Task Force on Emission Inventories and Projections

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CARABLACK

Characterization of atmospheric emissions of black carbon in stack discharge of plants

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INERIS maîtriser le risque pour un développement durable

CITEPA

ADEME Agence de l'Environnement et de la Maîtrise de l'Energie

Partners and collaborations

- Project coordinated by **INERIS** (French National Institute For Industrial Environment And Risks) as part of its activities supporting French Ministry for an Ecological and Inclusive Transition (MTES)

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- Partner: **CITEPA** (French Interprofessional Technical Centre for Studies on Air Pollution) responsible from French emission inventories and projections for MTES

- In collaboration with :
  - **LSCE** (French Laboratory for Sciences of Climate and Environment)
  - Industrial sites where the trials were performed

Work supported by:

ADEME (The French Environment and Energy Management Agency)

Context

- **Characterisation of BC in ambient air as requested by Directive 2008/50/CE**
  - ➔ One measurement method standardised in EU since 2017: EN 16909
- **But absence of requirement for BC measurement at the emission of stationnary sources; no emission limit value (ELVs)**
  - ➔ Limited emission measurement data from stationary sources
  - ➔ Measurement methods rarely described: comparability of methods and results?
  - ➔ No standardised methods
- **Nevertheless inventories are established, based on EF (emission factors) : 1st inventory in France carried in 2013 (CITEPA)**
  - ➔ Applied methods and characteristics?
  - ➔ Reliability of established inventories?
  - ➔ Way of improving?

Objectives and methods

- **Identify the measurement methods of black carbon in stacks:**
  - Already applied for the characterisation of stationary source emissions
  - Or those applied for ambient air but which could be adapted for emission

  ➔ **State of the art on black carbon measurement methods**

- **Assess the different measurement methods selected during a campaign of trials on INERIS bench test:**
  - Implementation
  - Performances
  - Comparison of results obtained during measurements on a same BC/PM matrix
  - Assessment of the size distribution of black carbon particles

  NOTE: inventories are based on BC EF (emission factors) expressed in most cases as a BC fraction in $PM_{2,5}$

  ➔ **black carbon emissions are derived from: $EF(BC/PM_{2,5})$ x $EF\ (PM_{2,5})$**

- **Measurement campaigns performed on 2 biomass boilers for heat and hot water production (capacity 3,5 and 5,5 MW): selected in a sector identified by CITEPA as an important contributor of black carbon emissions in France**

