BIPM CBKT Laboratory Programmes: Metrology for Safe Food and Clean Air

R.I. Wielgosz

Bureau International des Poids et Mesures

Quality of Life Challenges for our Populations Today

The food we eat

The air we breathe

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Quality of Life Challenges for our Populations Today

What are mycotoxins?

- Toxic secondary metabolites released by fungi growing on various agricultural commodities
- **POTENT TOXINS:** cyto-, nephro- and neurotoxic, carcinogenic, mutagenic, immunosuppressive, estrogenic effects
- Produced in the field or in storage
- Acute exposure

  Aflatoxicosis (Kenya 2004, 2010)

  Pet Food (South Africa, 2011)
- Chronic exposure: Oesophageal cancer

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Quality of Life Challenges for our Populations Today

STANDARD Digital

Prevalence of aflatoxin understated

By Isaac Kalua | Updated Sun, January 22nd 2017 at 10:00 GMT +3

In 2004, 125 Kenyans died because of consuming aflatoxin-infested food. Six years later in 2010, the government issued a public safety alert after finding that aflatoxins in maize in eastern Kenya and the coastal region were above tolerable levels.

Children under 15 at huge risk of aflatoxicosis in Kenya—study

SATURDAY NOVEMBER 16 2013

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Quality of Life Challenges for our Populations Today

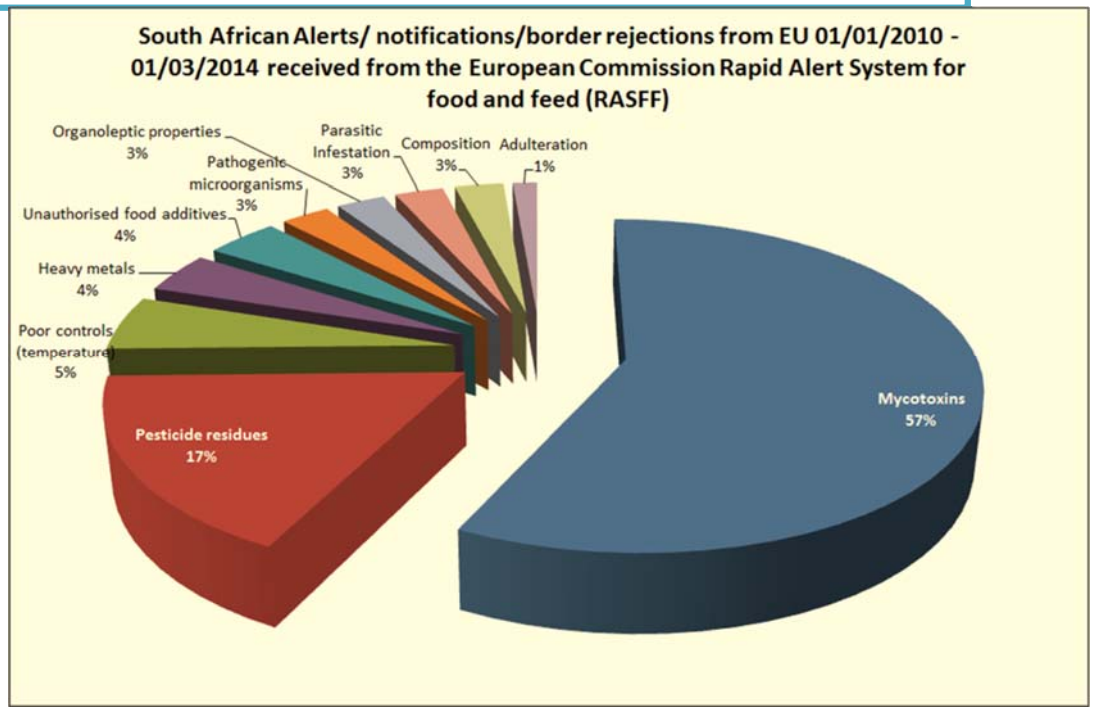
2010: Kenyan authorities reported that 2.3 million bags of maize had been contaminated with aflatoxins

2014:155,000 bags of 90kg maize disposed through incineration. *(Cabinet Secretary, Ministry of Public Service, Youth and Gender Affairs)*

