PORTUGUESE ENVIRONMENT AGENCY

Control and Quality Assurance (QA/QC) in the Network of Air Quality Stations in Portugal under the Directive EU 2015/1480

National Reference Air Laboratory (NRL)

João Matos, Nuno Oteda, Susana Casimiro

REPÚBLICA PORTUGUESA

ENVIRONMENT


http://www.apambiente.pt
AGÊNCIA PORTUGUESA DO AMBIENTE
PORTUGUESE ENVIRONMEN T AGENCY

1. APA: FACTS AND FIGURES

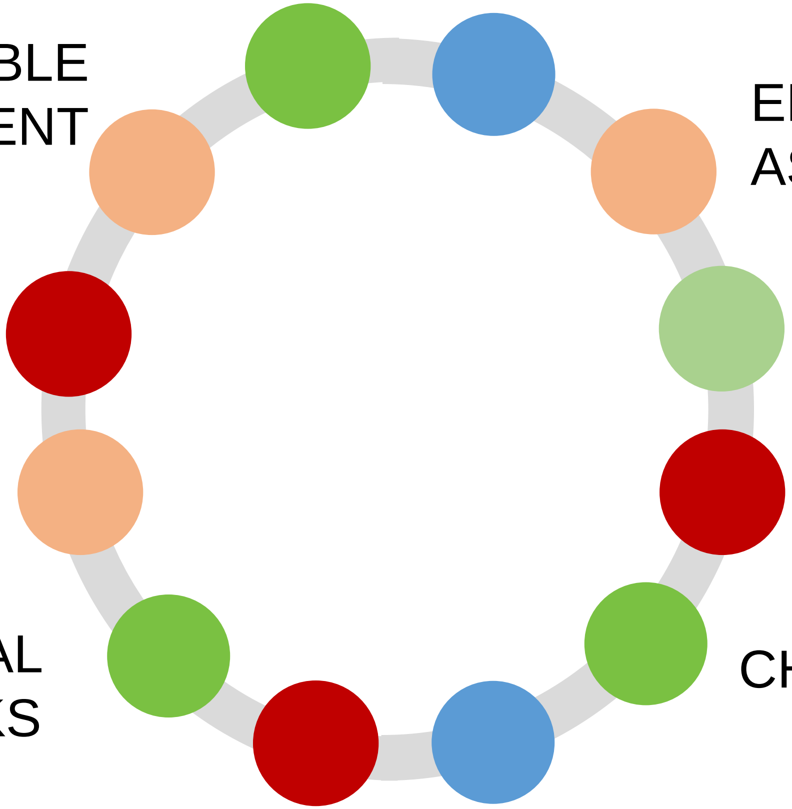
A APA is a modern public organization, created in 2012 in result of a merging process involving 9 different institutes.

MİSSİON

APA is the national public body whose mission is to develop and monitor the management of environment and sustainable development policies.

It works in close cooperation with other public, private and non-governmental organizations, to ensure a high level of protection and enhancement of environmental systems.

MAİN AREAS OF ACTİVİTY



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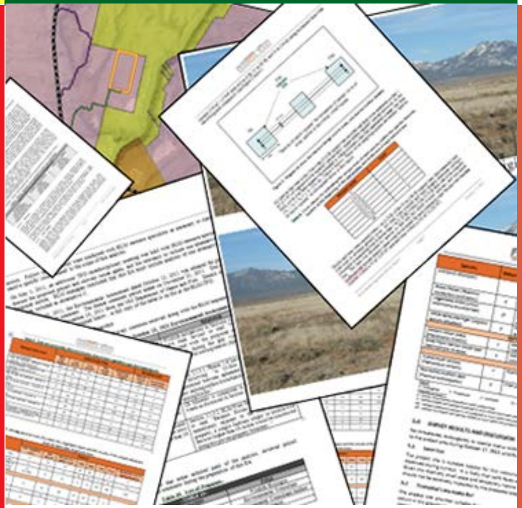
APA NATIONAL

Water Resources Monitoring Network

Environmental Documentation Center

Laboratorial Network

Air Radioactivity Monitoring and Warning Network



Air Quality Network

2. Air Quality – Directive 2015/1480 EC (Amends several Annexes to Directives

- Sets more detailed and stringent rules on collecting data and data validation.

- Prescribes newer reference methods for the sampling and analysis of arsenic, cadmium, nickel, polycyclic aromatic hydrocarbons, mercury in ambient air, and their deposition.

- Prescribes more recent reference methods for the assessment of concentrations of sulphur dioxide, nitrogen dioxide and nitrogen oxides, particulate matter (PM_{10} and $PM_{2,5}$), carbon monoxide and ozone.

- Member States' National Air Quality Reference Laboratories (NRL) are now obliged to follow air quality assurance programmes organized and evaluated by the JRC.
  - Periodicity: participate at least <u>every three years</u>
  - Report to the JRC on measures taken to remediate unsatisfactory results.

