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OVERVIEW OF A LONG-LASTING PROFICIENCY PROGRAM FOR WATER TESTING

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Abstract

Water is a valuable and limited resource which is the focus of present policies and strategies for the future, attracting interest from international bodies, governments, the scientific community and general public.

Monitoring the quality of water for compliance with regulatory limits is an integral part of public health and environmental management. The Waters (Chemical) proficiency testing program was initiated in Australia more than 20 years ago, to provide laboratories an independent measure of their abilities to analyse chemical and physical parameters of water. Today, regular participation in proficiency testing programs is regarded as a very important tool for assessing laboratory performance. In this paper we look back at the milestones and hurdles encountered, as well as at the strengths that make it such a durable program.

Key words

Water
Proficiency

1 INTRODUCTION

In 1983, the National Association of Testing Authorities, Australia (NATA) initiated a pilot proficiency program in the area of chemical testing of water. The exercise was repeated in 1984, 1987 and 1991.

Based on the experience gained, the NATA Waters (Chemical) proficiency testing program started in 1992 and offered six rounds of the program in the first year. Since then, the program has been run without interruption, with rounds 1 to 83 under the management of NATA and then continued with round 84 following a change of management to PTA in 2006. By the end of 2014, 172 rounds had been completed. The program evolved to incorporate more parameters, with a higher frequency of rounds. The selection of parameters and concentration levels takes into account the changing regulations in the area of water monitoring.

Australian laboratories have been the main beneficiaries of the program, however, the program attracts international participation, especially from other economies in the Asia-Pacific region. A continuous effort was made to observe participants' views and opinions, and to support these ideas for program improvement. Three customer surveys were carried out, in 2001, 2007 and 2010, with a fourth survey being planned in 2015.

The majority of difficulties encountered relate to the operational part of the program. Sourcing reliable sample suppliers, delays with transportation of samples, time-consuming customs clearance and damaged samples during shipping were some of the difficulties reported in the past and are still causing occasional concern today.

2 PROGRAM DEVELOPMENT

The general tendency was to expand the program, with gradually more rounds being planned each year. Figure 1 presents the number of rounds completed in two year intervals since 1992. Compared to the starting point, the number more than doubled, from nine to 23 rounds finalised in 2012-2013. At least the same level is being expected for the current 2014-2015 interval.

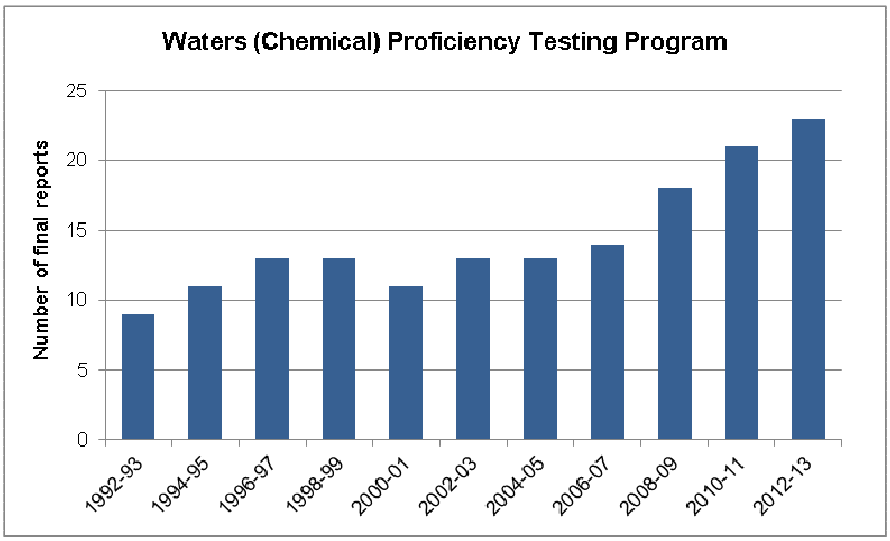

Figure 1. Waters (Chemical) proficiency testing program: rounds completed between 1992 and 2013, as number of final reports issued in intervals of two years.