Africa loses US$ 450 million a year from lost export trade to Aflatoxins

PACA- Partnership for Aflatoxin Control in Africa

FOOD BUSINESS AFRICA.COM

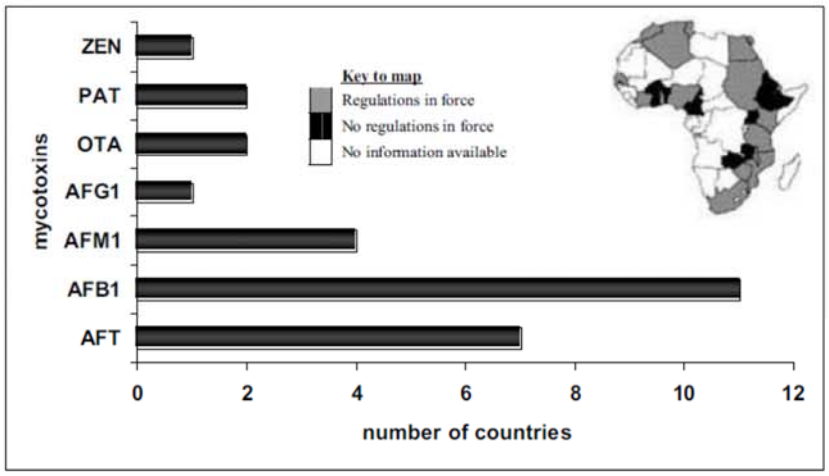


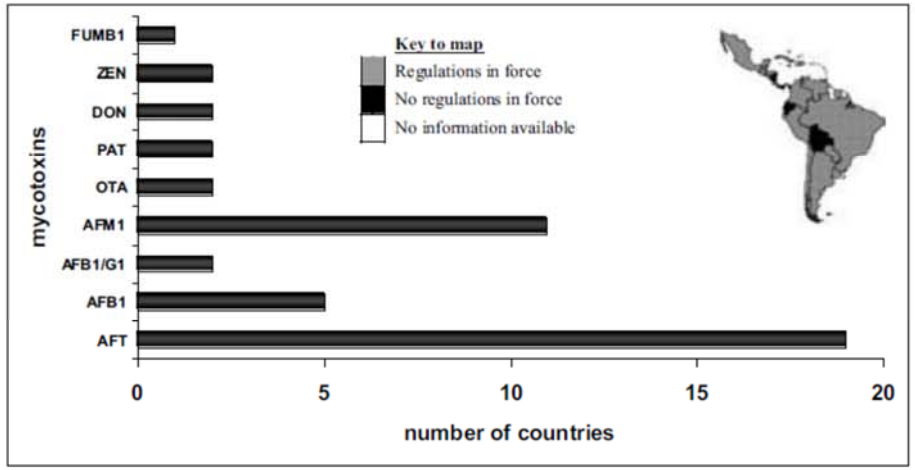
Government response: Regulation

Food and Agriculture Organisation (FAO) estimates in Asia and Africa, 8–18% of cereals are lost during postharvest handling and storage, the majority due to fungal growth and contamination with mycotoxins (toxic metabolites of fungi).

Over 100 Countries have implemented regulatory limits for mycotoxins in food and feed to protect their populations.

AFRIMETS has identified the regional need for certified reference materials to support its mycotoxin in food analysis requirements





South African Regulations:

- **Department of Health (human consumption)**
  - Aflatoxin (total)
  - **Aflatoxin B_1**
  - Aflatoxin M_1
  - *Ergot sclerotia*
  - **Patulin**

DEPARTMENT OF HEALTH, No. R. 1145 8 October 2004, FOODSTUFFS, COSMETICS AND DISINFECTANTS ACT, 1972 (ACT NO. 54 OF 1972), REGULATIONS GOVERNING TOLERANCE FOR FUNGUS-PRODUCED TOXINS IN FOODSTUFFS

- **Department of Agriculture (animal feed)**
  - Aflatoxin B1
  - **Deoxynivalenol**
  - **Zearalenone**
  - Fumonisin B1
  - Ochratoxin-A

DEPARTMENT OF AGRICULTURE, No. R. 1087 3 November 2006, FERTILIZERS, FARM FEEDS, AGRICULTURAL REMEDIES AND STOCK REMEDIES ACT, 1947 (ACT NO. 36 OF 1947), REGULATIONS RELATING TO FARM FEEDS

What can we do as Metrologists?: Needs expressed by AFRIMETS

BIPM has started in 2016 a Capacity Building and Knowledge Transfer (CB&KT) program for Metrology for Safe Food and Feed.

The CB&KT project is designed to allow the BIPM and National Metrology Institutes (NMIs) to work together to:

- ✓ strengthen mycotoxin metrology infrastructure;
- ✓ provide knowledge transfer to scientists developing capabilities in this area;
- ✓ enable NMIs to characterize selected pure mycotoxin materials, provide mycotoxin calibrants and matrix reference material and proficiency test materials to support mycotoxin testing laboratories within their countries.

Start up Meeting on Mycotoxin Metrology 15 April 2016

Capacity Building & Knowledge Transfer

NMIs committed to the Mycotoxin Metrology Capacity Building Program

2nd meeting 21 April 2017

Joined by:

CENAM – Centro Nacional de Metrología

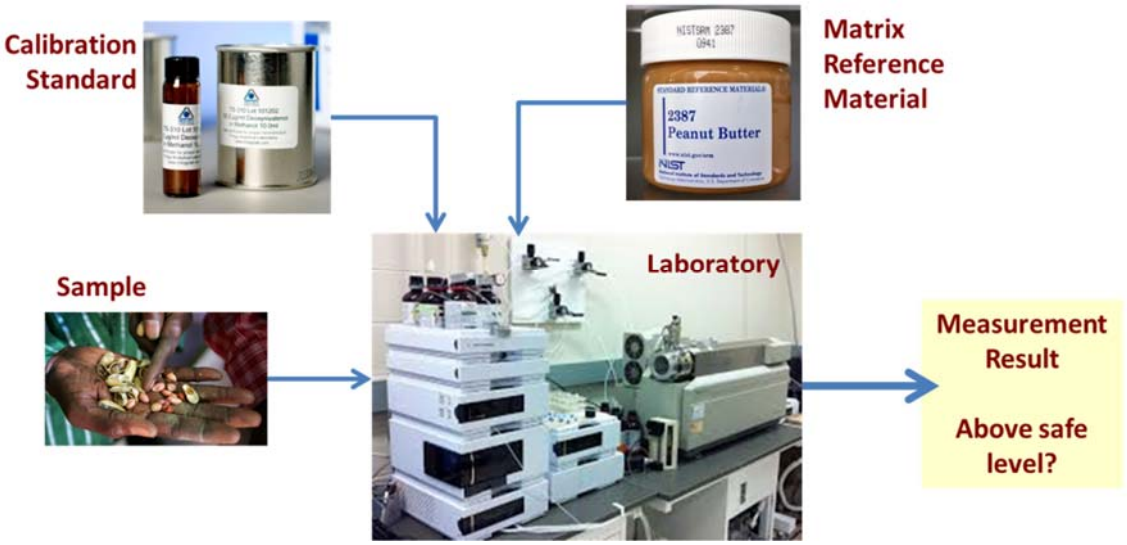
LATU

INRAP – Institut National de Recherche et d'Analyse Physico-chimique

i) Aflatoxin B1, (2018)
ii) Zearalenone,(2018)
iii)) Patulin,(2019)
iv) Deoxynivalenol, (2019)
v)) *Ochratoxin A

Mycotoxin Metrology – Laboratory Based CBKT

To establish Metrology Services for Mycotoxins, NMIs will need to demonstrate capabilities for:



a) Calibrant value assignment / production

CB&KT program at BIPM

b) Analytical methods for mycotoxins in food

CB&KT program at NMISA

c) Matrix CRM value assignment /production

CB&KT program at NIM

Start up meeting at the BIPM 15 April 2016:

'Give a man a fish, you will feed him for a day.

Teach a man to fish, you will feed him for a lifetime'

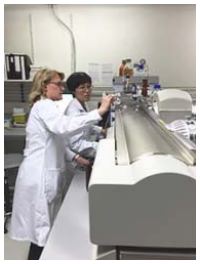
Safe Food and Feed – Mycotoxin calibrant reference materials

Capacity Building & Knowledge Transfer

Developing capabilities

BIPM + Expert visitors from experienced NMIs

- Characterization of pure, stock and calibration solutions



Dr Xiuqin Li (NIM) and Mrs A. Daireaux (BIPM) starting the characterization of mycotoxin calibrants by LC-MS analytical Methods (2016)

Transfer of knowledge

CB NMI scientists

- Learning techniques including prep of stock and calibration solutions, stability, homogeneity testing and value assignment
- Learning comparison techniques
- Receive stock solution from BIPM

For 2017 (12 week programme):
INTI, NIMT, NMISA, KEBS, INMETRO

Applying knowledge

CB NMI

- Applying the techniques at home:
- Preparing calibration solutions
- Value assignment

Demonstration competence

CB NMI

- Participation in BIPM piloted comparison to demonstrate competence

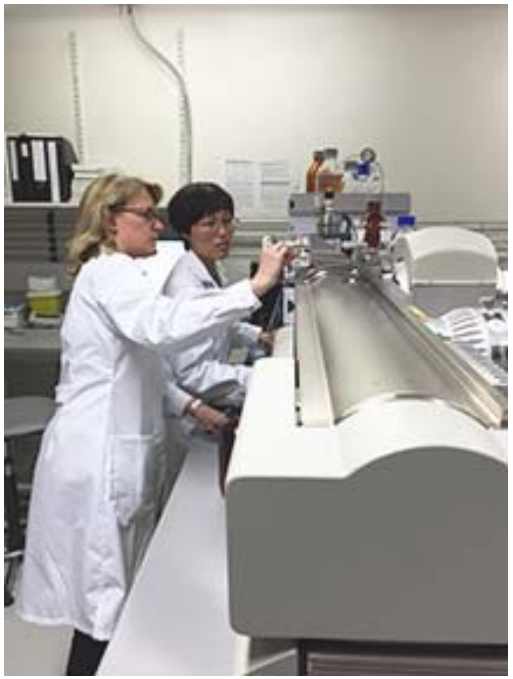
Providing services

NMI

- Self sufficient national *(and hub supporting other NMIs in the region?)*
- Providing CRMs, PT and measurements
- Running comparisons

At the BIPM → At the CB NMI → National expertise established

”Safe Food and Feed” – BIPM based CB&KT



Dr Xiuqin Li (NIM) and Mrs A. Daireaux (BIPM) starting the characterization of mycotoxin calibrants by LC-MS analytical Methods (2016)