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3. NATIONAL REFERENCE LABORATORIES

Implementing a Quality System (QA/QC) in the network by NRL

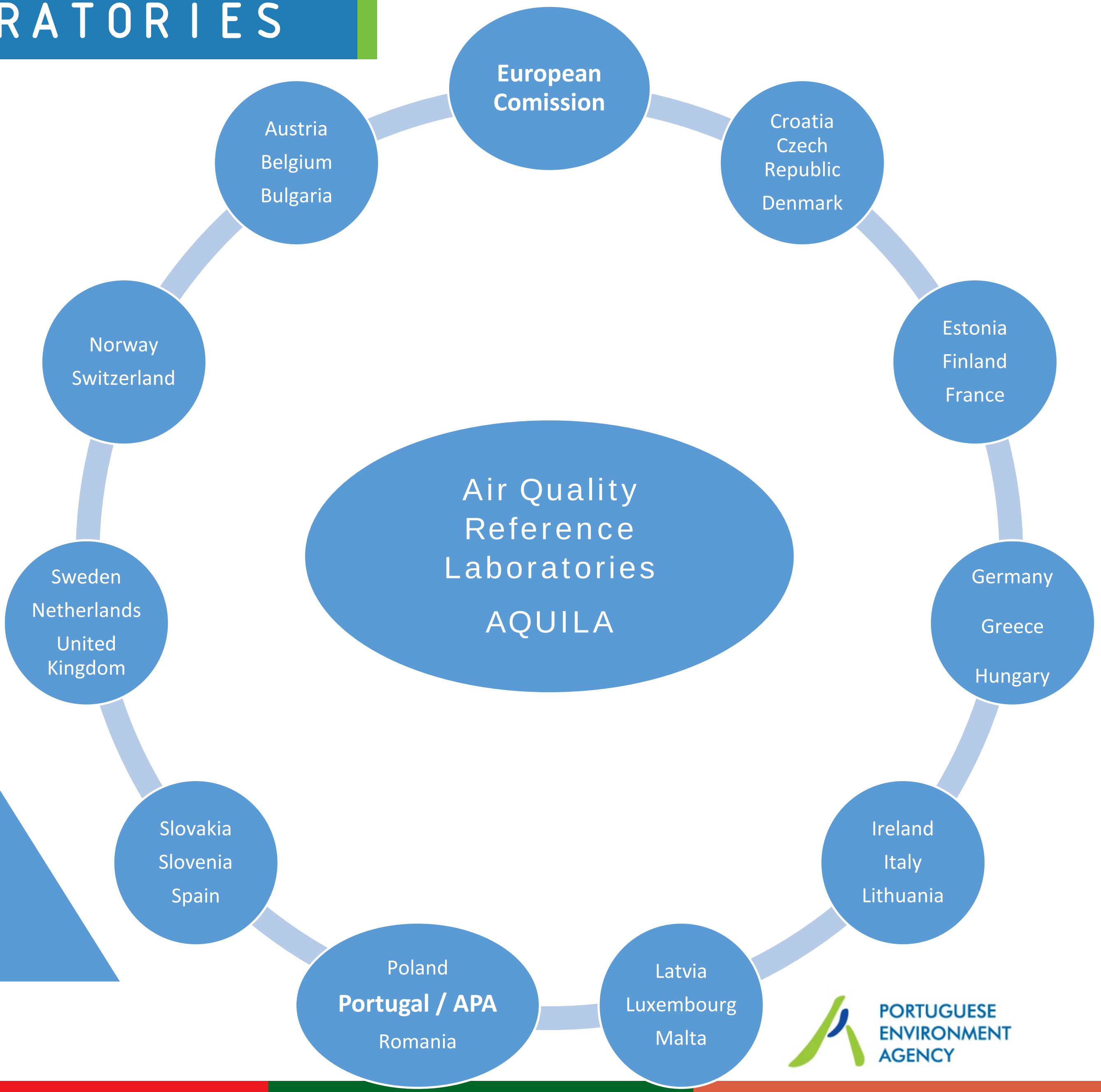
Approving measurement systems (instruments, laboratories, networks)

Ensuring the traceability of the measurements at national level by providing/certifying materials to netwoks

Organizing intercomparisons / Round Robin tests at national level and participating in European Commission QA/QC programmes

Responsible for demonstration of equivalence of ambient air monitoring methods

Exchanging information through the organization of training sessions, workshops, conferences and guidance documents



