QUALITY CONTROL IN DIFFUSIVE SAMPLING NETWORKS

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1. INTRODUCTION

The urban centres are growing extremely quickly throughout Latin America and, as a consequence air pollution is also growing due to increasing traffic. The Clean Air Programme, financed by the Swiss Agency for Development and Cooperation (SDC), was carried out by the Swiss Foundation for Technical Cooperation (Swisscontact) was carried out in 6 Central American cities [1]. The project's goal was to initiate the active implementation of environmental protection laws by supporting state-run and private institutions. This goal can be broken up in four different aspects:

1. Establishing the basic legal framework, technical norms and standards
2. Fostering a positive awareness of the urban population in regard to the issues of environmental protection and conservation
3. Training technical staff in exhaust gas monitoring of diesel and petrol vehicles
4. Measuring the main air pollutants for information purposes and in order to assess the performance of already implemented measures.

The diffusive sampling technique was implemented in 6 different institutions in the framework of the Clean Air Programme for Central America, taking place in 6 countries of the region. The quality of measurements was maintained in two ways: a) human aspect: continuous training of personal by means of seminars and external audits and b) the technical side via analysing standards and spiked samplers from a reference laboratory. This aspect has proven to be a prerequisite because the air pollution data were published in the mass media immediately.

2. PROCEDURE OF QUALITY ASSURANCE

2.1 Human Aspect

The human aspect is best evaluated by external auditing through an independent expert. A check list was worked out and some key points were evaluated by the auditor. A pragmatic evaluation system was established in order to measure the performance of the institutions. As key indicators were chosen:

Control aspect	Criteria used			
Application and following the common manual [2]	Not in use	Mixed with other descriptions	Some minor deviations	Complete accordance
documentation in the laboratories, control charts	none	Partly missing	Documented occasionally	Fully documented regular charts
Treatment of chemicals	Reagents not labelled			Properly stored and labelled
maintenance of equipment	none	LOG book no records	LOG book not regular	LOG book regular
Scores	0 -25	25 – 50	50 – 75	75 - 100

Table 1: Control aspects and criteria used in order to rate the laboratories

2.2 Analytical Aspects

The analytical chain for the measurement of air pollutants by means of diffusive samplers is as follows:

Steps of chain	Control items	Components or uncertainty
Manufacturing ↓	Deviation of samplers produced in remote labs [L]from samplers produced in reference Lab[R]	$u_M^2 = \frac{(SetR\text{-}SetL)^2}{3}$
Sampling ↓	Standard deviations of multiple samples	σ_p^2
Analytical procedure ↓	Deviations of analyte from known concentration Variation of calibration's slope	$u_A^2 = \frac{(c_{ref}\text{-}c_{lab})^2}{3}$ u_s^2
Calculation, overall	Comparison with spiked samplers from reference lab	$u_C^2 = \frac{(c_{ref}\text{-}c_{lab})^2}{3}$

Table 2: Analytical chain and contribution to uncertainty for passive sampler measurements

u_M: The manufacturing process was evaluated by exposing two sets of samplers at the same place: one set was manufactured by the remote lab and one set was prepared by the reference lab. A rectangular distribution was assumed.

σ_p :The variation of multiple samplers includes the microenvironment of a exposure site as well as the work performance by the laboratory personal.

u_A The deviation of laboratory measurements of the analyte with reference samples from traceable standards of the reference laboratory is a measure of accuracy of the specific laboratory. u_s : The variation of the slope of different analytical series of analytical reagents over a six month period.

$u_{C:}$ The comparison of spiked samplers give an indication on the lab's overall accuracy. Also computeral aspects are involved.

The quantitative output of the control items can be considered as contribution to the uncertainty of measurements in addition to the reference laboratory. The technical performance of the laboratories can be expressed in term of combined uncertainty. In these procedure, some double counting of uncertainties occurs e.g. Analytical procedure and comparison of spiked samplers. In order to rank the laboratories and to follow the quality trend, this was accepted. The quality score was calculated according the following equation:

$$u_t = \sqrt{u_M^2 + \sigma_p^2 + U_A^2 + u_s^2 + U_C^2} \quad \text{in } \%$$

The project lasted three years. In this time some parameters were available after some running time e.g. variation of calibration curve was available after one year. The manufacturing process was monitored in its entirety only for ozone and NO2 less frequently. The comparison of analytical standards was skipped after two years. So missing values were replaced with the mean of the existing values of a laboratory.

2.3 Spiked samplers

The reference Laboratory was equipped with a calibration system of Umwelttechnik GmbH, Ober- Mörlen Germany. Calibration gas is produced by constant emission of substances out of permeation devices in a temperature controlled heating chamber.

