nanoMONITOR

Challenges addressed by the project: monitoring the concentration of NMs in urban areas and industrial zones

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European Commission ENVIRONMENT LIFE Programme

Life

Outline

1. NMs in urban environments
2. Sources of NM release
3. Challenges encountered in the urban NM monitoring
4. NanoMONITOR project plan

nanoMONITOR

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ENVIRONMENT
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1 NMs in urban environments

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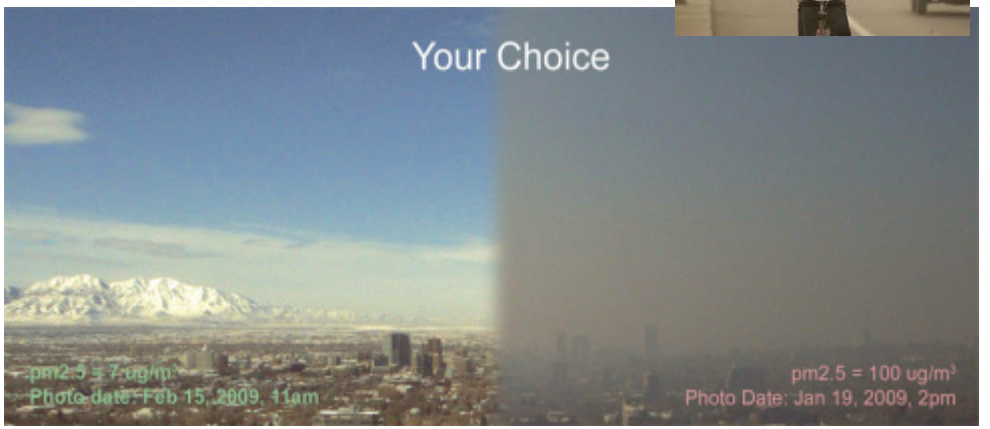
NMs in urban environment

Air quality and NMs

Air quality is still a major concern in many cities worldwide. Since the early 1970s, the EU has been working to improve air quality.

The parameters to determine the quality of the air we breathe (regulatory pollutants):

- Particulate matter (PM10, PM2.5)
- Carbon monoxide (CO) and dioxide (CO2)
- Nitrogen oxides (NOx, NO, NO2)
- Ozone (O3)
- Methane (CH4)
- Hydrogen sulfide (H2S)
- Hydorcarbons



Mexico city *(source: https://fieldguidetonature.wordpress.com/)*

It has been proven that products containing ENMs can potentially release NMs into their surrounding environmentat some point in their life cycle.

However, environmental air quality campaigns have not yet integrated the presence of NMs, either engineered (ENMs) or incidental (INMs), in complex outdoor urban environment.

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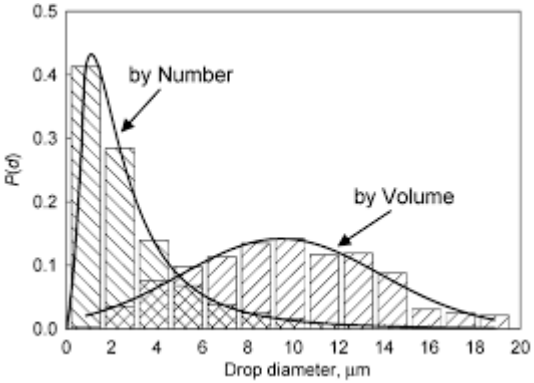
NMs in urban environment

Air quality and NMs

Growing concern on whether these particles may have a greater potential for adverse health impacts compared with their larger counterparts *(WHO, 2013)*.

Results show that even soluble metal oxide ENMs may accumulate in sufficient concentrations to exceed the minimum toxic threshold in freshwater and some soils.

Although NMs contribute a negligible portion of the total mass of particulate matter, they are the dominant fraction in terms of particle number, reaching three orders of magnitude higher than larger particles, thus a major proportion of emissions remains unregulated through ambient air quality standards.