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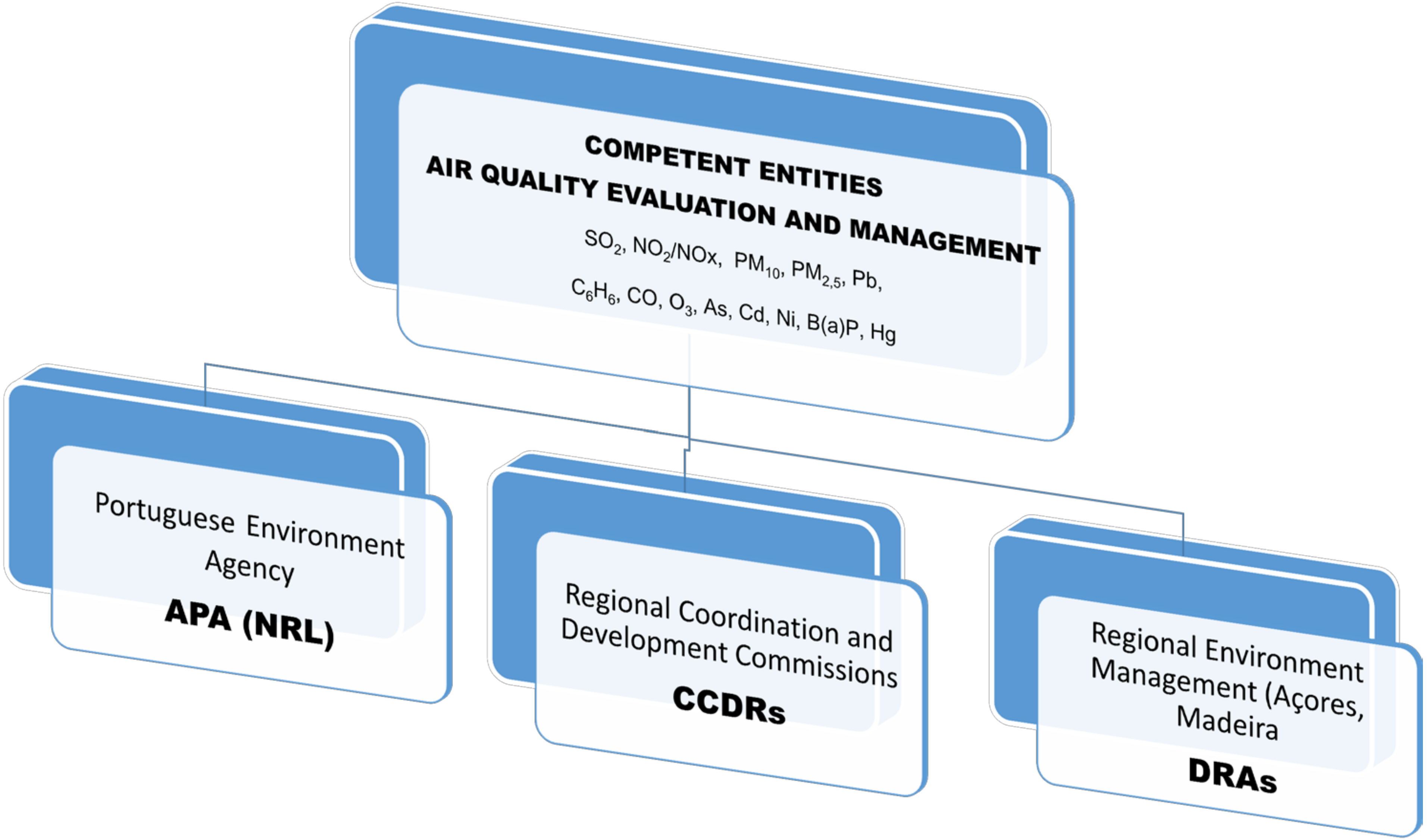
4. AIR QUALITY



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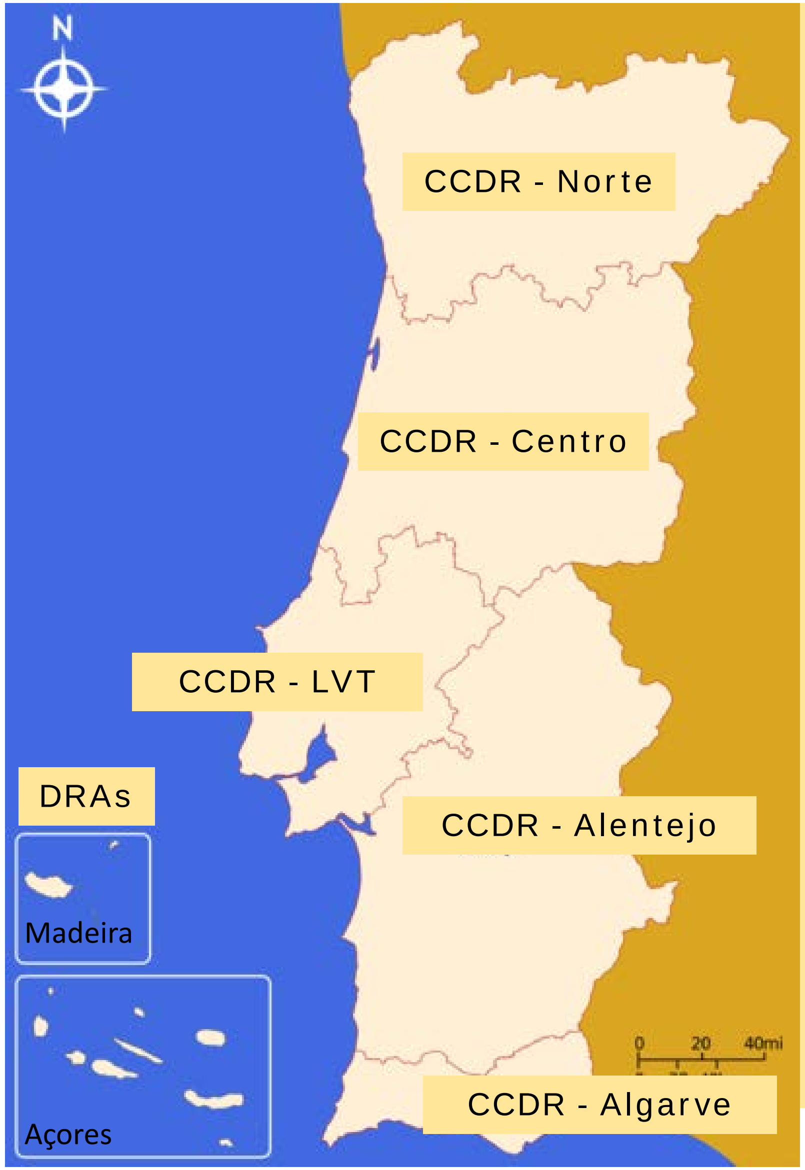
AIR QUALITY NETWORK – QualAr – On-line Air Quality Database



