Overall view of the LIFE NanoMONITOR project

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NanoMONITOR 4th Stakeholders´ Day. Safe Nanotechnology – Exposure Asseessment, Risk Management and Regulatory Challenges

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Outline

1. CONCEPT OF THE PROJECT
2. MAIN OUTCOMES AND PROGRESS AT GLANCE
3. SCHEDULED ACTIVITIES UNTIL THE END OF THE PROJECT
4. SUMMARY CONCLUSION

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1. Concept of the project

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1. Concept of the project

The concept of the project stems from the need of generating robust, accessible, comparable and interoperable data on the concentration of nanomaterials in workplaces and relevant outdoor environments, considering that :

- Studies conducted so far point out that a **significant release of submicron sized particles**, including single particles, aggregates and agglomerates (< 1000 nm) and embedded in a solid matrix (i.e. polymers) , can be expected during the production and downstream use of ENMs.

- Nanostructured materials can be released into the air, soil, and water in common industrial processes and /or accidental events and ultimately accumulate in the environment.

Emission Source	NPs Type	Measured levels range
Primary / SD1		
Liquid-phase reaction	PGNP	$4.0x10^4$ to $11.0x10^6$
Flame spraying	PGNP	$4.7x10^3$ to $1.0x10^6$
CVD	PGNP	Non-significant
Top-down (milling)	ENPs / PGNP	$3.0\ 10^3$ to $1.0x10^6$
Secondary NP aerosol / SD2		
Weighing of powders	ENPs	$2.0X10^4$ to $7.0x10^4$
Harvesting	ENPs	$2.0X10^4$ to $5.0x10^4$
Manual packaging (Bagging)	ENPs / PGNP	$20.0x10^4$
Bag emptying of powders	ENPs	Significant increase
Melt Blending	ENPs / PGNP	> $1.0x10^5$
SD3a / SD3b		
Spraying of liquid	ENPs	$2.0x10^8$
Spraying (gas)	ENPs	$1.6x10^5$ to $2.0x10^{10}$
Injection Molding	ENPs	> $8.0x10^5$
Brushing and rolling	ENPs	> $6.0x10^5$
Sonication of nanodispersions	ENPs	> $8.0x10^6$
Tertiary NP aerosol / SD4		
Abrasion of nanoproducts	PM / EMNP	$8.0x10^3$ to $2.0x10^4$
Drilling	PM / EMNP	$4.0x10^4$
Grinding	PM / EMNP	$3.0x10^3$ to $1.0x10^6$

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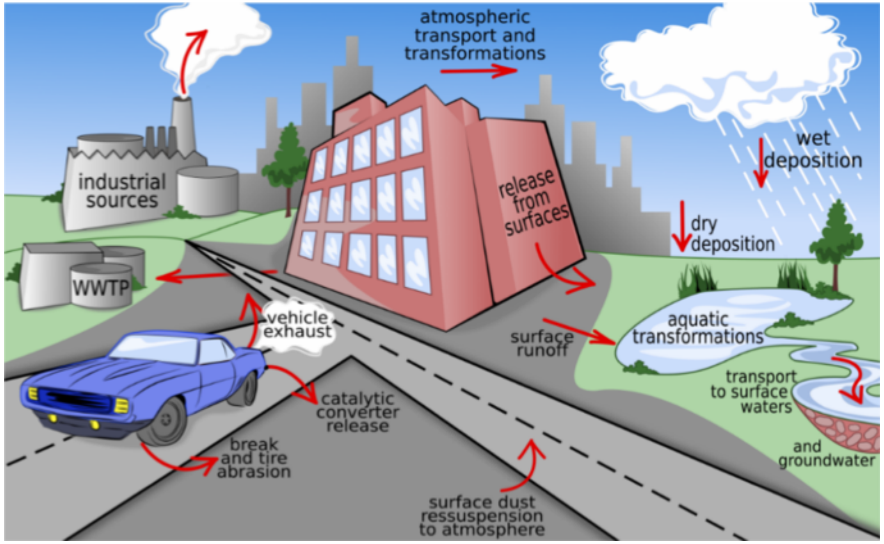
1. Concept of the project

- Accidental spills during production or later transport of nanomaterials, and release from wear and tear of materials containing ENMs **may lead to potential exposure** in urban areas

- Incidental nanomaterials (INMs) can also be generated in **outdoor urban environments** by automobiles, power plants and urban based industries

- Existing evidence suggest **that subway systems** may be also of interest, including elevated levels of fine (PM2.5) and coarse (PM2.5 -10) particulate air pollution, as well as ultrafine particles (UFP), understood as particles smaller than 100 nm, with a chemical composition based on elements such as Fe, Mn, Si, Cr, Cu, Ba, Ca, Zn, Ni and K.