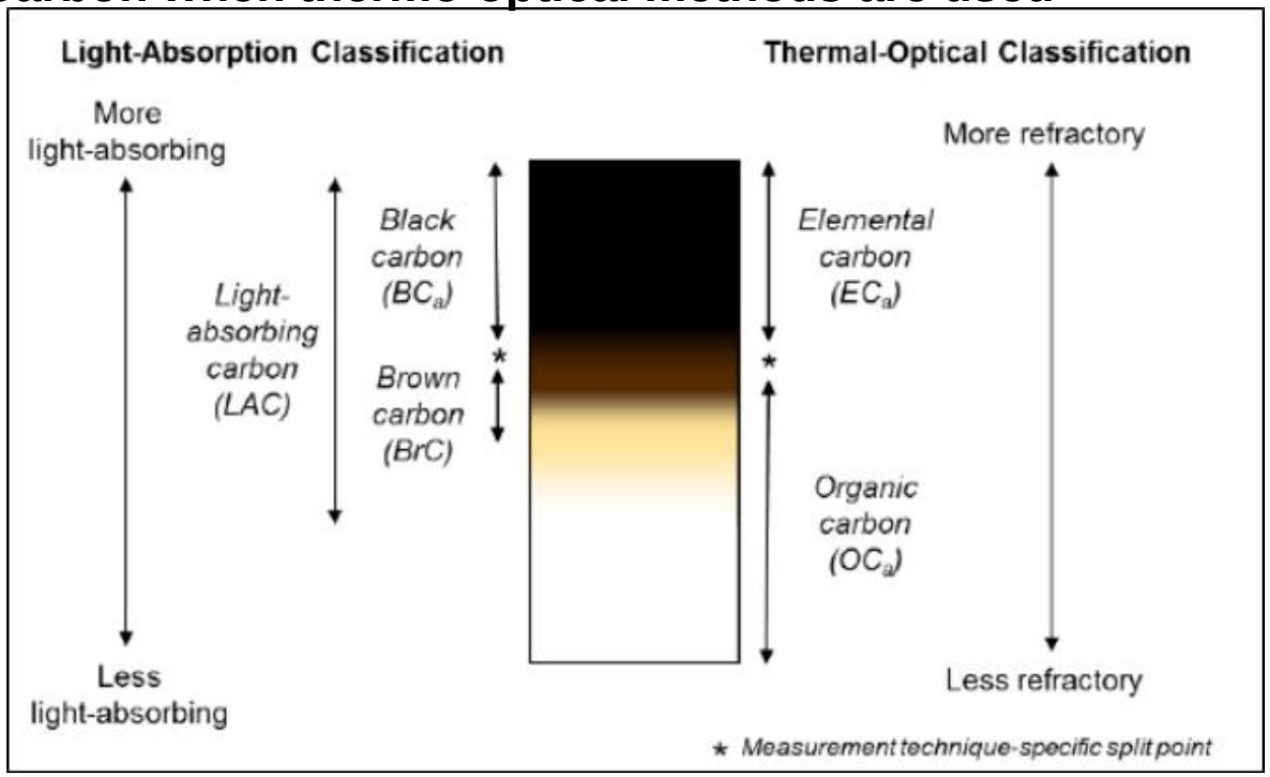
Some terms and definitions

The Scientific Advisory Group for Aerosols of the Global Atmosphere Watch program of the World Meteorological Organization (WMO) recommends:

Use BC as a qualitative term whatever the measurement method is

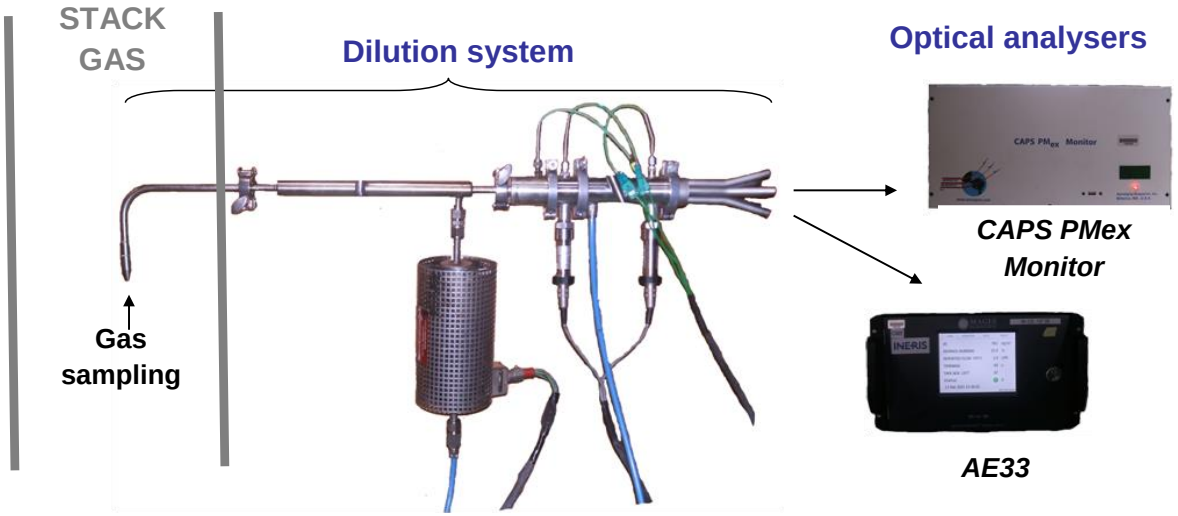
but use:

