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ADEME AGENCE DE LA TRANSITION ÉCOLOGIQUE

Between physicochemical characterization of atmospheric particles and their impact on human health - challenges and perspectives (RECORD project)

RECORD Study N°18-0677/1A

Atmos'Fair, Webinaire – 23 et 24 Juin 2020

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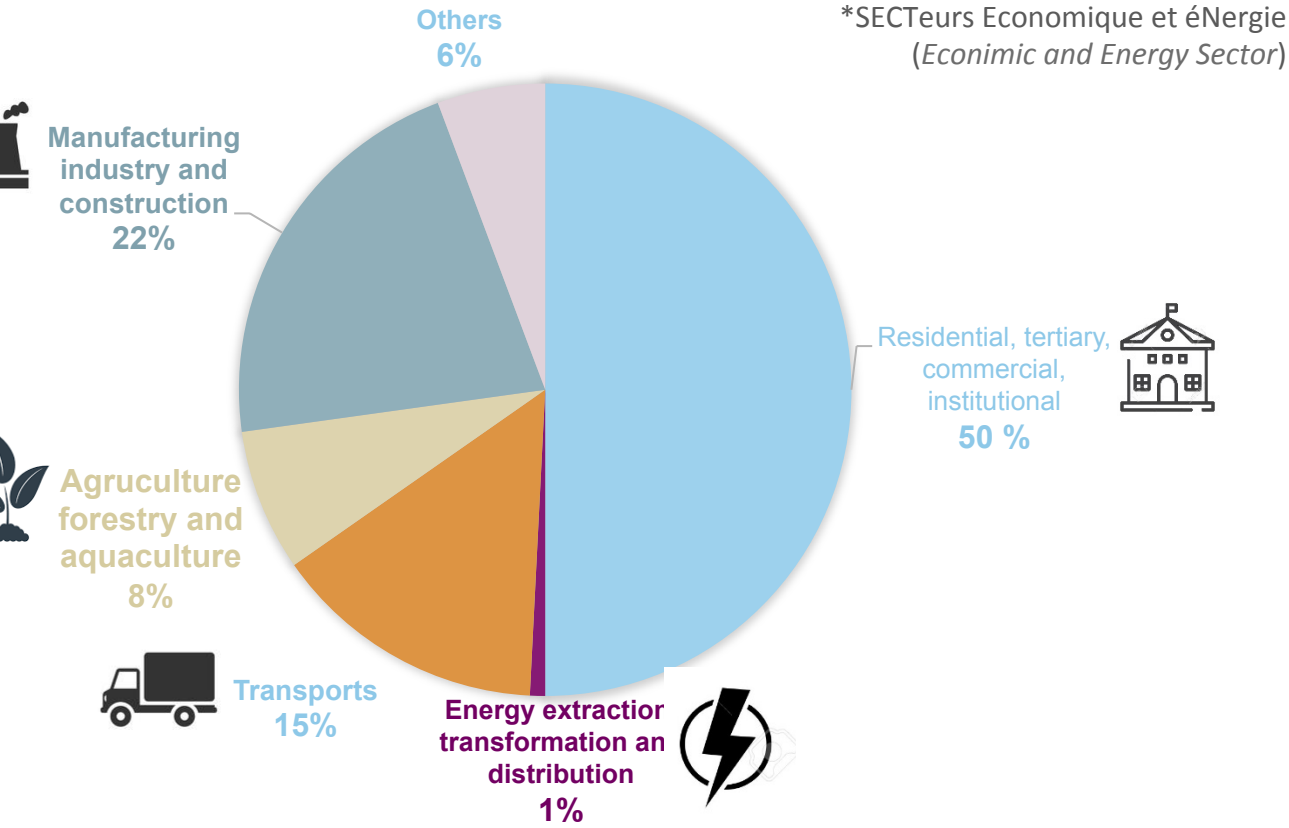
Introduction

Air pollution causes 48,000 deaths per year in France according to *Santé Publique France* (201
✓ Certain particulate and gaseous pollutants are considered as indicators of air quality

THE MAIN SOURCES OF $PM_{2.5}$ IN FRANCE IN 2017
CITEPA, 2019 - SECTEN FORMAT *

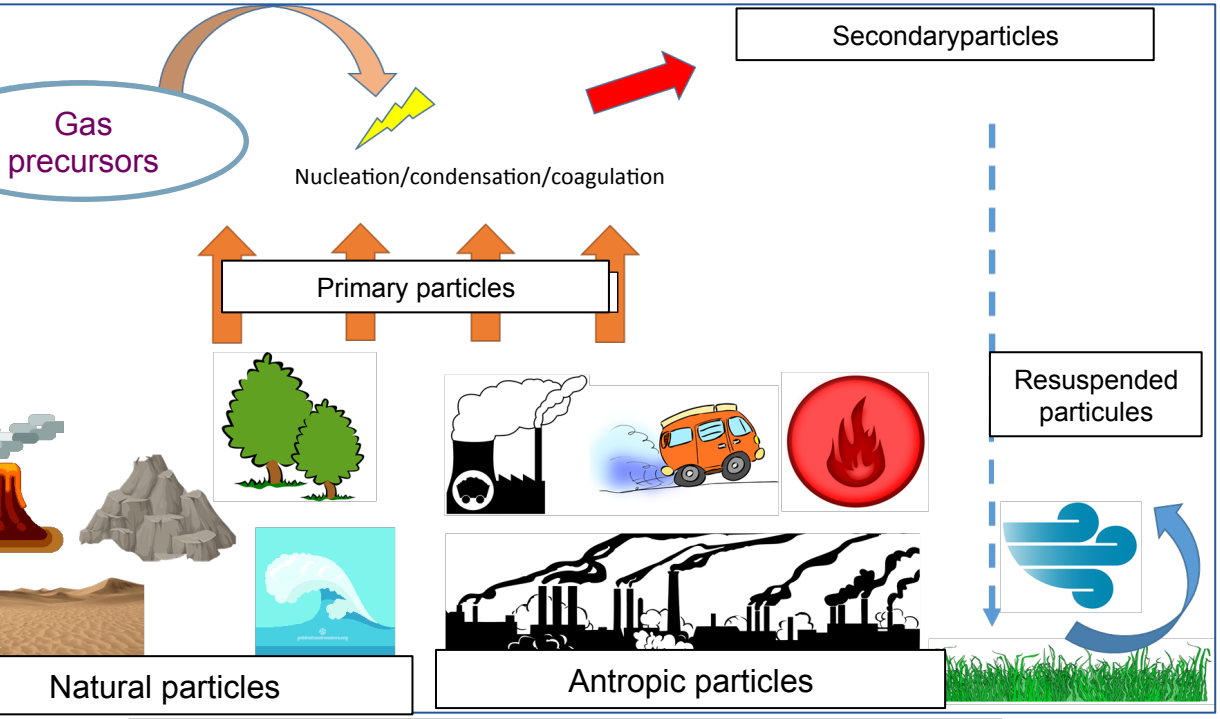


*SECTeurs Economique et éNergie
(*Econimic and Energy Sector*)