Source:Sources and pathways of outdoor urban nanomaterials in the environment (Baalousha, et al., 2016)

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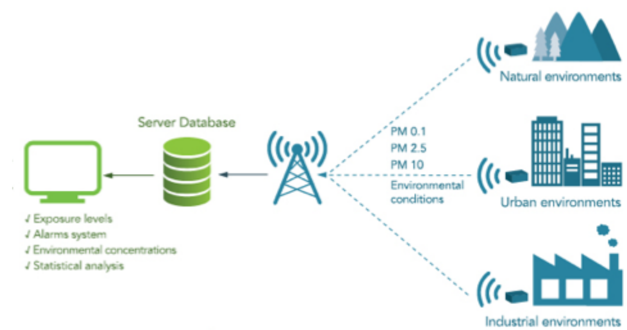
1. Concept of the project

Objectives

The overall aim of the project is to **develop a real-time information and monitoring system** as a key innovative tool for the risk assessment of nanomaterials on a regulatory basis, in particular, REACH regulation

The system is based on the development of an **online data analysis tool** for collecting and archiving data on the environmental concentration of ENMs, coupled with a newly developed **prototype and low cost nano-pollution monitoring system** able to continuously measure key airborne nano-pollutants.



By developing these tools, NanoMONITOR **promotes the use of measured data** to meet information requirements laid down on REACH for human and environmental risk characterization, including exposure data and predicted environmental concentration levels (PEC).

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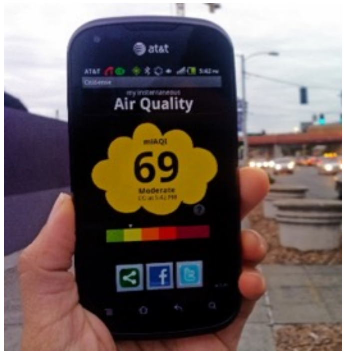
NanoMonitor - Overall view of the project

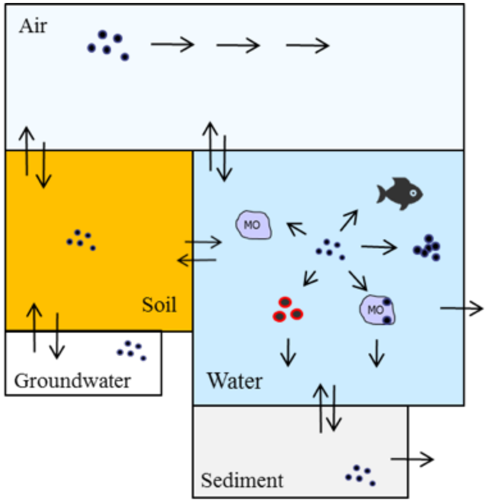
1. Concept of the project

❑ Specific Objectives

The **specific objectives outlined in the proposal** are:

- New low cost monitoring station prototype for the measure of indoor and outdoor concentrations of ENMs
- To develop a software application to store, exchange and manage data on the concentration of ENMs.
- To design and develop standardized sampling and data analysis procedures to ensure the quality, comparability and reliability of the monitoring data used for risk assessment
- To implement and validate the NanoMONITOR integrated systems in case studies
- Support the calculation of the predicted environmental concentration (PEC) of ENMs in the context of REACH
- Transfer and disseminate the project results to a large community of SMEs and potential stakeholders





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NanoMonitor - Overall view of the project

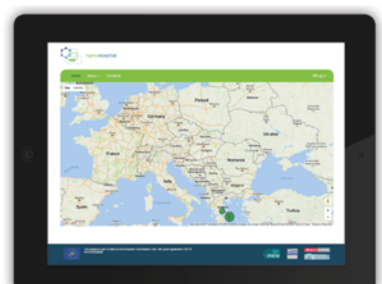
1. Concept of the project

nanoMONITOR

❑ Results

The key results of the project are:

- Delivery of up to 5 monitoring stations
- Delivery of the NanoMONITOR software platform for the on-line analysis of the measured data on ENMs concentration
- Generation of robust data on the concentration of ENMs in urban environments (high traffic areas + subway) and industrial facilities covering relevant processes in the ENM life cycle
- Validate the outcomes of the project in case studies, including 4 urban areas and 4 industrial facilities
- Transference of the project results to stakeholders other than those considered in the proposal
- Training and dissemination of the project



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NanoMonitor - Overall view of the project