- Reliable characterization of NPs in air is crucial for developing a regulatory framework.
- Knowledge of inhalation dosimetry is important to establish links between exposure and health effects
- Longterm exposure studies would be required to confirm these hypotheses, but are yet currently unavailable

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2 Sources of NM release

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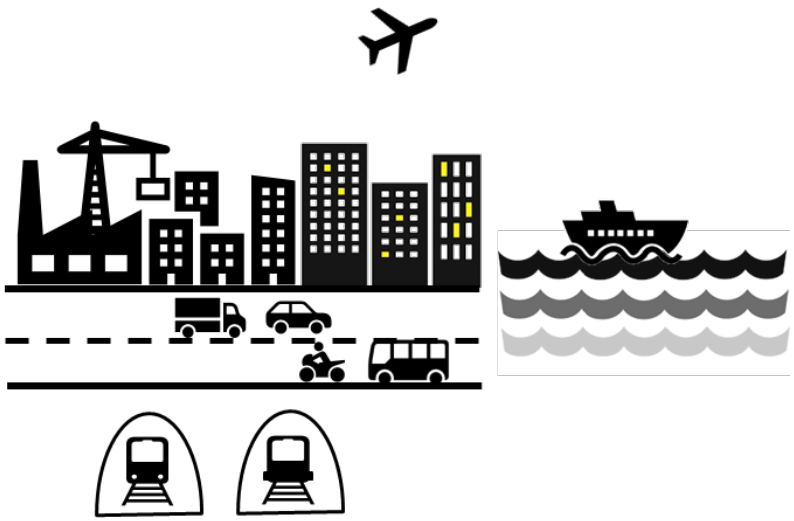
Sources of NM release

Different origins

Anthropogenic sources

- Manufactured (ENMs)
- Incidentally manufactured (INMs)
- Emissions from fuel vehicles
- Emissions from bio-fuel vehicles
- Tyre & road interaction, brakes



Natural sources

New particles formed in the atmosphere through:

- Coagulation
- Condensation
- Aggregation
- Dilution or mixing
- Dry deposition
- Evaporation
- Nucleation (photochemically induced or gas-to-particle conversion)

Other sources with large peaks but generally shortlived:

- Forest fires
- Dust storms
- Volcanic eruptions

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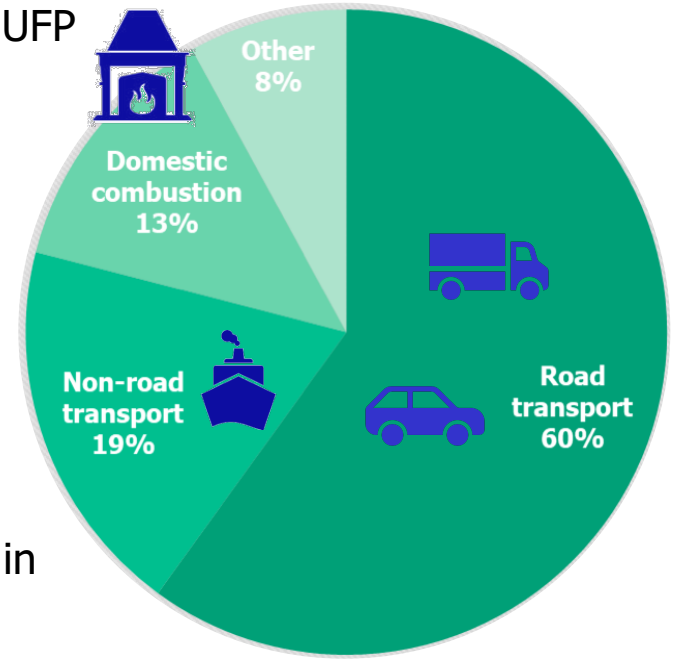
Sources of NM release