- ✓ Total suspended particles are "solid or liquid particles (...) which remain in the air for a certain time" *(GreenFacts, 2019)*
- ✓ Atmospheric particles coming from combust are composed of a carbon nucleus and act as vector for certain xenobiotics

- What are the physicochemical parameters the particles that influence the most thei toxicity following exposure by inhalation?
- How do the sampling and characterizatio techniques impact an assessment of the toxi of particles?

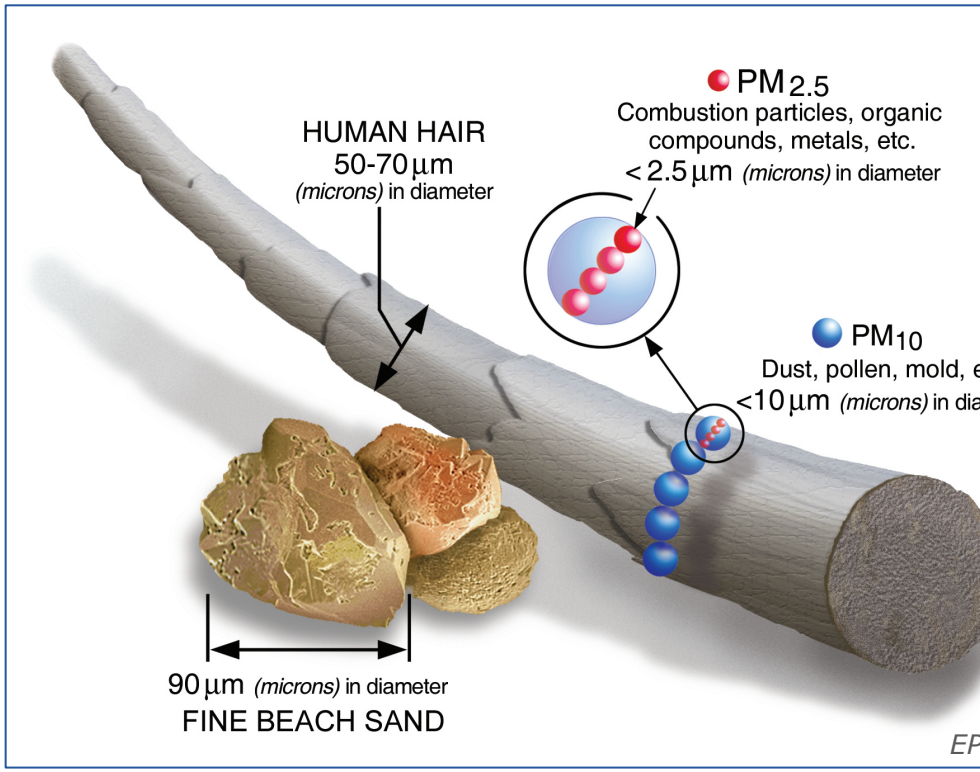
How to define the airborne particles?



The most common classification of atmosp particles is based on their size, often presented a aerodynamic diameter of the particles.

The three main classes of particles are:

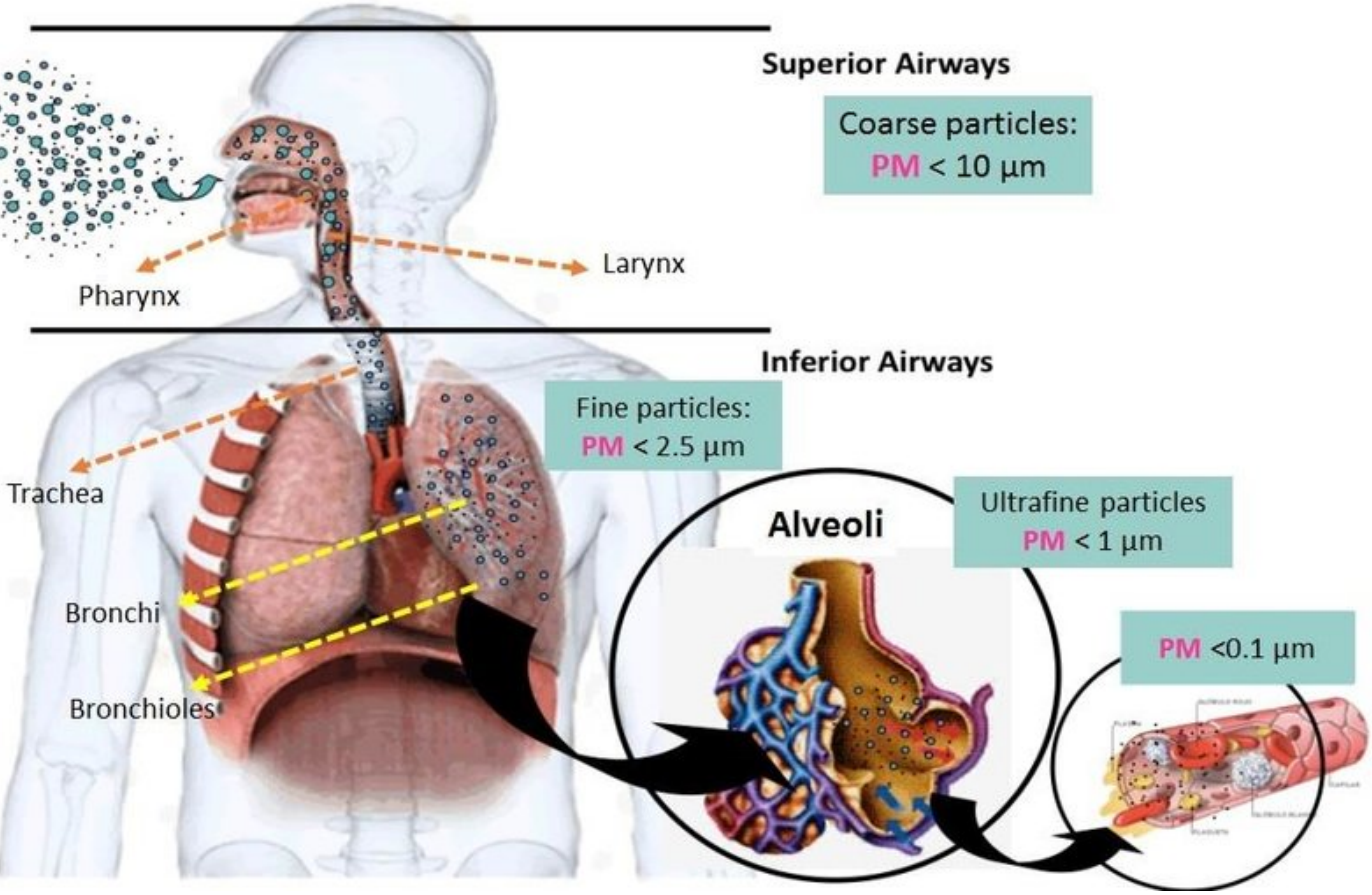
PM_{10}, $PM_{2.5}$, $PM_{0.1}$



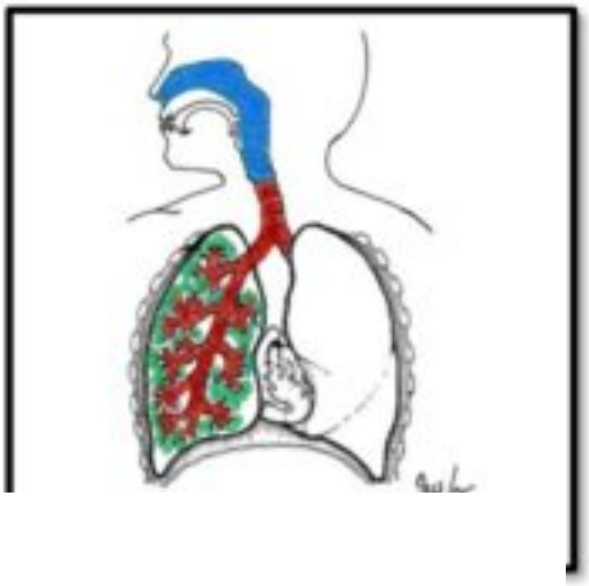
WHO recommendations and limit values in EU and France

	WHO recommandations	Limit values UE	Limit values France	Average period
	20 µg/m³ 50 µg/m³	40 µg/m³ 50 µg/m³	40 µg/m³ 50 µg/m³	1 year 24h
	n.d. 10 µg/m³ 25 µg/m³	20 µg/m³ 25 µg/m³ n.d.	n.d. 25 µg/m³ n.d.	3 years 1 year 24h

Deposition of atmospheric particles in human respiratory tract



Barazza 2017

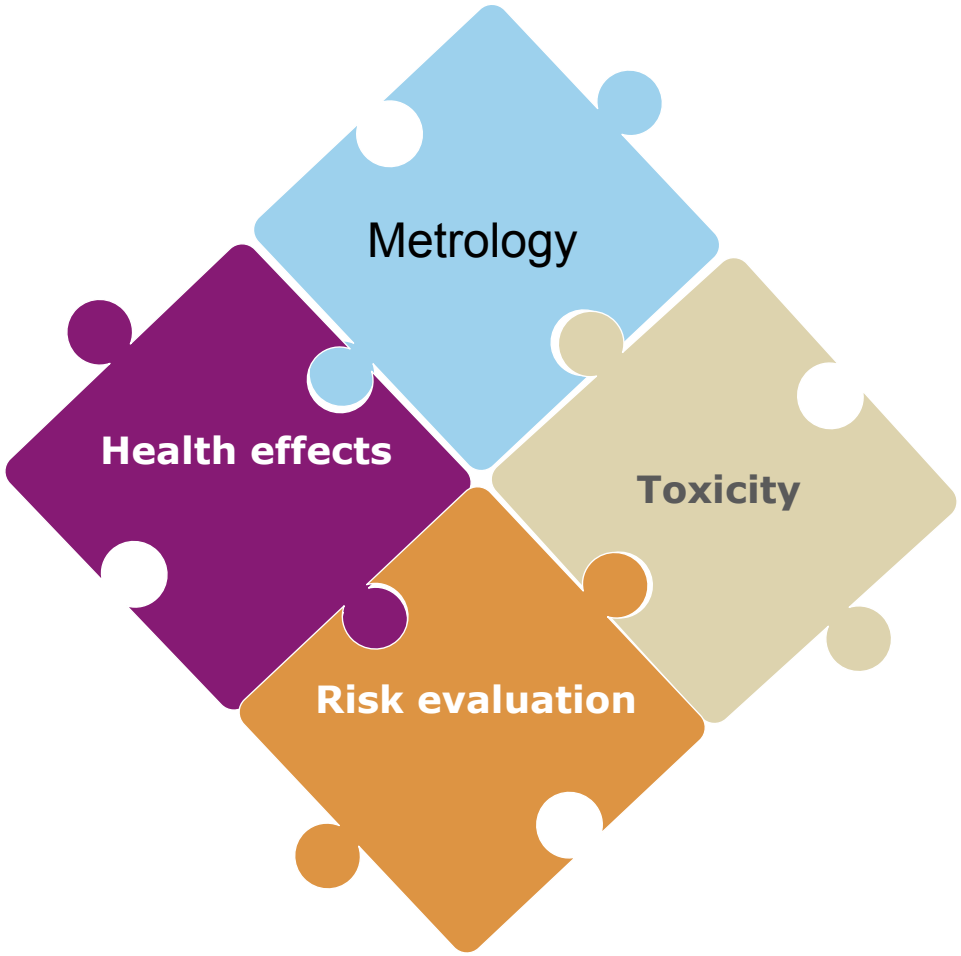


- Total fraction
- Extrathoracic region
- Tracheobronchial regio
- Raspiratory fraction