1. Concept of the project

❑ Consortium and main roles

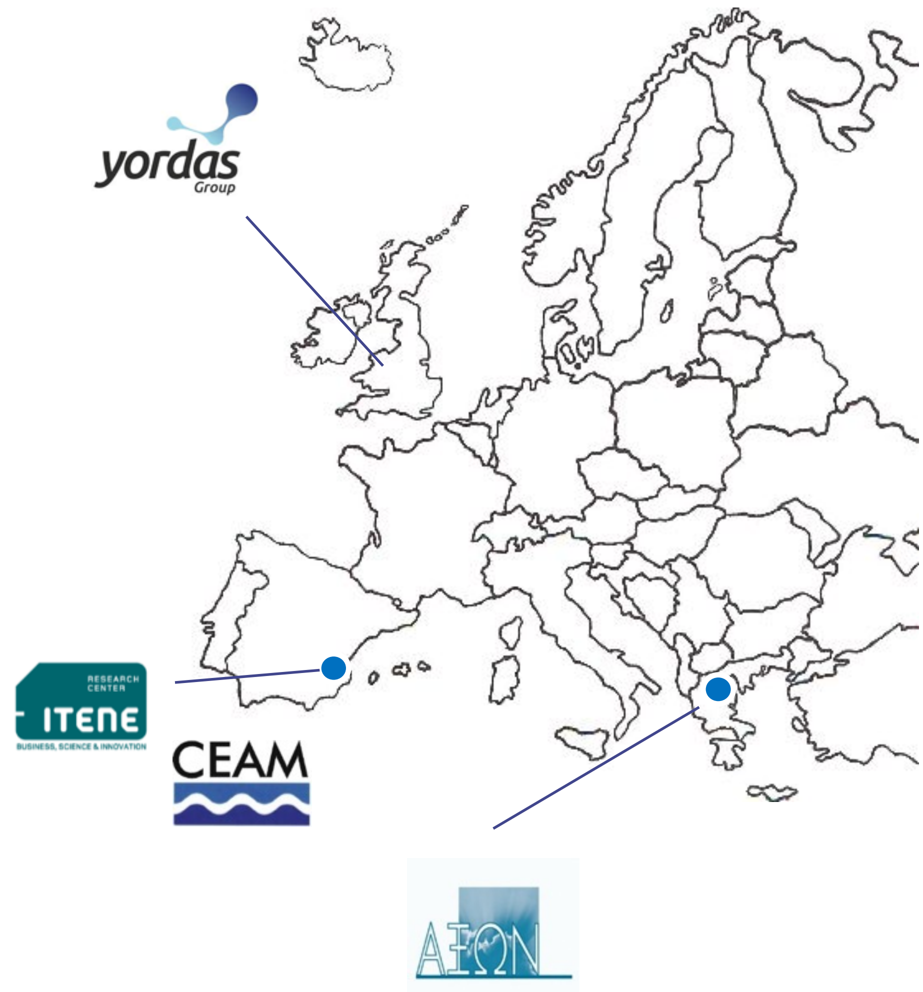
The consortium of the project consists of **4 organizations representing** 3 main areas: Spain, Greece and UK.

- **Coordinating Beneficiary**

  Instituto tecnológico del embalaje, transporte y Logística (ITENE)

- **Associated Beneficiaries:**

  - Fundación centro de estudios ambientales del mediterráneo (CEAM) - Spain
  - Yordas Group – Uk
  - AXON Enviro-Group Ltd (AXON) - Greece



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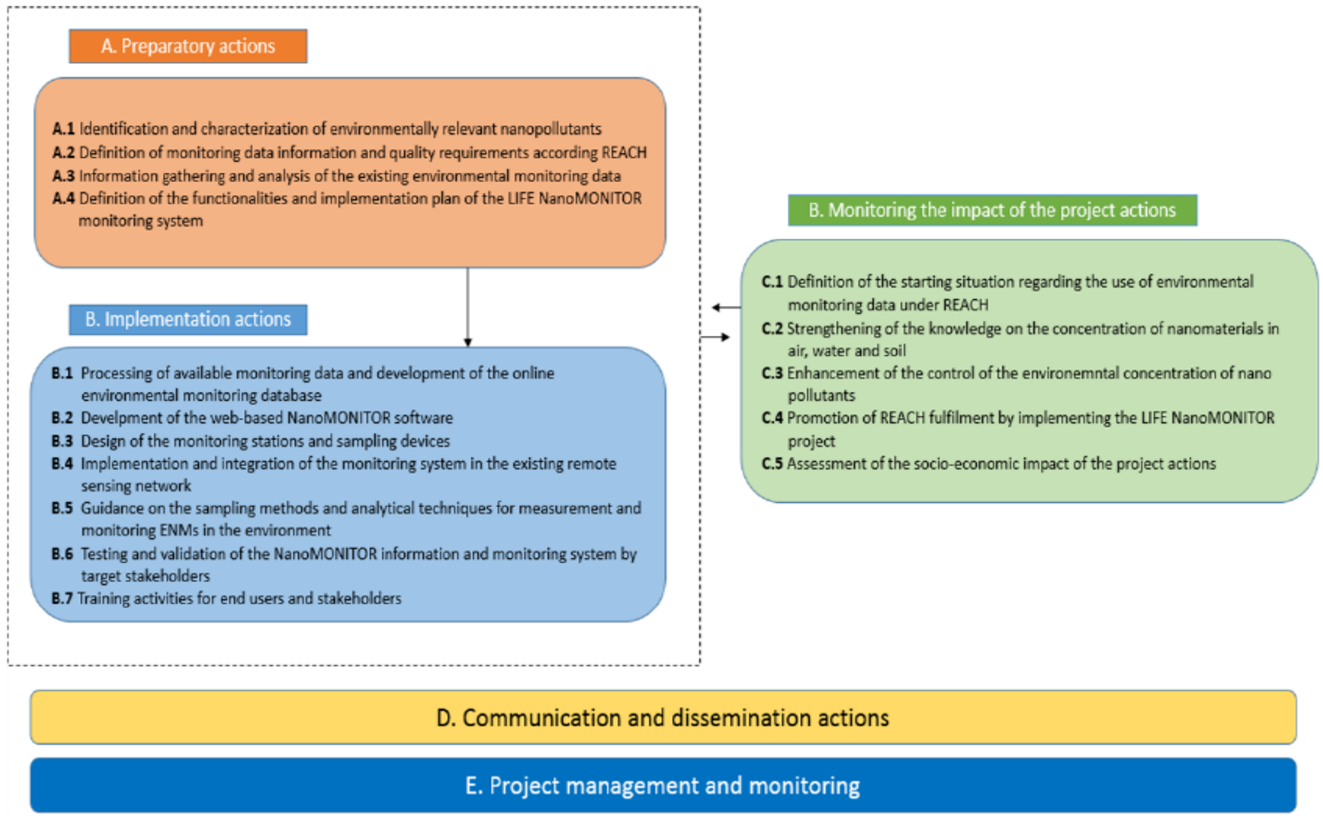
1. Concept of the project