Skills Broadening and Training Secondments established at the BIPM:

Activities covered at the BIPM:

1. Characterization of pure mycotoxin materials, stock and calibration solutions
2. Knowledge transfer and comparison of capabilities for pure material, stock solution and calibration solution value assignment
3. Coordination of an international comparison on mycotoxin calibrations solutions
4. Support of NMI programmes for mycotoxins in food

Visiting Scientists Can Choose:

TS 1: Q-trap on pure mycotoxin

TS 2: LC-UV, LC-CAD on pure mycotoxin

TS 3: EA, TGA, KF, SB and/or GC-VOCs on pure mycotoxin

TS 4: Calibration solution preparation and value assignment

SBS 1: qNMR on pure mycotoxin

SBS 2: Q-trap on pure mycotoxin

SBS 3: LC-UV, LC-CAD on pure mycotoxin

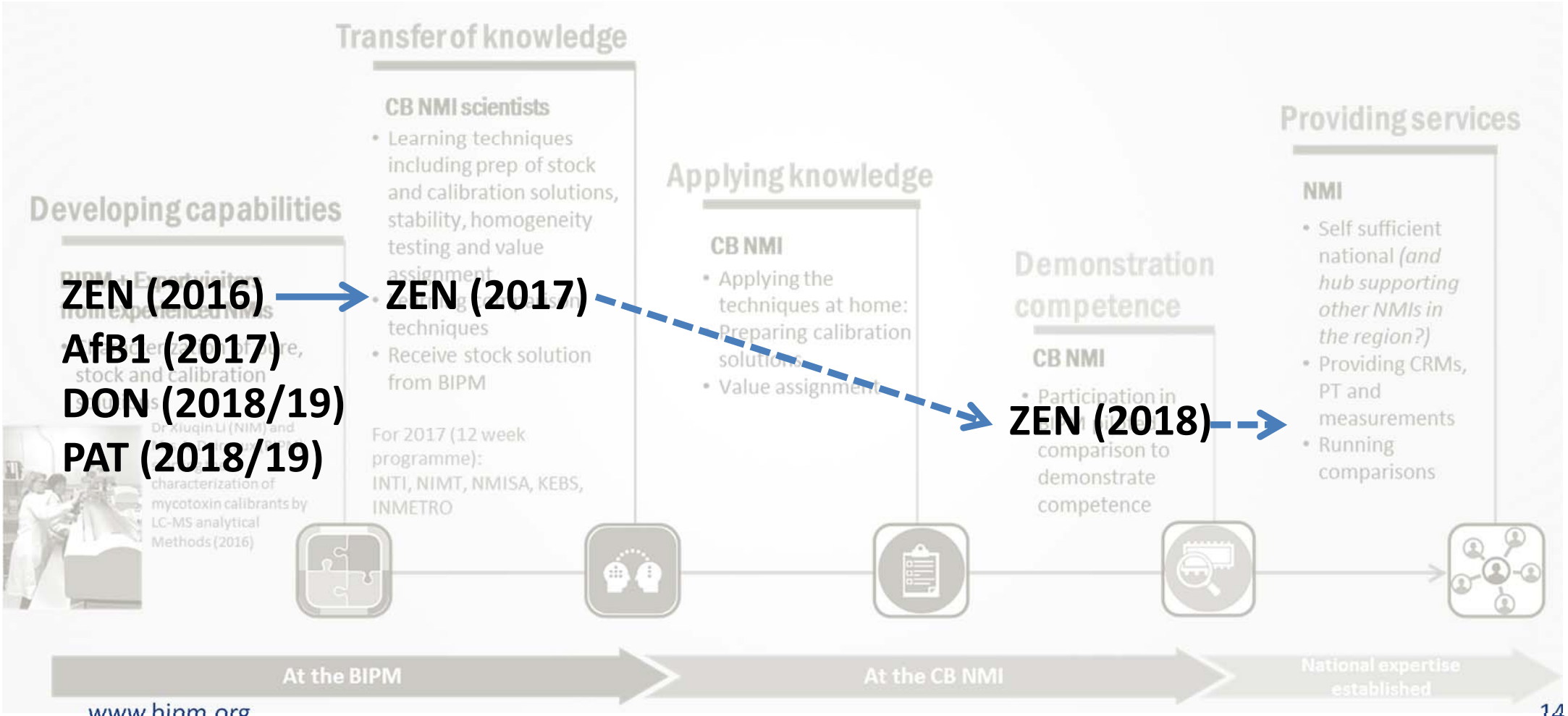
NMI Visiting Scientists at BIPM (2017): Chemistry Programs

Scientist (NMI)	Period	Project
XQ. Li (NIM)	12 Apr 2016-12 April 2017	Mycotoxin Metrology
XM. Li (NIM)	15 Feb 2017 – 15 Feb 2018	Mycotoxin Metrology
E.C. Rego (INMETRO)	1 Feb 2017 -30 April 2017	Mycotoxin Metrology
M.E. Simon (INTI)	1 Feb 2017 – 30 April 2017	Mycotoxin Metrology
S. Marbumrung (NIMT)	1 May 2017 – 31 July 2017	Mycotoxin Metrology
I. Mugenya (KEBS)	1 May 2017-31 July 2017	Mycotoxin Metrology
D. Prevoo (NMISA)	1 May 2017-31 Aug 2017	Mycotoxin Metrology
I. Un (UME)	1 Sept 2017 -30 Nov 2017	Mycotoxin Metrology