Witschger et Fabriès, 2005

determines the region where particles are deposited in the respiratory system

Objectives



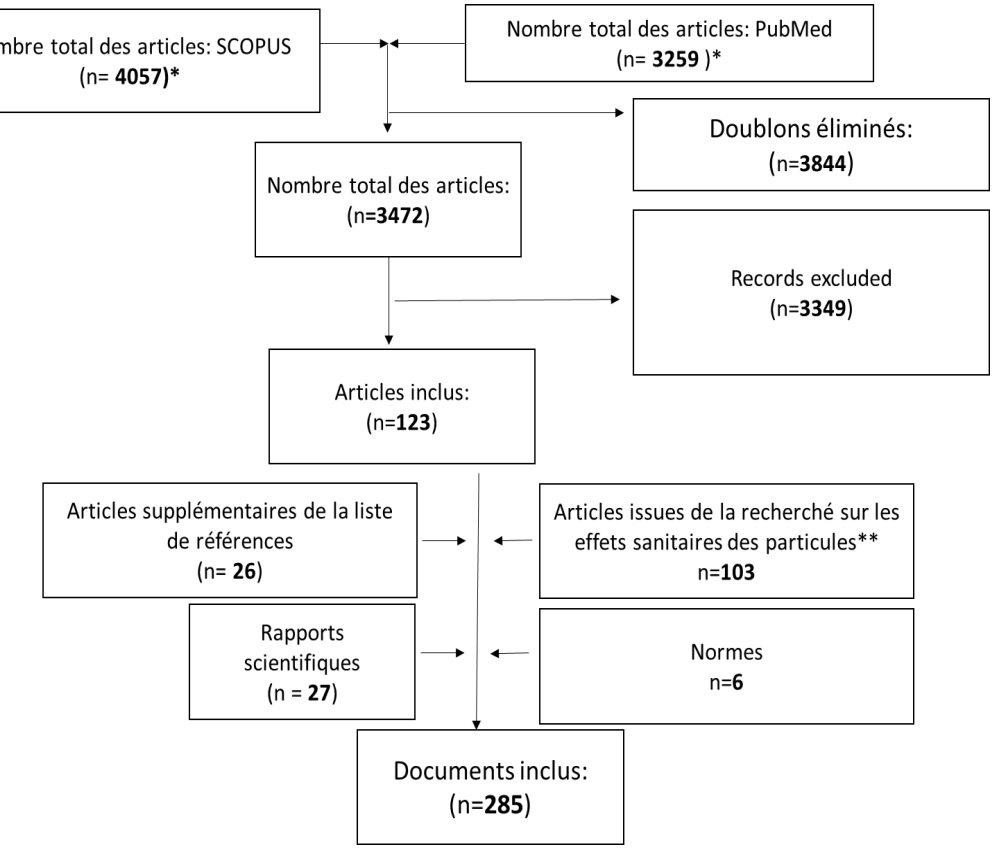
(1) To evaluate the relevance of sampling methods and analytical techniques used commonly for atmospheric particles

(2) To present the state of the art of the health effects of particles following exposure by inhalation

(3) To define the relevance of different physicochemical characteristics (shape, chemical composition etc.) of the airborne particles compared to the size as a commonly used criterion

(4) To study the relevance of tools for the assessement and management of the impact of air pollution on human health

Methodology



ulate matter" OR "$PM_{2,5}$" OR "PM_{10}" OR "$PM_{0,1}$" OR "airborne particles" OR "inhalable s" OR "alveolar particles" OR "ultrafine particles" OR "fine particles") AND ("toxicity" otoxicity" OR "inflammation" OR "oxidative stress").

✓ **Estimation of the level of scientific interest and the level on the scientific confidence**

Formules :

- "Particulate Matter"[Mesh] – all the particules of all the sizes and all the sources
- " Pathologies groups "[Mesh], for exemple« cardiovascular diseases », « liver diseases » in order to precise the group of pathologies
- A supplement: NOT ("Tobacco Use"[Mesh] OR "Tobacco Smoke Pollution"[Mesh] OR "Cigarette Smoking"[Mesh])

Bibliographic analysis ⇄ Expert opinions

Qualitative analysis: theoretical coding

RESULTS

Characteristics of atmospheric particles and their links with toxicity

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How to caracterise atmospheric particles?

Complex nature of particles

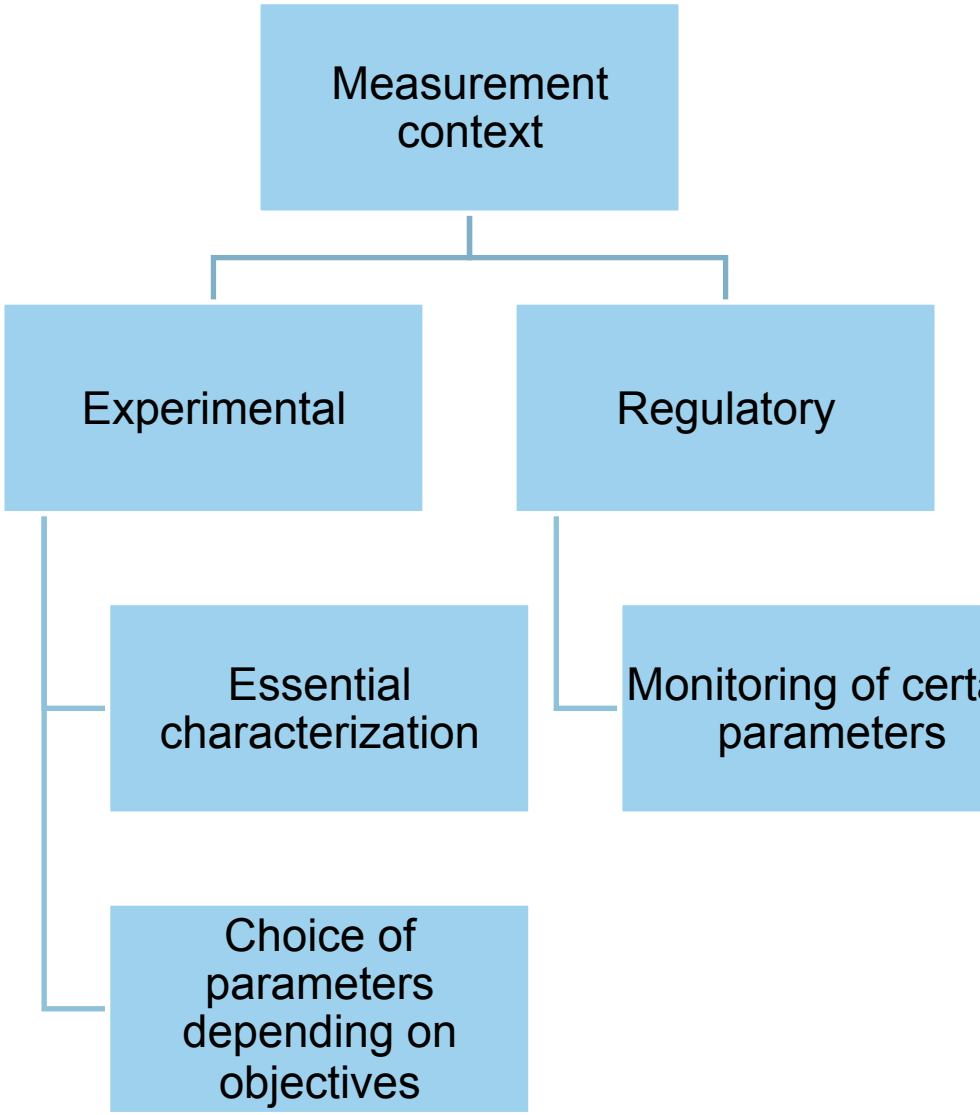
"Extremely complicated" to establish a link between specific characteristics and health effects, even if the both are very well identified