Overall, the Waters (Chemical) proficiency testing program covers a large number of parameters monitored in potable and waste waters. Each round of the program

proposes a selection of parameters based on their similarities, the likelihood of being tested together or simply to offer a diversity of tests to participants. Table 1 below lists a few of the parameters tested, as grouped currently by rounds.

Table 1. Example of parameters tested in the Waters (Chemical) proficiency testing program for monitoring potable and waste waters

Parameters	Sample matrix
Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Organic Carbon (TOC)	waste water
Calcium, Calcium hardness as $CaCO_3$, Total hardness as $CaCO_3$, Magnesium, Non-filterable residue (TSS)	waste water
Metals (Chromium, Copper, Iron, Lead, Nickel, Thallium, Zinc)	waste water
Sulphate, pH, Colour, Conductivity	potable water
Organochlorine Pesticides: (4,4') DDE, Dieldrin, Endrine, Lindane, gamma-Chlordane	potable water
Calcium, Magnesium, Sodium, Potassium	potable water

Whilst the majority of participants in the program have been Australian laboratories, international organisations (mainly from the Asia-Pacific region) were present from the very beginning. Today, the representation of Asia-Pacific countries other than Australia is very strong. For example, this region accounted for approximately 24% of the participants registered in the program in the July 2014 to June 2015 period. In the same time interval, participants from Africa, Europe, Middle East and North and South America entered the program, however in smaller numbers, corresponding jointly to approximately 10% of participants (Figure 2).

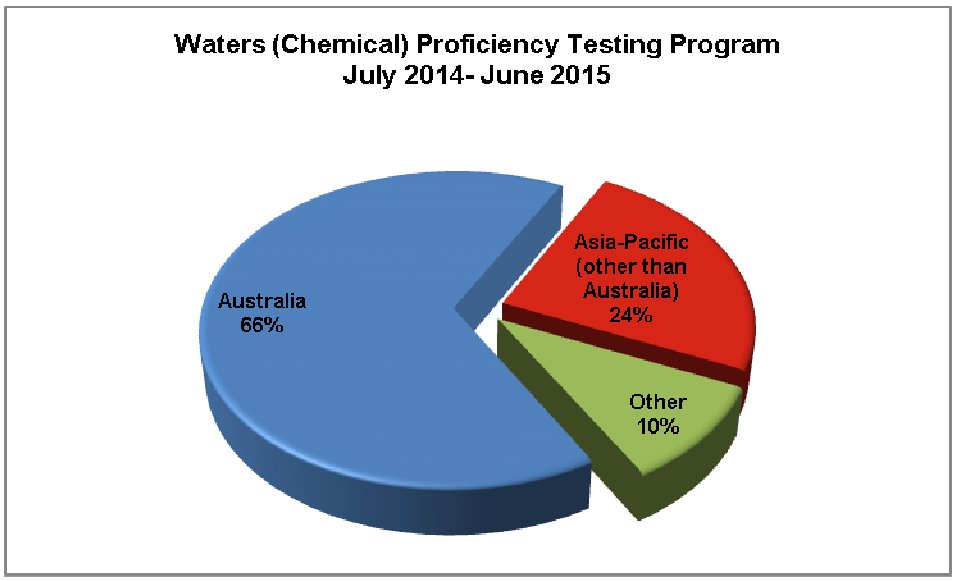

Figure 2. Distribution of participants in the Waters (Chemical) proficiency testing program between July 2014 - June 2015.

3 PROGRAM OPERATION

One of the goals of the program was to establish a predetermined set of rules, made available to all those involved, which were constructed taking into account the standardisation initiatives existing at the time to address the field of proficiency testing. Whether these were ISO/IEC Guide 43:1984 and 1997, ILAC Guide 13:2000 and 2007, ISO 13528:2005 and recently ISO/IEC 17043:2010 [1], it is worth mentioning that the main operation of the Waters (Chemical) proficiency testing program remains unchanged, with the same framework and the same principles being applied now as in the beginning. Most certainly, some of the knowledge arising from the program helped to shape the present form of proficiency standards through the contributions of several NATA and PTA members actively involved in ILAC proposals and advances for standardisation.