Skills Broadening and Training Secondments at the BIPM (2017):
TS4: Calibration Solution Preparation and Value Assignment
12 week Training Secondment

Week	Description
1	Safety and Quality documentation introduction
2-3	Accurate weighing, uncertainty calculation, ZEN ampoule solution preparation
4-5	LC-UV instrument operation and implementation of ZEN analysis method
6-7	Homogeneity testing and calculation of between ampoule variability
8-9	Stability testing and evaluation of results
10-11	Value assignment of unknown calibration solution
12	Finalisation of secondment report

Key Comparisons– Mycotoxin calibrant reference materials



ZEN (2016)
AfB1 (2017)
DON (2018/19)
PAT (2018/19)

ZEN (2017)

ZEN (2018)

Financial Support for Mycotoxin Metrology CBKT

- **NIM**: Funding own visiting scientists and Pure Mycotoxin Materials and visiting scientist programme at NIM (Matrix Materials)
- **NMISA**: Funding own visiting scientists and visiting scientist programme at NMISA (Analytical methods)
- **UME:** Funding own visiting scientists at BIPM
- **PTB:** Funding 4 times 3 month training secondments from NIMT, INTI, INMETRO and KEBS

African Food Safety Network Symposium 4-8 June 2018

Pretoria, South Africa

- Mycotoxin Standards and methods of analysis workshop
- Food contaminants
- Microbiology
- Food Allergens
- Food Additives

nmisa 70 celebration

nmisa
National Metrology Institute of South Africa

Bureau International des Poids et Mesures

IAEA
International Atomic Energy Agency

AFRIMETS
Intra-Africa Metrology System
Système Intra-Africain de Métrologie

agriculture, forestry & fisheries
Department:
Agriculture, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

Air Quality and Greenhouse Gases

Air Quality

Greenhouse Gases

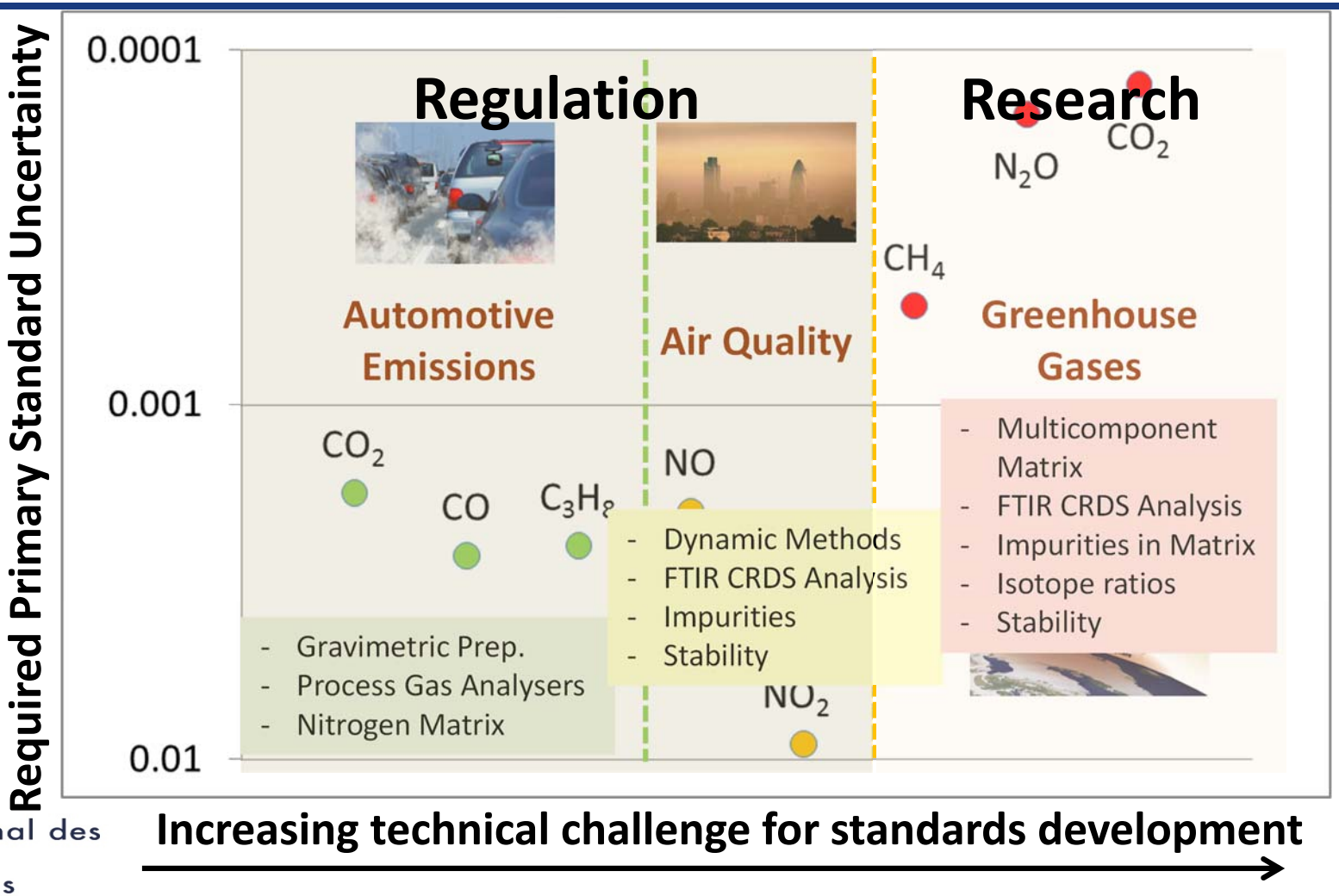
Pollutant	*Concentration*	*Averaging period*
Ozone	60 nmol/mol	Maximum daily 8 hour mean
Sulphur dioxide (SO_2)	120 nmol/mol	1 hour
	45 nmol/mol	24 hours
Nitrogen dioxide (NO_2)	100 nmol/mol	1 hour
	20 nmol/mol	1 year
Carbon monoxide (CO)	8 µmol/mol	Maximum daily 8 hour mean
Benzene	1.5 nmol/mol	1 year
Fine particles (PM2.5)	25 µg/m^3	1 year
PM10	50 µg/m^3	24 hours
	40 µg/m^3	1 year
Lead (Pb)	0.5 µg/m^3	1 year

