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Monitoring the environmental impact of atmospheric deposition:

Towards updated reference values for the interpretation of environmental data

Introduction

Assessment of environmental impacts of industrial emissions

Do releases from a specific industrial site present a risk to the **environment**?
If so, does direct or indirect long-term exposure may affect **health**?

Monitoring strategy

Adapted to the features of the facility and its environment
(type of emissions, local topography and meteorology, population density, etc.)

Multi-media, multi-contaminant measurement campaigns

Assessment using:

- **regulatory values**
- **local reference values** (initial state, local control environment)
- **national/regional reference values**

Introduction

Assessment of environmental impacts of industrial emissions

Environmental assessment studies:

- Definition of the local control environment (***ELT***)
- Monitoring of industrial impacts (***PSE ICPE***)
- Impact studies (***EI***), new project or modified facility
- Environmental state assessment study (***IEM***)

> Need for tools to make sense of environmental data

Content of the presentation:

1. Review of available reference values in environmental monitoring
2. A standard method for establishing **control reference values** (unexposed sites)
3. A procedure for determining **impact thresholds**

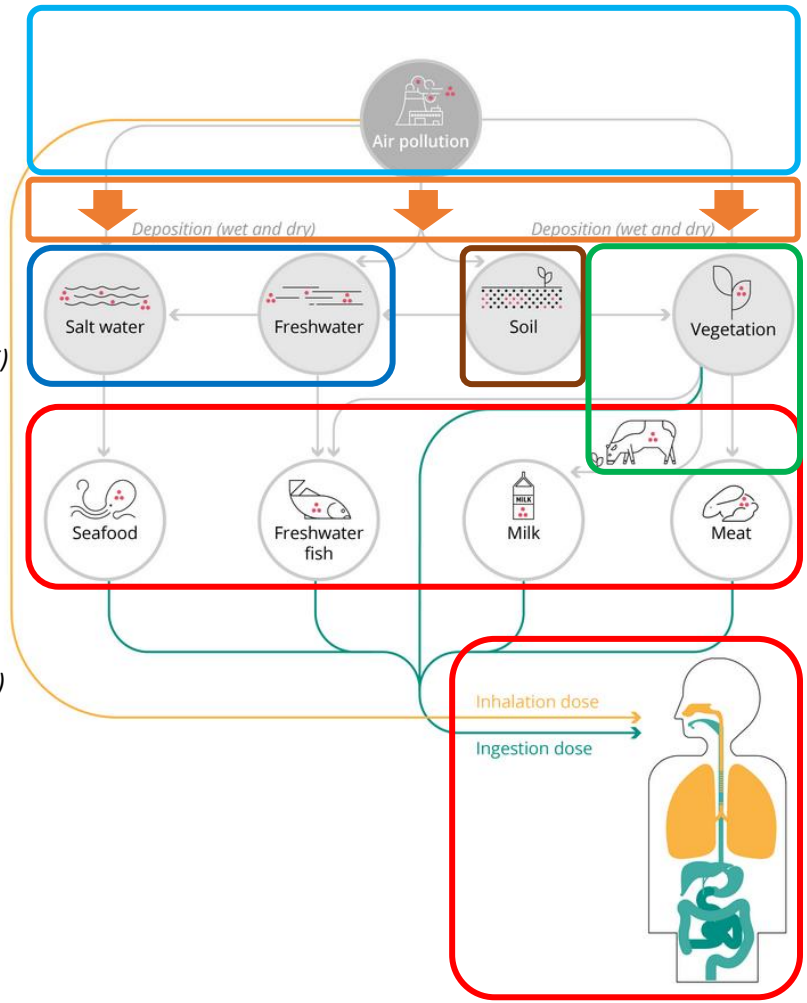
Focus: (bio)monitoring of atmospheric deposition

Introduction

Regulatory and reference values in France/EU

Water quality - Freshwater
EU regulation (*DCE, NQE*)
France: *LEMA*, *SDAGE*, *RSDE*
INERIS *:* Environmental guideline values *(VGE)*

Soil
Background reference values
France: INRA/ASPITET, GIS Sol, BRGM
Europe: JRC/ESDAC database
Contaminated sites
France: *Méthodologie SSP* (2017)
> standard methods (NF X31-620)
> reference assessment values (*VAS)*



Source: Adapted from EEA, 2014.