Some questions remain open:

hat is the quantity of particules actually inhaled?
ow toxic is it?
ill we be able to represent what is happening in the uman body?

There is no analytical method that can allow to study the particles as a whole, several techniques must be used"

Expert in physicochemical analyses

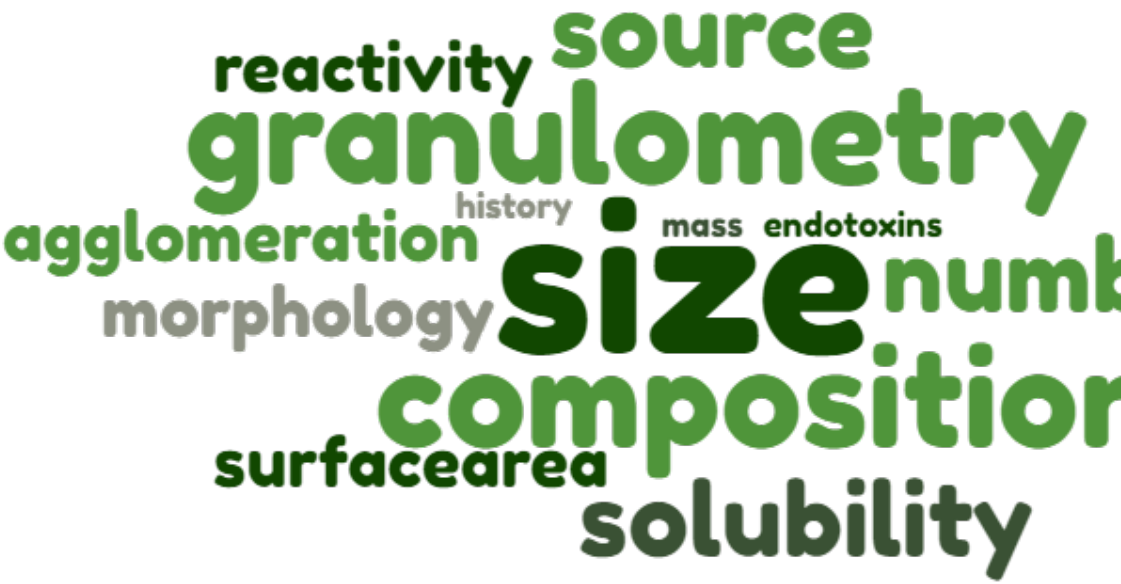


How to caracterise atmospheric particles?

- It is impossible to prioritize the physico-chemical parameters in order of importance related to the toxicity of the particles.

- According to experts, the parameters should be defined according to the objectives of the study.

- Parameters that influence particle toxicity include: the size, the specific surface area, the composition, the solubility, the oxygen content, the zeta potential and the surface charge, the aggregation and the agglomeration of the particles



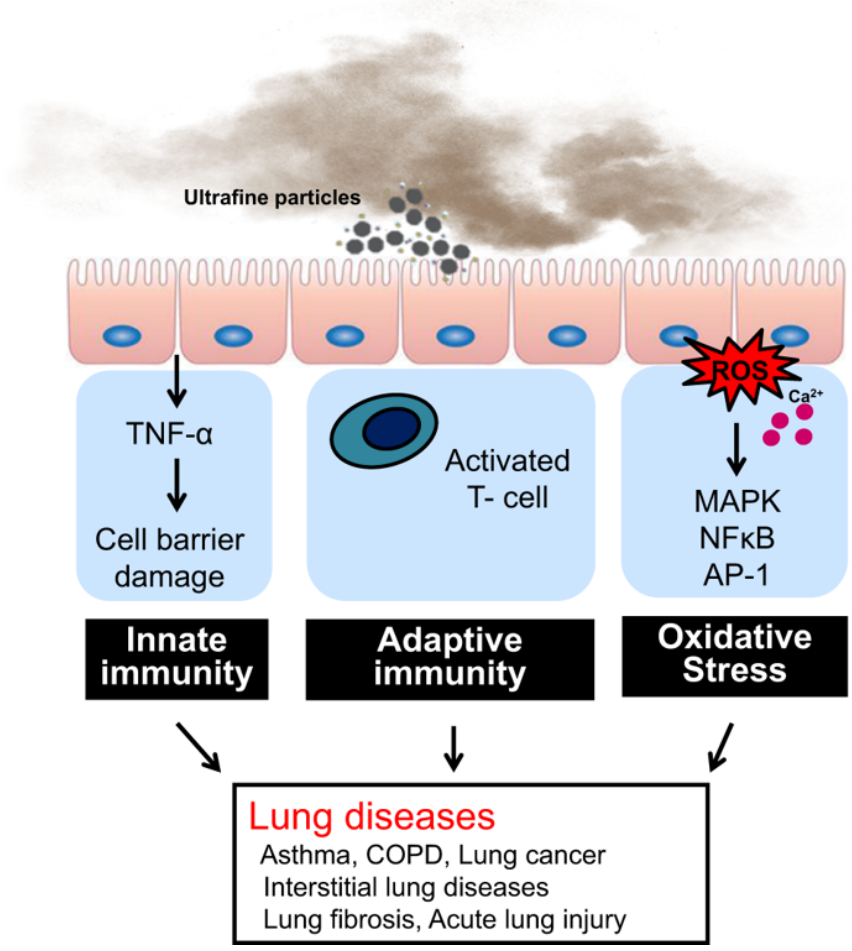
- These parameters can modify the reactivity of the particles and change their oxidizing potential.