Emissions from vehicles & INMs

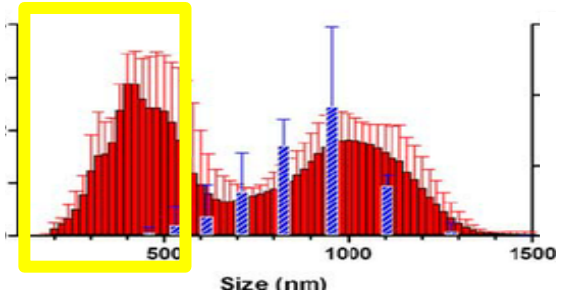
From the total particle number emissions, 84% lies within the UFP size range, and mainly is due to vehicle transport:

- Road transport >60%
  - semi-volatile engine emissions,
  - solid particle engine emissions,
  - brake wear and resuspension,
- Non-road transport ~19% (including ship traffic)
- Domestic combustion ~13%
- Other: Incinerators, smelters, power plants, and industries in urban areas



The large majority of commercially produced particles are highly polydispersed

↳ **not expected NM appearance!**



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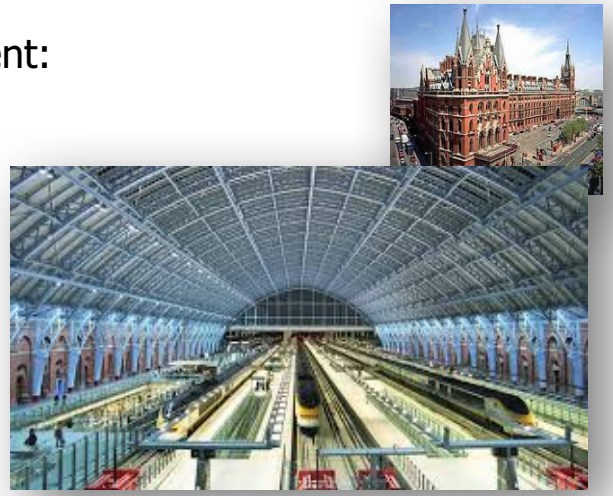
Sources of NM release

ENMs presence in urban infrastructures

ENMs are widely used in the context of the outdoor urban environment:

- Textiles and fabrics (e.g. ropes, sails, tents, traps): flame retardancy,
- In Concrete: self-cleaning surfaces, photocatalytic pavements
- In Steel: anti-crack, smoother surfaces, temperature restriction
- In Wood: moisture adsorbents, prevent discoloration, water repellance
- In Glass: temperature control, block UV & glare
- In Paints and Coatings: scratch resistant, Hydrophobic surfaces
- In Monitoring: sensors (stress, strain, vibration, cracking, corrosión…)
- Fuel additives: to enhance fuel efficiency
- Autos: High-performance tires
- Road markings: Antireflection layers



Roof panels of St Pancras Station in London (10000 m^2, 18000 Glass panels) with TiO_2 ENM photocatalyst & Self-cleaning

conventional glass | self-cleaning glass

Church "Dives in Misericordia", Rome, made by using self-cleaning concrete

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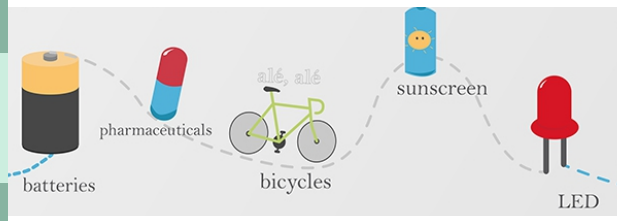
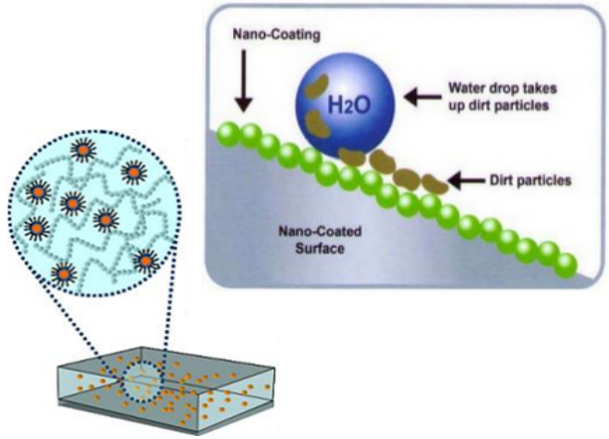
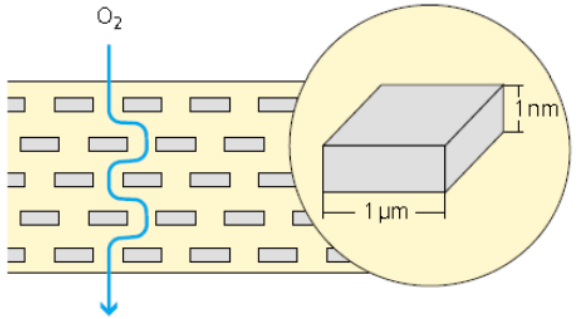
Sources