- ✓ **Equivalent Black Carbon (EBC) when optical methods are used.** The absorption rate of the aerosol is converted in EBC with the Mass Absorption Coefficient (MAC). The MAC should be always reported
- ✓ **EC Element Carbon when thermo-optical methods are used**



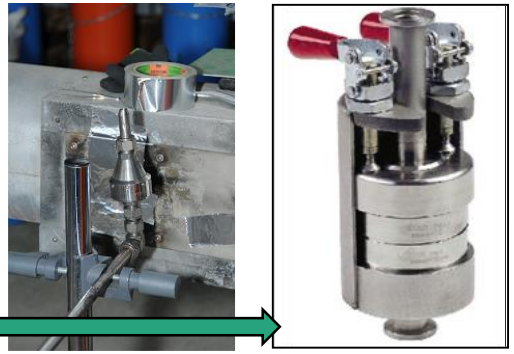
Measurement methods assessed

➢ Optical methods downstream diluter (automatic method)



➢ Thermal and thermo-optical methods

- **Sampling systems implemented:**
  - ➢ Sampling system of total particles onto filter
  - ➢ Impactor to determine size distribution: fractions PM_{10} and $PM_{2,5}$



- **Analycal methods tested:**
  - ➢ Thermal analysis: **method 2-Steps** developed by Cachier et al. (1989)
    NOTE: analytical conditions initially optimised for diesel BC ambient air measurement
  - ➢ Thermo-optical analysis (method standardised for ambient air ➔ EN 16909 since 2017)
    Interest compared to the thermal method: optical correction of artefact due to OC pyrolysis

Lessons from trials on bench test and on site

➢ Measurement methods assessed

- **Good repeatability of each method**
- **BUT significant differencies between results from optical/thermal/thermo-optical methods** (differencies also observed in ambient air)

  ➔Importance to specfiy the method, the protocol and the equipment used together with the results obtained

  Comparison of thermo-optical and optical methods

  Relatively good agreement during trials on bench tests:

  ➔ BC(optical method)/BC(thermo-optical method) = **between 0,6 and 2,8**

  (average = 1,5 - median = 1,5)

  But not so good on site:

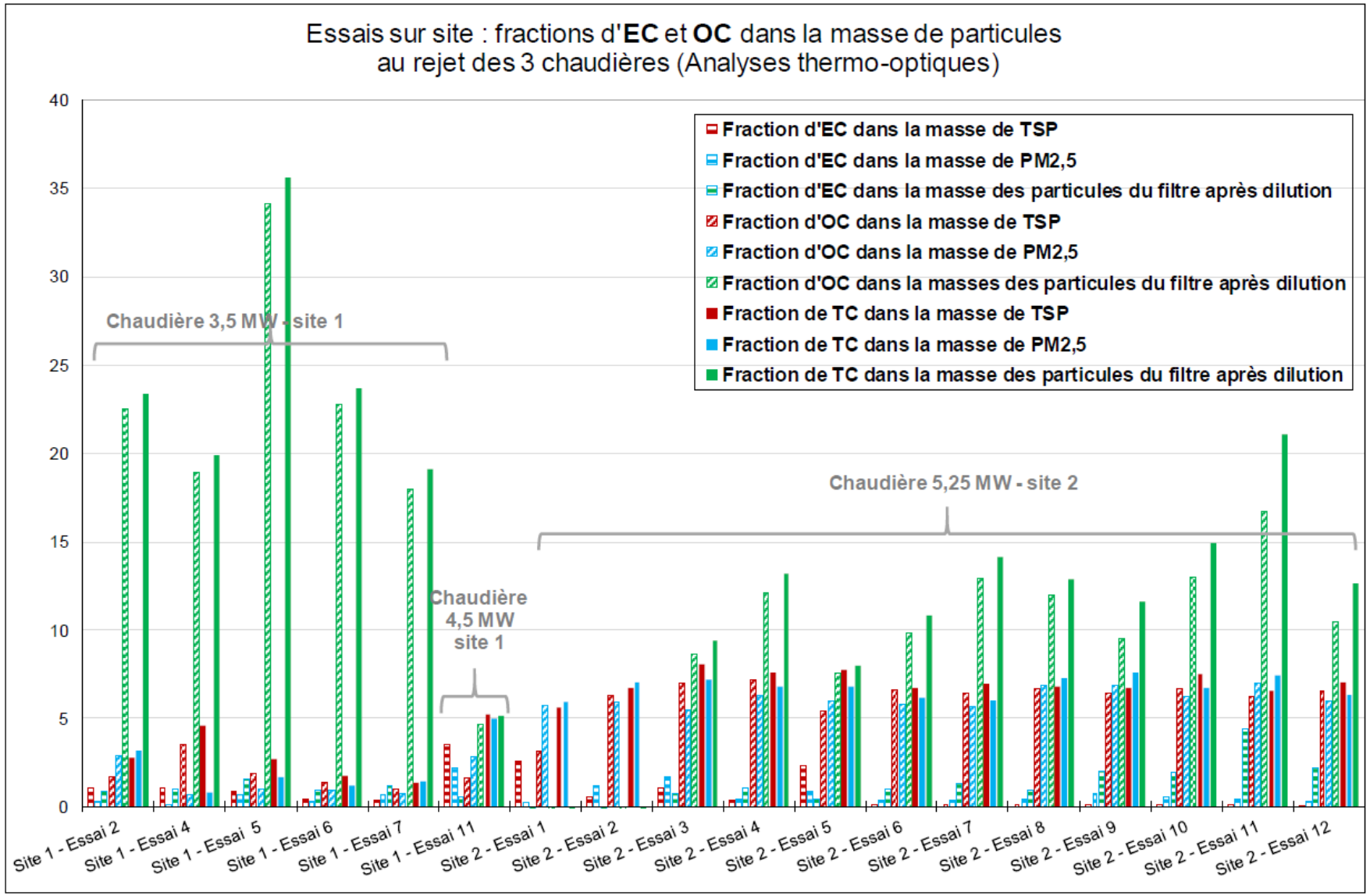
  ➔ BC(optical method)/BC(thermo-optical method) = **betwen 0,1 and 6,2**

  (average = 1,4 - median = 0,5)

- **Difficulties due to lack of reference material**

Lessons from trials on bench test and on site

BC is present in PM2,5 but also other fractions



Lessons from trials on bench test and on site

➢ Assessment of EF

- Estimation of input capacity of the boiler associated to uncertainties
- Main influencing factors for the 2 sites :
  - **Measurement method used**
  - **PM fraction considered, especially when PM larger than 2.5 are not negligible**

  ➔ **Recommendation: improvement of the robustness of BC EF determination by performing several measurements**

- Fractions [$BC/PM_{2,5}$] of the 2 sites compared to national inventory ratio:

	Site 1	Site 2	National inventory
[$BC/PM_{2,5}$]	< 1,5 %	< 1 %	10 %
[$TC/PM_{2,5}$]	≈ 2 %	≈ 7 %	

BUT  [$BC/PM_{2,5}$] of national inventory is applied for **combustion installations with a rated capacity below 50 MW, burning wood and similar waste** : **10 %**

➔ **Include all types of wood and waste, and different size of installations**

Conclusions and perspectives

- **No measurement method interely satisfactory**
  - No simple correction factor can be applied to the different methods
  - **Oncoming projects to be followed:**
    - **Feedback necessary on hybrid methods (incandescence and photo acoustic methods)**
    - **More comparisons on emission matrices needed**
    - **Development of a reference material**

- **Which method to be selected in case of practices harmonization?**
  - Choice can be guided by:
    - The capacity to use the method rapidly: Feasibility/easiness of routine measurements?
  - Good practices to be applied:
    - Measurement repetitions

- **Which PM fraction should we consider in emission inventories?**
  - BC fraction both in PM10 and PM2.5
  - Focus just on BC emitted by fine particles in order to deal with health effects?
  - Risk of underestimation of total BC emissions if BC just estimated from a ratio in PM2.5 ?