Characteristics of atmospheric particles and their links with toxicity

Parameter	Impact on
Size	Deposit area Sedimentation rate Concentration of particles on the surface of target cells Composition
ecific Surface Area	Quantity of contaminants adsorbed on the surface
Composition	Physico-chemical, toxicological properties Redox potential
Solubility	Bioavailability
Oxygen content	Aggregation / Agglomeration
Zeta potential/ surface charge	Aggregation / Agglomeration
Aggregation / Agglomeration	Interaction of particles and cells
xidative potential	Oxidative stress

Characteristics of atmospheric particles and their links with toxicity

xidative potential (PO) as a predictive indicator of particle toxicity?



Leikauf et al. 2020

„We are working with the oxidative potential, which global parameter that tries to measure the reactive ox species that have an impact on oxidative stress. It is no l a compound of the particle but its reactivity, it is a prox the cellular response which can be measured in atmosphere. Rather than analyzing several compounds o particle, we are looking for a parameter which aggregate size, the number, the morphology, the oxidizing potential

Expert in physicochemical an

RESULTS

Effects of airborne particles on human health

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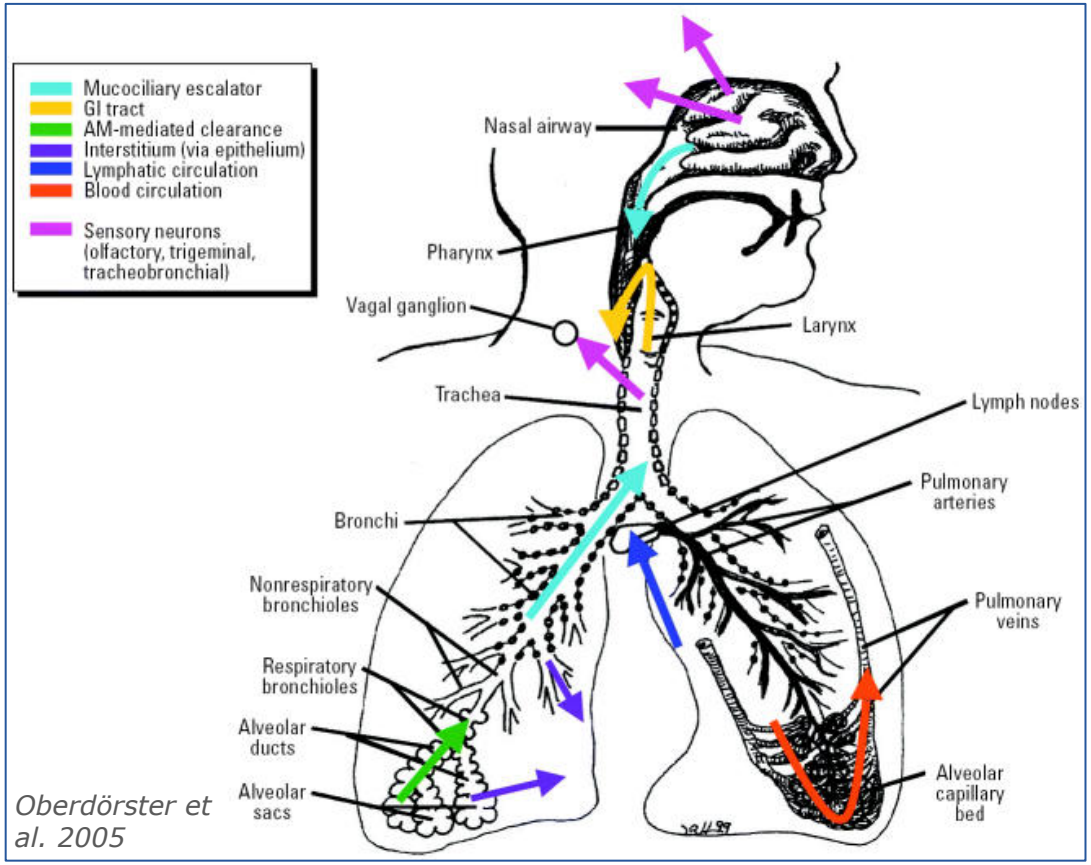
Effects of airborne particles on human health - mechanisms



Oberdörster et al. 2005

„From the moment the particles manage to cross t alveolar barrier, they pass into the blood system"

Expert in toxicology

The different categories of studies of the health effects of atmospheric particles