ENMs presence in urban infrastructures

Application	Property	Nanomaterial
Surface coating touch screens building facades paint	Anti-microbial	Ag, CuO, TiO_2, ZnO
Lighting street panels surface coating paint	Antireflection coating	SiO_2
Food packaging electronic devices	Gas barrier	Nanoclays
Paint surface coatings	Corrosion, abrasion and scratch resistance	Nanoclays, boehmite, SiO_2
Paint Coatings plastics	Electrical conductivity static charge dissipation	ITO, ATO, SnO_2
Prevent wild fires surface coating Asphalt plastics	Fire retardant	Nanoclays
Paint	IR-absorption/reflection	ITO, ATO, TiO_2, In_2O_3
Soils Rocks magnetic resonance imaging	Magnetic	Fe_2O_3
Dental bone implants cosmetics	Mechanical, scratch resistance	Al_2O_3, SiO_2, ZrO_2
Building facades Windows Paints pavements	Photocatalysis, self-cleaning	TiO_2, ZnO
Paint road marking	UV stability	TiO_2, ZnO, $BaSO_4$, CeO_2
Solar panels	Light trapping photo-carrier collection	CdS, CdSe, CdTe, ZnO, $CuInSe_2$, TiO_2
Touch screens sensors	Thermal and electrical conductivity	CNTs, graphene
Structures reinforcement fillers automotive / airplane manufacturing	Mechanical properties (strength)	CNTs





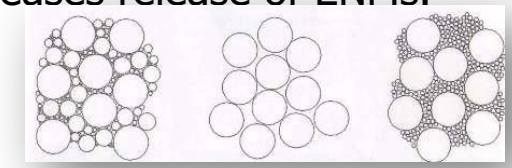


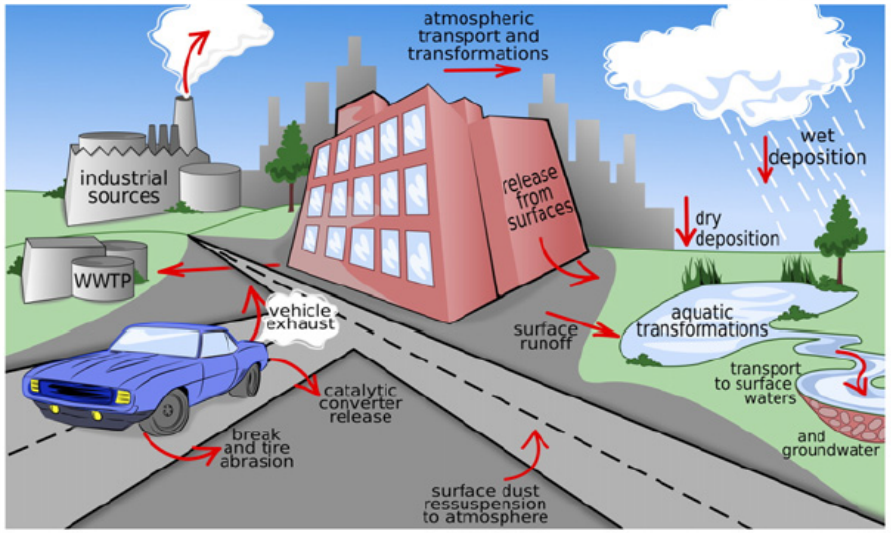
Baalousha et al, Sci.Tot. Env. 557–558 (2016) 740–753

Sources of NM release

How they release?