CCDR – Norte
21stations

CCDR – Centro
8 stations

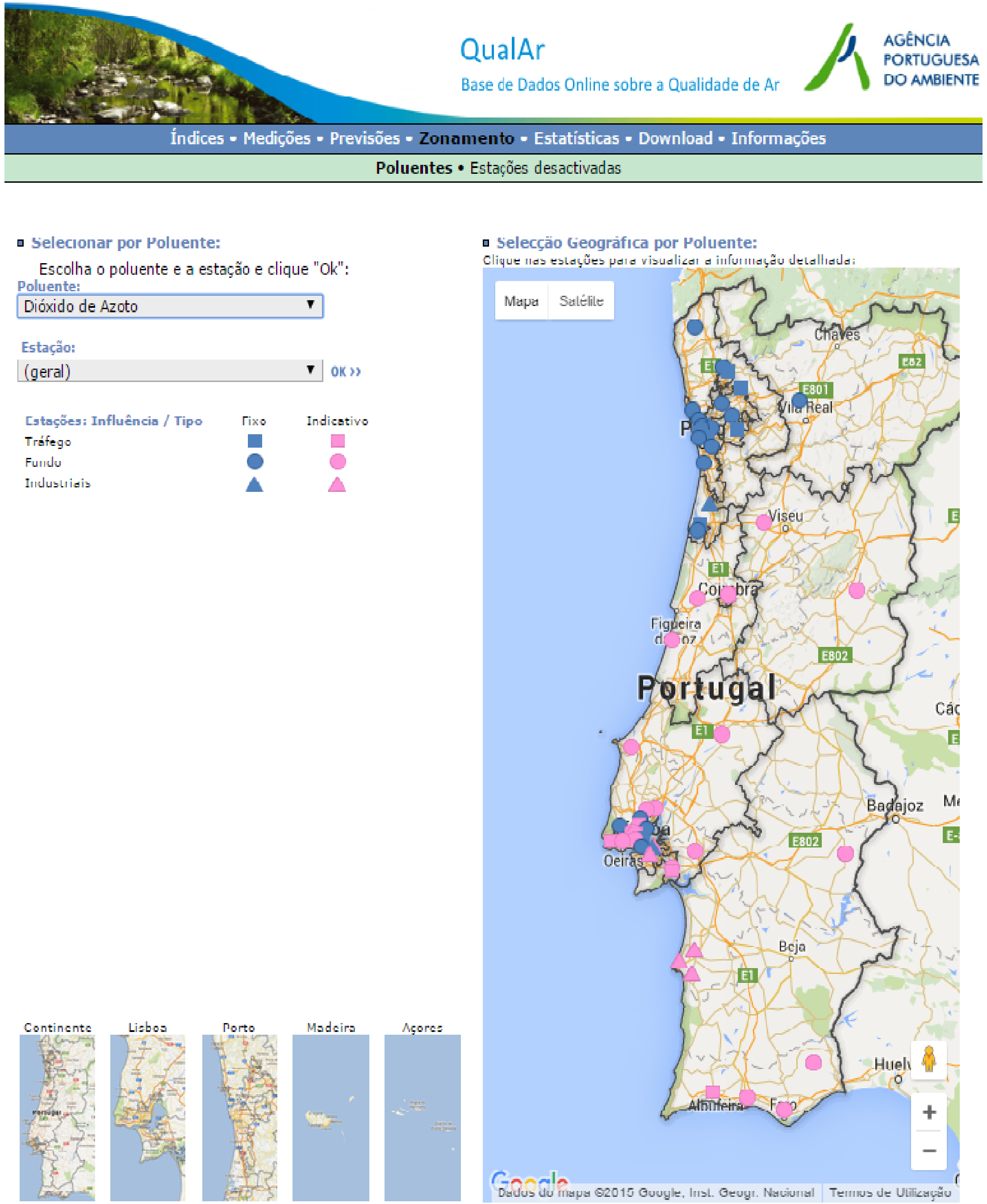
CCDR – LVT
23 stations

CCDR – Alentejo
5 stations

CCDR – Algarve
4 stations

Madeira
3 stations

Açores
1 station



QUALITY ASSURANCE / QUALITY

NRLs

Accreditation (EN ISO 17025)