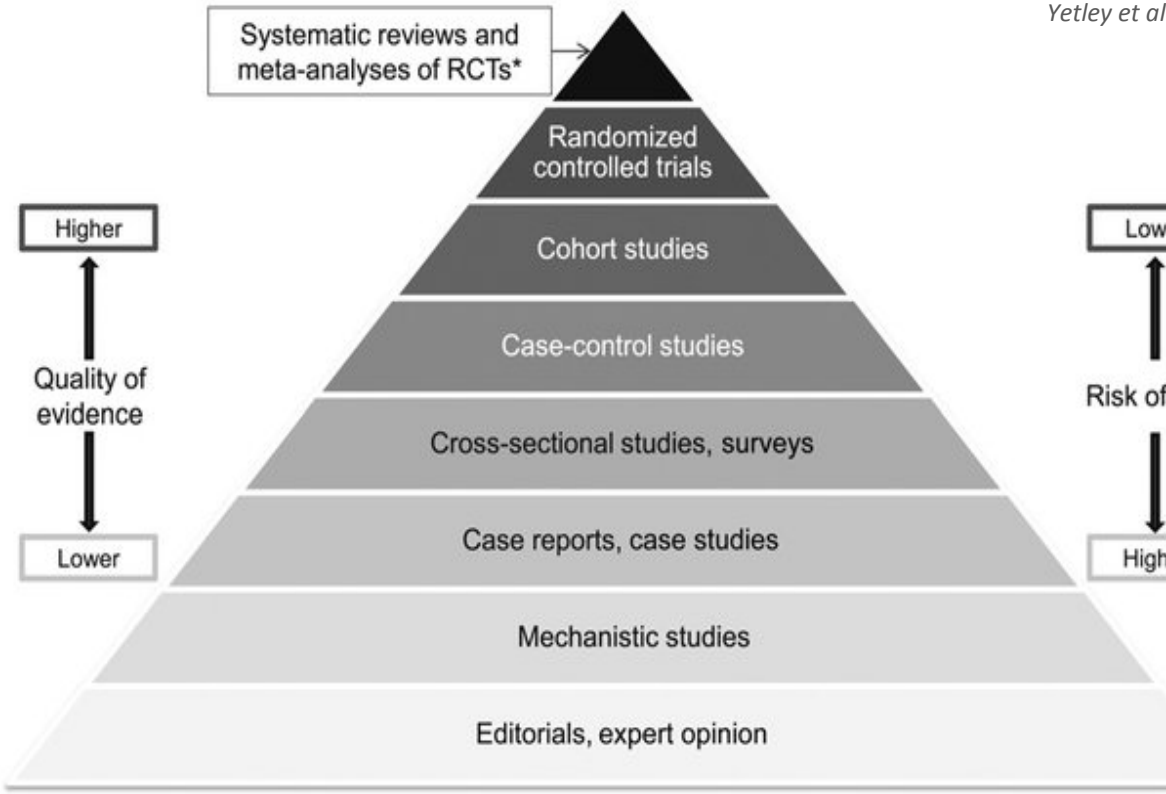
Long term effects

hronic exposure
evelopment of chronic pathologies

Short term effects

-7 days of exposure
ggravation of chronic pathologies
cute symptoms with varying
everities

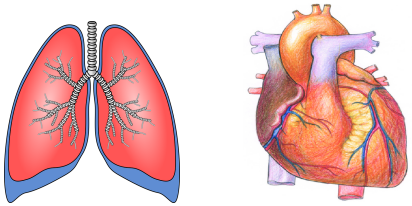
Hierarchy of studies in the context of the assessment of causality between a factor and a health effect



Effects of airborne particles on human health

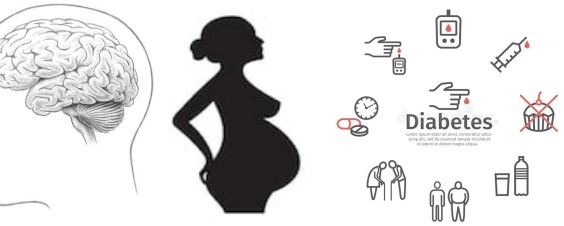
First circle of scientific interest

« proven effects»



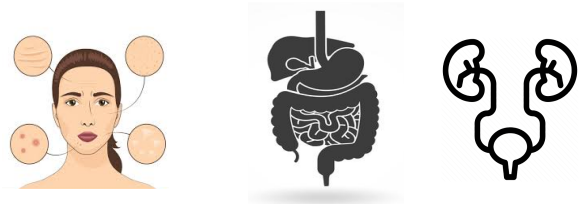
Second circle of scientific interest

« likely effects »



Third circle of scientific interest

« potential effects »



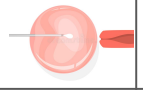
« without evidence »

- ✓ The health effects of particles have been classified according to target organs
- ✓ The most studied are the effects of particles on the respiratory and cardiovascular system
- ✓ There is scientific evidence of the link between air pollution and neurological, perinatal health and diabetes
- ✓ Toxicity to other organs has been investigated but no scientific evidence has yet been sufficient to confirm the link

Effects of airborne particles on human health

		Long-term effects	Short-term effects
roven effects onfirmed in at least 11 meta-analyzes founding and risk factors ken into account and do t change the confidence given to the results	Respiratory health 	**$PM_{2.5}$ PM_{10}**	**$PM_{2.5}$ PM_{10}**
	Cardiovalscular systen 	**$PM_{2.5}$ PM_{10}**	**$PM_{2.5}$ PM_{10}**
ikely effects onfirmed in 3-10 meta-analyzes founding and risk factors ken into account and can luence confidence in the results	Neurologic health 	**$PM_{2.5}$**	-
	Perinatal health 	**$PM_{2.5}$ PM_{10}**	-
	Diabetes / metabolism 	**$PM_{2.5}$ PM_{10}**	-

Effects of airborne particles on human health

		Long-term effects	Short-term effe
otential effects -2 meta-analyzes show a positive trend everal confounding factors nd the risk of bias reduce he reliability of the results	Skin diseases 	-	$PM_{2.5}$ PM_{10}
	Digestive tract diseases 	$PM_{2.5}$	-
	Urological diseases 	PM_{10} $PM_{2.5}$ $PM_{2.5-10}$	-
ffects without entific evidence • No meta-analyzes • A small number of epidemiological studies	Eye diseases 	-	-
	Autoimmune diseases and allergies 	-	-
	Skeleton and Joint diseases 	-	-
	Haematological diseases 	-	-
	Reproductive disorders 	-	-

RESULTS

How to assess the health impact o
atmospheric particles

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How to assess the health impact of atmospheric particles?

e assessment of the health impacts of pollutants is carried out in two contexts: professional / lustrial environment and public health.

he characterization of the particles ill help to target the sources and nrich the HIA in order to define the ources of pollution, on which we ust react most quickly. This is why he characterization of the omposition of particles in routine eems very important today"

Public Health Expert

The classic HRA methodology cannot be applied to particles due to the lack of TRV. A "substance by substance" approach is possible and currently used.