From an operational point of view, each cycle of the program starts by identifying a sample supplier and ensuring the availability and suitability of water samples. After that, potential participants are invited to register, a process performed now twice a year, when six to eight rounds are proposed. On this occasion, potential participants are informed about the analytes included, concentration ranges and expected timeframes for samples dispatch and for returning results.

A technical adviser is appointed for each round with the role of supervising the whole progression of the proficiency testing process. The technical adviser takes part in the formulation of instructions for testing, overviews the statistical analysis of results, contributes with commentaries for the final report and provides consultancy for any technical matters arising from that round.

The samples are dispatched according to the pre-advised schedule and the results are requested to be returned within two weeks from the date of dispatch. An additional week is granted to laboratories having difficulties meeting the return deadline.

All rounds of the program involve quantitative measurements of various parameters of water. The results returned are numerical values and, after they are inspected to make sure they resemble normally distributed data, the performance of participants is evaluated by assigning a robust z-score to each result. Robust statistical analysis is employed to avoid strong influence of possible extreme data on calculated statistics and z-scores. The assigned value for the parameters tested is the consensus value arising from that round [2]. For the Waters (Chemical) proficiency testing program, this is represented by the median of all results, a robust statistic. The normalised interquartile range (NIQR), also a robust statistic, is used to estimate the standard deviation of the results data set.

The robust z-scores measure the departure of each result from the median. Results which have a robust z-score with an absolute value less than or equal to 2 are considered to be “satisfactory”, between 2 and 3 “questionable”, and greater than or equal to 3 are considered to be “outliers”. Laboratories are encouraged to review their “questionable” and “outlier” results.

The outcomes are communicated to participants first through a summary report. This is issued to each participant and outlines the participant's reported results and the associated robust z-scores, together with corresponding statistics, for each parameter. At the end of each round, a final report is prepared comprising extensive details and commentaries. In the present form, the final report shows a synopsis of all outliers and questionable results, commentaries regarding the most frequent methods used, data related to measurement uncertainties reported by participants, estimates of reproducibility and graphical representations of results. For confidentiality, participants are identified in the final reports only through code numbers. The final reports are now made publically available on the PTA website.

One of the important challenges the program faced was ensuring confidential data were not identifiable in published reports. At the beginning, a unique identification code was assigned to each participant when first joining the program, however, it was revealed that in time the unique codes could be recognised. To limit this possibility, the identification codes are changed each year.

4 FEEDBACK FROM PARTICIPANTS

There has been continued interaction between the program coordinators and the participating laboratories, who are in turn encouraged to communicate their comments or suggestions about the program when submitting results.

Inevitably, the ways we communicate have changed since 1992 when the post, fax and telephone were the main channels for information exchange. The PTA website is a crucial interface between company and customers. While the traditional methods are still accepted, the communication between program coordinators and participants is now mostly by email, which is also the preferred method of reporting results. Moreover, starting in 2014, a newly developed service gave participants in the Water (Chemical) proficiency testing program the opportunity to submit and access their results online.

Participant feedback is welcomed at any time, however, in a systematic approach, participant feedback was sought via three separate surveys performed in 2001, 2007 and 2010. The surveys included between 23 to 26 questions arranged around five sections: Organisation, Statistical Analysis, Technical Validity, Laboratory Performance / Follow Up and General. The percentage of respondents rating the program as "Excellent", "Very Good" and "Good" in these surveys did not change significantly, varying between 94%-100%, showing that the program was well received (Figure 3). Suggestions from participants, indicating the need for new parameters, new sample matrices as well as an increased frequency of rounds offered each year, are evidently reflected in the program's evolution.