Accredited laboratories (EN ISO 17025) and approved by NRL / APA

Quality Control/Quality Assurance

Certification of analysers

- Before commercialization the manufacturers submit analysers for type approval according to reference methods (CEN regulations) to accredited laboratory (EN ISO 17025) and competent authorities of Certification (EN 15267-1 and EN 15267-2)

Analysers approval in monitoring stations

- CCDRs/DRAs submit analyser approval to NRL accredited by EN ISO 17025

Annual Reporting

- CCDRs/DRAs submit yearly analysers to NRL to compliance with ***Data Quality Objectives*** *of* Directive

Audits to network stations

- Audits of the Quality System / Compliance with Data Quality Objectives (DQO)

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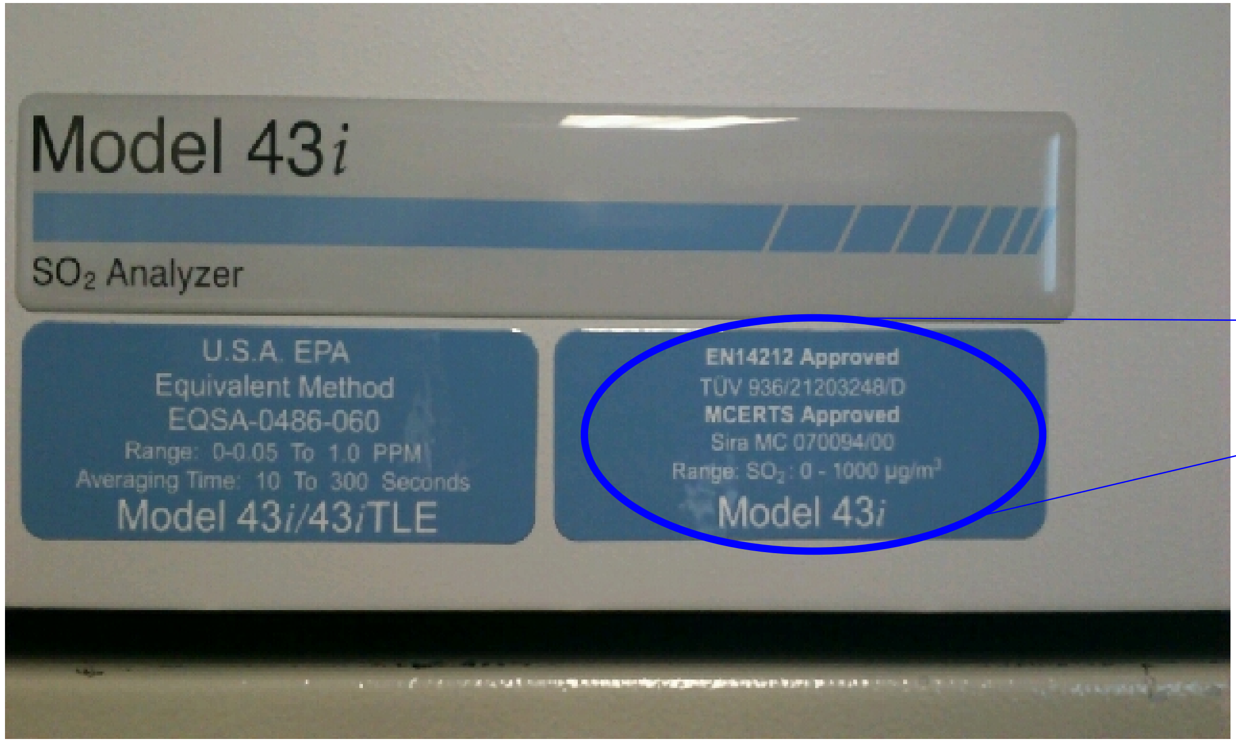
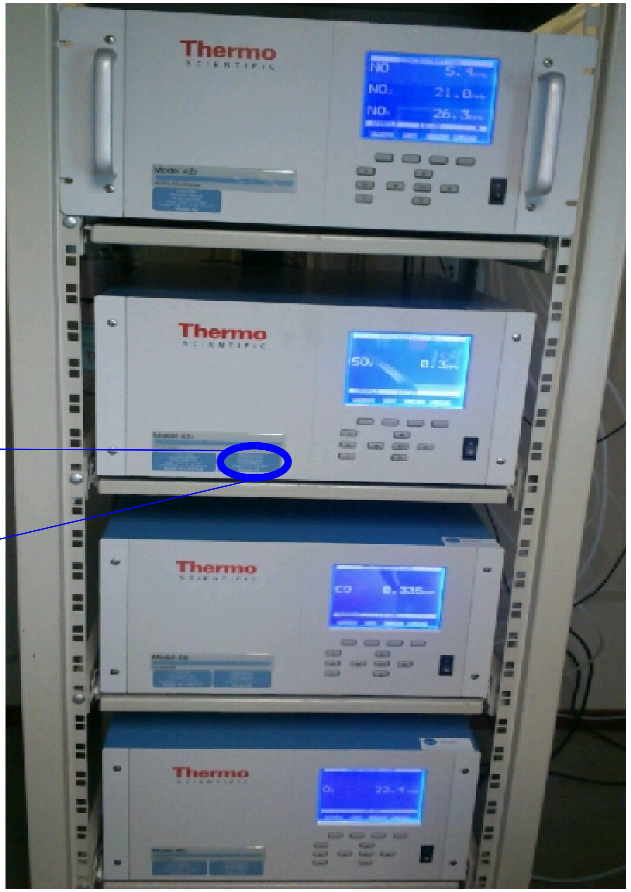
ANALYSER