GAS	**Recent tropospheric concentration**
Carbon dioxide (CO_2)	392.6 µmol/mol
Methane (CH_4)	1874 nmol/mol
Nitrous oxide (N_2O)	324 nmol/mol
Tropospheric ozone (O_3)	34 nmol/mol
Halocarbons	(0.003 to 0.5) nmol/mol

(Limit value concentrations)

Emission gases not included in list

BIPM Clean Air CBKT initiated after CENAM/PTB Workshop 2016



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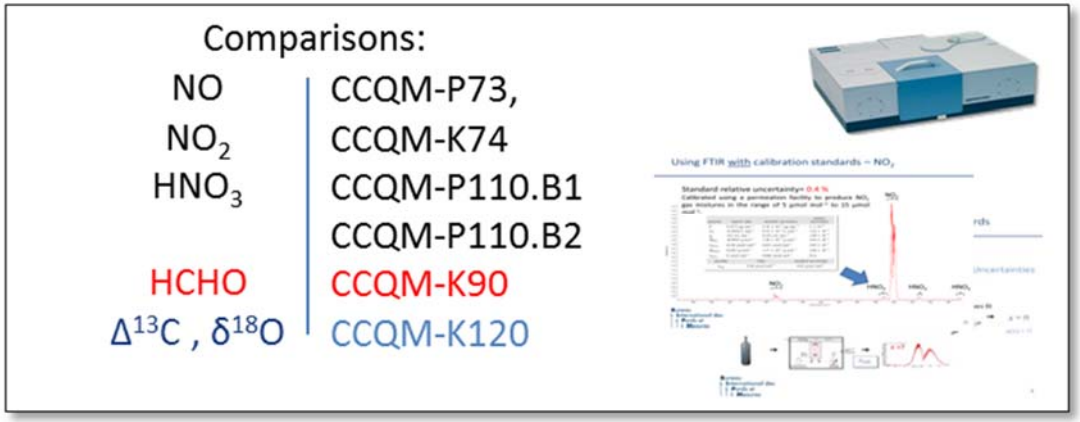
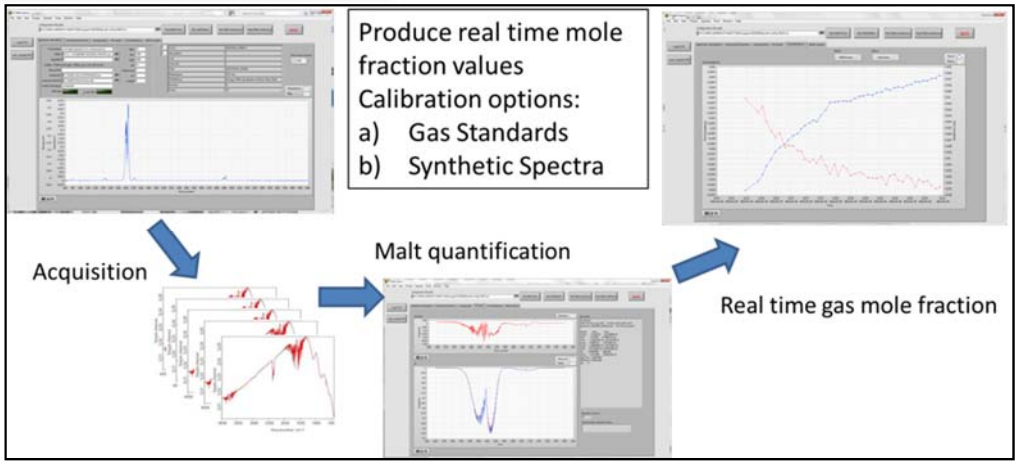
“Metrology for clean air” - Gas Metrology & FTIR