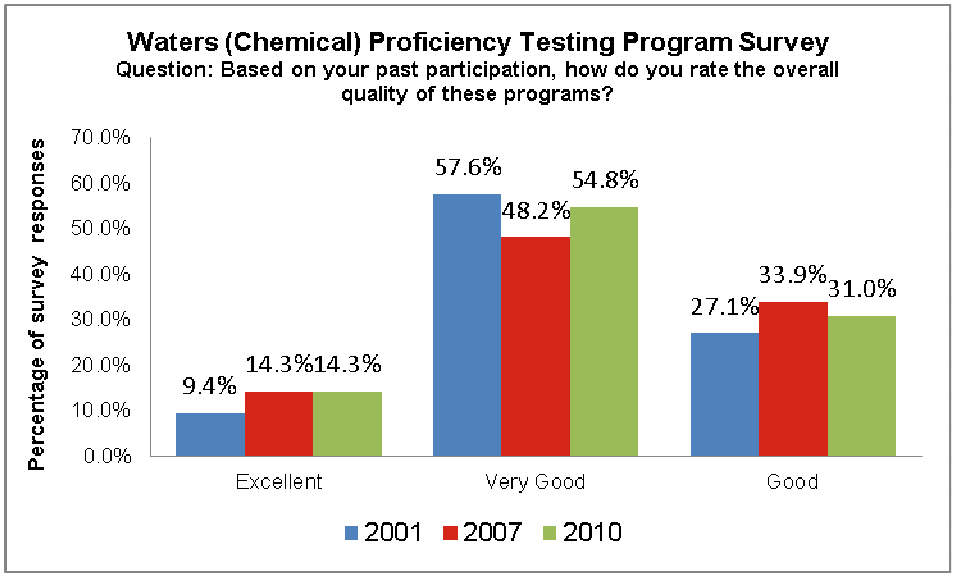

Figure 3. Waters (Chemical) proficiency testing program: Overall ratings of "Excellent", "Very Good" and "Good" by participants in 2001, 2007 and 2010 surveys.

5 A SNAPSHOT OF THE PROGRAM

The role of proficiency testing for assessing analytical performance is widely accepted. To have an insight into the Waters (Chemical) proficiency testing program an assessment of the performance of participants for one parameter was conducted to consider possible correlations between performance and regular participation, over a seven year period.

The parameter, Biochemical Oxygen Demand (BOD), was chosen as being one of the most frequently offered in the program, at approximately once a year. The timeframe, between 2007 and 2014, corresponds to the time the program has been conducted under the PTA name and was considered as the data were readily available.

Thus, between 2007 and 2014, six rounds of the BOD testing were performed and 123 different laboratories submitted results. Laboratories were grouped in three categories, based on the number of participations: one round, two or three rounds and four to six rounds.

On average, laboratories which participated in four to six rounds had 90% satisfactory results, those participating in two or three rounds had 80% satisfactory results and those participating in one round had 76% satisfactory results. The study indicates that laboratories which participated in four to six rounds had a higher proportion of satisfactory results than to those participating in two or three rounds (90% vs. 80%, χ_1^2 =4.61, p=0.032) and than those participating in only one round (90% vs. 76%, χ_1^2 =6.85, p=0.009).

6 CONCLUSIONS

The Waters (Chemical) proficiency testing program offers an external quality control tool assisting laboratories to evaluate their analytical performance. The program has developed since 1992 to include a large variety of chemical parameters monitored for water quality. The frequency of the rounds of the program has more than doubled since 1992, with now 16 rounds being performed each year.

Participants in the program are mainly from Australia and other Asia-Pacific countries. Several surveys of participants show that the program is well received and outline the need for further development.

PTA intends to expand the Waters (Chemical) proficiency testing program to continue to meet the demand from those involved in water testing. For more than 20 years, the program has provided an opportunity for laboratories testing chemical parameters in water to monitor their testing performance.

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