❑ Scheduled activities

NanoMONITOR consists of 5 complementary actions, including:

A. Preparatory actions
B. Implementation
C. Monitoring
D. Communication
E. Management



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2. Main outcomes and progress at glance

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2. Main outcomes and progress at glance

A. Preparatory Actions

These actions focus on the selection of environmentally relevant ENMs, the information and data quality requirements according REACH and the geographical coverage and sampling locations and frequency

Action	Action Title	Partner id	Status
A.1.	Identification and characterization of environmentally relevant nano-pollutants	ITENE	Competed
A.2	Definition of monitoring data information and quality requirements according REACH	ITENE	Competed
A.3	Information gathering and analysis of the existing environmental monitoring data	CEAM	Competed
A.4.	Definition of the functionalities and implementation plan of the LIFE NanoMONITOR monitoring system	AXON	Competed

Main outcomes are:

P1. Quality criteria to use measured data under REACH and relevant monitoring programs

P2. Procedures to determine the validity of measured data based on scoring criteria

P3. Inventory of data on the concentration of NMs in industrial, urban and environmental compartments

			PNC (particles/cm^3)		
Location	Country	Year †	Max	Min	Mean
Toronto	Canada	2006 – 2011	36800	11400	
Huelva	Spain	2008 – 2009			
Barcelona	Spain	2009	29449	6140	16847
Lugano	Switzerland	2009	47562	2751	14945
North Kensington	UK	2009	27295	795	12134
Bern	Switzerland	2009	93078	8888	28032
Marylebone	UK	2009	58017	4753	22156
Huelva	Spain	2009	67949	1091	17918
Sta. Cruz de Tenerife	Spain	2009	26249	1076	12008
Durham (NC)	US	2008			
Augsburg	Germany	2004 – 2006	24122	5387	
Milan	Italy	2009	117600	13500	
Mol	Belgium	2007			

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NanoMonitor - Overall view of the Project

2. Main outcomes and progress at glance

❑ B. Implementation Actions

The implementation actions focus on the development of the real-time information and monitoring system including the development of the web-based application and the design and implementation of the autonomous monitoring station prototype.

Action Nº	WP Title	Partner id
B.1.	Development of a web based library of exposure scenarios and measured data on the exposure and release of ENMs	ITENE
B.2	Development of the web-based NanoMONITOR software application	AXON
B.3	Design of the monitoring stations and measurement devices	ITENE
B.4.	Implementation and integration of the monitoring system in the existing air quality monitoring network	CEAM
B.5.	Sampling methods and analytical techniques for the measurement and monitoring of ENMs in the environment	ITEBE
B.6.	Testing and validation of the NanoMONITOR information and monitoring system by target stakeholders	ITENE
B.7.	Training activities for end users and stakeholders	TRC

Main outcomes are:

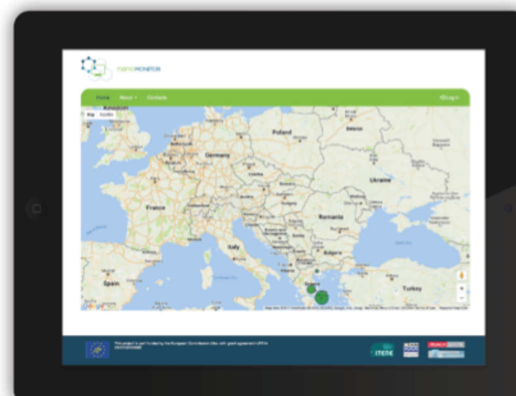
P1. On-line database of exposure scenarios – ES Library

P2. NanoMONITOR Software Platform

P3. Up to 5 NanoMONITOR monitoring stations

P4. Publication of a list of 10 well defined and standardised protocols for collecting and sampling ENMs for risk assessment purposes

P5. New interactive guidance on the sampling methods and analytical techniques for the measurement and monitoring of ENMs in the environment