- Loosely bound ENMs on the surface coatings by:
  - UV irradiation
  - mechanical damage
  - wash off
- Matrix formulation (type and concentration of binder and fillers) -> a higher proportion of binder decreases release of ENMs.





- Sources and pathways of outdoor urban nanomaterials in the environment -

Source: Baalousha et al, Sci.Tot. Env. 557–558 (2016) 740–753

- Weather conditions, triggering ENM erosion that can lead to air/water transport and deposition of these ENMs into/onto soil, surface water, and impervious surfaces
- Temperature, especially in hot geographical locations, may result in faster weathering (corrosion) of the paint, enhancing release of ENMs. **But no studies are found that record the impact of temperature.** !
- City structure, densely packed high-rise buildings limit air exchange and hence, the dispersion of NMs, further elevating their concentrations.

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3 Challenges encountered in the urban NM monitoring

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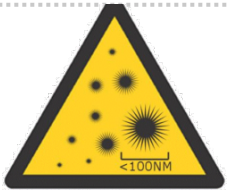
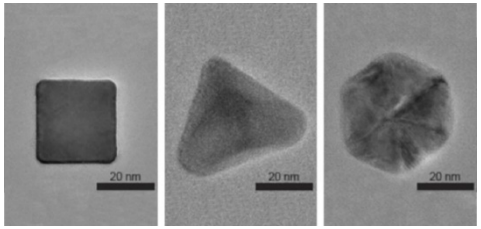
Challenges encountered in the urban NM monitoring

Challenges from the measuring element

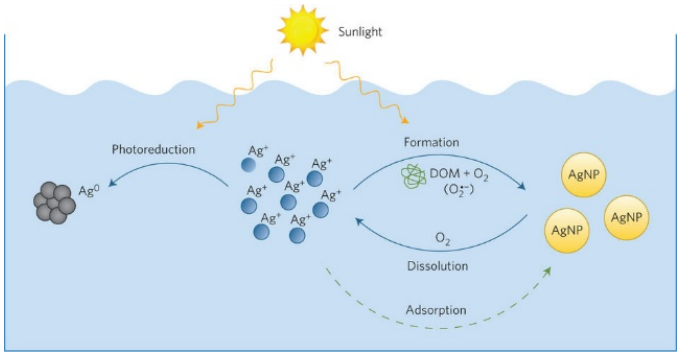


Understanding new particle formation in city environments is important to accurately estimate particle number concentrates and related exposure

- NMs in the atmosphere derive from a considerable number of sources, although road traffic emissions are frequently dominant.
- NMs can exist as single or aggregated particles.
- NMs can be manufactured with various shapes, coatings, and surface functionalities.



- NMs can undergo a number of potential transformations that depend on both the properties of the ENM and the local environment.



Challenge to predict their impact on the environment

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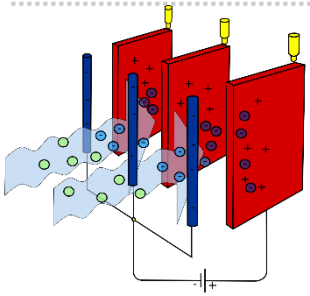
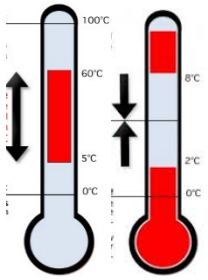
Challenges encountered in the urban NM monitoring

Challenges from the monitoriong devices



The main challenges faced by sensor platforms:

- Ensure their measurement reproducibility and assess any associated uncertainty.
- Data quality suitable for different applications (e.g., regulative purposes, exposure estimates, community monitoring, and education).
- Long-term performance -> lack of robustness for long-term unattended monitoring.
- Response to varying weather conditions.
- Safe levels of NM exposure are still ambiguous.