Ambient air - EU regulation
Limit values, long-term objectives, target values
Reference measurement methods
Data quality objectives
+ WHO guidelines for air quality
+ Toxicological reference values (*VTR*)

Atmospheric deposition

Animal feed - EU regulation

Foodstuffs - EU regulation
Total diet: ANSES EAT2 (France)

Risk assessment
Toxicological reference values (*VTR*)
Reference doses (RfD) and concentrations (RfC)
Tolerable/acceptable daily intake (*DJT*)
Inhalation unit risk (*ERUi*)

BioMonitor Conseil / Mesures en Environnement

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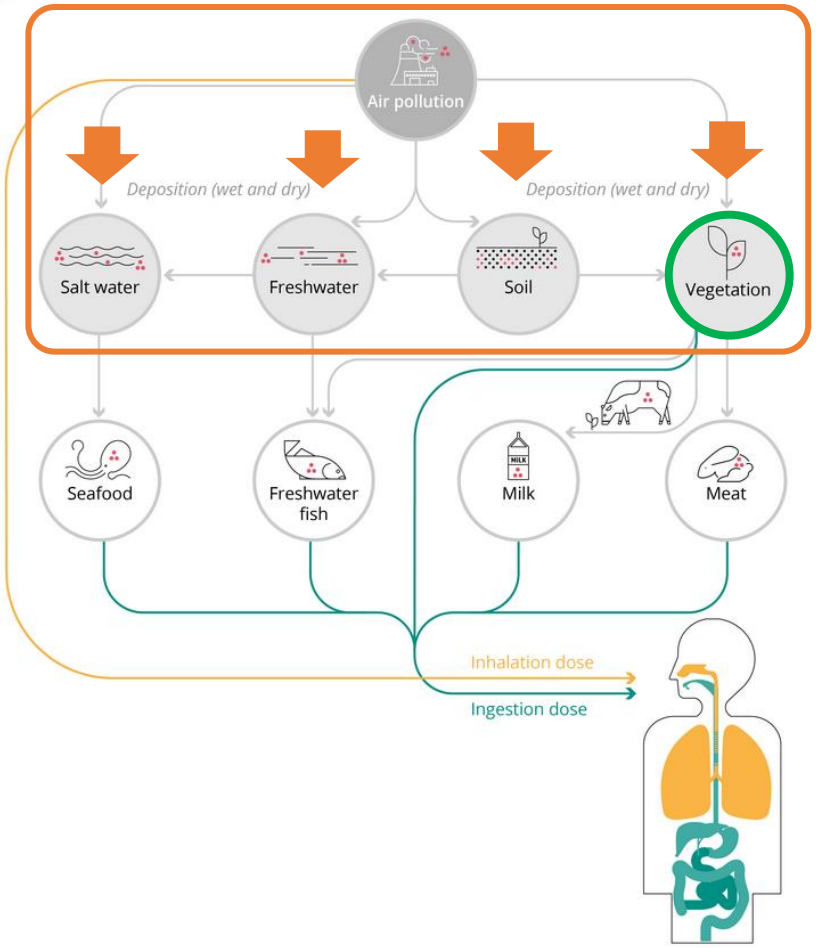
Monitoring of atmospheric deposition

Standardized methods (France)



Source: Adapted from EEA, 2014.

Dry and/or wet deposition

Total deposition — Deposit **gauges** - NF X43-014 (2017)

Dry deposition — Deposit **plates** - NF X43-007 (2008)

Passive biomonitoring

Lichens - NF X43-904 (2013)

Mosses - NF EN 16414 (2014)

Pine needles - NF X43-905 (2016)

Active biomonitoring

Standardized ray grass cultivation - NF X43-901 (2008)

Moss transplants - XP X43-906 (2015)

Standardized salad cultivation - XP X43-908 (2017)

Standardized curly kale cultivation - VDI 3957/Bl.3 (2008)

Moss bag - VDI 3957/Bl.17 (2009)

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Monitoring of atmospheric deposition

Reference values – Physical deposition process

Dry deposition: plates - NF X43-007 (2008)

Regulatory values:	**Germany** TA Luft (2002)	Dust fall
	Switzerland OAPC (2003)	Total dust deposition

France: NF X43-007 (2008), "pollution threshold" (data from 2001-2005)


Source: EMT Environement

Total deposition: gauges - NF X43-014 (2017)

Regulatory values:	**Germany** TA Luft (2002)	Dust + As, Cd, Hg, Ni, Pb, Tl
	Switzerland OAPC (2003)	Dust + Cd, Pb, Tl, Zn