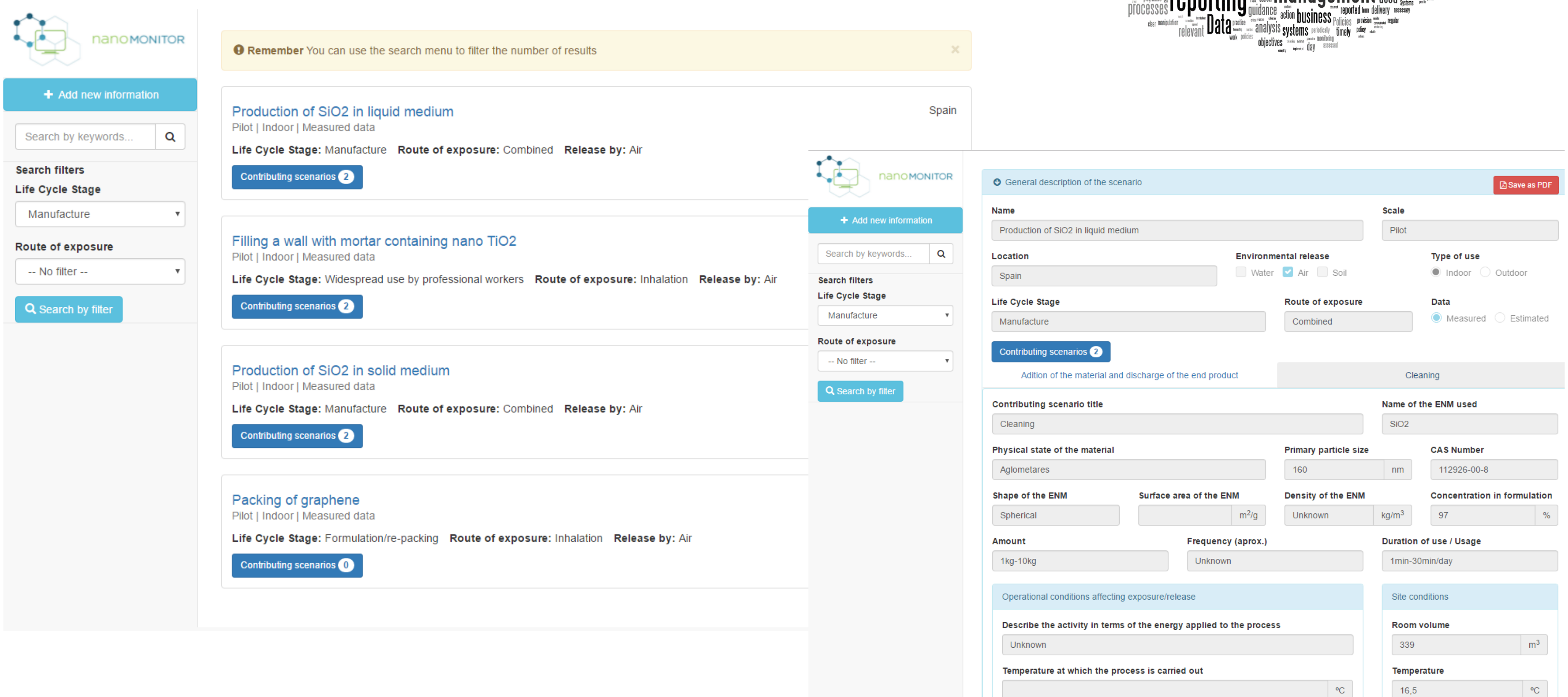


NanoMonitor - Overall view of the Project

2. Main outcomes and progress at glance

❑ Main outcomes per action

B1. Exposure Scenario Library



http://library.lifenanomonitor.eu/

NanoMonitor - Overall view of the Project

2. Main outcomes and progress at glance

❑ Main outcomes per action

B.1. Nano-specific environmental release categories

Application of ERCs (refined here to the specific case of NMs)

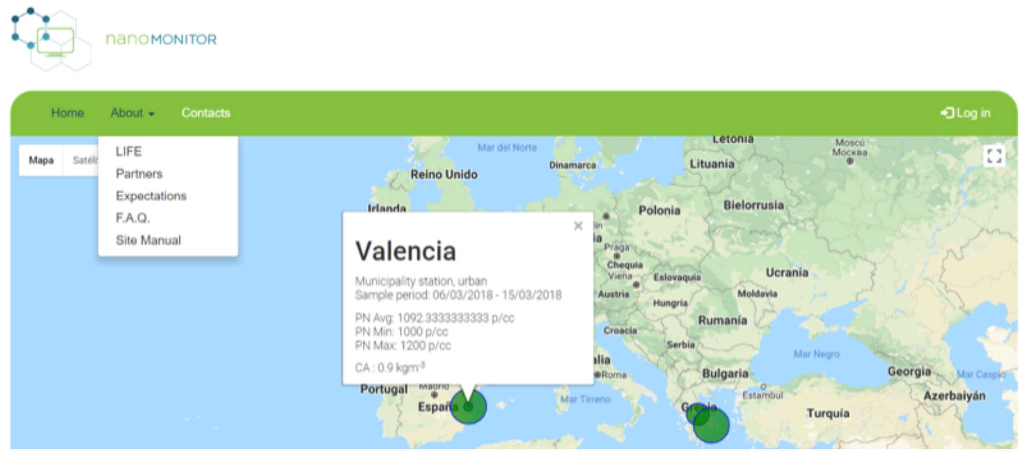
Stage	NRC	Air (%)	Water (%)	Soil (%)
Production	NRC1a	0,05619	6,74275	0,01124
	NRC1b	0,05615	6,73755	0,01123
	NRC2	0,05	0,06	0,00010
	NRC3	0,05	0,06	0,00010
	NRC4	5E-06	0,06	0,00010
	NRC5a	0,00562	6,74404	0,01124
	NRC5b	0,05565	6,67773	0,01113
Formulation	NRC6a	0,00561	6,72923	0,01122
	NRC6b	5,60769	6,72923	0,01122
	NRC7	5,61525	6,73829	0,01123
	NRC8	0,05	0,06	0,00010
	NRC9	0,05	0,06	0,0001
Manufacture	NRC10a	0,01086	7,14956	0,57817
	NRC10b	10,86905	7,15276	0,57843
	NRC11a	0,0000000	0,01	0
	NRC11b	0	0,001	0
	NRC12	0,0010	0,0715	0,0058
	NRC13a	0,48970	32,22657	2,60610
	NRC13b	10,85635	7,14441	0,57775
Use	NRC14a	0	0	0
	NRC14b	4,89923	0	4,89923
	NRC15	4,19918	0	4,19918
	NRC16	0,13395	0	0
	NRC17a	1,8	0	1,8
	NRC17b	5,0	0	5,0
	NRC18	1,8	1	
	NRC19	5,0	0	0
	NRC20	0,5	0	5,0
	NRC21	5,0	0	5,0
Disposal	NRC22	44,51640	0	0
	NRC23	0	0,12211	0
	NRC24a	0	0	14,83880
	NRC24b	0,05619	6,74275	0,01124
	NRC25	0,05615	6,73755	0,01123
	NRC26	0,056	6,74	0,011