FTIR provides a cost effective and accurate solution for the NMI
But, requires expert knowledge for operation and data analysis



BIPM expertise in use of FTIR in key comparisons supporting CB&KT at NMIs



B-FOS software: Spectra, Line Fitting and Gas Concentration in Real Time

Metrology for Clean Air: Capacity Building and Knowledge Transfer

Capacity Building & Knowledge Transfer

Developing capabilities

BIPM + support from experienced NMIs*

- FTIR and process gas analyser procedures (NO_x and CO_2)
- Working with Primary Reference Gas Mixtures (PRGM)*
- Calibration of secondary standards

Transfer of knowledge

CB NMI scientists

- Learning FTIR and process gas analyser techniques for gas standard value assignment (ISO 6143)
- Learning comparison and impurity quantification techniques
- Receive PRGMs* via the BIPM

Applying knowledge

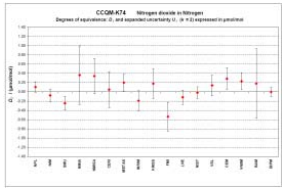
CB NMI

- Applying the techniques at home:
- Operating ISO 6143 compliant methods
- Operating BIPM B-FOS FTIR software
- Value assignment secondary standards

Demonstrating competence

CB NMI

- Participation in bilateral comparisons with BIPM for
- CCQM-K137 (NO)
- CCQM-K74 (NO_2)
- BIPM.QM-K2 (CO_2)



Providing services

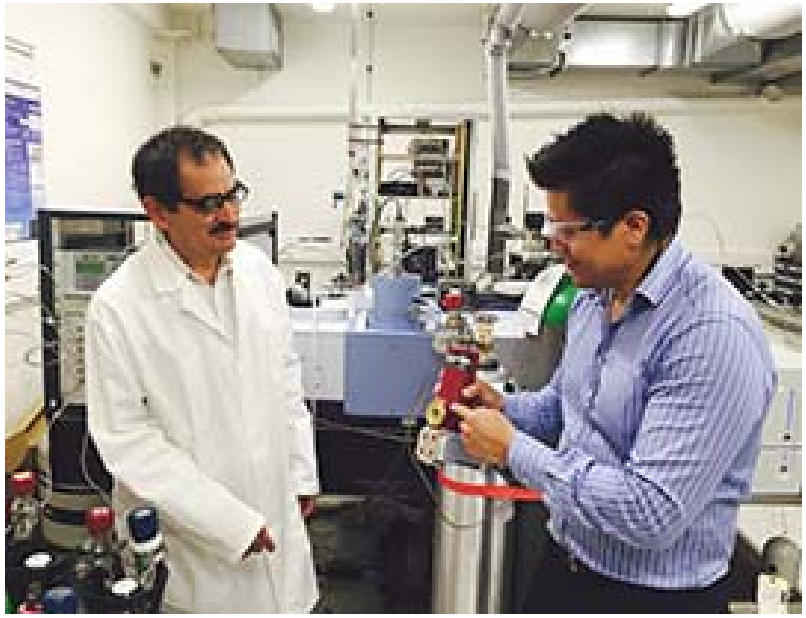
NMI

- Self sufficient national activity
- Providing CRMs, Calibrations in support of Emissions and Air Quality Monitoring

At the BIPM → At the CB NMI → National expertise established

“Metrology for clean air” – FTIR capabilities

Scientist (NMI)	Period	Project
M. Avila (CENAM)	1 June 2016- 30 November 2016	Clean Air CBKT: FTIR



List of activities
Introduction to FTIR spectroscopy
Operation of Nicolet Nexus and Bruker V70 FTIRs and Omnic and Opus operating software;
Gas cell path length alignment and measurement
Operation of MALT software both for manual processing and automated processing of spectra using both synthetic calibration and gas standard calibration
Uncertainty analysis of FTIR measurements
Undertake training on the operation of BIPM’s P-MALT automated spectral analysis software and system requirements for its installation on other FTIRs
Undertake training on operation of magnetic suspension permeation systems
Analyse gravimetric standards of NO_2/N_2 with FTIR and assign mole fraction values and uncertainties to NO_2, HNO_3 mole fractions and other impurities detected
Analyse gravimetric standards of CO_2 with FTIR and assign mole fraction values and isotope ratios
Report on activities

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Support from PTB Messen ▪ Forschen ▪ Wissen

“Metrology for clean air” – support from Expert NMIs

Support from

NPL National Physical Laboratory

PRGMs supplied to BIPM for transfer to CB NMI

Analyte	Matrix	Mole fraction Range	No of PRGMs in range
NO	Nitrogen	(30-70) µmol/mol	4
NO_2	Nitrogen	(1-20) µmol/mol	4
CO_2	Air	(400-800) µmol/mol	4