France

No regulatory values

Reference values, mainly from waste incineration

BRGM (2011), PCDD/F, 2006-2009

- Urban and industrial background sites
- Sites impacted by human activities
- Sites impacted by a nearby anthropic emission source

INERIS (2012), 1991-2012, PCDD/F + metals

- Background levels (rural and urban)
- Industrial sites


Source: BioMonitor

Monitoring of atmospheric deposition

Reference values - Biomonitoring

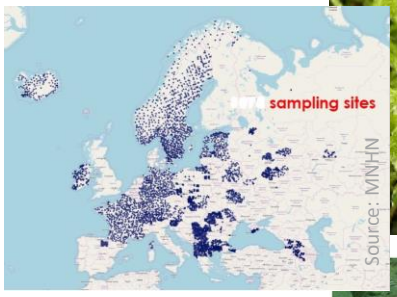
Passive biomonitoring

Lichens - NF X43-904 (2013)
Mosses - NF EN 16414 (2014)
Pine needles - NF X43-905 (2016)

Bioaccumulation of metals and POPs

No regulatory values
Reference values from various private and public operators

European Moss Survey (ICP Vegetation/WGE UNECE CLRTAP)
France: BRAMM (MNHN)
> Background reference values, but data from *remote forested areas*



LfU - Environment Agency of the German federal state of Bavaria
Spruce needles - VDI 3957/Bl.11 (2007)
PCDD/F, PCB and PAH, 17 rural areas + 1 urban site, since 1977

BioMonitor
Conseil / Mesures en Environnement

Atmos'Fair

Monitoring of atmospheric deposition

Reference values - Biomonitoring

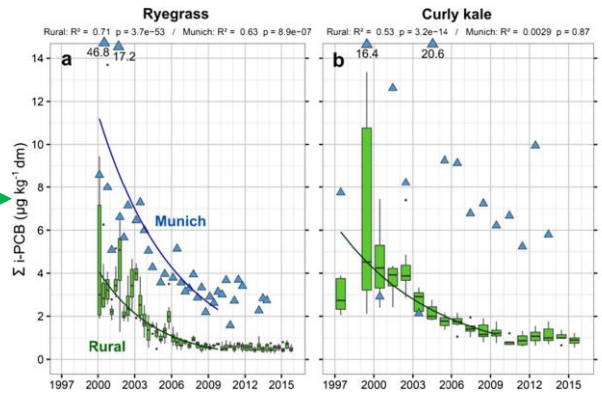
Active biomonitoring

Moss bag - VDI 3957/Bl.17 (2009)
Moss transplants - XP X43-906 (2015)

Standardized ray grass cultivation - NF X43-901 (2008)
Standardized curly kale cultivation - VDI 3957/Bl.3 (2008)
Standardized salad cultivation - XP X43-908 (2017)

No regulatory values
Reference values from various private and public operators

LfU (Bavaria, Germany)
Ray grass and curly kale
10 permanent observation stations (9 rural areas and 1 urban site)
PCDD/F, PCB and PAH monitored since 1997



Weber et al. (2018). *ESPR, 25*(17), 16344–16354

Reference values for atmospheric deposition monitoring

Atmospheric deposition (bio)monitoring methods:

- **Standardized** since 2008 in France
- **Commonly used** for industrial impact assessment
- **Recommended** by the French National Institute for Industrial Environment and Risks (*INERIS*)

But **lack of regulatory values** and **disparity of interpretative tools**

We propose a two-step method to generate updated reference values:

1. **Control reference values**, applying the XP X43-910 AFNOR standard (2020)
2. **Impact reference values**, using a method adapted from Cecconi *et al*. (2019)

Reference values for atmospheric deposition monitoring

XP X43-910 standard > Control reference values

June 2020

AFNOR standardization commission T95AIR : INERIS
MNHN, AgroParisTech, Univ. Lille 2, Univ. Paris-Est Créteil
BioMonitor, EDF R&D, Aair Lichens, Apilab

Users: Actors in QA biomonitoring (institutes, labs, private operators)

Standardized methods: mosses (NF EN 16414), ray grass cultivation (NF X43-901), lichens (NF X43-904), conifer needles (NF X43-905), moss transplants (XP X43-906), salad cultivation (XP X43-908), honeybees (XP X43-909)

Objectives:

- Establish **reference values** for the interpretation of data from a biomonitoring campaign
- Validate results from **control exposure site(s)** with respect to regional/national references
- **Harmonize operator practices** for handling data and establishing reference values

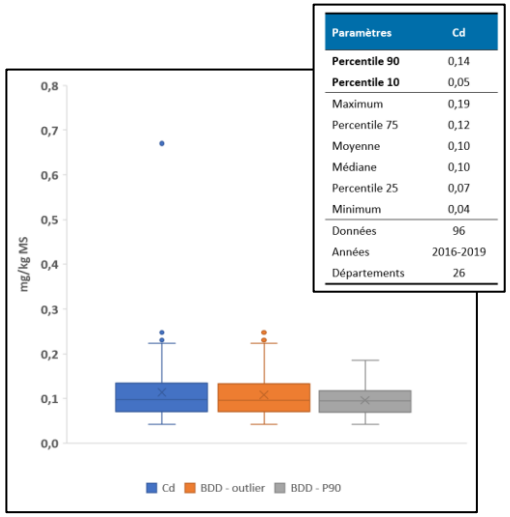
Data handling: Quantitative data, same requirements as for corresponding standards, <LOQ = LOQ
Metadata (study area, GPS coordinates, exposure typology, date, industrial facility, etc.)
For a given site, data averaged per year
For a given campaign, data averaged per site typology

Temporal representativeness: Data from the **last 4 years** of monitoring
Minimal requirements: **20 data points** per pollutant

Data processing: Elimination of proven outliers
Control sites: elimination of the last decile

Data representation: Boxplots + descriptive statistics

▸ **Reference interval:** **p10 – p90 of the final data distribution**



Paramètres	Cd
Percentile 90	0,14
Percentile 10	0,05
Maximum	0,19
Percentile 75	0,12
Moyenne	0,10
Médiane	0,10
Percentile 25	0,07
Minimum	0,04
Données	96
Années	2016-2019
Départements	26

Source: BioMonitor

Reference values for atmospheric deposition monitoring

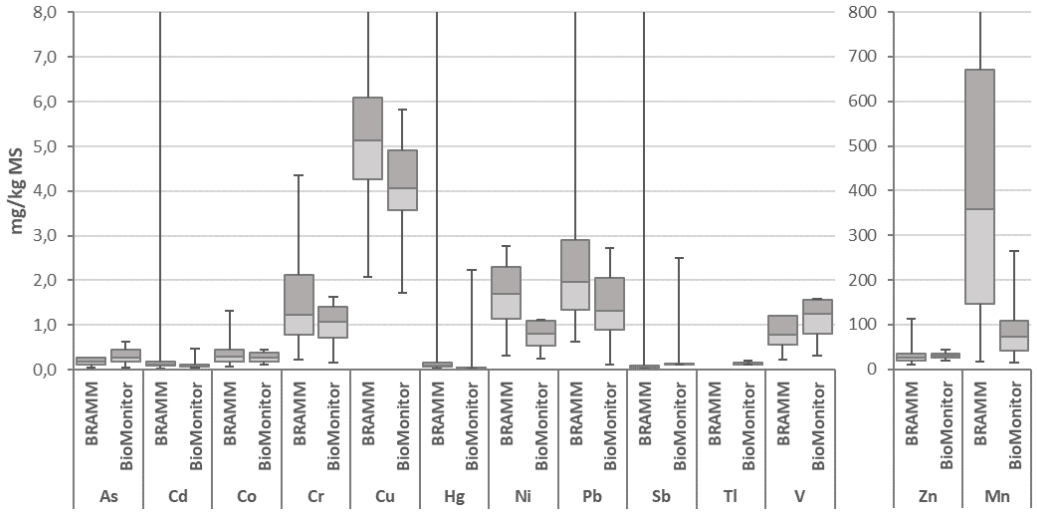
XP X43-910 standard > Control reference values

Applied by **BioMonitor** since 2020

Methods: **Mosses** (NF EN 16414), **ray grass** cultivation (NF X43-901), **lichens** (NF X43-904)
+ **Curly kale** (VDI 3957/Bl.3)
+ Atmospheric deposition (**gauges,** NF X43-014)

Pollutants: **Metals** (10-13 elements) and POPs (**PCDD/F**, **PCB**, **PAH**)

Case study: metallic trace elements in mosses, reference intervals for control sites, compared to BRAMM data (MNHN, 2018)