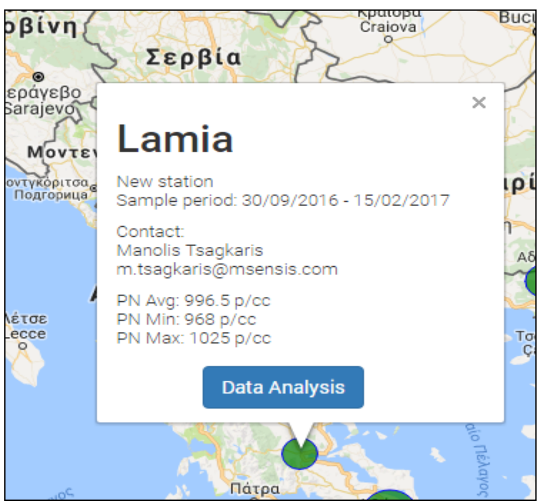
NanoMonitor - Overall view of the project

2. Main outcomes and progress at glance

B2. NanoMONITOR Software

- Multiple exporting data formats
- Real-time multiparametric graphical information
- Easy data management options, including data storage, comparative analysis and modelling
- High resolution maps
- Access from smartphones and tablets





Station: 1. Valencia | **Category:** Air Quality Data | **Metric:** CO | **From Date:** 01/03/2018 | **To Date:** 19/03/2018

Data Presentation | Statistics | Modeling | Risk

Station ID	Location	Period	Metric	Unit	Statistic	Value
1	Valencia	01/03/2018 - 19/03/2018	CO	mg/m3	Min	0.12143
1	Valencia	01/03/2018 - 19/03/2018	CO	mg/m3	Max	11.14340
1	Valencia	01/03/2018 - 19/03/2018	CO	mg/m3	Average	3.69643
1	Valencia	01/03/2018 - 19/03/2018	CO	mg/m3	Variance	18.63490
1	Valencia	01/03/2018 - 19/03/2018	CO	mg/m3	Standard deviation	4.31682

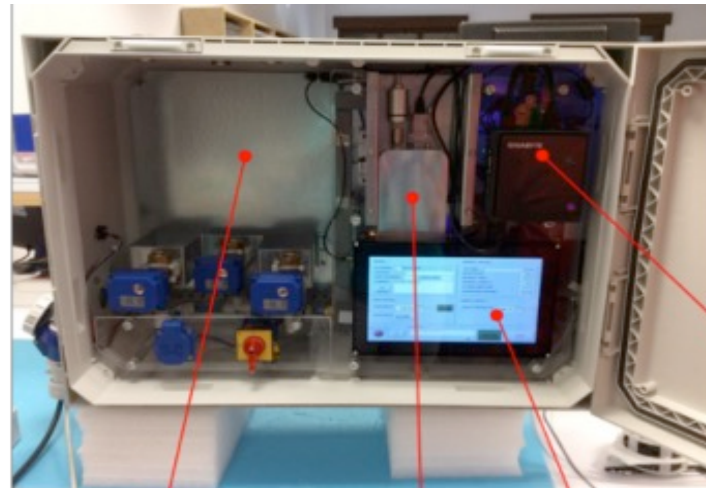
Export to Excel

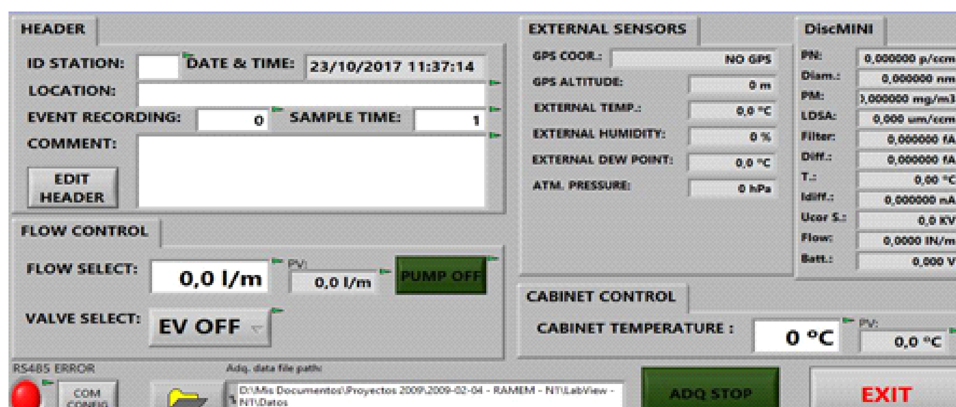
2. Main outcomes and progress at glance

B3. A Real-time Information and Monitoring System

Technical Details on the Monitoring Station:

- Detection of particles ranging in size from 10 to about 700 nm
- Geolocated real-time information on ENM concentrations
- Integrated plug and play solution designed for long term sampling and monitoring ENM concentrations
- Remotely configurable settings, readings and transmission periods
- Minimum maintenance requirements





2. Main outcomes and progress at glance

B4. Implementation and integration of the monitoring system in the existing air quality monitoring network of the Valencian Community and relevant urban areas

Air Quality stations

- Location 1. Pista de Silla / Urban / Coordinates 39° 27' 29" N - 0° 22' 36" W, 11 m.a.s.l..
- Location 2. Paterna-CEAM / Suburban / Coordinates 39° 33' 5" N - 0° 27' 39" W, 122 m.a.s.l.
- Location 3. L´Alcora / Industrial / Coordinates 40° 03' 07" N - 0° 11' 23" W, 160 m.a.s.l.
- Location 4. Coratxar / Rural / Coordinates 40° 41' 30" N - 0° 5' 5" E, 1200 m.a.s.l.

Subway

- Metrovalencia “colon”

Train and higs density traffic are

- Alfafar 1
- Alfafar 2

	Maximum instant concentration (particles/cm^3)	Minimum instant concentration (particles/cm^3)
Suburban environment	37159	150
Urban environment	59634	384
Industrial environment	53924	223
Rural environment	3935	101
Alfafar 1 (Railway)	1499978	202
Alfafar 2 (Traffic)	512040	248
Metro station	336300	202

NanoMonitor - Overall view of the project

2. Main outcomes and progress at glance

B5. Guidance on the sampling methods and analytical techniques for the measurement and monitoring of ENMs in the environment

- A list of 10 well defined and standardized protocols for collecting and sampling ENMs for risk assessment purposes.
- A new interactive guidance on the sampling methods and analytical techniques for the measurement and monitoring of ENMs in the environment.

Guidance for ENMs 7

ANALYSIS OF CURRENT KNOWLEDGE ON THE CONCENTRATION LEVELS OF ENMS IN INDOOR WORKPLACES AND THE ENVIRONMENT

3.1 Sources and forms of ENMs in target compartments

Airborne nanosized particles can originate from naturally occurring and incidental sources in addition to the engineered particles (ENMs) sources typically of interest in occupational settings. A highest exposure potential exists for workers in workplaces, where these materials are produced, used, or handled (*Asbach, 2015*).

The information on the concentration levels of ENMs in urban areas and/or ecosystems is still scarce, with a limited number of studies available. However, the number of published data on the levels of exposure to ENMs in the workplace has increased substantially over the last five years, including data on the particle number concentration (particles/cm3) and mass concentrations (μg/cm3) measured using real-time measurement devices.

The sources of ENMs in workplaces are related with the type of processes and work practices conducted in the industrial facilities. Schneider et al. proposed a classification based on the definition of four source domains (table 2) based on the life cycle stages, from production, downstream use, to end-of-life treatments.

The form and amount of the ENMs released in workplaces are determined by the activity emission potential and the substance emission potential. The activity emission potential is commonly related with the number of products (i.e. ENPs or nanoproducts) used, energy applied in the process and level of containment. Common forms of ENMs releases in workplaces include single particles and aggregates < 1000 nm, large agglomerates with a size range from 1 to 20 μm, as well as ENMs embedded into a solid matrix.

The substance emission potential can be considered specific of each ENM or nanoproduct. For ENMs in powder form, the emission potential will be determined by the dustiness of the material. In the case of colloidal dispersions containing ENMs, the concentration of the solute, diameter of dispersed ENMs, and viscosity of the mixture are key parameters influencing the emission potential.

Concerning urban areas, the study of the magnitude of the exposure to ENMs in cities is already a challenge. The main sources of release include unintentional emission from nano-enabled products used in urban building and other infrastructures, and industrial emission that can reach the urban areas due to complex transport process in the atmosphere.

Table 2. Examples of emission sources

EMISSION SOURCE	RELEASE POTENTIAL	SPECIFICATIONS
1. Point source or fugitive emissions		
Liquid-phase reactions	Likely	Single particles
Flame spraying	Likely	Single particles
CVD	Not Excluded	Single particles
Top-down (milling)	Not excluded	Single particles
2. Handling and transfer of bulk manufactured nanomaterial powders with relatively low energy		
Weighing of powders	Likely	Single particles and aggregates < 1000nm
Harvesting	Likely	
Manual packaging (Bagging)	Likely	
Bag emptying of powders	Likely	Single particles and aggregates < 1000nm Large aggregates 1 to 20μm
Melt Blending	Likely	Embedded particles. Limited release of fully dissociated NPs
3. Dispersion of either (liquid) intermediates containing highly concentrated (> 25%) nanoparticales or application of (relatively low concentrated < 5%) ready-to-use products		
Spraying of liquid	Very Likely	Single aggregates as well as large agglomerates
Spraying (gas)	Very Likely	
Injection Molding	Very Likely	Single particles and aggregates < 1000nm Embedded particles Limited release of fully dissociated NPs
Brushing and rolling	Very Likely	
Sonication of nanodispersions	Very Likely	Single particles and aggregates < 1000nm
4. Activities resulting in fracturing and abrasion of manufactured nanoparticles-enabled end-products		
Abrasion of nanoproducts	Not excluded	Embedded particles. Limited release of fully dissociated NPs
Drilling	Possible	
Grinding	Possible	

At present, there are few studies on revealing the concentration of ENMs in urban areas, however, ENMs are currently widely incorporated in new applications and products such as building façade paintings, fuel additives, photocatalytic concrete pavements or antireflection layers for road signs and pane, which means that a bigger number of ENMs that are likely to be released in the indoor and outdoor urban environments.