The weight loss of permeation tubes can be easily measured using a high precision balance. The air flow is measured by a piston flow meter. Both, weight and flow measurements are traceable to national standards [3].

A constant ozone source is available in the same equipment. The concentration is measured by UV Ozone Monitor Model 8810, which is calibrated regularly by the Swiss Federal office of Metrology and Accreditation.

For each institution 6 samplers were exposed and together with 6 blanks shipped to the laboratories, together with the reference samples of analyte, in this case nitrite.

3. RESULTS

3.1 Human aspects

In Figure 2 the summary scores over the project period are presented.

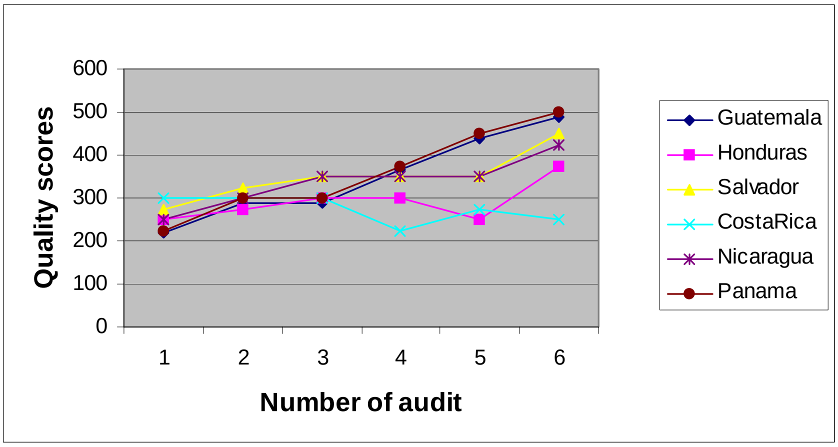
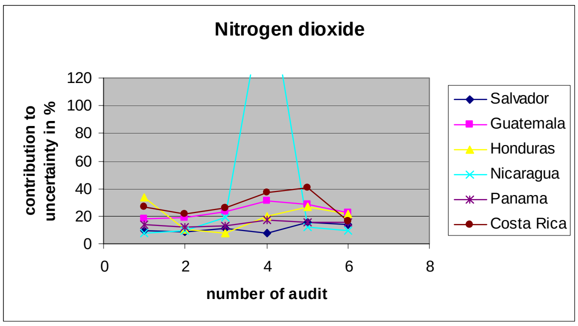


Figure 2: Trend of summary scores over the project period

The indicators for the human aspects in the institutions show an amelioration over the three years. Only two institutions reached the maximum level of 500 points. The quality for one laboratory decreased until the end of the project.

3.2 Analytical Aspects

The following figures show the development of combined uncertainties over the period.



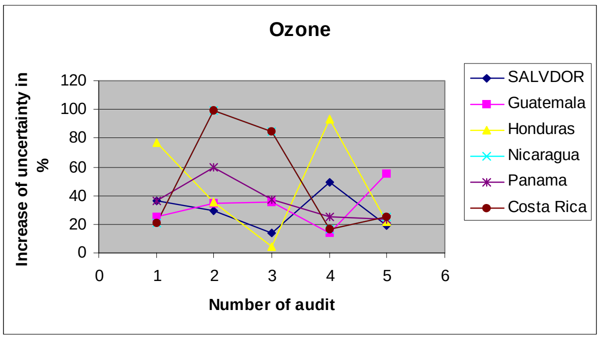


Figure 3: Trend of additional uncertainty over the project period.

The graphs show the following: there are laboratories with a continuous level (Salvador) and others had variation during the project phase. At the end, all laboratories reached a similar quality level.

Ozone samplers show a great variation. This is mainly caused by the production of the samplers. Also here, at the end of the project, the quality was acceptable.

4. CONCLUSIONS

The participants reported that the regular seminars following the audits were helpful and contributed to increase the information flux between the institutions.

The figures show, that there is a long way until the laboratories came up with a satisfactory quality. One reason might be, the turnover of employees amongst the laboratories.

The production of samplers should be centralized in a good performing laboratory

The results show, that is not enough to do a check once, but continuously in regular periods.

5. REFERENCIES

[1] M. Hangartner and B. Lang: Air Pollution Abatment in Central America. WHO Newsletter, July 1999

[2] Manual de Laboratorio: Programa Aire Puro para Centro America. Swisscontact, Agosto 2001

[3] M. Hangartner: Practical Approach of Uncertainty Measurement in Ambient Monitoring by Diffusive Sampling. International Conference: QA/QC in the field of Emission and Air Quality Measurements, Harmonisation and Accreditation. Praha, 21 – 23 May 2003.

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