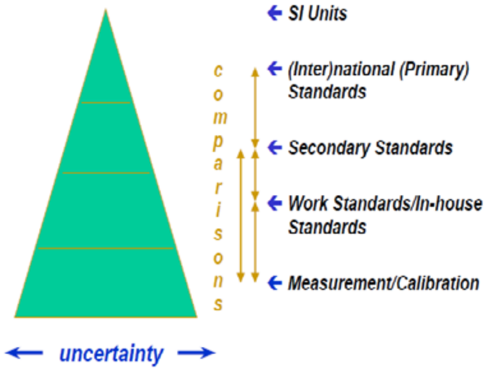

Model 43i
SO2 Analyzer
U.S.A. EPA
Equivalent Method
EQSA-0486-060
Range: 0-0.05 To 1.0 PPM
Averaging Time: 10 To 300 Seconds
Model 43i/43iTLE
EN14212 Approved
TÜV 936/21203248/D
MCERTS Approved
Sira MC 070094/00
Range: SO2: 0 - 1000 µg/m3
Model 43i


Thermo
Thermo
Thermo
Thermo

- Calibration gases used BTEX, CO, SO_2, NO/NO_2, by NRL / APA (VSL, NPL, NIST) are traced to national and/or international standards.

- The maximum allowed uncertainty to the calibration of the analysers at stations including dilution system for continuous operations is 5% for a 95% confidence level.

- The zero gas used, may not have a concentration greater than the detection limit of the analyser.



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OZONE PRIMARY STANDARD SRP 25 NIST (NRL / APA)

COMPARISON EXERCISES OF OZONE PRIMARY STANDARD SRP 25

839.03-08-049

Comparison of ozone reference standards of the APA and the BIPM (December 2009)

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Abstract

A comparison of the ozone reference standards of the Agência Portuguesa do Ambiente (APA) and of the Bureau International des Poids et Mesures (BIPM) has been performed. Both institutes maintain Standard Reference Photometers (SRPs) developed by the National Institute of Standards and Technology (NIST) as their reference standards. The instruments were compared over a nominal ozone mole fraction range of 0 nmol/mol to 500 nmol/mol and the results showed good agreement.

839.03-06-074

U.S. Department of Commerce
National Institute of Standards and Technology
Chemical Science and Technology Laboratory
Analytical Chemistry Division
Gaithersburg, MD 20899

REPORT OF ANALYSIS

February 9, 2006

Validation of NIST Standard Reference Photometer, serial number 25

Submitted to:

Instituto do Ambiente, Lisbon, Portugal

Job # 6036

The NIST Standard Reference Photometer, serial number 25 (SRP 25) owned by the Instituto do Ambiente (IA) was validated by comparison with the NIST Standard Reference Photometer, serial number 0 (SRP 0) (NIST's traveling ozone standard) during the period November 15-30, 2005. The relationship between SRP 0 and SRP 2 (NIST's highest level ozone standard) was checked before traveling to the IA during the period October 27 – November 1, 2005, and after returning to NIST during the period December 7-9, 2005.

Each comparison run performed in this report consisted of measurements of ten different concentration levels and two measurements of zero concentration. The measurements of the ten concentration levels were randomly ordered, while the measurements of zero concentration were obtained at the beginning and end of each comparison run. In all comparison runs sampling was done using a dual external manifold with 1-meter sample and reference lines feeding into the inlet ports on each SRP allowing all instruments to sample the same gases from the same source manifolds.