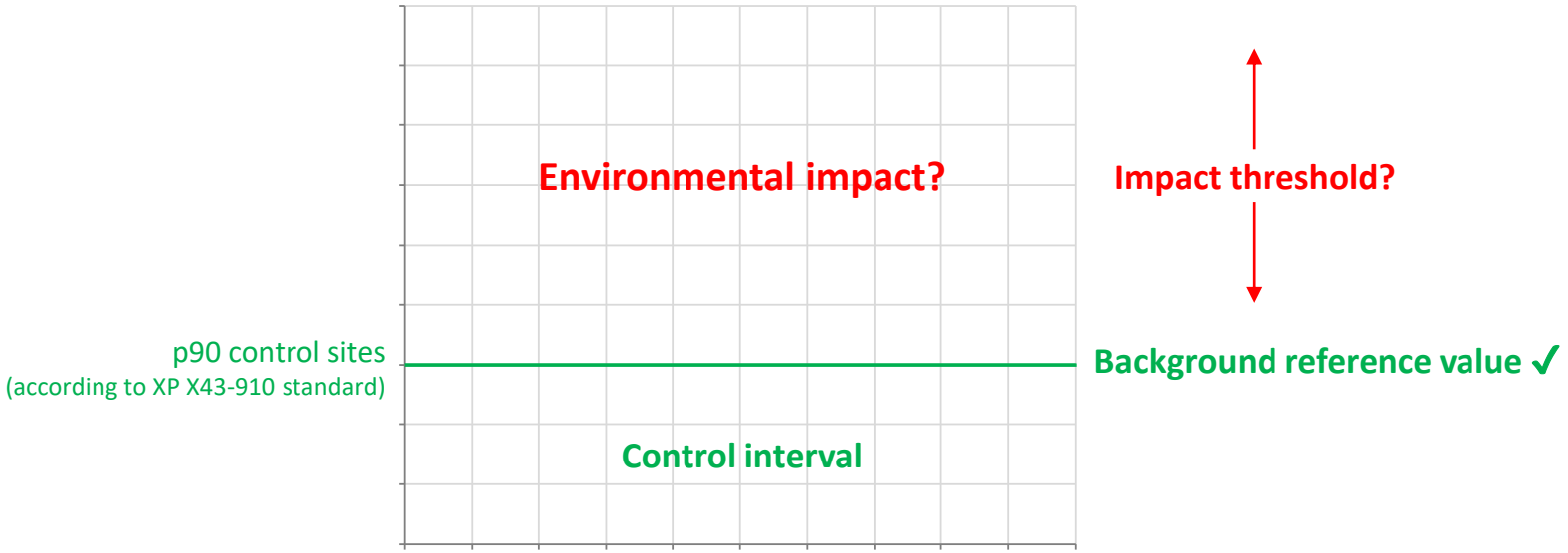
BRAMM, 2016 campaign
445 sites, background levels, rural sites (remote forested areas)

BioMonitor, 2016-2019
≈ 100 data points, all typologies (urban, periurban, rural areas)

Source: BioMonitor
Adapted from Meyer et al. (2018). Surveillance des retombées atmosphériques par analyse de mousses en France – Campagne 2016 du dispositif BRAMM

Reference values for atmospheric deposition monitoring

XP X43-910 standard > Control reference values ✓



Reference values for atmospheric deposition monitoring

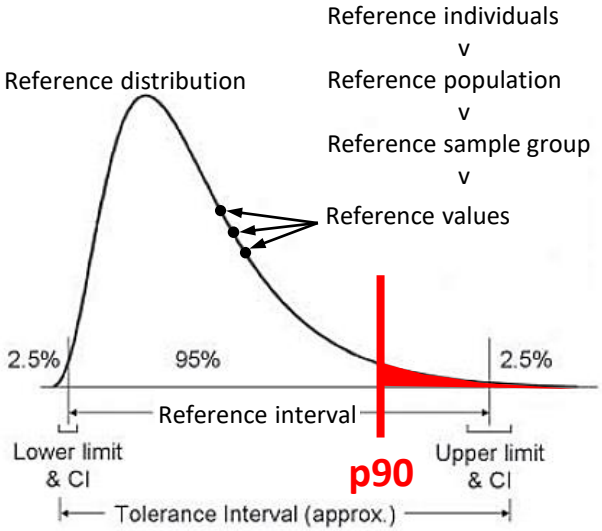
Establishing impact thresholds

Clinical and laboratory medicine / human biomonitoring:

IFCC/CLSI (2008): guidelines for establishing reference intervals (C28-A3)

IFCC International Federation of Clinical Chemistry and Laboratory Medicine

CLINICAL AND LABORATORY STANDARDS INSTITUTE®



Adapted from Geffré et al. (2009), *Vet. Clin. Pathology*, 38, 3

Environmental science: **Disparity of methods**

Environmental Science & Technology — Viewpoint — pubs.acs.org/est

What Makes a Concentration Environmentally Relevant? Critique and a Proposal

Lennart Weltje*,† and John P. Sumpter‡

Environ. Sci. Technol. 2017, 51, 11520−11521

- Collect <u>all data</u> in relevant habitats/environments, incl. ≤ LOD
- Critically inspect very high concentrations (misuse, accident, error?)
- Convert data ≤ LOD to numerical values
- Generate a cumulative distribution
- **p90 = highest environmentally relevant concentration**

Reference values for atmospheric deposition monitoring

Establishing impact thresholds

atmosphere

MDPI

Article

New Interpretative Scales for Lichen Bioaccumulation Data: The Italian Proposal

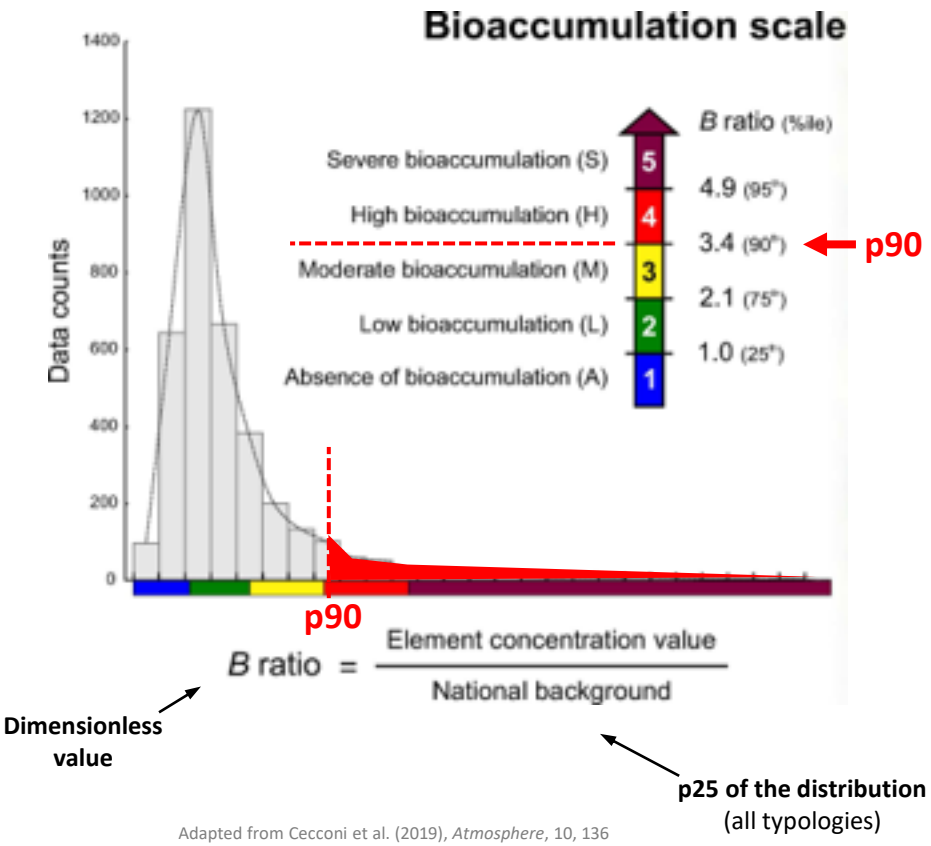
Elva Cecconi [1,†], Lorenzo Fortuna [1,†], Renato Benesperi [2], Elisabetta Bianchi [2], Giorgio Brunialti [3], Tania Contardo [4], Luca Di Nuzzo [2], Luisa Frati [3], Fabrizio Monaci [4], Silvana Munzi [5], Juri Nascimbene [6], Luca Paoli [7], Sonia Ravera [8], Andrea Vannini [4], Paolo Giordani [9], Stefano Loppi [4] and Mauro Tretiach [1,*]