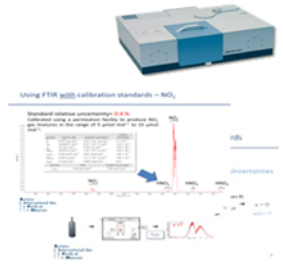
Scientist (NMI)	Period	Project
R. Soman Radha (NPLI)	1 Sept 2017- 28 February 2018	Clean Air CBKT: FTIR
N. Ntsasa (NMISA)	1 Feb 2018- 31 July 2018	Clean Air CBKT: FTIR
A. Nassibulina (KazInMetr)	1 Sept 2018- 28 February 2019	Clean Air CBKT: FTIR

Chemistry CBKT: Metrology for Safe Food and Clean Air

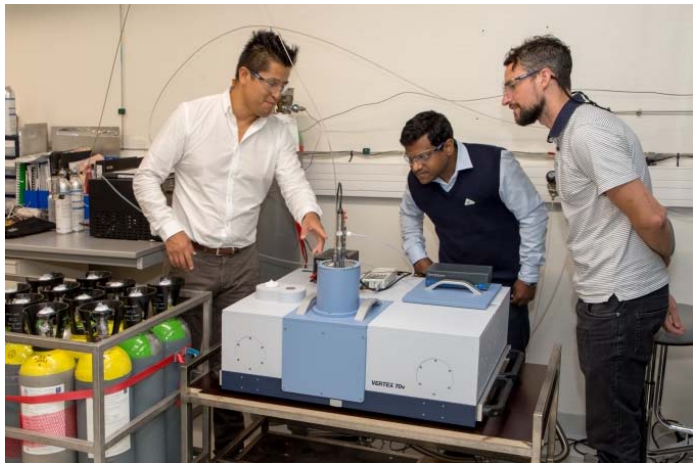
FTIR for Gas Standards

Comparisons:

NO	CCQM-P73,
NO_2	CCQM-K74
HNO_3	CCQM-P110.B1
	CCQM-P110.B2
HCHO	CCQM-K90
$\Delta^{13}C$, $\delta^{18}O$	CCQM-K120



Operation of FTIR for value assignment of gas standards: NO, NO_2 and CO_2



Participating NMIs in 2017:

Kenya Bureau of Standards
Standards for Quality life

INMETRO
Instituto Nacional de Metrologia, Qualidade e Tecnologia

NPL · INDIA

TÜBİTAK UME *

INTI

NIMT

nmisa * National Metrology Institute of South Africa

LNE *

NIM *

NPL National Physical Laboratory *

*Self funded

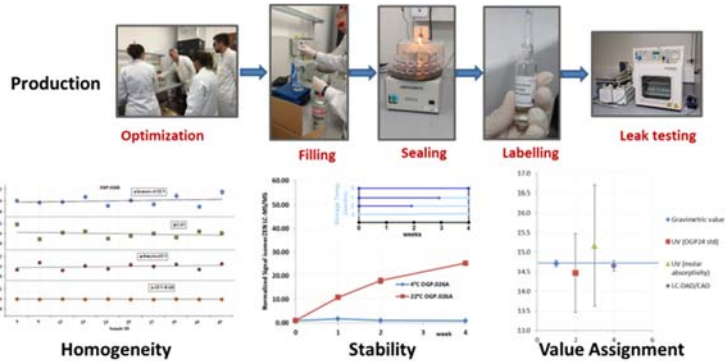
Financial Support from:

NIM

PTB Messen • Forschen • Wissen

NPL National Physical Laboratory

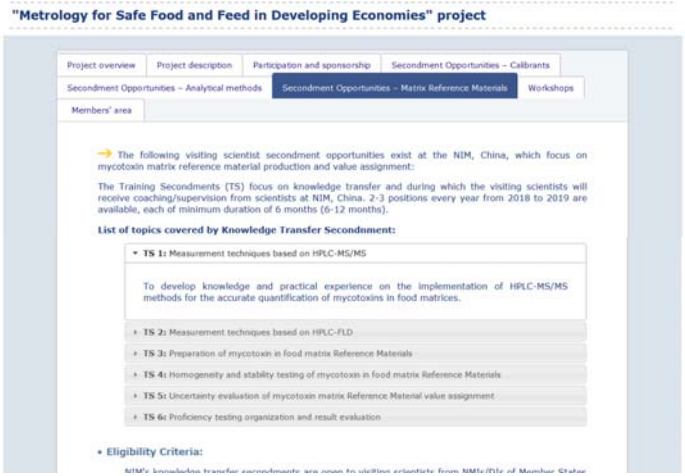
Mycotoxin Calibration Solutions



Preparation, homogeneity, stability and value assignment of mycotoxin standards

Further information on CBKT

http://www.bipm.org/en/cbkt/safe-food.html



http://www.bipm.org/en/cbkt/clean-air.html