Standard methods to measure airborne NMs are yet needed

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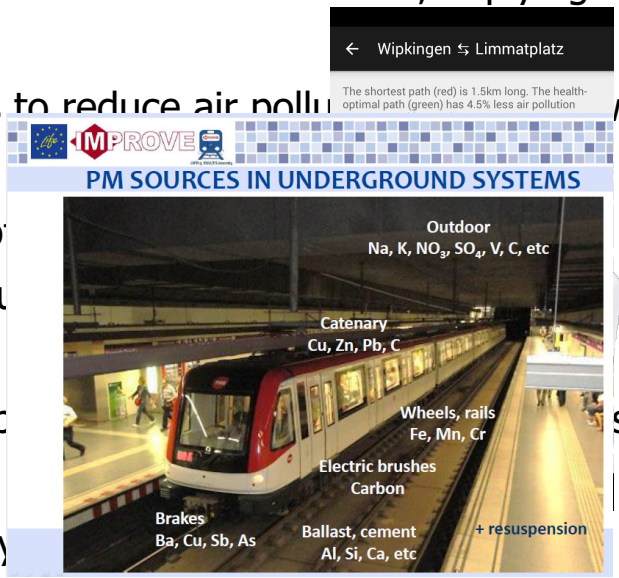
Challenges encountered in the urban NM monitoring

Lessons learned by other projects

- OpenSense: uses mobile platforms to monitor air pollution variation in cities, providing urban dwellers in Zurich a health-optimal routing service to reduce exposure to ultrafine particles
- AirCasting: an open-source solution for collecting, displaying and sharing air pollution data
- AirVisual: a crowdsourced community that has developed a home air quality monitor
- NanoDevice: to develop innovative concepts and reliable methods for characterizing ENP in workplace air with novel, portable and easy-to-use devices suitable for workplaces.
- Respira: Platform to measure pollutants from volunteering cyclists to prove the efficiency of urban plans in improvement of air quality and share technology of real world conditions, implying citizens.
- Improve: Implementation of methodologies and practices to reduce air pollu way environment.
- Airuse: to reduce PM2.5 and PM10 concentrations in air o considering a combination of diverse emission sources (du climatology.
- NanoFASE: integrated exposure assessment framework (p s, guidance ...) for the wider environment.
- NanoIndex: Comparability, accuracy and field-practicability to generate large dataset on workers' exposure.



4 NanoMONITOR project plan

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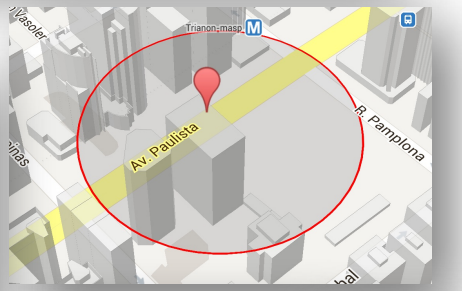
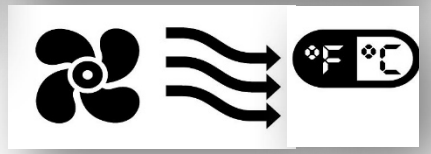
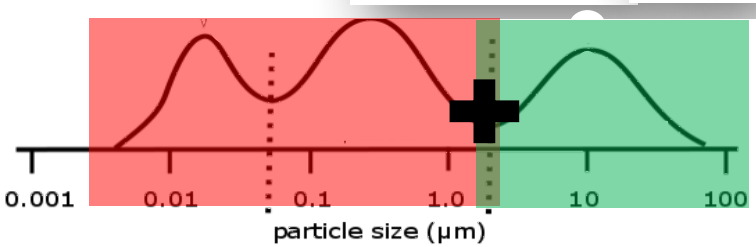
NanoMonitor project plan