Native lichen samples, µg/g DW, ≤ LOD = LOD

Initial dataset: 32,187 bioaccumulation data points
42 elements
5 lichen species (foliose and fruticose species)
18 administrative Italian regions

Methodological and temporal **data filtering**
(discard non HF extraction, data before 2008, <40 records, <3 regions)

Final dataset: 3773 data points
11 elements
2 foliose species: *F. caperata* and *X. parietina*
5 Italian regions



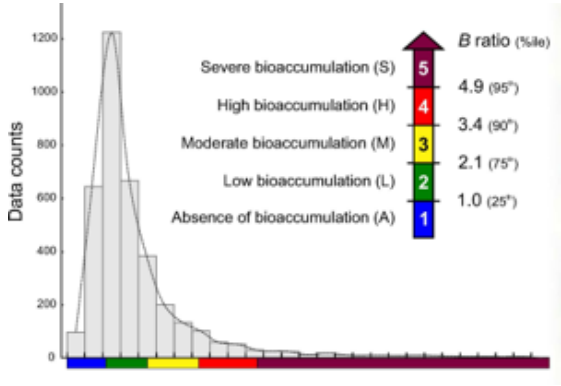
Adapted from Cecconi et al. (2019), *Atmosphere*, 10, 136

Reference values for atmospheric deposition monitoring

Establishing impact thresholds

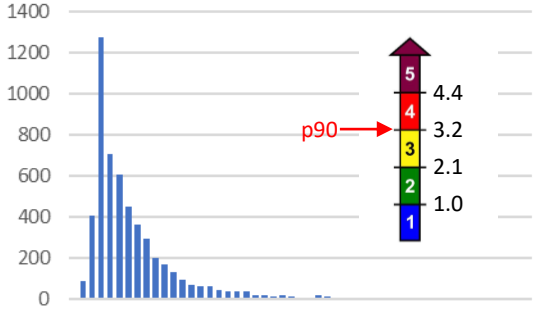
BioMonitor (France, 2016-2019)
PCDD/F + 10-13 elements

