How do we measure the Indoor Air Quality? Results of the first measuring campaigns.

Willemien Anaf - Sanaz Pilehvar
Offer heritage caretakers a user-friendly tool to manage IAQ.
Offer heritage caretakers a user-friendly tool to manage IAQ.
(Indoor) Air Quality

depends on

- temperature
- humidity
- sunlight
- clouds
- pollutants
- wind
How to measure?

Objects

Environmental parameters

Material behaviour
How to measure?

Environmental parameters

Material behaviour

Objects

Tudor Tapestry Hall

(Luxford et al., 2013)

(van der Burg et al., 2014)
How to measure?

Objects

Environmental parameters

Material behaviour
DATALOGGER
DATALOGGER with SENSORS

CONTINUOUS MEASUREMENTS

MODULAR

(TRANSPORTABLE)
Pigeon air patrol

$O_3 - NO_2 - VOC's$

Human air patrol

$O_3 - NO_2 - VOC's$

Airbeam – Aircasting

COMMON SENSE
Temperature
Surface temperature

Relative humidity

Lux and UV

Motion

Particulate matter

CO₂

Wind speed

Barometric pressure

Silver corrosion

Wood behavior

Humidity in books
Minerals (e.g. CaCO$_3$)

Organic (e.g. spores)

Elemental carbon (soot)

Sea salts (e.g. NaCl)

Ammonium-rich aerosol (e.g. NH$_4$NO$_3$)

(e.g., Seinfeld 1986)
AERODYNAMIC PARTICLE DIAMETER (µm)

Coarse Fraction

PM₁₀

PM₂.₅

PM₁₀⁻₂.₅

Fine Fraction

COARSE FRACTION

FINE FRACTION

PM₁₀

PM₂.₅

PM₁₀⁻₂.₅

AERODYNAMIC PARTICLE DIAMETER (µm)

10

2.5

0.1

0.001

HUMAN HAIR

50-70 µm (microns) in diameter

Combustion particles, organic compounds, metals, etc.

< 2.5 µm (microns) in diameter

PM₂.₅

Dust, pollen, mold, etc.

< 10 µm (microns) in diameter

PM₁₀

FINE BEACH SAND

90 µm (microns) in diameter

Image courtesy of the U.S. EPA
Instrument comparison

Continuous measurements

Extensive measurements

24h SAMPLING

PM_{10}  PM_{2.5}  PM_{1}
Continuous monitoring

Dylos
DC1100 pro
€ €

Shinyei
PPD 60 PV
€

Lighthouse
3016-IAQ
€€€€
Royal Military Museum, Historic gallery

Particle counts (relative)

Lighthouse 0.5-2.5 µm (particle counts)

Dylos, small (particle counts)

\[ y = 91x + 440000 \]

\( R^2 = 0.4 \)
Royal Military Museum, Historic gallery

Particle counts (relative)

Dylos (large)
Lighthouse (2.5-10 µm)
Royal Military Museum, Historic gallery

Particle counts (relative)

- Dylos (large)
- Dylos (small)
- Shinyei

\[
y = 0.27x + 103.89
\]

\[
R^2 = 0.66
\]

Graph showing particle counts over time for Royal Military Museum, Historic gallery, with linear regression equations for Shinyei and Dylos (small) particle counts.
Continuous vs. extensive monitoring

Magritte Museum, Royal Museums of Fine Arts
Harvard Impactor vs. Lighthouse particle counter

Harvard Impactor - PM10-2.5
Lighthouse particle counter - PM10-2.5

Harvard Impactor - PM2.5
Lighthouse Particle counter - PM2.5
Airborne particles on silver substrate
(National Tile Museum, Lisbon)
Soil Dust concentration (µg/m³)

Reserve OB
- PM2.5
- PM10-2.5

Show Gallery
- PM2.5
- PM10-2.5

Royal Museum of Fine Arts
Black carbon concentration ($\mu$g/m$^3$)

- Museum of Fine Arts
- Military Museum
Screen printed electrodes

Passive deposition of particles/dust

Electrochemical detection of redox-active compounds
Monitoring kit in different environments

Have a closer look at how we measure the IAQ.
Neem een kijkje hoe we de luchtkwaliteit meten.
Regardez comment nous mesurons la QAQ.
Central storage

Historic gallery
Particle counts (small particles, Dylos)
Particles (large)

Particles (small)

Motion

Activity

Particle counts

28/03/2016
29/03/2016
30/03/2016
31/03/2016
1/04/2016
2/04/2016
3/04/2016
CO$_2$ (ppm)
Silver thickness loss (Angstrom)

Historic gallery

- $y = 0.5x - 1.3 \times 10^6$
- $R^2 = 0.97$

Central storage

- $y = 0.8x - 2.3 \times 10^6$
- $R^2 = 0.99$
Present
Future?

Master Project, Product Design

Jeroen van Winckel