The results obtained by NIST Standard Reference Photometers are based on a molecular absorption coefficient of 308.32 $cm^{-1} \times atm^{-1}$ (natural logarithm base) [1] referenced to 273.15 K and 101.3 kPa for ozone at 253.7 nm. The uncertainty with which the SRP assays ozone is fundamentally dependent on the uncertainty of the value of the ozone absorption coefficient at 253.7 nm. The estimated expanded standard uncertainties [2] of the SRP ozone concentration measurements are 1 ppbv[a] (absolute) in the 0 ppbv to 100 ppbv range and 1 % (relative) in the 100 ppbv to 1000 ppbv range. SRP measurement uncertainties are being re-examined and will change in the near future.

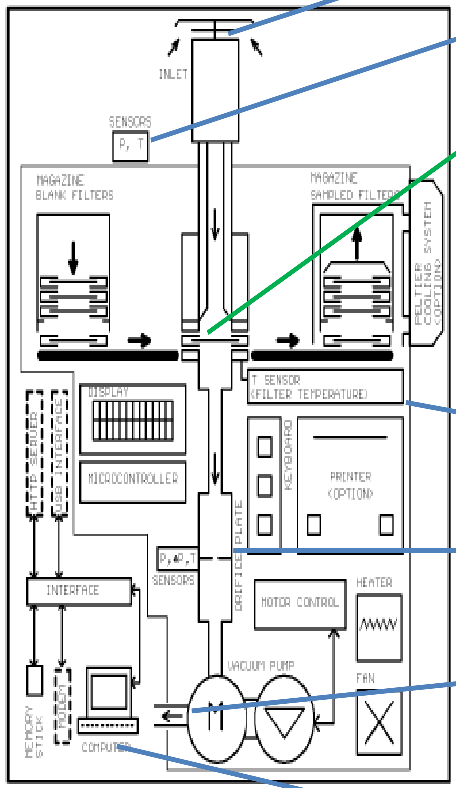
Experimental:

An initial set of 56-comparison runs were done at NIST between SRP 0 and SRP 2 over an average ozone concentration range up to 933 ppbv during the period October 27 – November 1, 2005. SRP 0 was then transported and delivered to the IA laboratory where it was setup and powered on around 12:00 PM on November 14, 2005 and allowed to warm up overnight. The operating

[a] The unit parts per billion by volume (ppbv), which is equivalent to nmol/mol, is most commonly used in ozone calibration work and hereafter will be exclusively used in this report.

MEASUREMENTS TRACEABILITY OF PARTICULE MATTER PM_{10} /

partículas atmosféricas $PM_{10}/PM_{2.5}$ EN 12341:2014



BLOCK DIAGRAM SEQ47/50

Valores limites de funcionamento

Cabeça de amostragem:
Especificações EN 12341:2014

Sensores da temperatura ambiente e pressão atmosférica:
Temp: ± 3 K / Calibração c/ Padrão *U(95%)* ± 1,5 K
Pressão: ± 1 KPa / Calibração c/ Padrão *U(95%)* ± 0,5 KPa

Laboratório - Pesagem do filtro ($m_{(f+p)} - m_{(f)}$):

a) Temp = 19 a 21 K; Sensor da temperatura da sala pesagem ≤ 0,2 K; Verificação Padrão *U(95%)* < 0,4 K; Calibração c/ Padrão *U(95%)* < 0,2 K;
b) HR = 45 a50% RH; Sensor da humidade relativa sala pesagem ≤ 2 % RH; Verificação Padrão *U(95%)* < 3,0 RH; Calibração c/ Padrão *U(95%)* < 2,0 % RH;
c) Resolução da balança ≤ 10 µg; *U(95%)* para intervalo 0 a 200 mg ≤ 25 µg;

Sensor da temperatura do filtro de amostragem:
$T_{amb} \geq 20$ºC, o filtro amostragem $T_{amb} - T_{ins} \leq 5$ºC;
Temp: ± 3 K / Calibração c/ Padrão *U(95%)* ± 1,5 K
Pressão: ± 1 KPa / Calibração c/ Padrão *U(95%)* ± 0,5 KPa

Sensores da pressão e da temperatura do caudal amostragem:
Temp: ± 3 K / Calibração c/ Padrão *U(95%)* ± 1,5 K
Pressão: ± 1 KPa / Calibração c/ Padrão *U(95%)* ± 0,5 KPa

Caudal amostragem (*Qv*):
2,3 m3/h
Variabilidade *instântania* ≤ 5% *Qv*; Variabilidade média ≤ 2% *Qv*
Verificação Padrão *U(95%)* ≤2,0 %/Calibração c/ Padrão *U(95%)* ≤ 1%