World Health Organization

HIA-AP can be performe for a pollutant-health effect pair for which ther is evidence of impact. I is a decision support too

Sant publi Franc

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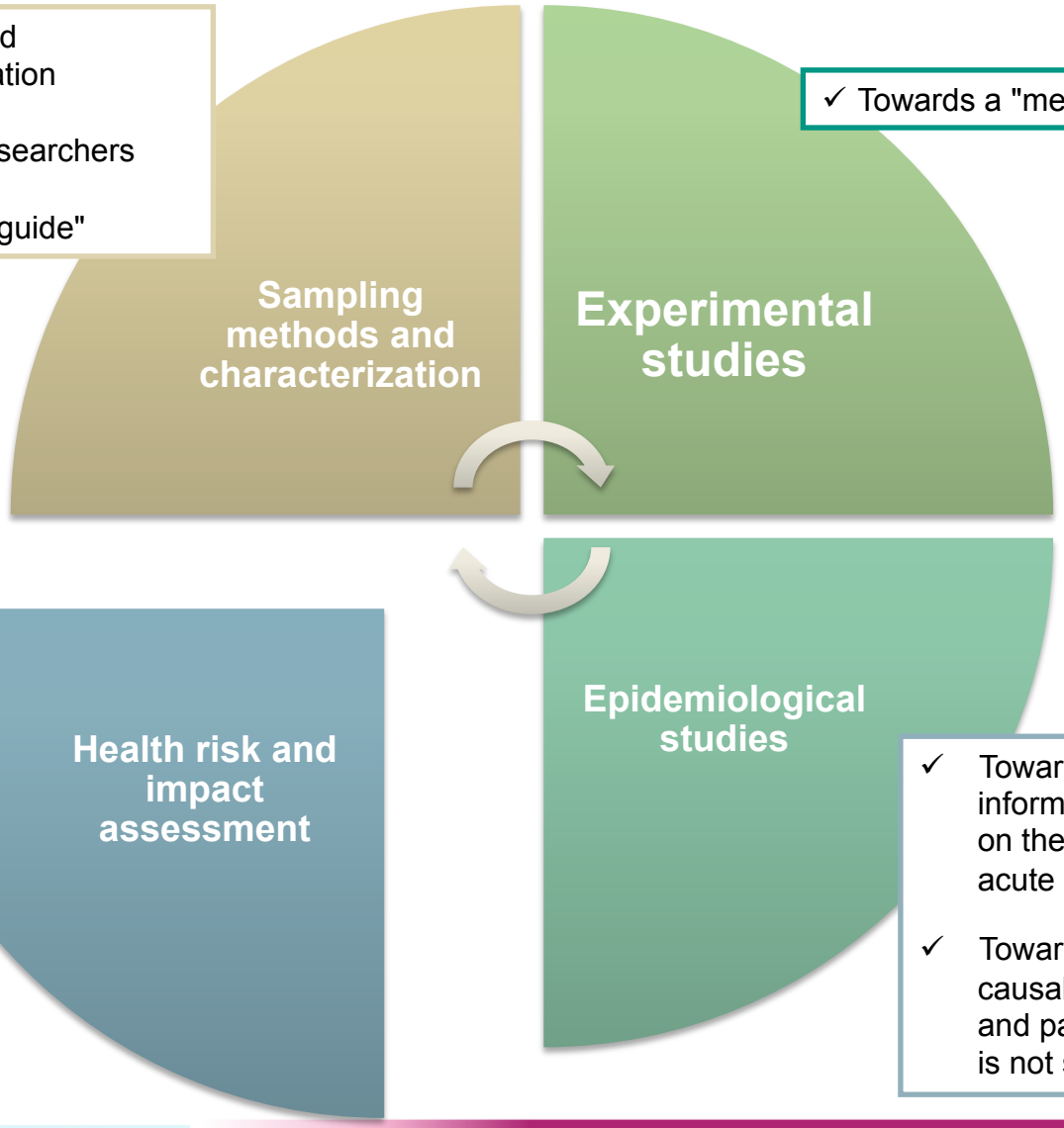
Health Risk Assessment and Health Impact Assessment – Air Pollution

	HRA	HIA - AP
Application domain	Industrial / Public health / Professional environment	Public health
Substances	All molecules that can be defined, for which the TRVs exist	Air pollution indicators $PM_{2.5}$, PM_{10}, O_3
Benchmarks	TRV	Limit and recommended values
Results	Risk index	Number of attributable or preventable cases, number of years of life lost or gained, variation in life expectancy, decrease in concentration necessary to achieve a health goal
Regulations	Labor Code Environmental Code	/

Epilogue

Conclusions, perspectives and recommendations

- ✓ Need for standardization and normalization and / or validation
- ✓ Communication between researchers
- ✓ Towards a "methodological guide"



- ✓ Towards a "methodological guide"

act assessment according to
rce

ection on one or more “particle”
:
hodological analogy based on
construction of “dust”
upational exposure limit values
logy for approach of mixtures -
PAHs
cept of toxic equivalency factors
ermination of the lower limit of the
e benchmark confidence interval
rating

- ✓ Towards a better acquisition of information on health indicators - focus on the effects of pollution peaks on acute health events of different severity
- ✓ Towards the assessment of the causality between atmospheric particles and pathologies for which the evidence is not sufficient

Recommendations

<u>Priorities</u>:

- ✓ Monitoring of ultrafine particles in the atmosphere
- ✓ Identification of sources (pollutants-tracers)
- ✓ Harmonization of definitions related to particles
- ✓ Cooperation between differant areas of expertise
- ✓ Act on the difference between the reglemantory and sanitary values
- ✓ **Prevent and reduce the emissions**

Thank you for your attention

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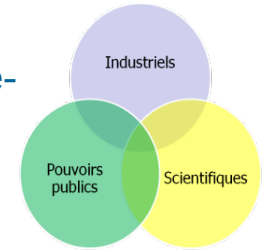
Develop applied knowledge and share experience around ***used products, waste, polluted sites,*** *resource efficiency in view of contributing to the* ***circular economy***

RECORD association is a network open to all organisations, public or private. RECORD enables studies and researches to be conducted as part of a peculiar three-party cooperation between **the industry, public institutions and researchers.** This cooperative environment makes of RECORD a privileged framework to **exchange** as well as a tool for **technological and scientific intelligence.**



Financing projects (alone or as part of wider partnerships)

(Bibliography, Field studies (metrology, trials, etc.), Technical state of the art, benchmarking studies EU / regulation, …)

Programmes receiving financial support from ADEME

From state of the art---> to PhD work

RECORD subjects for studies and research

- Knowledge and characterization – methods and tools (metrology, understand waste streams, etc.)
- Development of value chains to recover and treat waste (processes, effluent treatment, etc.)
- Assess sanitary and environmental impacts and risks (improve methodologies for sanitary and environmental risk assessment, population health, occupational health, upcoming: ecology engineering)
- Assess social and economic dimensions (economy, law – regulation, externalities, etc.)

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