Variables recorded

- ✓ Particle number concentration < 300 nm
- ✓ Mean size
- ✓ Surface area
- ✓ Chemical composition analysis from samples deposited in filters/impactors (x3)
- ✓ Weather conditions tracking (temperature, humidity, pressure,..)
- ✓ GPS location
- ✓ Cooling unit (Peltier)
- ✓ Long-time tracking
- ✓ Unatented / Wireless operation
- ✓ Hot spots indentification (indoor/outdoor)
- ✓ Operative recommended protocols
- ✓ Complementing oficial air quality monitoring spots







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NanoMonitor project plan

Generation of data - Hotspots

Background:

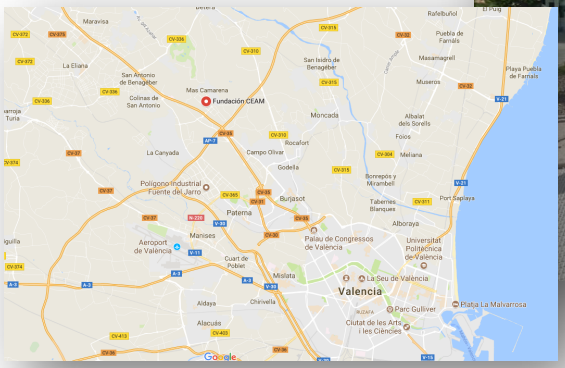
- Clean environment in mountains
- Isolated from urban influence

Urban traffic:

- Ring-road Valencia (Highway)
- Connecting to the port

Suburban area (CEAM):

- Technological park/ Residential area
- Proximity to highways
- Proximity to parks, gardens
- High traffic only during rush hours



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NanoMonitor project plan

Generation of data - Hotspots

Metro Valencia:

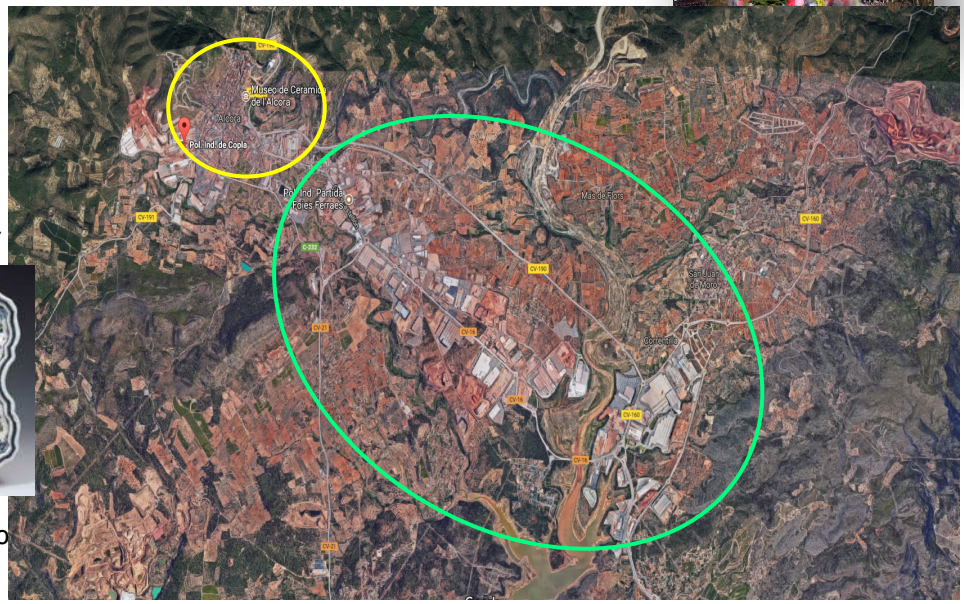
- Underground (2 levels)
- Sometimes goes ground level
- Only 1 line with forced ventilation 2 x day
- Influence from fallas (Fireworks, burning wood & polymer sculptures)

Alfafar Area:

- Highways
- Shopping malls (IKEA, Media Market, Bauhaus,…)
- Public transport
- Industrial park

Alcora surroundings:

- +600 ceramic industries (Porcelanosa, Keraben, Torrecid…)
- High volume of transport trucks
- Red dust covering the área
- Mountainous environment



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