Tempo amostragem (*t*):
24 h ± 1 h ; *U(95%)* ≤ 5 min

AIR QUALITY

NO_2 / NO_x EN 14211:2012

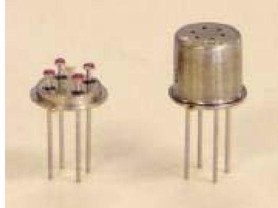
SO_2 EN 14212:2012

O_3 EN 14625:2012

CO EN 14626:2012

Benzene EN 14662:2005 *Part 3*

PM_{10} / $PM_{2,5}$ EN 12341:2014



Use of Low-Cost Air Quality Sensors

Application	Description	Example
Research	Scientific studies aimed at discovering new information about air pollution.	A network of air sensors is used to measure particulate matter variation across a city.
Personal Exposure Monitoring	Monitoring the air quality that a single individual is exposed to while doing normal activities.	An individual having a clinical condition increasing sensitivity to air pollution wears a sensor to identify when and where he or she is exposed to pollutants potentially impacting their health.
Supplementing Existing Monitoring	Data Placing sensors within an existing state/local regulatory monitoring area to fill in coverage.	A sensor is placed in an area between regulatory monitors to better characterize the concentration gradient between the different locations.
Source Identification and Characterization	Establishing possible emission sources by monitoring near the suspected source.	A sensor is placed downwind of an industrial facility to monitor variations in air pollutant concentrations over time.
Education	Using sensors in educational settings for science, technology, engineering, and math lessons.	Sensors are provided to students to monitor and understand air quality issues.
Information/Awareness	Using sensors for informal air quality awareness.	A sensor is used to compare air quality at people’s home or work, in their car, or at their child’s school.

Source: US EPA

SENSORS: CHALLENGES AND

- Due to their "low-cost" and ease of use, such devices also have the potential of becoming highly effective tools for introducing and engaging students and community groups in air quality matters.

- There are no independent objective means by which these devices can be evaluated, and data from these monitors are usually accepted at face value with no opportunity to evaluate their accuracy and overall quality.

- Preliminary tests performed in the U.S. and in Europe seem to suggest that many of the commercially available air monitoring sensors have poor to modest reliability, do not perform well in the field under ambient conditions, and do not typically correlate well with data obtained using "standard" measurement methods employed by regulatory agencies.

LEGAL FRAMEWORK

- No defined EC policy for the use of low-cost sensors for ambient air monitoring.
- Research on sensors is mainly financed with project funds and focus essentially on sensor material research or sensor applications. Data quality is not the main focus.
- The legal framework is the one of the air quality Directive: DQO for indicative measurements and objectives estimations. A new category called “informative method” without DQO.
- Little information is publically available about independent sensor evaluation, correction algorithms and software/electronic design of sensor platforms.
- Looking for independent evaluation of sensors.
- CEN TC264 (Air Quality), Working Group 42 (Sensors) is developing a protocol for sensor evaluation.

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PROGRESS SO FAR

- US Environmental Protection Agency

  Provide information how to select and use low-cost, portable air sensor technology and understand results from monitoring activities. The information can help the public learn more about air quality in their communities.

  √ **Information available**: https://www.epa.gov/air-sensor-toolbox

- South Coast Air Quality Management District has established the **Air Quality Sensor Performance Evaluation Center** to evaluate these devices in both the field and laboratory

  √ **Reports available:** http://www.aqmd.gov/aq-spec/evaluations#&MainContent_C001_Col00=2

PROGRESS SO FAR

- Research projects on sensors (mainly financed with public call for projects) FP7, H2020, life projects (many projects > 30)

European Comission-JRC
Gerboles M. *et al.;* Spinelle L. *et al., etc.*
√ **Reports available:**
ftp://ftp_erlap_ro:3rlapsyst3m@s-jrciprvm-ftp-ext.jrc.it/ERLAPDownload.htm

Norwegian Institute for Air Research (NILU)
Nuria Castell - project coordinator for CITI-SENSE project
30 partner institutions from Europe, South Korea and Australia. The project provides new opportunities for citizens in 9 European cities to monitor their local environments, as well as including indoor air measurements in selected school buildings.
√ **Information available : http://citi-sense.nilu.no/**

PROGRESS SO FAR

- **Next Aquila meeting (15th /16th November)**
  √Sensors – “ILC”

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CONCLUSIONS ON

- Low-cost sensors are a **promising technology**, with a rapid evolution in the market and performance of the sensors is improving.

- **Data quality is a main concern**. For many sensor platforms (even commercial), the error characteristics, long-term performance, and performance under different environment conditions hasn't been tested.

- The preliminary evaluation of the sensors' uncertainty assessing if they could reach the Data Quality Objectives (DQOs) defined by the European Air Quality Directive for indicative methods show **high uncertainty values that are exceeding the DQO**.

- The **high variability in the performance sensor to sensor**, as well as the variability in the performance depending on weather conditions or changes in emission patterns, etc. makes them difficult to use for air quality compliance applications.

CONCLUSIONS ON

- They are still in a research phase that **requires an exhaustive testing** and comprehension of the performance **of each individual sensor platform** before they can be deployed.

- For these data to be used to supplement air quality monitoring networks and for scientific research, it needs to meet a high degree of quality and **the uncertainty should be assessed**.

- The **use of low-cost sensors in combination with other sources of information** can help to reduce the uncertainty, providing more reliable results for air quality managers.

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Thank you for your attention

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