Native lichens (Italy, 2008-2018)
3773 datapoints, 11 elements

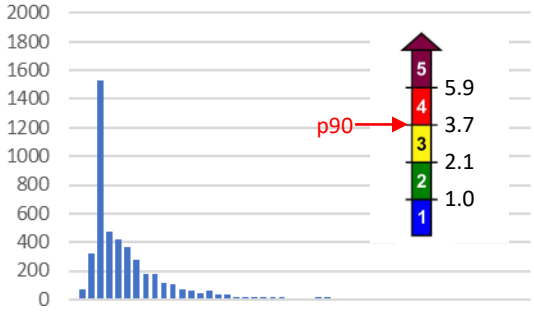


Adapted from Cecconi et al. (2019), *Atmosphere*, 10, 136

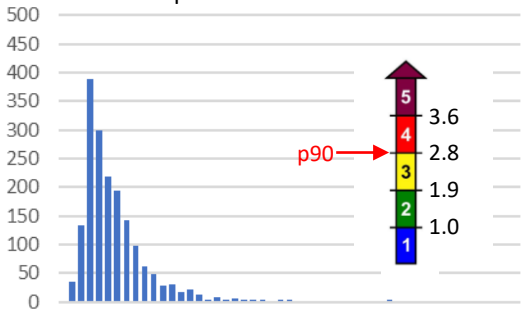
Mosses - NF EN 16414
5302 datapoints



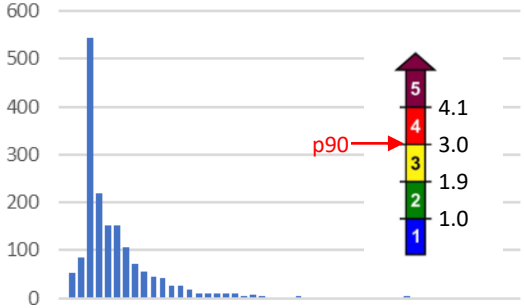
Ray-grass - NF X43-901
4684 datapoints



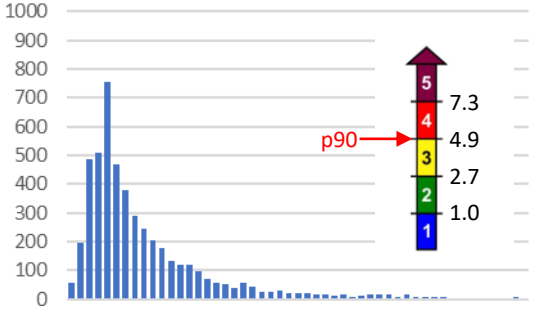
Lichens - NF X43-904
1807 datapoints



Curly kale – VDI 3957/Bl.3
1683 datapoints



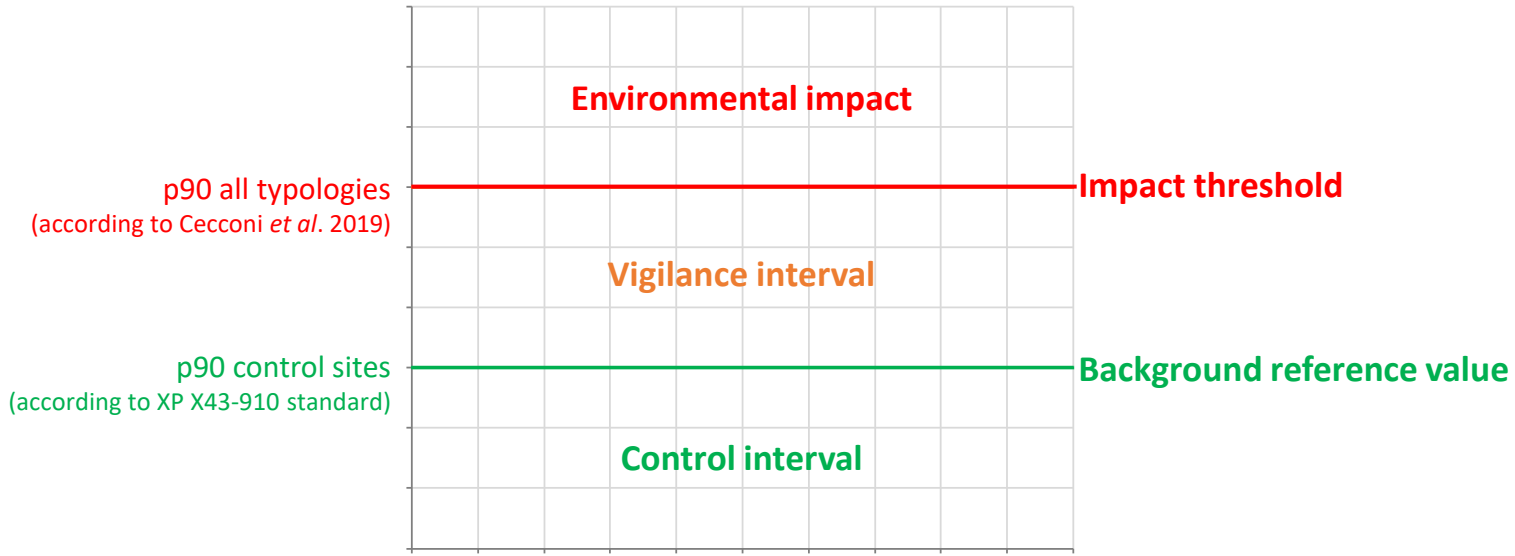
Gauges – NF X43-014
5003 datapoints



Reference values for atmospheric deposition monitoring

Summary

- A procedure for establishing **reference values** using robust statistical methods
  - Based on standardized (XP X43-910) or published (Cecconi *et al*. 2019) methods
  - Updated annually using the last 4 years of monitoring



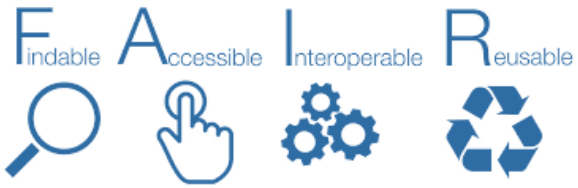
Reference values for atmospheric deposition monitoring

Limits

- Spatial representativeness
- Industrial facility profile

Prospect

- Data sharing
- “FAIRification”
- *Data usage licence?*
- *Database management?*



Findable (meta)data

Unique and persistent ID
Indexed in a searchable resource
Rich metadata

Reusable (meta)data

Data usage licence
Detailed provenance
Community standards

Accessible (meta)data

Standardized communications protocol
Open, free, and universally implementable

Interoperable (meta)data

Formal, accessible, shared, and broadly applicable language

Wilkinson et al. (2016) The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data*, 3, 160018

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Thanks for your attention


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