The effect of wind and rain, as well other weather conditions, triggers ENMs erosion that can lead to air/water transport and deposition, which implies a potential exposure to ENMs of citizens. In addition, as indicated in the previous chapter, incidental nanomaterials (INMs) can also be generated in the outdoor urban environment by automobiles, power plants and urban based industries. In this regard, INMs can be released due to road traffic via engine combustion exhaust, brake pad and tire abrasion, with average particle diameter below 300 nm (Kumar et al., 2014), and compositions ranging from metals and metal oxides to phosphates. These INM contribute to a negligible portion of the total mass of particulate matter (PM), but they are the dominant fraction in terms of particle number (Kukutschová et al., 2011).

Rail traffic is also a potential source of INMs, being mainly generated by the motion of trains movements and activities of commuters and subway staff, air ventilation and various stationary processes (Vania Ferreira, 2016). Evidence suggest that although abrasive forces between wheels, rail, and brakes can generate coarse and fine particles due to sharing, ultrafine particles can be generated via the high temperature of friction at interfaces between these components, with subsequent vaporization of the substrate (Sundh et al., 2009).

As an example, the levels of ultrafine particles measured with a condensation particle counter (CPC, TSI model 3007) reached an average value of 14.200 pt/cm3 for the metro systems of Toronto, Montreal, and Vancouver, in Canada (Van Ryswyk K, et al., 2017). In the subways system of Helsinki, UPF concentration reached levels rather similar to those in outdoor ambient air (31.000 pt/cm3).

A non-exhaustive list of the sources and types of ENMs in urban system is depicted in table 3.

Table 3. Examples of emission sources and types of ENMs in urban areas

SOURCE	EMISSION TYPE	MAIN USES OF ENMs
Nano-enabled products	Unintended releases during use	Metal and Metal Oxides (Ag, Cu, TiO2, ZnO, SiO2, CuO) Carbonaceous materials (Graphene) ENM particles heteroaggregated with background aerosols
Industrial emissions (Wet/dry atmospheric deposition in cities)	Direct release and transportation	Metal and Metal Oxides (Ag, Cu, TiO2, ZnO, SiO2, CuO) ENM particles heteroaggregated with background aerosols
Industrial emissions	Direct release and transportation	
Road Traffic		
Brakes/tires abrasion	Direct releases of Incidental Nanomaterials (INMs)	SiO2, CeO2, Zn, Mn, Fe, Co, Ni, Cd and Pb
Engine combustion exhaust		
Resuspension		
Rail Traffic		
Brakes/tires abrasion	Direct releases of Incidental Nanomaterials (INMs)	CuO Al, Ba, Ca, Cl, Cr, Cu, Fe, K, Mg, Mn, I, Pb, S, Si, Ti and Zn
Resuspension		

3. Scheduled activities until the end of the project

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NanoMonitor - Overall view of the project

3. Scheduled activities until the end of the project

On the basis of the timescale of the project, all the actions will have started, and it´s expected to complete actions B4 to B7, C2 to C5, and dissemination actions.

Main activities to be completed

B4. Monitoring activities in Lancaster (UK) in October and Thessaloniki (Greece) in November

B5. Publication of the interactive “multimedia” guideline in the project web site by November

B6. Cases studies to test and validate the monitoring systemin industrial sites

B7. Training activities

C2/C3. Continuous monitoring of the data generated

C5. Complete the socio-economic impact analysis following performance indicators

E. Development of the After LIFE implementation plan, including a monitoring activities and dissemination actios

4. Summary conclusions

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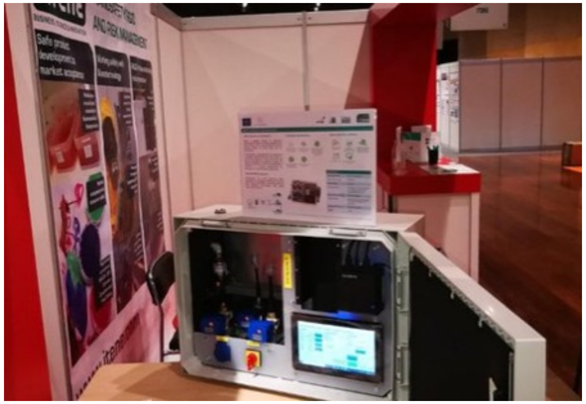
4. Summary conclusions

- 5 monitoring stations have been developed, being installed in several scenarios to generate a large amount of data (> 1 million values for urban environments available).

- Dissemination conducted at all scales, from local to international events, including conferences, workshops and EU cluster meetings.



- Implementation phase on going, including the installation of the stations in up to 9 strategic locations to gather relevant data on ENMs concentration, size and chemical nature.

- Promising after LIFE plan, with interest from local authorities in sampling PM0.1 and PM1 nano-pollutants.

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