gob.bo/sites/default/files/2025-01/QSTF%20Certificate%20IBMETRO_PT_Water_Minerals_Nov2024.pdf

APPROVAL OF QUALITY MANAGEMENT SYSTEM
APROBACIÓN DEL SISTEMA DE GESTIÓN DE LA CALIDAD
Instituto Boliviano de Metrología (IBMETRO) – Bolivia
Proficiency Testing in Physical Quantities: Mass and Temperature

https://ibmetro.gob.bo/sites/default/files/2025-01/QSTF%20Certificate%20IBMETRO_PT_Mass_Temperature_Nov2024.pdf

Future Work

In the future, it is planned to implement additional functions to provide a more comprehensive evaluation based on each analyzed parameter and method used.
Additionally, there are plans to implement a version with a graphical user interface using Shiny to facilitate its use by all IBMETRO personnel who require it.
Finally, there are plans to make the graphical user interface version available online for any NMI or laboratory interested in conducting participant performance evaluations.

Acknowledgements

This work was developed thanks to the PTB – Germany bilateral project " Promotion of quality infrastructure supporting drinking water and wastewater measurement and testing II".
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References

ISO/IEC 17043:2023. "Conformity assessment – General requirements for the competence of proficiency testing providers".
ISO 13528:2022. "Statistical methods for use in proficiency testing by interlaboratory comparisons"
Thompson, M., Ellison, S. L., & Wood, R. (2006). The international harmonized protocol for the proficiency testing of analytical chemistry laboratories (IUPAC Technical Report). Pure and Applied Chemistry, 78(1), 145-196

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